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He Guoxiong, Mu Xinan

(Nanjing Institute of Geology and Palaeontology, Academia Sinica)

Yin Jixiang and Wu Haoruo

(Institute of Geology, Academia Sinica)

In Xizang, the strata are unequal in development, sedimentation types are various, but fossils are very rich, amounting to 3800 taxa in 30 kinds or so.

Judging from the stratigraphical development, sedimentation types and biotic aspects, Xizang may be divided into 4 stratigraphical regions (Himalaya Region, Kangdese-Nyaingqentanlha Region, Tanggula-Hengduanshan Region and Holxil-Kunlun Region) and 11 subregions. The stratigraphical regions, extending forward parallel to the latitude, are separated respectively by 3 deep fault zones from south to north.

According to the crustal activities in the depositional process, the sedimentation types in Xizang may be divided into 6 zones, which consist alternately of 3 relatively stable types and 3 relatively active types. The sedimentation zones elementally coincide with the stratigraphical regions or subregions.

In Xizang, fossiliferous Cambrian sediments have hitherto been unobserved; but the Ordovician-Devonian, taken as a whole are in the sedimentation area of relatively stable type. Higher up in the Carboniferous and the Permian, the sedimentation zone of relatively active type came into existence in the northernmost part of Xizang. Up to the Mesozoic, the other two sedimentation zones of relatively active type were taking shape successively; while the original sedimentation areas of relatively stable type were cut apart. This is the reason why the stratigraphical regions were gradually formed in Xizang.

ESTIMATING ALTITUDES OF TERTIARY FORESTS

Daniel I. Axelrod

(University of California, Davis, California U.S.A.)

To estimate altitude, an adequate sample is required because each forest belt has a range of elevation. Some of its species may be distributed widely in it, but others are more restricted. A good sample indicates whether the fossil flora is similar to the upper, lower, or middle part of a similar modern forest.

Altitude is inferred from temperature requirements of similar modern forests. These cannot be assessed in terms of mean annual temperature (T) alone. The annual range(A) must be estimated, because it provides the annual wave of temperature that influences the modern flora similar to the fossil. Plotting data (T & A) on a Bailey nomogram provides an indication of (1) warmth of climate (W) by radii of specified temperature that define the *duration of the growing season* as the number of days (d) with mean temperature warmer than W, and (2) the temperateness or equability of climate (M) as shown by a field of arcs nearly normal to the W radii that provide an *index to thermal extremes* that increase in all directions from an ideal centered at T 14℃ (57.2F) and A 0°. The nomogram shows frost frequency lines significant in determining distribution today, as well as major biotherms such as tree line, the margin of the wet tropics, etc. For any point defined by the coordinates T and A, mean monthly temperatures can be recovered if it is assumed that the march of temperature lies under a sine wave. All factors are interrelated, so the nomogram can be used to assess any temperature field, either today or in the past.

To estimate altitude of a flora now in the mountains, reference is made to a flora at sea level. The difference in mean temperature, when multiplied by a normal *terrestrial lapse rate* (183 m/-℃, or 333 ft/-F°), gives an indication of elevation.

Examples will be presented on the use of the nomogram in estimating temperature and elevation.

VEGETATIONAL CHANGES IN THE PAST AND UPLIFT OF THE QINGHAI-XIZANG PLATEAU

Hsü Jen

(Institute of Botany, Academia Sinica)

By the late Carboniferous the *Lepidodendropsis* flora was flourishing in the northern Xizang, while the *Rhacopteris* flora was prospering in the northern India. During the late Permian, the northern Xizang was inhibited by the *Gigantopteris* flora, while in the southern Xizang was widespread the *Glossopteris* flora. The upper Triassic flora of the northern Xizang is closely related to that of south-western China and quite different from that of India. The Jurassic flora found in Tsaidam of Qinghai and the early Cretaceous flora found in Lhasa of the northern Xizang are closely related to those of the northern hemisphere, and show no relationship with those of the southern hemisphere. The late Cretaceous flora of Rikaze and the early Eocene flora of Ali region are also of northern hemisphere in affinity and show no relationship with the Daccan Intertrappean and the Eocene floras of India. Hence, the northern and the southern Xizang should have belonged to two different continents, Eurasia and Gondwanaland. Between them, a very wide sea, the Tethys, was situated. This strongly supports the view of continental drift that the India block drifted in late Jurassic-Cretaceous from the south-eastern corner of Africa and later on in Eocene joined up with Asia to become its subcontinent. The suture line between Euıasia and the India blocks perhaps lies in the belt of basic to ultrabasic rocks along the Yalu-Tsangpo valleys.

Judging from the nature of the floras ranging from the late Carboniferous to the early Eocene, the northern Xizang most probably was of lowland in topography throughout these periods.

The Miocene floras of the central and the northern Xizang were mainly composed of deciduous broad-leaved trees, though some evergreen trees existed somewhere else. It refl cts the land of the central and the northern Xizang had already uplifted to some extent before Miocene. During the time of Pliocene, the evergreen broad-leaved trees were gradually declining in their development in the northern Xizang. The vegetation of the Chaidamu (=Tsaidam) Basin further changed from deciduous broad-leaved to coniferous forests and then turned into grasslands and semideserts or deserts. It shows by that time the land of Xizang and Qinghai further upheaved.

Up to the late Pliocene, the vegetation of the northern Xizang and Qinghai further changed. But the vegetation of the Himalayan region was still [dominated by evergreen oaks and *Cedrus* forests. Most probably by that time the Himalayas was not so high as present. There was no barrier to prevent the seasonal winds of the Indian Ocean passing over the Himalayas.

The most active period of the uplift of the mountain ranges in Xizang and the Qinghai-Xizang Plateau is the Quaternary. By that time no evergreen broad-leaved trees could live in the northern Xizang. During the late Quaternary, the vegetation of most parts of Xizang gradually changed into alpine tundras. At last the Qinghai-Xizang Plateau turned into the present state.

THE DISCOVERY OF THE CATHAYSIA FLORA IN THE QINGHAI-XIZANG PLATEAU, WITH A SPECIAL REFERENCE TO ITS PERMIAN PHYTOGEOGRAPHICAL PROVINCES

Li Xingxue and Yao Zhaoqi
(Nanjing Institute of Geology and Palaeontology, Academia Sinica)

It has long been known that the Late Permian Angara flora and the Permo-Carboniferous Cathaysia flora appeared in the northern border of the Qinghai-Xizang (Tibet) plateau, *i. e.* the Nanshan profile of the W. Chilianshan. On account of the recent finding of a *Glossopteris* flora from Tingri and Dinggye counties in S. Xizang, the northern border of the Gondwanaland ought to be considered to reach further north to the Himalayas. Therefore, what kind of Permian floras would be found in the Qinghai-Xizang plateau proper become a most interesting problem.

Previously, there were a few Permian Cathaysia plants recorded in Wuli of S. Qinghai and Qamdo of E. Xizang. In the last decade, rather rich materials of the Late Permian Cathaysia flora have been found respectively from Shuanghu of N. Xizang, Toba, Qamdo of E. Xizang and Lasiu, Yushu of S. E. Qinghai. In addition, from the southern slope of the Eastern Chilianshan were known with a few Cathaysia plants of the North China type, while in the northern slope of the middle Chilianshan, *i. e.* the Sunau district, most recently has been surprisingly found that a typical Late Permian Cathaysia flora intermingled with some Permian elements of the Angara flora.

According to the discoveries mentioned above and in consideration of some new palaeozoological and geological information avaliable, it seems appropriate to outline the boundaries of Permian phytogeographical provinces in the plateau as follows (Map 1): (1) The boundary between the *Glossopteris* and the Cathaysia floras may be considered to be coinciding with a plate suture or a deep fault zone running more or less parallel to the valley of the Yarlung Zangbo River. (2) The Tienshan-Khingan deep fault zone, stands outside to the north of the plateau has generally been regarded as a natural boundary between the Angara and the Cathaysia floras, however, as the sea trough in this area disappeared at the end of early Permian, the Late Permian Angara flora spread southernly into the Chilianshan and made somewhat a mixture of the two floras. (3) The dividing line of the two subprovinces, *i. e.* the Northern and the Southern Cathaysia floral subprovinces in the plateau can also be recogniz d from the northern part nearby the Qinghai Lake extending northwesternly to the adjacent areas of Lenghu.

The new findings of the Cathaysia flora in this plateau might afford further a rather justifiable interpretation of strong support to the occurrence of Late Permian plants of the Cathaysia flora in Turkey of the Near East.

PALAEOBIOGEOGRAPHY ON THE QIHGHAI-XIZANG PLATEAU AND THE CONTINENTAL DRIFT

Wen Shixuan

(Nanjing Institute of Geology and Palaeontology, Academia Sinica)

On the Qinghai-Xizang Plateau, the marine faunas from Ordovician to Devonian quite resemble those of the South China, North China, northeast and northwest of China, and even relate closely to those of North America, Europe and Australia. This fact indicates that all these areas have been an entire vast palaeogeographical unit during the periods. It is an evidence of Wegener's pangaea.

According to the distribution of tl e marine faunas during Carboniferous-Permian and of the continental faunas and floras since Carboniferous, the area north to the Bangong Lake-Nujiang River fault zone belongs to the Eurasia Continent; the area south to the Xiangquan He-Yarlung Zangbo River fault zone is probably a part of the Indian Subcontinent; the area between the two fault zones is also probably a part of the Indian Subcontinent, or a small land in the Tethys between the two continents.

The delimitation between the Cathaysia-Tethys and Angara-Tethys faunas in Early Permian is probably an unchanged line and extends basically along the latitudinal direction at that age. The eastern and western parts of the boundary between the Gondwana-Tethys and Cathaysia-Tethys faunas are also parallel to latitudes, but the middle part of the boundary runs in north direction along 99° of east longitude. The tortuous of this delimitation was probably resulted from northward drifting of the Indian Subcontinent. According to the displacement of the eastern and western parts of the boundary line, it is estimated that the distance of the drift of the Indian Subcontinent was about 4400km.

The Pre-Carboniferous marine deposits on the eastern part of the pangaea were probably the initial tracks of the Tethys. During Carboniferous and Permian, the east part of the pangaea gaped due to the southward drifting of the Indian Subcontinent, and the East Tethys thus appeared. In Mesozoic, the Indian subcontinent happened to drift back-ward to the north, resulting in the reduction of the East Tethys. Finally, the history of the East Tethys entirely ended in middle Eocene.

ORDOVICIAN AND SILURIAN CEPHALOPOD PALAEOBIOGEOGRAPHY IN XIZANG, WITH A DISCUSSION ON THE CONTINENTAL DRIFT

Chen Junyuan and Chen Tingen
(Nanjing Institute of Geology and Palaeontology, Academia Sinica)

As a result of the Ordovician and Silurian stratigraphical and Palaeontological study in Xizang carried out in recent years, by the Scientific Expedition of Academia Sinica, it enables us to have a better understanding of Paleozoic geological history of Xizang and, in addition, brings about some questions about the formation of Xizang Plateau in terms of current plate tectonics.

Stratigraphically, Ordovician and Silurian in Xizang spread out over three belts: a, the Himalayan region, south of the Yarlung Zangbo River, in such counties as Gyilung, Nyalam, Dingri, Dinggye, and Yadong; b, nearby Xainza county; c, north-east of Dunggag lake in Bangkog county.

The cephalopod fauna in Xizang has been marked with the following features: in the early Ordovician period, the *Ordosoceras*(*Pomphoceras*)-*Wutinoceras* fauna is known as the leading members of fossil cephalopods, containing 12 genera and 18 species. Among them, actinoceroids make up 70 per cent of the total amount of fossils. They are endemic in the North China platform, while *Manchuroceras* is widely distributed in the western Pacific area. In the middle Ordovician, the cephalopods are characterized by *Sinoceras* fauna, contained in the Pagoda Limestone in Southwest China and confined only to the Chinese territory. They include 12 genera and 19 species. A wide regression is reported in Xizang of its late Ordovician with only a few *Michelinoceras*, and a floating type being f und. Graptolites are among major fauna in early Silurian, only several genera of cephalopods being recorded near the Dunggag lake of Bangkog county.
Michlinoceras together with its subgenus M. (*Kopaninoceras*) was overwhelming in full flourish during the middle and late Silurian and 17 species have been collected. There are 9 species of Orthoceroids covering 70 per cent of the tctal fossils, while Pseudorthoceratidae is less in number, totalling only 8 species. All of them are far and wide distributed in Europe and Central Asia. There were sediments of typical platform in Xizang during the Ordovician and Silurian periods.

Judging from the facts mentioned above, it may be concluded that: 1, Xizang area, between both sides of Yarlung Zangbo River, was a combined continent in the early Paleozoic era. The Ordovician and Silurian nautiloids are fairly similar to each other in the South and North of Xizang. 2, in the late early Paleozoic era from North China up to the continent, the Tethyan Sea gradually formed and the Pangaea had split into two large landmasses. Then, in the Mesozoic, they reattached to each other. 3, the early Paleozoic strata shown like three belts may be controlled by great faults, on the southern side of which lie the early Paleozoic strata.

PERMIAN PALAEOGRAPHY OF PENINSULAR AND HIMALAYAN INDIA AND THE RELATIONSHIP WITH THE TETHYAN REGION

J. M. Dickins and S. C.Shah

(Bureau of Mineral Resources, Canberra City, Australia, and Geological Survey of India, Paleontology and Stratigraphy Division, Calcutta, India.)

The close relationship between the Permian flora and fauna of Peninsular India, the Himalayas and southern Tibet is interpreted to mean that these areas formed a single area of deposition during the Permian along the southern margin of Tethys. The limits of the southerly incursions of the sea onto the Indian Shield or Plate are indicated. Iran, Afghanistan and southern China may also have been close.

The *Glossopteris* flora, characteristic of the non-marine sequences of Peninsular India is found in the Lesser and Tethyan Himalayas and in southern Tibet north of the Himalayas.

The *Eurydesma* and younger Early Permian faunas of Peninsular India are found in the Lesser Himalayas (including the Salt Range), in the Tethyan Himalayas and on the northern slopes of the Himalayas (southern Tibet). These faunas are cold and temperate water faunas. In the Lesser and Tethyan Himalayas and in southern Tibet they are overlain by a warm water Late Permian fauna.

During the Permian, Peninsular India, the Lesser and Himalayan India and southern Tibet are considered to have formed a single block or plate.

STRATIGRAPHIC DISTRIBUTION OF FOSSIL CORALS FROM XIZANG AND ITS PALAEOBIOGEOGRAPHIC PROVINCES

Wu Wangshi and Liao Weihua
(Nanjing Institute of Geology and Palaeontology, Academia Sinica)

The Palaeozoic, Mesozoic and early Cenozoic marine strata are well developed in Xizang. So far as we know, the oldest coral-bearing beds in Xizang are Lower Silurian and the youngest strata are known to be Middle Eocene (Lutetian).

The Palaeozoic, especially in early Permian, two biogeographic realms may be divided, bas ing on the characteristics of the coral faunas: the *Iranophyllum* fauna and the *Lytvolasma* fauna, with Yarlung Zangbo River as their boundary in general.

The *Iranophyllum* fauna was discovered in northern Xizang and it is characterized by hermatypic corals which were supposedly living in a warm-water environment and may easily be compared with those of the other regions of the Tethys, such as Afghanistan, Iran and Turkey.

In southern Xizang the so-called *Lytvolasma* fauna is only represented by some solitary corals associated with thick-shelled brachiopods. It is no doubt that this fauna should belong to the cold-water fauna and was distributed along the borders of the Gondwana Land such as Australia, Timor, Nepal and Pakistan.

On the contrary, beginning from the Mesozoic epoch, the distinction between the two biogeographic realms have gradually become indistinct. Both of them seem to belong to the Tethys type. These faunas are closely correlated with those of Portugal, Alps, Carpathians, Caucasus, Hindu Kush, Pamir, India as well as Timor.

The marine transgressions in Xizang were persisting finally until early Tertiary (Eocene), then the sea began to withdraw wholly from the Himalayas. Tremendous uplifting movement resulting in the formation of the Xizang plateau took place only after the Pliocen epoch.

Why is it that there is such a great difference between the south and the north to Yarlung Zangbo River in the aspects of coral fossils during the late Palaeozoic and that such difference became more and more indistinct and finally disappeared from the beginning of Mesozoic?

There seems to be two possibilities: first, during the late Palaeozoic, there was still a great distance between the Gondwana Land and the Eurasian Land. The northern Xizang within the Eurasian Land was situated in the tropics or the subtropics and therefore plenty of reef-building corals were living. On the other hand, southern Xizang, India as well as other portions of the Gondwana Land were located in frigid zones, while continental glaciers and mountain glaciers even appeared. So, only a few species of cold-water type solitary corals could exist.

From the beginning of Mesozoic, the Indian plate rapidly drifted northward and gradually got close to the Eurasian continent, until it reached the temperate zone, therefore, the characteristics of the coral faunas of both realms gradually tend to be in unanimity with each other.

The second possibility is that the climatic changes of the earth can be explained by the variation in the obliquity of the earth's ecliptic. From late Palaeozoic to Mesozoic, the warm climate zone was widened because of the change of obliquity. Consequently, both parts of Xizang belong to the same climate zone and the same biogeographical realm of corals.

ON THE PALAEOECOLOGICAL RELATION BETWEEN GONDWANA AND TETHYAN FAUNAS OF XIZANG

Jin Yugan

(Nanjing Institute of Geology and Palaeontology, Academia Sinica)

The Permian marine faunas of China were traditionally considered as a part of Tethyan realm. Primarily based on the distribution of brachiopods, three latitudinally extending faunal regions have been identified. The southern region is approximately restricted in the south to 32 degrees north latitude and the east to Nu Jiang (Nu River). Of which the faunas are closely related to those dwelled in other parts of northern marginal sea of Gondwana continent. The northern region or the Beishan region with its southernmost boundary at about 42 degree north latitude is a Paleozoic synclinal region and contects with the Boreal realm. The other areas streching from Kulunshan in the west to Taiwan in the east are all involved in the central region or Yangzi region and are characterized by flourishing of typical faunas of Tethyan Realm. The distributional pattern of these faunal regions essentially reflects the differrentiation of geographical climate zones. Furthermore, these regions may be divided into several provinces, each characterized by a suite of communities.

The Permian deposits in the southern region represent a transgressive sequence of facies both in vertical and lateral.The face change is best marked by diminishing terrestrial materials in the company of increasing carbonate rocks northward and upward and also is shown by shift from predominantly conquel limestone and biosparenite facies in the south to biorudite facies in the north. Correspondingly,there appear two suites of communities going from the strand line outward, the latest Carboniferous communities are the intertide *Eurydesma* community, subtide *Stepanoviella* community and the *Liraplecta* community of upper shelf. The Permian suite includes *Lingula*, *Spiriferella*, *Calliomarginatia*, *Monodixodina* and *Comuquina* communities. The last community characterized by a relatively diverse fauna is usually regarded as a representative of Tethyan faunas while the others are included in Gondwana faunas.

Because the faunas of the northern region share a great number of genera and species with those of the southern region and their communities are structurally similar, the inferred community model of the southern region may be tested by the data from another one. In northern region, the early Permian deposits consist of flysch-like sequences and thus the change of communities is relatively rapid. We have found some transitional relations between *Spiriferella* community and *Comuquina* community, *Monodixodina* community and *Miselina* community. These evidences lead us to come to a conclusion that the so-called Tethyan faunas and Gondwana faunas in southern region are communities having adapted to environments of various depth and substrate in the same sea. Using this community framework as a basis to restore the Palaeogeographical picture for the southern region, we can find that since latest Carboniferous time there wouldn't have occurred any large scale of "drift" in this area.

NATURE OF THE PERMIAN BIOTAS IN XIZANG AND THE NORTHERN BOUNDARY OF THE INDIAN PLATE

Wang Yujing Mu Xinan
(Nanjing Institute of Geology and Palaeontology, Academia Sinica)

In the introduction of this paper, the provinces of the Permian System in Xizang and the stratigraphic sequences, rocks and aspects of the Permian biotas in the provinces(subprovinces) are simply mentioned. Then we detail two problems.

I. The nature of the Permian biotas in Xizang and Permian biogeographical provinces.

According to the law that the present is the key to the past, we consider that the *Glossopteris* flora, the solitary individual coral *Lytvolasma* fauna and the ammonite genus *Uraloceras* of the Xizang Permian strata belonged to the cool-water biota and the Cathaysia flora, the calcareous algal flora and the colonial coral *Iranophyllum* fauna to the warm-water one. The cool-water biota distributed in the northern marginal sea of the Gondwanaland in south and the southern marginal one of the Angaraland in north, between them the warm-water biota developed. The factors controlling this distributional pattern of the biotas were probably related with the glaciations on the two lands in question. In view of the fact that we have subdivided the Tethyan paleobiogeographic realm into three provinces, known as the Gondwana-Tethyan, the Angara-Tethyan and the Cathaysia-Tethyan.

2 . On the northern boundary of the Indian Plate.

According to the fact that the cool-water solitary individual coral *Lytvolasma* fauna in Early Permian and the brachiopod *Stepanoviella* fauna in Upper Carboniferous are found in the Kangdese-Nyainqentangulha subprovince and the conglomerate slates of the Upper Carboniferous Pangdo Group in the above-cited subprovince all approximately correspond to the Chataje diamictite member on the northern slope of Mt. Jolmo Lungma and the diamictite of the Kalwoxigar formation in the area north of Kangmar, we consider that the two provinces above mentioned would have been a part of the Indian Plate and the northern boundary of the Indian Plate would have been located at the line of Bangong Co-Dongqe-Nu Jiang.

LATE TRIASSIC PHYTOGEOGRAPHY OF QINGHAI-XIZANG PLATEAU

Li Peijuan Wu Xiangwu
(Nanjing Institute of Geology and Palaeontology, Academia Sinica)

Late Triassic floras widely spread in China. According to the Palaeobotanical data, they can be classified into two types, namely, *Dictyophyllum-Clathropteris* flora in the littoral floral province and *Danaeopsis-Bernoullia* flora in the continental floral province.

The Late Triassic plant-bearing strata have been successively discovered in Qinghai-Xizang plateau. They are: the Bagong Formation, the Tumengela Formation, the Lamaya Formation, the Gyiza Group, the Babaoshan Group and the Nanyinger (Mole) Group. With the exception of the Nanyinger Group, which is chiefly of continental origin, all are alternations of marine and continental deposits with coal seams.

The floras of such formations as Bagong, Tumengela, Lamaya and such groups as Gyiza, Babaoshan are characterized by the dominance of *Dictyophyllum*, *Clathropteris*, *Goeppertella*, *Angiopteris*, *Danaeopsis*, *Marattia*, *Reteophlebis*, *Lüreticopteris* , *Pterophyllum ptilum*, *Pt. sinense*, *Anomozamites loczyi*, *Sinoctenis calophylla*, *Nilssoniopteris jourdyi*, *Lepidopteris*, *Ptilozamites*, *Hyrcanopteris* etc.; they correspond most likely to the flora of the Ipinglang Formation in southern China.

The flora of the Nanyinger Group is marked by the absence of Dipteridaceae, the flourish of *Todites*, *Bernoullia*, *Danaeopsis* and *Cladophlebis*, the moderate development of Ginkgoales and by the scarcity of Cycadophytes. This flora resembles closely that of the Yengchang Formation in northern China.

On the basis of both the floral and the lithological characters, the late Triassic floras in Qinghai-Xizang plateau are also divided into two different types. The floras of Bagong Formation, etc. belong to the type of *Dictyopyllum-Clathropteris* flora under the effect of oceanic climate, reflecting humid and thermal conditions. The flora of Nanyinger Group may be included in the type of *Danaeopsis-Bernoullia* flora under the influence of continental climate, showing slightly warm and moist conditions.

The dividing line of the two floras in Qinghai-Xizang plateau approximately lies between South Qilianshan and West Qinling (N 34.5°—38.5°).

PALAEOGEOGRAPHIC ZONATION OF NORTHERN TETHYS DURING CRETACEOUS AND LOWER TERTIARY (METHODS APPPLIED TO THE ALPINE GEOSYNCLINE)

D. Herm
(Institute für Paläontologie und Historische Geologie, Universität München, F. R. G.)

The Alpine area were increasingly affected through Cretaceous and Early Tertiary by syndepositional lateral and vertical movements, suggesting a continuous impact of syn- and dia-chronous tectonic activities.

The Tibetian area, also, as a part of the former northern Tethyan belt suffered a comparable history, where a broader geosyncline area has crustally shortened (subduction) to narrow and steep basins.

In the Northern Alps the paleogeographic response to the tectonic stimulation shows a typical northward migrating of synorogenetic sedimentary sequences during time. The sediments and the faunal content allowed a paleobathymetric and paleo-oceanographic r - construction of different sedimentation zones from north to south: northern coastal zone of Tethys — internal basins on the shelf—shelfslope—deep sea trenches with flysch deposits — north moving plate with differentiated paleogeographic setting caused by local transgressions and regressions.

The following methods have been used for paleobathymetric and paleogeographic reconstructions in the marine realm:

Ratio of planktonic versus benthonic foraminifera; ratio of different groups of planktonic foraminifera (e. g. globotruncanids versus heterohelicids); diversity of benthonic foraminifera; distribution of larger foraminifera; diversity and density (mean rank abundance) of gastropods and pelecypods have been very useful to arrange the fossil associations and the sediments into lateral biofacial patterns.

The paleoecological results support the reconstruction of the synorogenetic history and help us to better understand the geodynamic events in this northern Tethyan sections. The methods should be applied also to other sections of the northern Tethyan belt.

APPROACHES TO ELEVATION AND CLIMATIC CHANGES OF QINGHAI-XIZANG (TIBET) PLATEAU FROM FOSSIL ANGIOSPERMS

Guo Shuangxing

(Nanjing Institute of Geology and Palaeontology, Academia Sinica)

The present paper on the basis of fossil angiosperms from Qinghai-Xizang (Tibet) Plateau makes an approach to its elevation, climatic changes and floristic succession.

1. The Late Cretaceous flora of Xigaze Group from the Middle Yarlung Zangbo Valley consists mainly of subtropical and temperate broad-leaved deciduous forests with a few tropical evergreen trees. The fossil flora represents a subtropical and subhumid climate. Probably the altitude of the Middle Yarlung Zangbo Valley was low elevation during the Late Cretaceous epoch.

2. During the Early Eocene the flora of the lower part of Moincer Group in Gar county on the southern slopes of Kangdese Mountains consists mostly of tropical and subtropical broad-leaved evergreen forests with a few deciduous plants. The character of the fossil flora is quite similar to the living vegetation distributed on the coast of southeastern China. The fossil flora represents a tropical and wet climate and reflects a warmer and wetter climate than that of the Xigaze Group at that epoch. It is estimated that the altitude of the southern slopes of the Kangdese Mountains was not high at that time.

The Late Miocene flora of the upper part of Moincer Group from the same locality in Gar county consists all of temperate and warm temperate broad-leaved deciduous forests, among them the species of *Populus* was prevailing. This fossil flora is similar to the living vegetation of northern China, and it is identified to be a warm temperate and moist climate. During the Late Miocene the altitude of the southern slopes of the Kangdese Mountains was probably varying from about 1500 m. to 2000 m.

3. The Middle Miocene flora of Wulong Formation from Namling county in Xizang (Tibet) consists of a domination of subtropical broad-leaved deciduous forests with some evergreen alpine species of *Quercus* and *Rhododendron*. The fossil flora is similar to the living forests of western Sichuan and northern Yunnan. It represents a subtropical and subhumid climate. It is probably that the altitude of Namling area appeared about 1500 m. above the sea level at that epoch.

4. The Late Pliocene floras from western Sichuan and northern Yunnan in border of the plateau consist of the majority of subtropical evergreen species of Fagaceae intermingled with a few deciduous broad-leaved forests. The floras show a close resemblance to the living vegetation of the areas where the fossil floras occurred. The fossil floras represent a

subtropical and subhumid climate. It is likely that during the Late Pliocene the altitude of western Sichuan and northern Yunnan almost reached such a height as today's.

5. The Late Tertiary floras of Zeku county and Qaidam Basin of Qinghai in northern part of the plateau consist all of temperate broad-leaved deciduous forests and with a few aquatic or marsh herbs. The fossil floras represent a temperate and drought climate. The climate indicated by the fossil plants was probably warmer and wetter than today's.

TERTIARY PALYNOLOGICAL ASSEMBLAGES FROM XIZANG WITH REFERENCE TO THEIR PALEOGEOGRAPHICAL SIGNIFICANCE

Song Zhichen Liu Gengwu
(Nanjing Institute of Geology and Paleontology, Academia Sinica)

In this paper are discussed the division of the Tertiary floristic provinces and the uplifting ranges of the different parts of Xizang based on the palynological evidence.

The palynological study aims to indicate that during the time of Paleogene, there were two floristic provinces in Xizang region: the Northern Province and the Southern Province. The palynological assemblage of the Northern Province is markedly evidenced by the rich presence of angiospermous pollen, along with a number of *Ephedripites*, whereas Pinacea pollen is scarce. Such an aspect is quite likely to be comparable with that of the corresponding beds (the gypsum- and salt bearing Formation and the Jinsha Formation) of Hubei Province, suggesting, therefore, a fact of the Eocene central subtropical region of China. From the Late Eocene onward, the angiospermous pollen was almost completely replaced by the Pinaceae grains in this assemblage. As to the Southern Province, which is separated from its northern neighbour by the Kangdese Range, the dominant element of its paleoflora is chiefly Myrtaceae, emphasizing the thermophilous characters of this flora.

Palynologically, the difference between these two provinces seems to be present in the Late Tertiary, with the boundary existing from the Kangdese Range to the Nyainqentanglha Range. During that period, the principal members of the flora in the Northern Province were composed of various alpine species of *Quercus*, in association with some *Picea*, *Abies* and xerophilous Chenopodiaceae plants. Among the important elements of the Southern Province in Miocene are Polypodiaceae, *Pinus* and *Quercus*, with no tropical evergreen trees being found. During the Pliocene period, the Pinaceae pollen got a further development in number, which was accompanied by the common occurrence of *Picea* and *Abies*.

Results from analysing the palynofloras of these two provinces demonstrate that the climatic condition in the Southern Province was warmer and moister than that in the Northern Province throughout Tertiary, and that the uplifting ranges of the crust are not all the same in the whole Xizang region. The altitude in the Northern Province is estimated about 2000m high above sea level during the Oligocene. It was not until the end of Miocene, however, that the same altitude appeared in the Namling area to the south of the Nyainqentanglha Range. As far as the area farther away from the Himalayas is concerned, this altitude came into existence in the Middle-Late Pliocene.

GEOLOGICAL OUTLINE AND GEOLOGICAL HISTORY OF THE YARLUNG ZANGBO SUTURE ZONE

Wu Haoruo
(Institute of Geology, Academia Sinica)

The Yarlung Zangbo Suture Zone lies between the Indian block and the Kangdese block. Its north limit is a major unconformable plane formed in mid-Cretaceous time. It is separated from the Himalaya Zone on the south by the Lhagoi Kangri Fault. On the west side, it connects with the Indus Suture Zone and on the east side with the Indoburman Suture Zone, thus extends over 1000 km. It may be subdivided into two subzones, the south subzone and the north subzone. The former is characterized by "miogeosyncline" properties, mainly representing a Mesozoic bathyal environment of the continental slope in the north of the Indian block. The latter is furnished with "eugeosyncline" properties, which mainly represents a Mesozoic South Tethys deep sea environment. The study of the Palaeozoic rocks, which crop out in the suture zone on a small scale shows that this zone together with Himalaya and Kangdese all belonged to an epicontinental sea around the northern margin of Gondwana land in the Palaeozoic Period. As the Kangdese block drifted northwards, beginning from the Triassic, the South Tethys was formed therein. Analysing of sedimentary facies indicates that the South Tethys may be of a complex island sea environment before Late Cretaceous and was not a wide open sea. Untill the early Late Cretaceous, Kangdese drifted further northwards thus a wider South Tethys was formed. The spreading of the South Tethys in this stage may be explained why the Indian block drifted northwards rather slowly before 80 m. y., and after which the Indian block began to drift northwards at a faster rate and converged with the Kangdese again in the Eocene Epoch. Therefore, the Yarlung Zangbo Suture Zone only represents the suture zone between the old Asia and Gondwana land of the Mesozoic time. The north boundary of the Gondwana in the Palaeozoic is considered possibly at the southern margin of the Kunlun Ranges. And it is also possible that the separated blocks of the ancestral Asia might have ever drifted northwards in geological history. So the eastern part of the Tethys might not have been as wide as what R.S.Dietz and J.C.Holden(1970) postulated, and within interior of the sea there might have existed some intra-landmasses or microcontinents, by which the author attempts to solve the ploblem of the mixing of Gondwana and Eurasian fauna and flora in the Permian-Triassic time.

THE STRATIGRAPHICAL AND GEOLOGICAL CHARACTERISTICS OF PRE-ORDOVICIAN ROCKS IN THE CENTRAL HIMALAYAS

Yin Jixiang ZhangQi Li Daizhou Li Shaohua
(Institute of Geology, Academia Sinica)

The higher portion and its southern slope of the Central Himalayas consist mainly of pre-Ordovician metamorphic rocks, except the Sub-Himalayan belt where pre-Ordovician rocks are lacking. Within the several structural lithofacies belts of the Central Himalayas, the stratigraphical features of the Pre-Ordovician rocks are quite different from each other.

In the Tethys Himalayan belt, the slightly metamorphosed rocks lying conformably underneath the fossiliferous Ordovician successions are representatives of the North Col formation of the northern slope of Qomolangma Feng (Mount Julmo Lunhma) and the Larjung formation of the Thakkhola region in northeastern Nepal. They could be compared with the Parahio series and the Haimanta system in Spiti, so a Sinian-Cambrian age for them is inferred.

Metamorphic rocks of the High Himalayan belt are represented by the Nyalam group in Southern Xizang, China, the Himalayan gneiss or "Tibetan Slab" (i. e. "Dalle du Tibet") in ast central Nepal and the Dhumpu gnei s in northwestern Nepal. They are separated from the overlying light metamorphic rocks by a thrust sheet or tourmaline-muscovite granite, but locally seem to be continuous deposition. The lower part of the Nyalam group probably represents an inverse metamorphism.

The middle and lower parts of the Kathmandu group and the Midland meta-sediment group in Nepal are representatives of the pre-Ordovician light metamorphic rocks of Lower Himalayan belt. The upper part of the Kathmandu group contains fossils probably of Ordovician-Silurian, so the thick calcareous and arenaceous successions underlying are considered as possibly Cambrian in age. The upper part of the Midland meta-sediment group with stromatolites, may be compared with the Shali series in Khumaon of India, and the muscovite K-Ar age of 728 m. y. was obtained from this part, it is thus suggested that the Midland meta-sediment group belongs to Sinian.

The sedimentary characteristics of the pre-Ordovician rocks in Central Himalayas, the structural and palaeogeographic features of the High Himalayan belt or the Central Crystalline belt are also briefly discussed here.

PALAEOZOIC BIOSTIGRAPHY AND PALAEOGEOGRAPHY OF THE TETHYS HIMALAYA

V.J.GUPTA
Centre of Advanced Study in Geology,
Panjab University, India

The fossiliferous Palaeozoic rocks are exposed throughout the entire stretch of the Tethys Himalaya. The fresh collection of fossils by the author from different stratigraphic horizons has enabled to revise stratigraphic position of some of the rock formations and to define precisely the ages of some of the horizons which were hitherto considered to be unfossiliferous.

The boundary between the Algonkian and Palaeozoic is gradational and in none of the sections in the Tethys Himalaya, there exists any evidence for the presence of a unconformity between the two.

The Cambrian succession of Kashmir, Ladakh and Spiti has been reclassified on the basis of new trilobite collections. The find of *Redlichia* from Kashmir is significant as it is suggestive of the fact that the terrain comprising Iran, Salt Range, Kashmir, Indo-China and China was under the influence of western arm of Australo-Asian province.

The find of Early Ordovician graptolites from Kashmir suggests that this fauna had connections with the American-Australian-Asian Ordovician graptolite faunas. The Formation of Ladakh has been assigned Ordovician age. The Garbyang Formation of north-eastern Kumaun and its equivalents in Nepal has yielded flat gastropods (*Eccliopteris kushaensis* whereas the"Nodular Limestone"at Dung and northeast of Chorhoti Pass in Kumaun has yielded brachiopods of Ordovician age. The Ordovician crinoids has also been recorded from the Chandragiri area, near Kathamandu, Nepal.

The discovery of Silurian graptolites from the Harpatnar Beds of Kashmir and Central West Nepal has enabled to change the assumptions regarding the existence of land barriers between the Himalayan and Burmese regions during the Silurian Period. The lower units of Naubug Beds have yielded rich fauna of Late Silurian age whereas the upper units of Naubug Beds have yielded Devonian fishes. The beds lying immediately below the Muth Quartzite in Kashmir and Spiti have yielded Lower Devonian plant fossils.The Silurian-Devonian boundary in different parts of Himalaya is defined on palaeontological evidences.

The Karsha and Tanze Formations in the Luneak valley of Ladakh have been assigned precise ages. The presence of Ordovician-Silurian and Devonian fossils has also been described from the Phulchauki-Godavari section of Nepal.

The stratigraphic position of the Muth Quartzite has been defined on the basis of rich fauna found within these quartzites exposed at several places in different parts of the Himalaya. Devonian conodonts have been described from Kashmir, Ladakh, Kumaun and Nepal. The Tanawal Formation of Kashmir has been assigned age between Ordovician and Middle/Upper Carboniferous.

The Syringothyris Limestone of Kashmir and its equivalents have been assigned Tournaisian to Lower Visean age on the basis of new finds of conodonts, crinoids and brachiopods. The revision of fauna from the Fenestella Shales suggests its age between mid-Visean to Bashkirian. The fauna from the Fenestella Shales is approximately correlative with the similar faunas from the Middle Naxing Formation of Tibet. The occurrence of Carboniferous and Permian fossils has also been recorded from Lamayuru area of Ladakh.

The so-called"Agglomeratic Slate Succession"of Kashmir has been reclassified. The sedimentary intercalations within the Ralakung Volcanic Succession of Ladakh have yielded brachiopods of late Sakmarian to Kazanian age.

The Permian biostratigraphy of the Tethys Himalaya has been thoroughly revised and this succession can be divided into a number of faunal zones, i'e., the *Eurydesma cordatum* Zone(Late Asselian); *Taeniothaerus permixtus* Zone(Sakmarian); *Lamnimargus himalayensis* Zone(Punjabian);*Echinalosia kalikotei* Zone(Vedian)and *Claraia-Otoceras-Ophiceras* Zonal Complex(Gangetian-Ellesmerian) have been recognised in parts of Kashmir, Ladakh, Spiti and Nepal. In addition, vestiges of other zones are present, including *Brachythrinella narsarhensis* Zone in Garhwal and *Retimarginifera* fauna of Sakmarian or Baigendzinian age in Spiti and Ladakh and bivalve fauna of possible Djulfian age in Kashmir and Nepal.

The find of Lower Permian marine fossils(brachiopods, gastropods, pelecyposds, bryozoans,etc.) from the Boulder Slate Sequence of the Lower Bijni Tectonic Unit of Garhwal is significant as this fauna has close resemblance with the fauna known from the Chi-Lung Ji Long Group exposed on the northern slopes of Mount Everest, Tibet and Umaria Marine Bed of Peninsular India.

The Permian-Triassic boundary in Kashmir, Ladakh, Spiti and Kumaun is discussed.

NEW FOSSILS FROM THE DEVONIAN SERIES OF TANG CHU (BHUTAN, HIMALAYA)

V.J.GUPTA and G.TERMIER
(Panjab University,India)

The Tang Chu series has supplied a Givetian-Frannian fauna including *Atrypa* sp. cf. *reticularis*, an Elythid, *Fenestella?* , Phacopid, Hexacrinites? sp. New fossils have been found in the same locality but in a slightly lower horizon: *Spinocyrtia* sp.; cf. *Eleuthe-*

rokomma sp.(fragmented), *Megachonetes?* sp., *Hexacrinites* sp., a Proetid pygidium, a solitary Coral. Poorly preserved, these fossils afford a confirmation for the Givetian-Frasnian age of the Tang Chu series.

SPECIAL REMARKS ON THE GEOLOGICAL HISTORY OF THE HIMALAYAS

Wang Yigang
(Nanjing Institute of Geology and
Palaeontology, Academia Sinica)

This paper discusses summarily some problems on the geological history of the Himalayas based on some new stratigraphic and Palaeontological data obtained in recent years (1966—1968, 1973—1976).

Both the basements of the Himalayan geosyncline and Indian shield are different from each other. The Himalayan metamorphosed basement was a result of the metamorphism, possibly beginning from early Sinian and ended in early Ordovician. It seems that the geological conditions and ample evidences of the presence of "Paleohimalayan Ridge" are lacking. During Caledonian and Hercynian, the Himalayas were only influenced by epeirogeny; during Mesozoic, it was a region of stable subsidence, where sedimentary differentiation in beds was quite evident. A possible source of the so-called "Tibetan facies strata" came from the north of the present Himalayas but both were in the same basin. The end of marine sediments in the Himalayas and the Molasse of the North Tethyan Himalayas are also discussed.

On the basis of the above discussion, the evolution of the sedimentary region of the Himalayas may be deduced in space and time.

PERMIAN BRACHIOPOD AND BIVALVE ZONES IN THE HIMALAYA OF INDIA AND NEPAL

J. B. Waterhouse and V. J. Gupta
(Department of Geology and Mineralogy, University of Queensland, St. Lucia, Australia.
Centre of Advanced Study in Geology, Panjab University, Chandigarh, India.)

The Brachiopod and bivalve zones of the Himalaya in especially India and Nepal are discussed. Within the northern Himalaya, or Tibetan zone, the following zones are recognised; the widespread *Eurydesma* zone, of upper Asselian age correlative with the extensive *Eurydesma* faunas of Gondwana; the *Taeniothaerus* (*Reedoconcha*) *permixtus* Zone of mid-Sakmarian (Sterlitamakian) age, restricted to Kashmir but allied to faunas of Queensland; the *Retimarginifera* fauna found only in Ladakh, of probable Baigendzinian age, and the *Lamnimargus himalayensis* Zone, very widespread throughout the Himalaya, and correlated with the Punjabian Stage, as exemplified by the Kalabagh Member and lower to middle Chhidru Formation of the Salt Range, Pakistan. Late Middle and Late Permian zones are restricted to Nepal and Kashmir, with the basal Djulfian Stage exemplified by the *Pyramus silicius* Zone in Nepal, With allied faunas in Kashmir; and the upper Djulfian by the *Krotovia arcuata* Zone in Nepal. Late Permian is best represented in north-west Nepal, with the Vedian Substage represented by the *Marginalosia kalikotei* Zone, and the Ogbinan Substage by the *Atomoadesma variabile* zone, possibly found also as equivalent faunas in Kashmir (Faunal division IV of Nakazawa *et al.* (1975)).

The Gangetian horizon is widely represented by *Otoceras*, eg. *concavum*, followed by *Ophiceras*; both horizons containing latest Permian brachiopods as well. Correlation with nearby areas of the Salt Range, Karakorum and Pamirs is discussed. Fossils are fewer in the Main and Lesser Himalayas, but include the widespread zone of *Eurydesma*, and in Garwhal the early Sakmarian zone of *Brachythyrinella narsahensis* (Reed).

CHARACTERISTICS OF THE SEDIMENTARY FACIES-BELTS IN THE YARLUNG ZANGBO-XINGQUAN HE SUBSIDENCE REGION AND THEIR SEDIMENTARY MODELS

Wang Liencheng & Wang Tungan
(Institute of Geology, Academia Sinica)

The subsidence region of Yarlung Zangbo-Xingquan He, which runs in the west-east direction about 1600 km long and over 100 km wide, is situated between Kangdese and Himalaya ranges. In this region, the sedimentary strata, mostly Mesozoic and Cenozoic, are over 10,000 meters thick and an ophiolitic zone is included.

Based on the characteristics of sedimentary rocks and rock suites, the content of fossils and volcanic materials, and the tectonic movements and paleogeographic changes, six osedimentary facies-belts are recognized: the flysch-like facies-belt; **the sandstone and** shale facies-belt of bathyal and abyssal sedimentation; the olistostrome facies-belt; the radiolarian siliceous rock facies-belt; the flysch facies-belt and the molasse facies belt. Each of these belts all exhi bits as regularly distributed north-south narrow-longitudinal zones.

Large scale sedimentation of the referred subsidence belt started from Early Me--szoic. As time went on, the sedimentary facies-belts were differentiated one from the other. The Tethys was very likely to have often been changed in width and depth; thus gradually it gave rise to a continent; and finally, it was added to and as an integral part of the Qinghai-Xizang plateau.

The ev lutional processes of this region could be divided into 5 stages:

The flysch-like deposit formed in Triassic-Early Jurassic; the sandstone and shale series formed in bathyal or abyssal area in Middle and Late Jurassic-Early Cretaceous; the flysch and radiolarian siliceous rocks formed in Late Cretaceous; the olistostrome deposit formed in Middle-Late stage of Late Cretaceous; the molasse formed from the end of Cretaceous to Miocene.

The evolution of sedimentation and formation of the sedimentary facies-belts mentioned above are closely related with tectonic movements of Indian plate, which was drifted northward and subducted under the Eurasian continental crust; and finally, the two continents welded together by crustal collision.

THE LATEST MARINE SEDIMENTS IN XIZANG AND THE PROCESS OF THE EARLY TERTIARY REGRESSION

Zhang Binggao
(Nanjing Institute of Geology and Palaeontology, Academia Sinica)

The Lower Tertiary is up to now the latest marine sediments in Xizang. It is distributed chiefly in Tingri-Gangba region to the south of Yarlung Zangbo River. The Lower Tertiary here may be divided into the Zongpu Group in the lower part and the Zhipura Formation in the upper part. The problem discussing the uppermost marine sediments in Xizang in this paper is of the age of the Zhipura Formation.

The upper part of the Zhipura Formation contains the following large foraminifers: *Orbitolites complanatus* Lamarck, *Fasciolites(F.)oblongus* (d'Orbigny), *Nummulites lucasi* Douvillé, *N. incrassatus* de la Harpe, *Assilina rota* Davies, *Discocyclina clarki*(Cushman), *D. sowerbyi* Nuttall, etc. These fossils are common in the middle stage of Eocene. Only a few of them range to the Late Eocene. It seems that the fossil assemblage here resembles that from the middle parts of the Eocene in Assam region and in Salt Range. However, no *Pellatispira*, the typical foraminiferal form of the Upper Eocene in South Asia, has yet been found. Therefore, the age of the upper parts of the Zhipura Formation should be referred to the middle stage of Eocene(Lutetian).

There was a sea nearly in direction of east-west in the Himalayan region during the late stage of Late Cretaceous. From the beginning of the Tertiary the west parts of Kangdese Range uplifted and united with the Kumaon Uplifting. So two seas which disconnected with each other were formed in Himalayan region. The age of the marine sediments from both sides, east and west, of the west parts of Kangdese Range and Kumaon region outward is gradually younger. It indicates that the sea water regressed from both sides of them. The ancient sea in Xizang regressed from west to east, from the west parts of Nepal passing by Tingri-Gangba region to Assam and the west parts of Burma during the early Tertiary.

According to the theory of some tectonic geologists, the Indus-Yarlung Zangbo River is the suture line connecting Indian plate with Eurasian plate. But the contact age is quite different considered by various authors. Based on the conclusion that the west parts of Kangdese Range and the Kumaon region uplifted during the early Tertiary, the age at which the Indian plate collided with the Eurasian one must have been prior to Tertiary period.

THE ENVIRONMENT OF THE PLIOCENE BASIN OF JILONG, XIZANG

Cheng Wanyoung
(Institute of Vertebrate Palaeontology and Palaeoanthropology, Academia Sinica)

The basin of Jilong is one of the intermontane basins of the Himalaya fold belt during Cenozoic. According to the Hipparion Fauna found there the basin is chronologically Pliocene in age.

Based upon the characteristic features of the sedimemts, two assemblages of fluvi-lacustrine facies are divided: the first one is composed of basal conglomerate, greyish siltstone, yellow siltstone with brownish yellow ferruginous layers and iron nodules, and greyish mudstone; thus, it represents a sort of fluviolacustrine-swamp deposit, the second assamblage is composed of yellowish mudstone, yellowish and violet mudstone, sandstone and several thin gravel bed intercalations,a representation of fluvio-lacustrine sands and mud deposit.

Three kinds of clay mineral groups are distinguished. The kaolinite-hydromica group constitutes the bottom layer of the basin. It represents a sort of warm-wet climatical environment. The montmorillonite-kaolinite-hydromica group constitutes the middle part of the basin section and represents a sort of climatical condition of alternatively hot and cold, and wet and dry.

The last group of montmorillonite-hydromica occurs on the top of the basin-section. Its environment of deposition has been already dry and hot.

Based on the analysis of the heavy minerals, oragnic substances, carbonates, chemical make-up, pollen, aquatic living fossils and vertebrates, etc. of the Pliocene Jilong basin, and also in comparing these results with those of similar recent sedimentary environment,a conclusion is drawn that it might have been an environment of subtropic, rather hot and wet, having been absolutely different from what really is in this basin.

Based on the actual data mentioned above, maps of Palaeogeography, Palaeoclimatology and Palaeoecological environment of the *Hipparion* Fauna were restored concerning the Jilong basin during Pliocene.

This paper is not just an aid to the understanding of the changeable climate and natural environment before and after the uplifting of the highland of Qinghai and Xizang, but also is of benefit to make a further understanding on the palaeoecological environment of *Hipparion* Fauna and its development history.

THE CARBONIFEROUS AND PERMIAN FUSULINID SUCCESSIONS IN EASTERN QIHGHAI-XIZANG PLATEAU

Zhang Lin-xin
(Nanjing Institute of Geology and Palaeontology Academia Sinica)

The Carboniferous and Permian sediments widely distribute in Eastern Qinghai-Xizang Plateau. They are well exposed in Gemazhapu, a village of Zhongzan, south of Batang county, western Sichuan. In this section, the Carboniferous and Parmian strata exceeding 1400—1500 metres in thickness are composed almost of thick-bedded to massive limestones, and are extensively exposed in simple structure. The fusulinids are collected from the top of the Lower Carboniferous to the Upper Permian. The fusulinid succession is quite clear. Ten fusulinid zones are established in descending order as follows:

10. Zone of *Reichelina cribroseptata-Eoverbeekina batangica*
9. Zone of *Neoschwagerina cheni*
8. Zone of *Nankinella hunanensis-Pisolina excessa*
7. Zone of *Misellina claudiae*
6. Zone of *Staffella batangica*
5. Zone of *Zellia-Pseudoschwagerina*
4. Zone of *Triticites*
3. Zone of *Fusulinella-Fusulina*
2. Zone of *Profusulinella*
1. Zone of *Eostaffella*

The *Eostaffella* zone belongs to the latest Lower Carboniferous age and is regarded as the lowermost fusuline zone of the Carboniferous system. The *Profusulinella* zone and the *Fusulinella-Fusulina* zone belong to the Weiningian of the early Upper Carboniferous age. The *Triticites* zone, the *Zellia-Pseudoschwagerina* zone and the *Staffella batangica* zone belong to the Mapingian of the late Upper Carboniferous age. The *Misellina claudiae* zone is characterized by the presence of the *Misellina claudiae*, and represents the lowest fusuline horizon of the Permian system in this region. The zone of *Nankinella hunanensis-Pisolina excessa* represents the lower part of the Lower Permian. The upper part of the Lower Permian is characterized by the presence of *Neoschwagerina cheni*, and is referred to as the zone of *Neoschwagerina cheni*. In this zone *Verbeekina*, *Paraverbeekina*, *Pseudodoliolina*, *Chusenella* and *Sumatrina* are included. The zone of *Reichelina cribroseptata-Eoverbeekina batangica* belongs to the Upper Permian.

No *Palaeofusulina* has been found in Gemazhapu section, but it is found near the Toba village of Qabdo county and is found in the vicinity of Raudui of Markam county. The *Palaeofusulina*-bearing beds in these two localities may be correlated with the *Palaeofusulina* zone of South China.

NOTES ON THE THREE NEW SPECIES OF THE GLOSSOPTERIS FLORA FROM THE QUBU FORMATION, S. XIZANG WITH A DISCUSSION ON THE AGE OF THE FORMATION

Li Xingxue
(Nanjing Institute of Geology and Palaeontology, Academia Sinica)

The Qubu formation of southern Xizang(Tibet) has been well known in the circle of Earth Sciences since the discovery of a *Glossopteris* flora in it. However, the age of the Qubu formation is hitherto not quite settled. Some authors (Hsü, 1973. 1976, 1978; Yin et al ., 1976), based mainly on a few elements of the *Glossopteris* flora showing some resemblance to those of the Raniganj formation of India, insist to regard it as early Late Permian, while others (Zhang, 1974; Wu, 1975; Zhang et Ching, 1976; Wang et Mu, 1980) hold it to be Early Permian in respect to the study of a great deal of marine fossil invertebrates occurring in the immediately precedent and succedent rock formations.

As a result of careful comparison of the Xizang specimens described and figured by Hsü (1976, p. 324—326; pls. 1, 2, 3; figs. 13, 14; text-figs. 1—3) with the type- and/or other important published figures of the three new species concerned, it is found that these so-called new species were almost all established on unsatisfactory grounds. The material described by Hsü as *Raniganjia qubuensis* sp. nov. might belong to the genus *Stellotheca*, namely *Siellotheca qubuensis* (Hsü) n. comb. The specimens of the other two forms, treated by Hsü as *Dizeugotheca qubuensis* sp. nov. and *Dichotomopteris qubuensis* sp. nov., were founded only upon detached sterile fragments of pinna in which their fertile evidences, so important soral structure revealed by other typical specimens are lacking. It is also to be noted that all the definite known species of *Dizeugotheca* have been collected in the Early Permian deposits. Besides, other described species of the *Glossopteris* flora of the Qubu formation are all with wide vertical range, they may therefore not be regarded as reliable evidences for an age of Late Permian.

Taking into consideration all-sidedly,it is mostly convenient for the time being to consider the Qubu formation in which this *Glossopteris* flora occur to be of Early Permian in age.

THE GEOGRAPHIC DISTRIBUTION AND THE REALM OF TRIASSIC BIVALVES OF XIZANG

Chen Chu-Chen
(Nanjing Institute of Geology and Palaeontology, Academia Sinica)

The Triassic bivalves are abundant in Xizang. About 100 genera and subgenera including 329 species and subspecies have been described. They are mainly concentrated in the Tanggula-Chambdo and the southern part of the Lhasa-Kangdese regions.

During the early Triassic in the Tanggula-Chambdo region, a clastic succesion yielded a good fauna including many species of genus *Claraia* (*aurita*, *clarae*, *intermedia*, etc.), *Entolium discites microtis* Bittner, *Eumorphotis inaeqicostata* Benecke and so on. They are regarded as forms of the Northern sea coast of the Tethyan realm, and associated with the members of Boreal-Circum Pacific realm, bearing *Cl. stachei* Bittner, *Eu. multiformis* Bittner. This fauna differs greatly from that of the southern part of the Lhasa-Kangdese regions. In the latter region occur only a few endemic forms, i. e. *Cl. griesbachi* Bittner, *Cl. painkhandana* Bittner, *Cl. dieneri* Nakazawa which are repr sentatives of the southern part sea coast of the Tethyan Realm. It is deduced that at least in Himalayan region during the early Triassic the east Tethyan sea intervened between the Gondwana and Eurasian continents.

The east Tethyan sea seemed to diminish it when the Norian came, thus the Napeng fauna reached to all shall w water clastic facies of Xizang. The shallow water carbonate facies is constituted by limestone bearing Megalodonts and Napeng fauna. The deeper facies known in th Jilong-Shannan region. It is constituted by shale, rediolation siliceous bed with thin-shelled bivalves (*Monotis*, *Halobia*) of the Tethyan type.

The search for a cause of the members of the Boreal-Circum Pacific realm occurring in the Tanggula-Chambdo region during the early Triassic is discussed here.

THE JURASSIC SYSTEM AND THE BOUNDARY BETWEEN JURASSIC AND CRETACEOUS IN XIZANG

Sun Dong-li
(Nanjing Institute of Geology and Palaeontology, Academia Sinica)

In Jurassic period the transgression was very extensive in Xizang. The "Xizang Sea", as a part of Tethys, almost occupied the whole teritory of Xizang(including Tethyan Himalayan Region, Kangdese-Nyainqentanglha Region and Karakorum-Tangla-Hengtuan Mountains Region) except the extreme northern part of it (Kunlun-Hohxil Shan Region).

The banded Jurassic rocks expose broadly along the west-east direction, but the strike of the rocks turns round to the north-south direction in Hengtuan Mountains Region. The Jurassic marine sediment here is the most developmental one in China. In the paper the Jurassic strata distributing in the realm are divided into seven zones of the sedimantary formation according to the lithological and tectonic characters, the property of biological group and differences of the modes of deposition.

Recent study of the Jurassic ammonoids, Belemnoids, Brachiopods and microfossils has led to the subdivisions of the Jurassic strata and the establishment of the biostratigraphical sequence. The author dealed with the palaeogeographical position of "Xizang Sea" at that time and the changes of the transgressions and the regressions. In the article the boundary between Jurassic and Cretaceous is discussed in obedience to the point of view that Phanerozoic systems represent evolutionary stages in life history. From this point of view the author should prefer the boundary to be placed between Berriasian and Valanginian.

THE STRATIGRAPHICAL I MPORTANCE OF ORBITOLINAS(FORAMINIFERA) FOR THE SUBDIVISION OF CRETACEOUS NERITIC SERIES OF HIMALAYA-TIBET PLATEAU AND ADJACENT AREAS

Rolf Schroeder
(University of Frankfurt, F.R.G.)

The presence of orbitolinid foraminifera (genus *Orbitolina* and allied forms) in the Himalaya and adjacent areas is known since a long time; orbitolinid-bearing rocks could be attributed to Lower Cretaceous-Cenomanian. However, a more exact dating respectively a biozonation of the neritic series containing orbitolinid foraminifera was not possible till now because the definition of different species and evolutionary trends were not sufficiently known.

The revision of mediterranean orbitolinid foraminifera during the last decade rendered possible a subdivision of the neritic series in numerous well dated biozones. A re-examination of the published figures of Orbitolinas from the Himalaya and adjacent areas as well as a restudy of some expedition material from european collections has shown that the general evolution of these foraminifera was largely identical in the two continents. These facts emphasize the importance of this group for Cretaceous stratigraphy f the Himalayan region and give rise to a future collaboration between chinese and european micropaleontologists.

CHARACTERISTICS AND EVOLUTION OF GRANITOIDS OF SOUTH XIZANG (TIBET)

Tu Kuangchi Zhang Yuquan
Zhao Zhenhua Wang Zhonggang
(Institute of Geochemistry, Academia Sinica)

Granitoids are widely distributed in South Xizang covering an area of 100,000 km^2. and occuring in three parallel petrographic belts, each with its own characteristics. These are the Kangdese Belt to the north, the Lhagoi Kangri Belt in the middle, and the Himalaya Belt to the south.

The plutons of these petrographic belts all occur in the upthrust sides of the great thrust zones.

Time of formation of plutons becomes younger as one goes southwards; the principal granitoids of the Kangdese Belt have isotopic ages 120-70 m.y. with subordinates 50-10m.y., while the Lhagoi Kangri and the Himalaya granitoids have 50-30 m.y. and 20-10m.y. ages respectively.

The Kangdese Belt is characterized by the presence of huge batholiths, usually forming composite plutons. The main rock types are diorite and granodiorite with subordinate granites. Both the Lhagoi Kangri and the Himalaya Belts, on the other hand, have only small-sized and widely separated plutons with simple petrography. The main rock types are gneissic two-mica monzonitic granite and tourmaline muscovite granite.

The characteristic accessory minerals are magnetite, sphene, apatite, and allanite for the Kangdese granitoids, monazite, tourmaline, garnets and muscovite for the Lhagoi Kangri and the Himalaya Belts. The granitoids of the Kangdese Belt are rich in Ti, Fe, Mg,Ca, but impoveriched in Si, K. Opposite trend is observed for the other two Belts. In rare-earth distribution pattern, the Kangdese Belt is characterized by a smooth curve with indistinct Eu anomaly, while the Lhagoi Kangri and the Himalaya Belts have intensive Eu anomalies.

Granitoids of the Kangdese Belt are very similar with the I-type granitoids of the Western North and South Americas in their modes of occurrence, periods of intrusion, petrographic features, constituents of main and accessory minerals, as well as in their trend of evolution, close association with basic to intermediate volcanic rocks and Cu mineralization of the porphery type. Granitoids of the Lhagoi Kangri and the Himalaya Belts correspond with the S-type granitoids of Southeast Asia.

It is postulated that the granitoids of the Kangdese Belt were formed by the partial melting of the oceanic crust with its overlying sediments when the Indian Plate subducted downward below the Euracean Plate. Granitoids of the other two Belts, on the other hand, were produced by the remelting of continental crust during collision and compression of the two Plates.

Granitoids of the three above-mentioned petrographic Belts, together with those of the Tanggula and the Kunlung Ranges farther to the north, show obvious tendency of southward decreasing geological ages. The same is true for granitoids of Southeast China. This seaward migration of younger granitoids is to be explained by micro-plate accretion since the Paleaozoic. Late granitoids formation is also closely related to crust thickening and continental growth.

PETROCHEMICAL STUDY OF GRANITOID ROCKS IN SOUTHERN XIZANG

Wang Zhonggang, Zhang Yuquan and Zhao Huilan
(Institute of Geochemistry, Academia Sinica)

Based on two hundred analytical data on granitoid rocks in this region, the average chemical composition has been calculated by the area weight method for various granitoid rocks of different episodes and different stages, as well as for different rock-belts and the whole region. The origins of various types of granitoid rocks are discussed also. Several conclusions have been drawn as follows:

1. The average bulk chemical composition of all granitoid rocks in this region approximates to that of granodiorite and adamellite given by Daly.

2. The composition of granitoid rocks shows a tendency to become from comparatively basic to acidic with their ages changing from older to younger.

3. The development of the composition is not successive but intermittent in nature, indicating that different types of granitoid rocks were derived from different source materials.

4. According to Ab-Or-Q-H_2O Diagram, it is shown that all granitoid rocks, except diorite-granodiorite, are of magmatic origin with the formation temperature ranging from 700 to 750℃ and the pressure between 1000—2000 bars. The earlier diorite-granodiorite, however, has the formation temperature of about 750℃ and pressure of 5000—7000 bars. The assimilati n and contamination seem to have taken place in accompany with the formation of diorite-granodiorite.

5. Diorite-granodiorite was formed at the stage when the Indian Plate underthrusted towards the Eurasian Plate while other granitoid rocks were mainly formed at the stage when the intercollision between the two Plates proceeded.

THE MESOZOIC-CENOZOIC VOLCANIC ROCKS IN XIZANG AND THEIR BEARINGS ON GEOLOGY

Jin Chengwei
(Institute of Geology, Academia Sinica)

In Xizang, volcanic activities have occurred in the following important periods since the Mesozoic era: (1) Triassic, intermediate-basic eruption in both Yarlungzangbo and Jin Sha river or the intermediate-acidic in Qamdo reagion, (2) Jurassic, intermediate

magmatic eruption in the lake district of northern Xizang, (3) early Cretaceous, intermediate-acidic magmatic eruption of calc-alkali series in the large area from Yarlungzangbo to the lake district of northern Xizang, (4) late Cretaceous, eruption of intermediate-basic magma in the Yarlungzangbo ophiolite belt, (5) late Cretaceous (K_2)-early Tertiary(E), large-scale intermediate-acidic magmatic eruption of calc-alkali series in Kangdese; (6) Tertiary, acidic magmatic eruption in small-scale, and (7) Quarternary, eruption of alkali and calc-alkali series in the Qiangtang. Among these the volcanic activities of Cretaceous-Eogene is most magnificent.

The volcanic rocks of the Yarlungzangbo ophiolite belt consists mainly of tholeiite and alkali basaltic series belonging to the sodic subseries, but the K_2-E calc-alkali volcanic rocks in Kangdese belong to potassic and ordinary subseries. As seen from the diagram of SI versus Na_2O+K_2O, the evolutional trends of the volcanic rock in Yarlungzangbo is different from that of Kangdese. Whereas the evolutional trend of the early Cretaceous calc-alkali volcanic rocks on the north of the Yarlungzangbo is quite similar to that of the ophiolite belt of it.

The Ceno-Mesozoic volcanic activities is intimately related to the northward pushing of the Indian plate. Since the Cretaceous time, India and Australia were separated from each other and rifted toward the north. Thus, calc-alkali andesitic magma and island arc tholeiitic magma were produced during subduction of the oceanic crust. The rate of the northward drifting of the Indian Plate have attained to about 15—20 cm/yr. since the past 80 m. y. Aside from the magmas that were forned subduction of the oceanic crust, there were still others that were output of the crustal melting of the Kangdese induced by the mantle convection which were resulted from the increasing rate of plate drifting. One evidence of this speculation is that the Sr^{87}/Sr^{86} ratio is 0.708 for the K_2-E volcanic rocks in Kangdese. The great speed of plate drift was likely due to large inclinational angle of Benniof f belt. Therefore, large-scale volcanic activities occurred in a rather narrow zone. Tethys sea was closed up 40 M. Y. ago. At the same time, activity of the Yarlungzangbo convergence belt stopped. A new intracontinental convergence was formed. Quarternary volcanic eruption in northern Qiangtang plateau is caused by the southward downthrusting of the Talimu block along a new intracontinental convergence belt or the remobilizing Kunlum fault.

A PAIR OF METAMORPHIC BELTS IN SOUTH XIZANG

Zhang Qi, Li Dazhou and Li Shauhua
(Institute of Geology, Academia Sinica)

There are two metamorphic belts in South Xizang:

Kangdese metamorphic belt and Yarlung Zangbo Jiang metamorphic belt, their basic types are quite different. Kangdese metamorphic belt is mainly composed of slates, phyllites, schists, gneisses, amphibolites and migmatites. A great amount of related granitic rocks occurs in this metamorphic belt, thus contact metamorphism of country rocks was much developed. Index minerals of regional metamorphism is andalusite and sillimanite. The bo value of the potash white micas is 9.003 Å in metapelites. It corresponds to contact-low pressure regional metamorphism type. We think it probably belongs to low or low-medium pressure metamorphic facies series.

Yarlung Zangbo Jiang metamorphic belt is expressed on the south of Kandese metamorphic belt. Its distribution is rather narrow and quite discontinuous. Its important rock constituents are pelitic schists, phyllites and greenschists that accompanied ophiolite, The occurrence of glaucophane schists was reported from Lower Zayu district (Синха Рой, 1977). Almandine associated with albite in the Wa'nyai Qiao Formation at Namjagbarwa district. The b_0 value of the muscovite is 9.043 Å. The contents of RM* and MgO of the muscovite are higher. It appears that it could belong to high or high-medium pressure facies series.

In Kangdese belt strata of Ordovician to Cretaceous hare been found. The metamorphic rocks have K-Ar ages between 119—21 m. y, which correlates to Cretaceous-Miocene period. The stratigraphic position of Yarlung zangbo Jiang metamorphic belt is mostly of late Cretaceous. So it is suggested that the age of this metamorphic belt might be from the end of Late Cretaceous to Tertiary period.

The two metamorphic belts are quite different in characteristics and general outlook. But they are intimately related to each other in regional distribution. Their metamorphic ages are almost similar, too. It seems that they really possess many of the characteristics of a pair-metamorphism belt.

PETROCHEMISTRY OF GRANITES IN XIZANG AND AN APPROACH TO THEIR ORIGIN

Liu Guanjien and Zhang Kuiwu
(Institute of Geology, Academia Sinica)

The granitic rocks occur in a banded shape distribution in Xizang (Tibet). Tertiary tourmaline-muscovite granite and gneissic two-mica granite are widely exposed in Himalaya region of Southern Xizang. Northward, batholiths of gabbro, diorite, tonalite, granodiorite and granite of Late Cretaceous to Tertiaray in age are distributed in the Kangdese granite belt and Northern Xizang Granite belt. In the Qangtang-Qamdo area, the main rock types are granodiorite and granite of Jurassic-Cretaceous. In this paper, 171 petrochemical analysis of granitic rocks, the calculation of C. I. P. W. of normal minerals and the data of petrochemical characteristics of Zavariski are given. A vector diagram of Za-

* $RM = 1/2Fe_2O_3 + FeO + MgO$ (molecular proportion)

variski' petochemistry is drawn and also variation diagrams of Q-Ab-Or, An-Ab-Or and SiO_2 against other main elements as well. In these diagrams, the granitic rocks in the area mentioned above occupy a special distribution area respectively, which show their spatial trend of petrochemical variations as well as their possible origins. The tourmaline-muscovite granites in the High Himalayas contain higher SiO_2 (averagely 73.73 %), K_2O+Na_2O (averagely 8.17%) and K_2O/Na_2O (averagely 1.1), lower $FeO+Fe_2O_3$ (averagely 1.78%), Mgo (averagely 0.52%) and CaO (averagely 0.77%). The gneissic two-mica granite in Lhagoi Kangri contains similar composition, average $SiO_2=73.6\%$, $K_2O+Na_2O=7.28\%$, $K_2O/Na_2O=1.08$, $Fe_2O_3+FeO=2.39\%$, $MgO=0.76\%$, and $CaO=1.63\%$, respectively. From the diagram of Q-Ab-Or, We can see that the granites mentioned above formed under lower vapour pressure. The Kangdese granitic rocks contain higher $FeO+Fe_2O_3$ (averagely 4.70%), MgO (averagely 1.66%), and CaO (averagely 3.33%), respectively. The Northern Xizang granitic rocks contain also higher $FeO+Fe_2O_3$ (averagely 4.09%), MgO (averagely 1.46%), and CaO (averagely 2.87%) respectively. On the whole, as being indicated on the diagram of Q-Ab-Or, they obviously tend to distribute more closer to the Ab angle than the Himalaya granites, which shows that they formed under higher pressure. From the south to the north, the age of rocks has an order from old to young, compositions of the rocks show the increasing K_2O content and K_2O/Na_2O ratio. The authors consider that the Kangdese granites, Northern Xizang granites and the Himalaya Tertiary granites are associated with the northward movement of the Indian plate, its subduction beneath the Eurasian plate and their final collision. A few data of petrochemistry gained from Qangtang-Qamdo area show a contrary tendecy that of Kangdese granite belt. As compared with the data of melting experiments of granites, the authors suggest that the tourmaline-muscovite granites in High Himalaya, the gneissic two-mica granites in Lhagoi Kangri, and the small part of Kangdese granites might be emerged from the partial melting of crust rocks, while the quartz-diorite-granodiorite and granites in Kangdese and Northern Xizang might mainly be derived from the hydrous partial melting of pyrolite in the mantle wedge above the Benioff zone.

A STUDY ON THE INCLUSIONS IN SOME ROCKS FROM XIZANG

Lu Huanzhang
(Institute of Geochemistry, Academia Sinica)

Recognized in Xizang volcanic and intrusive rocks are a large number of glass and melting inclusions, as well as fluid inclusions. All these inclusions are the representives of magmas and silicate melts, and later hydrothermal fluids respectively, from which the rocks in Xizang were derived. Glass inclusions mainly occur in volcanic rocks whereas melting inclusions are only found in intrusive rocks, such as granites, diorites, olivinfels, etc. In this work, the author has found for the first time the liquid ring-bearing glass inclusions in acid volcanic rocks, which provide strong evidence of the development from magma to hydrothermal solution, and made an investigation into the cooling history of these rocks with reference to magmatic inclusions.

The results obtained by homogenization-and quenching-method are given in Tab. 1. The homogenization temperatures are in the range of 750—1250℃. The homogenization temperatures of volcanic rocks or hypabyssal rocks are higher than those of intrusive rocks, while those of intermidiate-basic rocks are much higher as compared with acid rocks. Heating experiments show that the temperatures of appearance and disappearance of daughter minerals can be used as indicators of the upper and lower limits of crystallization temperatures of rocks.

Based upon the foregoing discussion and compared with Nanling granites and Suzhow granites, it is concluded that Xizang rocks under consideration are of magmatic origin.

Table 1. Results of the Study on the Inclusions in Some Xizang Rocks

Rock Type	Observed Mineral	Type of Inclusion	N.D.	Homogenization Temp. of Fluid Inclusions	Glass and Melting Inclusions	
					Appearance and disappearance of Daughter Minerals	Homogenization Temperature (℃)
Acid crystallinoclastic tuff	Quartz	Ⅰ Liquid inclusion Ⅱ Glass inclusion	6		950—1150	1200
Liparitic porphyry	Quartz	Ⅱ Apo-glass inclusion	3			1050—1000
Basaltic porphyrite	Quartz Feldspar	Ⅰ Ⅱ (some inclu-dind daughter minerals)	4		650—1000	1040—1200
Andesite porphyrite	Feldspar	Ⅰ	7	220—250		
Harzburgite	Olivine	Ⅰ Ⅲ Melting inclusion	10			850
Giant hypersthenite	Feldspar	Ⅰ	2	750(decreption)		
Trachyteporphyry	Feldspar Quartz	Ⅰ Ⅱ Apo-glass inclusion	1			1150

Table 1. (continued)

Rock Type	Observed Mineral	Type of Inclusion	N.D.	Homogenization Temp. of Fluid Inclusions	Glass and Melting Inclusions	
					Appearance and disappearance of Daughter Minerals	Homogenization Temperature(℃)
Quartz-porphyry	Quartz	I II	9		840—1150	1250
Acid tuff	Quartz	II (containing liquid ring and daughter minerals)	8		650—1100	1200
Hypersthenite	Feldspar	III	2		~800	1000
Katabugite	Feldspar	III				1000
Granodiorite	Quartz	I, III IV Daughter mineral-bearing fluid inclusion	3		~700	900
Porphyritic two-mica granite	Quartz	I, III	2			900
Biotite granite	Quartz	I, III	3	270		900
Diorite	Quartz	I, III	4	420	~700	900
Granodiorite	Quartz	I, III	4	210		850
Monzonitic granite	Quartz	I, III	4	350		900
K-feldspar granite	Quartz	I, III V containing liquid CO_2 inclusion	2			900
Granite	Quartz	I III	2			800

THE CHARACTERISTICS OF FELDSPARS IN GRANITE AND THE EVOLUTION OF XIZANG GRANITES

Xie Yingwen　Zhang Yuquan　Deng Bingjun
(Institute of Geochemistry, Academia Sinica)

Late Yenshanian and early Himalayan granites are widespread in Kangdese and Himalaya Mountains in southern Xizang. Feldspars in these rocks are examined by optical measurement, chemical analysis and X-ray methods. The characteristics are as follows:

Alkali increase with the process of magma evolution as is indicated by the higher K (coefficient of alkli feldspar) and distribution frequency of later granite in comparison with that of earlier ones.

The An value of plagioclase of different ages and stages decrease from earlier to later stages. Difference has also been found in An value in different rocks of the same emplacement stage. The An value is higher for the phenocryst than that in grouandmass in the same sample. All of these evidences show that the plagioclase becomes more acid in composition from earlier to later stages.

The trend of alkali feldspar variation is: Ab values of earlier stages are lower than that of later stages. This is probably due to the different conditions related to rock forming process or sodium metasomatism.

The extent of order-disorder is found variable within a wide range for the alkali feldspars. Feldspars from the most ordered microcline to the disordered orthoclase have all been discovered in Xizang for most plutons, the extent of order-disorder is basically similar between alkali feldspar phenocryst and grouandmass.On the other hand,however, the order-disorder variation is quite limited in plagioclase. With only a few exceptions that should be a gradation to disorder species, the majority of plagioclase is of ordered type. Within a same pluton, the extent of order-disorder of plagioclase is always higher than that of alkali feldspar. Feldspars of late Yenshanian period is of higher ordered state than that of the Himalayan stage. But it must be pointed out that there are many factors, such as the size of plutons, the temperature and depth of formation and tectonic movement and etc., that may affect the structure state of feldspars and the age of rocks is just one among them.

In the light of composition and structure state as mentioned above it can be said that granites in southern Xizang have a magmatic origin and they trend to be more acid during their evolution from earlier to later stages.

FEATURES OF ACCESSORY MINERALS IN GRANITOID ROCKS IN SOUTHERN XIZANG

Pan Jingming, Zhang Yuquan and Hong Wenxin
(Insitute of Geochemistry, Academia Sinica)

The contents and average specific gravities of accessory minerals, and the ratios of volatile to non-volatile minerals and of the metallic to non-metallic minerals in 42 concentrations of heavy minerals have been determined. These concentrations were collected from 13 plutons in the Kangdese, Lhagoi Kangri and Himalaya belts. More than 50 kinds of accessory minerals have been found, and seven types of accessory mineral associations have been distinguished. Every type is named after the mineral which predominates in the association.

The authors described in detail the features of zircon, apatite, radioactive minerals and sulphide minerals, of which, the crystal forms of zircon in different rock belts or different plutons and different intrusion times are quite different, and the radioactive minerals change from Th-rich to U-rich from the Kangdese belt to Himalaya belt.

From early to late, it is found that certain regularities exist for the evolution of accessory minerals. For example, the percentages of minerals of titanium, iron, calcium and zirconium decrease, whereas, the percentages of minerals of niobium (tantalum), beryllium, uranium and tin increase.

Different belts show different features in the associations of accessory minerals. Generally speaking, the associations from the Kangdese belt are rich in sphene, allanite, apatite and magnetite, whereas the associations from Himalaya belt are rich in tourmaline, and the Lhagoi Kangri belt shows intermediate features.

After comparing the features of accessory minerals from different belts, from different types of granitoid rocks, different plutons and different intrusion times, we found that they show a quite similar evolution pattern, indicating that Yenshanian and Himalayan granitoid rocks in Southern Xizang were resulted from the partial melting of the crustal materials at various depths. Moreover, according to the differences in average specific gravities and in proportions of volatile minerals it could be said that the material source for the minerals of Kangdese belt is situated at somewhat deeper position than that for Himalaya belt, and the sources of all these two belts show a similar tendency of becoming deeper from West to East.

GENESIS OF X CHROMITE DEPOSITS, XIZANG AUTONOMOUS REGION

Chi Sanchuan and Shi Qizheng
(Wuhan Geological College)

The X ultrabasic igneous body is situated in the eastern segment of the southern Xizang ultrabasic igneous belt. It extends in a NWW-SEE direction and plunge due south. It is practically consistent with the orientation of the Yarlung Zangbo deep fault. It is a composite igneous body of multiple intrusions with marked intrusive contact relation to its country rocks $T_3{}^2$. The magmatic differentiation is rather complete. The state whenever the magma were intruded into the deep-lying magmatic chamber is considered to be still molten or in the state of "crystal mush" and could hardly be in cold solid state. The chromite-bearing body, being high in m/f ratio and rich in chromium, is a sort of magnesian ultrabasic rock.

Main ore bodies occurred chiefly in the middle and lower part of the dunite-harzburgite zone. The chromite deposits were formed under unstable tectonic environments. Structural deformations occuired in each mineralization stages, and fractures that were derived fiom the plastic deformation of the late magmatic stage, are the main ore-controlling factors.

We classified the ore deposits into three genetical types:

1. Deposits formed by crystallization segregation of late orthomagmatic stage. According to the manner of mineralization, they could be still subdivided into two subtypes, i. e., segregation in situ, and segregation by pressure filtering.

2. Primordial cumulative deposits of late orthomagmatic stage. The main feature of this kind of deposit is that the ore forming Cr-spinels are pissolitic, nodular and ellipsoidal in shape. They form nodular aggregates ores. The pissolites were oriented in a definite direction forming "sedimentary bedding" like structure by the graded granularity of the Cr-spinels. And this sort of nodular ore may at times give rise to massive ores. The contact between the ore bodies and their neighbouring dunite although gradational are rather sharp, they are considered to have been accumulated in the eddy currents of crystal mush by current differentiation and gravitational settlement,owing to the greater density of chromite in the magmatic chamber.

3. Late magmatic injection deposits. At the latest residual magmatic stage, rock body was plastically deformed by structural extruding pressure to form fractures and Cr-rich residual magma. The latter were migrated along the fracturs forming injection deposits.

The three types of mineralization mentioned above could occurr separately or in combination.

The genesis of the "Alpine-type" ultrabasic igneous rocks and the podiform chromite in geosynclinal terrains, especially the genesis of pissolitic ores, have long been argued. H.B. Pavloff suggested that the pissolitic ores had been formed by magmatic immissibility, and J. Dickey suggested that they had been formed as "snow balls trundling" in the mgmatic segregation zones at the margin of the plates. It is because the separation of chromite by magmatic immissiblbity in magnesian melt can hardly be possible as seen from the experimental data. Therefore, the present authors suggest that the pissolitic ore are formed as culmulative products of gravitational settlement through current differentiation.

ISOTOPIC VARIATIONS IN MANTLE AND CRUSTAL HELIUM AND THEIR SIGNIFICANCE FOR STUDIES OF THE TIBETAN GEOTHERMAL AREAS

H. Craig
(Scripps Institution of Oceanography, University of California, San Diego La Jolla, California, U.S.A.)

Investigations of helium isotope ratios in terrestrial rocks and volcanic and geothermal gases have shown that primordial ^3He is present in the mantle and that $^3He/^4He$ ratios in mantle rocks have distinctive patterns which charaterize various sour e regions. The most uniform source is the mid-ocean ridge basalt (MORB) reservoir. Measurements on trapped gases in the quenched glassy rims of oceanic tholeiites show that the $^3He/^4He$ ıatio is characteristically 9 times the atmospheric helium isotope ratio, and about 100 times the ratio in the "crustal" type helium produced by radioactive decay of uranium and thorium in crustal rocks. This typical MORB helium ratio is observed in basalts from the East Pacific Rise, the Mid Atlantic Ridge, back-arc basins such as the Lau Basin and Mariana Trough, and in the geothermal brines in the Red Sea. Helium emanations in hydrothermal fluids emerging at high temperatures on oceanic ridges can be traced for thousands of kilometers across the Pacific Ocean at a depth of 2500 meters. Somewhat lower $^3He/^4He$ ratios, about 6 to 8 times atmospheric, are observed at convergent plate margins and volcanic arc terrains such as Japan, Kamchatka, the Kuriles, the Marianas and Cascades, New Zealand, and other similar areas.

The highest ^3He enrichments in terrestrial samples have been found in areas which may represent deep mantle convection plumes, the so-called "hotspots". Helium has been studied in four such areas: Kilauea Volcano, the Ethiopian Rift Valley, Iceland, and Yellowstone Park in the continental U. S. The $^3He/^4He$ ratios in volcanic and geothermal gases in these areas range from 15 to 23 times the atmospheric $^3He/^4He$ ratio, indicating a more primitive and probably deeper mantle source, with distinctly different helium isotope and He/U ratios. At Yellowstone Park the area of very high helium isotope ratios is surrounded by rocks with typical crustal helium ratios, showing that even in a region of thick continental crust, the crust is essentially transparent to the emanation of "hot-spot" or Kilauea-type helium. Thus an obvious area of great interest for comparative study will be the geothermal regions in Tibet, where it may be possible to identify a similar mantle plume by helium isotope measurements, despite the lack of extensive volcanic rocks normally observed in such regions. If a mantle plume is present under the Tibetan Plateau, the helium isotope ratio in geothermal gases may be the only direct evidence for its existence.

ISOTOPIC GEOCHRONOLOGY OF GRANITOID ROCKS IN SOUTHERN XIZANG PLATEAU

Zhang Yuquan Dai Tongmo Hong Ashi
(Institute of Geochemistry, Academia Sinica)

In the study of isotopic geochronology of granitoid rocks in the southern part of the Xizang Plateau, 126 mica- and zircon-ages for 27 granite bodies were determined by K-Ar method and U-Pb method. All the samples under consideration were collected from granitoid rocks of different ages and those of a same age, but different intrusive stages in the Kangdese belt, the Lhagoi Kangri belt and the high Himalaya belt. Diorites, granodiorites and porphyritic biotite granites occurring in the main part of the Kangdese belt yielded an age range from 120—70 m.y., belonging to late Yenshanian which corresponds to the Crataceous period. Medium-fine-grained biotite granites and two-mica granites gave an age range of 50—10 m. y., turning out to be Himalayan in age, equivalent to the Palaeocene-Miocene epoch. Mica-age of about 30 m.y. was obtained for gneissose monzonitic granites in the Lhagoi Kangri belt, in which most of the intrusives are early-Himalayan in age, except a few individual plutons which had intruded earlier. Tourmaline-muscovite granites and two-mica granites in the Himalaya belt have an age range of 20—10 m. y., belonging to late Himalayan, corresponding to the Miocene epoch.

Based upon the above mica-and zircon-ages for the various types of granoid rock, together with their geological setting, three intrusive stages have been distinquished for granoid rocks in Southern Xizang: the first stage—120-70 m.y. (late Yenshanian); the second stage 50-30 m.y.(early Himalayan); the third stage—20-10 m.y.(late Himalayan). It is precisely evident from the characteristic zonal distribution patterns of the granoid rocks and the spacial-temporal consistency in their isotopic geochronology that there exists a close inter-connection between the underthrust stage and the collision stage.

A DISCUSSION ON ZIRCON U-Pb DATING OF INTERMEDIATE-ACID ROCKS IN SOUTHERN XIZANG

Chen Yuwei and Xu Yonghua
(U-Pb Research Group, Laboratory of Isotope Geology, Institute of Geochemistry, Academia Sinica)

U-Pb isotopic geological ages were determined on more than 30 specimens of zircon, feldspar, sphene and apatite from the Kangdese rock belt and its eastern Bome-Zayu areas in Xizang. The studies of common lead derivation and its mode of occurrence in zircon indicates that large amounts of common lead occur as sulphide-facies minerals or exist in the crystal lattice of zircon, rather than introduced by contamination during analytical procedure. Described in this paper is the validity of subtracting zircon containing common lead from the isotopic components of syngenetic galena, consequently leading to the conclusion that intermediate-acid rocks in the studied region are brought forth by late Yenshanian movement. Based upon the geological modes of occurrence of various plutons and their biotite K-Ar ages, three groups of zircon U-Pb ages can be recognized; the first group, roughly consistent with biotite K-Ar ages or slightly higher; the second group, older than biotite K-Ar ages; the third group, younger than biotite K-Ar ages The former two groups are in coincidance with the geological modes of occurrence, but the latter gives anomalous age values which account for the majority of the obtained age values. These anomalous zircon U-Pb age values are mostly yielded by rock samples taken from the middle-western segment of the eastern Kangdese belt, neighbouring ultrabasic rock belt or along the plate suture line. The authors try to give a reasonable explanation to the anomalies in terms of the influence on zircon U-Pb isotopic ages exerted by the accumulating amount of intermediate daughter isotopes from radioactive U-decay series in those extremely young minerals. It is suggested from the amount of common lead and the difference in lead isotopic composition that the western segment of the Kangdese belt and its eastern Bome-Zayu areas may have two different material sources. The plutons in the Bome-Zayu areas and the western segment of the Kangdese belt possess the characteristics of crust derived intrusive rocks, whereas the plutons in the middle segment and those with anomalous isotopic ages may have more diverse material sources, indicating that these rocks are plutonic rocks from different depths.

GEOCHEMICAL CHARACTERISTICS OF DEEP-FORMED FLUIDS IN XIZANG AREA

Shi Hui-xin

(Analysis and Prediction Center, State Seismological Bureau)

Xizang area is situated at the border of plates which still move right now. Various kinds of geological processes take place there, such as metamorphism, orogenesis, earthquake and strong hydrothermal activities. Investigation of geochemical characteristics of deep fluids rising just now becomes an important part of study in geotectonics on a global scale, geodynamics and seismology.

Contrasting the geochemical characteristics of deep-formed fluids in zones of contemporary subduction(island arc-trench type in West Pacific Ocean)with that in zones of suture(continent ollide type in Xizang), we have verified that contemporary tectonic movements in these two zones are two kinds of extremely various dynamic processes. Active volcano are situated parallel to island arc zone. There are acid, strong acid($pH<4$ even $pH<0.2$)superhot water and gases, superhot liguids of low mineralization ($M<4$)and simple composition (Cl-Na), warm and cold CO_2 fluids, and superhot brine supplied by groundwater of marine formation. Whereas in Xizang tensile fractures take place. Deep fluids are characterized as neutral, basic and strong basic water of low mineralization and various composition(Cl-HCO_3-Na)which corresponds with granite(mean composition of crust). High stress in crust makes CO_2 of various deep formations accumulate and diffuse in crust, so that Xizang becomes one of three major zones of concentrated discharges of CO_2 fluids(the other two are California and the Mediterranean-Minor Asia). Discharges of hot and warm CO_2 fluids in Xizang are more than in the other two zones. Later on we should strengthen investigation of stable isotopes(such as He^3/He^4, Ar^{36}/Ar^{40}, C^{12}/C^{13}, O^{16}/O^{18}) and radioactive elements and isotopes(such as U. Ra. Th. Rn) in deep-formed fluids in Xizang area. It will be fruitful for recognization of formation and evolution of Xizang plateau and geological processes taking place in Xizang right now.

OXYGEN ISOTOPIC COMPOSITION OF METEORIC WATER IN THE EASTERN PART OF XIZANG

Yu Jinsheng Zhang Hongbin
Yu Fuji Liu Deping
(Institute of Geochemistry, Academia Sinica)

The Xizang Plateau, commonly over 4000 m above sea level, is well known as "The Roof of the World". In order to study oxygen isotopic composition of meteoric water in the Xizang Plateau Region and its relationship with altitude, we made an investigation tour to Xizang starting from Guiyang from July to October of 1979, and 78 meteoric water samples were collected at different altitudes, including brook, well, lake, snow, firn, spring and running waters. Oxygen isotopic analyses indicate that the isotopic composition of meteoric water from Eastern Xizang and Western Sichuan-Guizhow shows remarkable altitude effect. There is a negative correlation between $\delta^{18}0$ and the elevation, which is characterized by $\delta^{18}0(‰) - = 0.0026H(m) + 7.75$. The average $\delta^{18}0$ value form eteoric water in the areas with an altitude of more than 4000 m above sea level turns out to be $-18.84‰$ It is evident that $\delta^{18}0$ value for lake water on the plateau is related to its water supply. $\delta^{18}0$ value for lake water, in which the evaporation is greater than supply, is approximately three or four times higher than that of supplied water, averaging $-5.74‰$. Oxygen isotopic composition of geothermal water is compared with that of local meteoric water, but shows $^{18}0$-shift, suggesting that meteoric water in the same area seems to be the main water-supply source.

GEOCHEMISTRY OF REE IN INTERMEDIATE-ACIDIC INTRUSIVE ROCKS IN SOUTHERN XIZANG

Zhao Zhenghua, Wang Yixian, Qian Zhixin,
Zhang Yuquan and Wang Zhonggang
(Institute of Geochemistry, Academia Sinica)

By area weight method,the REE abundances in intermediate-acidic intrusive rocks in Southern Xizang were estimated to be 194 ppm (REE oxide), much lower than the average REE abundance of intermediate-acidic intrusive rocks in the crust. The REE

abundances show a progressive decrease from Late Yanshanian to Early and Late Himalayan Period (200—138—136 ppm). The highest concentration of REE was found in biotite-granite (215 ppm) and porphyritic biotite-granite (231 ppm), whereas diorite, granodiorite (191 ppm), two-mica granite and tourmaline-muscovite granite (151 ppm) show the lowest REE concentration. Four types of REE distribution pattern have been distinguished, namely, (1), Rightly declined smooth curves, showing little Eu anomaly (δEu-values are 0.78—0.95) and relative enrichment of heavy REE. Diorite and granodiorite, for example, are characterized by such a pattern; (2), Rightly declined V-shape curves, displaying negative Eu anomaly (δEu: 0.50—0.70). Biotite-granite shows such a pattern; (3), Rightly declined V-shape curves with noticeable Eu anomaly (δEu: 0.36—0.39). two-mica and tourmaline-muscovite granites possess this pattern; (4), Rightly declined V-shape curves with strong Eu anomaly (δEu: 0.27—0.36). Porphyritic biotite-granite has such a pattern.

According to the diagram plotting La/Sm against La, the diorite, granodiorite, biotite-granite, two-mica granite, and tourmaline-muscovite granite conform to the partial melting pattern, whereas the porphyritic biotite-granite to the fractional crystallization pattern.

In summary, the intermediate-acidic intrusive rocks in this given area could be divided into two types, i. e., the hypogene type(diorite, granodiorite)and the hypabyssal type (two-mica and tourmaline-muscovite granites). The former (rich in Eu,but depleted in light REE) was formed by partial melting of materials in the lower crust at the stage when the Indian Plate underthrust towards the Eurasian Plate, while the latter (rich in light REE, but depleted in Eu) was formed by partial melting of materials in the upper crust at the stage when the intercollision between these two plates proceeded.

SOME GEOCHEMICAL CHARACTERISTICS OF TRACE ELEMENTS IN GRANITOID ROCKS IN SOUTHERN XIZANG

Wang Yixian, Zhao Zhenghua and Wang Zhonggang
(Institute of Geochemistry, Academia Sinica)

The types and intrusion times for granitoid rocks in Southern Xizang have been distinguished by discriminatory and cluster analyses. Based on the results obtained, we discussed quantitatively the correlations between trace and major elements and the characteristics of trace element evolution.

Abundances of Trace Elements: The abundances of Li, Rb, U, Th, Be, Nb and Ta are close to or somewhat lower than their abundances in crustal acidic rocks, whereas the abundances of V, Cr and Ni are higher than those in crustal acidic rocks. The reason for this can be evidently attributed to the fact that the average composition of the granitoid rocks in this given area are close to that of granodiorite and that the magmatic differentiation is not well developed. The concentration frequency distribution histograms of various elements show exclusively positively declined, indicating that these elements exist in dispersive conditions in the rocks.

Li, Rb, U, Be and F are enriched in tourmaline-muscovite granite which was formed during Late Himalayan Period. The ratios of Mg/Li, K/Rb and Ba/Rb could reflect the degrees of magmatic differentiation.

Of the granitoid rocks in this given area, all rock-types show poor evidence for the magmatic differentiation except for the porphyritic biotite-granite, and the enrichments of all trace elements are not explicit, indicating that the granitoid rocks of different times are not the products derived from consanguinical or consanguinical remelting differentiation. It has been shown that the granodiorite rocks stemed from the lower crust, granitic rocks from the upper crust, whereas the Lhagoi Kangri rock-belt and the Himalaya rock-belt have been resulted from the partial melting of the base rocks to various extents in the upper crust. Therefore, it may be concluded that all these rocks show poor evidence of successive development in the concentration distribution and evolution of trace elements.

THE MIGRATION AND EVOLUTION OF MAGMATISM AND METAMORPHIM IN XIZANG SINCE CRETACEOUS PERIOD AND THEIR RELATION TO PLATE MOTION——A POBSIBLE MODEL FOR THE UPLIFT OF QINGHAI-XIZANG PLATEAU

Zhou Yunsheng, Zhang Qi, Jin Chengwei
and Deng Wanming
(Institute of Geology, Academia Sinica)

Magmatism and metamorphism have extensively developed in Xizang since the Cretaceous. They occurred almost over the whole region, and their migration and evolution in space and time appear to have a clear regularity.

The Cretaceous-Eocene magmatic and metamorphic rocks outcrop mostly in the Kangdese-Nyainqentanglha tectonic region and Yarlung Zangbo Suture zone. In the former region, calc-alkaline volcanic rocks of the basalt-andesite-dacite-rhyoite suite, plutonic rocks of the quartz diorite-monzonite-granodiorite-granite suite and the low-pressure regional metamorphic rocks from greenschist facies to amphibolite facies distribute extensively. These rock associations and their variation trends in space and time indicate that this region shows signs of some charateristics of magmatism and metamorphism in a mature island arc and an active continental margin. In the latter region,a suite of ophiolites which cosists of ultrabasic rocks, gabbros, spilitic-tholeiitc volcanics and radiolarian cherts exposes. Although they have been undergone structuarlly complex dislocation, their original stratigraphic sequence representing possibly structures of oceanic crust may still be recognized. In addition there are also the island arc-type tholeiites associated with terrigenous sediments, and regional metamorphic rocks of higher pressure type. The association of the rocks reveal that they were formed in diverse environments from mid-oceanic ridge to the oceanic side of island arc.

The occurrences of magmatism and metamorphism from Eocene to Quaternary disclose their rule of migration from Yarlung Zangbo toward the southern and northern boundaries of the Qinghai-Xizang plateau. In the Kangdese and Himalaya regions, they were characterized by single granitic activity and associated low-pressure regional metamorphism, whereas in the southern margin of Kunlun range of northern Xizang, magmatism is characterized by extensive volcanic activity which has a calc-alkalic to alkalic compositional variation tendency from north toward south. All these activities occurred in the tectonic conditions differ from those as stated above. They were related to a large scale of thrust movements within continental environments.

Such migration and evolution of the magmatism and metamorphism are suggested to be connected with the three different stages of the northward drifting of the Indian plate, namely, the convergence stage of the Indian continent toward the Eurasian continent, the collision stage of the two continents and the intracontinental convergence stage appeared after the continental collision. The magmatic activities in the Himalaya and northern Xizang since Eocence could probably reflect the intracontinental convergence movements that occurred on the southern and northern boundary faults of the plateau, along which underthrusting activities of continental crust took place against each other. Such movements could transform the horizontal motion of the Indian plate toward north into a vertical movement within the plateau, resulting in the uplift of Qinghai-Xizang plateau as a whole on a great scale.

ON THE CRUSTAL MOVEMENT CHARACTERISTIC OF THE XIZANG PLATEAU WITH SPECIAL REFERENCE TO INTERMEDIATE-ACID MAGMATIC ACTIVITIES

Zhang Yuquan Wang Zhonggang Xu Yonghua
Lin Xuenong Zhao Zhenhua Xie Yingwen
Chen Fuming
(Institute of Geochemistry, Academia Sinica)

In view of their distinct NWW trending and their decreasing geological age from north to south, intermediate-acid magmatic rocks in the southern part of Xizang can be divided into three rock belts in general: (1) the Kangdese belt which streches along the Gar River-Yarlung Zangbo River and its north bank, southeastward to the Bome and Zayu areas, with the total length of 2000 km, covering an area of about 70000 km^2. It is characterized by multicyclic and multiepisodic intrusions on a large scale and diverse petrology with an age range of 120—10 m. y. The major part of the belt is mainly composed of diorite, granodiorite, etc., more intermediate in chemical composition and ranges from 120—70 m. y. in age (i. e. Yenshanian). Additionally, there occurs a minor portion of two-mica granite in the belt, which is more acid chemically with an age ranging from 52—10 m. y. (i. e. Himalayan); (2) the Lhagoi Kangri belt which is composed of gneissose two-mica granite and two-mica granite, characterized by their relatively small intruding extent and rather simple petrology as well as their higher acidity in chemical composition, with an age of about 30 m. y. (i. e. early Himalayan); (3) the Himalaya belt which is chiefly made up of tourmaline-muscovite granite and two-mica granite, similar to the Lhagoi Kangri belt in chemical composition and intruding extent. Its age ranges from 20 to 10 m. y. (i. e. late Himalayan). From their intruding features, spacial-temporal consistency, intruding scale, petrological characters and chemical composition, it is suggested that these three belts seem to be closely related to plate underthrust and collision.

It may be concluded that the major part of the Kangdese belt is resulted from the underthrust of the Indian Ocean Plate towards the Eurasian Continental Plate while the Lhagoi Kangri belt and the Himalaya belt are the results of collision of the Indian sub-Continental Plate overlying the Indian Plate with the Eurasian Continental Plate.

ON THERMAL HISTORY OF COMPRESSING PLATE WITH SPECIAL REFERENCE TO THE XIZANG PLATEAU

Zhu Bingquan
(Institute of Geochemistry, Academia Sinica)

The Xizang Plateau is situated on the margin of the Convergent plate between the Indian and Eurasian plates. The inter-collision and compression of the two continents caused the increase of the crust's thickness and concentration of radiogenic energy, thus leading to sharp changes of heatflow and temperature profile. Based on the available data on heat-flow of global plates including the Indian and Xizang plates, and the contents of radioactive elements in the varions shells of the Earth, as well as the relative moving rate between the two continents, the author has deduced a thermal conductive equation and calculated the correlation curves of temperature as a function of depth and age. Owing to the changes of temperature profile, the source regions of magmatism might move from the upper mantle to the upper crust. The calculation indicates that the crust of normal continental plate couldn't remelt after the Mesozoic period, but only granitic rocks could be produced by crustal remelting on the convergent plate margins where the crust had been thickened due to plate subduction or collision. In the Xizang Plateau, a lot of geochemical data on granitic rocks of different ages, such as negative Eu anomalies of REE, TiO_2/P_2O_5 and Al_2O_3/TiO_2 ratios, lead isotopic ratios, all indicate the tendency that the source regions of magmatism have moved from the upper mantle to the upper crust. The geochemical characteristics of granodiorites emplaced before collision show that they are the products of partial melting of the pre-subduction slab and upper mantle. However, the granites formed after collision (<45 m. y.)are marked by some geochemical features of crustal melting.

On the basis of the previous correlation curves of temperature vs. depth and age, we have estimated the uplift rates of various regions of the Xizang Plateau, taking into account the cooling ages of biotites and K-feldspars in pre-Mesozoic rocks. The K-Ar and Rb-Sr ages of these minerals are lower than the crystal ages of rocks. The results have shown that the High Himalayas, such as the Mt. Shisha Pangma and the Mt. Julmolungma areas, have uplifted at a rate of 0.60—0.84mm/yr., but the extensive areas from the Himalayas to the North have a lower uplifting rate of 0.36—0.46 mm/yr. The data from the North-Western Himalaya of India also show a similar uplifting rate of 0.69—0.85mm /yr.

Deduced from the thermal conductive model, an expression showing the plate thickness as a function of crustal thickness has been obtained. In the light of this expression, the correlation between crust and plate thicknesses for the Oceanic plates, normal continental plates and compressing plates can be easily illustrated. For the Oceanic plates and differentiated continental plates, the plate thickness increases with the crustal thickening, whereas the compressing plate thickness decreases with the crustal thickening. The calculated results show that the plate thickness of the Xizang Plateau in equilibrium state is about 74—85 km, and that the crustal thickness doesn't exceed 74 km; otherwise the crustal materials would have been melted and brought into the Asthenosphere. According to the calculated thickness of the Xizang Plateau, the elevation of the plateau has been estimated to be 4.5—5.7 km by means of isostatic equilibrium equations, which is well consistent with the observed elevation only with an exception of the Mt. Julmo-lungma area which is out of isostatic equilibrium state.

THE COLLISION OF INDIAN PLATE WITH EURASIAN PLATE AS VIEWED FROM GEOLOGICAL AND GEOCHEMICAL FEATURES OF THE KANGDESE MAGMATIC COMPLEX ZONE

Chen Fuming
(Institute of Geochemistry, Academia Sinica)

The zone of Kangdese magmatic complex, which is located to the north of Yarlungzangbo sutureline, consists mainly of diorites, granodiorites, granites. The zone shows systematic variations in petrology, geochronology, petrochemistry and primary-secondary structures of rocks. These variations indicate: (1) The Kangdese magmatic complex zone was a product of the anatexis of Indian plate underthrust towards the Eurasian plate, with higher diving angle; (2) When the Indian plate shifted northwards, its northwest part underthrusted toward the Eurasian plate at first, and then underthrust took place successively from the west to the east; (3) During the underthrust, horizontal compressions from both the north and the south were predominant, while both of the plates were in dextral motion; (4) The northwest part of the Indian plate collided with Eurasian plate at first, followed by the northward turning of its northeast part, resulting in a large scale collision. At that time the stress field was horizontally compressed from both the south and the north.

RECRYSTALLIZED BIOTITES IN GRANITOID ROCKS IN SOUTHERN XIZANG AND THEIR BEARING ON PIATE COLLISION

Zhang Yuquan Xie Yingwen
Xu Yonghua Lin Xuelong
(Institute of Geochemistry, Academia Sinica)

Recrystallized biotites occurring in granitoid rocks in Southern Xizang are mainly recognized in some plutons in the Lhagoi Kangri and Kangdese belts. Recrystallized biotite-occurring plutons are characterized by their well-developed micro-fractures, orientational arrangement of dark minerals and thus various gneissose structures. They are lathshaped and frequently occur as aggregates along the fractures. This is consistent with the fact that crystallized biotite K-Ar ages(30-17 m.y.)are much younger as compared with the host rocks. X-ray powder analyses have revealed that the crystal axes(b.)of crystallized biotites have considerably decreased; as to their chemical composition, the contents of FeO and Fe_2O_3 decrease while MgO shows a tendency to increase; trace elements, such as Be, V, Co, Sc, Zr, etc. become minimized and their polychroism greatly decreases. The above-mentioned features strongly suggest that recrystallized biotites are distinct from those having crystallized during diagenesis; the latter having post-diagenetically crystallized under thermodynamic conditions.

Recrystallized biotites mostly occur along the tectonic suture line between the Indian Plate and the Eurasian Continental Plate, i. e. in the neighbours of the Yarlung Zangbo River and its north bank, as well as in the Lhagoi Kangri Ranges. Based upon their field observations and the research results, the authors have postulated that when drifting north-northeastward, the Indian sub-Continental Plate was counteracted by the Kangdese belt resulted from the subduction of the Indian Plate underneath the Eurasian Continental Plate, and this consequently caused a dramatic increase of stress on the southern side, near the tectonic suture line, of the rock belt, followed by the elevation of temperature, thus giving rise to the recrystallization of biotites in some plutons. At the same time, the Lhagoi Kangri belt was being pressed from both sides, resulting in the recrystallization of biotites in early-Himalayan and pre-Himalayan rocks, and this is a strong response to the extensive metamorphism in Mesozoic strata in the Lhagoi Kangri Ranges.

TECTONIC COMPRESSION CHARACTERISTIC OF THE ULTRABASIC ROCKS IN DAZUKA PROFILE

Lin Xuenong

(Institute of Geochemistry, Academia Sinica)

The ultrabasic rocks in Dalangou Valley south of Dazuka is the eastern part of the Renbu-Yedon rock massif in the middle section of southern Xizang rock belt. The rock is high in Mg and outcrops up to 12 km across, and is classified as Alpine type. The rock is very fresh with little sign of serpentization because of its high elevation, rapid rise, extensive denudation and younger age. Texture and structure characteristics of compression during tectonic movement are commonly observed.

Undulatory extinction, polysynthetic twin(in olivine) and those phenomena such as the enlongation and contortion of olivine and orthopyroxene crystals are very common. In addition, tiny grains of olivine are usually found filled along joint. Radiating cracks are recognized around Cr-spinels.

These structures and textures are very complex with respect to their shape, size, combination form as well as time relationship, which show that compression subjected to the rocks are not simple and uniform. By considering other geological features of the rocks, it is suggested that the rocks were under constant action of tectonic compression during their evolution process as a whole and after they were basically consolidated. The compression must have been in operation for a long period (perhaps many stages can be divided) in a complex way.

In view of geological features, it is considered that the rock body was emplaced during early Himalayan period. Because the rock body located just in the sutureline where the collision between the Indian and Eurasian plates took place in the southern side of Yarlung Zangbo Valley, it is reasonable to consider that the tectonic compression was related to plate collision.

THE SEQUENCE, FORMATION AND EMPLACEMENT OF THE YARLUNG ZANGBO OPHIOLITE BELT, XIZANG

Deng Wanming, Wu Haoruo,
Chang Chengfa and Liu Guanjian
(Institute of Geology, Academia Sinica)

The Yarlung Zangbo ophiolite belt extends roughly along the Yarlung Zangbo valley in southern Xizang (Tibet). It runs westward into the Ladakh area and connects with the "Indus ophiolite belt". Eastward it encompasses the great bend of the Yarlung Zangbo Jiang and connects with the ophiolite belt stretching discontinuously along the India-Burma boundary. The middle segment of the ophiolite belt is more than 2000km long in southern Xizang.

Based upon the study of three sections, a possible original pseudostratigraphical sequence of the ophiolite were erected as following (in the upward order): 1), basal ultramafic complexes; 2), gabbro and gabbro-diabases; 3), mafic massive lavas; 4), mafic pillow lavas; and 5), eruptic sheets interbedded in the siliceous rocks.

This sequence is agreeable roughly with the typical ophiolite sections in the world and is similar to the present oceanic crust. The authors suggest that the Yarlung Zangbo ophiolite was formed on the Tethyan ocean floor in Mesozoic. During the continuous northward drifting of the Indian plate and its underthrusting beneath the Eurasian plate, a part of the oceanic crustal materials were emplaced upward and squeezed into the upper crust by compression during collision of the plates in Eocene. Accordingly, the Yarlung Zangbo tecto-lithofacies zone, with its characteristic constituents such as ophiolite, melange, and exotic blocks, represents obviously the suture zone between the Indian and Eurasian plates.

THE OPHIOLITE SYSTEM ON QING-HAI-XIZANG PLATEAU AND ITS GENESIS IN WEST XIZANG

Mei Houjun, Lin Xuenong, Wu Mingtang, Chi Jiaxiang, Zhang Guangyu
(Institute of Geochemistry, Academia Sinica)

Several ophiolite belts have been discovered in Ngari area during the recent investigation of Qinghai-Xizang Plateau. Running for about 1,400 km in E-W direction,the Yarlung zangbo-Xiangquan River ophiolite belt joins the N-W striking Indus River-Gaerzangbu ophiolite belt.

The rocks in Saga ophiolite section, Saga County,from north to south are as follows: flysch sandstone and shale(Upper Cretaceous), harzburgite, reddish silicolite with spilite, spilitic lava with flow-structure gabbro, reddish silicolite with spilitic lava, laminated and massive spilitic lava with limestone, and phyllite and shale. Only one ultramafic cumulate belt was discovered between harzburgite massif and slow-structured gabbro massif at Nanshan Mountain near Ngamring. The Cretaceous volcanic rocks of these ophiolite belts are spilitic lavas consisting of micro-grained epidote, actinolite and albite, altered basalts that preserves ophitic texture, alkali olivine basalt and basalt with diopside phenocrysts.

The basic and intermediate volcanic rocks in different segments of ophiolite beltsin West Xizang belong to different magma series respectively. Most of them belong to alkali basalt series, some to tholeiite series and other high-alumina basalt series. In view of their mode of occurrence, three magma series can be recognized that are rather likein a island arc. In the light of Ti-Zr and Zr-Ti-Sr discriminated diagrams, it can be seen that most of those volcanic rocks do not belong to oceanic floor basalt. Ti-K-P diagram suggests that most of them should be classified as basalt that constitute the continental crust. Thus, with the exception of only a few segment that might be remnant slices of ancient ocean floor, the majority of volcanic rocks in ophiolite belts in west Xizang should be marine in origin, constituting the continental crust, despite the fact that they are associated with silicolites and limestone.

Nearly in every ultrabasic massifs in west Xizang with hypidiomorphic texture, orthopyroxene crysts contain exsolution laminnae of clinopyroxene found. From Ngamring to Bainang there are quite a few rodingite inclusions within the ultrabasic massifs. It seems that the alpine ultrabasic massifs are the remaining part of a melted mantle which intruded into the lower crust as a crystal mush, and were then pushed and overcrowded into the upper part of the crust due to its increasing plasticity during serpentinization. The temperature forming Laang-Co ultrabasic massif is calculated to be 1015℃ by means of two-pyroxene geothermometer. The temperature of pegmatic norite dyke as determined by fluid inclusions in plagioclase cryst is 750°±5℃.

Now we can give a basical outline of Qinghai-Xizang plateau in terms of a 3,000 m contour-line over sea level. The trap represented by flood basalt (i.e. plateau basalt) has not developed in this plateau, in other words, no magmatic formation characteristic of platform has occurred in this plateau. It is just a huge mountain knot formed as a result of joining together of many orogenic belts represented by ophiolite belts during the period from Paleozoic to this moment. On the opposite, plateaus represented by trap in the world are nearly never higher than 3000m above sea level.The four mountain systems on this planet,i.e.,Qinghai-Xizang,Altai, Alps and Circum-Pacific mountain systems, are just the areas where ophiolite belts formed during the latest billion years concentrate. And the stable landmasses with trap and kimberlite distribute precisely between these mountain systems. So we may call the former as the four ophiolite systems. Most of the ophiolite belts were formed in island arcs and continental margins and thrusting lithosphere slab. The result of plate motion in the last billion years is to re-connect the landmasses that were brooken up by sea floor spreading and continent drifting during the joining of orogenic belts.

THE CYPRUS AND OMAN OPHIOLITES

I. G. Gass

(Open University, U. K.)

The Troodos massif, Cyprus and the Semail Nappe of the Oman are of particular significance among Tethyan ophiolites for, being well-exposed, relatively undeformed and readily accessible, they have been subjected to detailed study over the past 30 years In both cases a full (Penrose) ophiolite sequence is present ranging upwards from tectonized harzburgites, through cumulate peridotites and gabbros, to sheeted dyke complexes, pillow lavas and deep water sediments. Palaeogeographic, structural and compositional characteristics identify both these ophiolites as relics of oceanic lithosphere formally beneath small, possibly back-arc basins, although their mode of emplacement (obduction) onto continental margins differs. The structure, composition and emplacement of both ophiolite will be described before the evidence they provide on the structural evolution of Middle Eastern Tethys is discussed.

STUDIES ON THE IGNEOUS PETROLOGY OF THE YARLUNG ZANGBO OPHIOLITE, XIZANG

Deng Wanming
(Institute of Geology, Academia Sinica)

The Yarlung Zangbo ophiolite belt is made of an association of ultramafic and mafic plutonics and mafic lava. Their original lithological sequence is possibly similar to present oceanic crust.

Harzburgite being undergone extensive serpentinization is the main constituent of the basal ultramafic complex. It is all through deeply brecciated and foliated. The rock body is usually in fault contact with the surrounding rocks. Its characteristics of lithology, occurrence, and petrochemistry all indicate that it belongs to the "Alpine type". The ultramafic cumulate are dismembered and lacking in most districts within the ophiolite belt. Certain rock bodies of its eastern segment show rather well magmatic differentiation and cumulate structure. Gabbros occur as veins within the ultramafics mainly, although not very well developed in this area. The gabbro-diabase bodies are locally tremendous in thickness. And it occurs in the margin of ultramafic bodies sometimes. Volcanic series are relatively complex in this ophiolite belt. The mineralogical and chemical compositions of the massive and pillow lavas accord with those of abyssal tholeiite, whereas the sheets at the top part of the sequence are characterized by a much higher contents of Ti and Fe.

According to the study of igneous petrology and petrochemistry, the author suggests primarily that the Yarlung Zangbo ophiolite belt is made of several different kinds of rocks of different origin. The massive and pillow lavas were erupted out from the Tethyan mid-ocean spreading ridge, whereas the sheeted lavas were out-pourings some where away from the spreading axis. It is possible that these events of extrusion were developed under the environment of island-arc or marginal basin.

LITHOLOGICAL FEATURES AND GEOLOGICAL SIGNIFICANCE OF YALUNG ZANGBO JIANG OPHIOLITE BELT AND TRENCH SEDIMENTS IN XIZANG PLATEAU

Cao Ronglong
(Geochemical Institute, Academia Sinica)

A typical section of ophiolite at Tangga in Lhaze district shows the sequential association of ophiolite from north to south as follows: basal tectonized harzburgite, spilite and red radiolarian chert. The ophiolites are lithologically similar to current models of oceanic crust and upper mantle, representing the slice of Tethys ocean basin. It is late Triassic or Cretaceous in age.

About 20 km southeast of Xigaze at Chongdui basal serpentinite overthrusts in fault contact on the late Cretaceous turbidite called Chongdu Group(K_2).

The sediments of Chongdui Group is a suite of graywacke formation with flysch appearence. From its south margin where contact with ophiolite occurs, we have found a thick sequence of rhythmical deposits of thinly bedded acid tuff, radiolarian-bearing volcanic tuff, chert, tuffaceous chert, clastic chert interbedded with augite/hornblende feldspar graywacke composed chiefly of feldspar(more than 80%), augite and hornblende(about 15%)with a small amount of quartz and lithic fragments. In comparison with the recent sediments, it is believed that they are typical trench(foredeep)pelagic sedimentary association. So that, it marks the existence of an oceanic trench at the south margin of Eurasia continent as well as an old island arc bordered by it.

The evidence not only lend support to the concept about India-Eurasia continents collision, but also indicates that the site of subduction zone of the Tethys ocean plate is near this district and the downthrowing orientation is northword. As the convergence of continents continues, the intervening ocean basin closes and the ophiolites are emplaced along a suture zone as remnants of ocean lithosphere.Thus,Yarlung Zangbo Jiang ophiolite belt marks the boundary where the two continent plates are welded together.

SOME OBSERVATIONS ON THE OPHIOLITES OF LADAKH AND NAGALAND

V.J.GUPTA
(Centre of Advanced Study in Geology, Panjab University, India.)

The ophiolites of the "Indus Suture Zone" Ladakh and the Naga Hills of Nagaland have important bearing on the evolution of the Himalaya and the plate tectonics. In Ladakh, these constitute part of the so-called "Dras Volcanics" whereas in the Nagaland, these are classified as part of the Zepuhu Formation.

The ophiolites of Ladakh and Nagaland are composed of serpentinized ultramafics, lherzolites, gabbros, dolerites, basalts, spilites, fine grained limestones, radiolarites, jaspilites and cherts which are associated with Indus Flysch in Ladakh and Matriki Flysch in Nagaland. The ophiolites in both regions are associated with Middle Cretaceous glaucophane schists of blue schist facies. These ophiolites occur generally as large bodies in the form of melange in both regions.

The linear extent of ophiolites in Ladakh and Nagaland, occurrence of melange and terrigeneous and volcanogenic sediments; association of glaucophane schists of blue schist facies indicate their having been tectonically derived due to subduction related processes.

The stratigraphic position of the "Dras Volcanics" of Ladakh and"Zepuhu Formation" of Nagaland and associated sedimentary rocks in both the regions is discussed in detail.

OPHIOLITE EMPLACEMENT AND SUTURES

R.M.Skackleton (Open University, U.K.)

Complete or partial ophiolite sequences, which represent ancient suboceanic crust and upper mantle, are found throughout the Tethyan zone as well as in older fold belts. Although they may all appear to be similar, they do not all imply the same tectonic environment. One group, consisting of slices bounded on both sides by thrusts, occurs on sutures separating plates which have collided after subduction of intervening oceanic crust. These ophiolite slices may be vertical, flat or folded and the same suture may reappear several times in a single transverse section. A second group consists of ophiolites occurring in melanges. These may be olistostromes(submarine slide breccias)or tectonic melanges(formed in subduction complexes)or both. Ophiolitic olistorstromes are commonest in trenches, where they are derived from the inner trench sl pe, but they also occur along transform faults and probably on the flanks of midoceanic ridges. Ophiolitic olistostromes from any of these environments may be incorporated into a subduction complex.

THE HISTORY OF TECTONIC EVOLUTION OF THE QINGHAI-XIZANG (TIBET) PLATEAU

Chang Chengfa and Pan Yusheng
(Institute of Geology, Academia Sinica)

Based on the results of regional geological investigations, the Qinghai-Xizang (Tibet) Plateau can be subdivided into five tectonic units separated by sutures, that are the Kunlun folded system, the Kekexili-Bayankala folded system, the southern Qinghai-Qang Tang structural region, the northern Xizang structural region and the Himalayan structural region. The ages of the relevant main orogenic episodes are successively younger from north to south. The Qinghai-Xizang Plateau seems to have been formed by the successive accreation of continent and/or island arc fragments between late Paleozoic and late Cretaceous. Thus, apparently it wasn't a stable block for a long period of timo.

In the region of Jolmo-lungma of China, deposits with *Glossopteris* flora and *Lytvolasma*, *Taeniothaerus* and *Uraloceras* fauna reflecting cold-warm environment as well as marine glacial deposits with striated pebbles of Carboniferous-lower Permian were discovered. The glacial deposits extend as far as to the vicinity of Kangma county, about 50 km from the Yarlung Zangbo, where the pebbly slate is widely distributed. The lithofacies and fauna of these sediments are quite similar to coeval Gondwana sediments that occurred farther south. Thus, although it is commonly recognized that the Himalayas is just an integral part of the Gondwana land, yet opinions regarding the exact northern boundary of the Gondwana are still quite disputable.

The basement characters, the stratigraphic sequence of the Paleozoic, and the lithofacies and faunal contents of the Carboniferous and lower Permian between the Himalaya and the Northern Xizang are quite similar. We,thus, suggest that the northern Indian limit of the Gondwana continent was possibly situated along the Pangoon (Tso)-Don Qiau-Nuking line until Early Permian.

In northern Himalaya, there occurs a zone of late Permian to late Cretaceous rocks with a succession from neritic limestone to pelagic and turbidite sediments, and intercalation of intermediate-basic volcanics, ophiolite and flysch. These could probably be regarded as indications of the process of platform desintegration and evolution of a divergent plate boundary. Thus, it looks fairly possible that the paleo-Tethys was already came into being and new oceanic crust was then formed within the inner part of the Gondwana during the Triassic time.

The northern Xizang might have been united with the Gondwana-land and separated from the northern continent during the Paleozoic, but in early Mesozoic it was detached from Gondwana and attached to Eurasia in the late Mesozoic, and finally rejoined with the Gondwanian India in the late Cretaceous.

The other northern tectonic units, as the Litian Co-Margai Chaka-Jinsha Jiang suture zone and the southern kunlun suture zone may be subject to similar process of opening and closing. Following the closing event of each time, the tectonic unit situated at the south attached to Eurasia successively between late Paleozoic and late Triassic time.

Distinctive tectonic features of the Qinghai-Xizang plateau are characterized by widespread young thrusting and volcanism, as well as a thickened crust with a low velocity channel at about 30 km (south) to 50 km (north) below the surface. The thickening of the crust within the Qinghai-Xizang region is considered mainly due to the thrusting during Himalayan movement. The tremendous uplift of the Qinghal-Xizang plateau since late Cenozoic is the consequence of the thickening of crust and isostatic adjustment.

After the continental collision along the Yarlung-Zangbo line, orogenic deformation shifted southwards. Many nappes and thrusts were formed in the Himalayas and in the Northern Xizang. The evolution of the Qinghai-Xizang plateau has been interpreted in the framework of plate-tectonics theory. However, it is not now shown by the Benioff zone of seismicity under the plateau. In this case the formation of the low velocity channel under the Qinghai-Xizang plateau seems to be resulted from the splitting within the continental crust and its thrust shearing.

THE GEOLOGY OF THE SHAKSGAM VALLEY

A. Desio
(Institute of Geology, University of Milan, Italy)

The Shaksgam river is one of the left tributaries of the Yarkand river which together with the Kashgar flows into the Tarim.

As to the geographic position, the Shaksgam valley is situated between the Karakorum (south) and the Aghil range (north), that is at the extreme north-west corner of the Tibet plateau. The southern watershed, dividing the Shaksgam valley from the Baltoro and Siachen glacier valleys, run along the high crest of the Karakorum range reaching on the top of K^2, the second highest peak in the world, 8611m above sea level.

As to the geology, the stratigraphic marine series begins with the Singhié shales of the Carboniferous and ends with the Bdongo formation of the Late Jurassic. Up to now strata older than the Singhié shales are unknown in the Shaksgam valley.

The more widespread lithostratigraphic units are the so-called Singhié and Shaksgam formations of Carboniferous and Permian age and the Aghil Limestone of Triassic-Liassic age. The former two formations show a flysch facies, the last one a reefal facies. Between them a conglomeratic and/or lagoonal bed is inserted; it marks an uplift of the sea floor. Up to now Cretaceous and Paleogene marine deposits have not been found in the Shaksgam valley, but their existence cannot be excluded being present along the borders, at the North Rimu glacier snout and on the Falchan Kangri (Baltoro basin). The above mentioned formations stretch toward south-east, in the Linghzi-Thang, Western Chang-Thang, that is in the Western Tibet.

As to the tectonics, the Shaksgam valley is located near the contact of the Muztagh and Aghil tectonic zones, but they enter mostly the second one. It is characterised by a bundle of folds partly faulted, locally overthrust, and generally trending NW-SE, with some small deviations. This fold-bundle become progressively wider toward south-east and north-east, that is both along the strike of the tectonic axes (Upper Shayok and Depsang Plateau) and towards the north (Aghil Plateau). In the opposite direction the folds become progressively squeezed and faulted evidencing that in that direction the compressional tectonic stresses were greater; along the same trend there is a rapid passage to metamorphic facies. In this connection it should be added that along the same trend the Karakorum axial batholith outcrops more extensively affecting the tectonic structures of the southern area.

THIN-SKINNED PLATE TECTONICS AND OROGENIC UPLIFT

K. J. HSÜ,

(Geological Institute, Swiss Federal Institute of Technology, Zurich, Switzerland)

Plate-tectonic theory postulates compressional deformation along consuming margins of moving plates. Subduction predominates where an oceanic lithosphere can descend under a continental lithosphere such as the situation in the Circum-Pacific regions. However, continent-continent interaction is unavoidable after the total comsumption of oceanic plate; the Tethyan type of collision-orogens results from such interaction. Geological and geophysical investigations indicate that continued plate-movement and compression after continental collision led to underthrusting of successive crustal wedges (not lithospheric plate). Deep seismic sounding proved the existence of such thrusts in several areas. The thrusting of a crustal segment that had been decoupled from its underlying mantle, under other crustal segments led to doubling or trebling of crustal thickness. Where such underplating has been confined to a narrow zone such as the case of Swiss Alps, the isostatic adjustment led to orogenic uplift, and formation of lofty mountain-chains. The thickening of the crust under the Xizhang-Qinghai Plateau, however, resulted from repeated orogenesis and reached an extraordinary width; the isostatic uplift of the broad belt formed the plateau.

ON THE ACTION OF THE NORTHWARD PUSH AND COLLISION OF THE INDIAN PLATE AND THE FEATURES OF RECENT TECTONIC STRESS FIELD AND SEISMICITY IN WESTERN CHINA AND ITS CONTIGUOUS REGION

Luo Zhuo-li

(Sichuan Provincial Seismological Bureau)

From the point of view of the action of the push and collision of the Indian Plate and the Eurasian Plate, this paper deals with the features of the recent tectonic stress field and seismicity in Western China and its contiguous region. It has been pointed out that there exists two seismic zones, i. e. the eastern one and western one in this region. After studying the features of the large earthquake ($M \geqslant 8$) migration in the eastern zone, it has been inferred that the large earthquake ($M \geqslant 8$) would probably occur in the near future and the dangerous region has been also pointed out, where it would probably occur. Finally, the southeastward movement inclination of the Kang Dian rhombic block, the characteristic features of seismicity and geomorphology in this region and the moving velocity of the block are further discussed by using data of the geological structure and crustal deformation.

TECTONIC HISTORY OF WESTERN PAKISTAN

Kees A. De Jong[1], Robert D. Lawrence[2], and Abul Farah[3]

([1]Department of Geology, University of Cincinnati, Cincinnati, Ohio, USA [2]Department of Geology, Oregon State University, Corvallis, Oregon, USA [3]Geological Survey of Pakistan, Quetta, Pakistan)

The north-south striking Chaman plate boundary in western Pakistan consists of a 50—200 km wide zone with strike-slip faults, thrust faults, and folds. The boundary has been active since the Late paleozoic: first as a trailing-edge continental margin until the

Late Cretaceous, as a subduction margin in the Late Cretaceous and the Paleocene, and finally as a transform plate boundary. Paleocene collision between Asia and the Indopakistan subcontinent was accompanied by extensive obduction of oceanic crust in the Bela, Muslimbagh and Waziristan areas in western Pakistan.

Compression at the east-west Makran convergence zone in southwestern Pakistan is an active process. It is transformed into left-lateral strike-slip movement in the Chaman plate boundary; a major part of the movement is distributed over the Chaman and the Ghazaband-Zhob-Waziristan faults. Movement along the latter fault is transformed into compression in the Himalaya, and movement along the Chaman fault into compression in the region north of the Himalaya, including Tibet. Study of the strike-slip movement in western Pakistan can therefore lead to information about deformation in Tibet.

The tectonic history of western Pakistan will be illustrated with color slides of LANDSAT images.

SOME ANALOGIES BETWEEN THE TECTONIC HISTORIES OF AFGHANISTAN AND TIBET

M. Mattauer*, P. Tapponnier**, F. Proust*
(*Département des Sciences de la Terre, U.S.T.L. Montpellier, FRANCE
**Institut de Physique du Globe, Paris FRANCE)

The tectonic histories of Tibet and Afghanistan may have been similar in many ways since the end of the Paleozoic. Both appear to be result of successive accretion of fragments of Gondwana to the active margin of Laurasia. This margin, which, in Afghanistan, appears to lie along the present Herat and Panjchir faults, South of Hindu Kuch, swings around the central Pamirs and can presumably be traced along the present western Altyn Tagh and Kun-Lun faults, South of Kun-Lun. North of this boundary, Paleozoic rocks have been deformed in the upper Paleozoic, whereas south of it, there is no trace of the Hercynian orogeny. The first collision of Gondwanian fragments with Laurasia probably occurred in the early Mesozoic along the Hindu Kuch and Kun-Lun. To the South, ophiolites along the Panjaw and Pang Gong - Nu Chiang sutures (respectively in central Afghanistan and central Tibet testify to another suturing event in the upper Jurassic or lower Cretaceous. The Indus-Tsang-Po suture between India and Tibet corresponds, in eastern Afghanistan, to two ophiolite subbelts, near Kabul and Khost. Both ophiolite complexes have been emplaced between Maestrichtian and lower Eocene presumably by choking of two northward dipping subduction zones. In Pakistan, the Kohistan mafic sequence probably represents the crust of an intervening Island Arc obducted on top of the Indian margin. Blueschist metamorphism was associated with the obduction. After complete contact between the Indian and Asian continents was achieved, presumably in the end of Eocene, the penetration of India into Asia caused large scale intracontinental shortening. A large part of the shortening was accomodated by strike slip faulting along the Mesozoic and more ancient sutures. In particular, both Tibet and Afghanistan were extruded to the East and West respectively along the Herat and Altyn Tagh-Kun Lun sutures.

APPLICATION OF REMOTE SENSING IMAGES TO THE COMPILATION OF THE GEOLOGICAL MAP OF QINGHAI-XIZANG (TIBET) PLATEAU

Liu Xinji, Yu Xuezheng and Chen Yinxiang
(Geological Remote Sensing Center,
Ministry of Geology)

In this paper the authors summarized the application of remote sensing data to the compilation of the geological map of Qinghai-Xizang (Tibet) Plateau (1:1,500,000), the methods of the interpretation of remote sensing images, various factors affecting the effect of interpretation, the results of map compilation and some new knowledge about certain problems of regional geology of this area.

The new map is characterized by a number of features. All the large scale abyssal faults over the area were distinctly presented in it. Hence the tectonic framework of the whole plateau looks more clear-cut and more striking. A lot of conceal faults were revealed in large areas covered by Quaternary sediments and, above all, the folds scattered in Chaidamu Basin were exposed to a fuller extent. In northern Xizang, many Palaeozoic blocks were differentiated from vast Mezozoic strata surrounding them and some volcano-tectonic structures accompanied by a great deal of Quaternary basaltic lava were discovered. Moreover, the new map are greatly enhanced by a series of branchy-axis anticlines (domes) in the low divide range area in southern Xizang, the detailed presentation of ultrabasic rocks and the stretching tendency and southward sliding of Siwalic zone on the southern slope of Himalaya, etc.

Some criterions for the interpretation of strata, igneous rocks and geological structures were established on the basis of the aerophotographic images and Landsat images as well as the new techniques of pseudocolor composition and density slicing. The important ones were described and illustrated in this paper. Also we made a discussion of the new linear structures, circular structures and new tectonic movement discovered in the remote sensing images.

Apart from the pressing nature of the work, the lack of both qualified geologists and geological informations constituted the main difficulties confronting us. Nevertheless, having taken into full consideration of all the available geological data and made extensive use of the remote compilation work with better quality and higher precision in a short period.

Our practice shows that remote sensing images prove to be a powerful aid to regional geology investigation and the small-scale geological mapping and the broad prospects opened to their usage are really encouraging.

FINITE ELEMENT ANALYSIS FOR RECENT XIZANG PLATEAU UPLIFTING AND ITS RELATION TO SEISMICITIES

Loo Huanyen, Xu Yujian, Song Huizhen, Sun Junxiu, Guo Caihua, Zhang Ruze and Gu Zhijuan

(Institute of Geology, State Seismological Bureau)

Based on the geological and geophysical evidences and the geodynamics of basin and range structure, it is attempted to correlate the plate motions as well as the local tectonic motions with the neotectonic stress of the Xizang Plateau region. Seismic and gravity studies in and around the Xizang region have revealed a maximum elevation difference of more than 40 km along the Moho discontinuity between the Indian Ganges Plain and the continent-continent collision zone along the Yarlung Zangbo River, seismic soundings also indicate a wide existence of a low velocity zone varying in thickness and in depth within the crust of the plateau and being relevant to the location of earthquakes of magnitude equal to and larger than 6.

The current deformation and stress state in a simplified tectonic profile of the plateau, about 2000 km long and 80 km thick, have been analyzed using finite element method. The gravitational variation in body force alone can produce surface displacements similar to the plateau topography and there are complementary subsidences adjacent to the uplifts on either side. The effect of superimposing uniform horizontal movement on the southern end of the numerical model is only subjected to stress amplification, but decreasing as a function of horizontal distance from the end. Especially, the additional external force resulting from the India plate movement, does not make too much difference in displacement beyond the collision region. It seems that the plate motions take only the responsibility of causing the crust of the Plain buckling and the mantle upwelling so as to initiate a lateral variation in density, but these motions are not associated directly with the local stress system relevant to plateau uplifting and seismicities.

The lower crust just above the mantle uplift is under tension and the material moves laterally towards its edges, but the uppermost crust of the same location is under comression. The transitional zone between the plateau and the Ganges plain is highly compressed and its uppermost material moves upward and outward, these may be the mechanisms for the overthrusts in the transition zone.

The stresses often concentrate at the main fault ends near the low velocity layer, but the stress concentration would not occur, if the fault intersects the weak layer. Then the crust structural pattern are closely relevant to the stress distribution and associated with the development and the migration of continental crust earthquakes because of its plastic deformation and energy absorption.

To know more about the formation mechanism of the low velocity layer, experiments of two-mica gneiss specimens, collected from Xizang area, of 2mm thick and 6mm in diameter, have been set up at temperature and pressure conditions equivalent to about 30km deep in a solid-medium apparatus. The slope of the electrical conductivity versus temperature curve obtained experimentally changes around 650℃ and then the conductivity drops to minimum value of several Ω-m. The optical study of thin sections of rock and X-ray analysis of powdered crystal illustrate the evidences of dehydration and phase transition of the muscovite as well as the cracking of the quartz. The comparison of these phenomena with the velocity variation of serpentine under high temperature and high pressure conditions suggests that hydrolytic weakening at grain boundary and lattice breaking or thermal cracking of individual mineral may be the most possible causes for the development of a low velocity-low resistivity layer, but the heat in the particular layer may be generated from the local tectonic activities such as shearing along the layer as computed by the numerical model, and in turn the seismicity would be constrained by the weak layer.

ACTIVE NORMAL FAULTING IN TIBET

Paul Tapponnier*, Peter Molnar**
and Wang-ping Chen**.
(* Institut de Physique du Globe, Paris France
** Massachusetts Institute of Technology, Department of Earth and Planetary Sciences,
Cambridge, Massachusetts, U. S. A.)

From an interpretation of Landsat imagery of Tibet the most recent structures appear to be normal faults that trend approximately north-south. Brief visits to a few localities support this inference. Moreover, fault plane solutions of 15 earthquakes in the central part of the Xizang plateau indicate large components of normal faulting. Most solutions are not well constrained, but for the most reliable ones the T axes are oriented approximately east-west. One of these events occurred at 90 km depth. Only on the margins of the high plateau, where elevations are lower, do fault plane solutions show active

thrust faulting. These observations imply an east-west extension of most of Tibet at the present time. We relate this pattern to the collision of India and Eurasia and to deformation of a relatively weak Tibetan crust and upper mantle. India applies a pressure to Eurasia that maintains Tibet at a high uniform altitude, and the hydrostatic head caused by this elevation transmits the pressure northward. Accordingly, Tibet is the pressure gauge of Asia. At the same time a small east-west strain (or flow) of the lower crust and upper mantle of Tibet would stretch the surface layer. Tibet's position relative to India at the present time is analogous to that of a "dead" triangle in a plastic material indented by a rigid indenter (India).

PRELIMINARY ANALYSIS OF NEW AND PRESENT-DAY TECTONIC STRESS FIELD IN NORTHEAST PART OF QINGHAI-XIZANG PLATEAU & ITS ADJACENT REGIONS

Li Yulong
(Lanzhou Institute of Seismology,
State Seismological Bureau)
Xu Shu-ying
(Lanzhou University)

In this region, the trends of the active tectonic belts is principally NNW and NEE. These active tectonic belts interweave each other and construct a series of northeastward pointing arcs. Among them, those trending NWW are mostly of compressive and left-lateral type; whereas those trending NNW, are largely of right-lateral and compressive type; and the third, which trending NEE, are also predominately left-lateral compressive type.

At the same time, by analysis of directions of the principle compressive stress axis of focal mechanism of 26 strong earthquakes, 34 baselines of triangulation survey, and a lot of the largest shortened direction of baselines and together with consideration of the conspicuous belts of deformation and principle direction of compression of 5 strong earthquakes with a magnitude over 7, it could be demonstrated that for the present region, the stress fields of both the new and present-day tectonism are consisted with each other, i.e., the whole territory is subjected to a strong NE-SW compression.

The Qinghai-Xizang Plateau is also carved with a series of NE pointing arc-structures zones, thus it is presumed that this region is also subjected to forces of NE-SW compression.

Besides, both the pineplane surface developed in the mountainous terrain around

Qinghai-Xizang Plateau and the bottom of Tertiary basins are inclined toward the center of the Plateau. All this fact demonstrate that around the plateau region, there existed a sort of compressive roughly perpendiculay to the boundary of the plateau, i. e., the direction of the principle compressive stresses is mearly N-S in the Arljin range NEE-SWW in orders and roughly E-W in the Tsingling Range.

The characteristics of the stress field described above could be better explained by assuming that the northward pushing of Indian plate, and its induced lateral compressive stress both NW and SE.

PRELIMINARY INVESTIGATION ON TECTONIC FEATURES IN TANGGULA-YUSHU REGION, QINGHAI PROVINCE

Zheng Yanzhong
(Fifteenth Geological Team, Qinghai Geological Bureau)

The investigated region is located to the south of the Kekexili-Tongtianhe river and to the north of the Zuerkenwulashan-Tanggulashan Mountains, Qinghai province.

The stratigraphic sequence exposed in this region consists of sediments from lower Palaeozoic to Quaternary. This paper describes the northward land expansion-creation process of this region from Carboniferous-Permian geosynclinal stage to Triassic period, with emphasis on the development of the Late Triassic downfaulted trough and its paleogeography.

The main tectonic features in this region are the northwest trending structures, among which the most important one is the Xijinwulan Lake-Jiegu lithospheric fault zone. The control effect of this structural system and its role in tectonic division of this area are explained. This system is intersected by the northeast trending structures, and superimposed by latitudinal structures. Traces of the NNW, N-S trending structures and tectonic difference between the eastern and western parts of this region are demonstrated.

Magmatic activities were generally strong. The distribution and evolution of the intrusive and volcanic rocks are described. It is concluded that since Mesozoic era the magmatism has developed from north to south in a tendency from the older to the younger in age, and from the stronger to the weaker in intensity, and controlled by NW trending structures and by the different systems of structures during later periods. The igneous rocks tend to be in a tendency from basic-ultrabasic to intermediate-acid, acid and alkaline components.

Basing on the above description, it is concluded that the investigated region togather with Zuerkenwula-North Xizang (i. e. the area from Xijinwulan Lake-Jiegu fault to Bangong Lake-Nujiang fault) is one of the tectonic blocks within Qinghai-Xizang plateau. This block has rotated counter clockwise along the Xijinwulan Lake-Jiegu fault with respect to Bayankala on the northern side, and Bayankala might be subduced along this fault.

TECTONICS OF THE CHINHAI-TIBET HIGH PIATEAU

T. Boldizsâr
(Technical University Miskolc, Hungary)

The most magnificent and striking feature of the Earth's surface is the Chinhai-Tibet high plateau surrounded by the greatest Tertiary mountain systems of the Himalaya, Transhimalaya and Karakorum from the south and Altyn Tagh, Kunlun and Nansan from the north. Geologic data seem to suggest, that folding *took place* in late Paleozoic and Mesozoic in the northern part and in the Cenozoic in the south. Scarce geophysical data indicate crust thicknesses of 65—70 km and recent seismic data show normal faults in the NS direction. The large territory is not well mapped and the Landsat imagery is an important contribution to geography, but few geological information can be derived from it.

The explanation of the recent alleged east-west extension would be the supposed colliasion of India and Eurasia. The result of this colliasion would be the building up of the Himalayas and the elevation of the Tibet high plateau. The stress and displacement is considered transmitted across Asia, through Tarim basin, Tien Shan and Siberia /e.g. Molnár and Tapponnier/.

Present author do not believe that the continental crust or lithospheric blocks are able to push each other and to elevate mountains and thicken the crust or litosphere. The elevation of Chinhai-Tibet plateau and other Alpine mountain features all over the world is the consequence of isostatic adjustment of the thickening crust. The increase of crust or lithospheric thickness is taking place in seismically active zones. Where mountains are increasing in height, there are always neighbouring basins which are subsiding in the same time. The slow plastic mantle flow in the asthenosphere from the oceans and intermontane basin toward the emerging continents and mountain ranges gives support to the elevation, and is working against the erosion. The continents are elevating while the ocean and intercontinental basins are sinking and being filled up by sediments from the eroded mountain rocks. The main feature of mountain building is vertical uplift with normal and reverse faults. The slow asthenospheric plastic flow results sometimes in strike-slip faults, but high mountains and plateaus cannot be produced by them.

The energy causing the change of the face of the earth is the internal heat, that is why geothermal investigations are of extraordinary importance to establish the heat energy changes in the mantle.

ON THE NORTHWARD DRIFT OF THE AFRO-ARABIAN AND INDIAN PLATES

Zhang Wen-tang (W. T. Chang)
(Institute of Geology & Palaeontolgy, Academia Sinica)

Specialists in plate tectonics are inclined to believe that Wegener's Palaeozoic or Precambrian Pangaea, in a modified form, is composed of Mesozoic Laurasia in the north and Gondwanaland in the south, and it is now generally agreed that the Tethyan Ocean existed in an area between these two continents in the Mesozoic and probably in the Palaeozoic or even earlier. The Afro-Arabian and Indian Plates have been inferred as gradually moving northwards since the Permian and reaching the Eurasian continent towards the end of the Cretaceous. In studying the Cambro-Ordovician stratigraphy and palaeontology of the northern marginal parts of Gondwanaland and southern Laurasia I have come to the conclusion that on the contrary, Arabia, India and the remainder of Asia were immediate neighbours during that time. No wide ocean existed between the Indian Plate and Eurasian continent during the Cambrian and Ordovician Periods. The distributions of these early Palaeozoic, Asian, endemic faunas are discussed in relation to Wegener's Pangaea.

THE TIMING AND SIGNIFICANCE OF OROGENIC EVENTS IN THE HIMALAYA

Augusto Gansser
(Geological Institue, Swiss Federal Institute of Technology, Zurich, Switzerland)

The main orogenies of the Himalaya are restricted to the late Precambrian events forming an Indian shield type basement and to the Himalayan events beginning with the Triassic and culminating in the Mio-Pliocene. Only epeirogenic phases are noted within the long interval, a fact typical for the Himalaya.

Himalayan orogenic events begin in the north with the deep seated Suture Zone characterised by elements of oceanic crust and related plutonic activities present in the Transhimalaya plutons. They range from Triassic to Paleocene. The orogenies continue southwards with intracrustal thrusting such as the Miocene Main Central Thrust and the Pleistocene Main Boundary Thrust overriding an already eroded molasse. The last events are reflected in the Main Frontal Thrust involving Quaternary deposits. The present activities are shown by seismic unrest following new structural patterns unrelated to the

visible structural frame. Some of the youngest events seem to reflect the oldest tectonic features.

THE SEISMICITY AND THE RECENT CRUSTAL MOVEMENT IN THE HIMALAYA REGION

Ye Hong (Yeh Hung) Li Yin-huai Zhang Wen-yu
Yu Zhi-shui Xia Gin
(Institute of Geology, State Seismological Bureau)

In this paper three analyses are made for the recent crustal movement in the Himalayas on account of the observed earthquakes data recorded from 1897—1976.

1. The characteristics of the present active faults in this region were studies by the fault plane solutions.

2. The vectors of the tectonic movement of the lithosphere blocks are calculated by the null vector method.

3. The rate of the crustal slip is estimated from the seismic moment data.

In light of the analyses mentioned above, a model of recent crustal movement in the the Himalayas is tentatively presented:

1. According to the calculated results by the null vector method, the direction of the tectonic movement vector of the lower lithosphere in the Himalayas is NNE, and its plunge is nearaly horizontal, it indicates that the nature of the convergence between the NNE-ward drifting India Plate and the Eurasia was mainly a sort of collision. and intensive horizontal compression and shortening rather than underthrusting.

2. The regional trend of the western part of the Himalayan arc is nearly perpendicular to the direction of the tectonic movement of the India Plate. During the process of intensive horizontal shortening of the lithosphere, the upper part of it oere upthrusts with a rather low angle over the Ganges Plain, and now this type of movement is still going on chiefly along the main boundary fault and the Ganges Plain boundary fault. The Strike of the eastern part of the Himalayas is nearly parallel to the direction of the tectonic movement of the India Plate. Along this fault belt the India Plate is moving NNE-ward and has a left-lateral strike slip nt relative to the Eurasia Plate with some upthrust component.

3. As a result of the intensive pressure of the India Plate applied to the Himalayas, shortening of the latter at a rate of about 3.4cm/y was estimated. In the eastern part of the Himalayas the strain energy seems to be released chiefly by earthquake dislocations, but in the western part the strain energy seems to be released mainly through aseismic creeps. In the Xizang Plateau north of River Tsang Po, rate of shortening is probably

less than that of the Himalayas. The north-south shortening of the Xizang Plateau causes the thickening of the crust and the eastward flow of the crustal material; and consequently the intensive right-lateral strike slip along the fault Miju & Red River at the south-east of the plateau.

STRUCTURAL ANALYSIS AND TECTONIC EVOLUTION OF THE CENTRAL HIMALAYA OF NEPAL

Maurice Brunel, Michel Colchen, Patrick Le Fort, Georges Mascle and Arnaud Pecher
(CRECO Himalaya-Karakorum Centre National de la Recherche Scientifique, France)

The three structural zones that outcrop in Nepal Himalaya show a complex structural evolution. In the Tibetan sedimentaries there are four tectonic phases. Phase 1 and 2 are characterized by isoclinal to subisoclinal recumbent folds with associated cleavage and epimetamorphism; their axes vary from 80 to 130. In the Tibetan metamorphics (Tibetan Slab) the same phases are recognizable; the metamorphic foliation is reliable to the first two phases which frequently are not distinguishable (phase 1—2). In the Midlands formations four phases have been recognized; the main cleavage, which results of the Main Central Thrust Zone (MCT) motion as well as the metamorphism, plays as a sliding plane; a mineralogical or stretching lineation very well laid out is oriented N 20—30, approximately orthogonal to the N 100 axis of the structural belt. No major break in the structural or metamorphic patterns is observable in the MCT zone that corresponds to the zone of maximum shear strain. Some recumbent structures of megascopic scale with associated axial plane cleavage belonging to phase 1—2 are present in the southern Midlands; their axes are oriented N 90—100. In the South the Main Boundary Thrust zone (MBT) corresponds to the thrusting of the Midlands previously tectonized and metamorphozed over the Mio-Plio-Quaternary Siwaliks. The structures produced in the Siwaliks have a N 90 to N 120 axis; they are in agreement with an horizontal shortening and testify of the persistency of the contraction in this central part of the Himalaya.

THE ALPINE-HIMALAYAN ZONE OF CONTINENTAL COLLISION AND COLLISION AS A STAGE IN CONTINENTAL EVOLUTION

Kevin Burke, John Dewey, W. S. F. Kidd and A. M. C. Şengör
(Department of Geological Sciences, State University of New York at Albany, Albany, New York U. S. A.)

Three major orogenic effects result from continental collision. The relatively well-known gently-inclined thrust belts, exemplified by the Himalaya, generally affect only one of the two colliding continental margins, have a thrust polarity the same as that of the final subduction zone, and form long, narrow orogenic belts. Limited syn- to just post-orogenic silicic magmatism is associated with the inner parts of these zones. The second effect of collision, in suitable circumstances, is the generation of large strike-slip fault systems and subordinate rifts on which large crustal blocks move away from nodes of collision of irregular continental margins into neighbouring oceans or remnant oceanic tracts. Magmatism associated with this process is generally limited to rifts and pull-apart segments along transforms. This situation is exemplified by the motion of the Turkish-Aegean block moving along the North and East Anatolian transforms into the Mediterranean, and by the Altyn Tagh Fault at the northern edge of Tibet. The third major effect of collision is only seen along relatively restricted parts of collision zones. This consists of the formation of high plateaus accompanied by uprightfolding and associated subordinate thrusting of the previously undisturbed sedimentary cover, and the generation in or underneath them of large quantities of high-K calcalkaline silicic magmas, together with lesser alkaline magmas. The Turkish-Iranian and Tibetan Plateaus are the exemplars of this effect. The process of formation of such a plateau perhaps may be seen in progress now in the Tsaidam Basin where active WNW-trending folds affect the youngest playa sediments. Their orientation is distinct from E-W folds on the Tibetan Plateau suggesting that a major reorganization of the tectonics may have taken place recently, and that the Altyn Tagh Fault is a very young structure.

The extent of old Gondwanide crustal blocks in Tibet relative to material accumulated in subduction-accretion prisms and their related magnetic arcs is a problem of great interest. Zones of ophiolitic rocks on the plateau may represent sutures between such Gondwanide blocks or material in accretionary prisms. If they are the former, their pre-Cretaceous age indicates that they are the relic sites of the Palaeotethyan Ocean.

intermittent continuations of such Palaeotethyan sutures recognized westward through Turkey and eastward through Indo China and Malaya.

Ancient sites of continental collision indicate Tibetan-style shortening and crustal thickening with associated calcalkaline magmatism, at least partly derived from partial melting of the thickened, continental crust, are an important stage in crustal evolution which progresses through the stages: ocean floor to island arc to continent to two layer continent. Zones of "reactivation" so commonly recognized in the PreCambrian and mostly by thermal effects on isotopic systems, are readily accounted for by Tibetan-style collision-related orogenesis and magmatism. *Ad Hoc* non-actualistic models for such reactivation are unnecessary.

THE INDUS ZONE: POSSIBLE EVIDENCE FOR EARLY TRIASSIC OCEANIZATION

J.P.Bassoullet, M.Colchen, G.Mascle,
(GRECO Himalaya-Karakorum
C.N.R.S.France)

The Indus-Tsang-po suture zone(1)lies North of the Himalayan ranges between the Eurasiatic and the Indian continental blocks. On a large scale geological map(fig.1)it emphasized by a belt of discontinuous outcrops of ophiolites, approximatively lined up in North-South East direction with the exception of a few massifs lying South. The ophiolites are tectonically associated with Cretaceous to Eocene sedimentary units. On a cross section the suture appears as an asymetric fan shaped structure thrusting both India and Eurasia respectively to the South and to the North(1).

Recent studies(2,3,4,5,)conducted in Ladakh, bring new pertinent informations to our knowledge of the suture:

-the ophiolites are characterized by the presence of several facies typical of an ophiolite assemblage: ultramafic complex (particularly harzburgites with a metamorphic tectonic fabric: blastomylonites), gabbroic complex containing cumulates and pegmatites, volcanic flows (pillow lavas and agglomerates); tectonically associated manganiferous red radiolarites and pink limestones (Hallstadt facies).

-the ophiolites constitute in fact an ophiolitic nappe thrusted towards the South onto the Himalayan series. In the area of Photaksar, they outcrop particularly well in a large klippe about 25 km South of the main suture line, in a manner very similar to one of the area of Amlang La where they have been already described(6) and then interpreted(1) as a klippe.

-within the area two other structural units also exist. They are characterized either by a Middle Triassic-Jurassic calcareo-pelitic flysch(the Lamayuru unit)either by a Jurassic(?)to Cretaceous greywacko-pelitic flysch with some vulcanites(the Dras-Nindam unit)(3).

-structural and microstructural(3)studies indicate that the pseudo fan pattern aspect of the structure results in fact of the multiphazed tectonic evolution in which two major events can be distinguished. A first episode, occurring before the sedimentation of the Indus detritic series(Aptian-Albian to Eocene)characterizes essentially the ophiolitic and flyschs nappes which are displaced in a Southward direction. The second main event results in the refolding and the thrusting Northward of the Nappes onto the Indus detritic series and even locally onto the Ladakh granodiorites. This event appears to have been post Middle Eocene.

-associated with the ophiolites either within the suture or within the klippes exist also a few exotic calcareous blocks such as the Kiogar for example(7). One of them, near the monastery of Lamayuru, display a particular succession of facies(fig.2)(8): a Late Permian(Late Djulfian)neritic limestone rich in Algae, Foraminifera, Brachiopoda and Crinoida(*Colaniella* and *Palaeofusulina* biozone according to Dr. M. Lys, Orsay), appears eroded and locally coated by polymetallic crusts. Its surface is locally infilled by pelagic limestones(rich in Ammonites of Scythian age, several species of *Meekoceras* similar to the fauna of the "Meekoceras beds" of the Lilang section in the Spiti area according to Dr. J. Gueix, Lausanne)mixed with a few volcanic fragments; the series ends with a succession of tuffs, volcanic agglomerates, pillow lavas and radiolarites. A similar succession, associated with Triassic red limestones, exists also within the tectonized basis of the Photaksar ophiolitic tectonic klippe.

In conclusion, in the internal part of the himalayan orogen, there are evidences of:

-the presence of oceanic crust: the ophiolitic suite, regionally associated with pelagic Triassic facies,

-the occurence of a zone, possibly pertaining to a continental crust, with the succession in time of: neritic limestones, polymetallic crusts, pelagic sediments and volcanics. In our opinion this succession characterizes the typical evolution of a process of continental break up and the correlative installation of a passive margin regime.

In this case such an evolution occuring just between the Permian and the Triassic could emphasize the activity of the Tethys Ocean.

Furtherly the system was involved into a complex of nappes overthrusted southernly onto the Indian margin then northernly retrotectonized.

FORMATION AND DEVELOPMENT OF THE BLOCK STRUCTURES IN THE HIMALAYAS AND ADJACENT REGION

Li Yin-huai et al.
(Institute of Geology, Academia Sinica)

In this paper a suggestion is given on the tectonic belt along the Yarlung Zangbo-Indus river as a lithospheric fracture belt from the synthesis and analysis of geological and geophysical data of the Himalayas and adjacent region. This belt has initiated in late Triassic and controlled the development of Northern Himalayas-South Central Karakorum geosyncline for a long period, and completed in Tertiary and involved in early Himalayan fold tectonic belt. In the High and Low Himalayas as well as Siwalik belts, the sediments of platform type were deposited during Paleozoic-early Pleistocene periods forming the thrust-overthrust tectonic belt on the platform margin in the late Himalayan time.

The geotectonic features of the Himalayas and adjacent regions consist of the blocks of different size, cut through by the fractures developed in different depths since Mesozoic era. The "Plates" are referred here as the specific type of blocks and of first order. From this view of point the authors have proposed a new model of the formation and development of blocks in the Himalayas and adjacent region.

The new model of fault tectonic features consists of four phases: the formation of Precambrian basement, the development of united platform in Paleozoic era, the separation of platform with development of geosyncline, in late Triassic-late Cretaceous period and the recombination of fault-blocks during the phase of Cenozoic orogeny.

UPPER MANTLE UNDER TIBET

L. Knopoff
(Institute of Geophysics and Planetary Physics
University of California, Los Angeles,U.S.A.)

We have measured the dispersion of long-period surface waves across Eurasia for many intersecting event-seismograph pairs,using records of the Worldwide Standard Seismographic Network. Inversion has proceeded by dividing the continent into a small number of rather large regions and minimizing the phase travel times as a function of period; the minimization is taken with respect to the parameters of the cross-sections of each region. To reduce the number of degrees of freedom in the inversion, certain geophysically plausible assumptions have been made. The solutions are stable with regard to variations in these assumptions. The results show that the Upper Mantle under Tibet has a cross-section characteristic of an ancient Precambrian shield. This result can be modelled in terms of shallow-angle subduction of the ancient Indian shield beneath the present Tibetan plateau. The crust of the Indian shield has been emplaced beneath the ancient Tihetan crust; frictional heating at the common interface of the two crusts accounts for the attenuation of Lg waves across Tibet. we have also derived the upper mantle structure under Sinkiang. If the upper mantle under Tib t prior the emplacement of the Indian shield resembled that under present-day Sinkiang, then thc upper mantle temperatures were well above the shield temperatures, implying that the sub crustal material was relatively more mobile than present day shield material, and hence was capable of being moved laterally by the advancing shield. Confirmation of these results can be made by direct observation of surface wave phase velocity dispersion on smaller scale local networks of long period seismographs within the Tibetan and Sinkiang regions.

CHARACTERISTICS OF GEOPHYSICAL FIELD AND CONTINENTAL PLATE TECTONICS OF THE QINGHAI-XIZANG PLATEAU AND ITS NEIGHBOURING REGIONS

Teng Ji-Wen*
(Institute of Geophysics, Academia Sinica)

In this paper, we have collected all the available data that are pertinent to the study of this region, such as the crust and upper mantle structure in the Qinghai-Xizang region, the distributions of the geomagnetic field elements, the results of airborne magnetic survey, the palaeomagnetic pole wandering paths, gravity anomalies, geothermal activities, earthquake activities, fault plane solutions and other results of geophysical field features, and tried fo discover the relationships between these features of the geophysical field and the continental plate tectonics.

The preliminary results indicate that the northern boundary of the zone where Indian plate and Eurasian plate are in contact is Yarlung Zangbo Jiang and the southern boundary is in the northern edge of Ganges. Himalayan zone is a transitional belt of the collision zone and its width is about 300km or so. Most of fhe large and small earfhquakes occurring in this zone are of shallow foci. Only in the arcuate mountain system and at the vertices of the east and west area as well as at the turning points of the range the earthquakes of medium depths occured. In this transitional zone hot water activity is very strong and the gravity field is not in isostatic equilibrium.

From the north of Yarlung Zangbo Jiang to Damxung region, the crust is from 70—73km thick, but in the Himalayan region the crustal thickness decreases to about 68 to 45km and is upwarping towards the south. The crust is multilayered and there exists a low velocity layer in the lower crust. The fault plane solution shows that the fault is thrusting towards south, the principal compressional stress axis being in general direction to the southnorth, northeast and relating to the focal depth. It seems that the recent tectonics and earthquake activities gradually move towards the south reaching the great fault of the main boundary.

In the north of Yarlung Zangbo Jiang the focal depths of small earthquakes increase towards the south, but in the north of the Ganges it increases to the north. Moreover, in the two places mentioned adove some earthquakes of medium depths occur. Therefore,

* Joint work in field and indoor (in a order of the number of strokes in surnames) Wang Shao-zhou, Zhu Zhi-wen, Su De-yu, Zhou Wen-hu, Yang Bing-Ping, Xiong Yong-ren, Yao Zhen-xing, Chang Li-min, Xu Zhen-wu, Xan Guo-hui, Xiong Shao-bo, Wei Si-yu and others.

there are thrusting faults both southern and on the northern sides of Himalayan zone. In the Hindukush region, the plane of the foci of the medium deep earthquakes dip towards north; in the Pamir zone, they dip towards the south. So the plane of the foci forms "V" shaped region.

The stress and energy of the tectonic motion in the plateau and its adjacent regions have not been exhausted at all, and have direct influence on the earthquake activities and structure of the continent and provinces of Sichuan, Shanxi, Gansu and Ningxia.

THE DISTRIBUTION OF EARTHQUAKE FOCI AND PLATE TECTONICS ON THE QINGHAI-XIZANG PLATEAU

Huan Wen-lin Wang Su-yun

Shi Zhen liang Yan Jia-quan

(Institute of Geophysics, State Seismological Bureau)

In this paper, the data of focal depths of a large number of earthquakes which occurred recently on the Qinghai-Xizang plateau and its vicinity are analysed. We find that not only there are widely shallow earthquakes in this region, but also regularly intermediate ones. These intermediate earthquakes form three intermediate seismic zones in the region.

The first zone stretches along the plate convergence zone. The dip directions of focal planes of intermediate earthquakes in the areas of Hindukush and India-Burma mountain arc are consistent with that by other authors. The focal planes of intermediate earthquakes on the Indus and Yarlung Zangbo River convergence zone are all southward dipping. But the dip angle of the former is gentler, about 45°—55°, the deepest earthquake foci are about 280 km. The dip angle of the latter is about 65°—70°, while the maximum focal depth is about 230 km.

The second zone locates in the areas of Pamir, West Kunlun Mountain and the northern margin of the Qaidam Basin. The focal planes of earthquakes here are all dipping south at angles of 50°—70°. The focal depths in these areas are about 300km, 220km and 110km, respectively.

The third zone locates in the southern margin of Tianshan. The focal plane of the earthquakes here is south-dipping too. The dip angle is about 60° and focal depth is about 150km.

If the above-mentioned inclined focal planes along which many intermediate earthquakes occurred are taken as the subduction zones, then there are three south-dipping lithospheric subduction zones from the Himalaya Mountains to the Tianshan Mountain.

At the same time discontinuous distribution horizontally of the intermediate earthquakes zones implies that several strike-slip faults cut the subduction zones into some parts, rendering even still greater complexity tectonically. Such a broad tectonic framework is probably a result of the collision of the Indian ocean plate with the Eurasian plate.

As the areas to the south of Indus-Yarlungzangbo River lie in the frontal position of the collision by two plates, its south-dipping focal planes of intermediate earthquakes reveal that the Indian ocean plate upthrusted northward over the Eurasian plate, forcing it to go southward underneath the Himalayan Mountain on the northern margin of the Indian ocean plate. The result is just contrary to the conclusion as some authors suggested that the Indian ocean plate underthrusted beneath the Eurasian plate.

Elsewhere in the areas of the Pamir, West Kunlun and northern margin of Qaidam basin,and in the area of southern margin of the Tianshan exist south-dipping lithospheric subduction zones respectively. Their developing size has gradually decreased.

If the depth of the subduction zone is considered as the part disappeared in the mantle, then the crust on the Asian continent along above-stated three subduction zones has been subducted at least 300—700km, more in the western part and less in the eastern.

GEOIDAL FEATURES AND CRUSTAL STRUCTURE IN CENTRAL ASIA

Antonio Marussi
(University of Trieste, Italy)

The geoidal features of Eurasia obtained by satellite methods, prove that the Alpine-Himalayan orogenic belt is accompanied all along its extension by a relative geoidal rise stretching from the Atlantic Ocean to the archipelago of Melanesia. In the area of the Tien Shan-Hindu Kush-Kun Lun-Karakorum-Himalaya Syntaxis (Pamir Syntaxis) the belt is intersected by a marked geoidal low extending SW-NE from the Indian Ocean to the Baikal Lake and the Lena River basins. It thus appears that the upheavals of the geoid are correlated with orogenic belts, and downwarpings with belts of rifting. The Pamir Syntaxis is located at the crossing of two such belts.

Since the geoidal features reflect lateral density inhomogeneities located deeply in the mantle, a correlation is therefore suggested between mantle and crustal structures and processes.

Upheavals of the geoid correspond to denser materials in the mantle implying sinking currents; on its turn, sinking implies downwarping of the mantle-asthenosphere discontinuity that originates a geosyncline in which crustal material can possibly slide by gravity thus creating an orogenic zone (epigeosynclinal process). The reverse is true for areas of downwarping of the geoid that therefore correspond to zones of rifting(epiplatform process).

The rift zone of the Baikal basin characterized by normal and transcurrent faults, troughs and recent volcanism has been known since long time. Recent research based on the use of remote sensing techniques applied to the LANDSAT programme has proven that tensional features have also developed in recent geological times in the western part of the Tibetan plateau in the form of rifts and grabens which conform to the tensional axis and that in some cases intersect the Great Himalaya. Young volcanism is also present in NW Tibet.

South of the Alpine-Himalayan belt, the extensional zone of East Africa, of Arabia and of the Arabian Gulf possibly continues in the lower Indus Valley. Extensional zones are however present both to the E of the Indus, as is proven e. g. by the Deccan traps flow, and to the W, where the Sulaiman Range and the southern slopes of the Hindu Kush are marked by transcurrent faults, young volcanism and grabens.

Epiplatform processes, that are generally expected to initiate at the end of the epigeosynclinal processes, may have affected the Himalayan orogen in its last phases of development as is proven e.g. by the already mentioned faults and grabens affecting the northern slopes of the Great Himalaya in Tibet, and possibly by the Nanga Parbat accident the trend of which also conforms to the extensional axis.

CHARACTERISTICS OF THE GRAVITY FIELD AND THE CRUSTAL STRUCTURE IN THE EASTERN AND MIDDLE REGIONS OF THE XIZANG PLATEAU

Zhou Wen-hu Yang Zhan-shou Zhu Hong-bin
Wu Li-Gao
(Institute of Geophysics, Academia Sinica)

Gravity data were obtained from the eastern and middle regions of the Xizang Plateau in 1975—1977. In this paper, square grid method was applied to make the terrain corrections and a map of Bouguer gravity anomaly for this region was drawn. Meanwhile the same method was applied to make the isostatic corrections for the Hayford inner zones. Those for the outer zones were obtained from the table. A further study was made for correlations of space gravity anomaly and Bouguer gravity anomaly with the elevations of the observed points. Finally an approximate outline of the crustal bottom boundary in this region was obtained with least square fitting of the Bouguer gravity anomaly.

The results show that in the southern and northern Yarlung Zangbo Jiang the characteritics of the gravity field are different.

1. The maximum negative Bouguer gravity anomaly is less than 550 mgal.

2. Positive isostatic anomaly occurs in the Himalayan region and its maximum value is +120 mgal in the main ridge belt of Himalayas. The northern Yarlung Zangbo Jiang has almost reached isostatic equilibrium.

3. In the Himalayan region the correlation of space anomaly and Bouguer anomaly with the elevations are different from the northern Yarlung Zangbo Jiang.

4. Three step-like depressions appear in the bottom of the crust from east to west. The bottom boundary of the crust dips from south to north in the Himalayan region. In the nearby area of Yadong, the crustal thickness is comparatively thin, but in the neighbouring area of Yarlung Zangbo Jiang the crust thickens about 66km. The bottom of the crust is flat in the back-land of the Xizang Plateau north of Lhasa. The crustal thickness is about 70km in the belt of Nyainqentanglha-Nagqu—Amdo.

ISOSTATIC GRAVITY ANOMALIES IN THE AREA OF CENTRAL PORTION OF THE HIMALAYAN MOUNTAIN RANGE

Tang Bo-Xiong

(Seismological Bureau of Yunnan province)

Liu Yuan-long Chang Li-Min Zhou wen-hu

Wang Chien-Shen

(Institute of Geophysics, Academia Sinica)

In this article, the isostatic gravity anomalies in the central portion of Himalayan range is calculated on the basis of Airy — Heiskanen's isostatic hypothesis. The map of the isostatic gravity anomalies of the region is given under the condition of normal crustal thickness T=30km. It can be seen clearly from this map that the Himalayan region appears to have a positive isostatic anomaly. In the vicinity of Qomolangma Feng, the isostatic anomaly is about +120 mgal. Hence we can conclude that the crust in this region has not reached the stage of isostatic equilibrium. It is pointed out that these positive isostatic anomalies may be caused by the absence of "mountain root" in Himalayas.

EXPLOSION SEISMIC STUDY FOR VELOCITY DISTRIBUTION AND STRUCTURE OF THE CRUST AND UPPER MANTLE FROM DAMXUNG TO YADONG OF XIZANG PLATEAU

Teng Ji-wen Xiong Shao-po Sun Ke-zhong
Yin Zhou-xun Yao Hung Chen Li-fang
Mu Teng Lai Ming-hui Wu Ming-chu
Su De-yuan Wang Shao-zhou Huang Wen-jian
Ou Ren-sheng Hao We-cheng Shao An-min
(Institute of Geophysics, Academia Sinica)
Gao En-yuan
(Changchun Geological Institute)
Wang Meng-Lin
(Institute of Computing and Techniques, Ministry of Geology of China)
Lin Zhong-yang Qu Ke-xin
(Institute of Geophysics, State Seismological Bureau)

In order to study the layered structures and characteristics of the velocity distributions in the crust and upper mantle of the Xizang plateau region we have made detonations in the Lakes of Yarzhoyum, Pomu and Nam. Nine seismic records were obtained along a profile oriented in a nearly N-S direction and 430 km long.

Six groups of phases of seismic waves through the crust and upper mantle in the area are observed which show different kinematic and dynamic properties.

The result shows that the crust and upper mantle of Xizang plateau are stratified. Here the thickness of the sedimentary rock layer is from 4 to 5 km. The crustal structures along the two sides of Yarlung Zangbo river are different. The crustal thickness from the north of the river to Damxung region is from 70 to 73 km and the interfaces in the crust are essentially plane. Compared with that of the northern part, the crust of the southern part of the river is thinner. From the river to Yadong belt the crustal thickness is from 68 to 45 km. The crust of the Xizang plateau is also made up of high and low velocities layers. There is a low velocity layer in the lower crust and its thickness is

10 km, and its velocity, 5.67km/sec. A composite cross section and a model of the crust is given.

The northern boundary of the collision zone of the two plates is quite clear cut and every layer in the crust is upwarping towards south. It shows that the formation of a thick crust and the uplift of the plateau are due to the results of a long period of compression, deformation, and crustal shortening by folding in a large scale.

CRUSTAL AND UPPER MANTLE STRUCTURE OF QINGHAI-XIZANG PLATEAU

Ta-liang Teng
(Department of Geological Sciences,
University of Southern California, U.S.A)

One of the most outstanding landscapes of grandiose scale on the earth, the Himalayas and the Qinghai-Xizang plateau has long held the interest of earth scientists. Many recognized that in this vast region, having the highest as well as the youngest mountain ranges in the world, lies an important key to the tectonic past in a global sense. We have made repeated surface wave group velocity measurements over the same paths by using large earthquakes (M> 7) and their aftershocks recently occurred in and around China. Multiple filter technique was applied to the properly rotated three-component digital data from Seismological Research Observatory stations, and to other data from tations of the World-Wide Standardized Seismograph Network. Both Rayleigh and Love wave dispersion data were obtained over a number of paths crossing the Qinghai-Xizang plateau. These dispersion data were used to invert for an upper mantle and crustal structure for the plateau. In several cases, higher mode data were also derived and entered into the inversion process. An estimate of uncertainty of these dispersion data was obtained from the repeated measurements with identical source-receiver geometry. The dispersion curves for the plateau give substantially lower group velocity than the world-wide average. This group velocity low extends to periods as long as 120 seconds, indicating that the structural anomaly is deep-rooted, reaching into the upper mantle. In fact, the group velocities for the plateau are among the lowest of all regions of the world. Rayleigh wave group velocity ranges between 2.60 to 3.65 km/sec, and steep slopes occur in the dispersion curves between 40 to 60 seconds. Upon application of the generalized inversion technique, an eight-layer model was derived for the crust and upper mantle of the Qinghai-Xizang plateau. The dispersion data permitted the resolution of a 15 km upper crust, a 15—20 km middle crust, and a 25—30 km lower crust. The resolution of the data for the mantle was only sufficient to infer a low velocity layer in the upper mantle. The shear wave velocity structure for the plateau gives an approximately 70 km thick crust which may be broken into four layers. There seems to have a tendency that the

crustal thickness increases northward away from the Himalayas. The first crustal layer has shear wave velocities that range between 2.87—3.06 km/sec, suggesting a layer approximately 15 km thick of partly sedimentary origin. A second layer of 15 km thickness has shear wave velocities between 3.20 to 3.40 km/sec and suggests granitic or equivalent composition. A third layer, 15 to 20 km thick with shear velocities between 3.40 to 3.70 km/sec, seems also to consist of granite. The fourth layer gives shear velocities ranging from 3.85 to 3.95 km/sec. We note that these velocity values are consistent with that of granite under approximately 20 kilobars pressure, corresponding to depths of 60 to 70 km. The resulting shear wave velocities in the upper mantle are lower than either the Gutenberg model or the Canadian Shield model, with indication of a low velocity layer at about 90 km depth. The shear wave velocity at the top of the mantle is approximately 4.4 km/sec. Due to the small amount of information derived from inverting the dispersion curves in the upper mantle, the low velocity layer can only be inferred, and the existence of extremely low velocities of 4.1 km/sec there is tentative. These low values of shear wave velocity suggest a high degree of partial melting and a low resistance to deformation.

ON THE GROUP VELOCITY OF RAYLEIGH WAVES AND THE CRUSTAL STRUCTURE OF QINGHAI-XIZANG PLATEAU

Yao Zhen-Xing Li Bai-Ji Liang Shang-Hong
Zhu Pei-Ding Zhang Li-Min *
(Insitute of Geophysics, Academia Sinica)

The group velocity dispersion curves of Rayleigh waves through most of the Qinghai-Xizang plateau are obtained, using the single-station and multiple-filtering process. The observed period for the basic mode of Rayleigh waves ranging from 5.0 to 56.0 seconds. The standard deviations of the observed velocities are 0.08—0.15 km/sec. For the first mode, the periods are from 10 to 16 seconds, with the standard deviations of velocity determination 0.05—0.13 km/sec. By means of the generalized linear inversion of the dispersion curves, we obtained a five-layer crust model with a low-velocity layer at a depth between 27 to 40 km. The transverse wave velocity is 3.29 km/sec, and lower 0.21 km/sec than above zone.

* Li Bei-Ji is from the Seismological Institute of Yunnan Province, the others working in the Institute of Geophysics, Academia Sinica.

CONSTRAINTS ON THE SEISMIC WAVE VELOCITY STRUCTURE BENEATH THE TIBETAN PLATEAU

Wang-Ping Chen and Peter Molnar
(Department of Earth and Planetary Sciences
Massachusetts Institute of Technology, Cambridge, U.S.A)

We combine observations of group and phase velocity dispersion of Rayleigh waves, of the wave form of a long period P_L phase, of P_n and S_n velocities from unreversed refraction profiles using earthquakes, and of teleseismic S-P travel time residuals to place bounds on the seismic wave velocity structure of the crust and upper mantle under Tibet. From long period surface wave dispersion alone, the Tibetan crustal thickness can be from 55 km to 85 km, with corresponding uppermost mantle shear wave velocities of about 4.4 km/s to 4.9 km/s, respectively. The P_n and S_n velocities were determined to be 8.12 ± 0.06 km/s and 4.8 ± 0.1 km/s respectively using travel time data recorded at Lhasa from earthquakes in and on the margins of Tibet. With these estimates of the uppermost mantle velocity and with the surface wave dispersion, the crustal thickness is most likely to be between 65—80 km with an average shear wave velocity in the crust less than 3.5 km/s. A synthesis of one P_L wave form does not provide an additional constraint to the velocity structure but is compatible with the range of models given above. Measurements of both teleseismic S wave and P wave arrival times for nine earthquakes within Tibet show unusually large intervals between P and S compared with the Jeffreys-Bullen Tables. We infer that most of the large interval is due to delays in the S wave travel times. These delays are not a consequence of errors in the Tables, because S wave and P wave arrival times from eight earthquakes in the nearby Himalaya agree quite well with the Tables. A minimum delay of the S waves of two to three seconds exists even if the focal depth of Tibetan events were only 5 km, while Himalayan events were 33 km. Thus the P_n and S_n velocities apparently do not reflect high velocities in the mantle to a great depth beneath Tibet.

Q-VALUE FOR SURFACE WAVES IN THE EASTERN REGION OF XIZANG PLATEAU

Peng Rui He Zheng-qin
(Insitute of Geophysics, State Seismological Bureau)

Based on the seismic records of 5 earthquakes along 4 paths across the eastern region of Xizang Plateau, the Q_R-values for Rayleigh waves are obtained in the period range 7

to 51 sec.. The result shows that this region is distinctly a low Q region in the continental crust. The average values of Q_R are 31—376. At the shorter periods ($T \leqslant 15$ sec.) they are higher, $Q_R = 140—380$, and its scatter is greater, while at the longer periods ($T \geqslant 40$ sec.) they are lower, $Q_R = 30—40$. The observational Q-values are more approximate with the theoretical values in MM8 Q-model.

Such a character of low-Q distribution with frequency implies the stronger attenuation for seismic waves across the Xizang plateau. The reason is that not only the large variation of structure in the upper crust of this region, which causes seismic waves to scatter strongly, but also in the crust and the lower part of the lithosphere there might be partially molten regions which would absorb the energy of elastic waves. All these phenomena might be related to the plate collision.

RECENT TECTONICS OF THE QINGHAI-XIZANG PLATEAU

Yan Jia-quan　Shi Zhen-liang
Wang Su-yun　Huan Wen-lin
(Institute of Geophysics, State Seismological Bureau)

On the basis of fault plane solutions obtained of 135 large earthquakes ($M \geqslant 6$) occurred on the Qinghai-Xizang Plateau, the results of seismo-geological survey, the readings of Landsat imageries and the data of crustal and upper mantle seismic velocity structures, the present paper deals with recent tectonics in the plateau. The principal conclusions are as follows:

1. The deformation on the boundaries of the plateau is predominantly compressive. The fault plane solutions of the earthquakes occurred on the southern slope of the Himalaya Mountains show thrusting or overthrusting type of faults. Most faults in the Qilianshan, Lupanshan and Longmenshan fold zones, northeast of the plateau are chiefly of the thrusting type. It is relatively stable within the plateau. Here the tectonic deformations consist of mainly a series of more or less parallel and curved left lateral strike-slip faults with some thrust faults. Normal faults distribute themselves chiefly on the Ali Plateau of southern Xizang and the western part of Sichuan.

2. In the vast region between the Himalaya Mountains and the Qilianshan mountains, there exist rather consistently horizontal compressive stresses with the mean orientation of the principal compressive stress axis being 22° NE, dip angle 7°. East of the Zayü-Lanzhou line, the orientation of the principal compressive stress turns gradually from NE in the northern part to SE in the southern part of this region. The distribution of the principal compressive stress axis of the intermediate earthquakes in the region from Pamir to the Himalaya Mountains indicates that the earthquakes occurring here in the upper mantle are compatible to the stress distribution conditions in the

crust.

3. There exists probably a low velocity layer in the crust on the plateau. The materials in the top layer of the upper mantle of the plateau resemble that of the lithosphere. The velocity, however, of seismic waves in the crust and upper mantle is less than that of the Indian subcontinent and Alashan Massif.

4. The recent tectonics on the Qinghai-Xizang Plateau was mainly affected by the horizontal heterogeneity of the crust and the upper mantle, and the collision and compression by the Indian Plate. The process of tectonic deformation in this region could be visualized as the "forging die process" in machinery engineering. The impact of the Indian Plate from south brought about firstly strong deformation in the contact zone; and secondly, the shortening of the lithosphere in the direction of the compressive stress axis, causing topographic upheavals, thickening of the crust and thrusting of the crust toward the plateau northward and northeastward onto the adjacent platform. At the same time, crustal materials on the plateau became arched in form and the lateral movement of them is faster in the south than in the north, thus forming a series of left lateral strike-slip faults in the inner part of the plateau, pushing the crustal materials at the southeastern corner of the plateau to the southeast through a break of the "forging die".

SOME CHARACTERISTICS OF SMALL EARTHQUAKES IN THE ZHAMOG AND DAMXUNG DISTRICTS OF THE XIZANG PLATEAU

Yang Bing-ping Shu Pei-yi Zhang Zhi-he
Tang Wan-long Wen Ji-ping
(Institute of Geophysics, Academia Sinica)

In order to study the cause of rise of the Qinghai-Xizang plateau, and according to the earthquake acivities and transportation conditions in that area, regional seismological networks were installed in the zhamog and Damxung districts in 1976 and 1977 respectively. On the basis of the data thus obtained, the spacio-temporal parameters of the small earthquakes which occurred there were obtained by use of the Wadati method. A disc-shaped dislocation model was adopted for the focus of a small earthquake. After considering the effects of absorption in the transmitting medium and the frequency characteristics of seismographs, focal parameters of the earthquakes in the time domain were determined.

The results are as follows:

1. Small earthquakes are characterized by intense local concentration and shallow focal depths. The focal planes of the small earthquakes dip towards the south in Damxung region.

2. The mean stress drop of the earthquakes ranges from a few bars to tens of bars.

3. The Q_p values for longitudinal waves in that region are relatively low, with an average value of about 150.

4. At the depth of about 20 km in the upper crust, the average velocity of longitudinal waves is relatively low, with an average Vp value of 5.65km/sec.

THE AVERAGE STRESS FIELDS OF ZHAMO AND DAMXUNG REGIONS IN THE XIZANG PLATEAU

Zhang Li-min Shu Pei-yi
Yang Bing-ping Zhang Zhi-he
(Institute of Geophysics, Academia Sinica)

The average stress fields of Zhamo and Damxung regions in the Xizang plateau are obtained by smoothing the first motion patterns from the regional seismological observation data. The results are as follows:

1. The compressive axes in Damxung region and part A of Zhamo region are roughly in the north-south direction. The angle of elevations of these axes are small, being 23° and 14°, respectively. This indicates that the interaction between the plates is dominantly compression.

2. In part B of Zhamo region, the compressive axis is in the east-west direction with an angle of elevation about 51°. This seems to correspond to the uuderthrusting condition.

Such a result is basically in accord with the model of mutual collision between the Indian plate and Eurasian plate and agrees with the fault plane solutious of the major earthquakes which occurred in that region. This implies that all earthquakes whether large or small are all controlled by the plate movement.

DISCUSSION ON FORECAST OF EARTH-QUAKES (M≥8) IN XIZANG PLATEAU AND ITS BOUNDARY

Kuo Zeng-jian Qin Pao-yan Liu Guang-yuan
(Lanzhou Institute of Seismology,
State Seismological Bureau)

Great earthquakes (M⩾8) take place only occasionally in the whole world. But since the present century, there have occurred in Xizang Plateau and its edge belt already six great earthquakes (M⩾8). These events show that the modern tectonical activity in this area is very intensive. On the basis of some observed facts concerning seismicity and other related phenomena, this paper gives some speculations for predicting the future great earthquakes in Xizang Plateau and its vicinity.

1. Since this century, six great earthquakes (M⩾8) have already occurred in this region. Five of them were located at the edge belt of the plateau, and only one event occurred within the plateau. It seems that the possibility of occurrence of future great earthquakes is larger in the edge of the plateau than in its inner-part.

2. Seismic gaps of large area often appear prior to great earthguakes (M⩾8). This suggests that we should pay more attention to the study of the gaps surrounded by earthquakes of magnitude $5\frac{1}{2}-7$ in which great earthquakes (M⩾8) will probably take place.

3. About 1~2 years before great earthquakes, which occurred in the volcanic regions of the plateau or in its vicinity, there often occurred earthquakes with magnitude of 6~7. Therefore we should make serious studies of the seismic activity in those volcanic regions with a view to predict the great earthquakes in the near future.

4. About 1—2 years before great earthquakes, the earthquakes of (M≈6) often occurred in the extension of the tectonic belt from the great earthquakes. It follows that, if the earthquake (M≈6) once took place in the seismotectonic belt associated with a seismic gap, we should take into account the possibility of great earthquakes occurring in the following 1—2 years.

5. According to the response of great earthquakes in Xizang Plateau with the high tide of the volcanic activity in the whole world, we will consider the possibility that the great earthquakes (M⩾8) may take place when the volcanic activity in the whole world develops upward to the high tide.

It is preferable, however, that the above criteria should be applied collectively in order to achieve a better result in the prediction of great earthquakes.

VELOCITIES OF COMPRESSIONAL AND SHEAR WAVES IN SOME ROCKS FROM AN OPHIOLITE ZONE ALONG YARLUNG ZANGBO VALLEY

Wang Chi-yuen and Chen Yong*
(Department of Geology and Geophysics
University of California, Berkeley, USA)

Rocks from a long and extensively exposed ophiolite zone along the Yarlung Zangbo Valley between latitudes of 29 and 34°N are studied for their velocities of compressional and shear waves at high pressures. The ultramafic rocks include some pyroxene rich olivinite and serpentinites; the mafic rocks include some diabase, gabbro and basalt. Also included are some chert and greenstone of sedimentary origin. Velocities determined for these rocks may be used to aid in the interpretation of field measurement of seismic velocities and, in conjunction with known geologic context, to aid in the construction of a horizontal profile of seismic velocity across the tectonic belt. Some of the rocks show considerable anisotropy in seismic velocities. If carefully interpreted, this anisotropy may be useful in reconstructing the tectonics of the area.

* Permanent address: Institute of Geophysics, State Seismological Bureau, Beijing, China

CHARACTERISTICS OF GEOTHERMAL ACTIVITIES IN XIZANG (TIBET) PLATEAU AND THEIR CONTROLLING INFLUENCE ON PLATEAU'S TECTONIC MODEL

Tong Wei
(Department of Geology, Beijing University)
Zhang Mingtao
(Integrated Survey Commission of Natural Resources, Academia Sinica)

According to field observations during 1973—1976 and laboratory studies, the authors found that all the geothermal manifestations in southern Xizang form a huge geothermal belt, which may be called the Himalayan Geothermal Belt (HGB). It stretches from western Xizang to western Yunnan Province covering over one thousand kilometers. In this Belt no active volcano occurs nowadays, but there are very powerful hydrothermal activities. All the strong hydrothermal manifestations in this HGB such as hydrothermal explosions, high-temperature geysers, boiling and numerous hot springs etc. bear the characteristics of those which usually occur at the plate boundary rather than in the interior of a plate. They are thought to be the result of the underthrusting of the Indian Plate along the Indo-Gangetic Deep Trough beneath the Eurasian Plateau. Hydrothermal activities both sides of Yarlung Zangbo River are likely to be symmetric and the middle section of this River itself is a cold zone (no thermal spring issues). This suggests that the Yarlung Zangbo Fault may play no part in the present-day hydrothermal activities within HGB, but is only a fossil suture line at present. Hydrothermal activities occurring nowadays in the southern part of northern Xizang are but the remanent of the activities when Yarlung Zangbo River played the part of an active suture zone. When the suture zone migrated progressively southward to the south of the Himalayan Arc, the hydrothermal activities were developed in southern Xizang (HGB), while those in northern Xizang became old and feeble, and approached the dying stage nowadays. Some salt lakes were developed from these old hydrothermal areas in northern Xizang.

These characteristics of the hydrothermal activities might serve as limiting conditions when any tectonic model of Xizang Plateau is proposed.

CRUSTAL EVOLUTION AND THERMAL STATE OF TIBET

M. Nafi Toksöz and Albert Tong-kwan Hsui
(Department of Earth and Planetary Sciences
Massachusetts Institute of Technology
Cambridge, Massachusetts, U.S.A.)

The crustal structure and seismic attenuation under Tibet have been studied by seismic body and surface waves. The crust is about 70 km thick. Average velocities in the crust are lower than average continental values. The attenuation in the lower crust (below about 50 km) is very high. The Rayleigh waves in the period range of 30—50 seconds are highly absorbed. Shear wave Q values may be as low as $Q_s = 10$ in the lowermost part of the crust.

The above properties may be explained by the thickening of the crust through internal deformations and elevated temperatures. We have examined the thermal consequences of such an evolution. The initial conditions are those determined by the subduction processes that have preceded the Himalayan episode of continental collision. Internal heating due to shear deformations and crustal radioactivity contributes significantly to the thermal regime. The temperature in the crust increases steadily. Over a period of about 40 m.y., temperatures in the lower crust will exceed those of the typical continental geotherms by about 200℃. This would produce partial melting and result in excessive attenuation in shear waves.

PRELIMINARY RESEARCHES OF HYDRO-THERMO-EXPLOSION ACTIVITIES AND THEIR EXPLODING MECHANISM IN XIZANG (TIBET)

Zhang Ming-tao
(Integrated Survey Commission of Natural Resources, Academia Sinica)
Guo Guo-ying
(Department of Geology, Beijing University)

Hydrothermo-explosion is one of the most violent hydrothermal activity. In general, it is due to the superheated water which flashes to steam within shallow reservoir. Hydrothermo-explosions are relatively uncommon in the whole world. In southern Xizang eleven thermal areas with current activities and fossil explosion craters were discovered during 1975—1976. This paper emphatically discusses Qupu hydrothermal area in which an enormous explosion occurred on November 12, 1975, beside that the diameter of one crater reaches about 100 meters. The hot lake occurring in Yangbajing geothermal field roughly covers 7350 m^2, we would like to suggest, that this hot lake is the products of past hydrothermo-explosions. Using the energy comparative method, we have estimated the energy discharged from the hydrothermo-explosion occurred at the Y-1 drillhole of Yangbajing field on December 4, 1977, the result shows an equivalent about 3 tons of TNT.

Hydrothermo-explosions of Xizang were very young and many activities were under researcher's eyewitness. The size of the explosions were from moderate to miniature, but the frequency is very high. Hydrothermo-explosions often arised within broad valley basin at high altitudes. The hot reservoirs mainly consist of coarse-grained moraines-glacier deposits. The region between the northern slope of Himalaya and main ridge line of the Mt. Kangdese does not have recent and modern volcanic activity, but there are hydrothermo-explosions. The possible heat sources supplying the explosions might only be the magmatic bodies which have recently intruded into the shallow crust. Hydrothermo-explosion craters could convert into high temperature manifestations such as hot lake, pool, steaming ground or boiling springs, etc.

The main factors inducing hydrothermo-explosion probably are: the high-temperature water-pocket originating from intensifying heat source activity; a defective caprock over a shallow reservoir; the congestion of the uplifting channels by sinter deposits; along the rims surrounding the large or medium size explosion craters small explosions may take place again because they are weak zones; when the covering strata above the shallow reservoir is weakened by artificial breakage it bring about a hydrothermo-explosion; seismicity is another obvious triggering mechanism.

PROPERTIES OF GEOTHERMAL DISTRIBUTION AND CHARACTERISTICS OF GEOPHYSICAL FIELD OF XIZANG PLATEAU

Wei Si-yu Teng Ji-wen
Yang Bing-ping Hu Zhong-yi
(Institute of Geophysics, Academia Sinica)

The Xizang plateau is the most intense area for geothermal activities in our country and the crustal structure is very complex and earthquake activities are extremely frequent.

By use of geothermal date and various features of geophysical fields in the region this paper has made study and analyses. A unified interpretion of the nature the deep part of the crust is given. It indicates that the cause of geothermal distribution and its activity in Xizang plateau is due to the high temperature in the crustal medium and the existence of melting or partial melting matter in the crust. The geothermal display is affected by the deep crustal structure and material migration and the geothermal energy is provided by the quantity of heat produced by the collision process of the Indian plate and the Eurasian plate and the magmatic intrusion.

PRELEMINARY STUDIES OF HYDROTHERMAL GEOCHEMISTRY OF XIZANG(TIBET)

Zhang Zhifei Zhu Meixiang Liu Shibin
(Department of Geology, Beijing University)

More than 400 water samples, 24 samples of gases emitted from thermal springs and lots of sinter or travertine samples were collected during our field inspections between 1973 and 1976. The sample-waters were collected immediately from the main spring-vents.

The terms for examination consisted of Li, Na, K, Rb, Cs, Mg, Ca, F, Cl, SO_4, HCO_3, NH_4, As, B, SiO_2 and pH values. Some statistic diagrams for the results are given.

All the thermal waters are divided into five chemical types, and the analytical values of typical samples for each type are listed. We paid special attention to the boron-abundant sodium chloride type and bicarbonate-sodium chloride type waters, and would like to emphasize, that both the two types are rich in B, As, Li, Rb, Cs. The abundance of these elements in some thermal waters are considerably higher than their average abundance in the crust except Rb.

We made also the trend analysis for the geographical distribution of boron dissolved in thermal water, and it seems that the high-value belt runs along both sides of Yarlung Zangbo River. The geographical distribution of the high-temperature hydrothermal areas (its underground temperatures estimated by Na-K-Ca geothermometer are commonly above 150℃) and the siliceous sinter-deposited areas coincide with the boron-abundant belt. These characters also strongly support the presence and running direction of the Himalayan Geothermal Belt.

The authors would like to postulate that certain components dissolved in thermal water such as B, As, Li, Rb, Cs, at least partly, might be originated from intracrustal partial remelting, or from deep thermometamorphism of sedimentary rocks subducted to the deeper part of the crust.

ESTIMATION OF EXPLOITATION POTENTIALITY OF THE YANGBAJING GEOTHERMAL FIELD

Guo Guo Ying You Maozheng Liu Shibin
(Deprtment of Geology, Beijing University)

Yangbajing geothermal field is located in Himalayan Geothermal Belt, which is a grand scale geothermal field found so far in our country.

This geothermal field is located in centre of the Yangbajing Cenozoic graben basin, which has developed from the Nianjingtanggula fault and Danguolin-Maruguo fault for a long time. In this basin, the spacial distribution of Quaternary moraines-glacier deposits, river and lake deposits, active fault system and possible magmatic activity in the depth of the basin contributes to the field a remarkable geological structure.

Yangbajing geothermal field is a high-temperature hot water field. According to the geochemical thermometer, it is estimated that the reservoir temperature in this field is 200℃ to 220℃, the highest is about 275℃. The thermal source probably is magmatic pocket.

In 1975, for the first time we measured and calculated the natural heat flow with comparative method in Yangbajing geothermal field and thus estimated the exploitation potentiality of the field. The insitu test was continued in 1976. The centre of Yangbajing geothermal field is divided into 17 geothermal manifestation areas, the area is roughly 7.2 km^2. Natural heat flow is found to be 11.61×10^4 kg · cal · $sec.^{-1}$, heat flow rate is converted to be 575 hfu. The estimation of the exploitation potentiality is 15.5×10^4kw.

Yangbajing geothermal field is about 90 km away from the Lhasa City, With a flat terrain and has good transport facilities. In order to solve the shortage of energy resource in Lhasa City, geological exploration and electric power generation testing is presently under way.

EFFLORESCENCE IN GEOTHERMAL AREAS OF XIZANG(TIBET) AND ITS GEOLOGICAL SIGNIFICANCE

Zhu Meixiang   Tong Wei   You Maozheng
(Department of Geology, Beijing University)

Over 50 specimens of efflorescences taken from the geothermal areas of Xizang were examined for the first time. X-ray diffractions were mainly used in their examinations. Salt minerals discovered so far are as follows: simple sulfates (thenardite, epsomite and gypsum); carbonates (trona, thermonatrite and calcite) borates (borax, tincalconite, kernits, hungtsaoite and inderite); complex sulfates (potash alum, soda alum, ammonia alum, alunite and alunogen); fluorite, quartz etc. The first three kinds of minerals are often found in salt lakes of Northern Xizang. Their compositions are closely related to the chemical types of spring water. Its outstanding characteristic is that almost all the efflorescences deposited from the boron-abundant water contain boron minerals. This is very similar to the case of salt lakes. The last three groups of above-mentioned minerals originated only from high-temperature hydrothermal areas, and they have never been found in salt lakes.

This paper exclusively deals with the interrelation between efflorescences in geothermal areas of Xizang and salt lakes:

1) salt lakes and saline lakes of Northern Xizang often go together with hydrothermal activities. Warm spring, hot spring and widespread fossil travertines are usually found near salt lakes;

2) at present there are strong hydrothermal activities in southern Xizang. There is plenty of boron in spring water, but no salt lakes exist there (except Tajie lake). In Northern Xizang the hydrothermal activities are weak nowadays. There is a little boron in spring water. But the salt lakes in Northern Xizang are growing and they are rich in boron. Their geochemical features are different from those of the salt lakes in other areas of our country. Thus the authors of this paper have deduced, that the extent and scale of hydrothermal activity used to be much larger than those of the present time. In

Northern Xizang, some of the salt lakes containing much boron may be the vistige left over by the hydrothermal activity in geological history. The geothermal fluid has been important recharge source of some components in salt lakes. Under specified conditions, some consitituents containing of hot water may be the only source of the materials in salt lakes.

HYDROGEN AND OXYGEN ISOTOPIC STUDIES OF THERMAL WATERS IN XIZANG

Zheng Shu-hui Zhang Zhi-fei Ni Bao-lin
Hou Fa-gao and Shen Min-zhi
(Department of Geology, Beijing University)

Deuterium and oxygen-18 measurements have been made of thermal waters from 34 geothermal areas in Xizang. According to δD value of thermal water, the region is divided into four parts. The first district is located in the south of the High Himalayas and in the southeast end of Xizang. δD is approximately -100. The other districts are located within the Tibetan plateau. The δD value increases from -160 (south) to -80 (north), while it must decrease under the effects of altitude and latitude. This can be accounted for by the evaporation effect due to the arid climate. The ratio of annual evaporation to precipitation in the north of Xizang is larger than 5.0. It causes the concentration of heavy isotope in surface water.

Deuterium, oxygen-18 values and the chemical composition of thermal waters from drillholes and natural springs in the Yangbajing geothermal field have been investigated. The thermal waters are moderately enriched in the heavy isotope along a line whose slope significantly deviates from local meteoric values. The $\delta^{18}O$ values of the waters in hot springs are roughly proportional to their Cl content. These facts suggest that the waters are predominantly meteoric in origin but contain a small amount of NaCl rich deep fluid of a high heavy isotopic ratio differing from the meteoric water. The isotopic compositions of recharging ground water are obtained by extrapolation of the mixing lines. It seems that the recharging water is not the surface water from the vicinity of Yangbajing but might be an ice-snow water with lower values of δD and $\delta^{18}O$ coming from distant places.

The isotopic and chemical investigations of thermal water in Gudui thermal field are similar to that of the Yangbajing geothermal field.

SETTINGS OF THE GEOTHERMAL ACTIVITIES OF XIZANG AND A DISCUSSION OF ASSOCIATED HEAT SOURCE PROBLEMS

Liao Zhijie
(Department of Geology, Beijing University)

Xizang is one of the foremost Chinese geothermal regions in which there are about 600 geothermal areas, more than 300 of which have been reconnoitred between 1973 and 1976. The reconnaissance survey confirmed that an active geothermal belt, the Himalayan Geothermal Belt, extends about 2000 km across southern Xizang along the Indus-Yarlung Zangbo Suture.

Amongst the 300 thermal areas studied so far, there are 43 areas with two-phase (i.e. steam-water) manifestations including 10 with recent hydrothermal explosion craters, 3 with active geysers, one with boiling-spouting springs, and 29 with boiling springs; the other areas are characterised by warm or hot springs. The occurrence of hydrothermal explosions and geyser activies, as well as composition of the fluids (high B, Li, Rb, Cs and F), suggests that within the crust of the Xizang Plateau there are hot igneous rocks which serve as the heat source for these geothermal systems. High temperatures beneath the Xizang crust are also indicated by the scarcity of intermediate and deep focus earthquakes and the presence of a thick, seismic low velocity layer with a low attenuation coefficient Q.

The geothermal activity of the Himalayan Geothermal Belt is ultimately the result of the convergence of the Asian and the Indian continents. The question of whether the southern continent has been thrust under Asia along the Main Boundary Thrust since the Pliocene is still unsettled. However, the high $^{87}Sr/^{86}Sr$ ratios of the granites of the High Himalayas suggest that the Indian crust is still being subducted under the Asian Continent. The rate of subduction appears to be very small and crustal remelting and formation of a "molten granitic layer" beneath Xizang may still occur. Granitic magmas from this layer are thought to constitute the heat source for the geothermal activity in Xizang.

The intrusions may have occurred during the Late Middle Pleistocene when violent folding and faulting took place, but these intrusions are not yet exposed.

GEYSERING WELLS IN YANGBAJING GEOTHERMAL FIELD

Zhang Zhifei   Sen Minzi
(Department of Geology, Beijing University)
Zhou Changjin
(Commission for Integrated Survey of Natural Resources, Academia Sinica)

Since explorating the Yangbajing geothermal field, geysering hydrothermal activities caused by drilling were encountered for many times, among which well Y-7 is a typical artificial geysering well. In June 1979 observations were made of its 88 sequential eruptive activities. Each cycle of eruptive activity continued about 17 minutes. At first there was an intermission lasting a little more than 12 minutes. When water level recovered to the top of the well there emerged an overflow going on a little more than 2 minutes. Then abruptly began the starting phase of eruption, which turned into the violent stage, gradually passed on to the passive stage and finally terminated. The whole eruption lasted about 3 minutes. During the violent stage the column of water and steam reached a great height of 30 meters. Besides, observations was also made of recovery of water level in relation to time. The water level could decline to the largest depth 45 meters. under the head of the well at the end of each eruption, then it recovered again. Measurements of the temperature at the head of the well in geysering activity and at different depths of the well during the intermission were made. Some tests were taken for the section of the well in relation to eruption and for lasting overflow by injection of cold water. By determining the variation of chlorinity in water during eruption, it was found that the content of chloride is higher at the beginning of overflow and the end of eruption, but lower in the middle. About 2900 liters output of water per eruption and about 300 Kcal/sec average heat discharge were estimated. This paper finally discussed the mechanism of the geysering well Y-7.

THE CHARACTERISTICS OF DYNAMIC VARIATIONS OF XIZANG GEYSERS

Zhang Mingtao
(Commission for Integrated Survey of Natural Resources, Academia Sinica)
Zhang Zhifei
(Department of Geology, Beijing University)

The geyser is in the phase of periodical variations and produce intermittent eruption. It signifies that there is high-temperature hydrothermal system in subsurface. There are eight columnar geysers in three geyser areas which were discovered in Xizang.

According to the characteristics of activities, the general model of geyser's underground structure seems to suit that in Xizang, but among which the reservoir probably evolved from hydrothermal explosion crater. This evolutional relation indicates that to the north of Yarlung Zangbo Jiang's sutrue line, where the geysers are distributed, the history of hydrothermal activities are longer than that to the south. The heat source of the heating system, probably is the cooling igneous terrain which intruded into upper -crust.

Geysers in Xizang often show the feature of shifting, extinct and reappear, by the main cause of earthquake. The regularities of the geyser activities are not evident. The mobilities of the main spring mouth in Tagejia geyser area are very complex, and with explosive eruption. There are certain seasonal variations in the main spring mouth and №2 eruption mouth. Probably these phenomena are related to tie hydrological dynamic variations of high-land and the complicated subsurface structrues.

As comparing with the famous geyser areas in the world, the geysers in Xizang region seem to be occurred in a more mobile geologic environment.

SULFUR-ISOTOPIC ANALYSIS AND STUDIES UPON THE ABYSSAL HEAT RECHARGE OF THE XIZANG HYDROTHERMAL ACTIVITIES

Tong Wei Zhu Mei-xiang
(Department of Geology, Beijing University)
Chen Minyang
(Institute of Geology, Ministry of Metallurgical Industry)

An attempt has been made to discuss the abyssal heat recharge of the high-temperature hydrothermal activities occurring within Xizang Plateau. 44 samples were examined, and for the purpose of comparison, 9 samples from Tengchong Volcano-Geothermal Region in western Yunnan Province and 2 samples of other volcanic sulfur were also examined. The samples of Xizang are mainly the natural sulfur originated from the high-temperature hydrothermal activities. Also a few samples of the nardite, tschermigite, alunogen, epsomite, red opiment and metallic sulfides such as antimonite was determined. All samples were prepared under vacuum in the form of SO_2, then isotopically examined by mass-spectrometer CH_4/58-Ⅳ. The measurement made clear that the $\delta^{34}S$ of the sulfur flowers originated from Xizang's high-temperature hydrothermal areas are considerably close to the $\delta^{34}S$ of CDT. The authors therefore postulate that the abyssal heat recharge for the high-temperature hydrothermal areas might exist. It is probably the magma pocket originated from intracrustal partial melting. The $\delta^{34}S$ of salt incrustations from low-temperature hydrothermal areas are significantly different with CDT, but falls within the same variation range of $\delta^{34}S$ of the salt minerals deposited from the salt lakes in northern Xizang. This fact might imply the evolution trend of some hydrothermal activities into salt lake under circumstances such as those in northern Xizang.

THE INDIA-ASIA COLLISION, UNDERTHRUSTING OF THE TIBETAN PLATEAU AND POST-COLLISIONAL DEFORMATION OF SOUTH CENTRAL ASIA: IMPLICATIONS FROM NEW PALAEOMAGNETIC DATA

Chris T. Klootwyk

(Research School of Earth Sciences, Australian National University, Canberra, Australia)

Implications will be discussed from new palaeomagnetic results from north eastern Baluchistan, the eastern Hindu Kush, the Indus-Tsangpo suture zone in Ladakh, Kashmir, the Krol Belt, the Thakkhola Graben and from DSDP cores of the Indian Plate.

Results from Ladakh, from the Thakkhola Graben and from DSDP cores indicate that initial collision of continental Indo-Pakistan and south central Asia occurred during Late Palaeocene-Early Eocene times at an equatorial to low northern((less than 10°N) palaeolatitude. While convergence continued both continental masses may have become jammed at about the Eocene-Oligocene time boundary as suggested by a notable decrease in convergence rate.

A comparison of palaeomagnetic results from the Tibetan Sedimentary Series of the Thakkhola Graben(Nepal Himalaya)with corresponding palaeomagnetic results from Indo-Pakistan, indicates that the post-collisional counter-clockwise rotation of the Indian Shield exceeds that of the sampled region by 10 to 15 degrees. This is interpreted as a measure for the magnitude of intracontinental underthrusting of Greater India along the Main Central Thrust(M.C.T.)beneath its former leading edge and beneath the Tibetan Plateau.

Assuming a pivot point in the Western Himalayan Syntaxis or possibly further to the west, such a differential rotation points to 200 to 350 km of underthrusting at the longitude of the Thakkhola Graben. The surface projection of the frontal part of the Indian Shield thus subducted along the M.C.T.(assuming a 15 degrees N dip)broadly coincides with a line of Neogene to Recent acid volcanics in southern Tibet, north of the Indus-Tsangpo suture zone.

A minimal estimate of the northern extent of Greater India can be obtained from the magnitude of underthrusting along the M.C.T. as suggested here combined with estimates of crustal shortening within the Himalaya and of subduction along the Indus-Tsangpo suture zone. In the modified Smith and Hallam Gondwanaland fit such a minimal estimate of Greater India satisfies constraints on its northern extent from facies analysis along the Western Australian continental margin.

Post-collisional northward movement of continental Indo-Pakistan has resulted in large scale indentation of south central Asia over more than 2500 km. More than 1000 km of this convergence have been taken up since the Palaeogene in the region north of the outer Pamir-Transalai Zone.

The Hindu Kush-Pamir-Karakorum Syntaxial bend is a secondary feature resulting from this indentation as evidenced by a consistent pattern of counterclockwise rotations in its western limb and clockwise rotations in its northeastern limb.

In Extrapeninsular Indo-Pakistan collision tectonics have resulted in large scale inward movement of thrust sheets. Rotational components of some thrust units have been established palaeomagnetically:

an about 50 degrees clockwise rotation of the Loralai Range (northeastern Baluchistan),

an about 45 degrees clockwise rotation of the Kashmir Basin, contrasting with

a possible about 20 degrees counterclockwise rotation of the Salt Range-Potwar Plateau unit at the opposite limb of the Western Himalayan Syntaxis,

an about 45 degrees clockwise rotation in the studied part of the Krol Belt, which occurred during and after the Middle Tertiary.

PALAEOMAGNETIC INVESTIGATION IN XIZANG AND CONTINENTAL DRIFT

Zhu Zhi-wen Zhu Xiang-yuan
Zhang Yi-Ming
(Institute of Geophysics, Academia Sinica)

Up to now opinions are different on the location of the contact zone between the Eurasian plate and the Indian plate. Some scientists assert that it is at the southern foot of the Himalaya Mountain and others assert that it is in the zone of the upper Indus River to the Yarlung Zangbo River valley; Someone even suggests that it is at Pangkog Co. To resolve this question, we have collected a large number of orientated rock samples from the two sides of Yarlung Zangbo Jiang during the scientific expedition in Qinghai-Xizang Plateau. The palaeomagnetic studies have been made on the Pliocene sediments in Pagri; Paleocene and Late Cretaceous red sandstones in Lhünzhub and Biru, Granodiorite in Zhamo (K-Ar age 76.3 M. Y), Cretaceous limestone in Tingri; Late Jurassic limestone in Lhasa; Jurassic slate in Gyangzê; Triassic sandstone in Tulung; Precambrian and Early Cambrian quartz sandstone and mica-gneiss in Nyalam and Yadung.

The results indicate that the northern side of the upper Indus River and the Yarlung Zangbo Jiang belong to the Eurasian Plate, while the southern side belongs to the Indian plate.

According to the palaeolatitude variations, the Indian plate drifted towards the north. Since Cretaceous it has been moving with an average speed of less than 5.5cm/yr.

SOME CONSTRAINTS ON THE AMOUNT OF NORTH-SOUTH SHORTENING IN TIBET DURING THE CENOZOIC

Peter Molnar and Wang Ping Chen
Department of Earth and Planetary Sciences.
Massachusetts Institute of Technology
Cambridge, U.S.A.
Paul Tapponnier
Institut de Physique du Globe, Paris, France

We have made reconstructions of the relative positions of India and Eurasia at various times in the late Cretaceous and Cenozoic. These reconstructions are made by combining the known histories of sea floor spreading in the Indian Ocean between India and Africa and in the Atlantic Ocean between Africa and North America and between North America and Eurasia. Between about 70 my and 40 or 50 my ago, India moved rapidly north towards Eurasia at more than 100mm/yr. Since about 40 my ago this rate has been only about 50 mm/yr.

The slowing down accords well with the inferences that collision between India and Eurasia occurred approximately 40 to 50 my ago and that it is difficult to subduct continental crust. Since 40 to 50 my ago, there has been 2000 to 3000 km of convergence between India and Eurasia, that presumably must have caused crustal shortening in Asia. It is likely that most of it occurred in Tibet and further north in Asia. Paleomagnetic data from late Cretaceous-early Tertiary rocks in Southern Tibet accord well with this inference. When compared with the late Cretaceous-early Tertiary paleomagnetic pole for Eurasia, the pole for southern Tibet indicates 2000 km of convergence between them. This convergence must occur north of the Indus-Zangbu suture and therefore not by underthrusting of India beneath Tibet.

THE CHARACTERISTICS OF AEROMAGNETIC ANOMALIES OVER THE SOUTHERN XIZANG AND THE STRUCTURE OF THE EARTH'S CRUST

Pan Zuo-shu Shen Jiang-shang Wang Xiao-pei
(Changchun Institute of Geology)

This study on the basis of the characteristics of aeromagnetic anomaly in southern Xizang deals with the structure of the earth's crust around the Yarlung Zangbo Jiang.

Stress on the magnetic field in the greater depth, low-pass filtering techniques, such as reduction to pole, upward continuation, pseudo-gravimetric anomaly and method filtering processings are applied. By calculating the depths of the density surface and using the Maqart optimization method, model parameters such as the inclination, top and bottom depths, width and magnitization of the magnetic rock are obtained.

Based on the quantitative analyses,the occurrence and extension of the great fracture zone of the Yarlung Zangbo Jiang are discussed. The depths of the top and bottom surfaces of magnetic rock and the uplift of the isothermal surface of Curie points are obtained.

In the whole district, the top surface of gigantic magmatic rock is about 0—16 km, being shallow in the west of Yarlung Zangbo Jiang and deeper in the middle and the north. But the depth of Curie points isothermal is about 18—33 km deeper in the west and shallow in the east. All these account for the difference in the characteristics of the crustal tructure and in the ascension of magma between the eastern and western portions. According to the negative magnetic anomaly over the central portion of the district, the uplifted portion of the isothermal surface of Curie points is delineated.

The strike of the aeromagnetic anomaly belt at Yarlung Zangbo Jiang is approximately in the east-west direction.

It reflects the existence of a gigantic and steep zone of ultrabasic rocks.

CHARACTERISTICS OF THE EARTH'S MAGNETIC ANOMALY IN XIZANG PLATEAU

Xu Zhen-wu Xia Guo-hui
Wang Ju-yi Jia Shi-zhong Kong Fan-wen
(Institute of Geophysics, Academia Sinica)
Shen Jiang-Shong
(Changchun Institute of Geology)

This paper gives the characteristics of the total magnetic intensity of the regional and local magnetic anomalies on the basis of the data of ground geomagnetic survey in the Xizang Plateau and its surrounding regions.

1. The spatial variation of the intensity of the regional magnetic anomaly in the Xizang Plateau decreases gradually from the interior of the Plateau to its boundary area, and the gradient of the changes increases.

2. Between Kandese and Himalayan arcuate mountain systems there are three local magnetic anomaly zone alternating positive and negative magnetizations divided by Yarlung Zangbo River and southern Xizang low watershed.

3. A geomagnetic total intensity profile which is over 1000 km long across the Yarlung Zangbo River is given and its strength variation shows a great leap in the region of Yarlung Zangpo River. The maximum difference between intensities on the two sides of the River is 1300 gamma.

The preliminary results mentioned above indicate that on the two sides of Yarlung Zangbo River, the magnetic properties of the rocks in the crust may be quite different and that variations of the crustal thickness in this region may also contribute a part of the difference.

MAGNETIC TAPE RECORDING SYSTEM APPLIED TO THE INVESTIGTION OF THE CRUST AND UPPER MANTLE BY EXPLOSION SEISMIC SOUNDING

Lai Ming-hui Wu Ming-chu Yu Wu-yuan Xu Min
Fan Xu-bang She Ren-fu Tian Dong-sheng Shen Meng-pei
Gao Ji-yuan Pan Wei-ping Li Su-Wei Ni Da-tai
Cui Gui-cun

(Institute of Geophysics, Academia Sinica)

In order to study the structure of the crust and the upper mantle in Xizang Plateau, We have developed a set of analog magnetic tape recording system. In this system, four channels of frequency modulation signals with 2kc central frequency and one channel of 2kc frequency standared signal are recorded simultaneously on a $^1/_4$ inch tape with 5 tracks magnetic head of a speed of 19.05cm/sec. Each set of seismograph consists of three 2 Hz seismometers of type Ls-1, three amplifiers of Type DDF-5 [$Kv=10^4$, the noise level equivalent to the input terminal is less than 4uv peak to peak], three modulators and one magnetic tape recorder of Type DCJ-1, a quartz clock which sets time automatically and a radio.

The freguency band (velocity) of the seismograph is 2 to 20Hz. Time error is$\leqslant$0.1 second. The N/S radio of the system is about 50 db which is improved by the fluter compensation and filtering techniques. The system amplitude error is$<$10%. Higher efficiency of data application and signal searching precision have been improved after analog magnetic tape is converted to the digital magnetic tape by use of an A/D convertor, and then data processing is done on computer.

The field operation and the data analysis prove that this instrument can meet the needs for the study of the crust and the upper mantle. After some slight changes, the instrument can also be utilized for low frequency vibrational test.

A THREE-COMPONENT FLUX-GATE MAGNETOMETER

Liu Shi-Jie   Lu Jun   Gao Lin-Zheng
Su Xian-Ying   Zhou Cheng-bing
(Institute of Geophysics, Academia Sinica)

This paper gives a brief account of the principle, performance and usage of the three-component flux-gate magnetometer for electromagnetic deep sounding in Qinghai-Xizang Plateau.

The technical specifications of the instrument are as follows: the resolution is 0.2γ, sensitivity is 100 mv/γ; temperature coefficient is $1\gamma/℃$; recording frequency band is 0—1.0Hz; power consumption is 18w.

The instrument has been used for continuous field observations in five localities in the north and south of Xizang. A complete recording of a magnetic storm was obtained during the period of survey which showed that the instrument was satisfactory.

II The characteristics and evolution of the fauna and flora of the Plateau and the effects of its rise on them

ON THE LAND-VERTEBRATE FAUNA OF QINGHAI-XIZANG PLATEAU WITH CONSIDERATIONS CONCERNING ITS HISTORY OF TRANSFORMATION

Cheng Tso-hsin Feng Zuo-jian
(Institute of Zoology, Academia Sinica)
Zhang Yong-zu
(Institute of Geography, Academia Sinica)
Hu Shu-qin
(Zhengdu Institute of Biology, Academia Sinica)

Qinghai-Xizang plateau is the highest, the biggest and also one of the youngest plateaus in the world, usually referred to as the "roof of the world". The characteristics of the fauna constitute one of the most interesting problems worthy of investigation. As to the history of transformation of the fauna, it has also become one of the foci of discussion in recent years. The present paper is to be presented in three parts: (1) Résumé of mammalian fossils of the fauna, (2) Analysis of the characteristics of the fauna, and (3) Discussion of the problem concerning the history of transformation of the fauna.

I. A résumé of mammalian fossils of the fauna

Based on the mammalian fossils so far discovered in the plateau, the earliest ones were recorded in the Oligocene of the northern parts of the plateau. During Pliocene, there appeared successive groups of *Hipparion* and associated animals. In the Pleistocene, the plateau became increasingly uplifted from 2,000m to about 5,000m, and the mammalian fauna gradually underwent changes with the disappearing of *Hipparion* to become more and more similar to that of the Holocene period.

Besides the mammalian fossils, we have not so far found fossils of any other land vertebrates, except for the fossil eggs of ostriches in the Tertiary of the Chaidamu Basin (Bohlin, 1957). It seems most likely that ostriches might once inhabit the area under consideration.

II. Analysis of the characteristics of the fauna

Since the founding of the New China, we have conducted more than 10 long-term investigations and collectings of mammals and birds in Qinghai-Xizang plateau. In 1973, the Zhengdu Institute of Biology made an expedition of reptiles and amphibians there. Beijing University and Beijing Natural History Museum also took part in some expeditions. Altogether we have 191 species of mammals, 532 species of birds, 49 species of reptiles and 24 species of amphibians, totalling 788 species, belonging to 4 classes, 31 orders and 96 families. Among the species recorded, there are included 7 new species and 11 new subspecies.

A. Faunal components The faunal components of the plateau are mainly Palaearactic and Oriental, the remaining being endemic species, widely distributed species, and a few others of uncertain affinity. About 85—90% of the plateau fauna belongs to the Palaearctic Realm and only 10—15% to the Oriental Realm. The Palaearctic portion possesses 52 Palaearctic species of mammals and 165 Palaearctic species of birds, occupying respectively 27.4% and 31.0% of the total number of mammals and breeding birds of the plateau. The Oriental portion, though much smaller in size, possesses, however, 68 species of Oriental mammals and 172 Oriental species of breeding birds, occupying respectively 36.4% and 33.0% of the total number of mammals and breeding birds of the plateau. Thus it may be seen that the Palaearctic portion is much larger in size but has a lower percentage of mammals and breeding birds, whereas the Oriental portion, on the contrary, is much smaller in size but possesses a higher percentage of mammals and breeding birds. From a zoogeographic point of view, this is a point worthy of further studies.

As to endemic species, the plateau has 44 species of mammals and 23 species of breeding birds, occupying respectively 23.6% and 4.3% of the total number of mammals and breeding birds of the plateau. The lower percentage of endemic birds of the plateau is apparently due to the higher mobility of the birds.

B. Dividing of the zoogeographical regions

Zoogeographically speaking, Qinghai-Xizang plateau may be divided into two I-order regions, three II-order regions (subregions), and seven III-order regions (infraregions), as may be shown in the following diagram:

O-order(realms)	I-order(regions)	II-order(subregions)	III-order(infraregions)
Palaearctic realm	Qinghai-Xizang region	Qiantang plateau subregion	Qiantang plateau infra-region
		Qinghai-zangnan subregion	Qilian-qingnan infra-region
			Zangtung hilly infra-region
			Zangnan hilly infra-region
Oriental realm	Southwest region	Himalayan subregion	Bome-zayu infraregion
			Medog-qirong infra-region
			Danlong-dawang infra-region

The seven infra-regions are each characterized by representative species of land vertebrates, particularly birds and mammals. Based on the faunal composition of the different infra-regions, the 1st and 2nd infra-regions belong to the Palaearctic realm, the 5th-7th infra-regions to the Oriental realm, whereas the 3rd-5th infra-regions may be considered as more or less transitional between the two realms.

C. Vertical distribution The vertical distribution of birds and mammals is closely related with the zonation of vegetation. In the region of Mt. Jolmo-Lungma, the northern slope may be divided into 2 zones, *i.e.*, alpine steppe zone (4,000—5,000m), and alpine meadow zone (5,000—5,700m). The southern slope may be divided into 4 zones: Evergreen broad-leaved forest zone(1,500—2,500m), montane mixed forest zone(2,500—3,000m), montane dark coniferous forest zone (3,100—3,900m),and montane shrubby meadow zone (4,000—4,500m). Each zone is characterized by a number of dominant species of birds and mammals. The two zones on the northern slope are Palaearctic, while on the southern slope, the zones ranging from 2,000m downwards are mainly Oriental, the zone from 4,000m upwards Palaearctic, whereas the montane dark coniferous forest zone (3,100—4,000m) is more or less transitional between the two zoogeographical realms.

From an analysis of the vertical distribution of birds, such Phasianidae and Timaliinae, it may also been clearly seen that the great majority of Palaearctic species are found upwards of 3,000m, while most of Oriental species are found below 4,000m alt. The boundary line between the Palaearctic and Oriental realms is, therefore, considered to be situated between 3,000m and 4,000m alt.

III. Discussion of the problem concerning the history of transformation of the fauna

There have been different viewpoints and opinions concerning this problem. Some writers consider the plateau fauna to be of an ancient origin, while others are of the opinion that the plateau fauna was evidently formed in the late Quaternary era and is thus of a recent origin without any distinct characteristics of antiquity. There is another argument to the effect that the history of the faunal transformation is both recent and ancient. As a matter of fact, in any faunal region, we may find out certain ancient species and also a number of comparatively recent ones. Consequently, any faunal region may be considered as being recent as well as ancient. As for the plateau fauna, it seems appropriate that we should better make concrete analysis of the concrete situation.

In our concrete analysis of the plateau fauna, we may take note of the following facts.

(1) The scarity of endemic genera and species On the plateau, there is only one endemic genus of mammals, *i.e.*, *Pantholops*, and only one in birds, *i.e.*, *Pseudopodoces*. With respect to endemic species, the percentages are also quite low, with only 26% among mammals and 4.5% among birds. The scarity of endemic genera and species indicates that the plateau fauna just began to develop during the mountain-building movement in the Mid-Tertiary. The fauna as a whole may not be considered as very ancient. On the other hand, the existence of the endemic genera and species is in itself an evidence that the plateau fauna is not entirely recent, that is to say, not entirely formed after the glacial period.

(2) The eastern margin of the plateau, especially the region connected with the Meridional Ranges was not much affected by the influences of the glaciers, thus forming a shelter for some relics, such as *Ailuropoda melanoleuca*, *Ailurus fulgens* among mam-

mals, and *Picoides tridactylus*, *Perisoreus internigrans*, *Tetrastes sewerzowi* among birds. The presence of relics is, without doubt, an indication of antiquity.

(3) Distributional centers There are some genera of the plateau which have become centers of distribution, such as *Ochotona* in mammals and *Montifringilla* in birds. We consider it most probable that species of these genera have existed on the plateau for a long period of time and have thence spread to other regions, thus forming centers of distribution. Furthermore, species of *Ochotona* and those of *Montifringilla* have become ecologically associated with each other. This serves to show that these species are both adequately adapted to the conditions of the plateau. Such adaptative phenomena, involving both birds and mammals may, indeed, be also considered as an additional evidence of antiquity with respect to the species under consideration.

THE BIOGEOGRAPHY OF THE QINGHAI-XIZANG PLATEAU IN RELATION TO THE GEOLOGICAL HISTORY OF CENTRAL ASIA

Lawrence W. Swan
(State University of San Francisco, U. S. A.)

The present relictual distribution of several Pelobatid frog genera, the genus *Scutiger* in particular, in climatically favored areas along the fringes of the Tibetan plateau, suggest a more widespread pluvial period in Central Asia. The snake *Thermophis* (*Natrix*) *bailey* is likewise a relictual species and exists in remote isolation from other snakes in a precarious and temporary environment that is warmed by hot springs. Whereas these various species have retreated during the rise of the Tibetan Plateau and the developing rain shadow of the Himalaya, the lizards of the genera *Agama*, *Alsophylax and Phrynocephalus*, with Mediterranean affinities, have invaded the Plateau from drier areas to the west. Similarly, several mammals such as the kiang and the chiru have expanded onto the plateau from the west. Isolation and speciation of the fish that once lived in the extensive tributaries of the Salween, Mekong, Yangtse and Indus, and are now separated into lake populations along old water courses, emphasize the recent geological and climatological changes of the Plateau. This whole picture of rapid change is accentuated by the migration patterns of birds, particularly the bar-headed goose, *Anser indicus*, that crosses the Himalaya from warm and fertile India to bleak and severe niches in Tibet. It is probable that this migratory pattern preceeded the uplift of Tibet and the Himalaya to illustrate by a persistent behavior the youth of this physiographic region.

THE GEOGRAPHICAL DISTRIBUTION AND ORIGIN OF THE MAMMALS IN QINGHAI-XIZANG PLATEAU

Zhang Yongzu
(Institute of Geography, Academia Sinica)

Cheng Chanlin
(Northwest Plateau Institute of Biology, Academia Sinica)

According to recent estimates, the mammalian fauna of the Qinghai-Xizang plateau and the surrounding mountain ranges comprises more than 190 species. Analysis of their distribution patterns (belonging to 7 types and 23 subtypes) enables us to present a tentative discussion concerning the origin of the plateau fauna.

The plateau forms an important obstacle to the spread of the Oriental species, such as *Macaca* spp., *Paguma larvata*, *Martes flavigula*, etc., which can not extend over the Himalayan ranges, but spread over to the basin of the Yangtze river, north China and even to the Amur area in the northeastern part of China. Only in the Meridional Ranges some of them penetrate along the valley and reach the eastern margin of the plateau. On the contrary, many of the Palaearctic elements, such as *Cervus elaphus*, *Moschus* spp., *Mustela sibirica*, *Equus hemionus*, *Gazella subgutturosa*, *Allactaga sibirica* and *Meriones meridianus* spread in the plateau in different extents and are found in the environmental conditions resembling those of the boreal populations. The endemic species of the plateau, such as *Ochotona curzoniae*, *Marmota himalayana*, *Pitymys leucurus*, *Procapra picticaudata*, *Pantholops hodgsoni*, etc. show close relationships to the same genus inhabiting the boreal region. Their fossils are found in the Pleistocene and Holocene strata of the plataeu, which may be considered as indigenous faunistic elements, and developed of the periglacial climate since the Pleistocene. The evolution of *Pantholops* has reached the level of genus. *Poephagus grunniens*, the periglacial relic element, retreated to the plateau during the Post-glacial period, its fossils being found in the Pleistocene strata in the northern Asia and Alaska.

In the southeastern margin of the plateau, due to the favorable conditions for a refuge during the glacial periods, many earlier species, such as *Ailurus fulgens*, *Budorcas taxicolor*, *Zapus setchuanus* and many small insectivores which are preserved here at lower elevations may be regarded as thermophilic relics. On the other hand, at present the southeastern margin of the plateau is characterized by such complex topographical and climatic conditions as to become an important centre of distribution of some recent groups, such as *Ochotona* and *Eothenomys*. The ranges of their species more or less overlap here.

We may presume that simultaneous with the retreat of the thermophilic elements and the extending of boreal elements during the Pleistocene ice age occurring in Eurasia, the migration of faunal elements of the Qinghai-Xizang plateau may be more intensive due to the uplift of the plateau. Due to the changes of the environment on the plateau, the sylvan fauna retreated toward the southeastern places of lower altitudes and the steppe and even desert fauna invading from the central and northern Asia has also developed as indigenous cold-alpine species and remained as periglacial relics.

ON MAMMALS FROM SOUTHEASTERN XIZANG (TIBET)

Feng Zuo-jian
(Institute of Zoology, Academia Sinica)

Zheng Chang-lin   Cai Gui-quan
(Northwest Plateau Institute of Biology, Academia Sinica)

This paper presents results of our mammalian survey in southeastern Xizang (Tibet) during May-Sept., 1973. Altogether 498 specimens were collected, and they have been identified as 80 species, belonging to 7 orders, 16 families, and 46 genera. Among them, the number of Oriental species occupy 46.2% in the total number of species, Palaearctic species occupy 37.2%, while the remaining 16.6% consists of widely distributed species.

According to our investigation, the mammalian fauna of the region north of Bomi-Zogang-Markam line and that southward are different; the former region belongs to Palaearctic Realm, while the latter to the Oriental Realm.

The region under consideration is situated at the southeastern border of Xizang (Tibetan) plateau (between 28°20′—31°30′ N, and 94°10′—99°00′), near the western border of the Meridional Ranges (Hengduan Shan), with the Himalayas and Nyainqentanglha Shan meeting here, and this region also adjoins the Indo-China peninsula. The mammalian fauna of this region includes species of the Himalayan-Meridional Ranges in southwestern China, such as *Nectogale elegans*, *Ailurus fulgens*, *Rattus eha*, etc., and also Indio-Malayan components, such as *Aonyx cinerea*, *Callosciurus pygerythrus*, *Mus pahari*, etc. Besides, there are a number of endemic species of Qinghai-Xizang plateau, as *Cervus albirostris*, *Ochotona curzoniae*, *Marmota himalayana*, etc.

With respect to the vertical distribution of mammals, the authors attempt to divide the region into four vertical zones: (1) montane broadleaved forest-coniferous forest belt, (2) montane mixed broadleaved and coniferous forest belt, (3) montane dark coniferous forest belt, (4) montane shrubby meadow. Each zone is characterized by a number of representative species.

STUDY OF MAMMALIAN FAUNA IN MEDO REGION, XIZANG (TIBET)

Cai Gui-quan Zhang Nai-zhi
(Northwest Plateau Institute of Biology, Academia Sinica)

We carried out mammalian surveys in the summer of 1973 and 1977 in Medo region, Xizang (Tibet). Results obtained are presented in this paper.

Situated on the southern slope of the Himalayas, with the Yarlung Zangbo Jiang (Brahmaputra River) passing through from north to south, Medo region has a climate affected deeply by the monsoon, an abundant rainfall and a rich vegetation, presenting sights of tropical seasonal rain forests. Hence the natural features of the region completely differ from those of the northern slopes of the Himalayas and the Xizang (Tibet) Plateau.

Altogether 30 species of mammals were collected during the two surveys, belonging to 14 families and 6 orders. Among them *Sphaerias blanfordi motuoensis** Cai et Zhang subsp. nov. and *Dremomys lokriah motuoensis**Cai et Zhang subsp. nov. are new to science, the former is also a new record of species for China. *Capricornis sumatraensis jamrachi* and *Callosciurus erythraeus sladeni* are new subspecies records for this country. A number of species are new records for Xizang (Tibet) region.

As to the characteristics of mammalian fauna in this region, Oriental components are dominant, but tropical faunal components are also rich to a certain extent.

The faunal composition of this region is vastly different from that of the northern slopes of the Himalayas and that of the extensive Xizang (Tibet) region; whereas it is similar to that of the mountain ranges of the southwestern China, Indo-China peninsula, Nepal and Sikkim (including Bhutan, southern and northern India).

Comparisons of the faunal composition of this region and that of the southern slopes reported by Qian Yanwen and Feng Zuojian (1974) show that the mammalian fauna of Medo region has far more Oriental components than those of the latter, with a great prominence of Chiroptera and Sciuridae.

In accordance with the differences of the climate, vegetation and composition of mammalian fauna, Medo region may be divided into two infraregions: (1)The subtropical evergreen broad-leaved infraregion (1100—2800m alt.) Some Oriental species of mammals inhabiting at higher altitude, such as *Macaca assamensis*, *Ailurus fulgens* and *Dremomys lokriah*, etc. are found present in this infraregion.(2) The tropical rain-forest infraregion (below 1,100m alt.) Most of the mammalian species belong to the Oriental realm, such as

* The new subspecies will be reported in another paper.

Sphaerias blanfordi, *Presbytis entellus*, *Viverra zibetha*, *Muntiacus muntjak*, *Callosciurus macclellandi* and *Mus pahari*, and others.

Owing to the complicated natural conditions, the habitats are varied and the structures of animal community quite complicated. A certain number of mammals dwell separately in various habitats, for example, the haunt of *Callosciurus pygerythrus* of the family Sciuridae is related to the distribution of banana plants, while *C. macclellandi* and *C. erythraeus* almost dwell in the depths of the forests only. On the contrary, the presence of *Dremomys lokriah* is closely related to the distribution of oak forests (*Quercus* spp.). In addition, some species of Chiroptera feed on insects, while the others take the plant fruits as their food. The species of mammals are numerous in this region, but the number of each species is relatively less than that in simple environment, such as the northern Xizang Plateau, where the structure of animal community is not complicated. Moreover, owing to the constant weather, rich food and good shelter conditions, the mammals have no marked migration. This shows not only the effect of environment on mammals but also the adaptations of animals to the environment.

THE EVOLUTION OF BLUE SHEEP (PSEUDOIS NAYAUR)

George B. Schaller
(New York Zoological Society, U.S.A)

The blue sheep (*Pseudois nayaur*) is a typically Tibetan species. It is an animal with physical traits so intermediate between true sheep (*Ovis*) and goats (*Capra*) that taxonomists have had trouble classifying it, although it is generally held that it is an aberrant goat with sheep-like affinitites. Ist he blue sheep behaviorally and ecologically closer to *Ovis* or *Capra*? To answer this question, several species of sheep and goats were studied in Pakistan and the blue sheep in Nepal.

In general, the behavioral evidence, particularly the various aggressive patterns, confirms the morphological evidence that blue sheep are basically goats. Many of the sheep-like traits of blue sheep can be ascribed to convergent evolution, the result of the species having settled in a habitat which is usually occupied by a sheep. Goats inhabit cliffs, whereas sheep prefer less precipitous terrain; blue sheep resemble the Asian snow sheep (*Ovis nivicola*) in that they are found on grassy slopes near cliffs, which are used mainly to escape predators. But blue sheep do more than just show that a presumed change from a cliff to a less precipitous habitat may modify behavior. In many respects, blue sheep remain generalized. The structure and shape of their horns are not quite like those of sheep or goats; their glands are either tenuously present or absent; in certain aspects of behavior, such as in their threat displays, they remain unspecialized. The species has straddled an evolutionary fence, and if it had to make a choice of whether to become an *Ovis* or *Capra* it could become either with only minor alterations. The blue sheep probably split early from ancestral goat stock. A hypothetical precursor from which the sheep and goat line diverged would in many ways resemble a blue sheep in appearance and behavior. That such an animal still survives in Tibet, the probable evolutionary center of many alpine vertebrates, is suggestive.

THE OCHOTONA (LAGOMORPHA: OCHOTONIDAE) OF ASIA

Richard M. Mitchell
(Office of Endangered Species, Fish and Wildlife Service, Department of Interior, U.S.A.)

At least 16 species of *Ochotona* are known to occur in Asia, of which 7 species have been reported from the Qinghai-Xizang (Tibet) Plateau. Since 1956, 5 new taxa (3 species from Nepal and 1 species and 1 subspecies from the Tibetan Region of China) have been described. Some authors think this genus should be divided into three subgenera. I chose to follow Bonhote and divide the genus into three groups (*ladacensis*, *rufescens*, and *curzoniae*) based on the shape of the incisive and palatal foramina. Certain signs of intergradation, or even overlapping, in this character can sometimes be seen in individual specimens.

A very approximate geographic range is given for each species. Altitudinal ranges, preferred life zones and biotopes are briefly discussed and vegetational characteristics of habitats are described. Species attributes which have immediate or potential systematic value are included. A brief description of each species, interesting field notes from published records, natural history observations from Nepal, breeding biology, food preferences and behavorial aspects are also discussed.

Key words: species; groups; distribution; habitat; taxonomic notes; field notes.

OBSERVATIONS ON THE BIOGEOGRAPHY OF THE TIBETAN PLATEAU AND ADJACENT HIMALAYAN RANGE AS REPRESENTED BY BIRDS

S. Dillon Ripley
(Smithsonian Institution, Washington, D.C.,U.S.A.)

Consideration of the structure, geography and orogenics of the Tibetan Plateau reveal three main regions through which birds are dispersed; the northern xeric Tibetan Plateau proper, an arid high-altitude zone, related ornithogeographically to the Palaearctic Region, a middle zone encompassing the main east-west chains on inner Himalayan ranges, bisected by important river systems, and the main Himalayan range. The latter, forming the principal zonal boundary between China and the lands to the south of the main range, serves also as a highly important zoo-geographic boundary, due to the climatic control exercised by the rain shield action of the immensely high ridges of mountains, and their effect on the annual prevailing rainfall patterns of the monsoons.

In certain areas, the ridges are at lower levels, or bisected by tilted plateaux, as in northern Nepal (Dolpo and Mustang), and here there is an interesting mix of Palaearctic and Indochinese fauna, complicated by the presence of a persistent relict fauna. The Himalayan range itself declines in elevation in the eastern part, where the mountains approach the north-south axis of folding and synclinal activity, postulated by most geologists as the eastern end of the Himalayan upthrust. Here a complex of rivers penetrate the abruptly-folded hills, ranging from the Brahmaputra and its feeder rivers, east to the Salween and Yangtse. The immense erosion and northward-moving action of these river systems, has aided in penoetrating the mountains in a northward creep, adding further complexity to the present intermixing of Indochinese and northerly faunal and floristic elements. Southeastern Tibet, so-called, marks a richly varied, at times subtropical zone, where temperate and subtropical forms meet. Most workers feel that this area, ranging from Bhutan through northern Arunachal Pradesh and southeast Tibet to the northern tip of Burma, and Yunnan and southern Sichuan is the most interesting and least understood area of active speciation in Asia. From the days of the botanical explorers to the present, the complex and rich evolutionary picture remains to pose many problems which the underlying geological events help to compound in their own complexity. Surely the paleozoogeographic history will still yield many facts which should help to complete our understanding of the meteorological as well as geological recent history of this important distribution center.

Some tables of the bird fauna will reveal proportional representation of tropical Indochinese elements as against the pressure of northern representatives of bird fauna, from Palaearctic as well as temperate Chinese sources. Additionally there is an old evolutionary element, perhaps derived from Miocene times of residual Tethyan humid conditions, during an early phase of mountain-building. Some evidence has been presented by Indian zoogeographers in related classes of animals and plants, of the presence of Himalayan refugia during Cenozoic and late Pleistocene climate fluctuations. Such refugia seem to have provided opportunities for persistence of early-evolved forms such as pheasants, among birds, as well as Tethyan relicts. Present climatic shifts, east to west also demonstrate the existence of barriers which create breaks in the species distributions, forming recognizable subspecies zones illustrating ecological rules-of-thumb, such as Gloger's and Bergmann's hypotheses.

ON THE GALLIFORMES OF THE QINGHAI-XIZANG (TIBET) PLATEAU

Christopher Savage
(World Pheasant Association, England)

The Galliformes of Xizang (Tibet) are of interest and importance to the world (and in particular to the World Pheasant Association) for three main reasons:

- the Galliformes are important sources of protein throughout the world for human consumption; in terms of the World Conservation Strategy, preservation of genetic diversity of such species is of high priority; nearly all the wild forms are now rare in the wild if not endangered with extinction;
- the Galliformes of Xizang, thair evolution and ecology, are as yet little known and clearly very different from those of species which have been studied intensely elsewhere;
- the Galliformes of Xizang are birds of great beauty which till now have been known mainly from Chinese art and from a few birds introduced to zoos mostly in the XIXth Centuary.

Recent work in the Himalayas and discussions at the First International Symposium on Pheasants held in Kathmandu, November 1979, throw some light on the Galliformes of the outer Plateau of Qinghai, the characteristics of which are distinct from those of the moister Eastern Plateau. The species of particular interest were:

The snowcocks—Genus *Tetraogallus*

The blood pheasants—Genus *Itnaginis*

The tragopans—Genus *Tragopan*

The monals—Genus *Lophophorus*

The eared pheasants—Genus *Crossoptilon*

The ecology, distribution and evolution of these species can now be pieced together as will be shown, but much more needs to be known of the climate, geology and vegetation of the region before conclusions can be drawn. It may be noticed, for example, that in the Western Himalayas the genera *Tragopan* and *Lophophorus* are restricted to the southern (moist) side of the mountain chain except where the great rivers have allowed penetration such as up the Sutlej Valley. Further east near the start of the eastern Ptateau, the pattern is reversed and the moister slopes where the pheasants are to be found are north facing. The genus *Crossoptilon* is to be found only to the north of the mountain chain.

The conditions of the region have resulted in very considerable geographical variation within species. This is not unusual and can give clues to differences in ecology which may be important when consideration has to be given to relocations or reintroductions. The experience of the World Pheasant Association suggests, however, that the study of the wild birds in life, in the wild and in captivity, can quickly produce information of practical values for conservation. The World Pheasant Association is ready to collaborate in any way possible to advance such research.

ON THE VERTICAL DISTRIBUTION OF BIRDS ON THE NORTHERN AND SOUTHERN SLOPES OF HIMALAYAS

Wang Zu-xiang
(Northwest Plateau Institute of Biology, Academia Sinica)

The Himalayas, rising in the violent orogenesis since Miocene epoch, are the highest and the largest mountains in the world. Standing along the southern rim of the Qinghai-Xizang (Tibet) Plateau, they extend for about 2,400 kilometres from Mount Nanga Parbat of Kashmir (8,126m) in the west to Mount Nangabawa (7,756m) at the big bend of Yarlung Zangbo Jiang (Bramaputra River) in the east. The average height of these mountains is more than 6,000 metres. The monsoons blowing up from the Indian Ocean have been blocked by the string of lofty Himalayan peaks. As a result, the natural landscape of the northern slopes is completely different from that of the southern slopes and the distribution of plants and animals are affected tremendously.

Since liberation, especially in recent years, Chinese scientists and institutions organized by Academia Sinica have successively and systematically investigated the birds of Xizang (Tibet). Emphases have been put on Himalayan region. There are 274 breeding species and 23 breeding subspecies recorded in this region, belonging to 43 families and 16 orders, of which there are 95 Palearctic species, 130 Oriental species, 17 endemic species, 27 species widely distributed in both Palearctic and Oriental realms and 5 species of uncertain affinity.

Through comparative studies, the author has found that the birds in Himalayan region occupy more than 70% of the total number of species (473 spp.) recorded from Xizang(Tibet). The bird species on southern slopes are rather abundant, found in tropical and subtropical forests. Among them a certain number of Palearctic species are found to occur on the higher slopes. On the contrary, the northern slopes of the Himalayas are relatively poor in birds. Most of them are alpine and steppe species belonging to Palearctic Realm.

In accordance with differences in avifauna and natural landscape, the Himalayas are divided into four regions: Eastern Xizang(Tibet) Mountain Region, Southern Xizang (Tibet) Mountain Region, Danglong-dawang Region and Medog-qirong Region. The former two regions belong to Palearctic Realm, while the latter two to the Oriental Realm.

The Himalayas have risen to a great height and the vertical differences of the natural landscape are unusually pronounced. With the changes of the natural landscape, the vertical distribution of birds is correpondingly affected.

The southern slopes of the Himalayas may be divided into four vertical zones: Zone of montane broad-leaved evergreen forests, zone of montane broad-leaved and coniferous mixed forests, zone of montane dark coniferous forests and zone of alpine shrubby meadows. According to the composition of avifauna, the birds found below 2,600 metres are all Oriental species. The birds found to occur between 2,600—3,200 metres are in the transition zone between Palearctic and Oriental regions. Those above 3,200 metres belong to Palearctic Realm.

The northern slope may be divided into three zones: Zone of montane coniferous forests and shrubs, zone of plateau steppe, and zone of alpine meadows.

Although one or two Oriental species are distributed along the valleys and up along the northern slopes, the avifauna, as a whole, is found to belong to the Palearctic Realm

Owing to the adaptations to the harsh environment over a long period of time, some species have gradually become specialized as endemic species of the plateau.

ON DISTRIBUTION OF TIMALIID SPECIES IN XIZANG (TIBET) AND THEIR ADAPTATIONS TO THE PLATEAU

Li De-hao

(Northwest Plateau Institute of Biology, Academia Sinica)

Subfamily Timaliinae is representative of the Oriental Region. In Xizang (Tibet) Plateau, studies of the distribution and adaptations of this group are quite important in the understanding of the development history of the fauna of Qinghai-Xizang (Tibet)

Plateau.

There are 58 Timaliid species (with 11 subspecies in addition) heretofore recorded from Xizang (Tibet), occupying 44.6% of the total number of Timaliid species recorded from all China.

The distribution of Xizang Timaliinae is quite related to the plateau uplift. About 90% of the species and subspecies are found dispersed over rim regions of the plateau, but there are a number of species and subspecies, about 10% of the total, found in the hinterland of the plateau. Based on the differences in geographical distribution, the Timaliinae of the Xizang plateau may be divided into three district groups.

1. Forms found in the Indian-Himalyan Area. About 77% of the total number of species and subspecies of the Xizang Timaliinae are distributed in the southern rim of the plateau, which may be called Indian-Himalayan Area. Of these thrusts, 75% are found between 200 and 2,000m alt., constituting the typical distribution pattern of the inferior rim of the plateau. Furthermore, there is no subspecific differenciation to be detected between the subspecies found in this area with those in the adjacent districts. This shows that these birds are native inhabits of the rim region of the plateau at a lower altitude. They vertically migrate to the higher places of the plateau only in summer as well as this area having transitionary geographical and ecological conditions with those of adjacent districts. There are no sharp geographical isolation between them.

2. Forms found in the Heng-Duan Range. They constitute 20% of the total number of forms of the Xizang Timaliinae, being less in number than those of the above-mentioned group. This group are generally dispersed over the plateau at an altitude higher than 3,000 m. Because the most varied topographical as well as ecological conditions in this district, the subspecific differenciation of the thrusts is comparatively complicated. Some subspecies are similar to those of neighbouring districts, while the others have adapted themselves to the plateau environment. Even the endemic species of this district, such as *Babax kozlowi*, *Garrulax ellioti*, etc. exhibit subspecies differenciations also. There are a few endemic species in Xizang (Tibet) and most of them are confined to this district. This shows that the said district has a longer geological history and is more strongly influenced by conditions of the plateau.

3. Forms found in the basin of middle reaches of Yarlung Zangbo Jiang. The avifauna of this district is relatively impoverished, occupying only 39% of the total number of species and subspecies in Xizang (Tibet). There are some species and subspecies similar to those of the above-mentioned districts, while other birds are endemic species confined to this district, such as *Babax waddelli*, which also has subspecific differenciation.

The adaptations of the Xizang Timaliinae to the conditions of the plateau may be given below.

1. The Xizang Timaliid birds, especially those subspecies found in the Indian-Himalayan Area, have seasonal habits of vertical migration. Generally, they live at the altitude below 2,000m, but in the summer may migrate up to 3,800m. A few species may even reach 4,200m.

2. The body feathers of these birds show a distinctly dull colour, which may ab-

sorb more light and heat, and reduces or weakens ultraviolet radiations in high altitudes.

3. The body feathers and the barbs become elongated for keeping body temperature more independently from the environment influences.

4. The bird's body becomes enlarged and the body weight becomes also increased, the accumulation of fats in the body serves to conserve more heat.

5. Owing to a decrease of animate foods on the plateau, especially in the winter, the feeding habits of most birds become omnivorous, while the birds inhabiting lower altitudes are mainly zoophagous.

ORIGIN AND EVOLUTION OF SCHIZOTHORACINE FISHES IN RELATION TO THE UPHEAVAL OF THE XIZANG PLATEAU

Cao Wen-xuan   Chen Yi-yu
(Institute of Hydrobiology, Academia Sinica)

Wu Yun-fei   Zhu Song-quan
(Northwest Plateau Institute of Biology, Academia Sinica)

Having investigated the origin, evolution and distribution of Schizothoracine fishes with the viewpoint that organisms live in conformity with their environments, the authors elucidate the congruity between the phylogeny of Schizothoracine fishes and their adaptation to the environmental conditions of the Plateau. Morphological, paleontological and zoogeographical evidences demonstrate that these fishes arose from primitive barbine fishes distributed over the area of Xizang during the late Tertiary period. Schizothoracine fishes constitute a natural group which has adapted itself to the special conditions of the Plateau. According to the modifications of scales, pharyngeal teeth and barbels, the eleven genera of the subfamily Schizothoracinae can be divided into three grades with different degrees of specialization, representing three developmental stages during the course of evolution. Based on the degree of specialization of the oropharyngeal organs, each grade may be subdivided into a trunk genus and several branch genera. Moreover, the trunk genus of the lower grade could further evolve to form the next trunk genus of a higher grade, which in turn would give rise to certain branch genera of the corresponding grade. The orderly succession of the morphological characteristics and the distribution in altitudes of the trunk genera signifies that evolutionary course, having been in close connection with the marked environmental change (mainly with reference to temperature) caused by violent upheaval of the Plateau, passed through three times of leaps from the primitive to the specialized types. Within each grade, the evolution of the trunk genus into the branch genera was the result of divergence in food habit and took place gradually in a relatively stable environment. From this it may be inferred that the upthrust of the Xizang Plateau since late Tertiary was passed through alternate violent uplifts and relative stabilities thrice, and after each violent uplift the height attained by the Plateau was, in a general way, commensurate to the altitude colonized by the corresponding trunk genus which is still in existence.

NOTES ON THE SCALELESS LOACHES (NEMACHILINAE, COBITIDAE) FROM THE QINGHAI-XIZANG PLATEAU AND ITS ADJACENT TERRITORIES

Zhu Song-quan
(Northwest Plateau Institute of Biology, Academia Sinica)

The scaleless loaches from the Qinghai-Xizang Plateau and its adjacent territories are characterized by the total absence of any scales. They fall into three genera *Oreias* Sauvage, *Triplophysa* Rendahl and *Hendinichthys* Rendahl, belonging to the subfamily Nemachilinae of Cobitidae, while the genus *Hendinichthys* includes two subgenera, the nominative subgenus *Hendinichthys* and the new subgenus *Qinghaichthys*.

However, several ichthyologists have referred many scaleless loaches to the genus *Nemachilus* van Hasselt. Evidence from a critical examination of the fishes of *Nemachilus* and the scaleless loaches was adduced in support of the conclusions that the two groups are very distinct from each other. The important distinction lies in the small scales which are present in *Nemachilus*.

The physical factors governing the life of scaleless loaches in the Plateau were discussed and it is shown that these loaches are adapted to their respective streams. The characteristics of the scaleless loaches are examined and their closed correlation with envisronmental factors of the Qinghai-Xizang Plateau is indicated.

The geographical and vertical distributions of scaleless loaches are given and it is indicated that they reach as high as 5200 m, the highest altitude attained by the fishes distributed all over the world.

The origin of *Oreias*, *Triplophysa* and *Hendinichthys* was demonstrated. The genus *Oreias* is derived from *Nemachilus*, whereas the genus *Oreias* is the ancestor of *Triplophysa* and *Hendinichthys*.

APPROACH AND PRACTICE OF IMPROVEMENT ON FISH FAUNA IN QINGHAI-XIZANG (TIBET) PLATEAU

Zhao Li-hua Chen Yuan Zhang Yu-shu
(Northwest Plateau Institute of Biology, Academia Sinica)

On the Qinghai-Xizang (Tibet) Plateau there are many lakes and reservoires which may be the acceptable habitats for many species of fishes. Owing to the geographical and ecological isolation, the fish fauna in this area is mainly made up of Schizothoracinae and *Nemachilus* (*Nemachilinae*) fishes. The fishery development in these water bodies was prevented by the slow growing of the local fish, so it is considered quite an important task to improve the fish fauna of the Qinghai-Xizang (Tibet) Plateau.

During the past twenty years, some efforts have been made in improving the fish fauna in three types of different water bodies by introducing fishes into this area. It was successful when *Cyprinus carpio*, *Carassius auratus*, *Hypophthalmichthys molitrix*, *Aristchthys nobilis* and *Ctenopharyngodon idellus* introduced into the fresh-water Koluke lake. The results show that *Cyprinus carpio* and *Carassius auratus* have grown faster than the native and other nonnative fishes. The same fishes were introduced into some reservoirs in the eastern agriculture area of the Qinghai Province, where the growth rate is lower than that in water bodies on the plain because the fish have stayed all the year round at lower temperature below 20℃. The experiment, however, failed when *Cyprinus*, *Carassius* and *Mugil soiug* were introduced into the brackish Qinghai lake.

The success of introducing fishes into the Koluke lake shows that the fish fauna of the Qinghai-Xizang (Tibet) Plateau may be improved. The populations of introduced fishes, especially those of *Cyprinus* and *Carassius*, increase rapidly in number after being adapted to the plateau environment, with the population of local fish reduced in competition with the introduced fishes. Based on the results of the experiments of improving fish fauna of the plateau, it is shown that the characteristic features of environmental factors, such as topography, climate as well as physico-chemical and biological factors in different water bodies of the plateau are important. The distribution of the fishes is mainly limited by low temperature, food sources, and the salt contents in different water bodies.

HIGH ENDEMISM AND ECOLOGICAL SPECIALIZATIONS OF LEPTOMIAS FAUST (COLEOPTERA: CURCULIONIDAE)

Chao Yung-chang Chen Yuan-qing
(Institute of Zoology, Academia Sinica)

Leptomias is a typical high-altitude genus of the Himalayan region. Its outstanding peculiarities are high endemism and the pronounced ecological specializations.

So far, the genus comprises 93 species of which 45 are described from the Qinghai-Xizang plateau district by the writers(1980). Of the 93 species, 58(56+2) are distributed over the Xizang district of the Himalayan region, 19(21-2) over other countries or districts of the Himalayan region, and 16 are dispersed over regions or counties other than the Himalayan region. All of the 58, 19 and 16 species are endemic to their respective regions. Though there are five species found on both the northern slope and the southern slope of Himalaya; yet they are endemic to a narrow area, including both a part of the northern slope and a part of the southern slope of Himalaya, as their recorded localities are approximate, and there is actually no barrier at all to prevent them from intermingling with each other.

The 52 Xizang species out of 58 with the both horizontal and verticle distributional data are distributed over three zoogiographical subregions, *i.e.*, the Southern Xizang Subregion, Eastern Xizang Subregion(including Nyingchi and Qomdo districts)and Southeastern Xizang Subregion. All the species in each Subregion and in each altitude are endemic. But there are six species which are found present in two or three subregions.

With respect to ecological specializations, are dealt with a few morphological features of the *qomolangmaensis* species-group and the *kindonwardi* species-group which are particularly sensitive to environmental conditions.

Judging from the morphological features of *qomolangmaensis* species-group, we may see that the *qomolangmaensis* species-group adapt themselves specifically to the drastic high-altitude environmental conditions under which they live. They are characterized by having dark body coloration and small body size. The dark pigmentation, by its absorption of radiant heat, is important to alpine animals in connection with the increased proportion of ultraviolet radiation. The small size of body enables the high-altitude insects to effectively reach the sheltered niches and may perhaps be related with the scanty of food supply under high-altitude conditions.

On the contrary, the adaptations of the *kindonwardi* species-group may be seen in their foliage-freqenting habits accompanied with their gay body coloration. As they are apterous, flightless and slow in movements, they have to adopt protective measures by harmonizing themselves with their natural surroundings so as to render them inconspicuous and easier to escape from their enemies. This is apparently a specialized type of struggle for existence in the case of the broad-leaved forest insects to their particular environmental conditions.

Regarding the structural specializations in relation to the prothorax and elytra, most species of *Leptomias* possess a carina at the base of elytra. But in all the species of the *qomolangmaensis* species-group, two species of *aeneus* species-group and one species of *longicollis* species-group, there is no carina at the base of their elytra. The carina atrophy might be associated with their life habits under stones. There is a tubercular prominence on the anterior edge of the lateral sides of prothorax in such species as *L. aeneus*, *L. longisetosus*, *L. opacus* and *L. crinitarsus*. As these species fall under different unrelated groups, this structure is apparently not derived from a common origin, but independently acquired in the process of adaptive convergence. In all the three species of the *thibetanus* subspecies-group of *squamosetosus* species-group, and two of the three species of *crinitarsus* species-group, there are two deep foveae on each side of the median furrow of the prothorax. In the two species of *acutus* species-group and the one species of genus *Xizanomias*, both distal portions of the basal carina of the prothorax and elytra are greatly raised and projected at both ends. Likewise, the two above-mentioned structures may be considered as examples of convergence. But what are the particular environmental conditions to which these structures adapt themselves? It is hard to say.

In addition, most species of the genus occurring in the Qinghai-Xizang plateau district are clothed with fine and pointed hairs and covered with feathered scales on the lateral sides of prothorax and ventrites of abdomen, while those species from other parts of China clothed with scale-like hairs truncate at their apex, and covered with no feathered scales or at most with rudimentary feathered scales. These are two more examples of special adaptations.

ADAPTATIONS OF GRASSHOPPERS AND LOCUSTS IN THE QINGHAI-XIZANG PLATEAU

Yin Xiang-chu

(Northwest Plateau Institute of Biology, Academia Sinica)

Grasshoppers and locusts are important pests in the pasture of the Qinghai-Xizang Plateau. Up to the present, 172 species and subspecies of grasshoppers and locusts have been recorded from the Qinghai-Xizang region. Among them 82 species are endemic. The physical features of the plateau are high altitude, harsh winds, low air pressure, low air temperature, highly variable weather, short growth period and sparse vegetation. The plateau adaptations of endemic species may be described below.

1. Elytra and wings degenerating or entirely lacking: Apterus-32 species, 39.0%; elytra lateral-23 species, 28.0%; abbreviate elytra and wings-18 species, 22.0%; longipen-

nate-9 species, 11.0%.

2. Sound organ degenerating or entirely lacking: With the degeneration of elytra and wings, sound organs have correspondingly degenerated. 45 species are short of sound organs (54.9%); 37 species possess sound organs (45.1%).

3. Tympanum degenerating or entirely lacking: The degeneration of sound organs leads to the degeneration of tympanum. Tympanum is found present in 51 species (62.2%) and lacking in 31 species (37.8%).

4. Body becomes smaller in size: Small form-55 species, 67.1%; medium form-20 species, 24.4%; large form-7 species, 8.5%. With the altitude rising, the size of body of any species becomes smaller.

In part of endemic species, the arolia of tarsus have increased in size and the lateral lobi of pronotum have projected and changed into alae. The increased arolia produce a cushioning effect and the body adds buoyancy with alae. This is favourable for the grasshopper touching the ground after jumping.

In addition, there is a yearly generation in the endemic species and diapause is possible. Protective colorations of the endemic species of the plateau are more intense than that of the species found on the plains.

The process that the longipennate species evolved as the apterus species needs a long period of time, therefore, the apterus species may be an indicatory animal which shows the early time of rising of the distributional locality.

In a word, with the plateau rising, endemic species have adapted themselves to the natural conditions of plateau in a long period of time. The changes of natural conditions of plateau induced variations of species which have gradually evolved as endemic species of the plateau.

THE ORDER ZORAPTERA AND ITS GEOGRAPHICAL DISTRIBUTION

Huang Fu-sheng
(Institute of Zoology, Academia Sinica)

The author collected specimens of the zorapterans from the districts of Zayu and Medog of the southeastern Xizang during 1973—1975 and also samples of winged forms from Medog in 1974 and 1975. The author described *Zorotypus sinensis* Huang in 1974 which is the first record of Zoraptera in China, and *Z. medoensis* Huang in 1976.

Up to the present, there are 27 species of Zoraptera known. Most of them are distributed over the tropical rain-forest and monsoon forest regions between the Tropic of Capricorn and the Tropic of Cancer. Some of them are endemic in Central and South Americas, whereas others are found to occur in Africa including Ghana, Congo, Madagascar and Mauritius. A few of them occur in Fiji and Hawaii of the Pacific Ocean. Owing to the fact these insects are adapted to conditions of high temperature and moisture, so they are distributed in maritime districts of continents and islands, Geographically speaking, the entire Zoraptera order have an extensive distribution. In both eastern and western hemispheres, there are many areas where these insects are distributed. But the distributional ranges of different species of this order are rather limited. This phenomenon indicates that the Zorapterous insects are not capable of wides dispersion. All the Zorapterous insects living on an island undoubtedly belong to a species peculiar to that island. The origin and evolution of the insects of this order are related to geographical continental changes. Thus continental drifts are considered to have favorable influences on the evolution of Zorapterous insects.

The Zorapterous insects are found distributed on both sides of the equator between the Tropic of Capricorn and the Tropic of Cancer. But there are 3 exceptions; one is *Zorotypus hubbardi* Caudell which is found to occur at 40°N. lat. in U.S.A. and the other two are Z. *sinensis* Huang and Z. *medoensis* Huang in the southeastern Xizang where the climate is warm and moist though both species are located at high altitude. The latter two species are distributed more northward than all known species of South Asia. One supposes that species of Zoraptera became dispersed northward in periods of warm climate and recede to regions southward of northern latitude 15° during the glacial epoch.

But the Zorapterous insects of Southeast Xizang probably survive because of the fact that the Himalayas might have the effect of preventing the insects from being eliminated by the cold climate.

The two species are very much alike in structural features and they are thus considered as closely related species. The distance between their distributional ranges is only 200 kilomestres but as far as know the two species are never overlapping in distribution. It is assumed that these Zerapterous insects are originated from a common ancestor living in the broadleaved forest area of a low elevation. When the area of Xizang became uplifted due to the orogenic movement of the Himalayas, the ancestral forms evolve as different species in different localities through geographical isolation.

ADAPTATIONS OF XIZANG INSECTS TO PLATEAU CONDITIONS

Huang Fu-sheng
(Institute of Zoology, Academia Sinica)

Owing to successive uplifts, the plateau of Xizang presents tremendous differences in altitude. The difference in climate, soil and vegetation at different altitudes of the plateau exert influences on the insects in their living and breeding.

The natural enemies threaten insects existing in the ever-green broadleaved forests of low altitudes, which possess a stable environment, warm-moist wearther and rich food. The small insects are attacked by middle-sized insects and large animals attack all the insects. At the same time, the small insects endanger larger insects and animals with parastism and infective diseases, etc. The insects also compete with each other and as a result, they develop variations. Therefore the adaptations of the insects of low altitudes are mainly developed to defend against natural enemies.

The antithesis between breeding and harsh climate is the main contradiction of the plateau insects. The Xizang plateau gradually rises with the orogenic movements. Then the ecosystem change, the climatic conditions becoming increasingly harsh. Quite a number of the insects are eliminated as they are not adapted to the environmental conditions after the uplifting of the plateau. The remaining insects adapt themselves to the environment and become dominant on the plateau. The ability to protect themselves from the adverse circumstances and harsh climate is, therefore, one of the principal aspects of evolution.

1. Colour blackening: The blackening of the body colour is an adaptation of the plateau insects. The body colour of the plateau butterflies, moths, and locusts is darker than that of similar species of low altitudes. Even individuals of the same species exhibit different shades of colours in different altitudes. The blackening of the body color not only guards against the injury of strong ultraviolet rays but is also capable of absorbing heat of the sun. The blackening of body coloration enables plateau insects to complete their life cycle in a shorter time.

2. Body size: The insects inhabiting the plateau are generally small in size, as smallness of the body size is advantageous to the flying of insects on account of the thinness of air on the plateau. There are no insects of considerable size on the plateau.

3. Pile: The insect species of the plateau hava a denser clothing of hairs than species found on the plain. Some underground insects have only a few hairs covering their bodies.

4. Habits: Owing to the coldness, dryness and other harsh climatic conditions, the majority of the insect species on the plateau are found underground. The underground species of Xizang occupy 50% of the agricutural pests.

5. Degeneration of wings: Though some of the insect species of the plateau develop wings, yet their flying is very weak, for example, *Gyaephora* app. In case of most plateau insects, wings tend to degenerate, and in a number of cases, wings have completely degenerated.

With regard to the subfamily Galerucinae, there are two groups. One group consists of *Geinella*, *Geinula*, as for example, *Geinella nila* (Maulik) and *Geinula jacodsoni* Ogl. These galerucid beetles are characterized by strong plasticity, strong adaptation, degeneration of both anterior and posterior wings. Most of them become evolved as endemic species of the shrub-steppe of the plateau. Though their wings have degenerated yet they are numerous in number and become dominant members of the plateau. The other group consists of *Galeruca*, as for example, *G. rutoga* Chen et Jiang. They are characterized by a narrow rang of variations. There are three species of the genus *Galeruca* collected from Rutog district, North-west Xizang plateau (5100 m alt.). They are small-sized and dark-brown beetles, having two pairs of complete wings. When these beetles are alarmed, they do not fly. It is probable that their wings serve to preserve warmness and moistness in the cold and dry plateau.

The above-mentional aspects are some of the adaptations of the insects to the environmental conditions of the plateau. The insects possess inexhaustible potentialities of variations. Variations offer ample material for natural selection and it is natural selection which acts as the principal motive of evolution.

THE CONTINENTAL DRIFTS AND THE ORIGIN OF THE INSECT FAUNA

Huang Fu-sheng

(Institute of Zoology, Academia Sinica)

The present paper attempts to discuss the correlation between continental drifts and the origin of the insect fauna.

Wegener's theory of continental drifts proposes that the present continental pattern is the result of continental drifts over a long period of time. At the present time, many scientists insist that the continental drift exerts a tremendous influence on the animal distribution. (Croizat, et al.). Different species of insects are intermingled with each other, when they are in the same continent. The insects maintain interchanges through the following channels.

1. Separating and drifting of continents;

2. Spreading and migrating of insects themselves.

Some of the recent writers claim that the formation of Xizang plateau is the result of Indian tectonic plate drifting northward and plunging into the Eurasian tectonic plate.

The insects of the Xizang area were presumably derived from those inhabiting the northern Eurasia and those on the Indian tectonic plate.

The Xizang area underwent sudden uplifts due to the orogenic movements of Himalayas at the end of Pliocene. This area rose up to an elevation of 2000 metres in the early Pleistocene (Q_1) and up to an elevation of about 3000 metres in the Mid-Pleistocene (Q_2). The insect fauna of this period possessed many members as those now found present on the southern slope of the Himalayas. The Xizang plateau was uplifted again in late Pleistocene (Q_3) and possessed an average elevation of 4500——5000 metres by now. The Himalayas provided a great natural block against the Indian monsoon. The climate of the plateau became cold, with low pressure and strong ultraviolet rays. These conditions exerted a tremendous influence on the development of the insect fauna. Some insects were eliminated while others became adapted to the new environment with new vitality. Different climatic conditions led to differentiation between the insect fauna on the southern slopes and that on the northern slopes of Himalayas.

When the uplift of the Xizang area occurred during the Quaternary period between the glacial and interglacial eras, influences were exerted on the insect fauna again and again. Genus *Angaracris* is a northern genus. During the glacial era the species of the genus gradually migrated to the south due to the cold threat and intruded into Xizang. When the temperature went up again during the interglacial era most species of the genus migrated northward. Others remained in Xizang plateau and evolved into the endemic species of Xizang, as for example *Angaracris morulimarginis* Huang. Genus *Leptomias* possesses numerous species. Most species of the genus are distributed along the banks of Yarlung Zangbo River. The genus came into being after the uplift of the Xizang plateau. These beetles are adaptive to cold climate. In the glacial era, most of them still existed on the plateau, and in the interglacial eras, some of them spread in a northeastern direction, others in a northwestern direction. The northeastern ones intruded into the inland of China and the northwestern ones spread to the centre of Asia. When the glacial era came again, most of these beetles retreated toward Xizang plateau again. But few of the species still remained in their original area and evolved as endemic species.

Each continent of the world possesses its own natural landscape and biological community. Each area has its own peculiar species and genera. The continents may have certain classes, orders, families and genera in common. It is probable that certain species of Asia may have similar ones in Africa or other continents. The occurrence of similar groups indicate that although the continents are far apart now, they had once joined together. The subfamily Lithidinae and the genus *Merilia* are mainly distributed in southern Africa but their allied groups are discovered in Xizang and Indian subcontinent. They have undoubtedly a common origin. Their ancestries might have stemmed from the same continent —— Gondwana. Since the Cretaceous period, the Indian tectonic plate had drifted to the north after having been separated from Africa. Their ancestries were then separated into two groups. One group remained in Africa, and evolved as the African group, while the other group drifted northward to the southern Asia, and has evolved as the Xizang and Indian group.

If the insect faunae distributed in two separate continents show similarities only with respect to the higher categories and the similar groups are more primitive in origin and fewer in number, these continents could have separated at an earlier period and for a longer time. When the insect faunae distributed in two continents show similarities not only in higher but also in lower categories and the genera or even species are similar to each other, these two continents could have separated at a later period and for a shorter time. All continents have an origin in common. They might have evolved from a single continent, i. e. pangaea. That continent might become then separated and transformed into a number of continents and the insect might thus become differentiated with the continental sepraration.

NOTES ON SOME ECOLOGICAL AND FAUNAL FEATURES OF BRANCHIOPOD CRUSTACEA OF THE XIZANG PLATEAU

Jiang Xie-zhi (= Chiang Sieh-chih)
(Institute of Hydrobiology, Academia Sinica)

Branchiopod Crustacea from various regions in the Xizang Plateau are reported in this present article. The material is chiefly based on collections made by the author's colleagues, members of the Comprehensive Scientific Expedition of the Qinghai-Xizang (Tibetan) Plateau during 1966, 1973—1976. Only 3 species of Anostraca representing 3 families and 3 genera, and 56 species of Cladocera representing 6 families and 24 genera, are at present found in the Xizang Plateau. Among them, *Chirocephalus spinicaudatus* var. *chyzeri*, *Diaphanosoma perarmatum*, *Daphnia pamirensis* and the male of *Daphniopsis tibetana* are recorded for the first time from China, and *Simocephalus himalayensis* and *Alona aliensis* are probably new species.

An ecological analysis of Branchiopod fauna of the Plateau is chiefly based on two main environmental factors, *i. e.*, type of habitats and the altitude above the sea level. The results may be shown below. (1) The species which are distributed in rivers and their branches may also be seen definitely in lakes, permanent ponds or shallow pools. (2) The species of Anostraca are only found from lakes and pools, but most species of Cladocera inhabit the small bodies of till-water, such as temporary pools and depressions or permanent ponds. But the genus *Bosmina* seems to be suitably adapted to the lakes only. (3) Few species of Branchiopoda, especially of Anostraca prefer halophilous habits. *Artemia salina* is a typical example, as its distribution seems to be strongly influenced by the salinity of the medium. Meanwhile, it must be pointed out that *Artemia salina* is recognized as a relict species occurring in northern Xizang. This is of significance as it may be correlated with the formation and uplift of the Plateau. (4) The widespread and strongtolerating species of Branchiopoda in the Xizang Plateau are *Branchinecta orientalis*, *Daphnia magna*, *Scapholeberis kingi*, *Simocephalus vetulus*, *S. vetuloides*, *Ceriodaphnia quadrangula*, *Macrothrix rosea*, *Eurycercus lamellatus*, *Alona afflnls*, *A. guttata*, *A. costata*, *Alonella excisa* and *Chydorus sphaerlcus*.

With respect to the vertical distribution, a preliminary analysis may be made. (1) All species of Anostraca are distributed within the limits of 4000—5000 m alt. above the sea level. (2) Most species of Cladocera, such as the vast majority of Daphniidae and Chydoridae are found to occur continually at the altitudes from 2000 to 5000 m. Only the endemic species, *Daphnia pamirensis* and *Simocephalus himalayensis* are distributed more than 5000 m alt. above the sea level. Moreover, few species, auch as *Daphnia ob-*

tusa, *Bosmina longirostris* and *Oxyurella tenuicaudis* are found below 2500 m. alt. above the sea level.

So far as the two groups of Anostraca and Cladocera are concerned, they are principally composed of four major elements, cosmopolitan, palaearctic, oriental and endemic, the first two elements comprising a larger proportion. Besides, it is noteworthy that the Cladoceran fauna is characterized by the extension of the southern derivatives, such as *Scapholeberis kingi* and *Ceriodaphnia cornuta* to the northern parts of Xizang.

A ZOOGEOGRAPHICAL ANALYSIS OF THE ROTATORIAN FAUNA OF THE QINGHAI-XIZANG PLATEAU

Gong Xun-ju

(Institute of Hydrobiology, Academia Sinica)

This paper summarizes the results of surveys on the rotatorian fauna of the Qinghai-Xizang (Chinghai-Tibetan) Plateau during the expeditions of 1966 and 1973—1976. Altogether 208 species have been identified, of which 96 taxa, including *Notholca tibetica* sp. nov., *Testudinella magna* sp. nov. and *Notholca acuminata cincta* ssp. nov. are recorded in China for the first time.

The rotatorian fauna of the Plateau consists of four components: ubiquitous species, austral species, boreal species and endemic species.

Ecologically, they are freshwater forms which there are moss-dwelling, planktonic and benthic-periphytic forms. There are a few species being belonged euryhaline forms. Besides, certain species are thermophilic, inhabiting in warm or even hot (60℃) springs. *Lecane nana* (Murray) is more abundant than *Colurella adriatica* Ehrenberg and *Lecane luna*(Müller) among the thermophilic species.

The number of rotatorian species as well as the abundance of the individuals decreases gradually from the forest zone at low altitudes (830—4000 m alt.) to the desert region of a high altitude (over 4800 m). Rotatorian fauna of the southeastern part of Xizang is different from that of northwestern part. The former is characterized by the presence of more numerous species and, at certain places, of austral species such as *Pedalina mira* (Hudson) and *Anuraeopsis fiss* (Gosse), which are absent from the latter part. The number of rotatorian species decreases gradually from Ngari (Ari) to the northern part of Xizang; the latter has only one-third of the number of rotatorian species as compared with that of Eastern Xizang.

The faunistic composition, geographical and ecological distributions of rotatoria on the Plateau reflect the effects of the upheaval of the Plateau as well as the results of ecological adaptation on the part of the rotatorians to the complex environment of the Plateau.

The increasing salinization of water from the southeastern part toward the northwestern part of Xizang is thought to be responsible for the reduced number of species.

Notholca caudata Carlin is a holarctic species with weak dissemination capacity and is rather restricted in its distribution. Hitherto it has only been reported from northern Europe. But now it has been discovered at Gara Co (lake) of Kangmar Xian (county) southward of the Yarlung Zangbo Jiang (Yalu Tsangpo River).

ON THE GEOGRAPHICAL DISTRIBUTION AND ECOLOGICAL CHARACTERISTICS OF PROTOZOA OF THE QINGHAI-XIZANG (TIBET) PLATEAU

Shen Yun-fen

(Institute of Hydrobiology, Academia Sinica)

The hydrobiological samples were collected by the members of the Comprehensive Scientific Expedition of the Qinghai-Xizang Plateau. Among them, 458 species of Protozoa belonging to 170 species of Sarcodina and 288 species of Ciliata have been identified. Detailed diagnoses of all species are given in the monograph "Protozoa of the Xizang Plateau".

The characteristics of the geographical distribution of Protozoa have been analyzed. The natural conditions of the Plateau are characterized by the horizontal zonation. As a rule, the climate of the Plateau is warm and humid in the southeast, while cold and arid in the northwest. Accordingly, the number of protozoan species decreases gradually from the southeast to northwest. And the species dominating alter accordingly. For example, the first predominant species is *Difflygia globulosa* in the northern Xizang and Ngari regions, while *Centropyxis aculeata aculeata* in the southern and eastern Xizang and Chayu regions. As a whole, the genera *Centropyxis*, *Difflugia* and *Arcella* of Sarcodina occupy the most predominant position and they are considered as faunal elements of the palaeartic realm. But in the Chayu region and on the southern slopes of Mt. Qomolangma. *Trinema lineare* is found to be dominant, which is a faunal element of the oriental realm. Besides, the author has never seen any species of the freshwater Tintinnia (Ciliata) which is widely distributed in other regions of China. This phenomenon is considered to be correlated with the upheaval of the Qinghai-Xizang Plateau.

Almost 85.5% of the total area of lakes in Xizang are distributed in the northern region; and most of them are brackish or saline lakes. Both the variety and abundance of Protozoa in these lakes are very scarce. And the majority of species are those that are able to survive in freshwater as well as in brackish water. The new species and new subspecies, *Centropyxis triangularis* sp. nov. and *Centropyxis aerophila triangula* ssp. nov., are found to have an peculiar outline of triangular shape; and the former is a representative species in this region.

The Plateau is also considered as very peculiar in having numerous hot springs. The samples collected from the hot springs reveal a total of 52 species of Protozoa, consisting of 30 species of Sarcodina and 22 of Ciliata. In the chliarothermes (18—28℃), the protozoan fauna is mainly composed of Ciliata; while in the euthermes (28—44℃.), it is mainly composed of Sarcodina. In the acrothermes (44—65℃.), Ciliata becomes very rare. And although many species of Sarcodina are still to be found, the abundance is reduced. In the hyperthermes (>65℃.), all protozoans have practically disappeared except for a few species of Testacea, such as *Difflugia pristis*.

Numerous species of Protozoa have been found in the moss samples from the Plateau, especially from the north slopes of Mt. Qomolangma where the moss species amount to 45% of the total protozoan species in this area. It is, therefore, considered that the major environmental factor influencing the growth of Protozoa is the moss niche rather than the altitude of the Plateau.

THE BLUE ALGAE OF XIZANG PLATEAU

Lee Yao-Ying
(Institute of Hydrobiology, Academia Sinica)

The present paper embodies the results of an extensive taxonomic study of the blue green algae collected from various localities in the Xizang Plateau from 1966—1976. Altogether 285 species, 22 varieties are recorded. Among them, 15 species, 5 varieties are described as new to this region. Type specimens of the new algae are kept in the herbarium of the Institute of Hydrobiology, Academia Sinica.

In various parts of the Xizang Plateau are conspicuously characterized by their own peculiarities concerning the topographical, geological and meteorological conditions. Thus, the blue green algae distributed in these parts also show their prominent local peculiarities:

1. In the salt lakes of northern Xizang, majority of the blue green algae may inhabit in both fresh and salt waters. The typical freshwater forms are rare. This condition shows that the halophilous species may be derived from the freshwater forms due to a gradual incease in the salinity of waters through a long period of the upheaval of Xizang Plateau.

2. In south-east Xizang, especially in the lower canyones of the Zayu, Bowo and Meto districts, both the air temperature and aerial moisture are high, so the blue green algae are very rich in species and much luxuriant in growth. Most of the dominant species are thermophilous. As a whole, the blue green algal flora of these districts is closely

related to those reported from the subtropical or tropical regions of Szechuan and Yunnan provinces, as well as India.

3. In southern Xizang, particularly the Shigatze and Qomolangma regions, as well as in northern Xizang, some typical arctic-alpine species are commonly occurred. In the lakes, the oligotrophic forms are rather abundant, and the planktonic ones rare. These facts clearly show that the blue green algal flora of these regions is arctic-alpine in nature.

4. In different localities where provided with dissimilar altitudes, but with the same natural condition, such as the hot springs on different parts in the mountain regions, the blue green algal flora is almost the same in species composition; conversely, the localities even provided with a similar altitude, but with quite different natural conditions, such as some localities situated on a same altitude in the northern and southern slopes of MT. Qomolangma, the blue green algal flora is quite dissimilar in species conposition.

5. Because of the distribution of algal flora largely depending upon the variation of natural conditions, the zonations are not found in the algal vegetation. This fact differs from the distribution of higher plants. However, the variation of altitude does influence the distribution of blue green algae, such as the arctic-alpine species mostly distribute here and there in the high altitude regions.

CHARACTERISTICS OF THE GREEN ALGAL FLORA OF XIZANG AND UPHEAVAL OF THE PLATEAU IN RELATION TO CERTAIN ENDEMIC SPECIES

Hu Hongjun Wei Yinxin

(Institute of Hydrobiology, Academia Sinica)

The algal flora of Xizang is relatively rich in species. In the specimens collected, 466 species, varieties and forms of the green algae belonging to 81 genera have been identified, 30 discribed as new to the science.

As the topographical, geological, limnological and meteorological conditions vary with the different parts of Xizang, the greenalgal flora presents the following variation patterns viz., 1). progressive decrease in the number of species from the southeast to the northwest; 2). progressive increase in the alpine and arctic species from the southeast to the northwest; 3). tropic and subtropic species mostly distribute in southeast Xizang, but alpine saline and brackish water species widely disperse over the north. The flora shows a conspicuous speciality in both regions.

Based upon the marked regional differences on both number and characters of the green algae collected in diverse localities of Xizang, the flora may be divided into four regions: 1. tropic-subtropic species region-includes the southern slopes of the Himalaya and southeastern Xizang; 2. alpine and arctic rich species region, including the Yarlung Zangbo river basin above Mainling; 3. alpine and arctic poor species region, including Ngari district of the upper reaches of the Indus river in western Xizang and 4. alpine and arctic, brackish and saline water species region, including the vast Changtang Plateau in northern Xizang

Two (endemic) filamentous algae have been discovered in Xizang. The first, *Ulothrix geminata* Jao, is a strict freshwater species, widely distributed all over the eastern, Southern and western parts of Xizang and probably has been existed also in north Xizang before the upheaval of the plateau. The second, *Didymonena tibetica* Wei & Hu, has been found only in a salt lake in north Changtang. These two algae are quite similar in their cell structure, but distinguish from one another on the basis of the thallus construction. Namely, the thallus of the former is a simple filament consisted of a single row of cells, while that of the latter is a narrow ribbon composed of two longitudinal rows of cells. Although the thallus of the latter is a two cells narrow ribbon, but its base is distinctly uniseriate. This fact cleary shows that the latter may be derived from the former due to a great change of the natural conditions of northern Xizang, especially the salinity of water, during certain period of the upheaval of the Qinghai-Xizang Plateau.

Another peculiar alga, *Cloniophora tibetica*, sp. nov., also has been discovered in Xizang. This genus consists of only a few species. All of them have been found in freshwater along the sea coast. It is unusual that *C. tibetica* exists in the Xizang plateau far from the sea. Thus this alga may be considered as a relict species which existed in Xizang even before the Qinghai-Xizang plateau upheaved from an ancient sea.

A BIOGEOGRAPHICAL ANALYSIS OF THE LICHEN FLORA OF MT. QOMOLANGMA REGION IN XIZANG

Wie Jiang-chun Jiang Yu-mei

(Institute of Microbiology, Academia Sinica)

The lichen flora of Mt. Qomolangma (i. e. Mt. Everest) Region in Xizang of China is classified according to the bioclimatic and chorological principle into 9 geographiaal elements as follows:

1. Arcto-alpine element
2. Montane-subarctic element
3. Boreal element
   (1). Panboreal type
   (2). Eurasian-North American type
   (3). Amphi-Pacific type
4. Montane element
   (1). Eurasian type
   (2). Eastern-Asian type
      A. Pan-eastern-Asian subtype
      B. Sino-Himalayan subtype
5. Noto-boreal element
6. Nemoral element
7. Arid element
8. Pantropical element
9. Multi-range's element
   (1). Arcto-alpine-holarctic type
   (2). Subarctic-montane-holarctic type
   (3). Boreal type
   (4). Nemoral type
   (5). Montane-holarctic type
   (6). Holarctic type

Through the biogeographical analysing of the lichen flora of Mt. Qomolangma Region, we can see clearly that most of the elements of the lichen flora of this region are immigrants from its neighbouring regions. The reason is that the Himalayas belong to a young mountain system and were damaged by the glaciation in the Quaternary period. The Climate of Mt. Qomolangma Region changed cold after the upheaval of the Himalayas took place at the end of the Tertiary period, resulting in the violent change of the constitution of the lichen flora and the climate of Mt. Qomolangma Region which should be influenced by the geographical latitude originally. At the same time, as an unique habitat of natural geography, Mt. Qomolangma Region is advantageous to the differentiation and the replenishing formation of lichen species. Therefore, the lichen flora of Mt. Qomolangma Region is not basically constituted by Pantropical elements (approx. 8%), but rather by Arcto-alpine elements (approx. 16%), Montane element of temperate zone of Holarctic (approx. 72%) and Notoboreal element (appox. 4%), which cover 92% of the total elements of the lichen flora in this region. Among these elements, approx. 18% is endemic to Sino-Himalayan element.

On the other hand, it is interesting to note that five of the six species belonging to the subgenus Chlorea of the genus Lehtariella are distributed over the Himalayas, while the remaining species over the Canaries; also that Thamnolia subuliformis f. minor (Lamy) Mot. is found in Mt. Qomolangma of China as well as in Mt. Dore of France. This kind of disjunctive distribution seems to be resulted from the geographical isolation of the members of the lichen flora of the Palaeomediterranean Sea-front caused by the upheaving of the Himalayas.

A STUDY ON THE HIGHER FUNGAL FLORA AND GEOGRAPHIC DIVISION OF XIZANG (TIBET)

Zang Mu (Kunming Institute of Botany Academia Sinica)

Zong Yu-chen (Institute of Microbiology Academia Sinica)

The Xizang (Tibetan) plateau is the highest,largest and youngest plateau on the earth. There is a mycoflora extraordinarily rich in nature.It has long been fucused attention of the international scientific circle. Before the liberation of China, the fungi have only rarely been recorded from Xizang.

Since the beginning of New China, especially in recent years, Chinese botanists have carried out many systematic, multiple-disciplined investigations and collections.In 1974–1976, the authors participated the mycological expedition to the Xizang plateau, to study fungal flora in this part of China. In addition they were also aiming to investigate the effect of the upheaval of the plateau on natural eniviron ment and on the geographical distribution and species differentiation of higher fungi.

About 1500 numbers of fungal specimens from different localities were collected, over 880 species have been identified.they are distributed among 271 genera and 76 families, there are included some new taxa, they are *Acetabula purpurea* Zang, *Boletus magasporus* Zang, *Lamptercmyces luminescens* Zang, *Marasmius* Zang, etc.

Some geographic divisions and floristic elements, however, system are itemized as follows:

I. The geographic divisions of higher fungi of Xizang

1. The region of S. E. Xizang (Hengduan mountains and E. Himalaya)
2. The tropical region of southward from Himalaya and subtropical region or Zayu
3. The region of south Xizang
4. The north Xizang Chiong Tang plateau region
5. The region of west Himalaya and west of Ari prefecture

II. The floristic elements of higher fungi from Xizang

1. Cosmopolitan area type. There are 104 species belonging to this type. and they amount to 12% of the total number of species.
2. North temperate area-type. they amount to 441 species and share 50. 3%
3. Area-type of eastern Asia and north America. 38 species, 4, 3%,

4. Old world temperate area-type. 105 species, 12%

5. Sino-Himalaya area type. 75 species, 8.5%

6. Sino-Japan area-type. There are 17 species, 1.9% of the total number species. e. g. *Tricholoma matusutake* (Ito et Imai) Sing. etc.

7. Endemic area-type. 39 species, 4%

8. Pantropic area-type. 19 species 0.2%

9. Tropical America and tropical Asia area-type. 20 species, 2%

10. Tropical Asia to tropical Australia area-type, 8 species, 1%.

11. Tropical Asia to tropical Africa area-type. 3 species. 0.5%

12. Tropical S. E. Asia (Indo-Malaya) 40 species. 4%.

In this paper several problems concerning fungal migriation and differentiation also were discussed.

ON THE EVOLUTION OF SOME RUST FUNGI IN QINGHAI-XIZANG PLATEAU

Wang Yun-chang
(Institute of Microbiology, Academia Sinica)

Nowadays uredinologists recognize that the host of ancestral rust fungi must be ferns and conifers. These plants originated in the Eurasian temperate region of North hemisphere and the rust fungi should have also been restricted their origin to this territory. In fact plant association in Sino-Himalayan and neighbour regions are less disturbed by human activities. Therefore the origin and evolution of rust in this region are easier to be traced. The author is attempting to study the evolution of the following four rust genera affected by the changes of natural conditions caused by the rising and steadily uplifting of the Plateau.

Ghrysomyxa is one of the more ancient rust genera. The species of this genus alternatively infect spruce as aecial host and Ericaceous and related plants especially of *Rhododendron* as telial hosts. 9 species have been reported from this area, including also from northern Indian territory. The telial sori of this genus usually are formed under the epidermis of the host leaf and emergence after maturation as pulvinate, without any stalk. But in Qinghai-Xizang Plateau the telial sori of some species do have a stilbum-like stalk under the telial head which appears above the leaf surface up to 2 mm high. It shows that a humid-temperate climate must be predominantly over this area long time ago. Members of *Chrysomyxa* have settled in and radiated to adjacent areas especially the colder and drier area where the stalk of telial head disappeared gradually. Such is the case of Chr. succinea on *Rhododeneron* in Qinghai. This species has shorter stalk. Ultimately species originated in cold-dry places have no stalk at all and are distributed where Ericaceous plants exist.

Cronartium is a well-known genus. *Cronartium ribicola* has caused severe damages to 5-needle pine in Europe and North America. The place of its origin has been assumed to be the central part of Eurasia, where lived the ancestral 5-needle pine *Cembra-Strobus* group. Afterwards, there have been derived *Cr. occitentale* on *P. albicandis* in N. America and *Cr. ribicola* on *Pinus sibirica* in Asia. In North Eastern China *Pinus koraensis* is the main host. Artificial inoculations showed this rust could infect *Ribes* and *Pedicularis* simultaneously. Furthur eastward to Kamtchatka *Cr. kamtchaticum* has been evolved on *Pedicularis* as its telial host and *Pinus pumila* presumably as its aecial host. Any individual species of the genus which had moved to the Qinghai-Xizang Plateau inhabited *Keteleeria* sometime in history and migrated toward western Yunnan and finally evolved the micro-form *Cr. keteleeriae* on it.

The origin of the genus *Gymnosporangium* is obviously of later date than *Chrysomyxa* and *Cronartium*. Its distribution is restricted to warmer temperate region. Three species in Sino-Himalaya region are all authentic ones, with no uredinal stage. But in the east of Sinkiang *Cymnosporangium gaeumanii* a species of cedar rust with uredinal stage has been collected.Thus it may be judged that Qinghai-Xizang Plateau is newer than Tienshan mountain region. Species of *Gymnosporangium* was losing gradually their uredial stage and becoming eventually to-day's typical cedar rusts. Meanwhile *Gymnosporangium* has been evolving vigorously due to the continuously rising of the Plateau and further evolution should have forced the derivation of new forms. *Gymnosporangium tsingchenensis* with one-celled teliospores has been therefore derivated.

Coleopuccinia is a genus of still younger age to be derived than the genus *Gymnosporangium* from which it is supposed to be derived. Its evolutionary trend is the shortening of life cycle from long cyclic- to micro-cyclic forms on the host of original aecial stage, e.g. *C. sinensis*. There are 3 species distributed in the west, south China and Japan.

THE RUST FLORA OF THE SINO-HIMALAYAS

Chen Momei

(Chinese Academy of Forest Science)

All uredinales are obligate parasitic fungi. As early as the Carboniferous period, uredinales were parasitic to ferns. It has been found that in historical geological periods,the evolution of rusts were closely associated with that of flowering plants. Back to 1925

Mordsilko obtained valuavle data by using rust as a target for the distribution of parasitic plants. But few mycologists have made studies of the rust flora of the Sino-Himalayas over the past 50 years.

A systematic pathological and mycolgical investigation was made by the author in 1975—76 in Xizang forests below an altitude of 5,000 meters. Our firdings show that there is a ccmplete and comprehensive spectrum of vertical distribution of forests. This provide an unique natural laboratory for the study of the rust.

Our preliminary study shows that there are 25 genera and 102 species of rust flora. among them. 9 genera and 34 species are Melampsoraceae; 10 genera and 47 species, Puccinicese; 6 genera and 34 species, imperfect rust fungi. Among them, 17 species have been described as new species.

Rust flora in this region has been classified into three types, according to the conditions of moisture and temperature. 1. The plateau type: representative of this type is the *Melampsora larici-capraearum* Kled. which is distributed in arid and semi-arid areas, 3,500 meters above sea level. Some others are distributed in *Picea* and *Abies* forests in the frigib-temperate zone on high mountains, where diseases of the cones and needles of different coniferous trees are found. 2. The temperate zone type: some rusts, such as *Coleosporium*, *Cronartium* and *Melampsoridium* are usually in existence in the northern temperate zone. They can also be found here. More than half of them inhabit *Rosaceae*, *Ericaceae*, *Compositae*, *Gramineae Salicaceae*, *Pinaceae* etc. mostly plants belonging to large families in the temperate zone. They not only manifest the characteristics of Himalayan flora but also are served to demonstrate that the Sino-Himalayas belong to the type of temperate zone. 3. The sub-tropical zone type: rusts found here adapt themselves to damp and warm conditions. Indigofera is often found to be parasitized by *Revelinia* and Ampelopsis by Phakopsora respectively. On the whole, this area may be considered as the northern fringe of the tropical zone.

Due to the complexity of the ecological geography of this area and the influence of the natural history of the Qinghai-Xizang(Tibet)Plateau, the migration, differentiation and fusion of flora of higher plants and rust flora in this area are extremely complicated. Our preliminary study of this region shows some characteristics as follows:

1. It is an area where new types of rust are found. Examples of new genera are the *Coleopuccinia* and the living fossil rust *Hyalopsora*. Many species of host plants found here have been recorded for the first time. These include the genera *Piptanthus*, *Pilea*, *Centella* and *Morina* etc.

2. The rust flora in this region is related to those in other regions. There are species spreading in a disjunctive manner between East Asia and North America and between the Himalayas and the Mediterranean. Most of the species found in the Himalayas can also be found in Japan. This shows that they are of a same origin.

3. Potential sources of tree diseases. Diseases in the virgin forests in the Sino-Himalayas have not yet developed to catastrophic epidemics. But the potentiality for outbreaks must be taken into account. Afforestation requires a knowledge of the rust flora as well as the relationship between these rusts and their hosts. An ecological system and forestry management must be worked out for controlling catastrophic outbreaks of forest diseases in the light of the structure of plant community.

THE POLYPORACEAE OF THE SINO-HIMALAYAS

Chen Momei

(Chinese Academy of Forest Science)

Polyporaceae in an advanced type in the contemporary classification of fungi. It has a larger herbaria pore fungi specimens, the gymenophore of typical genera has many pores of different shapes. It is fond of mild temperture and dampness. It can convert the energy of plants in forests.

The mycologists knew little about the Himalayan pore iungi in the past. Some fragmentary species were collected by Berkely, M. J. Bolfour-Browne Fr. L. and Rokuya-Imazaki and others.

In China, the frist systematic study of pore fungi near the Himalayas was made by Prof. Deng Shuqun. Recently, the author, together with Zang Mu, collected about four hundred specimens of pore fungi and appraised many kinds of pore fungi such as Pinus, Abies, Tsuga, Quercus, etc. found in the forest.

The author has appraised about a hundred species of pore fungi belonging to twenty genera. Our study of the pore fungi of the Sino-Himalayas is based on materials of paleoforestry and analysis of the population structure of composition distribution of pore fungi of different species.

Our findings show that there is a close relation between the pores fungi and the hosts. The examples are shown by the following fungi and hosts: on the *Pinus larix* are *Phellinus pini*. On the *Tsuga parastitis Ganoderma tsugas*. On *Betula parasiti Polyporus* betulinus, etc.

The pore fungi flora evolution from the lower level to the higher may be divided into three types:

1. In the Sino-Himalayas, such as Hirshiporus etc., which is close to Hydanceae constitute about 9%.

2. Typical pore fungi, such as Polyporus, Fomes, constitute about 60%.

3. Types in the process of transition from pore fungi to pleat fungi constitute about 31%.

So typical pore fungi form the majority. This is because, the ecological conditions on the plateau are becoming dry and the old types are greatly reduced and the new types of pore fungi are increased.

The most important fact is that the pore fungi flora belonging to the N. temperate zone constitute about 90%. In geographical composition, many are found in areas close to N. America and E.Asia. Many pore fungi are definitely known only in the Himalayas and Japan.

According to the pore fungal geographical composition, there are the following regions:

1. S. Xizang high mountain and gorge region;
2. The middle and lower reaches of the Yaluzhangbu River.
3. Hengduan mountain region; and
4. Central Xizang region.

The author has studied the ecology of Ganoderma including six species from cold temperate zone to sub-tropical zone. The study shows that the Sino-Himalayas are most rich in a great variety of *Ganoderma lucidum*.

THE CHARACTERISTICS AND POSSIBLE ORIGIN OF THE BRYOFLORA OF THE SOUTHERN FLANK OF THE EAST HIMALAYAS

Wu Pan-cheng Lou Jian-shing
(Institute of Botany, Academia Sinica)

In the south-east and south Xizang, including Mèdog, Zayü some western separate valleys Yadong, Kama near Chentang in Dinggye, Boqu near Zhangmu in Nyalamo and Gyirong, a mild climate prevails because of the very high mountains and the very deep valleys. According to our preliminary survey, 4/5 of the genera and 7/10 of the species, i. e. approximately representing all families and genera of the tropical and subtropical bryophytic flora of Xizang, are restricted to these localities below the altitude of 2300 meters. It almost agrees with the previous presumption that the Tsangpo gorge is the line of connection between two paleocontinents——Laurasia and Gondwana.

Moreover, the bryoflora of these localities, besides the Indo-Malasian elements and east Asian elements as the main components, has at least about 40 genera in common with south America, Australia and Africa. According to the historical phytogeographical point of view, the distribution range of certain genera is formed through a period of long historical development. The same is true for the area of different species, although they are found in widely separate areas right now, yet they might have once a continuous distribution in certain historical age. The Indian subcontinent collided against the eastern part of Laurasia and afterwards the Australasian plates moved to the north. All these might have dispersed the Gondwana elements as far as to the southeastern part of Xizang.

It is very interesting to note that of the 32 genera of bryophytes endemic to East Asia, 13 have recently been found in the southeast and south Xizang and also in the neighbouring regions, i. e. Yunnan, Sichuan, where there are many genera being in common with southeast and South Xizang and also highly concentrated in distribution.

This may suggest that the Himalayas, being the highest and youngest mountain range, have changed the atmospheric circulation,and have created a new ecological condition between tropical and frigid zones,which have given the distribution of the newly formed genera a suitable circumstance to survive. It may be presumed that the region covering Mèdog, Zayü, Yadong etc.in southeastern and southern parts of the Himalayas is a new center of distribution of bryophytes under the influence of the upheaval of the Himalayas.

ON THE GEOGRAPHIC DISTRIBUTION AND ITS FLORISTIC ANALYSIS OF THE MOSSES IN THE QINGHAI-XIZANG (TIBET) PLATEAU

Cao Chien Cang Kwang-chu
(Institute of Forestry and Pedology, Academia Sinica)

Zang Mu Li Xing-jiang Zeng Shu-ying
(Kunming Institute of Botany, Academia Sinica)

Though Qinghai-Xizang Plateau is situated within the subtropical latitudes its central and northern parts form a vast peneplain, 4500 m. above the sea level on an average. Since the warmer and moister aircurrents coming from the Indian Ocean northwardly was blocked by the high and steep Himalayas, the Xizang interior remains rather dry and cold, and hance the liverworts and mosses taxa are relatively simple and poor. In the southern and south-eastern parts of the plateau (i. e. East Himalaya and South Hengduan Shan) with complicated topography and climate, there are high mountains and deep valleys and the precipitation is plentiful since the warm and moist aircurrents come from east and south-east along river valleys. The tropical, subtropical and alpine vegetation distribute vertically only within several teen-kilometers. The moss flora is extraordinarily rich in species and forms with intricate distribution patterns. The moss flora inside the Qinghai-Xizang plateau is known to be consisted of 641 sp. with some var. belonging to 44 fam. and 206 gen.The main floristic elements are as follows: The Holarctic areal-type, 89 gen. 332 sp., accounting for 54 per cent of total species; 2. The E. Asia areal-type, 69 gen. 201 sp., accounting for 31.6 per cent; 3. The Tropical areal-type, 68 sp., accounting for 11 per cent; 4. The endemic areal-type, 99 sp. (incl. 51 sp. in common with East Himalaya), accounting for 19.3 per cent and 5. The cosmopolitan areal-type, 36 sp., accounting for 5.6 per cent.

Based upon the geographic distribution of the mosses in Xizang, it may be tentatively divided into three regions: 1. South-east region, of which the west boundary is limited by the forest from Baqen to Lunze, including mainly the East Himalaya and Hengduang Shan regions where 150 gen. and 365 sp. with 31 endemic sp. are found; 2. South region, of which the north boundary is Nyainqentanglha Shan, including Xigaze and the areas adjacent on both sides, and 92 gen. 281. sp. with 13 endemic sp. are present; 3. North region of which the south boundary is Nyainqentanglha Shan, mainly including the Chang-Tang region, and there are 43 gen. 67 sp., with 4 endemic sp. are found.

The characteristics of the floristic elements and its geographic distribution of the mosses in Xizang are as follows: 1. As the south boundary of Xizang plateau perhaps was a part of Gondwana and the main body of this plateau has upheaved and become the roof of the world since the end of Tertiary period, the topography and climate become very complicated. In addition, the advance and retreat of the three glaciations during Tertiary and Quaternary had a profound influence upon the moss flora which related with those found in all other parts of the world. 2. Although the Xizang bryoflora is extraordinarily complex, it still belongs to the subregion of holarctic kingdom, because this flora consists of species predominant in holarctic areal-type with some East-Asian Tropical and Endemic elements. 3. Owing to the uplifting of the Plateau the south and south-east parts display a great diversity of the topography and climate, It becomes not only the refuge of some relict plants, but also the place of origin of several local new taxa so Xizang has become one of the centres of speciation and differentiation of the bryophytes. 4. No endemic family of bryophytes was discovered in this region yet, and the endemic genera are mostly oligo-specific, so the geological age of this plateau should be quite young. 5. The north region may have close relationship with central Asia according to the bryoflora, for example, *Indusiella thianschenica* being common in these two regions.

STUDY ON THE GEOGRAPHICAL DISTRIBUTION AND BRYOFLORAL ELEMENTS OF POTTIACEAE FROM XIZANG (TIBET)

Li Xing-jiang

(Kunming Institute of Botany, Academia Sinica)

Plants of *Pottiaceae* are usually small and erect tufted, often growing in patches or forming cushions. They distribute in the temperate zones and on the mountains of the northern subtropical region, especially in eastern Asia.

Some valuable studies of Xizang bryophytes were made by W. Mitten (1859), Salmon (1900), P. C. Chen (1940, 1962) and others. In 1951—1979, several Chinese bryological collectors participated in the scientific expeditions to Xizang Plateau, to study bryo-flora in this part of China. In addition, we were also aiming to investigate the effect of the upheaval of the plateau on natural environments and on the geographical distribution of bryophytes and their species differentiation. The present article deals with a study of 879 specimens of *Pottiaceae* collected from the whole Xizang Plateau.

The total number of taxa recognized after determination are 28 genera and 102 species, constituting 13.5% of the total number (753 species) of all the Xizang bryophyts. Among them 7 new species are discovered.

(I)

By analysing the climatic conditions, topography, geological history and different habits of bryophytes, the author suggests the following subdivision of regions:

1. The region of S.E. Xizang (Hengduan Mountains、E. Himalaya.yadong and Nyalam County): There are23 genera and 76 species of which 5 new taxa were discovered.

2. The region of south Xizang: There are 8 genera and 20 species among which a few species may be relics of the tropical elements-(Indo-Malaya) .

3. The region of west Xizang: There are 20 genera and 53 species, among which most belong to the north temperate elements while a few are the same as those found in C. Asia, W. Asia and N. Africa.

4. The north Xizang Chang Tang Plateau region: About 9 genera and 17 species are known with the main elements belonging to boreal flora.

(II)

The analysis of the floristic element of *Pottiaceae* from Xizang may be divided as follows:

1. Cosmopolitan. There are 9 species belonging to this type and amounting to 8.4% of the total of *Pottiaceae* of Xizang

2. Holarctic. 24 species, 23%.

3. Old world temperate. 3 species, 2.9%.

4. E. Asia and N. America. 1 species, 1%.

5. E. Asia (Sino-Himalaya and Sino-Japan) 19 sp., 18.3%.

6. Pantropic. 2 sp., 2%.

7. Tropical Asia to Tropical Africa. 1 species, 1%.

8. Tropical S. E. Asia (Indo-Malayan). 9 sp. 8.7%.

9. Endemic. 34 sp., 32.7%

(III)

Through studying and analysing the *Pottiaceae* flora of Xizang, the following characteristic features may be described:

1. Owing to the complex natural environmental conditions caused by the uplift of the Xizang plateau, a great diverity of *Pottiaceae* mosses developed and differentiated. 7 new species were discovered. In this region, the genus *Rhamphidium* is new to China.

2. As the Xizang plateau is situated between the Laurasia and Gondwanaland, quite different elements of bryoflora were therefore mixed together and differentiated with each other, which made the floristic elements belong to Sino-Himalayan or endemic element which altogether amounts to 51% of the total.

3. The wet monsoons blow norhard from the Bay of Bengal, bringing large amount of precipitation into the highland directly. Therefore the climatic condition of the southeastern region is generally much warmer and wetter than that of the north-west. The *Pottiaceae* in southeastern region is also far richer than that of the north west. Some tropical and primitive species, Such as *Reimersia inconspicua* etc. are seen in S. E.Xizang, while some xerophytic and psychrophilous species. e. g. *Barbula reflexa*, *Desmatodon*

suberectus etc. only occur in N. W. Xizang and other alpine regions.

4. Because of the rapidly uplifting of the landmass, the low er temperture, the heavy wind and the strong ultraviolet radiation, mosses growing under such environmental conditions certainly will show conrresponding differentiation in their morphology, in order to form new taxa of alpine speciation, for example, *Tortula reflexa* , and *Desmatodon raucopapillosum* etc. These plants are generally dwarf and minute, cushion like caespitose, often with hyaline hair-points on leaves tips, cell wall papillose and whole plants often dark brown in color etc.. These characters often represent also the analogous variations in different genera and species in adaptation to the alpine cold and dry environment. simultaneously.

5. Some tropical species such as *Oxystegus cuspidatus* and *Barbula constricta* are often seen above 5000 m. among boulders in glacial area and different localities of the high alpine meadow. It seems most likely that these originally more primitive low land species of tropical forest has been gradually adapted to the present environment during the course of the uplift of the plateau.

STUDY ON THE TAXONOMY, DISTRIBUTION AND BRYOFLORA OF POLYTRICHACEAE IN XIZANG(TIBET)

Xu Wen-xuan Xiong Ruo-li

(Department of Biology, Yunnan University)

I. A brief account of the general survey on polytrichaceae in Xizang.

The survey on bryophytes in Xizang area began with the scientific investigation of Qomolangma Feng (Mount Jolmo Lungma) area in 1959. In that year, 2 genera, 6 species of Polytrichaceae were collected. Then, a comprehensive scientific survey team was sent to Xizang by Academia Sinica for nine times in 1972—1978. The survey covered the area: E. 83—97°, №27.5—32°, from Qando Xian (Chando County) in the east to Zhongba Xian (D ongpa County) in the west, from Yadong Xian (Yatung County) in the south to Biru Xian (Biru County) in the north, including the city of Lhasa and 21 counties, alt. 800—5600 m, pH 5.5—6.5.

II. Taxonomy of Polytrichaceae in Xizang.

According to our preliminary determination, in Polytrichaceae there are 7 genera, 28 species, 4 varieties including 1 new genus, 5 new specics, 3 new varieties, (see the list).

III. A general picture of the distribution of Polytrichaceae in Xizang

1. the distribution in the area of Xizang; and the relationship between its neighbouring area.

a. The distribution in the area of Xizang:

13 counties S E, 7 counties S, and 1 county W.

b. The relation between Xizang and its neighbouring area.

There are 19 species common with those in Yunnan, and 17 with those in India.

2. The law of the vertical distribution.

(1) Frigoridesertic zone: over alt. 4800m., 2 species.

(2) Alpine meadow zone: alt. 4500—4800 m., 8 species.

(3) Alpine shrub zone: alt. 4100—4500 m., 9 species.

(4) Forest zone:

a. Subalpine needle leaf forest zone: alt. 2800—4100m., 16 species.

b. Montane broad leaf forest zone: under alt. 2800m., 12 species.

Ⅳ. A preliminary analysis on the origins of the bryoflora.

1. Cosmopolitan species: 2

2. Holarctic species: 5

3. Old world tropical species: 4

4. Eastern Asia species: 7

5. Himalaya species: 9

6. Endemic species: 7

Ⅴ. The uses of Polytichaceae

1. Medical uses: Anti-carcinoma and angiocardikinetic.

2. Agricultural uses: Prevention of Piricucaria oryzae and other disease.

3. Forest uses: determination of forest type and conservation of water and soil.

A PRELIMINARY ANALYSIS OF THE HEPATICAE FLORA IN XIZANG(TIBET)

Lou Jian-shing   Wu Pan-cheng
(Institute of Botany, Academia Sinica)
Lin Pang-juan
(South China Institute of Botany, Academia Sinica)

So far as we know there are 23 families, 48 genera and 146 species and varieties of the Hepaticae in Xizang, approximately amounting to 51% of the families, 35% of the genera and 20% of the species of the total Hepaticae flora in China. The results of a preliminary analysis are shown as follows:

Ⅰ. The floristic elements of the Hepaticae in Xizang

1) The predominant taxa belong to the *Lejeuneaceae*, of which there are 13 genera and 28 species, all of tropical and sub-tropical region, then the *Porellaceae* with 1 genus and 23 species, and third the *Frullaniaceae* of the sub-tropical region. The families of second importance are the *Plagiochilaceae* of the warm-temperate region, and the *Herbertaceae* and *Jungermanniaceae* of the temperate region as well as of the tropical mountain region. The above 6 families constitute the main body of the Hepaticae flora in

Xizang because of their great number of species and wide distribution in the whole region. It is apparent that the Hepaticae flora in Xizang mainly consists of sub-tropical families and genera, but is also adequately represented by tropical and temperate families and genera, besides a limited number of the arid and frigid taxa.

2) The Hepaticae flora in Xizang consists of the following geographical elements:

(1) Holarctic elements: 32 species, approximating to 27.2% of the entire Hepaticae flora in Xizang.

(2) East Asiatic elements (including Sino-Japanese, Sino-Himalaya): 65 species, approximating to 40.5% of the entire Hepaticae flora in Xizang.

(3) Cosmopolitan elements: 25 species approximating to 17.2% of the entire Hepaticae flora in Xizang.

(4) Endemic elements (including 11 Xizang endemic species and 13 endemics, mainly distributed in Yunnan, Szechuan and Taiwan, approximating to 15.8% of the entire Hepaticae flora in Xizang.

Ⅱ. The horizontal and vertical distributions of the Hepaticae flora in Xizang.

The growth and development of Hepaticae are closely related to atmospheric moisture and temperature. The number of species and frequency of the Hepaticaei in Xizang are gradually decreasing from south-east to north-west, because rain and temperature become gradually less and less from south-east. The range of distribution lies east of Jilong and south Nyainqentanglha mountain. The horizontal distribution can be divided into two zones. One is along the Himalayas Mountain range including Gyirong, Nyalam, Dinggye, Yadong, Cona, Lhünze, Sangngagqoiling, eastwardly to Médog, Zayu, here the Hepaticae are very rich both in taxa and density. Another zone is along the river of Yarlung Zangbo river including Tingri Nang-Xian, Mainling Nyingchi Bomi, etc. Here taxa and density are gradually increasing from west to east. The vertical distribution in the south-eastern Xizang is evident. Here the tropical and sub-tropical species mainly distribute in broad-leaved forests below the altitude of 2500m., while sub-tropical and temperate taxa appear in coniferous and broad-leaved mixed forests and the temperate families and genera are frequent in coniferous forests. In shrubs and grass-land on the plateau only some cold-resistent taxa occur.

Ⅲ. Conclusions

1) There are marked difference between the south and the north part of Xizang in natural environmental conditions. Most Hepaticae flourish best in forest zones south of Zangbo river. Here the floristic elements are very complex, mostly of the East-Asiatic origin. The tropical and sub-tropical elements are richer than at the same latitude on the other parts of China. This is especially true of the south-eastern Xizang, where the warm and moist monsoon from Indian Ocean favours the development of Hepaticae flora. Geologically south-eastern part of Xizang has a very rugged topography, which offers an effective protection as refuges for the plant life during glaciation periods, thus becoming a centre of distribution for the Hepaticae, too.

2) The Hepaticae flora in Xizang is closely related to those of the neighbouring regions such as Yunnan and Szechuan in China, India, Nepal, Bhutan, Sikkim, Burma, etc.

3) The flora as a whole in the north western Xizang is poor, because of the strong upheaval of the Himalayas has brought to the plateau a dry and cold climate unfavourable

to the life of plants loving warmness and moisture. This accounts for the poverty of the Hepaticae flora in the north-western part of Xizang, too.

THE FLORISTIC CHARACTERISTICS OF THE XIZANG PTERIDOPHYTE FLORA IN THE RELATION TO THE UPHEAVAL OF THE HIMALAYAS

R.C.Ching
(Institute of Botany, Academia Sinica)
S.K.Wu
(Kunming Institute of Botany, Academia Sinica)

1. Xizang boasts of a rich and complex pteridophyte flora, consisting of 44 families, 113 genera and about 475 species to date. They are concentrated in the South-eastern part and the southern flank of the Himalayas. Their distribution patterns correspond to those of forests in Xizang, as they are always found in association with forests and other ligneous plants of various kinds, whose canopy may perhaps serve as an effective protection during the long winter season. However, their horizontal distribution is insignificant, being chiefly confined to a narrow belt along the south-eastern part and the southern flank of the Himalayas. The vast areas south of Gandise Shan and Nyainqentanglha Shan are poor in ferns, only with a few lowly and drought resistent species sporadically hidden in sheltered rock crevices as their favoured habitat, while north of this line are still poorer in ferns. In other areas on the plateau practically no ferns are in evidence. In contrast, the vertical distribution spectrums in the Himalayas are always very evident five distinct altitudinal zones on the southern flank, for example, being present, among which the zone at the elevation of 1200-2600 m. is the richest in the species of ferns. The marked climatic differences between zones and areas, one warm and humid, and the other arid and frigid, is sufficient to account for great disparity in distribution pattern and most of the differences in the floras in respective zones and areas.

2. Of the 113 fern genera in Xizang, 70(61.7%) are of tropical and subtropical nature with most genera represented by 1-2 species only and totaled up to 195(33.2%) of the entire fern flora. There are 34 (33.2%) temperate fern genera represented by 275 species and amounting to 58.3% of the total. The above figures indicate that the pteridophyte flora of Xizang is dominated by temperate species and its south-eastern part is already the northernmost limit of the geographical range for tropical ferns. In this respect the Himalayas, especially the East Himalayas may phytogeographically be considered as a meeting point for both the tropical and temperate ferns in Asia.

3. Of the total number of species of the Himalayan fern flora there are about 240 endemic species, mostly inhabiting the temperate zone and indicating the speciation is very active at this particular altitudinal zone. Of the 16 mainly Sino-Himalayan fern genera 6 are endemic in the Himalayas and the close neighbourhood (Yunnan and West Szechuan). They are probably advanced types derived from related genera during the course of the upheaval, of which one recently published Polypodiaceous genus, *Platygyria*, appears to be most extraordinary in its sporangia provided with a very broad, complete and vertical annulus of scarcely indurated cell-walls and indistinct stomium. It may likely represent an ancient relict of more extensive types of the *Polypodiaceae*, which might have become extinct with the rise of the plateau, as shown by the fossil records of ferns (chiefly spores) in the vicinity of the plateau.

4. The uprising of the Himalayas, thus completely preventing the southwestern monsoon from the Indian ocean advancing farther north, no doubt has played a profound influence upon the fern flora of Xizang, namely, the great majority of original species once existed on that was a wet and warm low land covered by thermophilous plants before the uprising were forced to gradually retreat southward as far as the warm humid southern flank of the mountain and were thus separated themselves from the fern flora of Central Asia to the north, e. g. Tian Shan, by the Xizang Plateau, Kun-lun Shan and the Takla Makan Desert, as shown by the presence of relict species there today. On the other hand, the existence of the Himalayas serves as a migration route for fern (or for plants in general) from West Asia to East Asia or vice versa. What is more important is that the rise of the Himalayas has created a series of new environments (ecological niches) for speciation and isolation of new forms of plants, thus greatly increasing the complexity of its floral composition. In pteridophyte flora this is especially evident in the genera, such as *Dryopteris*, *Polystichum*, a group of *Athyrium* (known as *Pseudocystopteris*) and the family *Polypodiaceae*, of which particular mention may be made of the genus *Lepisorus*, which is very striking in that it displays a multifarious and almost uninterrupted series of forms found in ecological niches at different altitudes, thereby posing many taxonomical problems as to their proper status.

F. KINGDON WARD AND HIS IMPACT ON WESTERN KNOWLEDGE OF THE RIVER GORGE COUNTRY OF SE TIBET

U. Schweinfurth

(South Asia Institute, University of Heidelberg,
Department of Geography, Fed. Rep. Germany)

F. Kingdon WARD ranks amongst the foremost explorers from outside the area of SE Tibet or the river gorge country. He began his lifelong career as an explorer more or less casually in 1911 and never actually stopped: he died in 1958 when he was 73, while preparing for the next expedition. The professional plant hunter and seed collector he became in the course of exploring, made him an outstanding observer. Seed gathering in unknown, unmapped, unexplored, and difficult country, by observing flowers and finding his way back to specific habitats during the fruiting seasons, forced him to make himself familiar with his chosen hunting grounds. Many an area was revisited by F. K. WARD during his explorations time and again. His narratives reflect his keen eye for the country, his perception and his love for this spectacular part of Asia. However, F. K. WARD never chanced to compile an overall comprehensive account of the river gorge country, which he would have been so outstandingly suited to write. This fact, together with the impossibility for Western scientists to follow F.K. WARD's footsteps in further exploration for more than 30 years by now and the realisation that F.K. WARD never kept records of his own writings and further that his work is hidden in so many different journals, lead the author to compile a bibliography of his writings: 25 books and 709 original contributions to journals were traced, thus presenting a compilation of the bulk of his work. (Contributions to newspapers, very numerous, indeed, have not been considered.) Together with the annotated bibliography, a map (scale 1:1,000,000) was composed, showing area and places of F. K. WARD's expeditions as mapped or named in his own publications. The annotated bibliography, with the map and regional as well as subject indices, was published in 1975 (*SCHWEINFURTH, U. & SCHWEINFURTH-MARBY, H.: Exploration in the Eastern Himalayas and the River Gorge Country of Southeastern Tibet. Francis (Frank) Kingdon WARD* (1885—1958). *Wiesbaden* 1975.) Its major aim was to facilitate working with F.K. WARD's publications based on the wide range of his travels, partly to areas he was the first to visit and to report about to the Western world, excelling in perceptive observations and ecological thoughts, and outstanding in their vivid descriptions of a part of the globe that is at the same time fascinating and of absorbing scientific interest.

RELATIONSHIPS BETWEEN THE FLORA OF QINGHAI-XIZANG (TIBET) PLATEAU AND THE FLORA OF THE HIMALAYAS

J.F. DOBREMEZ
(Laboratoire de Botanique, Grenoble Cedex, France

Twelve years of research on Flora and Biogeography of the Himalayas, mainly Nepal Himalayas, have elucidated the relationships between the South wet high mountains environment and the North dry Plateau.

In a previous paper I have pointed out the sharp limit between centrasiatic and himalayan phytogeographical regions based on climatological and biogeographical data.

As far as the Flora is concerned, the differences are due to the complete lack of elements from Indian, south-east-Malaysia and Sino-japanese regions on the Plateau. On the other hand centrasiatic species are forming more than 25% of himalayan subalpine Flora and more than 40% of alpine. The species coming from Iranturanian region occur in both Plateau and Himalayas.

This is suggesting the effects of altitude (temperature), rainfall and specially the effect of barrier of the himalayas on plant migration from North to South and from South to North.

The plants coming from South and from East have been migrating all along the Himalayas but due to their thermophilic or hygrophilic characters, they have not been able to colonise the Plateau through the high passes.

The plants coming from North and from West which sustain both dryness and coldness have colonised all the suitable regions of the changing southern slopes of the Himalayas.

The rise of the Himalayas and of the Plateau has separated, on climatological and biogeographical point of view two entirely different worlds, but the northern one is slightly passing beyond the boundary, where it can be observed from South.

The knowledge of the Himalayan ecology is progressing since last few years. Now the collaboration with Chinese scientists is necessary to elucidate the great changes which take part in a few kilometers between the southern slopes of the Himalayas and the Qinghai-Xizang Plateau.

(The presentation of paper will be illustrated by vegetation maps, lists of Plants and climatological diagrams).

THE PHYTOGEOGRAPHY OF THE XIZANG RANUNCULACEAE

Wang Wen-tsai

(Institute of Botany, Academia Sinica)

1. The Ranunculaceous plants of Xizang (Tibet) total up to 172 species belonging to 22 genera, of which 48 are endemic. The majority of them are found in the montane regions of eastern and southern parts of Xizang with only a few species in the northern and western parts of the plateau. In respect to the altitudinal distribution the majority of species have a range of elevations between 2500—5000 m. above sea level; some species (*Caltha scaposa*, *Delphinium glaciale*, *D. caeruleum*, *Paraquilegia microphylla*, *Thalictrum rutifolium*, *T. squamiferum*, *T. alpinum* var. *elatum*, *Anemone imbricata*, *Adonis coerulea*, *Ranunculus longicaulis* var. *nephelogenes*, *R. bangueensis*, *R. involucratus*, *R. glareosus*, *Oxygraphis glacialis*, *Halerpestes tricuspis*) may come up to as high as 5200—5400 m. elevations, *Trollius farreri* and *Callianthemum Pimpinelloides* to 5600 m., and

Delphinium brunonianum even to 6000 m., being the only species known of the *Ranunculaceae* reaching the highest altitude. Only two species are found under 2000 m., i. e. *Clematis grewiiflora* in the savanna of the valley of southern Xizang at elevation of 1800 m. and *C. metuoensis* in subtropical evergreen forests at an elevation of 860 m. in southeastern Xizang.

2. There are 44 species, 1 subspecies and 7 varieties (about 26 per cent of the total number of species), which are common with the neighbouring provinces of northern Yunnan, western Sichuan (Szechuan) and eastern Qinghai (Chinghai). Most of them are found in the eastern and southern parts of Xizang, only a few species reaching its western parts. 29 species, 3 varieties (about 17 percent) are common with both above mentioned regions and the neighbouring countries of the southern flank of the Himalayas, and are mainly found in the eastern and southern parts too. All the above mentioned species taken together amount to 73 in number (about 43 per cent). Considering the fact that the northern Yunnan and western Sichuan are the centre of distribution for the *Ranunculaceae* and are especially rich in primitive forms of this family, it might reasonably presumed that the above-mentioned species might all have originated in that region and later extended westward to Xizang or even farther on to its adjoining regions. Furthermore, it may be possible that some species found at the higher altitudes, such as *Caltha sinogracilis, C. scaposa, Trollius tanguticus, T. farreri, T. ranunculoides, Anemone imbricata, Adonis coerulea*, might be derived respectively from more primitive forms, such as *Caltha palustris, Trollius yunnanensis, Anemone demissa, Adonis brevistyla*,all found in regions at lower elevations possibly through dwarfing in response to their adaptation to more severe ecological conditions caused by the uplifting of the plateau.

Of the 172 species of Xizang *Ranunculaceae*, 48 (about 29 per cent) are endemic, among which *Beesia* is represented by 1 species, *Aconitum* by 22, *Delphinium* by 18, *Thalictrum* by 2, *Anemone* by 1, *Ranunculus* by 3, and *Halerpestes* by 1 respectively. The majority of these endemic species are confined to one or a few particular peaks of the eastern or southern Xizang and evidently all are neoendemics likely formed during or after the uplift of the plateau. It is very interesting to note that in Xizang there is not a single endemic genus of the *Ranunculaceae* discovered.

22 species, 1 subspecies (about 13 per cent), found in southern Xizang,are also common with southern neighbouring countries and are all endemics of the Himalayas.

So far about 3 species of western Xizang are also found in Kashmir and Pakistan.

There are very few widespread species of the *Ranunculaceae* in Xizang. Mention may be made of *Caltha palustris* and *Thalictrum minus*, two widely distributed species in Northern Temperate regions, probably entering into eastern and western parts of Xizang from its eastern and western adjacent regions respectively. An Eurasian species, *Thalictrum foetidum* probably extends its range to the southern parts of Xizang from western Sichuan and to the northern parts from Pamir and Kunlun respectively. Another example is *Adonis aestivalis* var. *parviflora*, which has widely distributed from Europe to western Asia and reaches Gyinong in southwestern Xizang along the southern flank of the Himalayas from Asia Media. Again, *Halerpestes cymbalaria* and *Ranunculus natans*, both widespread in northern Asia may come to Xizang via Qinghai.

Clematis metuoensis, endemic in Metuo in southeastern Xizang, is a vicareous species

Clematis metuoensis, endemic in Metuo in southeastern Xizang, is a ricareous species for *C. loureiriana*, widespread in tropical Asia, and is the only representive of the Xizang *Ranunculaceae* belonging to the Indo-Malayan flora.

In conclusion, the Xizang Ranunculaceous flora, just like the entire flora of Xizang, is mainly derived from the species of the surrounding countries. Among them, the Tertiary alpine flora of northern Yunnan and western Sichuan had certainly played a most important role; it also has a close affinity with the alpine flora of the southern slope of the Himalayas. The flora of the western part of Xizang is closely related to that of Kashmir and adjoining regions. The influence of the Europe-Siberian and Indo-Malayan floras on the Xizang flora is rather weak.

3. *Aconitum* and *Delphinum*, both characterized by zygomorphic flowers and containing complex chemicals (diterpenoid alkaloid), and the third genus, *Consolida*, together constitute one of the advanced groups of the *Ranunculaceae*, i. e. the Tribe *Delphineae*. The first two genera are presented by a high concentration of species and high endemism along the southeastern margin of Xizang Plateau and neighbouring regions. There have been found nearly all the primitive taxa in these two genera. For example, in *Aconitum*, there are four monotypic sections (Sect. *Galeatum*, Sect. *Fletcherum*, Sect. *Alatospermum*, Sect. *Sinaconitum*), the primitive species of Sect. *Lycoctonum* (*A. chrysotrichum* and *A. brevicalcaratum*) and Sect. *Aconitum* (*A. tanguticum*, *A. spiripetalum*), while in *Delphinium*, there are most primitive existing group, Sect. *Aconitoides* and the majority of primitive species belonging in Subsect. *Brevicalcarata* and Subsect. *Umbellata*, two primitive groups of Sect. *Elatopsis*. Considering the advanced systematic position of these two genera in the *Ranunculaceae* and the distribution patterns of their primitive taxa with their high endemism in Xizang Plateau, the author is of the opinion that these two genera might have originated from a common ancestor in the southeastern part of the Xizang during or a little before the uplift of the land.

THE TAXONOMIC SYSTEM AND GEOGRAPHIC DISTRIBUTION OF THE GENUS MECONOPSIS

Chuang Hsuan

(Kunming Institute of Botany, Academia Sinica)

The genus Meconopsis has been credited with 49 species, all except one western European species distribute in the Sino-Himalayan region, 38 species being recorded from China.

On the basis of elaborating the taxonomic systems by pioneer workers and in a wholesale analaysis of the different plant organs, a more natural system of the genus has been suggested, and further discussions are made about the phylogenetic system among the taxonomic groups and the dialectical relationship between phylogeny and environments.

South-western China with neighbouring eastern-Himalayan regions is the center of distribution of this genus. The old montane region of Central China and its neighbour hood may be its birthplace, while on the margin of Qinghai-Xizang Plateau may be the secondary center of de velopment. At the same time, the present paper has also discussed the relationship between the Himalayan uplifting and the speciation and development of species groups of the genus.

THE EVOLUTION OF SOME SECTIONS OF THE GENUS CORYDALIS VENT. IN QINGHAI-XIZANG PLATEAU

Wu Cheng-yih Shu Tsi-yin Chuang Hsuan
(Kunming Institute of Botany, Academia Sinica)

The genus *Corydalis* containing about 350 species in the world is one of the big genera in north temperate flora. They widely distribute in the north temperate zone, but a few species have been discovered along the edge of north African-Indian desert and in the mountain of Eastern Africa.

The total number of species of this genus in China run up to about 290, about 83% of the world's total. The genus reaches its highest morphological diversity and greatest concentration in southwestern China and the Himalayas.

There are 94 species in Xizang belonging to 15 Sections, about 27% of total species of the genus and 33% of the total species in China. Thus number of species in Xizang is only a little less than that in Szechuan. Endemic species among them are 37, about 42% of entire *Corydalis* in Xizang and a little less than that of Szechuan. They are important elements in Xizang flora.

The species of this genus in Xizang distribute between 27°—33° N and 79°—98° E. The abundance of the species and endemic species forms a distinct distribution-pattern which gradually decrease in abundance from the south-eastern to north-western Xizang. This pattern of distribution reflects that different natural regions have quite different environmental factors which are either favorable or unfavorable to different species groups. This will serve as a basis for the phytogeographical regionalization of Xizang.

Xizang species of this genus are chiefly alpine forms coming into existence rather late in geological times. Great majority (72%) of them distribute up to the elevation of 3800 m. and others (37%) up to 5000 m. Many species develop in common a habit capable to adapt aridity and frigidity. Among different species and populations the variants as well as intermediates generally exist. For example, in the Sec. Mucromiferae Fedde, an endemic section in Qinghai-Xizang plateau not only there are species possessing cushion-like habit, flattened petiole, large bract, often mucroniferous lobules of leaves and bracts and so on, but also obviously among species or different populations of certain species intermediate forms may be seen. Among them, *C. hendersonii* Hemsl. and *C. inopinata* Prain are striking examples. In the morphology of flowers and root systems, they appear to be direct descendants in the higher altitude from Sect. *Chrysocapnos* Wendelbo, which widely distribute in Sichuan, Yunnan and Xizang.

The Sect. *Oreocapnos* M.Popov distribute essentially in Xizang. They have all developed the bulbs as a means to resist aridity and frigidity at high altitude. The species of Series Clavatae C. Y. Wu et H. Chuang and Series Fusiformes C. Y. Wu et H. Chuang in Xizang and its neighbouring regions develop a thickened fleshy root system. These two series are not only posses sing the similar root and flower morphology to that of Sect *Trachycarpae* Fedde and Sect.Rapiferae Fedde respectively but also intricately overlapping in their range. No doubt, they are the result of the parallel evolution in the two latter sections in adaptation to the natural environments of the high plateau. Of the Sect. *Oreocapnos* M. Popov, a gro up of species, Series Fibrosae C. Y. Wu et H. Chuang, are distributed in Central Asia. A rather farapart geographical isolation is present between these and the two series discussed above. This distribution pattern may imply that all species of Sect. *Oreocapnos* M. Popov had been of a continual distribution during the ancient geological period, but they were afterwards isolated from each other by the upheaval of Qinghai-Xizang plateau and the glaciation in the Quaternary Ice Age. Some intermediate groups which erstwhile distributed in areas between Qinghai-Xizang plateau and Central Asia were annihilated by natural selection while some other groups since then survived in certain specific regions in Central Asia. The species of Series Fibrosae C. Y.Wu et H. Chuang with rigid and fascicled roots which may be a variation produced at lower altitude where the water conditions are more favourable than on the plateau. They are, however, more closely related with Series *Clavatae* H. Chuang which tends to northward distribution.

The evolution and differentiation of Sect. *Mucroniferae* Fedde and Sect. Oreocapnos M. Popov indicate the influence of the upheaval of Qinghai-Xizang plateau and its complicated natural environments on *Corydalis*. Sect. *Mucroniferae* Fedde is a direct by-product of the upheaval of Qinghai-Xizang plateau and the Sect.*Oreocapnos* M.Popov formed its centre of differentiation in Qinghai-Xizang plateau since time of upheaval.

THE FLORISTIC CHARACTERISTICS AND PHYTOGEOGRAPHIC DISTRIBUTION OF THE ROSACEAE OF XIZANG

Yü Te-Tsun Lu Ling-di Ku Cui-chi
(Institue of Botany, Academia Sinica)

There are 30 genera and 242 species in the Rosaceae of Xizang. It is one of the five large families, after the Compositae, Graminae, Leguminosae and Ericaceae. The Rosaceae of China contains 48 genera and about 860 species, so the Xizang rosaceous plants cover about 63% in genera and 28% in species of the whole country.

The four subfamilies of Rosaceae including the primitive, the intermediate and the advanced forms can be found in this same area.

The 30 genera of Xizang Rosaceae consist of 11 types of floristic composition, i. e., 4 genera belong to cosmopolitian, 9 genera belong to North Temperate, 3 E. Asia-North America, 2 Sino-Himalaya, 3 Sino-Japan, 2 Old world Temperate, 2 Mediterranean-W. and C. Asia, I Central Asia, 1 Tropical Asia, 1 Temperate Asia and 1 Endemic in China. Among these elements the temperate is mostly dominant. While there is no endemic genus in Xizang.

The characteristics of Xizang rosaceous flora can be summarized as follows: (1) very rich in species and varieties; (2) rather complicated in floristic composition, however, Eastern Asia temperate elements are mostly dominant; (3) many endemic species and local varieties, showing the differentiation of species taken place actively; (4) combination of old and new floristic elements, including the primitive and advanced groups. It is clearly showing that the rosaceous flora of Xizang developed gradually after the upheaval of the Himalaya mountains.

The geographical distribution of rosaceous plants has close relationship with many areas. In China, Xizang plants have many common species with those of NW. Yunnan and W. Sichuan. In Asia, there are more species in common with Nepal, Sikkim, Bhutan, North India and Upper Burma.

In the Xizang proper, there are much more species in the south-eastern part, fewer species in the south part, while in the north-western and northern parts very sparse. Therefore the distribution of plants in Xizang has a tendency of gradually decreasing of species from south-east to north-west. Likewise, the types of plant habit in the south-eastern part of Xizang there are many trees, shrubs and large herbaceous plants, but gradually become lower shrubs, even cushion-like scrubs and dwarf perennial herbs in the north-western and northern parts of Xizang. It is also indicating that the uplift of Himalaya mountains has a strong effect on the geographical distribution and

THE FORMATION AND DIFFERENTIATION OF THE LEGUMINOUS FIORA IN XIZANG

Li Pei-chun Ni Chi-cheng

(Institute of Botany, Academia Sinica)

Xizang is rich in leguminous flora, comprising 41 genera 258 species so far known, exclusive of the commonly cultivated or naturalized taxa (11 genera and 16 species) . There are 4 endemic genera (7 species), 10 temperate genera (175 species) and 19 tropical genera(46 species),as well as the representatives of those genera with their distribution centers in East Asia-North America, Mediterranean region and West Asia-Central Asia.

I. There are altogether iour endemic genera of Leguminosae in this region. According to their morphological characters, systematic position and geographical distribution, it would appear that *Salweenia* and *Piptanthus* are Tertiary paleo-endemics, while *Stracheya* and *Cochlianthus* are neo-endemics. *Salweenia* and *Piptanthus* may be some of more primitive members in the Subfamily *Papillonasae* and their allies are largely distributed in the Southern Hemisphere. The other two genera might have been derived from the northern temperate genus *Hedysarum* and the East Asian-North American genus *Apios* respectively, because of their morphological resemblance. They probably came into existance during the uplifting of the Himalayas.

II. An investigation has been made with reference to the differentiation of some temperate genera such as *Astragalus*, *Oxytropis* and *Caragana*, and the tropical genus *Desmodium*. The result shows that:

(1). The number of endemic species for these genera is rather high, reaching 111 species, up to 43 per cent of the total (258 species) . This is probably due to the particular climatic and geographical conditions of Xizang. Apparently, Sino-Himalaya region is now the center of differentiation and distribution for some groups, such as *Astragalus* subgen. *Pogonophace* Bge. and *Desmodium* subgen. *Podocarpium* (Benth.) Ohashi.

(2). Durihg the uplifting of the Himalaya mountains, the speciation seems to be notable. In some genera, such as *Thermopsis* and *Chesneya*, we found here certain advanced representatives and they are all Sino-Himalayan endemics.

(3). The horizontal and vertical vicarism of endemic species is evident, indicating that these endemic species might be formed by the specialization of the alien and native elements, and that the tropical and subtropical elements of this family are related to those of Southeast Asia and Africa, while the temperate elements to those of Southwest China and West and Central Asia.

ON THE ORIGINATION AND DISTRIBUTION OF THE GENUS SALIX IN QINGHAI-XIZANG PLATEAU

Fang Zhin-fu Zhao Shi-dong
(Institute of Foresty and Pedology, Academia Sinica)

1. Uplifting of Qinghai-Xizang plateau has brought great influence on the origination and distribution of species inside the genus Salix. There are 91 sp., 16 var. and 3 f. belonging to 15 Sect. in this region, among these species the endemics attain to 58 sp., 14 var. and 3 f..So it has become one of the most important centres of distribution of Salix in the world. Species common with other regions attain only to 32. Thus it is also clear that correlation between salicaceous flora in this region and that of other regions is not so much developed, and that the salicaceous flora of Qinghai-Xizang plateau was mainly originated autochthonously during the upheaval of plateau.

2. Along a demarcation line delineated from Gyirong through Lhasa and Qamdo to Lanzhou, to the north-western region the total number of species of this genus is summed up to 7 sp. and 1 var.(incl.2 cult.sp.),and they distribute only in the West Himalaya and Pamir-Kunlun regions. Besides 2 cult. sp., there is only 1 endemic, and others all should be migrants from Europe or West Asia. In the south-eastern part, because the climate is moister, the species of Salix may be summed up to 84 sp., 15 var. and 3 f., among them 73 sp., 20 var. and 3 f. are endemics, accounting for 68 percent of the total.

3. In East Himalaya and South Henduan Shan(southward of lat. 30°N.)there are 78 sp., 12 var. and 4 f., among them 50 sp., 10 var. and 2 f. are endemics. They represent the different stages of phylogenitic development of this genus. So here may be the centre of origination and distribution of Salix species in the all Sino-Himalaya flora. The common species between East Himalaya and South Henduan Shan regions attain to 41. Because the latter forms a part of Sichuan and Yunnan plateau and the former did not become a land until Quaternary Period. the plants of the former mainly are the migrants from the latter.

4. The most characteristic group of Salix in this region is Sect. Lindleyanae Schn. with a total of 18 sp. and 1 var..This group adapting to the somewhat environment changes is quite different from Sect. *Retusae* A. Kern. in the Arctic and high mountains of higher latitudes in many characters, so it should be originated autochtonously, and it is certainly not a migrant from Arctic.This Sect. seems to be developed from Sect. *Floccosae* Hao and in turn from Sect. *Sclerophyllae* Schn. and *Denticulatae* Schn., This developmental direction has assumed an important branch in the phylogenetic development of the whole genus.

5. In addition, there are two interesting and important regions on the north-eastern and eastern to Qinghai-Xizang Plateau, i. e. on the north-east Anymaqen Shan(Amnemachin mountain)and on the east Qiong Lai Shan. There are many endemic species pertaining to these two parts, among these species some may be ancient relicts since Tertiary. It is to be expected that more additional scientific results will be obtained after some more extensive works done in these two regions.

THE DISTRIBUTION AND FIORISTIC CHARACTER OF CHINESE ANACARDIACEAE

Ming Tien-lu
(Kunming Institute of Botany, Academia Sinica)

There are 15 genera including 52 species of Anacardiaceae in China. They are distributed in those tributaris southern to Yangtze River basin especially in the south-western and southern part of China.

Of the 15 Chinese genera, 9 belong to the Tropical Areal-Types, and 6 belong to the Temperate Areal-Types, altogether constituting 8 distribution patterns. By analyzing of these distribution patterns, it reveals from one side that Chinese Flora is widely connected with different floras of the whole world in their historical backgrounds. The flora of southern to south-western China(especially in S.to S.E.Yunnan and S.Kwangsi)has the closest relationship with that of Tropical Asia(especially Indo-China Peninsula), which may be probably the birthplace of the genera *Pegia* and *Drimycarpus*. The old montane regions of Central and South-western China are centers of distribution of some temperate genera, and moreover, are most probably the birthplace of the genera *Toxicodendron*, *Choerospondias*, *Cotinus*, and *Dobinea*.

Yunnan province is a meeting ground for distribution of these tropical and temperate genera. All Chinese genera are concentrated here, with 45 species out of 52, and the per centage of endemic species are also very high(up to 12 species).

The Himalayan Orogenesis and the upheaval of Qinghai-Xizang plateau play an important role for distribution of some genera(e. g. Cotinus and Pistacia), presenting disjunctions between eastern and western Himalayas.

XIZANG UMBELLIFERS: THEIR GEOGRAPHICAL PATTERNS AND FLORISTIC CHARACTERISTICS

Shan Ren-hwa Sheh Meng-lan
(Jiangsu Institute of Botany)

There are about 93 genera and more than 500 species of the family *Umbelliferae* in China, of which 39 genera and 108 species including 2 new genera and 22 new species and varieties are recorded in Xizang. They are summarized as follows:

1 . Umbellifers in Xizang generally inhabit the humid temperate regions, and grow abundantly on both flanks of the central Himalayas (over 73%) and southeastern Xizang (over40%) with a few extending to northern (13%) and northwestern (0.64%) Xizang.

2 . The floristic composition may be listed in following types:

1) Sino-Himalayan type: *Chamaesium, Cortiella, Cyclorhiza, Haplosphaera, Pachypleurum, Sinolimprichtia, Trachydium, Vicatia, Acronema.*

2) Sichuan-Yunnan-Xizang type: *Physospermopsis , Sinodielsia, Sinocarum, Pternopetalum, Notopterygium.*

3) East Asia-North American type: *Osmorhiza.*

4) Sino-Japanese type: *Nothosmyrnium.*

5) Indo-Malayan type: *Hydrocotyle, Centella, Oenanthe.*

6) Eurasian type: *Chaerophyllum, Pleurospermum, Bupleurum, Carum, Pimpinella, Seseli, Selinum, Ligusticum, Angelica, Peucedanum, Heracleum, Sanicula. Eriocycla.*

7) Mediterranean type: *Ferula.*

8) Cosmopolitan type: *Foeniculum, Daucus, Coriandrum, Apium.*

3 . Most genera of the Sichuan-Yunnan-Xizang type were endemic to the Hengduan-Shan range and later as the developing centre ranging over southern and southeastern Xizang and even extending to northeastern Xizang.

4 . The genera of Sino-Himalayan type were endemic to Qinghai-Xizang Plateau and with Xizang as the developing centre ranging over Sichuan and Yunnan in the southeast, and through Qinghai or Sichuan to Gansu in the northeast and even westwardly to Xinjiang; some genera grow southwardly to Sikkim and Nepal.

5 . There is a close relationship between the flora of Xizang and the flora of Yunnan and Sichuan. The chief members of the family in Xizang are very likely to have been originated from the borderland of Yunnan and Sichuan rather than from the Central Asia. A very striking evidence can be elucidated by the distribution pattern of the family, there are 24 genera in Xinjiang and most of them are related to the flora of Central Asia, but none of them are found in Xizang except one species of Ferula.

Thus, the Xizang Umbellifers primarily consist of the Eurasian elements and they are fundamentally characterized by the salient Sino-Himalayan features combined with some minor elements related to the adjacent floras. It presents itself as a distinctive flora.

THE DIFFERENTIATION AND DEVELOPMENT OF THE GENUS RHODODENDRON DURING THE UPLIFTING OF THE HIMALAYAS

Fang Rui-zheng Ming Tien-lu

(Kunming Institute of Botany, Academia Sinica)

The *Rhododendron* is one of the largest genera of plants in the Northern Temperate Zone. The center of its distribution ranges from southwestern Szechuan, northwestsrn Yunnan, southeastern Xizang(Tibet), and Upper Burma, and westward to the eastern Himalayas. It comprises great many species and various groups (i.e. Sections and Subsections) in this region, and the most primitive groups still survive in this part of the world.

The genus *Rhododendron* plays an important role in the flora and vegetation of Xizang. In Xizang, there are 170 species known accounting for 20% of the world's total (850 species) or 36% of China's total (460 species); 70% odd of them distribute in southwestern China as well as in the extra-Chinese regions and countries of the southern flank of the Himalayas; About only 26% of them distribute in Xizang. However, none of the species distributing in Indo-China Peninsula, Malaysia, Europe or North America has been found in this region.

Analysis the present and historical distribution of the genus Rhododendron in relation with the geological history of the Qinghai-Xizang Plateau, it is obvious that the upheaval of the Himalayas has changed the horizontal and vertical distribution of the genus, and the influenced deeply on the differentiation of the genus as shown by the following facts:

1. Although the profound influence of the orogeny of the Himalayas on the physical features of Xizang is well reflected by the endemic species and the distribution of the primitive and alpine endemic groups of Xizang, the floristic composition of the Rhododendron flora in Xizang is closely related with those of Szechuan, Yunnan and Burma, whence most of the species spread westwards with a prominent phenomenon of horizontal or vertical replacement as a result.

2. Endemic species are predominant in the Rhododendron flora in Xizang and they concentrate on the southern flanks of the Himalayas, especially in the southeastern part of Xizang. There are 5 endemic subsections on the Himalayas, each consisting of

only a few species and there is no endemic subsection on the Qinghai-Xizang Plateau at all.

The above facts indicate rather convincing that the origin and evolution of genus Rhododendron are comparatively old, while the geological history of the upheavals of both the Himalayas and Qinghai-Xizang Plateau is relatively young.

NOTES ON THE DISTRIBUTION OF THE GENUS PRIMULA IN XIZANG

Chen Feng-hwai Hu Chi-ming
(South China Institute of Botany, Academia Sinica)

The genus Primula L. is one of the largest genera among the flowering plants. It comprises about 700 species, subspecies and varieties in the northern hemisphere, especially in the alpine-montane areas of the temperate regions. The greatest concentration of species is found along the Himalaya range and the Hengduan mountains of western China. In Xizang, there are 113 species in 15 sections:

As to the altitudinal distribution, the majority of the species are found at altitude of about 3000—5000 meters, particularly between 4000—4500 meters (fig.1.). At these altitudes the meadow and stony pasture, cliffs, screes and sheltered crevices in the mountain ranges are the favored habitats for the genus.

To sum up the foregoing information, it brings out an important point that a great number of species of the genus are concentrated at higher elevetions in East Himalayas, and more species are known from the south side of the mountain range as well as in the areas between Yunnan, Xizang and Burma. Only a few species are found in West Himalayas and Xizang plateau proper.

Out of a total of 113 species, 33 are in common with western Yunnan, Sichuan, 43 species are also found in adjacent parts of Nepal, Sikkim or Bhutan and 34 species are endemic or only known from the type collection. On the contrary, the species common to both West Himalaya and East Himalaya are rather few.

It is clear that there is a very high degree of floral continuity between the western Yunnan and East Himalaya, but some of the species that are found in one of these regions are replaced by subspecies or varieties of the same species or closely related but different species in the other region. For example, *P eucylia* W. W. Sm. et Forr. of western Yunnan is replaced by the vicarious species *P. vaginata* Watt; *P. denticulata* Smith and *P. capitata* Hook of the eastern Himalaya each with a variety in western Yunnan. The most interesting species are *P. yargongensis* Petitm. and *P. involucrata* Wall. The former is widely distributed along the border of Yunnan, Sichuan and East Xizang, while the latter is restricted to southern Xizang. The general morphology of the two species is almost the same but *P. yargongensis* Petitm. has the chromosome number $2n=44$ while its ally $2n=20$. These differentiations as well as the relatively great number of endemic species in East Himalaya serve to show that the flora of these two regions are closely associated, but their continuity has been broken in some degree in recent geological period. On the other hand, its relationaship with Central Asia is exceedingly slight.

The above statements also indicate that the distribution pattern of the species in Xizang is closely associated with its physiographic features. Primulas aremoisture-loving plants. The dominant factor determining the distribution pattern of the genus seems to be the relative humidity of the atmosphere affected by the south-west monsoon. The Himalayas, as a rainscreen running mainly West-East bring an exceedingly heavy precipitation on its southern side. On the eastward, the Hengduan mountains stretch almost due north and south with many deep gorges, along which, the moisture-laden wind blows and form a wider high cloud zone. It is just within these zones of higher precipitation the species populations of Primula are flourishing best. North of the Himalayas especially on the Xizang plateau, few species occur, because of lack of sufficient moisture.

Considering the foregoing floristic evidence and the geological history of the area it might be reasonably presumed that before the uplift of the Himalayas, Primulas were widely distributed in the mountains of Sichuan, Yunnan and Upper Burma, as well as in Central Asia. But later, when the uplift occurred and brought about new habitats, the genus has spread rapidly westward along the mountain ranges, whose abundant atmospheric moisture and cool humid alpine meadows have favoured the development of the genus. On the other hand, the rising of the Himalayas shut off the moisture-laden wind from northern and western parts of Xizang which ultimately turned into a vast high steppe and semi-desert thus forming a wide disjunction of the species between Xizang and Central Asia.

NOTES ON THE FLORISTICS OF GENTIANACEAE IN XIZANG (TIBET) AND ITS GEOGRAPHICAL RELATIONSHIP

Ho Tingnong
(Northwest Plateau Institute of Biology, Academia Sinica)

I. Analysis of floristic composition: The family *Gentianaceae* recorded in Xizang (Tibet) comprises 15 genera, 161 species, of which 39 are endemic, occupying 1.3% of the total genera and 3.2% of the total species of Xizang seed plants respectively.

1. Distribution patterns of genera: There are 15 genera of *Gentianaceae* occurring in Xizang (Tibet). According to the distribution ranges of the genera, we may divide them into following patterns:

A. North temperate zone: *Gentiana* (99 spp.), *Lomatogonium* (12), *Gentianella* (5), *Comastoma* (5), *Gentianopsis* (2).

B. Sino-Himalayas: *Veratrilla* (2), *Megacodon* (1).

C. E. Asian: Crawfurdia (6), *Tripterospermum* (1), *Pterocalyx* (1).

D. Eastern Asia-North America: *Halenia* (1).

E. Disjunct distribution in Asia, North America and Africa: *Swertia* (22).

F. Indonesia and Sino-Himalaya: *Cotylanthera* (1).

G. Endemic genera:

a. Himalayan Mountains: *Kingdon-Wardia* (1).

b. Qinghai-Xizang (Tibet) Plateau: Lomatogoniopsis (2).

From above, it may be suggested that: 1. The genera of the north temperate distribution pattern are more in number than those of any other patterns mentioned above. 2. Strictly speaking, there are no endemic genera in Xizang.

2. A majority of species and primitive groups in the distribution pattern of north temperate zone are found to occur in China, especially in Hengduan-Shan mountain region (including eastern Xizang), such as the genus *Gentiana* (155/270/400, namely, the species from Hengduan-Shan/those from China/the total species of this genus), the primitive Section *Otophora* (8/8/8); *Lomatogonium* (14/20/24), with its primitive species (4/4/5). Therefore, Hengduan-Shan mountain region might be the cradle of these genera and their birthday perhaps not later than Tertiary period.

3. The endemic genera *Lomatogoniopsis* and *Klngdon-Wardia* might be derived res-

pectively from their closely related genera *Lomatogonium* and *Swertia* since the uplift of the Himalayas.

4. The genus *Cotylanthera* represents one of the paleotropical relic genera which have survived since Tertiary.

II. Geographical divisions and relationships

1. On the basis of floristic composition as well as geographical and climatic conditions, the Gentianaceous flora of Xizang may be divided into six floristic regions:

A. Easter Xizang (Tibet) region, comprising 11 genera, 76 species and 5 endemic species.

B. Southeastern Xizang (Tibet) Region, 15 genera, 84 species and 20 endemic species.

C. Northeastern Xizang (Tibet)Region, 6 genera and 24 species, without endemic species.

D. Southern Xizang (Tibet) Region, 7 genera, 46 species and 2 endemic species.

E. Western Xizang (Tibet) Region, 6 genera, 23 species and 1 endemic species.

F. Qiang Tang Region, 2 genera and 3 species, no endemic species.

In general the Gentianaceous flora is rich in the southeastern Xizang (Tibet) and becomes poorer towards northwest.

2. The Gentianaceous flora in Xizang (Tibet) is closely related to those in western Sichuan and northwest ern Yunnan, with altogether 13 genera and 70 species in common. They may be combined together to constitude the Gentianaceous flora of having 13 genera (except widespread ones), 217 species and 138 endemic species, and here may be the birth-land of Xizang Gentianaceous flora. From here westwardly along the Himalayas extending to western Xizang (Tibet), and northwards to Tanggula-Shan, the Xizang Gentianaceous flora has been formed.

3. The Xizang and Himalayan Gentianaceous floras are closely related to each other, 13 genera and 49 species, including 1 endemic genus and 25 endemic species being found to occur in both regions. The Gentianaceous flora in Xizang(Tibet) has also some relationships to that in Tangut, 11 genera and 38 species being in common, but no marked relationships can be found between the Xizang and the Central Asian flora, for they share only 6 genera and 11 species for both.

III. Characteristics of the Gentianaceous flora in Xizang.

1. This flora is rather young in a state without endemic genera, but plentiful of endemic species.

2. It is an westward extension of the Gentianaceous flora from Hengduan-Shan.

3. It has characteristics of north temperate flora but notable with alpine features.

ON THE ORIGIN AND DISTRIBUTION OF THE GENUS CREMANTHODIUM BENTH.

Liu Shang-wu
(Northwest Plateau Institute of Biology, Academia Sinica)

The genus *Cremanthodium* Benth. is one of the comparatively advanced genera of the tribe *Compositae-Senecioneae* and is an endemic genus in Sino-Himalayan region. Altogether 64 species and 7 varieties are recorded up to date. Among them, 61 species occur in China, including 42 endemics; 22 species are dispersed over Burma, Bhutan, Sikkim, Nepal and Kashmir, among them only 3 endemics in Burma. This shows that China boasts of the greatest number of species of this genus.

The genus *Cremanthodium* may be divided into two sections: *Cremanthodium* and *Pinnatinervia*. The former represents a relatively primitive group with kidney-shaped leaves and palmate nervation, possessing 17 species, being 26.5% of the total. Section *Pinnatinervia* with 47 species and making up 73.5%, is relatively advanced, their leaves being linear to rounded and nervation pinnate.

The distribution range of the genus *Cremanthodium* is between the Himalayas and the Karakorum, Kunlun, Qilian Mountains, eastwards to the Xiqing Shan, Daxue Shan, Lunan Shan mountains, westwards to Kashmir. This triangular area is between 75° and 103° East Longitude and 26° and 39°20′ North Latitude. We may divide it into four geographical regions: (1) Southeastern River George Region, situated between 92° and 100° E, 27° and 30° N, has 43 species, 67% of the total, including 35 endemic species. Among them are 16 species of Section *Cremanthodium*, including 13 endemics. (2) Himalayan Region (including Kashmir) has 19 species (11 endemics), among them 4 species (1 endemic) belong to Section *Cremanthodium*. (3)Eastern Qinghai-Xiang Plateau Region, lying east of 92° East Longitude and north of 30°10′ North Latitude, has 11 species with 5 endemics, among them Section *Cremanthodium* only has one species and no endemics. (4) Chang Tang Plateau Region, situated to the west of 92° East Longitude and north of 30°10′ North Latitude, only has 4 species of Section *Pinnatinervia*, without endemic species. As stated above, most species are in Southeastern River George Region, where a lot of endemic and primitive species may be found. Undoubtedly it is the present distribution centre of this genus, while the centre of origination may be Hengduan-Shan systems, thence westwards along the Himalayas the species notably decrease in number, there being only 5 species in Kashmir; northwards along the Hengduan-Shan systems to Qilian Mountains with only two species. Apparently reason for such a distribution pattern is that the unfavourable climatic factors and the rapid uprise of Himalayas have restricted the dispersion of species.

The genus *Cremanthodium* perhaps derived from the Section *Corymbosae* of the genus *Ligularia* (L.) Cass. The uplifting of the Himalayas has impelled it to get "activation", the effect of which is fully demonstrated by an increase in number of species of the Section *Pinnatinervia* and by an enlargement in the distribution range of the genus.

HIMALAYAS-HENGDUAN MOUNTAINS —THE CENTRE OF DISTRIBUTION AND DIFFERENTIATION OF THE GENUS ARISAEMA

Li Heng
(Kunming Institute of Botany, Academia Sinica)

The genus *Arisaema* was established in 1831 by Martius on the basis of three Himalayan species. At present 151 species have been recognised, of which 139 species or 92.6% have been collected from Asia, 6 from eastern Africa, 6 from eastern North America, but none have been found from Australia, Europe, or from South America. This may serve as an indication of its Laurasian origin centering in Asia.

In Asia, the genus is widely distributed, particularly in SW China, S. China (including Taiwan) and NE China, comprising 80 species with 57 endemic ones and constituting 58% of Asia,s total or 53% of world's total. There are 26 species in India and Ceylon, 21 in Japan, 12 in Thailand, 9 in Indonesia, 6 in Kashmir, Afghanistan and Pakistan, and 4 each in Malay Peninsula, Vietnam, Laos and Korea, 2 in Cambodia, and 1 in Philippine. From this, it may be inferred that the center of the distribution of *Arisaema* in Laurasia lies in China.

Paleogeographical analysis shows that the genus dispersed to North America before Pliocene, to Africa in Miocene, to India and Ceylon in Post Mid-Eocene, and to Malaya before Pleistocene. The most primitive types of *Araceae* are of Paleocene and Mid-Eocene. Unquestionably the genus *Arisaema* has come into existance since early Paleocene.

The primitive types of the genus belong to sections *Fimbriata* and Attenuata. In the former sections, there are 13 species, of which 4 species, *A. penicillata*, *A. grapsospadix*, *A. calcareum* and *A. smitinandii* with thick rhizome and evergreen leaves are presumed to be more primitive than those with globose bulbs and annual leaves. The former three occur in SE Yunnan, S. Guangxi, S. Guangdong and S. Taiwan. It seems to be that the region of eastern Asia between 20—25° N may be the center of origin of *Arisaema*. A similar conclusion may also be drawn from a floristic analysis of the section Attenuata.

The range of *Arisaema* in Asia may be divided into 3 floristic subregions: 1. Tropical Asian subregion with 33 species from 6 sections; 2. Sino-Japanese subregion with 44 species from 7 sections; 3. Himalayas-Hengduan (the water sheds of four rivers) subregion with 64 species from all the 12 sections, amounting to 43% of the known species of the genus. The recent center of speciation of the genus is certainly the Himalayas-Hengduan subregion, where the genus has differentiated into a great number of species (i. e. 57 endemic species and 4 endemic sections), ranging from the primitive to the most advanced, in addition to some monotypic sections (e. g. *Dochafa* and *Exappendiculata*).

A STUDY ON THE GEOGRAPHICAL DISTRIBUTION AND FLORISTIC FEATURES OF THE XIZANG (TIBET) ORCHID FLORA

Lang Kai-yung
(Institute of Botany, Academia Sinica)

The orchids in Xizang so far known comprises 64 genera and 192 species with 2 varieties, of which 36 are endemic to China and over 70 including 21 newly recorded species are found all over the Himalayas. Orchids represent one of the big families of flowering plants in Xizang and also an important component in the Xizang flora as a whole.

1. The geographical distribution of Xizang orchids

(1) The range of distribution.

The distribution of orchids in Xizang ranges from Chiangda and Markham in the east, to Tzada in the west, and from Yatung in the south, to Sog in the north. The centre of distribution is in the south-east and southern parts, particularly in Meto and Zayu regions. In these two regions there are 52 genera and 131 species, of which 40 genera and 91 species are recorded from the former and 29 genera and 51 species from the latter. The floristic composition of Meto is closely related to that of East Himalayas and of Zayu to that of Yunnan and West Sichuan.

(2) The distribution of the Xizang orchids on the south and north flanks of the Himalayas.

On the southern flank the orchids have 56 genera and 145 species, while in Meto are most noteworthy both in genera and species, namely 40 and 91 respectively. Changmu region has 21 genera and 32 species being more than the Jilong. The epiphytes in Meto are more abundant than terrestrials. On the contrary, the relative abundance in epiphytes and terrestrials in Changmu and Jilong regions is just the reverse. The highest distribution limit of epiphytes on the southern flank is 2300 (-2400) -2800 (-3100) m. alt., while that of terrestrials on the southern flank is 3900—4500 m. alt..

On the northern flank the orchids chiefly distribute along the middle and lower parts of Zangbo River and its tributaries, more abundant in Milin and Linchin, westward reaching Namling and northward to Sog. Here, no epiphyte has been yet found, while the uppermost distribution limit of the terrestrials is 4200—4500 (- 4600) m. alt. However, *Herminium pugioniforme* can ascend even up to 4900—5200 m. alt. at Dazhi region, being so far the highest altitudinal limit of the orchid distribution in Xizang.

The localities at different altitudes with different natural conditions on the southern and northern flanks reflect difference in dominant tree species as well as the species and floristic composition of orchids. On the northern flank all orchid species belong to the Eastern Asian elements, while on the southern there are not only the Eastern Asian elements but also some Indo-Malesian elements.

(3) The orchid flora in Xizang are very closely related to those of Yunnan and Sichuan as well as north-east India, Bhutan, Sikkim and Nepal with many genera and species in common. With Yunnan the Xizang orchids have 63 genera and 140 species, and with Sichuan 49 genera and 76 species, and with Himalayas 58 genera and 133 species in common. However, with Indo-Malesian Peninsular the Xizang orchids have only 53 genera and 67 species in common, thus, showing clearly in certain degree the Indo-Malesian influence.

2. The floristic features of the Xizang orchids

(1) Of the primitive tribe, such as *Apostasieae* with two or three stamens is Indo-Malesian element, inhabiting chiefly tropical Asia, none is found in Xizang, while of *Cleisostominae*, a large tribe including tropical epiphytes and inhabiting also chiefly tropical Asia, being Indo-Malesian element, we have only 8 genera and 11 species, 6 genera being monotypic, so that the tribe is poorly represented in Xizang and also indicates the northern limit of its range.

(2) Of all subtribes of *Orchidinae* the terrestrials rank first with 13 genera and 55 species with 1 variety, amounting to about 28.6% of the total Xizang orchids known. Except for a few genera such as *Habenaria* which inhabits the tropics, most other genera are temperate and subtropical members. *Orchidinae* representing the majority of species and covering the widest area of Xizang, is the main component in the Xizang orchid flora.

(3) Among all Xizang orchids there are no primitive genera, such as *Neuwiedia* with three stamems and *Apostasia* with two stamems. In addition, there are no endemic genera, but 6 endemic species and 1 variety are found in Xizang. This implies that the orchid flora in Xizang is derivative and young in age of formation.

(4) The terrestrials are represented by 34 genera and 107 speies with 2 varieties, exceeding half of the total, and more abundant than epiphytes and saprophytes.

(5) Remarkable differentiation exhibits in the eastern and south-eastern Xizang orchids as a result of the occurrence of the intergeneric types and existence of the new species and the varieties of some others.

From the above it is clear that the orchid flora in Xizang had derived largely from that of Yunnan and Sichuan mountainrange and are younger in age of formation than that of Yunnan and Sichuan as well as Indo-Malesian Peninsula. It largely composes of terrestrial species. Hence, its elements are mainly of the temperate and subtropical Eastern Asian (Sino-Japanese) Region, though with some Indo-Malesian elements and elements from other regions.

In conclusion, it may be summarized as follows: the orchids in Xizang are prolific in species, concentrated in distribution, complicated in components, and characterized considerable differentiation.

THE FLORISTIC FEATURES AND EVOLUTION OF GRAMINEAEIN XIZANG

Liou Liang

(Institute of Botany, Academia Sinica)

The Xizang Gramineae is the second major family of the Xizang Angiospermae representing about 104 genera with 335 species. They may be divided into 3 subfamilies and 9 supertribes establishing above 24 tribes. The systematic order according to evolution will be represented as follows:

(I). Subfam. Bambusoideae consisting of 2 Supertribes: Bambusodae and Arundinarodae (Keng et Keng f.) L. Liou (II). Subfam. Pooideae consisting of 5 Supertribes: Pharodae L. Liou, Arundodae L. Liou, Eragrostodae L. Liou, Poodae and Stipodae L. Liou (III). Subfam. Panicoideae consisting of 2 Supertribes: Panicodae and Andropogodae L. Liou.

Through floristic analysis of the Xizang Gramineae flora shows the characteristics followingl:

1. The constituents of the Xizang Gramineae flora consist of tropical elements including 7 supertribes, 12 tribes, 56 genera and 116 species distribute in the area southeastern of Mt. Kandese, and the temperate elements including 2 supertribes, 7 tribes, 48 genera and 219 species, Which are the predominant constituents of the Gramineae flora inside the Xizang plateau proper. The number of temperate species attain about twice as many as that of the tropical species.

2. From the historical evolution of the supertribes of the Xizang Gramineae, it shows that the poverty of the primitive and thermophilous taxa is apparent, but the advanced taxa such as drought-resistant Supertribes Andropogodae and Eragrostodae have been received certain degree of development. There is a greater development of the temperate flora, such as supertribes Poodae and Stipodae, With the relatively primitive representatives occuring in the south-eastern more warm and humid parts of Xizang. Under the conditions of the cold-drought part inside the plateau, there appear specialized types of taxa.

3. Because of the geographical position and the much variable enviromental conditions of Xizang, the diversification of species is very intensively going on. There evolves a number of endemic species and genera. According to the information accumulated at

present, there are 5 endemic genera and a number of endemic species, amounting to $^{1}/_{4}$ of the total.

4. Floristically the Xizang Gramineae Flora may be divided into 2 regions and 7 areas, i. e.: I. The southern Himalayan forest region; Ia. The eastern Himalayan forest area, Ib. The central Himalayan forest area. II. The south-eastern Xizang bush-forest region; IIa. The eastern Xizang forest area. IIb. The north-eastern Xizang meadow area. IIc. The southern bush-steppe area. III. The north-western Xizang steppe-semidesert region; IIIa. The northern Xizang steppe area. IIIb. The western Xizang semidesert area.

5. The relationships between the Gramineae flora in the Xizang and that of its neighbouring areas are as follows: The flora of the southern Himalayan floristic region (including 2 floristic areas)has closest relationships with the flora of Indo-Malayan; The flora of the south-eastern Xizang floristic region (including 3 floristic areas) belongs to the Sino-Himalayan flora of East Asia; The north-western Xizang floristic region (including 2 floristic areas) belongs to the flora of Central Asia.

6. The relationships of the Xizang Gramineae Flora between the tropical and the temperate regions are very noteworthy, for example of the subfamily Pooideae has 3 supertribes of tropical flora and 2 supertribes of temperate flora. In the structure of the spikelets, the temperate supertrib. Poodae and tropical supertrib. Arundodae and Eragrostodae are fundamentally indentical, reflecting to their close relationship and common ancestry. However, there are marked differences in other characters, as for example, only the temperate supertribes poodae possess the large-size chromosomes with n=7, while the other tropical supertibes of the same subfamily or other supertribes having small-size chromosomes with n=9, 10, 11 and 12. Furthermore, the seedlings and the epidermis of the supertrib. Poodae all become specialized. On the other hand, the tropical subfamilies and tribes all have more or less primitive characters in these respects. But in the members of supertrib. Eragrostodae the leaf structure is very much specialized, physiologically constituting the high photosynthically efficient C_4 plants, and form the predominant elements in arid savanna in the tropics.

EVOLUTIONAL SYSTEM OF CULTIVATED BARLEY

Shao Qi-quan

(Institute of Genetics, Academia Sinica)

Li Chan-sen Basang Ciren

(Institute of Agronomy, Xizang Autonomous Region)

A large number of seeds and plant samples of wild barley were collected during scientific expedition to Qinghai-Xizang Plateau in 1974—1976. Systematical, cytological and genetical studies were subsequently carried out in Peking and Kunming. The data indicated that two-rowed wild barley not only occurs in the southwestern part of China, but also is of wide distribution from the east Daofu County, Ganze Autonomous perfecture, Sichuan Province to the west Xigaze County, Xigaze Perfecture; from the south Cona County, Shan-nan Perfecture to the north Dolongdeqien County, Lhasa Perfecture, lengthwise and crosswise about 1500 km, alt. 2800 to 4100m. above sea level, involving the agricultural areas of Yarlung River Valley, Jinsha River Valley, Lancang River Valley, Nu River Valley, Yarlung Zangbo River Valley and its tributaries-Lhasa River, Niyan River Nianchu River and Lhunze River. Wild barley, like any species naturally occurred, is apparently polymorphic. The three major varieties of two-rowed wild barley, identified during the past 120 years throughout the would, all are grown in the above-mentioned areas too. They are: *H. spontaneum* var. *ithaburense* (Boiss.) Nàbělek, the basic difference taxonomically with a blunt-rounded tip of the lateral inefficient spikelet of the triplets: *H. spontaneum* var. *zschnatherum*(Cosson) Thell., with a sharp angled tip of lateral inefficient spikelets of the triplets; *H. spontaneum* var. *proskowetzii* Nàbělek, with awn-shaped tip. In addition, six-rowed wild barley (*Hordeum agriocrithon* Aberg) , in which abundance in variety types and polymorphism of species were apparently found, was also widely distributed in these areas. The "bottle-shaped" wild barley (*H. lagunculiforme* Bacht.) with varieties was recorded for the first time in this area too. Cytological study showed the first and the longest chromosome pair of the wild form had a microsatellite of one terminal and was of a_1 a_1 karyotype, while cultivated barley varieties in Xizang belong to a_1 a_1 karyotype too. Close relationship was demonstrated cytologically between wild barleys and cultivated forms. Data of genetical analysis showed the characters, such as two-rowed, brittle-rachis, lateral spikelet with stocks were dominant. Spikes of Fl plants from the cross of six-rowed wild barley (♀) with two-rowed wild barley (♂) had two-rowed brittle rachis. From the cross of six-rowed wild barley (♀) with "bottle-shaped" wild barley (♂) , the lateral spikelets of triplets of F_1 plant were efficient but had stocks, while from the cross of "bottle-shaped" wild barley (♀) with two-rowed wild barley (♂) , the lateral spikelets of triplets were inefficient. The wild barley in Xizang, very similar to primative cultivators, has been used for a long time by the natives as resources of starch, wine and forage. The main aspect of our hypothesis is that the origin and evolution of cultivated barley went through a continuous process but with various stages. The two-rowed wild barley is the oldest ancestor and is the first stage evolution of cultivated barley, the six-rowed wild barley (*Hordeum agriocnithon* Aberg emend Shao) is the second stage, while the cultivated barley denotes the third, the final stage of evolution of cultivated one.

There has been pointing out the new systematics of wild bailey, closely relevant of cultivated barley, as follows:

Hordeum spontaneum C. Koch

var. *ithaburenes* (*Boiss.*) Nàbělek

var. *ischnatherum* (Cosson) Thell.

var. *proskowetzii* Nàbělek

Hordeum agriocrithon Åberg emend. Shao

var. *lagunculiforme* (Bacht) Shao

var. *agriocrithon* (Åberg) Shao

var. *nudus* Shao

Latin diagnoses of new varieties

Hordeum agriocrithon var. *nudus* Shao var. nova.

Hexastichus spontaneus, cum vel sine matthiola, caryopsis nudus est

SEMI-WILD WHEAT FROM XIZANG (TIBET)

Shao Qi-quan
(Institute of Genetics, Academia sinica)
Li Chan-shen Besang Ciren
(Institute of Agronomy, Xizang Autonomous Region)

Semi-wild wheat was discovered during scientific expedition to Qinghai-Xizang plateau in 1974 and large number of seeds and plants samples were collected and were analysed cytologically and geneltically. Semi-wild wheat was usually grown as weed in barley and wheat field. The matured spikelets were freely separated and fallen on the ground and thus naturally grown. It was first discovered in Jitan District, Chagyab county, Qamdo perfecture and samples were collected later in Jiacha and Gunga counties while it was found in Lonze and Renbu counties too. Identification of the genetically stable lines of semi-wild wheat showed, the majority were with stable trait of brittle rachis although segregation in this trait was found in individual lines. Semiwild wheat could be grouped into various types of varieties and polymorphous species was apparently demonstrated. The correct position of the semi-wild wheat in the evolutionary proccess of wheat is an important problem worthy of further theoretical investigation. Significant difference occurred between Xizang semi-wild and *spelta* wheats. Spikelets of *spelta* have fragile rachis which usually are broken on the top of the rachilla and each rachilla sticks to the belly and connects with the lower spikelet. While the spikelet of semi-wild wheat in Xizang is broken in the base of the rachilla, so that each spikelet is set on its own rachilla and similar to that of *Triticum aeativum* ssp. *yunnanensis*. But the former is more primitive than the latter. Semi-wild wheat in Xizang is different from ssp. *yunnanensis* that fragile rachis is of a primitive cultivated form and its rachis will be broken when it is pressed with small force. Semi-wild wheat is of a form with freely separated brittle rachis known to be rare in hexaploid wheat. Semi-wild wheat root tip squash revealed $2n=42$, a hexaploid. It can be very easily crossed with common wheat. But sterile lines were regregated in off springs,that significant difference, an interspecific isolating mechanism, occurred. Semi-wild wheat is important in practice, since it can be served as natural resources to produce Sterile lines in wheat breeding. Because of these significant differences semi-wild wheat from *Triticum spelta* and ssp. *yunnanensis*, we

suggest that semi-wild wheat could be separately divided into a new subspecies of *Triticum aestivum* as *tibetanum*.

THE ROLE OF RESPIRATORY FUNCTION IN THE PATHOGENESIS OF HYPOXEMIA IN CHRONIC MOUNTAIN SICKNESS

HU SHU-TSU GU ZHENG-ZHONG NING XUE-HAN
ZHOU CHANG-FU LIN HUA-YING
(Shanghai Institute of Physiology, Academia Sinica)

Severe hypoxemia has been described as one of the outstanding manifestations of chronic mountain sickness (CMS). It is believed that the primary cause of the hypoxemia is failure of respiratory regulation. While most of the studies were done on the Andean population, few reports were based on studies on Chinese. During the period 1969—1972, in order to throw some light on the role of respiratory funtional impairment in CMS, we measured at an altitude of 3,890 m ventilation, diffusion capacity, oxygen saturation, acid-base status and 2,3-DPG concentration in red cells of 52 CMS patients (all unacclimatized lowland natives) and 56 well acclimatized lowlanders were also studied for comparison.

The experimental results showed that the patients had poor ventilatory function. Their tidal volume was much lower than that of the well acclimatized. Their alveolar ventilation was only 70% of the latter, though respiratory rate was higher. The lower oxygen saturation and higher $Paco_2$ provide a strong evidence for the ventilatory insufficiency. The diffusing capacity (DLCO) was 41.3% lower than that of the well acclimatized lowlanders, and was even lower than the sea-level value. The red cell 2,3-DPG was 20.1% higher than that of the acclimatized. The higher 2,3-DPG would have shifted the oxygen dissociation curve to the right, thus decreasing the oxygen saturation and oxygen capacity.

It may be noted that training the CMS patients (at 3890 m) to breathe deeply could increase the tidal volume significantly, and alleviate hypoxic symptoms to certain extent.

These results strongly suggest that respiratory failure is most probably the immediate cause of the severe chronic hypoxemia which conceivably contribute to the pathogenesis of CMS. This hypothesis also offers a possibility to prevent CMS by constantly improving the ventilatory function.

EFFECTS OF ADAPTIVE TRAINING ON ELECTROENCEPHALOGRAM RECORDED UNDER ACUTE HYPOXIA

GU ZHENG-ZHONG, LI CHANG-MING
(Shanghai Institute of Physiology, Academia Sinica)

18 healthy young men were engaged in daily adaptive training (rapid-deep breathing or load-running) at low altitute (250m) for one month. Unipolar electroencephalograms (EEG) were recorded under acute hypoxia (inspiring 8.4% O_2 mixed gas) before and after the adaptive training. Before training, 14 out of 18 subjects showed after hypoxic gas inhaltion EEG changes characterized by decreased frequency, increased amplitude, more slow waves and less α wave. After the training the following differences in the hypoxic EEG were noticed in 7 out of 14 subjects having taken the training for one month: their α wave index increased from 59% to 90%, slow wave index decreased from 52% to 15%, and the high amplitude wave (above 50uv) decreased from 24.7% to 7.7%. However, these changes were not observed in the rest 7 subjects.

Taking that EEG changes may reflect in some way the tolerance of the body to hypoxia, the present preliminary results suggest that the adaptive training may influence favorably in improving the tolerance of the brain to acute hypoxia.

EFFECT OF EXPERIMENTAL INTRACRANIAL HYPERTENSION ON CEREBRAL BLOOD FLOW IN RABBITS UNDER ACUTE HYPOXIA

SAI ZHENG-YUAN, GU ZHENG-ZHONG, LI CHANG-MING
(Shanghai Institute of Physiology, Academia Sinica)

16 rabbits were used to study the effect of experimentally elevated intracranial pressure on cerebral blood flow under acute hypoxia (inhalation of low oxygen gas mixture

simulating 5000m) . Intracranial hypertension was produced by perfusing mock cerebrospinal fluid into cisterna magna. Cerebral blood flow was determined by an electromagnetic blood flowmeter.

Following the acute hypoxia, the intracranial pressure and cerebral blood flow increased but the systemic blood pressure did not change obviously. The cerebral perfusion pressure and cerebrovascular resistance decreased at the same time. This suggests that the autoregulation of cerebral blood flow is likely to be still present at 5000m. Under the acute hypoxia, an experimental elevation of intracranial pressure, instead of raising the systemic blood pressure, lowered it as well as the cerebral perfusion pressure, causing the cerebral blood flow to decrease quickly.

It was also demonstrated that under simultaneous hypoxia and experimental intracranial hypertension there exists, within a range of cerebral perfusion pressure lower than 80 mm Hgs, linear relationship between cerebral blood flow and cerebral perfusion pressure. This result suggests that autoregulation of cerebral circulation might be impaired easily when hypoxia is combined with intracranial hypertension.

SOME PHYSIOLOGICAL PARAMETERS OF DOMESTIC ANIMALS AT VARIOUS ALTITUDES IN XIZANG

HUANG WEN-XIU

(Commission for Integrated Survey of Natural Resources, Academia Sinica)

The respiratory rate, pulse rate, body temperature, number of red cells, hemoglobin concentration, and total white cell count and its differential count were measured in the goat, sheep, cattle and yak native to the altitudes between 1,700 to 5,000 m. The results showed that there was a remarkable progressive increase in respiratory rate, pulse rate, red cells and white cells along with increasing altitude. These parameters reached their maxima up to an altitude between 4,000-4,700 m and then declined somewhat, with the exception of the yak. The elevation at which the above parameters reached their peak values was different in different animals. It was highest in yak and lowest in cattle. The change in hemoglobin concentration showed a tendency similar to that in red cells, but to a lesser extent. No regular change in differential white cell count was observed

In the animals moved from lowland to the Xizang plateau, the acclimatized fine-wool sheep from Xinjiang had similar respiratory rate, pulse rate, red cells and hemoglobin concentration values as compared to their high altitude counterparts, while the unacclimatized cattle from Sanho had lower red cells and hemoglobin concentration than in the lo-

cal breed.

The significance of the changes of the above parameters in relation to altitude is discussed.

RHEOENCEPHALOGRAPHY UNDER ACUTE HYPOXIA

CHOU CHAO-NIEN HUANG SHAO-YUNG

(Shanghai Institute of Physiology, Academia Sinica)

Rheoencephalography(REG)was performed on three groups of subjects: 1)normal sea-level residents(aged 22-30 years), 2)sea-level residents(aged 22-44 years)under acute hypoxia(simulated altitude of 5,000m in a hypoboric chamber), and 3)lowland residents (aged 16-23 years)after ascending from 2,200m to 4,800m. The REG changes in cases with acute mountain sickness were also analyzed. In most of the normal sea-level subjects, the REG tracing started with a steep ascending branch reaching rapidly to its apex(first peak), while the descending branch began with a small kink("prenotch wave")and then led to the dicrotic notch and the dicrotic wave(second peak). In about one fourth of them, a marked "prenotch wave" appeared. During acute exposure to 5,000m simulated altitude, there was an increase in both amplitude and angle of inclination, and the dicrotic notch deepened; whereas, there was a decrease in the angle of first peak, rising time, and the ratio of rising time to total duration of the curve. All the REG changes during acute hypoxia indicate a decrease in cerebrovascular resistance and an increase in cerebral blood flow. Such changes, particularly those in dicrotic notch, rising time, rising time-total duration ratio, and in the angle of inclination, were more remarkable and lasting in subjects suffering from severe acute mountain sickness than in the mild cases. After ascending from 2,200m to 4,800m, the REG in lowland reisdents showed a deepened dicrotic notch, which seemed to be more profound in those suffereing from bad headache.

The results in acute simulated altitude hypoxia suggest that changes in intracranial hemodynamics might play a certain role in the pathogenesis of acute mountain sickness. Moreover, REG might be helpful in the diagnosis and prognosis of acute mountain sickness.

VENTILATORY CONTROL IN XIZANG HIGHLANDERS

HUANG SHAO-YUNG, CHU SHOU-CHENG, PA CHENG-FUNG, HU SHU-TSU
(Shanghai Institute of Physiology, Academia Sinica)

Previous studies on the Andean highlanders and the Himalayan Sherpa highlanders have demonstrated that the highlanders show relative hypoventilation as compared to the acclimatized lowlanders at the same altitudes. The highlanders have less minute ventilation($\dot{V}_E$), lower alveolar oxygen tension(P_{AO_2})and higher alveolar carbon dioxide tension (P_{ACO_2})than the acclimatized lowlanders. The difference in tensions of the blood gases between the two groups follows that of the alveolar gas. Further investigations demonstrate that at high altitude, the peripheral chemoreflexive ventilatory response to hypoxia and hypercapnia in highlanders is remarkably lower than that in acclimatized lowlanders. The blunted peripheral chemoreflex response persists even after migrating to sea level, and so is considered irreversible.

However, the results of our recent observations concerning the ventilatory control in Xizang highlanders appear to be in some way different from the literature data:

1. At 5,000m, resting $\dot{V}_E$ in Xizang highlanders(THL)and acclimatized lowlanders (ALL)were 11.9 ± 0.18 and 11.6 ± 0.20L/min BTPS(mean$\pm$SD), P_{AO_2} 49.9 ± 3.64 and 49.5 ± 4.00 mmHg, P_{ACO_2} 25.2 ± 2.83 and 24.6 ± 2.97 mmHg, and post-expiration breath-holding time 16.9 ± 8.67 and 14.3 ± 5.77 sec respectively. The results show that there is no significant difference in ventilatory function between these two groups of subjects at 5,000m.

2. At 3,890m, resting $\dot{V}_E$ in THL and ALL were 16.9 ± 6.0 and 15.5 ± 4.0 L/min BTPS, P_{ACO_2} 30.7 ± 6.49 and 28.2 ± 1.69 mm Hg, pHa 7.412 ± 0.024 and 7.419 ± 0.016, and SaO_2 83.1 ± 5.46 and 84.8 ± 3.43%, respectively. The results again indicate that ventilation levels are similar in both groups at same altitudes.

3. With the CO_2 rebreathing technique, the slopes of the CO_2 response curve in THL and ALL at 5,000 m were 2.35 ± 1.18 and 2.41 ± 0.92 L $min^{-1}\cdot mmHg^{-1}$, and the intercepts of the curve 30.9 ± 4.6 and 31.2 ± 5.2 mmHg respectively. No significant difference in ventilatory response to CO_2 was found in THL and ALL at altitude. After moving to 50m, the slopes of the curve in THL and ALL decreased to 1.49 ± 0.63 and 1.58 ± 0.80 $L.min^{-1}.mmHg^{-1}$, while the intercepts increased to 35.9 ± 7.4 and 38.6 ± 4.8 mmHg, respectively. It shows that in both groups after the descent to sea level, the sensitivity of the ventilatory response to CO_2 decreases while the threshold of ventilatory response to CO_2 increases.

4. With 3-breaths "N_2 test", "CO_2 test" and "CO_2 in N_2 test" performed at 50m, the relative increments in ventilation($\triangle\dot{V}$%)brought about by the test gases in THL after

their descent were 16.5±12.9, 39.3±16.2, and 81.6±50.5%, and in lowlander natives 24.9±16.6, 33.0±16.0, and 82.3±47.7% respectively. It can be seen that the two groups of subjects have similar peripheral chemoreflexive ventilatory responsiveness at sea level.

Our results do not indicate that the THL hypoventilate at high altitudes, and also do not necessaril indicate a blunted chemoreflex ventilatory activity in THL after their descent to sea level.

COMPARATIVE STUDY ON LEVEL OF PYRUVIC AND LACTIC ACID, AND LACTIC-PYRUVIC RATIO IN BLOOD IN THE EXERCISED AND UNEXERCISED LOWLANDERS DURING ASCENDING TO HIGH ALTITUDE

Zhang Jin, Zhou Dian-song
(Shanghai Institute of Physiology, Academia Sinica)

The increase of lactic content and lactic-pyruvic ratio in blood is one of the important indications of anoxia in tissues. When oxygen content in tissues decreases, the direction of the reaction, $CH_3\text{-}CO\text{-}COOH + DPNH_2 \rightleftharpoons CH_3\text{-}CHOH\text{-}COOH + DPN$, is to the right, thus the lactic acid would be accumulated in venous blood. It was known from experience that lownative subjects after exercising seemed in some way acclimatized themselves better to hypoxia at high altitude. However, the mechanism of acclimatization is not yet clear. This paper was aimed to compare the level of lactic and pyruvic acid and lactic-pyruvic ratio in venous blood of the exercised subjects with those of the unexercised ones in order to get some insight of the mechanism of the acclimatization to hypoxia at high altitude.

The test subjects consisted of 69 healthy young men aged 17—22. All the subjects stayed at 350m for 28 days and were randomly divided into 3 groups: (1) the control group; (2) the hyperventilation group, the subjects taking hyperventilation exercise daily during 28 days; and (3) the load-running group the subjects taking load-running exercise daily during 28 days. The subjects of all three groups took a journey by bus through 2300—5300m for 10 days, and finally stayed at 3700m for 2 months. The blood samples were taken at 350m before (350 I) and after (350 II) exercise, and at 4400m as well as at 3700m. For measuring lactic and pyruvic acid content we followed the methods described by Summerson & Barker and Friedmann & Haugen with some modifications.

The results were presented in table 1. It was shown that (1) After hyperventilation and load-exercise the blood level of lactic acid and lactic-pyruvic acid ratio in lowlanders was decreased. This would be of benefit to human acclimatization to hypoxia. (2) The decrease in lactic acid level after exercises at 350m was not permanent, and when the exercised subjects reached 4400m within 10 days, the level of lactic acid in the blood returned to that before exercise. (3) After arriving 4400m the lactic-pyruvic ratio in blood both in exercised and unexercised was higher than when they stayed at 350m, however, it became lower again after the subjects stayed at 3700m for 2 months.

Therefore, hyperventilation and load-running exercises at low altitude might be of some benefit to the human acclimatization to hypoxia, but its effect is not permanent.

Table I. Changes in level of lactic and pyruvic acid and lactic-pyruvic ratio in blood at various high altitudes.

Groups	Altitude (meter)	Test subjects (number)	Lactate content (mg%)	Pyruvate content (mg%)	Lactate / Pyruvate
Control	350 I	24	17.1±0.88	1.49±0.04	11.4±0.4
	350 II	24	17.5±0.99	1.39±0.05	12.7±0.7
	4400	23	16.7±1.03	1.08±0.06	15.9±1.0
	3700	21	12.7±1.02	1.12±0.05	11.7±1.1
Hyperventi-lation	350 I	21	18.6±1.09	1.48±0.07	12.4±0.5
	350 II	21	14.4±0.90	1.28±0.05	11.4±0.6
	4400	17	18.4±1.33	1.27±0.08	15.9±1.8
	3700	17	15.3±1.64	1.20±0.09	13.0±1.2
Load-running	350 I	20	19.5±1.17	1.45±0.08	13.2±0.3
	350 II	21	15.3±1.03	1.43±0.07	10.9±0.6
	4400	19	18.1±1.34	1.01±0.05	17.6±1.2
	3700	20	12.4±0.96	1.12±0.07	11.4±0.8

EFFECT OF ALPHA-ADRENERGIC BLOCKING AGENT PHENTOLAMIN (REGITIN) ON ACUTE HYPOXIC PULMONARY HYPERTENSION IN AWAKE DOGS

HU SHU-TSU, NING HSUEH-HAN,
CHOU CHAO-NIEN AND HUANG HUA-YU
(Shanghai Institute of Physiology, Academia Sinica)

Six awake dogs with a silicone rubber tubing chronically implanted in the pulmonary artery trunk were exposed to a moderate hypoxia (P_{IO_2}=80mm Hg), and pulmonary arterial pressure was measured. The results showed that the acute hypoxic pulmonary hypertension may be markedly depressed by intrapulmonary infusion of the α-adrenergic blocking agent, phentolamin (Regitin, 1.5 mg/kg). β-adrenergie blocking agents failed to affect the hypoxic pulmonary hypertension response. The present work helps to confirm that the sympathetic nervous system is involved in the development of hypoxic pulmonary hypertension.

A PARALLEL OBSERVATION ON THE VENTILATION AND ARTERIAL AND CISTERNAL FLUID PCO₂, pH IN DOGS UNDER ACUTE HYPOXIA

GUNG MEI-CHUEN
and HU SHU-TSU
(Shanghai Institute of Physiology, Academia Sinica)

There has long been a dispute as to the part played by CSF acid-base composition in regulating ventilation during acute hypoxia. Above all, the problem of basic facts about the relative changes in arterial and CSF acid-base status resulted from acute hypoxia seems to be still unsettled. In the present study the ventilation and the arterial and cisternal pH, P_{CO_2} and $[HCO_3^-]$ of the dog were determined in parallel in the course of inhalation of a low oxygen gas mixture (10% O_2) for 4 hours.

Anesthetized Dogs

In 8 dogs under anesthesia, marked hyperventilation (50% increase) occurred within the first 1/2 hour of hypoxia, and persisted at an even higher level throughout the whole course. As expected, Pa_{CO_2} came down and pHa went up, both in a way reflecting the prevailing hyperventilation; $[HCO_3^-]_a$ showed a compensatory stepwise decrease. In CSF, the P_{CO_2} curve was almost parallel to that of the arterial blood, with a difference of about 9 mm Hg higher in CSF. The pH_{csf} in the first 1/2 hr. increased from 7.318 to 7.377, but then remained at this level until $1\frac{1}{2}$ hr. Afterwards it gradually returned to 7.360 at 4 hr.. There was considerable drop of $[HCO_3^-]_{csf}$, from 23.7 meq/l to 17.2 meq/l at 4 hour. Apparently this could account for the returning of pH_{csf} towards its original level.

Abrupt interruption of hypoxic inhalation resulted in a fall of ventilation which, however, was still above the original control at 1/2 hr. after the interruption. Both arterial and CSF pH fell markedly, in the case of CSF to a level 0.016 unit below the control value at 1/2 hr. after the interruption. There was no marked re-increase of $[HCO_3^-]$ in both arterial blood and CSF within this 1/2 hr. post-hypoxia period.

Awake dogs

The above experiments were repeated in 2 awake dogs. While the general picture was similar to what was seen in the anesthetized experiments, there remained a continued hyperventilation, accompanied by a CSF pH having fallen to a level distinctly below the control, following the abrupt interruption of the hypoxic inhalation.

It is postulated that under our experimental conditions the ventilatory drive offered by the return of CSF acidity, as manifested by a fall of pH to below the control following an acute termination of hypoxia, could at least partly account for the secondary hyperventilation after the initial ventilatory response to hypoxia.

RELATIONSHIP BETWEEN CORONARY FLOW AND MECHANICS OF CARDIAC PUMP IN DOGS

HU SHU-TSU, CHOU CHAO-NIEN,
NING HSUEH-HAN, LOO HSI-CHENG
(Shanghai Institute of Physiology, Acedemia Sinica)

In 20 anesthetized male adult mongrel dogs the left coronary blood flow (left circumflex branch) was observed when room air, graded hypoxic gas mixtures and pure nitrogen were inhaled in succession. When the inspired oxygen tension (P_{IO_2}) was 84 and 64 mmHg, the coronary blood flow progressively increased to a peak value. The flow then diminished when P_{IO_2} was 54 mmHg. Finally, when the animal inhaled pure nitrogen, the coronary blood flow dropped to its control level and the animal was going to die.

The increase of the coronary blood flow was found to be related to the degree of hypoxemia rather than the blood pH changes.

Our previous study has shown that in the course of progressive hypoxia the size of the "cardiac force loop" (L_0), which expresses the force aspect of the cardiac pumping performance, first enlarges (a positive "force effect") during light hypoxia and then diminishes (a negative "force effect") during moderate hypoxia. In the present investigation it was found that both two phases were accompanied by a steady increase in the coronary flow till a peak flow was reached. Apparently the decline of the pumping performance represented by the shrinkage of the loop was not resulted from any shortage of coronary blood flow. The present study also revealed that the coronary flow would begin to diminish only when the cardiac pump had already been at the brink of collapse, as manifested by a very much reduced cardiac force loop (L_0) and an increased ratio of the rapid relaxation phase of the loop to the entire loop (L_{IV}/L_0). Thus the coronary flow should not be considered as a dependable indicator of the functional state of the cardiac pump. Its reduction, however, serves an alarm for the death of the heart.

The heart rate was related to coronary flow in that it was kept constant as long as the coronary flow was increasing, and slowed down as soon as the flow began to reduce.

CHANGES OF CARDIC MECHANICS ECG AND MYOCARDIAL LACTATE IN ANESTHETIZED DOGS UNDER PROGRESSIVE SYSTEMIC HYPOXIA

HU SHU-TSU, NING HSUEH-HAN, CHOU CHAO-NIEN
(Shanghai Institute of Physiology, Academia Sinica)

In 10 anesthetized male adult mongrel dogs exposed to acute progressive hypoxia, changes of cardiac mechanics as expressed by the "cardiac force loop" (Lo), findings of a bipolar limb leads electrocardiogram (with the animal lying on the left side), and myocardial lactate were studied. The results were as follows: In early hypoxia, with an enlarged Lo and decreased "cardiac force efficiency" (SV/Lo), no significant changes were found in frontal plane QRS mean electrical axis, P-R interval and the ventricular repolarization process (ST segment and T wave). At the early stage of cardiac pump failure, when Lo shinked and SV/Lo increased, some marked changes in the ventricular repolarization occurred, i. e., elevated ST segment ($P<0.05$), increased amplitude of T wave ($P<0.01$) and a significant decrease of the heart rate ($P<0.05$),

A marked shrinkage of the "cardiac force loop" signifies a collapse state of the heart. Arrhythmias such as ventricular premature systoles or ventricular fibrillation appeared at this time in 4 out of 10 dogs.

In other 8 dogs under similar experimental conditions, when severe hypoxia led to Lo shrinkage, the myocardial lactate determined at this stage was much higher than that of the control ($P<0.05$).

The results of the present investigation indicate that the changes of cardiac mechanics, i. e., the enlargement of Lo and decrease of SV/Lo, occur earlier in the course of progressive hypoxia and could be expressed quantitatively. Thus in assessing acute hypoxic tolerance of the heart, mechanical events offer much more sensitive parameters than the electrical.

PREDICTIVE EVALUATION OF MOUNTAINEERING PERFORMANCE AT GREAT ALTITUDES

NING HSUEH-HAN, HUANG SHAO-YUN, GUNG MEI-CHUEN
SHI CHUNG-YUAN HU SHU-TSU
(Shanghai Institute of Physiology, Academia Sinica)

A noninvasive "cardiac pump function test" (CPF test) which involves measurements of systolic and diastolic arterial blood pressure, ventricular systolic and diastolic time from a cardiophonogram, and heart rate has been designed and tried as a method for the predictive evaluation of the hypoxic tolerance and of the climbing performance of mountaineers during the 1975 Chinese Mountaineering and Scientific Expedition to Mt. Jolmo Lungma (Mt. Everest). Several indices representing the inotropic properties of the cardiac pump were derived from the recordings of the test done either at rest or during exercise. The indices were used with the chronotropic parameter heart rate to evaluate graphically. It was found that certain indices in conjunction with the heart rate were valuable in assessing hypoxic tolerance and climbing performance.

CHEMOREFLEXIVE VENTILATORY RESPONSE AT SEA LEVEL IN SUBJECTS WITH PAST HISTORY OF SEVERE AMS AND GOOD ACCLIMATIZATION

HU SHU-TSU, HUANG SHAO-YUNG, CHU SHOU-CHENG
PA CHENG-FUNG
(Shanghai Institute of Physiology, Academia Sinica)

Four lowland subjects with past history of severe acute mountain sickness(AMS susceptible subjects) were assessed at sea level for their peripheral chemoreceptive ventilatory sensitivity with a 3-breath hypoxic-hypercapnic test. A parallel study was done on six subjects who had been shown to acclimatize normally at high altitude (well acclimatized subjects). The ventilatory sensitivity was found to be remarkably low in the AMS susceptible subjects in contrast to the values in the well acclimatized. The blunted sensitivity was characterized by an exceedingly low ventilatory response to either hypoxia or

hypercapnea, and a failure of superimposed hypoxia to greatly augment the hypercapnic response. By means of a "single vital-capacity breath test", which is supposedly even more specific for the peripheral chemoreceptors, the contrastive difference between the two groups was verified.

The preliminary study brings to attention the possibility of extra low ventilatory responsiveness of the chemoreflexive mechanisms to hypoxia and hypercapnia in some individuals to play a part in their high susceptibility to AMS.

HYPOXIC TOLERANCE OF CARDIAC-PUMP FUNCTION IN DOGS AS STUDIED BY FLOW-ACCELERATION AND FLOW-PRESSURE LOOP DISPLAY METHODS

Ning Hsueh-han, Chou Chao-nien, Loo Hsi-cheng
Hu Shu-tsu
(Shanghai Institute of Physiology,
Academia Sinica)

The hypoxic tolerance of the cardiac function as a pump in anesthetized dogs was put to quantitative graphic analysis with designed "loop methods" in which some pertinent aspects of hemodynamics are represented. Three kinds of loop display have been utilized to our advantage: (1) a "cardiac force loop" (CFL) for displaying the LVP and dP/dt recorded from the left ventricle; (2) an "intra-aortic driving force loop" (IADFL) for Q and dQ/dt recorded from the ascending aorta just beyond the aortic valves; (3) a "cardiac power loop" (CPL) for P from left ventricle and Q from ascending aorta.

It is shown that the size of the CFL is comparatively sensitive to the degree of hypoxia, being enlarged at the early stage of hypoxic exposure ($P_{IO_2}=80$ mmHg). A shrinkage of the loop is a signal of decompensation and impending heart collapse, and therefore may be taken as the transition from hypoxic tolerance to intolerance.

The IADFL size is shown to correlate well with the computed intra-aortic driving force on the blood ($r=0.96$). As in the case of CFL, the IADFL also shrinks after a previous enlargement, but the shrinkage comes later. Its appearance is the direct evidence of cardiac collapse.

The CPL has the merit that it actually represents the power exerted, and the pump resistance may be derived from it. The evolution of its size in the course of progressive hypoxia generally leads ahead of that of the IADFL.

A SUGGESTED MODIFICATION OF SEA LEVEL CLASSIFICATION OF PHYSICAL WORK RATE FOR USE AT HIGH ALTITUDE

Hu Shu-tsu, Shi Chung-yuan, Chu Shou-cheng, Gung Mei-chuen, Ling Hwa-ying, Gu Cheng-chong, Chou Dian-sung, Wei Chuen-hwa, Wang Fu-yung Ning Hsueh-han

(Shanghai Institute of Physiology, Academia Sinica)

In general, the terms "light", "moderate" and "heavy" load have been used to describe the severity of muscular work, based on the measurement of oxygen consumption. 900 kgm/min is considered as a heavy load, and 600 kgm/min moderate. While it is rational to grade physical work on the basis of energy expenditure, the factor of physiological cost paid for a given amount of work done should always be taken into consideration. Thus this sea-level classification of physical work is but of limited use at high altitude in view of the fact that the physiological cost at high altitude is higher than at sea level for any given amount of work or oxygen consumption, especially so when the load is heavy. A man fit for doing a specific heavy physical work at sea level could become unfit for the same work at high altitude due to exhaustion. This situation prompted us to make comparison of the physiological reaction to the same work done at different altitudes.

Miners working and residing at elevations of 2,600 m and 4,000 m were studied, with comparable sea level miners as the control. It was found as expected that at 4,000 m the maximal oxygen consumption and maximal aerobic work capacity both fell to 78% of those at sea level ($p<0.01$)、Ventilation, heart rate recovery curve, "oxygen pulse", blood lactic acid, and ECG findings at different altitudes were compared. With a load of 600 kgm/min at 4,000m, the cardiac cost ($\triangle$heart rate), minute ventilation ($\dot{V}_E$) and peak value of the blood lactate were similar to the values to be expected at a work rate of 900 kgm/min at sea level.

Thus the physiological response to a moderate load of 600 kgm/min is more or less equivalent to that of a heavy load of 900 kgm/min at sea level. That is to say there is a difference of one grade of severity of physical work (classified as light, moderate and heavy grades) between 4,000m and sea level. Similarly, it has been shown that the difference between 2,600m and sea level is about half grade.

A heavy load of 900 kgm/min at sea level became not only exhaustive to the the average men at 4,000 m, but also injurious in a part of them, as evidenced by the findings of anoxic changes in the ventricular repolarization as well as a peak blood lactate higher than 99mg%. The incidence of this type of ECG under 900 kgm/min load at sea level, 2,600m, and 4,000m was 0%, 5.4% and 26.3%, respectively.

The incidence of the ECG findings brought about by this exhaustive load of 900 kgm/min at high altitude was correlated with a high "recovery" heart rate, and a linear regression equation for the relationship between "recovery" heart rate and blood lactate may be found ($p<0.01$). Hence the "recovery" heart rate could serve as a simple index to evaluate a miner's fitness for doing heavy work at high altitude, and also as a safeguard against overexertion.

INCIDENCE AND CHARACTERISTICS OF HIGH ALTITUDE PULMONARY EDEMA

W. Brendel

(Institute for Surgical Research, Klinikum Grosshadern Univ. of Munich, Fed. Rep. Germany)

It has become abundantly clear during the last 2 decades that high altitude pulmonary edema (HAPE) must be considered one of the most dangerous complications of mountaineering at altitudes above 4000 m. However, the pathophysiology of this disorder is far from understood. Therefore, careful analysis was conducted of 160 cases of high altitude pulmonary edema (24 studied by the author, 142 taken from the literature) to better understand the phenomenon as far as incidence in relation to altitude, distance in altitude which was actually clim bed, age and initial symptoms are concerned. These parameters were considered highly pertinent in order to obtain information useful for propylaxis and treatment.

Results: HAPE occurs at any age. However, adolescents younger than 20 years may be particularly susceptible. In all cases studied, devel op mentofpulmonary edema occurred, if differences in altitude of more than 600m have been climbed, and if the height of start was higher than 3500m. Even climbers adjusted to altitudes of 4000—5000m may fall victim to high altitude pulmonary edema, if they exceed differences in height of more than the critical distance of 600m during climbing. The majority of cases studied developed HAPE 1—3 days after climbing this distance. Initial symptoms are: headache, insomnia, and vomiting. HAPE develops in a spot-like manner involving any part of the pulmonary lobes without particular preferences. But HAPE does never affect the lung in total during the early phases. Without treatment, HAPE spreads subsequently through the remaining normal lung within a few days. Until now, ventilation with oxygen and transport to lower altitudes is the only treatment proving successful. In some cases, development of pulmonary hypertension could be observed. Inhibitors of formation of prostaglandins such as acetylsalicylic acid and indomethacine in high doses have been recommended. However, convincing results have not been observed so far. Almost all cases died (i. e. 11%) which did not receive oxygen, nor were transported to lower altitudes. On the other hand, in patients subjected to proper treatment, HAPE disappeared after 8 days.

Conclucions: The fact, that HAPE only occurs in cases where difference of height of more than 600m have been climbed should be borne in mind already if a trip or a tour to high altitudes is in the planning phase. In cases where larger height distances have been climbed, a day of rest is advisable by all means. Oxygen should be available for therapeutical purposes.

CARDIO-RESPIRATORY EFFECTS OF CHAMBER PRESSURIZATION ON HIGH ALTITUDE SOJOURNERS AT REST AND DURING EXERCISE

Hu Shu-tsu, Ning Hsueh-han, Chu Shou-cheng
(Shanghai Institute of Physiology, Academia Sinica)

27 high altitude (4500m)sojourners were subjected to pressurization in a mobile compression chamber built as an ambulance, and the cardiorespiratory effects produced were studied. The chamber pressure was raised to and maintained at a level which exceeded the outside atmospheric pressure by 0.30 or 0.15 ATA.,thus simulating an altitude of 1250m or 2800m inside the chamber.

60 min after the beginning of the pressurization the alveolar oxygen tension and the "oxygen pulse" increased significantly ($P<0.01$), while the respiratory rate, minute ventilation, ventilatory equivalent, heart rate, indirectly estimated myocardial oxygen consumption (heart rate X systolic pressure) and all the values of the "cardiac pump function test" were significantly reduced ($P<0.05$) .

Observations were also made of cardiorespiratory effects during physical exercise in 13 subjects being pressurized. They showed lower ventilation, alveolar ventilation, and ventilatory equivalent, and higher alveolar O_2 and CO_2 tensions, as compared to what was obtained in the natural ambient environment. In the "cardiac pump function test" they showed improved cardiac reserve capacity, reduced "cardiac load index" and myocardial oxygen consumption, and downward shifted heart rate recovery curve. In some subjects the post-exercise anoxic changes in ECG under the natural ambient condition did not appear under pressurization.

The physiological responses measured after the termination of the pressurization depended upon the rate of de-pressurization. If the rate was faster than 0.69m/sec, the heart rate and respiratory rate would return to their respective higher levels prior to the pressurization, and the symptoms of AMS, such as headache, nausea etc., were likely to occur. When the depressurizing rate was less than 0.33m/sec, no obvious symptoms were noticed and the existing lower heart rate was maintained within 4 hours after the completion of depressurization. Respiratory rate, however, began to rise when a simulated altitude of 3600m was reached in the course of reascent.

Symptoms of AMS or CMS from which some of the subjects were suffering were alleviated by daily pressurization to 2800m in the night when the subjects were sleeping. Effect of night pressurization on cardiorespiratory functions under work load, if any, probably did not last beyond several hours, since measurements during exercise load after 8 hrs of ususl daily activity did not differ significantly ($p>0.05$) from the control without pressurization.

Four subjects experienced 18 times of pressurization (10 times in the night) during the period of 33 days of their sojourn at 4,500m. The degree of acclimatization attained at the end of this period, as judged by their cardiorespiratory functional changes, was similar to that of a group of four sojourners who were never pressurized during the same period. It seems that the process of high altitude acclimatization is not interfered by frequent intermittent pressurization.

Possible uses of the mobile pressurizing chamber as a tool for helping high altitude sojourners to tide over their unacclimatized stages and as lodging facilities for high altitude field workers are discussed.

A PRELIMINARY STUDY OF HEMODYNAMIC CHANGES AT HIGH ALTITUDE

Cai Ying-nian Deng Xi-xian Yun Jun-ti
(Institute of Basic Medical Sciences, Chinese Academy of Medical Sciences)
Liang Yi Liao Deng-hua
(The Branch of Chinese Academy of Medical Sciences)

A preliminary study of the hemodynamics and functional changes of both left and right heart, resulted from high altitude exposure and altitude migration, including those

during the recovery at sea level, were presented in this article.

Pulmonary arterial pressure, pulmonary vascular resistance, rheography of lung, pressure of systemic circulation, volumes of cardiac atria and ventricles, diameters of the greater vessels, stroke volume, cardiac output, left ventricular end-diastolic volume, cardiac index and ejection fraction were measured and/or calculated by means of non-invasive methods such as those for pulmonary rheography, vectorcardiography, systolic time interval etc. and a method established in this laboratory for the indirect measurement of systolic pressure in the pulmonary artery with echocardiography. Two hundred young healthy male sojourners were divided into 5 groups according to the level of altitude (4500m, 2800m and 80m)at which they used to stay, and the intensity of physical labour they were engaged in. A sequential observation was made on 35 young healthy males (divided into 2 groups)who migrated between the levels mentioned above, i.e. starting from the level of 2800m up to 4500m and then coming down to 80m. Routine physical examination, ECG and VCG were done in all of them.

The results indicated that environmental hypoxia primarily had obvious effect on the hemodynamics of the right heart. The main change obtained in those cases at 2800m was an increase in the pulmonary vascular resistance. In spite of the increase, it did not exceed the normal range, nor were there any symptoms with regard to the increased burden of the right ventricle. The ECG and VCG remained unchanged. At 4500m, more profound changes developed, including elevation of pulmonary vascular resistence and pulmonary arterial pressure, reduction of stroke volume of right ventricle, widening of right pulmonary artery and right ventricular outflow tract. All these indicated an increase of right ventricular load as well as a tendency of lowering down of the right ventricle ejection fraction, which supposedly reflects the mechanical efficiency of the right cardiac pumping. There was a remarkable increase of incidence of right ventricular hypertrophy as evidenced by ECG and VCG. All these changes were more frequent with increasing altitude, intensity of physical labour, and the length of the residing period at high altitude. After returning to sea level, the values of the physiological measurements became normal rapidly except the widening of right pulmonary artery and right ventricular outflow tract. These are the main points concerning the influence of altitude hypoxia on cardiac function.

Changes of the left heart, however, was not remarkable. There was no definite change of pressure load, or just some mild changes which were still within normal range. In comparison with those of the healthy subjects at sea level, the stroke volume, cardiac output, ejection index and ejection fraction of left heart were still maintained within normal limits. In some cases the stroke volume was somewhat reduced and the cardiac output and their mechanical efficiency of left heart pumping seemed to be normal, which indicated that the left heart was adapting itself to the hypoxia quite well. Since some change of the systolic time interval did occur, it should be pointed out that the influence of altitude hypoxia on the left heart should not be overlooked.

The significance of the alterations of the hemodynamics was discussed.

Ⅲ. THE FORMATION, EVOLUTION AND DIFFERENTIATION OF GEOGRAPHIC ENVIRONMENT ON THE PLATEAU

THE HEAT SOURCES AND SINKS OVER THE QINGHAI-XI ZANG PLATEAU AND SOME ASPECTS OF THEIR INFLUENCE ON THE GENERAL CIRCULATION

Yeh Tucheng

(Institute of Atmospheric Physics, Academia Sinica)

Gao Youxi

(Lanzhou Institute of Plateau Atmospheric Physics, Academia Sinica)

This paper first gives the 12 monthly means of the total energy transport (Q) to the atmosphere from the ground surface of the Qinghai-Xizang Plateau and the intensity of heat source (E) of the atmosphere over the plateau, Q is positive throughout the year and E positive in the summer half year with maximum in June and negative in December. Due to the variation of E, there arise the following changes of circulation from summer to winter.

1. On the mean 600 mb maps there is over the plateau a high in winter with its top not reaching 500 mb and a low in summer with its height reaching 500 mb surrounded to its north and south by narrow belts of high pressure. Because of this change of circulation there is also a corresponding change of prevailing wind in the surface layer from summer to winter, called the plateau monsoon.

2. In the longitude belt of the plateau to the south of the plateau there exists in winter a typical Hadley circulation the intensity of which is strongest in the northern hemisphere. But in summer it is a huge monsoon circulation with the mean ascending branch over the plateau and descending branch penetrating into southern hemisphere. Because of this huge monsoon circulation, the mean Hadley circulation of the whole northern hemisphere is weakest in summer.

3. within the above stated huge monsoon circulation there exist two small vertical meridional cells, one over the southern and the other over the northern part of the plateau with the two descending branches respectively near the southern and the northern periphery of the plateau. Below these two branches of descending current there exist two narrow belts of high pressure.

4. In summer from the plateau to the east Pacific Ocean there is a huge west-east circulation (ascending over the plateau and descending over the east Pacific)

Because in summer the mean ascending current over the plateau may flow to remote regions, there exists a tele-connection between the plateau and these remote regions.

THE ROLE OF THE ELEVATED HEAT SOURCE OF THE TIBETAN HIGHLANDS FOR THE LARGE-SCALE ATMOSPHERIC CIRCULATION (WITH SOME REMARKS ON PALEOCLIMATIC CHANGES).

H. Flohn

(University of Bonn, Fed. Rep. Germany)

The occurrence of a quasi-permanent summer-time heat source in the upper troposphere (200—500 mbs) above southern Tibet has been demonstrated (1968); temperatures are up to 11°C higher than the equatorial belt. This produces a high level easterly jet-stream, stretching from the Philippines up to western Africa, with two opposite cross-circulations in the entrance (direct cell) and exit area (indirect cell). This strongly modifies the planetary tropical Hadley cell; the reverted (indirect) cell above Africa is responsible for the limited shift of the tropical summer rain-belt towards north and thus partly responsible for the anomalous extension of the continental Sahara desert up to Lat. 14—16°N. Some remarks on the effect during other seasons will be given.

Due to the uplift of the Tibetan highlands, this effect has increasingly modified the climate of northern Africa from a semi-humid Savanna climate during Pliocene into a full grown desert. The large-scale boundary conditions of repeated moist periods in the Sahara before the last glaciation and during the early Holocene, which are apparently inconsistent with this view, will be discussed in the light of recent evidence.

THE INFLUENCE OF THE XIZANG PLATEAU ON SEASONAL VARIATION OF GENERAL CIRCULATION

Gao Youxi, Li Ci

(Lanzhou Institute of Plateau Atmospheric Physics, Academia Sinica)

The main influences of the Xizang Plateau on the seasonal variation of general circulation may be divided into three kinds:

1. Barrier effects:

Because the Plateau is very high and great, in the lower troposphere, during the seasonal variation, the axis of the subtropical strong westerlies shifts discontinuously at levels somewhere below 300mb. In June, the axis jumps from the south to the north side of the Plateau, while in October it jumps back again. In the upper troposphere, however the movement of westerly jets are continuous. The extent of axis of subtropical strong westrlies moving southward and northward is larger in the low than in the high troposphere and also larger over the plateau than to its eastern and western sides. The time at which the axis begins to move southward or retreats northward is earlier and the speed of this latitudinal shift is slower at the east or west side than over the plateau.

2. Frictional and thermodynamic effects:

Lateral and vertical boundary layers are formed over the Plateau and its neighbourhood. There are many synoptic systems of medium scale in this layer. In summer, the heat low exists mostly over the plateau with many small highs around it, while in winter, the case is reversed. The horizontal range of the boundary layer is greater in summer and smaller in winter, and the vertical range is thicker in summer than in winter. Hence, the existence of the boundary layer makes an influence sphere of the Plateau twice greater in area than the Plateau itself. The vertical range may reach as high as 6000—7000 meters (above sea level).

3. Thermodynamic effects:

From winter to summer, the sudden change of subtropical westerlies caused by the plateau's thermal effect occurs earlier and more frequently near the Plateau, but later and less frequently farther away from the Plateau. The speed of zonal winds at the southern and northern sides of the Plateau at 200mb level is larger than that of the same latitude outside plateau in midsummer. This is because the Plateau's influence enlarges the temperature gradient at the southern and northern sides and thus intensifies the zonal winds.

METEOROLOGICAL INTERACTION BETWEEN QINGHAI-XIZANG (TIBET) PLATEAU AND SUMMER MONSOON RAINFALL

C. C. Chang
Professor Emeritus
(Catholic University of America)
and
Honorary Research Professor
(Institute of Atmospheric Physics, Academia Sinica)

In view of the period of break-monsoon in southwestern China, including the eastern portion of Qinghai-Xizang(Tibet) Plateau(hereafter called the Plateau), it seems reasonable to consider both China and India as parts of an integrated system of the southwestern summer monsoon. It seems to be an open system rather than a closed one as modelled by Krishnamurti and Bhalme. Many contributing elements to the monsoon rainfall system, some of which may not have been discovered or recognized. First let us consider (Ⅰ) the permanent contributing elements of normal/monsoon, then investigate (Ⅱ) the modulatory elements of break-monsoon, and lastly enumerate (Ⅲ) some of the operating mechanisms of the monsoon process.

Ⅰ. Contributors to normal monsoon in India.

A. Orographic cliffs on the Plateau—a half loop shaped barrier fencing the moisture and convection to the south of the Plateau, i. e. India.

B. Gigantic heat source averaging 4.5 km. in elevation and 2×10^6 km^2. in area. The energy release rate may be several times greater than that of a large typhoon.

1. Surface heat low on the Plateau.

2. Tibetan high at 200 mb which increases the westerly velocity on the north side and introduces the second easterly jet to the south.

C. Somalia low level cross-equator jet (hereafter called low level jet) from the Southern Hemishere supplying in the order of 5×10^{12} tons/day flux of air and 4×10^{10} tons/day flux of water vapor (Saha estimate). Its northern trajectory is presumably controlled by the intensity of the Mascracrene High and the location of the monsoon trough. As the result of normal monsoons in India, the monsoon trough runs in parallel with the Himalaya range at about 300 km. south. At 500 mb stable descending motion is above the Plateau where the weather is clear, and unstable ascending motion or low above the monsoon trough of the Indian plains, which has a heavy cloud cover. Usually some depressions, deep depressions, and/or tropical storms move westward along the monsoon along the monsoon trough. Under these conditions, break-monsoon is likely to occur in China concurrently.

Ⅱ. Contributors to break-monsoon from India.

A. Strong troughs moving westerly across the Plateau reaching the Indian plains at 500 mb or wandering near the eastern end of the Plateau, thus guiding the low-level jet to climb up the Plateau to China.

B. Weak low-level jet or weak Mascraciene High which is insufficient to supply moisture to maintain a deep depression in the monsoon trough.

C. Low temperature air current moving east as a high pressure ridge at a level of 500mb, reaching the Indian plains, causing descending motion. Sometimes the ridge reaches both the Plateau and India, causing break-monsoon in both areas, as was the case in 1972, when numerous strong typhoons were in the western Pacific.

D. No cyclonic disturbance in the easterly wave or at 700 mb level can be identified moving across the Bay of Bengal.

E. Portion of the 500mb subtropic high of the Western Pacific extends to India or even up to the Plateau, preventing any massive vertical convection.

Low pressure cells or shear lines north of the Himalaya Range can induce low level jet climbing up cyclonically to the Plateau.

In the above cases the monsoon trough becomes weak and moves northward closer to the Himalaya, consequently causing break-monsoon in India. Simultaneously, low level vortexes and shear lines on the Plateau usually bring monsoon rainfall to the eastern portion of the Plateau further to the northeast of China.

Ⅲ. Operating mechanisms of monsoons.

A. Biweekly cycles of monsoon activity in India is also confirmed by the meteorological observation on the Plateau. However, it does not become a useful rule of thumb for forecasters.

B. High relative humidity is found in both India and on the Plateau regardless of whether a monsoon is active or not. Lack of a source of cold air to condense moisture seems to be the cause of break-monsoon.

C. Residual vorticity in the cloud clusters or faded typhoons moving westward with the easterly jet is necessary to trigger the sudden growth of a deep depression in the Bay of Bengal, where both the north and south branches of the low level jet meet. It is interesting to point out that a vortex can still survive, where no close counter pressure can be identified, and be drawn to the ground and to the 500 mb level. Presumably, the high humidity and shear line can supply enough vorticity and ascending motion to keep them alive and eventually grow to a deep depression in the monsoon trough of India or become the so-called "southwest low-level vortexes" which give good monsoon rainfall.

DYNAMICAL EFFECTS OF THE RISING OF XIZANG PLATEAU ON CIRCULATION OVER EAST-ASIA

Wang Anyu, Wang Qianqian, Ju Chang,
Qian Yong fu, Yan Hong
(Lanzhou Institute of Plateau Atmospheric Physics, Academia Sinica)

The numerical experiments of the evolution of the dynamic effects in the different stages of the uprising of the Xizang Plateau on general circulation over East-Asia are performed by using two layer primitive equations model in P-σ mixed coordinate system. In order to examine the evolution of the dynamic effect on the motions caused by the Plateau's rising, 8 kinds of the topography have been designed and the idealized summer and winter zonal flows used as the initial conditions.

From results it is found that 1, for winter cases prior to the height of the plateau reaching 3000m, the flows mainly pass over the Plateau, relatively weak troughs and ridges with short wave lengths resulting only in. In this stage, the weak cooling takes place on the lee side, being caused by the horizontal advection from the north. And the weak cooling due to the ascending motion occurs to the Plateau. When the Plateau having risen to 3000m or higher, the passing action becomes more pronounced with the rising of the Plateau, and the flows eventually turn around the Plateau rather than passing over it. In the meantime, the dynamically produced disturbances greatly intensified and there appeared two quasi-stationary longwave troughs, one on the lee side and the other on windward side of the Plateau, with a stationary longwave ridge to the north. And some synoptic scale pressure systems appear on the Plateau. In this stage, the cooling on the lee side becomes more intense. 2, For summer cases the flow is not so markedly different from that in winter. When the Plateau only rises to 2500m, the flow turns around rather than passing over the Plateau. But because in summer the winds are much weaker in the troposphere, the position of the westerlies jet is situated more northward than in winter. Further the dynamically produced pressure systems weaker and the phase velocity smaller in summer than in winter. Besides, It is worth noting that the synoptic scale pressure systems above the Plateau by the dynamical effects are not similar to those in winter. 3, It is seen that for the large mountain barriers such as the Xizang Plateau the orographic gradient plays a relatively small role compared with its size in dynamical effect of orography.

NUMERICAL EXPERIMENTS OF DYNAMIC EFFECTS OF XIZANG PLATEAU ON GENERAL CIRCULATION IN EAST ASIA.

Wang Qianqian, Ju Chang, Yan Hong, Qian Yongfu
(Lanzhou Institute of Plateau Atmospheric Physics, Academia sinica)

In order to study dynamic effects of Xizang Plateau on the East Asian general circulation both in summer and winter, some numerical experiments have been performed by using two-level primitive equations model with P-σ incorporated coordinate system. Using two different surface boundary conditions, namely(i) purely circulating around the Plateau and (ii) purely climbing over it and idealized zonal wind field and temperature field as initial conditions, the dynamical effects of the Plateau on the flows are examined and the relative importance of the two kinds of boundary condition is estimated.

That one of the dynamic effects of the Xizang Plateau on the general circulation in East Asia is to make rounding flow more pronounced than climbing across the Plateau both in summer and winter, the rounding flow being more remarkable in summer than in winter. Comparing the monthly mean flow patterns it is also found that a close relation exist between the dynamic effects of Xizang Plateau and the formation of pressure systems in the westerlies in East Asia, such as the planetary westerly long wave troughs to the west and the east of Xizang Plateau; the separation of subtropical high pressure zone to the south of the Plateau; the convergence line near 30°N in lower streamline fields; the depression over the Plateau in summer at 500 mb; the Qiang Tang pressure ridge; the temperature ridge above Lhasa in winter at 500 mb etc., and that dynamic effects are more pronounced in winter than in summer especially in the region of Xizang Plateau. It seems also that dynamic effects of the Plateau are mostly notable in middle and lower troposphere, but its effects might propagate up to very high levels. It may assume that the study of dynamic effects of Xizang Plateau on general circulation, should we ignore the differences of initial states of the general circulation.

THE ROLE OF THE QINGHAI-XIZANG PLATEAU IN FEEDBACK MECHANISMS AFFECTING THE PLANETARY CIRCULATION

Elmar R. Reiter
(Colorado State University, U. S. A.)
Ding Yihui
(Academia Sinica, Visiting Scientist,
Colorado State University)

It has been recognized for some time that the Qinghai-Xizang plateau is of great importance in generating planetary long-waves, which in resonance with similar waves induced by the Rocky Mountains, lead to the familiar pattern of quasi-stationary Rossby waves observed on the monthly mean upper level pressure charts. Such waves have also been produced in experiments with fluids in rotating cylinders. The principle of conservation of potential vorticity, in first approximation, accounts for the effects of these large mountain ranges on the formation of planetary waves.

Seasonal forcing of flow patterns appears to be particularly strong in the Qinghai-Xizang plateau region. It has been pointed out by some authors that the effects of an elevated heating surface, which this plateau represents especially after the snow-melt period of spring, trigger the northward m vement of the subtropical high-pressure belt and the development of the summer monsoon, which is then maintained to a large degree by the release of latent heat.

Recent investigations suggest that the Qinghai-Xizang plateau may also be involved in feedback mechanisms which control in an important way the interannual variability of the general circulation of the atmosphere. The suggestion by Chen Lieh-Ting merits consideration, according to which snow cover in the plateau region might provide a "memory" for the earth-atmosphere system, by which the summer circulation over China following winters with excessive snow cover differs from that following winters with little snow. From the work conducted in the People's Republic of China it appears that these circulation differences leave a measurable impact on the monsoonal weather of most of southern and eastern Asia.

Our own investigations suggest that the "memory" between winter and subsequent summer circulations observed over the Qinghai-Xizang region may be part of a complex system of feedback mechanisms that involves, among other things, circuation characteristics of the southern hemisphere and air-sea interaction. It turns out that years with relatively few typhoons, compared with years with many typhoons, show upper-air circulation changes over the Qinghai-Xizang plateau similar to those observed between summers following snow-poor and those following snow-rich winters. These circulation changes seem to effect wide areas of the Pacitic Ocean, the Indian Ocean, and even Africa. Indications are that the "southern oscillation", which modulates the intensity of the Walker ciculation, is involved in the "teleconnections" underlying some of the observed circulation changes. This conclusion raises the suspicion that the air-sea interactions, perhaps mainly through sea-surface temperature anomalies in equatorial and may be also in temperate latitudes are involved with the thermal effects of the Xizang plateau, in the observed interannual variability of snow cover in the Qinghai-Xizang region, typhoon frequency, and other general circulation characteristics.

It thus appears that the effects of the Qinghai-Xizang plateau on the interannual variability of the atmospheric circulation over Asia, aptly described in some of the recent literature, are but one important manifestation of a network of feedback mechanisms, ranging from the El Niño problems along the Peruvian coast to the droughts in the region A better understanding of each of the mechanisms involved will lead us closer to successful long-range forecasting of some of the weather phenomena which have a considerable effect on local and regional economics.

We welcome the opportunity to exchange ideas with our colleagues from the People's Republic of China and to collaborate with them in the search for solutions to these difficult problems involving earth-atmosphere-ocean feedback mechanisms.

SOME EXPLORATIVE STUDIES ON THE EFFECT OF MT. QOMOLANGMA ON THE ATMOSPHERE

Gao Dengyi
(Institute of Atmospheric Physics, Academia Sinica)

The meteorological exploration of Mount Qomolangma in 1959—1975 provided valuable surface and upper-air data of about 20 months. From these important data some special weather phenomena tor Mount Qomolangma and its effect on the atmosphere are derived, some important lines of thought to the meteorological of the Qinghai-Xizang Plateau and some suggestions to the effective weather forecast for climbing up Mount Qomolangma are presented.

The day-time flag clouds, the lee wave clouds, the eddy clouds, the lenticular clouds on the north side of this peak and other orographic clouds have intimate relation to the topography, the air thermal stratification and to the local circulation.

The Mount Qomolangma is a strong and big "heating island" in the atmosphere from April to July. Owing to this heating effect, the temperature in the region 500—200 mb within 600km downwind is higher than within 600km upwind from Mount Qomolangma. Due to this strong heating effect during April and May the meridional temperature gradient to the north of Mount Qomolangma increases greatly, thus the height of the westerly jet immediately north of Mount Qomolangma is about 1—2km lower than the height of the jet stream further from the Himalaya both to the north and south. When the upper air current is from southwest, the meso-scale synoptic systems are often observed on the northern side of Qomolangma at its peak level. These systems cause a fast and large change of wind speed at the peak level, being very dangerous to the mountain climbers. The meso-scale highs with strong wind are in the rear of the lee wave trough, while the mesos cale lows with light wind are in front of the lee wave trough.

As the auther sees it, these meso-scale synoptic systems are derived in the lee waves.

THE SOUTH ASIAN HIGH

Zhu Fukang Lu Longhua Chen Xianji Zhao Wei
(Institute of Weather and Climate Research, AMS, Central Meteorological Bureau)
Li Guigin Zhang Hongcai Huang Fujun Liu Fuming
(Institute of Meteorology, Meteorological Bureau of Sichuan Province)
Sun Guowu
(Institute of Meteorology, Meteorological Bureau of Gansu Province)

The South Asian High is a circulation system peculiar to the upper troposphere over South Asia. Obviously, it shows both integrity and persistence with a tendency to increase or decrease its intensity as a whole and a quasi-triennial oscillation period. The possible mechanism of its long-range oscillation is presented.

The central intensity of the South Asian High enhances gradually from April to July as it moves west-northwestward. Especially in June, when the general circulation of the Far East changes from winter pattern to summer pattern, there is a significant change in the centre location and the intensity of the High. At the same time, it jumps northward to the Qinghai-Xizang plateau. this phenomenon might be related to the thermal

condition over the Plateau.

There is quite a pronounced process of the east-west oscillation of the High in mid-summer. It is found that the variation of the general circulation pattern at 100mb in summer is closely related to the process of the east-west oscillation of the High and also associated with the advance and retreat of the West-Pacific subtropical anticyclone at 500mb. It is directly responsible for the distribution of drought and flood of China in summer.

Finally, the authors discuss the mechanism of the east-west oscillation of the South Asian High. It is pointed out that the process of the east-west oscillation of the High is correlated with the planetary wave adjustment of westerlies, the interaction of the tropical systems and the distribution of the heating field over the Qinghai-Xizang plateau and its adjacent area.

MECHANISM OF THE EAST-WEST OSCILLATION OF THE SOUTH ASIAN HIGH

Zhang Hongcai
(Institute of Meteorology, Meteorological Bureau of Sichuan Province)

The definition of the east-west oscillation of the South Asian High and the main purpose of this study are described A brief examination of the synoptic features on 100mb surface and of the spacial variation of winds and isobaric heights in two typical cases of the east-west oscillation shows that a good correlation exists between the development of a high cell and the redistribution of a long wave to its north and of a downward propagation of the stratospheric easterlies to the south. Corresponding changes also appear in the related fields from troposphere to stratosphere. The study of the evolution of the circulation in stratosphere during the transitional season shows that the intensification of the stratospheric polar high has a controlling effect on the downward propagation of the easterlies and a dominating cause of the northward movement of the 100mb subtropic high. Topography of the Qinghai-Xizang plateau and the distribution of land and sea on the east coast of Asia give some effects on the perturbation of the zonal easterlies and consequently, produce the intensification of the High on the 100mb and the western Pacific subtropic high on 500mb as a consequence. A study of the evolution of stratospheric circulation during the east-west oscillation also shows that the intensity change of the stratospheric polar high responds well to the causes of, a long wave redistribution, the downward propagation of the stratosperic easterlies, the deviation of the polar vortex position, and the variation of intensity of the zonal wind on both sides of the South Asian High, etc. All these contribute to a primary explanation of the east-west oscillation. Some new ideas may be recommended to the research in subtropic meteorology.

THE QINGHAI-XIZANG ANTICYCLONE ON 100mb SURFACE IN SUMMER

Luo Siwei
(Lanzhou Institute of Plateau Atmospheric Physics, Academia Sinica)

In summer a mean anticyclone on the 100mb surface extends over the Eurasia continent with its center over the Qinghai-Xizang Plateau and is so named.

This anticyclone's center oscillates in a period of about 12-days. When the center is located to the east of 100°E and the ridge line of the anticyclone at 120°E moves northward, the subtropical high over western Pacific Ocean on 500mb surface strengthens and jumps northwestward. In this period a drought occurs to the middle and lower reaches of the Changjiang and is called the east pattern. On the contrary, the west pattern centering to the west of 100°E brings rainy weather to the Changjiang, resulting in floods. In between these two patterns there is a zonal pattern which is in the transitional period.

Case study shows that the Qinghai-Xizang Anticyclone is strongest at 150mb surface and becomes a thermal low at 600mb surface. The anticyclone is strengthened when its center is located over the air column which has upward motion at the base and divergence at the top The anticyclone decays when its center is located over the air column which has downward motion and convergence at the top. In the east pattern the subtropical high is strengthened and jumps to the continent under the effects of descending motion. In west pattern, when there is a northwestly strengthening descending motion over northwest China (to the northeast side of Plateau), the subtropical high which is acted under the effects of the ascending motion near 120°E moves back to the ocean.

Although the Qinghai-Xizing anticyclone occurs mainly due to the thermal effects of the Plateau, the transformation between patterns results from the combined thermal and dynamic process. When the sensible heat on the ground over the central and west parts of the Plateau is strengthened, the anticyclone moves westward and the east pattern transforms to the west pattern. When the sensible heat is decayed and specially when there is a liberation of latent heat in the Changjiang Valley, the anticyclone moves eastward and transforms to the east pattern.Some studies have shown that,during the adjustment of the long wave in the middle and high latitude, if the main trough is just located over the Qinghai-Xizang plateau, the anticyclone would move eastward and transform to east pattern. On the contrary, if this trough decays, the anticyclone would return to the Plateau and restore to the west pattern.

VORTICES AND SHEAR LINES AT 500MB LEVEL OVER THE QINGHAI-XIZANG PLATEAU IN SUMMER

Sun Guowu*

(Institute of Meteorology, Meteorological Bureau of Gansu Province)

In summer, the vortices and shear lines at 500mb are the primary precipitation systems over the Qinghai-Xizang plateau and its adjacent regions. Using the synoptic and satellite data from 1969 to 1976, a study has been made in great detail on their generation, development, movement, and temporal and spatial distributions. The mechanism of their generation is also discussed. When the vortices deve lop over the plateau, they are usually warm and below the 400mb level. Their horizontal extents are about 400-500 km. The distribution of vorticity is nearly symmetrical to the low centre, but unlike the other physical parameters. The shear lines are usually lower than 400mb level, and become weak convergence lines above this level. Sometimes they pass across the whole plateau.

The generation and development of the vortices and shear lines are associated closely with the upper and lower circulation patterns around the plateau. The low systems by the south side of the plateau provide mainly warm-moist SW currents which induce the formation of the vortices and shear lines over the Plateau and intensify the rainfalls.

In certain circulation conditions, the vortices move eastward off the plateau and pass over to the boundary layer lows to the east. These processes intensify the development of lows which lead to precipitation in East China.

The mechanism of generation and development of the vortices is similar to that of the tropical cyclones, and the upper divergence in front of the vortices is caused by non-geostrophic winds and the eddy potential energy is converted to eddy kinetic energy through the agency of activities. The generation and development of vortices are mainly due to the heating effect of the Qinghai-Xizang plateau. However, some lows at 500mb can be formed by the wake phenomenon as the westerly current flow around two sides of the plateau, a small low forms to the SE side and a small high to the NE side of the Plateau

These circulations around the plateau and the vortices and shear lines are summed up in four models, and some short-range forecast methods presented.

* This paper is a collaborate resesrch result of "the Synoptic Research Group, Lhasa".

SHEAR LINES IN THE BOUNDARY LAYER OF THE QINGHAI -XIZANG PLATEAU

Luo Siwei
(Lanzhou Institute of Plateau Atmospheric Physics, Academia Sinica)

The shear lines are the main rainy systems in the Changjiang Valley and in the Xizang Plateau. Their horizontal dimension is 500-1000 km and their vertical dimension 2-3 km. They are the weather systems in the boundary layers over the Plateau.

The shear lines located to the eastern side of Plateau are quite clearly shown on the 700mb surface. Their mean position is parallel to the orientation of the Changjiang River and oscillates in the latitudinal zone occupied by the Qinghai-Xizang Plateau. There is a close relation between the shear lines and the small anticyclones formed near the northeast edge of Plateau. The anticyclone's diameter is about 200-250km and its life cycle is about 6-12hr.The shear lines and anticyclones are not develohed under the control of the temperature field and upper pressure field and can pass through the frontal zone from the cold air mass into the warm one. The formation of these small anticyclones and their southern shear lines may be due mainly to the dynamic effect of Plateau.

The shear lines on the 500mb surface are west-east in direction passing through the whole Plateau and their structure is somewhat like the Intertopical Convergent Zone. Their formation related to the thermal effect and also the dynamic effect of the Plateau. The curvature and the lateral friction of the 5Km isohypse at the northern side of the Plateau contribute to the formation and development of the small anticyclone and the shear line located to the south of the anticyclone.

ON THE RADIATION AND HEAT BALANCE OVER THE QINGHAI-XIZANG PLATEAU

Kou Youguan, Zeng Qunzhu, Xie Weirong and Xiao Shu
(Lanzhou Institute of Glaciology and Cryopedology, Academia Sinica)

The solar radiation is the main source of energy for the ablation of glacier and permafrost. Since the beginning of the sixties, extensive research work on solar radiation and surface heat balance has been carried on by the Lanzhou Institute of Glaciology and Cryopedology at as many as 18 selected locations of mountain glaciers and permafrost regions in West China.

Two highest observation points are at 7029 m and 6325 m respectively. longest period of observation reached 14 months at Fengxuoshan in the region of plateau permafrost (34°43'N, 92°52'E, 4745 m a. s. l.) from June, 1975 to July, 1976.

The items of measurement such as: (1) Direct solar radiation, (2) Sky radiation, (3) Reflective radiation, (4) Radiation balance, (5) Thawing depth of the permafrost and, in addition, air temperature, humidity, wind speed, soil temperature, and soil heat flux at different heights or depths, and so on were also measured.

The higher the sea level, the larger the direct solar radiation, global radiation and the effective radiation. The intensity of the direct solar radiation at 6325 m is as high as 1.79 cal/cm^2. min. A difference in height of 1000 m will bring about a difference of annual amount of possible global radiation of 9.59 kcal/cm^2, but a difference in latitude of 1° gives only about 1.3 kcal/cm^2 difference. So the change in elevation has a greater influence on radiation than the change in latitude.

The values of the global radiation, the effective radiation and the radiation balance on Qinghai-Xizang Plateau are all the largest in China. But on the plateau high values are obtained in the southwest part, respectively 190 kcal/cm^2. year, 70 kcal/cm^2. year, and 80 kcal/cm^2. year Qaidam basin has the next highest values, Sichuan basin the lowest values.

As the albedo of glacier surface over 5000 m is strong, the absorbed radiation and the radiation balance decreases obviously. On the fine days with almost equal amount of the global radiation, the absorbed radiation is about 3 times less and the decrease of the radiation balance is over 400 cal/cm^2, day. On the surface of the firn at 6325 m at East Rongbu Glacier in Mt. Qomolangma, the daily amount of radiation balance is only 39 cal/cm^2. day and the annual amount is negative, similar to the polar regions.

an inversion exists over the surface of ice-snow both in day and at night during the ablation period in summer, so that the ground is the cold source to the atmosphere. Of the total heat input to the glaciers, the radiation balance takes the first place and sensible heat, the second. Of the total heat output, ablation heat consumption is the largfst.

The total annual amount of global radiation at Fengxuoshan station is 157.68 kcal/cm^2 and of radiation balance, 57.4 kcal/cm^2. From January to December all values of radiation balance stand positive. Ground surface is a permanent source of heat for the air.

The monthly total value of radiation balance on the Qinghai-Xizang Plateau is lowest in December. The zero line of December radiation balance passes northern side of the Kunlun and the Altun mountains. With the exception of ice-snow-coverred regions most parts of the Plateau possess positive values of surface radiation balance in the period from January to December, that is to say, the surface absorbs radiant energy and transmits practically all of it to the atmosphere in form of sensible heat and latent heat. Therefore, the earth's surface is always the source of heat for the atmosphere regardless of to the seasons.

BASIC CHARACTERISTICS OF THE CLIMATE OF QINGHAI-XIZANG PLATEAU

Tang Maocang Shen Zhibao
(Lanzhou Institute of Plateau Atmospheric Physics, Academia sinica)

In this paper, the distribution of mean temperature, pressure, wind, humidity, heat source and sink, and mean temperature stratification over the Xizang plateau has been analyzed. The seasonal and diurnal variations of these meteorological elements and their mean fields have been analyzed. The extreme values of these distributions are all centered in the highest part of the plateau. As seen from surface mean charts, the air temperature, humidity and pressure are minimum and the surface wind is strongest over the plateau in the world as compared with the same latitude belt. However, the temperature, pressure, and humidity in the upper troposphere are maximum in comparision with any region of the same levels and latitudes in the world in summer. Similarly, the lapse rate of temperature are largest over the plateau. The temperature stratification is conditional unstable and similar to the atmosphere over the seas in the tropics

The seasonal and diurnal variations of climate over the plateau are remarkable. The mean pressure and temperature fields at 600 mb level is a cold high in winter and a heat low in summer. The seasonal variation of the streamline field and pressure field both reveals a marked monsoon phenomenon over the plateau. The values of the seasonal variation decrease outwards to a distance of 300—500 kilometres, and then increase from there. In other words, there is a minimum belt around the plateau, which divides the plateau and its neighbourhood into two different climatic units. The climatic characteristics over the Qinghai-Xizarg plateau are mainly caused by the dynamic and thermal effects of the plateau. Hence, the Qinghai-Xiza g plateau is itself a climatic unit.

CHARACTERISTICS OF WEATHER SYSTEMS OF QINGHAI—XIZANG PLATEAU

Yuan fumao
(Lanzhou Institute of Plateau Atmospheric Physics, Academia Sinica)

The weather systems of the Plateau have been divided into two kinds; (1)the weather systems generated over the Plateau and (2) the weather systems having generated outside but moving in or over the Plateau. The frequency of the former is maximum in the world compared with the same latitude belt and at same level, while the latter is also with the most remarkable seasonal variation.

The interactions of these two kinds of weather systems are discussed briefly. At last, it is concluded that the Plateau is not only a climatic unit, but also a generating source region of weather systems.

CLIMATIC CLASSIFICATION OF QINGHAI-XIZANG PLATEAU

Lin Zhen yao Wu Xiang ding
(Institute of Geography, Academia Sinica)

In this paper, a climatic classification of Qinghai-Xizang Plateau is made on the basis of the data of 191 stations for the years up to 1970. The Xizang data are up to 1975.

The temperature is taken as the first category for the classification. This includes the number of days with temperature≥10℃ and the mean temperature of the warmest month, which is related to the heating condition. On this basis, the Qinghai-Xizang Plateau may be divided into three climatic zones, i. e. plateau temperate, plateau sub-frigid and plateau frigid, while the southern slopes of the Himalaya may divided into tropical and subtropical montane climatic regions.

Secondly, aridity (the ratio of the potential evaporation and the precipitation, the potential evaporation being obtained from the H. L. Penman's formula) and annual preci- pitation are used as the secondary category which shows the humidity condition. Based on this, the abore three climatic zones are subdivided into humid, sub-humid,

semi-arid, arid and dry types.

Finally, according to temperature and humidity, the Plateau is divided into the following 13 climatic regions.

I_{A} North tropical montane humid region of southeastern Xizang.

II_{A} Subtropical montane humid region of southeastern Xizang.

HIII_{A} Plateau temperate humid region of western Sichuan.

HIII_{B} Plateau temperate subhumid region of eastern Xizang.

HIII_{C1} Plateau temperate semi-arid region of southern Xizang.

HIII_{C2} Plateau temperate semi-arid region of Xining.

HIII_{D} Plateau temperate arid region of Ngari Diqu.

HIII_{E} Plateau temperate dry region of Qaidam.

HIV_{A} Plateau subfrigid humid region of southeastern Qinghai.

HIV_{B} Plateau subfrigid sub-humid region of Nagqu.

HIV_{C1} Plateau subfrigid semi-arid region of South Changtang.

HIV_{C2} Plateau subfrigid semi-arid region of Qilian Shan.

HV_{D} Plateau frigid arid region of North Changtang.

PROBLEMS OF CLIMATIC CLASSIFICATION OF XIZANG

Zhang Yiguang

(Commission for Integrated Survey of Natural Resources, Academia Sinica)

Huang Chaoying

(Climatic Data Center, Central Meteorological Bureau)

Being the main part of the Qinghai-Xizang plateau, Xizang is a unique physiographic unit. The nonzonal climatic character had been emphasized in the previous climatic classification, but the relations between Xizang and its neighboring areas have been often neglected. Based on the scientific expedition on the plateau, we have respectively classified the climate of Xizang and of the Qinghai-Xizang plateau. In the classification emphasis has been put on the functions of zonality factors, both horizontal and vertical.

1. As a whole, the topography of Xizang slopes downward from northwest to southeast. Mountain ranges and rivers are oriented from west to east. The Heng-duan mountains to the east of the plateau block the warm and moist air flow from the southwest and force it to move toward northwest. The latitudinal and the altitudinal changes of the

temperature strengthen the horizontal zonality.

2. The vegetations of the plateau follow the same laws governing the general vegetation of East Asia, and are closely related to its eastern and western neighborhood. The same vegetation zone, however, goes from east to west gradually to higher latitude and altitude. The distribution of climatic zone is just the same. The elevation of the plateau results in "the third pole of the earth."

3. Although the isotherms in Xizang are affected by mountains and rivers, they are in general parallel to the latitudes.

4. A preliminary calculation shows that the annul mean temperature are closely related to the latitudes. The temperature decreases northward about 0.63℃ per latitude degree. The lapse rate of the temperature is about 0.57℃ per 100 m. From west to east the temperature increases 0.13℃, while the precipitation increases 100 mm.

Zonality is a universal phenomenon of the natural world. It expresses in horizonal and vertical changes. It is the result of a close interaction of several natural phenomena. Xizang extends more than 10 degrees in latitude and 20 degrees in longitude. The difference of height is about over 8700m. From southeast to northwest and from lowland to highland, the climatic appears in regular zones. The task of climatic division is to reflect the laws objectively.

In order to reveal the essence of the climate in Xizang, the genetical principles have been implemented in the Xizang, climetic division and it is based on the regional climate of lowest latitude of sea level in Xizang.

Though the index of thermal zone in Xizang region is lower than that in east China, in the same climatic zone, the soil, vegetations and the biological conditions foundamentally are the same.

CLIMATES OF QINGHAI-XIZANG PLATEAU BEFORE AND AFTER THE UPHEAVAL

Wu Xiangding Lin Zhenyao
(Institute of Geography, Academia Sinica)

This article is an attempt to investigate into, based on an analysis of the atmospheric circulation and thermal correction, the climates of the Qinghai-Xizang Plateau before and after the upheaval.

As regards the temperature correction, three factors must be considered. the First, with rising of the land surface, its temperature steps down. Thus, there is a need for "altitude correction" according to present air temperature at stations. Secondy, the large-scale fluctuation of climates within the same latitude zone must be considered. Third,

the change of the atmospheric circulation parttern may have a great effect on temperature.

Two critical periods are recognized. In late Tertiary, the elevation of the Qinghai Xizang Plateau was about I km above sea level, the annual average thermal isotherms ran latitudinally, and the thermal gradient from north to south was not so steep as today. After the rapid uplift, there had undergone a great change. During the late middle Pleistocene, the Plateau was raised about 3 km above sea level, the thermal distribution has already been quite similar to that at present.

A PRELIMINARY ANALYSIS OF CLIMATIC CHANGES DURING THE HISTORICAL TIME OF QINGHAI-XIZANG PLATEAU

Wu Xiangding Lin Zhenyao

(Institute of Geography, Academia Sinica)

Based on tree-ring data, meteorological records, historical literature, pollen records, landscape changes of and others, an attempt has been made to analyze the climatic changes for past thousands of years of Qinghai Xizang Plateau. the temperature change of the two thousand years and the historisal of droughts and floods in the last several hundred years have been considered.

From the climate stand-point five significant periods have been recognised: I) the climatic optimum, 2) the neo-glacial period, 3) the warmer period, 4) the little ice age, and 5) the last warm period.

The chief characteristics of the climatic changes may be summarized as follows:

1. The general features of climatic variation of the Plateau are similar to those of East China. But, the rising temperature over the Plateau since the last glaciation has been more noticeable than in its neighbouring areas.

2. An analysis of the variability and stability and other facts show that the Qinghai-Xizang Plateau is more sensitive to climatic change than any other place within the same latitude zone.

3. By analysis of the power spectra on various series, we obtain many cycles, such as the "quasi-two year pulse", quasi-II and-22 year cycles, the "Brückner Cycle" and so on.

Besides, the higher the altitude, the larger the amplitude of climatic variation.

A GLACIOLOGICAL RESEARCH OF THE QINGHAI-XIZANG PLATEAU

Shi Yafeng
(Lanzhou Institute of Glaciology and Cryopedology, Academia Sinica)

Li Jijun
(Department of Geology and Geography, Lanzhou University)

From the 50s of this century up to the present, Chinese scientists have obtained the following results in glaciological research on the Qinghai-Xizang Plateau.

(1) Glacier distribution and statistics: It makes rather sure now about the distribution of glaciers on the Qinghai-Xizang Plateau. The total glacierization area of various mountains on the Plateau in China is over 47,000km^2, occupying 82% of the total glacierization area in China or half of that of High Asia. About 3,000 glaciers in Qilian Shan have been inventoried. Stereophotogrammetry has been applied to the surveying of Mt. Qomolangma and of Batura Glacier in Karakoram Mountains in Pakistan, and glacier maps of high quality have been published. Besides, a map of glacier distribution in the Xizang region at 1:1,000,000 has been compiled.

(2) Study on the relationship between glacier and climate: The particular climate of the Qinghai-Xizang Plateau exerts great influence on the development of its glaciers. The isolines of snow line take a manner similar to the irregular concentric circles on the Plateau, showing the difference in precipitation and thermal effects of the Plateau. The distribution of glaciers on the Plateau, such as the centering of the largest glacierization area on its western border, the concentration f glaciers in its southeastern part and the small glaciers appearing in its northern part, etc., is closely related to the atmospheric circulation. The study of radiation and heat balance in certain glaciers contributes greatly to the explanation of ice formation and ablation. The observation of annual firn layer cooperating with short climatic records ascertains that there exists a second high or maximum precipitation zone in the mountain glacier area. The dendroclimatological study is helpful to the estimation of the variation of glaciers in history.

(3) Study on the physical properties and types of glaciers: Studies on ice temperature, ice formation, mass balance, flow and ablation of certain glaciers in the sixties, render the result that the glaciers in West China could be classified into continental type and maritime type. To the former belong those in most parts of the Plateau from the great Himalaya to Qilian Shan with low precipitation while to the latter, those in its southeastern part with high monsoon precipitation. In recent years, the study of the Batura Glacier in Karakoram gives rise to a third supplementary type -- the complex type. They are large valley glaciers with a vertical height of over 3,000 -- 4,000m. Their properties are more complex.

(4) Study on variation and prediction of glaciers: In recent years, it is found that

the snow line on the northern slope of Qilian Shan is much lowered, the mass budget appears positive, and the glacier recession slows down. According to statistical data, among the 116 glaciers on the Qinghai-Xizang Plateau, 35 are advancing, 62 retreating, and 9 stable or without signigicant variation, agreeing with the general trend of variation in the world. Moreover, we have made a forecast of advancing value for Batura Glacier in this century.

(5) Study on the relationship between the evolution of glaciers and the uplift of the Plateau: It is estimated that the uplift of the Qinghai-Xizang Plateau in Quaternary was over 3,000m. If it is considered correlatively with the climatic variation, a particular model of glacier evolution could be induced. At least four glaciations could be discriminated. The greatest glaciation occurred in the middle Pleistocene, the third from the last, but no ice sheet was formed. After fhis, the successive uplift of the Plateau in combination with the change in climate towards frigidity and aridity limited the magnitude of glaciers and diminished the lowering value of the former snow line to the existing snow line. Under the conditions of different altitudes and landforms, over the bordering mountains of the Plateau developed a group of valley glaciers, and in the interior of the Plateau developed a group of ice cap or flat-topped glaciers.

(6) Studies on meltwater-fed streams and glacial mud flows: According to the data observed from some months to several years at different localities, it is roughly estimated that the annual glacial meltwater on the Plateau in China amounts to about 40,000 million m^3 with C_v value at about 0.2. The depth of ablation runoff for the continental type glaciers is 400-800mm/year, while that for the maritime type glaciers reaches more than 2000mm/year. The glacial mud flows appear mainly along the Sichuan-Xizang Highway in the southeastern part of Xizang and along the Sino-Pakistan highway in the southwestern border of the Plateau. The steep slope in high mountains and deep valleys facilitate its occurrence. Its sudden burst may blockade rivers and interrupt highways, entailing catastrophic damages.

In the eighties, the study of glaciers on the Plateau will be directed to the following subjects: To continue and complete the inventories of all glaciers of the Plateau based on the increasing data on the measurement of glacier depth with a view to clear the glacier resources. To select representative glaciers for systematic observations, especially to carry forward the geochemical analyses of a sample collected from ice core for the purpose of studying glacial dynamics, so as to reconstruct the environmental variation since the Little Ice Age and to establish a sound foundation to forecast glacial advance and recession. Studies must be deepened in the processes of erosion and deposition of glaciers, glacial meltwater and mud flows and of the prevention of the calamities possibly occurred. We should cooperate with other relative disciplines in the study of the Quaternary, and make a chronological table of glacial and interglacial stage; comparable to other parts of the world. We must work hard to improve all kinds of technical means in field investigation and in laboratory experiments, at present giving the first place to the application of the technique of remote sensing and remote measurement. We will take the greatest glacirl area on the western border of the Plateau as stressing point to extend our work to the need of industrial and agricultural development in the arid regions. We look forward to international cooperation in raising our level of glacial research.

FEATURES OF CONTINENTAL GLACIERS ON THE PERIPHERIES OF THE QINGHAI-XIZANG PLATEAU

Xie Zichu

(Lanzhou Institute of Glaciology and Cryopedology, Academia Sinica)

The glaciers both on the northern side of Qilian Shan and the southern side of the Middle Himalayas of the Qinghai-Xizang Plateau develop under relatively arid and cold conditions. The northern side is drier and colder than on the south side, and hence with more prominent characteristics of continental glaciers.

The mass balances of glaciers on both the southern and the northern sides of the Plateau show the characteristics of the typical monsoon nourishment and ablation. In warm seasons when the accumulation period coincides with the ablation period, both the ablation of ice tongue and net accumulation of firn area are weakened. Nevertheless, in cold seasons this phenomenon is vice versa. Therefore the change of mass balance in a year is not great, while the difference between accumulation area and ablation area becomes greater.

Due to the above-mentioned hydrothermal conditions and monsoon glacial balance on both sides of the Plateau, the infiltration-congelation process in the formation of glacier ice is well developed, and the thickness and the extent of superimposed ice of the glaciers are greatest in the middle and low latitudes. According to the surface structures of glaciers, their mass and heat balance and runoff features, the author divides the seasonal infiltration-congelation zone into two subzones, the upper and the lower, and the infiltration zone into upper, middle and lower subzones. The author also points out that the vertical variation of all subzones is changing with climatic fluctuations. The temperature under the active layers of glaciers on the northern side of the Plateau is lower than that on the southern side; the ice velocity is slower and ice surface morphology is comparatively simpler These differences, in addition to hydrothermal conditions described above, are relevant to the intensity of solar radiation, especially of the direct radiation at different latitudes and to the proportion in heat balance and radiation balance.

It follows that most of the glaciers on the northern side of the Plateau are called the monsoon middle latitude continental type; those in the eastern part of Qilian Shan, the monsoon middle latitude subcontinental type; most glaciers on the northern and southern slopes of main range of the Himalayas the monsoon low latitude subcontinental type. Only those in the most eastern and the most western parts and the most southern edge of the middle part of the Himalayas may belong to maritime glaciers.

MONSOON MARITIME GLACIERS IN SOUTHEAST XIZANG

Li Jijun
(Department of Geology and Geography, Lanzhou University)
Zheng Benxing
(Lanzhou Institute of Glaciology and Cryopedology, Academia Sinica)

In southeast Xizang, there is a tongue-like rainy zone stretching northward, where monsoon maritime glaciers develop, covering about 8000 km^2. in area. In the light of mass balance, abl'tion intensity, heat balance in the ablation period, ice temperature and characteristics of movement, the glaciers closely resemble the maritime glaciers in the Alps and in New Zealand, but differ from the continental type in inland China. High temperature in this part of Xizang due to the summer monsoon and to the low latitude make the warm infiltration-recrystallization ice formation zone extend vertically for at least 1500 m. Thus, the main constituent of the glacier is warm ice, which is decisive to its special warm property making the abundance in organism on the glacial surface possible. Ice tongues extend to subtropical forest. Sliding movement in its bottom is evident. Heavy and successive rain and extraordinary high temperature in summer provoke abrupt gliding of the glacier, causing tremendous calamities in the form of overflow of glacial lake, glacial mud flows, etc. Here the glacial termini are very low (the lowest at 2400m) . Such a topographical feature is closely related to the local landscape of high mountains and deep valleys. The thickness of surface moraines on the ice tongue is not necessarily a sign of glacial recession, but is a reasonable prerequisite for its strong downward extension. Therefore, thermal karst phenomenon may have no relation to glacial recession.

CHARACTERISTICS OF THE GLACIERS IN THE NEPAL HIMALAYAS

Keiji Higuchi
(Water Research Institute,
Nagoya University, Nagoya, Japan)

Glaciological and meteorological observations of glaciers and climates in the Nepal Himalayas were carried out as the "Glaciological Expedition of Nepal (GEN)" in 1973, 74, 75, 76, and 78, with the permission and cooperation of His Majesty's Government of Nepal, the leader being K. Higuchi. The results obtained by these observations were published as "Glaciers and Climates of Nepal Himalayas", Part I (1976), Part II (1977), Part III (1978), and Part IV (1980) in the special issue of "Seppyo" ("雪氷") by the Japanese Society of Snow and Ice. On the basis of these papers, characteristics of the glaciers in the Nepal Himalayas can be summarized as follows.

1) The glaciers in the Nepal Himalayas can be classified into two types, "Nepal type" and "Tibet type". The lowest elevation of the glaciers of the former type is lower than that of the latter type. The length of the glaciers of the former type is longer than that of the latter type. For both types, the glaciers of the Nepal Himalayas are longer in the east part than in the west.

2) A glacier inventory in the Dudh Kosi region, East Nepal, was made mainly on the basis of field observations and aeral photographs in 1974—76. It was found by the analysis of the inventory that the lowest elevation of the debris-free glaciers in the basin of the Dudh Kosi tends to be higher in the sub-basin of the upper-stream. A comparison of the inventory with Müller's earlier one shows that most glaciers of the debris-free type in the upper part of this region were retreating during the period 1960—1975. Fluctuations of termini of 14 debris-free glaciers in this region were measured during the period 1970—1978, when 7 glaciers were retreating, 3 stationary, 3 advancing, and 1 irregular.

3) In the case of a large glacier with lower part covered by debris, the cover effects on the ablation rate. In the ablation area of the Khumbu Glacier, the rate was nearly zero at the lowest part with debris more than 3m deep and averaged 2.5cm/day at the upper part with thin debris.

4) Since the mass balance of the glaciers in the Nepal Himalayas depends mainly on the summer balance, accumulation and ablation measurements were carried out during summer on the Rikha Samba Glacier in central Nepal on northern side of the Great Himalayas, and the Glacier AX 010 in east Nepal on southern side of it. In the case of the Rikha Sambe Glacier ($4.81 km^2$) during the summer of 1974, total volume of accumulation, ablation and balance are 1.22, 0.99 and $+0.23 \times 10^6 m^3$ respectively. In the case of the Glacier AX 010 ($0.57 km^2$) during the summer of 1978, total volume of accumula-

tion, ablation and balance are 4.0, 6.6 and $-2.6\times10^5 m^3$ respectively.

5) 60% of the total precipitation during the monsoon season in the ablation area of the Rikha Samba Glacier occurred at night in the form of snow. If this amount of precipitation occurred in the daytime in the form of rain, the ablation of glacier ice would increase instead of melting of snow deposited on the glacier surface. It can be concluded that the present position of the terminus of the Rikha Samba Glacier has a relation to the tendency of precipitation in this area to occur frequently at night.

6) According to the measurements in the summer of 1973, surface velocity in the ablation area of the Khumbu Glacier was 4~6m/month in the upper part, 2m/month in the middle and nearly zero in the lowest. Thickness in the upper part of ablation area was estimated as 190m from the surface velocity, and 220m from the gravitational method.

7) Ice temperature at 5,360m in the upper part of the Khumbu Glacier was -5.3℃ at the depth of 2.7m in the end of November 1974. It was found from the observations of temperature profile in summer and winter during the period 1978—79 that ice temperature of the Glacier AX 010 was below zero.

BATURA GLACIER OF KARAKORAM MOUNTAINS, AN EXAMPLE OF THE COMPLEX TYPE OF GLACIER

Shi Yafeng   Zhang Xiangsong
(Lanzhou Institute of Glaciology and Cryopedology, Academia Sinica)

In the sixties, according to the properties of glaciers, i. e. their accumulation, ablation, ice formation, temperature and motion, glaciers of High Asia may be grouped under two headings: continental glaciers and maritime glaciers. The former include most glaciers of west China, while the latter refer to those in the Hengduan Shan and in southeast Xizang.

In the seventies, we discovered a lot of large glaciers at Karakoram, Pamir and the higher peaks of Tian Shan. They may also occur on the south slope of the Himalaya. Several large glaciers, having a great difference in altitude of over 4,000 m from the source to the terminus, stretch across several climatic zones including permafrost, temperate and subtropic. Such glaciers have changed greatly, and form what we called the complex type of glaciers. Taking the Batura Glacier at the northwest part of Karakoram as an example, it is 59.2 km long with an area of 285 km^2, being a valley glacier of dendritic form. The highest peak at its source, Batura Muztag, is 7,795 m a. s. l. and its terminus descends to 2,540 m in Hunza Valley with a difference in altitude reaching

5,455 m. The main characteristics of the Batura Glacier may be summed up briefly as follows:

The change of snow layers into glacier ice is of a cold metamorphic type, and the ice formation is due to infiltration and congelation. The volumes of both supply and waste are great. The ice temperature is of a cold type in the upper reaches of the ice tongue, but it belongs to the temperate type in the lower ones. It is a normal, active glacier with a comparatively higher rate of motion. Its advances and recessions are frequent but they are within narrow ranges. It has some characteristics of the continental glaciers with also quite a number of features of the maritime one. Therefore, we call it a "complex type of glacier".

In the second part of this paper, the author presented some remarks on the following problems: the cause and distribution of the complex type glaciers, the relationships between zones in mountain glaciers and their dimension and latitude, and the problem of glacier classification.

RECENT VARIATIONS OF THE EXISTING GLACIERS ON THE QINGHAI-XIZANG PLATEAU

Zhang Xiangsong Zheng Benxiang Xie Zichu
(Lanzhou Institute of Glaciology and Cryopedology, Academia Sinica)

Based on the repeated measurements at the stations, geomorphological investigation, documentary records, (especially compared with the landsat images in the 70s and aerial photo maps in the 60s), and the recollections of the residents, the recent variations of the glaciers on the Qinghai-Xizang Plateau are discussed.

In the 50s and at the beginning of 60s, the glacial behaviours on the Qinghai-Xizang Plateau were all in a state of shrinking. Taken as a whole, the changes in the positions of glacial fronts for the 1970s present a very heterogeneous picture. Although most of the glaciers were still retreating in the 1970s, it has been discovered that quite a number of the glaciers in the Kunlun, Karakorum, Pamir, and the Himalaya are in a state of advancing. In recent years, positive values of mass balance began to appear, the snowline descended, and the rate of many glacier retreat has been slowing down. The main characteristics of the glacial variations of the Qinghai-Xizang Plateau are as follows:

(1) On the Qinghai-Xizang Plateau 116 glaciers have their records of periodic change for 10 to 30 years or so. According to preliminary statistics, 62 of them have a clear sign of recession, while 35 are obviously advancing.

(2)A comparison of the existing glaciers of the Qinghai-Xizang Plateau with those of other districts in the world indicates that the variation rate of glacier on this Plateau are not small. Roughly speaking, the range of glacial variation decreases from the marginal mountains towards the interior of the Qinghai-Xizang Plateau.

(3)Comparing our maps newly prepared with foreign maps of the twenties or thirties of this century, we found that for the past forty years the terminus of Rongbu Glacier has been remaining at the same place without any significant change. This is because the lower part of the ice tongue was covered by thick superglacial moraines, thus fundamentally free of the influence of solar radiation and atmospheric diffusion. As the ends of glacier tongues were within the zone of permafrost, the ablation within and under the ice is highly restricted. The stationary termini of glaciers under the cover of thick moraines are very common on numerous glaciers of the high peaks over 7,000-8,000m a.s.l., such as Mt. Qomolangma, Mt. Qogir(Čhogori, K_2)et al.

(4)The common features of the termini of the advancing glaciers on this Plateau are the steep and giant ice cliffs at the snout. The front of ice cliff has always a push moraine, formed by the pushing of advancing glaciers. A lot of rounded pebbles appear in the push moraine.

(5)We discovered that the general tendency of advance and retreat of the glaciers on the Qinghai-Xizang Plateau seems to be much the same as that of the existing glaciers in the Alps, except with the difference in time fluctuations.

(6)The response time of the glaciers in Qilian Shan to climatic change is more than 10 years.

(7)It is estimated that the retreat of glaciers on the Qinghai-Xizang Plateau will soon come to an end and, maybe, it will be replaced by a new advance. Because this new advance is the glacier fluctuation over decades, which is superimposed on the overall trend of glacier recession as responses to over centuries climatic warming trend, therefore, the time of this glacial advance is not long and amplitude of advance is small.

QUATERNARY GLACIATION OF THE QINGHAI-XIZANG PLATEAU

Zheng Benxing
(Lanzhou Institute of Glaciology and Cryopedology, Academia Sinica)
Li Jijun
(Department of Geology and Geography, Lanzhou University)

According to the remnants of paleoglaciers and other evidences on the Qinghai-Xizang Plateau, four glaciations can be recognized: namely, the Xixabangma, the Nynyxunglha, the Qomolangma I(Guxiang)and the Qomolangma II(Baiyu). In the peripheral districts of existing glaciers, there generally exist some end moraines formed by the glacial advances of Neoglaciation in Holocene. Due to the successive uplift of the mountains and the alternating erosion and accumulation, the glacial landscape often exhibits a telescoping and stepped structure. The remnants of older glaciers occupy a higher position. The weathering of moraines of different glaciation varies in a wide range, reflected in the proportion of stable minerals, in the type of paleosol and their difference in clayey mineral components. The dimension of Nynyxunglha glaciation was the greatest and the most intense on the Plateau, and the climate of the interglacial period after it was the warmest. The uplifting Himalayas in the late Pleistocene became a barrier for the incursion of the Indian monsoon. Thus, the scale of the glaciation in the interior of the Plateau diminished more sharply than before. It was only in the southeastern part of Xizang that the precipitation was heavy, and large valley glaciers at 100-200km long appeared in that period. However, ice sheet had never formed even in the greatest glaciation. Large valley glaciers were mainly developed along the bordering high mountains of the Plateau,and ice caps or intermont basin glaciers were formed in the inner part of the Plateau, such as the ice caps in Medica and near the Douchen County reaching an area about 3,000km^2. The climate in the late Pleistocene became more and more arid and cold, so permafrost was prevailing on the Plateau except several valleys at a low elevation. Furthermore, the permafrost on the northern Plateau and higher mountains still exists today.

The variation of glaciation in the Holocene may be divided into three stages: the recession in the early Holocene(10,000-8,000B.P.); the disappearance of most glaciers of the Hypsithermal period(8,000-3,000B.P.)in the middle Holocene; and the fluctuations(3,000 up to present) of glaciers(Neoglaciation)in the late Holocene. During the Neoglaciation, there were three eminent advances, i.e.the Xurdam Advance (C^{14}2980±150B.P.), the Ruoguo Advance (C^{14}1920±110B.P.) and the modern Little Ice Age Advance of 17-19th centures.

GLACIER REGIME AND GLACIAL SEDIMENT FACIES: A HYPOTHETICAL FRAMEWORK FOR THE QINGHAI-XIZANG PLATEAU

Edward Derbyshire
(Soils Laboratory, Department of Geography,
University of Keele, U. K.)

Glacial sediment facies discrimination is a potentially valuable but poorly developed palaeo-environmental method. Glacial sediment properties are influenced by (i) the lithology of the bed; (ii) the type, incidence and rate of degradation of the mountain slopes; and (iii) the glaciological regime. The third of these factors determines (iv) the mode of glacier flow and(v) the activity index of the glacier. Factors (ii), (iv) and (v) influence (vi) the debris flow paths within the glacier and (vii) the glacial sediment facies.

Glaciers in deep, steep-sided valleys are frequently covered with supraglacial debris in which the transport environment is passive. The resultant depositional facies is coarse, angular and relatively well sorted (meltout till) . Transport in the basal zone produces lodgement till but this facies tends to be thin, extremely poorly sorted and dense with subrounded clasts. Deposition as slurries (flow till) is quite common but localized. This is type A facies.

In mountain ice caps and some large piedmont glaciers, passive transport of supraglacial, subaerially-derived debris is less widespread.Tills produced by comminution in the basal zone of traction are more important (type B facies) .

Tills deposited by the primary processes of lodgement and meltout, and by the secondary processes of flow and slide, vary systematically in their particle size, particle shape and fabric (including microfabric) .

(1) In continental climates with cold summers, ablation is dominated by radiation, and evaporation and sublimation are relatively high. Snowfall totals are low, glaciers tending to have low activity indices.Both lodgement and meltout tills tend to be sporadic and thin and to have a metastable microfabric ("collapsing soil") . Flow till is rare. On ice-free surfaces, solifluction may by entirely absent and non-sorted (ice-wedge) polygons widespread.

(2) In continental locations with warm summers,glacier activity is moderate to high. Lodgement and meltout tills occur but the latter is often dominant. Flow till is localized. Mechanical eluviation of fines occurs in all till types. Deposition by slide is common. On ice-free surfaces, debris fans and mudflows are widely distributed on the steeper valley

sides. Solifluction mantles are thin and sorted and non-sorted polygonal mounds occur.

(3) In cool, montane climates where snowfall totals are heavy and ablation predominantly by turbulent eddy transfer, glacier activity indices are moderate to very high. Debris released from the glacier maintains high moisture levels, flow tills are common but localized, the slide facies is rare and meltout till is usually predominant. Solifluction mantles are widespread and often thick on glacier-free surfaces. Sorted ground patterns are widespread and mudflows and avalanche debris tongues are common on mountain slopes.

In the early Pleistocene (Xixabangma epoch), the glaciers which developed on the highest summits of the Plateau were probably of isothermal, high activity type (glacial facies type A3, with type B occurring on the northern side of the Himalaya). Glaciofluvial sedimentation was abundant.

In the Nieniexiongla glaciation (Middle Pleistocene), there should be abundant evidence of type A3 and B3 in the Himalaya and type A3 in the Nyainqentanglha Shan, but a transition to type A2 and B2 is to be expected for this period in the Tanggula Shan and the central and eastern Kunlun Shan.

A trend towards increasingly cold continental facies (type 1) to the north and northwest of the Tangula Shan, as a result of desiccation of the Plateau with the accelerating rise of the Himalaya, is to be expected in the sediments of Qomolungma (Late Pleistocene) and Neoglacial (Holocene) age, with the exception of the westernmost Kunlun Shan which probably attained its highest activity condition at this time, depositing type A3 and A2 facies in the Holocene.

GLACIAL HISTORY IN THE KHUMBU REGION, NEPAL HIMALAYA, IN RELATION TO UPHEAVAL OF THE GREAT HIMALAYAS

Horoji Fushimi
(Water Research Institute,
Nagoya University, Japan)

the Himalayan region is situated in the south part of Inland Asia which has been rising up since the late Cenozoic and there are found areal characteristics of topography and climate causing various glacial phenomena as one of natural histories of the Great Himalayas.

Studies on glaciations were mainly carried out in the Khumbu region, east Nepal, from 1970 to 1978 as a part of activities of the Japanese Skiing Expedition to Mt. Qomolangma (Sagarmatha, Everest) and of the Glaciological Expedition of Nepal in order to clarify the glacial history of Nepal Himalayas a typical glacial phenomena in central part of the Great Himalayas in relation to topographic as well as climatic changes caused by processes of the mountain buildings.

Present studies give the following results.

1) The past U-shaped valleys with tills and lake deposits are classified into three series having several stages of glacier advances. At the time of the oldest and maximum expansion, the total area of glaciation was about 5 times larger than at present.

2) The series of U-shaped valleys show that the younger the age of the U-shaped valley is, the shallower the valley depths and also the smaller the glacial area. Glaciers in this region have been gradually waning through late Cenozoic when the Great Himalayas rose.

3) Topographic and climatic conditions make areal distributions of glacier groups in the Great Himalayas. Glaciers in the Nepal Himalaya have small scale and higher terminal positions as characteristics of a Central Himalayan glacier group. The Central Himalayan glacier group is further subdivided from south to north.

4) Studies on recent glacier fluctuations including an advance of the 16th century hare been made in relation to people's migrations of the Great Himalaya region.

5) The present areal characteristics of glacial phenomena can be explained by the history of the rising Great Himalayas and the related climatic changes.

THE TERRESTRIAL STEREOPHOTOGRAMMETRIC SURVEYING AND MAPPING IN THE REGION OF QOMOLANGMA AND THE BATURA GLACIER IN KARAKORUM

Wang Wenying   Chen Jianming
(Lanzhou Institute of Glaciology and Cryopedology, Academia Sinica)

In order to meet the need of the research work on glaciology and geology as well as of mountaineering expeditions and the building of highways, we have made terrestrial stereophotogrammmetric maps covering large areas in the region of Qomolangma and of the Batura Glacier in Karakorum, Pakistan. From 1966 to 1978, we have drawn and published the maps respectirely of the Qomolangma region 1:25000 and 1:50000 and of the Batura Glacier at 1:60000 Favourable comments were received at home and abroad.

In this paper we explain briefly the main procedures of surveying and mapping by terrestrial stereophotography, emphasizing how to raise the surveying accuracy and to probe into the method of expressing glacial landforms.

Basis of surveying control. The frame of a map is its controlling points. The framework of the Qomolangma region was carried out by the National Surveying and Mapping Bureau and the triangular points of 2nd and 3rd orders (including astronomical, leveling and gravimetric) were extended close to its vicinity only about 6 km from Mt. Qomolangma. For the lack of national unified controlling points in the region of Batura, the initial base line and the intermediate checking lines of the triangulation chain were determined by adopting 2m invar subtense bar tacheometry and the rhombic base nets were extended; the relative accuracy of extension lines reached 1:23000.

Field work in terrestrial stereophotogrammetric survey. The spatial point position determined by adopting terrestrial stereophotogrammetric surveying corresponds to the photographic front intersection of two terminal points of the base line. Therefore, the choice of the photographic base line condition and its carrying out will directly affect the efficiency of field and indoor work, and reduce the dead space of photography, thus raising the accuracy of mapping. Theoretically, the allowable length limits of the photographic base line and the photo y-distance were estimated, and on the basis of practice, the formula for estimating the number of base lines in the region was worked out, thus favourable to plan the whole work and the preparation of equipments. In case of high elevation, the projection geoid corrections should be added to the length of photographic base line; it is a problem which should not be neglected.

Indoor work in terrestrial stereophotogrammetric survey. The purpose of indoor work is to draw complete and proper maps from the photographs taken in the field with required accuracy. The errors in the field work of terrestrial stereophotography were checked and limited through these orientation controlling points actually measured within the stereo model. Thus the accuracy of the extension points would meet the requirements of mapping.

It is proved that the accuracy of the original topographic maps satisfied the required standard after careful on the spot examination.

The way to express glacial landforms. From the analysis of the regions and by practice, it is clear that the expression of glacial landforms is mainly in its "dynamics" and emphasis should be placed on the surface of glaciers. We expressed the unique natural landscape in glacial regions by organizing those static points, lines, marks, brush shades and colours, so that their inner relationship could be seen through their superficial phenomena with half an eye.

In a word, the maps of Qomolangma region and of the Batura Glacier are both adequate in surveying accuracy, and are vivid, appropriate and rich in scientific significance. They are two hard-earned maps.

APPLYING LANDSAT IMAGES TO THE STUDY OF GLACIERS ON THE QINGHAI-XIZANG PLATEAU

Zeng Qunzhu Mi Desheng Liu Jinghuang
(Lanzhou Institute of Glaciology and Cryopedology, Academia Sinica)

About 82% of the glacial area in our country is concentrated on the vast Qinghai-Xizang Plateau. The existence of glaciers is closely related to the industrial and agricultural development on the Plateau and its adjacent regions.

Using the Landsat 1, 2, 3, and MSS 4, 5, 6, 7 band images, and a few RBV images and referring to the aerial photogrammetric maps, we have investigated the present-day glacial area on the Qinghai-Xizang Plateau, particularly its distribution, advance and recession. We have interpreted as far as possible the snowline, ice tongue, firn basin, etc. Applying the coaxial false color composite method to 4, 5, 7 band images, we have got the false color composite picture of the glacial group at Mt. Xinqing (35°40′N, 91°10′ E) on the border between Qinghai and Xinjiang. Because of the difference in color of moraines, ice tongues and firn basin, by visual examination, we can roughly point out the position of snowline and the extent of ice tongue and firn basin zone.

We have got an isodensity color picture by using Color Digit Phosdac-1200 Model. It shows that the new and old moraines are yellow and yellowish green in color respectively, the firn is middle blue or dark blue, the bare ice is grass green or light blue, the lake and bog are purple black. Besides, the positive transparent of MSS image in the above region is scanned by autodensidater and we have got its relative brightness value which has been transferred to the topographic map. Therefore, we can draw an isopleth map of relative brightness It shows that the relative brightness value of firn is greater than 1.20, the bare ice about 1.00—1.10, the lake and bog smaller than 0.70.

We have traced the glacial zones based on 1:1,000,000 MSS 5,7 band black white picture with no cloud or few clouds and false color composite picture, then the glacial area is measured. When the aerial photogrammetric map at a large scale in these regions is available, we have directly measured the glacial area in these maps. According to preliminary statistics, glacial area on the Qinghai-Xizang Plateau is about 48,000km^2. (Table1)

From the preliminary analysis, we found that most errors of the calculated glacial area from the landsat MSS 1:1,000,000 black white pictures or false composite pictures are from three sources: (1)The scale error of the Landsat images. The scale of images does not exactly equal to 1:1,000,000 because of the expansion and contraction of the photographic paper as well as the technics of duplication. (2) The error from demarcation line. When the image of glacial region is clear, we always draw lines of 0.2mm width to demarcate the glacial borders. Because it is difficult to draw lines precisely enough to demarcate the borders, there must be some errors or mistakes in measurement of the glacial area. (3) The error in measurement and statistics. Every glacial area is measured and calculated by two persons and the difference of values is restricted to within ±2.0%. Of all the above errors, that of demarcation is more pronounced.

Comparing the 1:50,000 or 1:100,000 aerial photogrammetric maps, we have noted that the measured error of the glacial area from 1:1,000,000 landsat MSS images does not exceed ±10%.

We have investigated tentatively the glacial advance and recession from the 1:50,000 topographic map and landsat 1:1,000,000 MSS images. We have interpreted the tendency of glacial advance and recession and determined the total amount of variation for ice tongue terminus at certain period and its annual average rate. Comparing landsat 1:1,000,000 MSS images with the data actually measured at №18 and №20 Glaciers of Laohu Kou in Qilian Shan and at №1 Glacier in Tian Shan in the upper reaches of Urumqi River, we found that the direction of advance accords with that of, but their annual average rate differs a little.

GLACIER SURGES IDENTIFIED ON LANDSAT

Robert M. Krimmel
(U. S. Geological Survey)

The Landsat series of satellites has been in operation since July 1972; by early 1979 much of the Earth's land area between 82° North and South latitudes had at least one time, nearly cloud free coverage with the 80-meter resolution MSS (multispectral scanner) sensor.

Features of glaciological interest are often identifiable on Landsat images. For example, the following two sets of time-sequential images show notable surges. Landsat image 1354—05224 (12 July 1973) of the Soviet Pamir mountains includes the Bivachnii Glacier (A), which is a surging type glacier (Rototaev, 1978). Its major south tributary exhibits contorted medial moraines easily identifiable on Landsat imagery. The geometry of the repetitive loops suggests that the 1973 condition of flow between glaciers A and B is similar to the condition before a surge of A displaces the terminal ice of B downglacier. This pattern led to the prediction of a surge of A (Krimmel and Meier, 1975). In 1976 the Bivachnii Glacier was reported to be surging (Kotlyakov, V. M., personal communication, October 1976). Image 2980—04445 (28 Sept 77) shows Bivachnii tributary A after a displacement of about 2000±200 meters from its position in 1973. In this scene the loop at position 1 is displaced to position 2. If the magnitude of the last two advances, which displaced loops at 2 and 3, is repeated, the surge was completed at the time of the 1977 scene and tributary B will slowly advance into A forming a new loop at 1.

A second set of Landsat scenes from an area along the Xinjiang-Qinghai (Sinkiang-Tsinghai) border (Latitude N36, Longitude E91) also shows a surge. In image 1358—04031 (16 uly 1973) glacier A appears to have an ice-filled accumulation zone and a stagnant terminus. In image 2678—03400 (30 Nov 1976) glacier A appears to be in an entirely different state, now with a bulging terminus and small accumulation area. The mass redistribution is major, and the terminus has advanced about 600±200 meters between the two dates. In the 30 Nov 76 image, glacier B appears to have an overextended terminus, perhaps evidence that it too surged some time before 1973, and the stagnant terminus is now ablating away. The comparison is somewhat complicated by differences in solar elevation 60° on 16 July, 24° on 30 November, which has the effect highlighting the relief on the glaciers and moraines in November.

WATER SUPPLY FROM THE GLACIERS OF XIZANG

Robert M. Krimmel
(U. S. Geological Survey)

A glacier acts as a large water reservoir, being depleted in hot, dry years and replenished during cool, wet years. Because of the ice melt contribution the minimum discharge from glacier-fed rivers is significantly above that of non-glacier-fed rivers during dry years. An estimation of the ice melt discharge can be made by considering the area of ice cover within the basin and the amount of melt of the ice cover.

The Rongbuk Glacier basin, which drains the north slope of Mt. Qomolangma, has been well mapped and some glaciological data are available for the region. Annual firn accumulation on the Rongbuk Glacier has been measured to be 540—790 mm of water equivalent. Discharge measurements in 1959 show that 530 mm of glacier ice was melted. This ice melt contribution to the river discharge will tend to be higher in dry years and lower, but compensated by snow melt, in wet years.

Landsat MSS satellite data is an ideal data source for measuring ice area. The 100-m resolution is in itself sufficient to determine the area of typical glaciers to within 2—5 percent, depending on the geometry and size of the glacier. Complicating factors of shadows, new snow cover, and debris covered termini decrease the accuracy. These factors are compensated for in this analysis. The relatively low latitude results in small shadows, careful image selection has minimized new snow cover, and areas of debris-covered ice are of lesser importance in water production.

Landsat images combined with small-scale drainage and topographic maps are used to delineate drainage basins. Using areas of clean ice measured from images, and making the assumption of a 500 mm ice melt/year in these basins, the contributions to runoff due to ice melt can be determined. The ice area and resulting water supply of basins within the area approximately defined by N28°/E85°, N28°/E91°, N32°/E85°, and N32°/E91° are discussed.

HYDROLOGICAL FEATURES OF THE BATURA GLACIER REGION, KARAKORAM

Li Nianjie
(Lanzhou Institute of Glaciology and Cryopedology, Academia Sinica)
Li Jian
(Chengdu Institute of Geography, Academia Sinica)
Cai Xiangxing
(Lanzhou Institute of Glaciology and Cryopedology, Academia Sinica)

The Batura Channel originates in the northwest part of Karakoram Mountains and on the northern slope of Hunza Karakoram- runs from NWW to SEE and joins the Hunza River, a tributary of the Indus River. Its total drainage area is 687 km^2, of which the ice-covered area is 332 km^2, occupying 48% of the whole drainage area. Its mean altituhe is 4,800 m a.s.l. The main glacier in it, the Batura Glacier, has a length of 59 km.

On the basis of the data collected during the Batura Glacier investigation program in 1974—75, analytic calculation was made on its hydrological features with the following conclusions:

1. Of the annual flow volume, an average taken in a number of year, of 1265 mil. cubic metres, about 75% is from snow and ice ablation, 19 from areas without ice cover, while the discharge of summer volume from glaciers makes up 6% only. Therefore, we may presume that Batura is nourished by melt-water.

There is a close relation between discharge and temperature. Its calculation model is: $Q=1.75e^{0.22t}$, where Q is the mean discharge in decade or month (m^3/s), t the mean temperature in decade or month (℃), and e the base of natural log.

(2) As a result of mutual supplement and adjustment between the discharge of the glacial ablation and the discharge of rainfall as well as the adjusting effect of strong stagnant water in ice caverns, the annual range of discharge is comparatively small with $C_v=0.210$.

The discharge of the year is extremely unequalwith $Cr=0.54$. The dry season lasts 8 months (from October to next May), and its discharge accounts only to 13% of the total, the wet season lasts only 4 months, its discharge amounts to 87%.

(3) The mean depth of many-years' discharge in the drainage area is 1840 mm, and the discharge module is 58.4 $l/s/km^2$. The mean depth of discharge in the glacier covered area reaches 2980 mm, and the discharge module is 156 $l/s/km^2$.

As a result of the difference in thickness of superglacial moraine cover, the distribution of mean discharge depth in the drainage area deepee in the middle reaches and shallower both in the upper and the lower reaches, In the area below the glacial terminus, the mean discharge depth is about 60 mm; in the region at 3200m a. s. l., it reaches more than 5000 mm; and above 5150 m a.s.l., there is a zero value zone for 171 km^2, which occupies about 1/4 of the drainage area.

(4) Floods appear soon after the beginning of ablation during the period from mid-April to early October (overcast and rainy days excluded). One flood process occurs everyday. The biggest floods appear generally from the last decade of July to the first decade of August, particularly in the first decade of August

(5) As a result of the vigorous collision of subglacial torrents and the collapse of ice cavern, the Batura Channel is characterised by its large quantity of floating ice in summer, besides the normal icing conditions of mountainous rivers.

A COMPARTIVE STUDY OF HYDROLOGICAL CHARACTERISTCS OF THE GLACIER-FED STREAMS (QIANGYONG GOU AND ZHUXI GOU), SOUTH XIZANG

Yang Xijin

(Department of Geology and Geography, Lanzhou University)

South Xizang concentrates a lot of glaciers of China. They are of two categories: the continental glacier and the maritime glacier; to the former, belongs the Qiangyong Gou, and the latter the Zhuxi Gou; the glacier-fed area occupies 77.2% of the drainage for the former, and 27.9% for the latter.

An analysis of the data collected in 1975 and 1976 reveals the following points:

1. The ablation of the Zhuxi Gou far exceeds that of the Qiangyong; the ablation period lasts 9 months for the former and 6 months for the latter. The runoff amounts to 6435 mm for Zhuxi Gou (at Qiaotou station) and 586mm for Qiangyong Gou (at Qiang station).

2. The seasonal variations of runoff differs greatly in the two gullies. The Qiangyong experiences a dry period of exhausion for seven months in the year and the maximum monthly discharge occurs in June, the coefficent C^r being 0.60. The same items

for the Zhuxi are respectively, three months, August, and 0.48.

A diurnal variation occurs to the runoff, but the Qiangyong Gou shows a curve with a pointed peak and a low, long, and stable minimum, while the Zhuxi Gou a smooth curve with symmetrical upper and lower parts and a relatively higher minimum.

CHARACTERISTICS OF GLACIAL HYDROLOGY IN SOME MOUNTAINS OF WESTERN CHINA

Yang Zhenniang
(Lanzhou Institute of Glaciology and Cryopedology, Academia Sinica)

The glacial area in the mountains of west China approximate $5.7\times10^4 km^2$. The rich ice and snow feed the rivers with meltwater.

The relationship among the depth (h, m. m.) of glacial ablation, air temperature (T, ℃), and the relative value (b) of radiation balance is

$$h=0.382b^2(T+4)^{2.7}.$$

Based on this, the average depth of glacial ablation at the glacial terminus of west China has been calculated as folows: 19,000mm in southeast Xizang, 2,500—3,000mm on the north slope of Qomolangma, 1,500mm in Pamir, 1,000mm in west Qilian Shan, 3,000mm in east Qilian Shan, and 2,000—4,000mm in west Tian Shan.

The runoff coeffcient is far greater for the glacier-fed rivers than for the rain fed ones, the former approaching 1.0. Outside the meltwater-supplied area, however, it is generally at 0.4—0.5.

The more the aridity, the larger the glacial runoff coefficient. Generally, the coefficient may reach 0.70, with its maximum close to 1.0.

The runoff of continental glaciers is far smaller than that of maritime glaciers, the former reaches only 500—800mm, while the latter exceeds 2,000mm. These figures are respeectively 2—3 times that at the outlet of the valley. The module of maritime glaciers reaches 200 $l/s/km^2$, and that of continental glaciers, 30—40 $l/s/km^2$.

The ablation period of continental glaciers lasts from May to September, the discharge curve rises and drops abruptly, the runoff is highly concentrated from June to August. The volume of discharge in this period reaches about 90% of the annual total. The maritime glaciers ablate from April to October, the discharge curve being comparatively smooth with one peak or two, and the volume of discharge from June to August reaches about 60% of the annual total.

The interannual variation of glacial runoff Cvy is mainly determined by the variation of temperature, precipitation, the types and the scales of glaciers, the Cvy generally approximates 0.20 (except for the large-scale glaciers). As to the pluvial runoff, with the freezing coefficient $K \geqslant 10\%$, and the ratio of melwater $\geqslant 25\%$, the $C'vy$ is generall $\leqslant 0.20$. Also the $C'vy$ of meltwater-fed or mix-supplied rivers is smaller downstream than upstream, i. e., the water volume is comparatively stable.

The proportion of meltwater supply to the rivers is about 45% in Kunlun and Karakorum (in Xinjiang), 13% in Pamir, 17% in Tian Shan, 12% in Qilian Shan, 5% in Qinghai, and 13.7% in Xizang respectively. The total volume of meltwater over the mountains of west China is about $490 \times 10^8 M^3$, being 14.5% of the total runoff volume or 2.0% of the total volume of the country.

SOME CHARACTERISTICS OF STABLE ISOTOPIC CONTENT IN THE HIMALAYAN WATERS

Hisao Wushiki
(Department of Chemistry Faculty of Science
Tokyo Institute of Technology
Tokyo, Japan)

Various kinds of meteoric waters and terrestrial waters were collected by the author since 1971 along the Himalayan Range. and mass-spectrometric measurements of deuterium and oxygen-18 were carried out on these samples in order to disclose the regional and local stable isotopic characteristics and their seasonal changes. Although the systematic collection is still going on and the analyses are not numerous enough, some noticeable results have been obtained.

Rains and Snows

A round year collection of precipitations was done in 1974/1975 at the temporal glaciometeorogical observatory in the Mt. Sagarmata(Mt. Chomolungma)region at 4,480m above sea level in Nepal.

Remarkable seasonal changes, which we could not have anticipated, were observed; less depleted ($\delta D^* = -72.6‰$ in average) in the heavier component in winter season, but more depleted ($\delta D = -139.7‰$ in average) in summer monsoon season; in the transitional season, i. e. premonsoon, several series of rain started with extremely high isotopic contents ($\delta D = +5.7 \sim +10.9‰$) and rapidly depleted and then recovered ($\delta D = -102.9‰$ at minimum).

The seasonal changes with higher isotopic content in winter and lower content in sum-

* referred to SMOW (Standard Mean Ocean Water)

mer were recently suggested by the isotopic stratigraphy of the firn of Snow Lake in the Karakoram Range, about 1,500km north-west of Mt. Sagarmatha, to be present even there (Wushiki and Suizu, 1979, not published yet). Consequently this seasonal change seems to be prevailing along the southern edge of the Qinghai-Tibetan Plateau. The cause of this phenomenon is presumably due to the difference of wind trajectory between winter and summer. This difference means different evaporational location for the water vapour in the air, and the different water vapour provides different precipitation from the point of isotopic content.

The premonsoonal phenomenon with extraordinary high isotopic content in the initial rain and rapid decrease of the heavier isotopes in the following rains is tentatively explained to be due to the direct transportation of water vapour from the Indian Ocean without significant precipitational loss at the foot-hill region. This phenomenon may contribute some effect on the unexpectedly rich isotopic contents of snows at the very high altitudes, reported in the Alps and in Mt. Chomolungma (Moser et al, 1970 and Zhang et al, 1973).

Glacier Ices and Melt Waters

By the co-operations of many mountain climbers the author collected water samples from various localities, extending from the Hindu Kush Range, through the Karakoram Range, the Ladakh Himalaya and the Kumaon Himalaya, to the Nepal Himalaya.

The graphical plots of deuterium and oxygen-18 contents depicted a geographical changing zone of d-index (Dansgarad, 1964). Referring to this zone (roughly at 80°E), glaciers were classified into two categories, western type and eastern type.

The results of the precipitation analyses showed less value of d-index in monsoon and larger value in premonsoon and winter, so the difference of the two categories means the difference of the main glacial accumulation season.

Preliminary firn ice studies, done both in Nepali and Karakoram glaciers, brought us a possibility to utilize isotopic analysis for the determination of annual accumulation boundaries. In the case of the Nepali glacier, there are noticeable features in the distribution of the heavier isotope content, which indicates two-major-icelayer formation in a single glaciological budget year.

We found the latest annual layer preserves wide range of variation in isotopic content, but the preceding layer keeps no more such variation, in stead the quite smoothed distribution might presumably resulted from the refreezing of melt water. But in the case of the Karakoram glacier, clearly figured crests of high isotopic content are present in the firn icelayers. These parts can be regarded as premonsoonal precipitation layers. So these maxima are good indicators of locating the boundaries of annual layers.

These characteristics of the Himalayan waters can be extensively used in the Himalayan glaciological researches and should be related to the results obtained in the Qinghai-Tibetan region. These characteristics are certainly caused by the high altitude of the region and the movement of orographic region may intensify them more.

HYDROCHEMISTY OF THE XIZANG RIVERS

Chen Chuanyou Guan Zhihua
(Commission for Integrated Survey of Natural Resources, Academia Sinica.)

Four aspects of hydrochemistry of the Xizang rivers have been studied.

Ⅰ. **The hardness and mineralization.**—Both vary greatly over Xizang. The mineralization of the river water in the southeast Xizang is weak, in the south and southwest medium, a few of them high, and in all the interior drainage slightly intense or intense. In general, the mineralization of a river is low in the upper and lower streams, but relatively strong in the middle. The inter-annual variation is low, but the seasonal is high. Of the former, the exterior rivers may reach 1.5~2.5, and the interior ones over 2.5. The diurnal variation of the melt-water fed rivers is significant, reaching the maximum before the uprising of the temperature and the minimum after the highest temperature.

The total hardness of the Xizang rivers varise from 0.24 to 6.4 mg-equivalent/litre. In the south, most of the water is ulti-soft and soft, in the east it is medium hard except the upper reach of the Nu Jiang; and most of the interior water in N. Xizang is hard and medium hard.

Ⅱ. **The ion composition and hydrochemical type.**—In the vast area comprising the Indian Ocean and the Pacific Ocean drainages as well as the interior rivers of south Xizang, the hydrochemical type is uniform and simple, mainly being C_{I}^{Ca} or C_{II}^{Ca}. The order of ion content ranges $HCO_3>SO_4>Cl$, $Ca>Na+K>Mg$. But exceptions occur in minor regions, such as the Niyang Qu, a tributary of the Yarlungzangbo, where the water is S_{II}^{Ca} and S_{II}^{Na}. Of the interor rivers in north Xizang, the situation is more complicated. 55% of the water belong to the bicarbonat group, 33% to the sulfate, and 12% to the chlorides. All the following types occur. C_{I}^{Ca}, C_{II}^{Ca}, C_{III}^{Ca}, C_{I}^{Mg}, C_{II}^{Na}, C_{II}^{Ca}, and Cl_{II}^{Na}. The total ion content of the bicarbonate water is usually below 500mm/litre and of the chloride over 1000mm/litre, with the sulfate water in between, The ion content also varies along the river course, in the seasons, and inversely as the discharge.

The pH value of Xizang rivers fluctuates from 5.6 to 8.9, in form of neutral alkaline water. The Yarlungzangbo varies from 6.5 to 8.3. At any station the seasonal variation is small with the annual range not more than 1.2.

Ⅲ. **Ion discharge.**—The annual sum of salts dissolved in the Xizang rivers is about 40 mill. tons, making up 9.4% of China's total. The exterior rivers transport 28 mill tons; and the interior ones, 12 mill; the latter being 25% of that of all the interior rivers of China. The salts of the interior drainage accumulate in the interior lakes, leading to the alkalization of the later.

The ion discharge of a river is mainly determined by its woter discharge, with the result that the distribution pattern of ion discharge is the reverse of thet of mineralization, the ion discharge of the exterior rivers being larger than thet of the interior. Of the exterior rivers, the ion discharge ranks in the following order; the Southeast, East, South, and the Northwest.

Ⅳ. **Hydrochemical Zonation;** According the physical environment of the river valleys and their hydro-chemical characteristics, four zones may be recongnized. They are; the humid zone of the southeast, the subhumid zone of the northeest, the semiarid zone of the south and easl, and finally the arid zone of the north.

HYDROGRAPHICAL FEATURES OF THE YARLUNGZANGBO RIVER

Guan Zhihua Chen Chuanyou
(Commission for Integrated Survey of Natural Resources, Academia Sinica.)

The Yarlungzangbo River, i. e. the source stream of the Brahmaputra, is 2057 km long and has a drainage area of 240,480 km^2, being one of large rivers of China and an important one of the world. Its discharge volume is smaller than that of the Yangtse or thet of the Pearl, and its hydropower potentiel only next to the Yangtse. The Yarlungzangbo valley is the political, economic, and cultural centre of the Xizang Autonomous Region, concentrating most of the population and the important cities.

Many of the hydrographic charocteristics of the Yarlungzangbo reflect the high-cold environment and some others, the geomorphic and geologic conditions. The main features are the following:

1 . The river water comes from various sources including ground water, rain, and melt water. From the upper reaches the ground water supply lessens in proportion towdar downstream, e. g. from 36% in Nugosa (station) to 30% in Nuxia. The Lhasa River, a tributary, is rain-fed, while 2 tributaties, the Nyang Qu and the Parlung Zangbo,are melt water fed, and still another tributary, the Nyang River, is ground water fed.

2 . The value of Cv, 0.2—0.3, may be considered small in China. The seasonal variation, however, is rather significant; the discharge of the 3 greatest months together amounts to 60% of the annual total, being one of the highest, if not the highest, of the country.

3 . The flood discharge is rather constant, the Cv being the smallest of the country. The flood period lasts about 2 months, some year about 4 months, with no abruptr ise and fall in the stage.

4 . The suspended load is insignificant in China, being 0.098—1.25 kg/m^3. The interannual variation is slight, the ration of the maximum annual load to the minimum ranging about 3—6. The maximum month occurs in August and the minimum in December or January, with a ratio over 20. The flood peak is synchronous with the load peak.

5 . The temperature of the water, in general 4°—10℃, is lower than that of China's other rivers of similar latitude, and even that of rivers in North China and south Northeast China. It varies within 1.0℃ in the year, but about 10—15℃ in the month. The thermal variation, however, differs among the tributaries, or sections of a tributary, of different water supply.

6 . The chemical quality of water usually falls in C_{I}^{Ca} or C_{II}^{Ca}. The mineralization varies between 50—250 mg/l, and the hardness 0.2—2.3 mg equivalent/l. It is mineralized more slightly in the upper and the lower streams than in the middle. The variation is slight interannually, but significant seasonally.

CHEMICAL CHARACTERISTICS OF THE LAKES IN XIZANG

Fan Yunqi
(Nanjing Institute of Geography, Academia Sinica.)

Lakes in Xizang account for approximately 30% of the total area of all lakes in China. An analysis of 76 lakes reveals the following chemical characteristics:

1 . The mineralization increases steadily from southeast toward northwest and from south toward north with the result that fresh water lakes become gradually salt water lakes, and then saline lakes.

2 . With the increasing mineralization, the ion content of $Na^{+}+K^{+}$ and Cl^{-} in the salt water and saline lakes increases accoordingly, The increase of $Mg^{2+}$and So_4^{2-}ions is less significant, and Ca^{2+} and HCO_3^{-} change very slightly. In fresh water lakes, however the bicarbonate, $Na^{+}+K^{+}$, and $HCO^{-}{}_3$ ions are closely correlated with mineralization. While, for Ca^{2+} and Mg^{2+}, the correlation with mineralization is clear, when the mineralization is $<$ 600 mg/l; but not clear, when it is$>$600 mg/l.

3 . The total hardness of fresh water lakes is generally below 5 mg·eq/l, being basically of linear correlation with mineralization. But in salt water and saline lakes, the total hardness does not increase with the mineralization.

4 . In most fresh water lakes, the water belongs to the C^{Ca} type; in a great majority of the saline lakes, it is the Cl^{Na} type. Salt water lakes are of three types, being transitional in character.

5. To classify the saline lakes in accordance with characteristic coefficients derived from equivalent forms, no chloride type has been found.

The climate factors play a leading role in affecting the chemical properties of the Xizang lakes. For instance, the gradual changes both in mineralization and in chemical property of the lake waters are identical with the distribution of precipitation decreasing from southeast to northwest and from south to north. But the influence of the non-zonal factors should not be neglected. For instance, the fact that most lakes in southeast Xizang are fresh water lakes is certainly consequent to the relatively aboundant precipitation; but it is also due to the dissection of the land surface by the exterior drainage, which in unfavorable for salt accumulation in the lakes. Similarly, the large number of saline lakes in north Xizang does not only result from the aridity of climate, but also from the strata of marine origin, as well as from the enclosed topography favorable for salt accumulation.

HYDROLOGIC CHARACTERISTICS OF THE EAST BANG GONG LAKE

Ou Yuxiong

(Nanjing Institute of Geography, Academia Sinica.)

Lake Bang Gong, 604 Km^2 in area, lies at the boundary between China and Kashmir. The lake is narrowed in 2 localities, hence dividing it into 3 sections. The eastern, the middle, and part of the western sections belong to China, conventionally under the name East Bang Gong Lake with an area 412.5 Km^2. The rest of the lake belongs to Kashmir. This enclosed lake lies in a rift valley, and the surface stands at 4242 m above sea level.

During Aug. 10—20, 1976, an investigation was made in the East lake. The maximum depth was found to be 41.3m, mean depth 20m, storage capacity 6600 mill. m^3, water colour 3—5, and transparency 13.3m. From the surface to the depth, 11 bottles of water were taken for chemical analysis, when 1458 measurments of temperature were made along 71 vertical lines. Short-term semi-fixed observations on other items were also ta ken.

The maximum temperature of the surface water is 18.4℃ and the minimum at the bottom 7.8℃, safeguarding the normal thermo-stratification of a temperate lake. In the open parts of the lake, the dynamically mixed layer may reach as thick as 20m. Heat storage approximates 8×10^{16} cal.

The mineralization of the lake is about 700mg/1. in the east, 2700mg/1.in the middle, and over 11000mg/1. in the west. Near the boundary and beyond, no observation has been made. The extremely high salt content over the west part of the lake results from the west-ward flowing of the water, which accumulates the mineral matters. Furthermore, the 2 narrow points of the lake inhibit the water from moving freely all over the 3 sections, but promote the mixing up within the individual sections. Hence, the mineralization is rather even in any one section, but differs greatly in the 3 sections, increasing from east to west in a step-like manner.

The East Bang Gong lake maintains a fresh water volume of 4660 mill. m^3, being an invaluable treasure in Xizang. The general retrogression of lakes in Xizang urges the proposal of taking some reconstruction measures at the 2 narrow points to lengthen the life of this fresh wafer lake.

THE SALINE LAKES ON THE QINGHAI-XIZANG PLATEAU

Cheng Kezao Yang Shaoxiu Zheng Xiyu
(Qinghai Institute of Saline Lake, Academia Sinica)

The saline lakes are well developed on the Qinghai-Xizang Plateau. From the Pliocene period up to the present, there have been two periods of mineralization one after the other. The first period of mineralization took place in Piocene, in which such minerals as gypsum, glauber salt,and halite were major products.The second period of mineralization took place from late Pleistocene up to the present, during which boron, lithium, and potassium were highly concentrated—one of the most significant characteristics of this period. The saline lakes on the Qinghai-Xizang Plateau can be classified into two zones: the sulfate-chloride type in the Qaidam Basin and the carbonate-sulfate type in north Xizang. Some of the saline lakes have developed on the basis of the Neogene fossil lakes, while others are newly grown in the Quaternary. Most of them are tectonic lakes. Rocks and hot springs are the main sources of saline lake minerals.

BORATE MINERALS IN THE QINGHAIXIZANG PLATEAU

Gao Shiyang Li Bingxiao
(Qinghai Institute of Saline Lake, Academia Sinica)

Many years ago, it was known to the world that there was borax in the regions of the Qinghai-Xizang Plateau. The pinnoit in the Da Qaidam Saline Lake and the carnallite in the Qaergan Saline Lake were discovered by a scientific survey group, Academia Sinica, in 1957. Since then research works undertaken by the various institutes, universities, etc., have shown that there are about fifty kinds of salt minerals, of which the deposit minerals in these saline lakes are more than 40 including 14 borates.

Along both sides of the Kunlun Mountains, three new borate minerals—hungtsaoite ($MgO \cdot 2B_2O_3 \cdot 9H_2O$), carboborite ($MgO \cdot B_2O_3 \cdot 2CO_2 \cdot 8H_2O$) and hydrochlorborite ($3CaO \cdot CaCl_2 \cdot 4B_2O_3 \cdot 22H_2O$) have been discovered. The borates spread widely in north Xizang where the borax is mainly distributed in a zone (more than 1,000 Km long from Heihe County to Ali County) between 31° and 33° north latitude. However, the hydrated Mg-borates are only found in the Zacang Chaka Saline Lake. On the other hand, in the Qaidam Basin, a few alkali earth metal hydrated borates have been found largely in the regions of Da Qaidam Saline Lake and Xiao Qaidam Saline Lake. The borax only appears sporadically and locally.

It is known that both the Zacang Ćhaka Saline Lake and the Da Qaidam Saline Lake belong to a new type of salt lake—borate lake of $MgSO_4$-subtype. In the regions of these two lakes, a few hydrated Mg-borates are precipitating, and the deposit of borate which consists of hydrated Mg-borates, gypsum, carbonate and mud, as well as the deposit of borate with mirabilite have been found. It has also been found that the hydrated Mg-borate may be present in the precipitation stage of halide, and also in the precipitation stage of epsomite and astrahanit, even in the schoenite precipitation stage. The environment in which these borates were formed and the conditions of the paragenesis of minerals can not be explained either in terms of the salt-forming process of temperature, or in terms of the salt-forming process of evaporation.

Based on the results of our field work and laboratory experiment we may conclude that during the solar evaporation of the brine, the borates generally do not precipitate as a solid phase, but accumulate in the concentrated brine. In the meantime we have measured the compostiton of borate in the eutectic brine. We have studied the form of borate existing in the concentrated brine by two methods (one is called the formation of salt by species paired, the another is the hydrochloric acid-pH titration). Based on these results, we come to the conclusion that the form of borate existing in the concentrated brine is a comprehensively statistical one of tetraborate $B_4O_7(OH)_4^-$.

In our experiments, we have first obtained the crystals of inderite ($2MgO \cdot 3B_2O_3 \cdot 15H_2O$), huntsaite ($MgO \cdot 2B_2O_3 \cdot 9H_2O$), etc. by diluting B-containing concentrated brine with different volume of water and then discovered a new salt-forming process of dilution. These results have suggested a new experimental explanation of the formation of these hydrated Mg borates in the regions of the Qinghai-Xizang Plateau.

HYDROCHEMICAL CHARACTERISTICS OF THE SALINE LAKES ON THE QINGHAI-XIZANG PLATEAU

Yu Shengsong Tang Yuan
(Qinghai Institute of Saline Lake, Academia Sinica)

The water in the saline lakes in the areas of the Qinghai-Xizang Plateau is a highly mineralized and concentrated brine which mainly belongs to the sulfate type. The carbonate type and the chloride type saline lakes have not been found in the regions of Qaidam Basin and northern Xizang The hydrochemical characteristics themselves explain the evolution of the saline lakes.

There are nearly 40 chemical components present in the lake brine of the Qinghai-Xizang Plateau. Among them sodium, potassium, magnesium, lithium, boron, etc. make a highly geochemical concentration and are closely coexistent. They form a complex liquid deposit specific to the saline lakes on the Qinghai-Xizang Plateau. Other elements such as rubidium, cesium, uranium and thorium are also relatively rich.

Potassium, boron, lithium, rubidium and cesium are in normal distribution. The relations between these chemical elements and the types of brine are: boron is mainly concentrated in the carbonate type and sodium sulfate sub-type brine; lithium is mainly concentrated in the sodium sulfate subtype brine and partly in the magnesium sulfate subtype brine; potassium is enriched in the brine of all the four types; and rubidium and cesium are mainly enriched in the sulfate type brine. The chemical components in the brine vary with the environment and time.

In addition to potassium, boron, lithium, rubidium and cesium, high contents of fluorine, phosphorous, silicon and arsenic are also in the saline lakes in north Xizang —another characteristic of the brine in this area. Moreover, components in the brine correlate among themselves linearly.

Around the mineralized basins on the Qinghai-Xizang Plateau, the weathering of rocks supplies a basic source of minerals in the saline lake brine. In west Qaidam Basin, the leaching of the Tertiary salt bearing rock series furnishes most important material sources for the saline lakes while the chemical components in the brine of the saline lakes in north Xizang are the main products of the strong hydrothermal activity in the said area.

MINERALIZATION PERIODS FROM LATE PLEISTOCENE TO THE PRESENT ON THE QINGHAI-XIZANG PLATEAU

Cai Biqin　　Huang Qi　　Yu Junqing
(Qinghai Institute of Saline Lake, Academia Sinica)

C^{14} dating proves that evaporites of the late Pleistocene in the Qaidam Basin formed about 24,000 years ago, while those in northe Xizang some 9,000 years ago. We generally call it the period of mineralization from the end of the late Pleistocene to the present.

According to the sedimentary rhythm, we can classify the mineralization period into four stages which represent respectively 33,800 years, 21,000 years, 15,000 years, and 9,000 years up to the present, As time goes on, the dis-tribution of evaporites expands gradually, and so does the mineralization. A variety of deposits such as borate, glauberite, halite, carnallite, etc. were formed one after another.

THE PLIOCENE AND QUATERNARY STRATA AS RELAED TO THE PHYSICAL ENVIRONMENT OF QINGHAI-XIZANG PLATEAU

Wang Fubao
(Nanjing University)
Li Bingyuan, Zhang Qingsong
(Institute of Geography, Academia Sinica)

The Pliocene period in Xizang can be divided into three stages and their strata are chiefly lacustrine deposits. Of the early stage, the deposits consist of red and yellow brown sandstone conglomerates interbedded with mud stone and turf (Bulong Group, lower Woma Group, Pulan Group). The climate was warm humid tropical and subtropic al over the southern valleys. During middle Pliocene, the land surface being further peneplaned, the deposits became fine-grained. Over the south, predominated the yellow-brown mud stones and siltstones (middle Woma Group) interbedded with ferriginous layers under tropic savanna climate. In late Pliocene (upper Woma Group, Tati Group), the grey and yellow-grey mud stones and siltstones were the main deposits occasionally interbedded with marlites. The climate was undergoing a transition from subtropical to warm temperate. In the north, however,it was evidently drier, a thin layer of gypsum having been accumulated. By the end of pliocene, uplifted the Plateau in great expanse, although the interior depressions subsided moderately and relatively to the surrounding uplands.

The first arrival of glacial climate marked the advent of Pleistocene and contributes the "Gongba Conglomerates" series to south Xizang. Overlying the Pliocene beds unconformably or disconformalby, the series is principally composed of sandstones and conglomerates interbedded with siltstones and cemented by calcareous materials. The dissection of the Plateau has not been intense. In north Xizang, the deposits are rock clay plus siltstones (Qiangtang Group) of lacustrine origin, despite the alternation for 3 times between forest and steppe conditions. The middle Pleistocene started a new stage of geomorphological evolution, when the deposits were mainly coarse clastic materials of morainic and fluvioglacial origins overlying unconformably the strata beneath. Then, as well as in late Pleistocene, occurred the four glaciations with three interglacial periods. The climate turned cold and dry, ending up finally with polar conditions. During the Holocene, the lake district accumulated a series of clay rock-siltston-sapropel clay of lacustrine origin in the south and evaporites in the north. The climate varied considerably, at first cool and then warm. Evidences are that man was in the now "no man's land" . Since Neoglaciation (3000 years ago), cold aridity has developed rapidly, terminating the forests, disintegrating the lakes, and rendering a part of the former exterior drainage an enclosed Lake Yamzhoyong Hu south of Lhasa.

PRELIMINARY STUDIES ON THE VEGETATION OF THE QINGHAI-XIZANG PLATEAU DURING NEOGENE AND QUATERNARY

Kong Zhaochen Du Naiqiu
(Institute of Botany, Academia Sinica)

On late Miocene, subtropical broadleaved to deciduous forests and needle to broad-leaved mixed forests were flourishing in the Kunlun Mountains , Tanggula Mountains and the Gandis Ranges. The climate was then warm and wet.Ferns would have grown under some forests or epiphytic on some trees. By that time the vertical vegeta tional belts were not quite clear.

During the late Pliocene, *Cedrus* (*C. deodara*, *C.* sp.) and *Quercus* (*Q. semicarpifolia*, Q. spp.) forests were widespread in the Himalayas. *Abies* and *Picea* forest would have developed somewhere in the Kunlun Mountains near the Qaidam Basin. Due to the effect of fall in temperature, deciduous forests were gradually decreasing and xerophytic plants (*Ephedra*, *Nitraria*. etc.) were gradually increasing in this region.

As a result of the uplift of the Plateau and fall in temperature, the nature of vegetation changed rapidly during the Quaternary period. At the glacial and the interglacial periods, forests and alpine tundra developed alternately.

At the interglacial in early Pleistocene the forests of *Picea* and *Abies* did appear in the plateau. Meanwhile many lakes and marshes might have existed somewhere in the Qaidam Basin and north Xizang. These places were inhabited by some aquatic plants, such as *Potamogeton*, *Sparganium*, *Typha* and *Nelumbo*. But during the glacial periods only herbs and shrubs could have grown in the Qaidam Basin, Ali and north Xizang, though some spruces and firs might have migrated down to some valleys. At the interglacial period of the middle Pleistocene and the late Pleistocene, some *Picea* forests,though ill-developed, did appear in Ali, north Xizang and the Qaidam Basin.

Some broad-leaved forests still existed in eastern Xizang and brushed of *Rhododendron*, *Viburnum* and *Rhamnus* were flourishing in Yali southern Xizang.During the post-glacial period, the elevation of Yali region could be estimated at about 3700—3900 m above sea level.

A POLLEN STUDY ON THE EVOLUTION OF THE NATURAL ENVIROMENT OF CENTRAL AND SOUTH QINGHAI-XIZANG PLATEAU IN THE HOLOCENE

Huang Cixuan, Liang Yulian
(Institute of Geography, Academia Sinica)

In recent years, we have carried out pollen analysis of some sediments during the Holocene on the Qinghai-Xizang Plateau. We have analysed the sections of Naro Yumco, Yamzhog Yumco, Ngamring Yumco, etc. in south Xizang; that of Coqen in north Xizang and that of Chagcam Cake (LakeII and LakeIII) from the southeast to the northwest.

The feature of the sporo-pollen groups of the abovementioned localities is that the herbaceous pollen occupies a dominont position. It reaches about 50—90 per cent of the groups. The *Xylophyte* pollen makes up (the part) less than 50 per cent. The *Pteridophyte* makes up the least part of it, with only a few percentage. The main species of the *Xylophyta* are *Pinus*, *Betulaceae*, *Quercus*, *Ephedra* and *TamaviCaceae*. The herbaceous includes *Cyperaceae*, *Artemisia*, *Polygonaceae*, *Ranuculacae*, *Thalictrium*, etc. The feature of the sporo-pollen groups varies according to the different locations on the Plateau. On the premise of prevailing herbaceous, the number of *Xylophyta* increases in the sporo-pollen groups in the southeaste part of the Plateau. In the *Xylophyta* species the broad-leaf trees have a large number. In addition, there are more hydrophilous and mesophyfic herbaceous plants such as *Cyperaceae* and so on. The herbaceous reaches the highest point in the sporo-pollen groups on the section of northwest plateau. In these groups there are some more coniferous trees in the part of *Xylophyta*, and more drought-enduring plants such as *Tamaricaceae*, *Ephedra* and *Artemisia*.

According to the variety of the sporo-pollen group in section, it can be divided into three stages of development of the vegetation. And the plants in the second stage have grown best. Combining it with the dating of absolution chronology by using C^{14}, the Holocene is divided correspondingly into three climatic periods; the early period from about 13000(?) to 7500 B. P., the middle period 7500—3000, and the late period from 3000 to present. The climate of the past varies from dry-and-cold, rather warm-and-humid, to dry-and-cold, and the middle period had the optimum climate. It was much warmer and more humid than it is at present.

Since Holocene the drought-enduring components of the vegetation have continuously increased and the part of the herbaceous grown more and more, the *Xylophyta* has decreased constantly and even extincted. The climate reveals a tendency of being still drier.

THE CLIMATE AND UPHEAVAL OF THE QINGHAI-XIZANG PLATEAU IN LATE PLEISTOCENE AND HOLOCENE

Huang Wanpo   Ji Hongxiang
(Institute of Vertebrate Paleontology and Paleoanthropology, Academia Sinica)

In this paper we attempt to study the mammalian remains and archaeological evidences which would deepen our understanding of the climate and the uplift of the Qinghai-Xizang Plateau during the late Pleistocene.

In the Qinghai-Xizang Plateau, animal fossils of the late Pleistocene age include several species. One of them *Bibos* sp. is now limited to South China. Probably the climate of the Qinghai-Xizang Plateau when *Bibos* lived there was not so dry and cold as it is now in this region.

On the other hand, some archaeological evidences from north Xizang show warm climate. However, it has become "no-man's land" with cold climate at the.

Both mammalian remains and archaeological evidences show that the climate of the Qinghai-Xizang Plateau during the late Pleistocene has undergone a change from warm to cold. This is in conformity with the history of uplift of the great Plateau during the same period.

EVOLUTION OF PALEOGEOGRAPHICAL ENVIRONMENT OF THE TANGGULA MOUNTAINS PLIOCENE-QUATERNARY

Xu Shuying
(Department of Geology and Geography, Lanzhou University)

During the Piocene period, the Tanggula Mountains were both low and level. The greater part of the ranges was a surface of peneplaln with an environment of sub-tropical forest-steppe. There were karst landforms like rock forests and so on. Among the piedmont and intermontane basins crisscrossed by rivers and lakes, thus forming a thousand-metre deposit of fluvial-lacustrine facies. Since the end of Pliocene, the tectonic movement has chiefly been characterised by its extensive and greatamplitude arching and block-faulted uplift. In the great part of Q_1, the environment was warm and humid. There grew mixed forests consisting of needle-leaf and broad-leaf trees. At that time, the difference of elevation between the mountains and the plateau on their two flanks was smaller, so that the planation surface of the Pliocene was retained in the main. During the Q_2—Q_3, the glaciation occurred three times. They are called the Tanggula glaciation, the Zhajiazangbu glaciation and the Basicuo Barschou glaciation respectively. The scale of glaciers showed a tendency to reduce gradually. In the Tanggula glaciation the ice cap covered the axis of the mountains and the glaciers run along the broad valleys formed in Q_1 to the piedmont belt. The later two glaciations appeared to be of the continental glacier type in the valleys. In Q_3, as it became arid and cold, along with the mountain uplift and the climatic change the periglacial zone extended, the periglacial landforms were similar to those in the high latitude areas today. It is possible that the thick permafrost layers existing now in the mountains might be developed at the beginning of the Zhajiazangby glaciation. During the last glaciation, there was an extensive accumulation of periglacial loess and aeolian drifting sand in the proglacial zone.

BASIC CHARACTERISTICS OF NEOTECTONIC MOVEMENTS OF THE QINGHAI-XIZANG PLATEAU

Zhang Qingsong, Li Bingyuan, Yang Yichou, Yin Zesheng
(Institute of Geography, Academia Sinica)
Wang Fubao
(Nanjing University)

This Paper mainly deals with the initial period of the neotectonic movements of the Qinghai-Xizang Plateau, the basic characteristics as well as the dynamic aspects of the Plateau's upheaval.

1 . *The initial period of the neotectonic movement.*We consider the neotectonic movement as a crustal movement which has produced the present landforms.As for the Qinghai Xizang Plateau, the initial period of the neotectonic movements coincides with the initial period of intense uplift of the Plateau. The present plateau surface(4,500-5,000m. above sea level)now widely distributed over various parts of the Qinghai-Xizang Plateau is the planation surface which was formed during the Pliocene.It was then about 1,000m.above sea level, and might be called as the "primitive plateau" . Therefore, the Plateau has been formed mainly in the Quaternary. The regional unconformity(or disconformity)during the Pliocene and lower Pleistocene, and the very thick coarse conglomerates deposits of the lower Pleistocene were the manifestation of strong tectonic movements during the end of Pliocene and the beginning of Quaternary. The giant conglomerate of upper siwalik at the southern piedmont of the Himilayas and the Xiyu conglomerate at the northern piedmont of the Kunlun Mountains are 1800m. and 2000m. thick respectively. The Gongba conglomerate in the interior of the Plateau mighr also be 200-500m. thick. They are completely different from the deposits which were mainlg formed with the lacustrine clay siltstones in the Pliocene. Therefore, it can be concluded that the neotectonic movement of the Qinghai-Xizang Plateau at the end of Tertiary and the beginning of Quaternary, representing a real "mountain making" (plateau-making)movement.

2 . *The characteristics of the neotectonic movements of the Qinghai-Xizang Plateau.* The large-scale uplift of the whole plateau is the first manifestation of its nature. The Qinghai-Xizang Plateau, with an average altitude of more than 4,500m. above sea level, is the highest of the several huge geomorphological staircases in China. Although the Plateau shows a tendency of slow declining from northwest to southeast, and local differences are found in its interior, on the whole, it is still a great unified plateau. This specific point has been precisely determined through the massive block movement of the uplift of the whole Plateau. On the other hand, the elevation and subsidence due to

fracturing within the plateau are also obvious. The depression of the Qaidam Basin and the break out of various multi-block mountains belong to the former case, and the "tilting" of the Himalayas is the latter case. Meanwhile, the upheaval process of the Plateau has distinct stages. Based on the available information, we infer that three rapid-uplift periods might have existed. They are (1) the end of the Pliocene—the beginning of Pleistocene; (2) the end of early Pleistocene; and (3) the end of Middle Pleistocene. And three big gradient breaks (knick points) occurred correspondingly on the longitudinal profiles of the valleys. For instance, three knick points of the Yarlung Zangbo Jiang are respectively to the west of Saga (4500m), Gyaca Gorge (3500m), and Daguaiwan Gorge east of Pai (2800m).

3. *The dynamic source of the Qinghai-Xizang Plateau's neotectonic movement.* Many evidences have revealed that the upheaval plateau is the result of strong compression from both the south and the north. This is principally associated with the northward drift of the Indian plate as well as the collision of it with the Eurasian plate. It is generally considered that the fractured zone of the Yarlung Zangbo Jiang was the collision boundary of the two plates, but it was an old "sature" of Cretacious. It became much more stable in late Tertiary. Hence it didnot relate directly to the uplift of the Plateau. The main boundary fault at the southern piedmont of the Himalayas is a huge low-angle overthrust, where the crustal thickness changes rapidly and the seismic activities occur intensely. Thus it can be said that the present-day Indian plate mainly underthrusts northward along this fractured zone. The gigantic horizontal pressure transmits towards the north through the more or less consolidated Qinghai-Xizang block, thus causing the Kunlun Mountains and the Qilian Mountain overthrusted northward and the Tarim land-mass block underthrusted passively southward. With the rapid upheaval of the Qinghai-Xizang Plateau, its interior fracture should adjust correspondingly, either elevate and subside vertically or glide horizontally, to display local variations. On the other hand, the velocity of northward drift of the Indian plate might be sometimes fast and sometimes slow. This may be the reason for the occurrence of the uplift of the Plateau in stages.

THE PROCESS OF THE UPHEAVAL OF THE QINGHAI-XIZANG PLATEAU

Li Jijun, Li Bingyuan, Wang Fubao, Zhang Qingsu, Wen Shixuan, Zheng Bengxing

(The Comprehensive Scientific Expedition to the Qinghai-Xizang Plateau, Academia Sinica)

The Tethys Sea, situated between the Eurasian plate and the Indian plate, has experienced a series of mountain-making movement and become gradually closed-up since the late Palaeozoic period. The Qinghai-Xizang Plateau, as part of the Tethys Sea, kept away entirely from transgression due to the collision of the continents from both the south and the north in the middle of the Eocene, but it didnot cause an immediate upheaval of the Plateau. Existing evidences indicate that no planation surface earlier than early Tertiary has existed on the Plateau. Until the end of early Tertiary, the highly peneplaned surface wasnot yet formed on the Qinghai-Xizang Plateau; nowadays the remnants only occurred on the top surface of the various mountain ranges. Owing to the violent mountain-making movement in the Miocene, the Himalayas began to rise, but another planation surface was formed once again over the Plateau near the end of Late Tertiary. In fact, it is the very origin of the present plateau surface which constitutes the basic feature of the Plateau proper. It is estimated that the altitude of the Plateau surface then was only about 1000m based on the available data from landforms, deposits as well as fossils of plant and animals. The violent uplifting of the Qinghai-Xizang Plateau chiefly took place in the Quaternary, and up to now the accumulative magnitude of the uplift amounts to 3,000—4,000m. Three stages of the upheaval, showing an accelerated tendency, are identified, i,e, the beginning of early Pleistocene, the end of early Pleistocene and the period after the end of middle Pleistocene. On the background of the blocked-uplift of the Plateau as a whole, superimposes an undulating movement. It is manifested by the fact that there arose many roughly west-east stretched mountain ranges, broad valleys, and basins as well as a sub-order undulation which was transversing the aforementioned mountains, valleys, and basins. Many facts demonstrate that the plates' collision couldnot cause a violent upheaval of the Plateau, and that only after a breakup inside the Indian plate itself, followed by an underthrust within the plate (just like a pushing wedge from beneath the woodplate), could there exist the real mechanism for a large-scale upheaval of the Qinghai-Xizang Plateau.

BASIC CHARACTERISTICS OF LANDFORMS OF THE QINGHAI-XIZANG PLATEAU

Yang Yichou, Li Bingyan, Yin Zesheng,
Zhang Qingsong
(Institute of Geography, Academia Sinica)
Wang Fubao
(Nanjing University)

The Qinghai-Xizang Plateau is a region of strong block uplift that has occurred since late Cainozoic era. It is composed of WE-trend huge mountain ranges with broad valleys and basins. The average altitude of the mountain ranges of Gangdis Shan, Nyainqentanglha Shan, Karakorum Shan and the Tanggula Shan is over 5000m. and that of the basins and broad valleys about 4000m., relative altitude being 1000m. The average altitude of the Himalayas and the Kunlun Mountains situated on the margir of the Plateau is over 6000

m. They stand aloft over the peripheral plains and basins with a throw of 6000m. and 4000m., respectively.

The plateau surface is a formed of undulating hills and ridgesplus, flat lake basins and broad valleys, the former being a part of Pliocene planation surface, while the latter chiefly the additional forms of Quaternary. It declines from NW towards SE, with an elevation of 5200m. gradually to about 4000m.; but in The N-S trend, it manifests an more pronounced relief, with the towering mountains and depressed lake basins and broad valleys.

Glaciation appeared four times on the Qinghai-Xizang Plateau during Quaternary, of which the scale in middle Pleistocene is the largest, with valley and piedmont glaciers well developed and overburden glacier occurring loaclly.However, no evidence of an unified large ice-cap had ever been found. After middle Pleistocene, the scale of glacial development become smaller and smaller and the regional differentiation larger and larger correspondingly. The lower limit of palaeoglacial evidence moved from about 2000m. above sea level at the margin of the Plateau. to over 5000m. in the interior of it. Vast area of permafrost belt was formed at northern part of the Plateau. There existed a great variety of periglacial morphologic types, especially with rock glaciers, selfextrusive pingo, thaw slide masses and stratified debris as their special features.

Both the large- and medium-sized lakes on the Plateau are inland lakes controlled by structures, which are distributed in a clear direction. Since Holocene, lakes tend to be diminished remarkably,There are barrier lakes and glacial lakes dotting the mountainous areas around the fringe of the Plateau.

North Xizang belongs to an interior drainage region and its periphery is the source region of the upper reaches of several big rivers, namely, the Chang Jiang, Nu Jiang, (Salween) The Lancang (Mekong), the Ganges, and the Indus. Most of the plateau rivers are adapted to the tectonic evolution and convergences of both main channels and tributaries are characterized with grid drainage systems. Since late Pleistocene, the climate in the interior of the Plateau has become drier, causing the extension of interior drainage. On the other hand, the exterior rivers in the outer part of the plateau, namely, the lower and middle reaches of Yarlung Zangbo Jiang, Jinsha Jiang, Lancang Jiang and Nu Jiang have cut downward 1500—2000m, developing deep gorges, hence, headward erosion expanded intensely towards the inner part of the Plateau.

Besides, there are residues of palaeokarstic landforms on limestone hills of the Plateau. Newly developed accumulative landforms by wind-drift sand emerge in some broad valleys and basins, while in northern Xizang there exist present-day volcanic landforms and the like.

The geomorphologic types of Plateau distinative regional differences which may roughly be classified into three regions:

1. *High-mountain and deep-gorge region in south Xizang.* Dominated by fluvial action, the geomorphologic landscape with deep incised parallel ridges and gorges resutr from indicion and disintegration of th plateau surface.

2. *Piedmont plain and broad-valley and lake-basin region in south Xizang.* With fluvial and intermittent fluvial action in predminance, lake and periglacial areas occupy a

certain proportion, thus forming geomorphologic landscape with moderately incised Piedmont-plain, lakebasins and broad valleys.

3. *Lake basin region of north Xizang Plateau.* Dominated by periglaciation, this region of lakes manifest a landscape with old-age characteristics.

FORMATION AND EVOLUTION OF THE DRAINAGE SYSTEMS ON THE QINGHAI-XIZANG PLATEAU

Li Bingyuan, Jing Ke, Zhang Qingsu
Yang Yichou, Yin Zesheng
(Institute of Geography, Academia Sinica)
Wang Fubao
(Nanjing University)

The Qinghai-Xizang Plateau is the source region of several world-famous rivers, such as the Chang Jiang, Lancang Jiang, Nu Jiang, Yarlung Zangbo Jiang, Ganges, and the Indus. It is also a vast area of interior drainage taking a series of lakes such as Nam Co, Serling Co, and Bangong Co as its centre.

The present drainage systems were formed mainly during the Pliocene with undulaing terrains, composing broad and shallow lake basins and clusters of river-lakes. Most of the rivers and lakes, however, are exterior, leaving only a small part belonging to interior.

Since the Quaternary, the drainage systems of the Plateau have undergone a fairly complicated evolution process, of which two basic cases may be distinguished:

1. *Rejuvenation of drainage and river capturing.* With the uplift of the Plateau in great magnitude and deep cutting the of rivers, headward erosion extended rapidly from the fringe of the Plateau to the interior, so that a number of Pliocene lakes were drained and dissected by rivers (such as the Zauda basin of the Xiangquan He valley), and the river capturing occurred in some places (e. g. the capture of the Gerzabu by the Xiangquan He). In the process of incision three gradient break were developed on the longitudinal profiles. This process was active before the middle Pleistocene, weakened afterwards, but is rejuvenating strongly at the margin of the Plateau.

2. *Change from exterior drainage into interior.* This transfor mation took place in the interior of the Plateau where headward erosion did not reach. The area of the interior drainage system was enlarged gradually from the interior to the borders of the Plateau, so that the interior system inside the Plateau was disintegrated and withered away. Based on the data of the following aspects such as sediments on divide area,

ancientlake strandline, salt concentration and salt mineralization period for the watershed pass,it is proposed that the evolution of the above-mentioned drainage systems appeared chiefly during the end of the late Pleistocene and the Holocene.

Besides the control by the great uplift of the Plateau prover,the evolution of lho drain age systems also reflects the tendency of climatic change from wet to dry in the interior of the Plateau. It must be pointed out that this process is inconsistant with the global climatic fluctuation, but a result of the influence by the uplift that modified the atmospheric circulation, leading to the decrease of precipitation in the Plateau. Hence the uplift of the Plateau is the basic cause of drainage changes.

Up to now, the Plateau still retains the tendency of uplifting and its interior continues to desicate. The drainage system in the interior will further shrink. On the Plateau interier where the headward erosion of the exterior rivers has not reached lakes lying in the broad valleys will Soon change into the interior system. Such lakes are few in rumber, the areal extent so affected would be limited, and the fringe of the Plateau will continue to be subject to incision.

PLANATION SURFACES OF THE QINGHAI-XIZANG PLATEAU

Zhang Qingsong, Li Bingyuan,
Yang Yichou, Yin Zesheng
(Institute of Geography, Academia Sinica)

Based upon the observations made in the Qinghai-Xizang expedition during 1973—1976, in adclition fo topographic map analysis, we found that two-levelled planation surfaces of different periods exist universally over the Plateau.

The upper surface is manifested by peaks and platforms of simillar altitudes. This surface bevels the folded strata of the Nummulitic limestone of Euocene and the Oligocene-Miocene fluvio-lacustrine beds which mainly consist of silts and fine sands are considered as its correlated sediments. This planation surface is underlain by the intermediate basic volcanic rock and Pliocene charmabao formations in the western part of Tanggula Mountains and the Zurkengwula Mountains, so the period of its formation is considered to be Oligocene-Miocene. Since it is more typical over the Tanggula Mountains, it is known as Tanggula Planation Surface (it is called Zhi Buri Planation Surface in south Xizang) .

The lower surface is part of the present plateau. It consists of the weakly dissected and smoothly unudlated hills and ridges with open flat lake basins and broad valleys in the northern part of Xizang. It is represented by "platform" , or dissected surfaces or lake basins and broad valleys in southe Xizang, ar by shoulders in the river valleys below the summit surface. This planation surface bevels all the strata prior to late Tertiary (including Miocene). The Pliocene fine fragment fluvio-lacustrine strata containing fauna fossils of the *Hipparion* is apperently its correlated sediments. Between the top surface and the denudation plane exists a gradual transitional belt. The top surface is uncomformably overlain by early Pleistocene coarse conglomerates The planation surface belongs to Pliocene. It is known as Lunpola Planation Surface in north Xizang and Yarluxunla Planation Surface in south Xizang.

The two-levelled planation surfaces are comparable with those in the other parts of China, and conform to the classification of global planation surfaces proposed by L. C. King (1962) and D. A. Timofeev (1964). So the viewpoints on the existence of the only one planation surface offered by E. Norin (1935), H. De Terra (1933), and Lo Laixing, Yang Yichou (1963) are still open questions. The periods of planation surfaces given by each of them are indefinite.

The Qinghai-Xizang Plateau had uplifted strongly since the end of Pliocene and the beginning of Quaternary, so the planation surfaces also became disintegrated. Consequently, on macrostructure, it resulted in a great delineation from northwest to southeasfoward the lower-levelled planation surface which declined from 5100—5200 m of the piedmont of western Kunlun Mountains, to 4000—4300 m over Mangkang of south Xizang, and the relief presented in a S-N orientation—the Himalayas, Gongdis Mountains, Tanggula Mountains and Kunlun Mountains bad an altitude of 5500—5800 m and 5000—5300m respectively; but the zone of lake basins and broad valleys lying between them dropped to 5000—5200m and 4600—4800m respectively. The latter type of disintegration is precisely correlated with the large-scale folded massive block movement. The commonly seen disintegration forms for local planation surfaces are that of fault, tilt, and arch.

It is necessary to point out that in some places of north Xizang the evolution process of the lower-levelled planation surfaces lasted till late Pleistocene. Under the present periglacial environment, local planation process is still in progress. Hence, the present plateau in north Xizang may be called a compound planation surface.

ORIGIN OF LAKES OF THE QINGHAI-XIZANG PLATEAU

Chen Zhiming
(Nanjing Institute of Geography,
Academia Sinica)

Regarding to the origin of the lakes on the Plateau, opinions differ. the three current views are: 1) The lakes are sapping depressions by continental glaciation (E. Huntington, 1966; E. Trinkler, 1930; B.M.Cinitjen, 1956), 2) The basins are dammed up valleys (F. Drew, 1875; R. O. Oldham, 1880; Burard and Hayden etc.), 3) A few authors, however, touched upon the structural origin (Albert Heim, Seven Hedin). None of them has forwarded with sufficient evidences.

It has been found that both glacial lakes and barrier lakes are generally small in size, the latter being mainly at the periphery of the Plateau. Contrary to this are the numerous lakes of large and medium siges all over the Plateau.

Based on the distribution pattern and morphological characteristics of the lakes, a tectonic origin has been proposed with the following evidences:

1) Most of the lakes are of linear shape with steep slopes and occasional facets. Hot springs are often found in the vicinity. The length of the lake is about 4-10 times greater than its width.

2) The linear arrangement of lakes conforms with the pattern of tectonic belts. 8 longitudinal belts (trending W-E), 9 transversal ones (N-S), and 13 diagonal ones have reminded us of more or less rift origin, respectively with 81,16,and 53 lakes. The stress field of the rift zones are conformable to that of the upheaval of the Plateau.

3) The formation of the lakes has been synchronous with the upheaval of the Plateau. First, the earliest stage of the upheaval and the oldest lakes are both of Eocene. Secondly, the strongest movement of the Himalayas occurred in the 2nd (middle Miocene) and the 3rd (late Pliocene) stages, when the greatest number of lakes (respectively 33 and 24 lakes) were formed.

MAPPING THE GEOMORPHOLOGICAL TYPES OF XIZANG

Yin Zesheng, Yang Yichou, Li Bingyuan,
Zhang Qingsong, Xü Jingfang
(Institute of Geography, Academia Sinica)

Geomorphological types of Xizang region are various and complicated in morphology, origin, and evolution. This paper discusses mainly th geomorphological types of Xizang as well as the way to express them on maps.

1. *Denudational-accumulational morphologic types and theirs mapping.* According to certain quantitative indication and morphologic features, landforms in Xizang can be dividedin to four basic types, namely, mountains, hills, table lands, and plains. The four types may be further subdivided by the differences of the exogenetic forces of formation (denudation-accumulation).

In the Xizang, four principal exogenetic forces can be Summarized: 1) glaciation, 2) periglaciation, 3) fluvial processes, and 4) lacustrine processes. The mountains, hills, table lands, and plains under each exogenetic force have their own characteristics, and 22 denudational-accumulational morphologic types are given in the article. The four exogenetic forces may be designed into four chromatic systems. The four morphologic types may be expressed with different colour scales under the above-mentioned chromatic systems.

2. *Morphotectonic types and mapping.* The Qinghai-Xizang Plateau is a region which underwent a most intensive uplift during Cainozoic era, hence both old and new tructures are distinctly manifested in geomorphological types. The morphotectonic types described in this paper include "style of neotectonic movement and relative activity" (principally the scale and intensity of elevation and subsidence), "tectonic pattern (rift system, folded system), lithologic composition" (only expressing limestone and granite landforms). While plotting the symbols of black and colour points and lines or literal notation are superimposed on chromatic system representing denudative-accumulative morphologic types.

3. *Morphostructural analysis and mapping.* To reflect more objectively the features of geomorphological types of Xizang in vast variety of different morphostructural aspects, the paper will carry out morphostructural analysis for geomorphologic types originated by various endogenetic and exogenetic forces. The results are to be displayed on maps. The morphologic types to be analysed will include that of tectonic, denudative, fluvial, glacial, lacustrine, karstic, periglacial, gravity, biologic as well as those formed due to human activity. The analytical results can be marked on certai ι fixed locations with black and colour point-line symbols, and numerical notation with quantitative marks.

A sample of geomorphological map (scaled on 1:1000000) for some southern parts of northern Xizang is attached to the paper.

PERIGLACIAL LANDFORMS AND THEIR CHARACTERISTIC OF THE QINGHAI-XIZANG PLATEAU

Tsuei Zhiqiu
(Department of Geography, Beijing University)

Except the ice wedge polygons and a few other types which exist only in the polar regions, the total number of the type of periglacial landforms on the Qinghai-Xizang is over fifty. Among these types, some are rarely seen in the world. They are: rock ice cap and rock glacier, pingo and self-extrusive pingo, thaw slide masses, stratified scree, etc. The above-mentioned types can all be found in the continental periglacial region of the northern part of the Plateau.

Based upon the characteristics of the periglacial landforms, the climatic conditions, the distribution of the types of permafrost, etc., three regions of periglacial landforms may be distinguished:

(1) The North Region, where periglacial landforms well develop, belongs to a continental type. It is represented by frost heaving and thawing. This region consists of large area of permafrost.

(2)The South Region, where the periglacial landforms moderately develop, belongs to a transitional region. The frost heaving and thawing is weaker than is in the North Region, and the nivation is weaker than ls in the East and the Southeast Region. It is covered with stripes and masses of permafrost.

(3)The East and Southeast Region belongs to a maritime type, the nivation well develops, but other periglacial processes less develop. This region makes up masses of permafrost, seasonally frozen ground and nonfrozen ground.

The three regions mentioned above have different vertical zonal spectra. In the North Region the base zone is an alpine tundra zone. Below the snow line the altitudinal range of the permafrost zone reaches 1000m or more. In the South Region the base zone is a subalpine grass land, and the altitudinal range of permafrost zone is about 600 m or more. In the East and Southeast Region, the base zone is a mountain subtropical zone or a coniferous and evergreen broad-leaf mixed forest zone. The lower limit of the permafrost zone coincides with or is higher than the snow line. Below the snow line no permafrost exists at all.

On a profile from south to north, it is found that the same type of periglacial landforms(e.g. rock stream, stone stripe and rock glacier)prevails. The lower limit of its development follows the lower limit of the permafrost. It rises 120-140 m with the decrease of latitude. Taking the longitude 95°E as a profile, most favourable for the development of various periglacial phenomena are the North Region. Toward the north till the western end of Qilian Shan and Harlik Mountain at the eastern section of Tian Shan, and toward the south till the mountainous regions of the southeastern Xizang, periglacial processes are relatively weak under the very humid or very arid climatic conditions. The most favourable conditions for the development of various periglacial phenomena are the continental climate. Here the mean annual temperature is about $-5°$ to $-7°C$, the mean annual precipitation is 350 - 400 mm, the mean annual range of temperature is 22° - 25°C and the mean diurnal range is 22° - 25°C.

We discovered that there is a distinctive lower limit which exists in the mountainous regions of extensively developed rockfield. This may be called the rockfield line. Like the snow line, it is a significant climatic geomorphic line. Generally it is 200 - 250m or 400 - 500m lower than the snowline in the same place and at the same time. Its altitude decreases with the increase of latitude.

In the high mountains of the Qinghai-Xizang Plateau various periglacial processes extend to 200 - 2000m above the snow line. This is conformable to the general infiltration-freezing of the ice forming process of this region. Even the summit of the Qomolangma Feng is not excepted. For example, there are frost-heaving blocks in Kunlun Mountains on the snow line (5200m), and large sorted circles above the snow line (5400m) in Tanggula. There are debris solifluction at 1600m above the snow line(6000m), and also frost weathering debris at 8700m above sea level. These show that the assumption, i. e., the snowline is the upper limit of periglacial process is not accurate. It appears that the periglaciation exists not only around the outer fringe of the area of glaciation, but should include the glaciation itself. Taking the snowline and 0°C isotherm in summer as a base line, the periglacial area above and below them may be called the upper periglacial zone and the lower periglacial zone respectively.

CRYOPLANATION TERRACES: INDICATORS OF ALPINE PERMAFROST

Troy L. Péwé,
(Arizona State University, Tempe, Arizona, USA)

Cryoplanation terraces are minor step-like or table-like land forms consisting of nearly horizontal bedrock surfaces covered by a thin veneer of rock debris and bounded by ascending or descending bedrock scarps or both. They generally occur as a series of rock-cut steps on spurs of hills and mountains above tree line. The scarps of cryoplanation terraces range in height from 3 to about 75m and slope from 9 to 32° when covered by rubble; nearly vertical scarps exist where bedrock is exposed or thinly buried. Where cryoplanation terraces are active or well preserved, permafrost is present from 0.5 to about 2 m below the ground surface.

The terraces are formed by the retreat of the scarps that cut the stepped profiles in bedrock. The ascending scarps are excavated into the crests and flanks of alpine ridges and hills by nivation attacking bedrock in transverse nivation hollows. Nivation does not affect the floor of the hollow where the ground is perennially frozen. Thus, the top of shallow permafrost acts as a local "base level of nivation", which controls the essentially horizontal displacement of the floor of the transverse nivation hollow during scarp recession. Bedrock structures are indiscriminately truncated during scarp retreat.

Cryoplanation terraces occur in high latitudes and moderate high altitudes in areas of modern or past periglacial climate. They form below the snow line and are known in North America from elevations of about 100 m in the far north to about 3000 m in temperate latitudes. Distribution of the terraces is fairly well known in North America and many parts of Europe, and they have been reported quite widely from the U. S. S. R.; however, more information is needed concerning the distribution of active and inactive terraces in the high Himalayan Mountains and Tibet Plateau.

BASIC FEATURES AND FACTORS OF PERMAFROST ON THE QINGHAI -XIZANG PLATEAU

Tong Boliang
(Lanzhou Institute of Glaciology and Cryopedology, Academia Sinica)

The permafrost on the Qinghai-Xizang Plateau has an area of about 1,500,000km^2, the most widely distributed area covered by a very thick layer. It also records the low st temperature and the highest elevation, in the middle-lower latitudes. The lower limits of permafrost on the Plateau can approximately be indicated by annual mean air temperature; those of insular permafrost at—2.5℃; of discontinuous permafrost at—3.6℃; continuous permafrost at—5.6℃, the latter being 1.5°—2.5℃ lower than the southern limits in the high latitudes of the N. Hemisphere.

The permafrost features on the Plateau are limited chiefly by elevation, and the vertical zonality is very obvious. An increase in elevation for 100 m results in a decrease of annual mean ground temperature of permafrost for 0.8—0.9℃, and an increase in thickness for about 20 m. consequent to the vast expanse, a horizontal zonality also exists within the plateau,but such zonality is often interfered and influenced by geological and geographic factors, such as tectonic faults, ground water, lithological character, surface water, rock exposure, snow-cover, vegetation and so on. These factors, forming areas of thawing, determine the differential characteristics of permafrost in the continuous distribution on the Plateau in its interior, and lead to the disappearance of parts of the permafrost, whieh results insular distribution, in the peripheries of the plateau.

Intensive uplift of the Qinghai-Xizang Plateau provides favourable conditions to the development of permafrost, but the tectonic faults formed in the process of uplift have provide good channels for circulation and drainage of ground water in deep layers, and accordingly often form areas of thawing. The snow-fall on the Plateau takes place mainly in summer, and is rare in winter, thus promoting the existence and development of permafrost layers, but detrimental to the development of seasonal thawing layers. The vegetation favorable to the permafrost is the alpine meadow steppe, effective for its protection. The exposure of mountain slopes has a bigger effect in the interior of the Plateau than at a lower elevation in the same latitudes. But on the slopes of the Himalayas, permafrost on the southern slopes develops more deeply than on the northern slopes, due to the different climatic conditions. The degree of transforming surface water to permafrost is directly proportional to its volume. In the bordering regions of the Plateau, surface water and swampy grounds are good signs for locating the insular permafrost. The effect of snow-cover, vegetation and exposure on the seasonal thawing layer is stronger than the seasonal freezing layer.

The ground temperature curve of permafrost on the Plateau belongs to the thermal dissipation type and a bigger geothermal gradient is found in the vicinity of the surface water body and the structural geothermal talik areas and at those places where subpermafrost water comes up. In the bordering regions of insular permafrost, geothermal gradient is always smaller.

As compared with the permafrost in higher latitudes of Northern Hemisphere, the permafrost on the Qinghai-Xizang Plateau possesses the characteristics of higher ground temperature and thinner in thickness. This is decided by the history of development of the permafrost layer on the Qinghai-Xizang Plateau. The existing permafrost has been mainly formed since the late Pleistocene.

FEATURES OF GROUND FREEZING AND THAWING IN THE INTERIOR OF THE QINGHAI-XIZANG PLATEAU

Huang Xiaoming, Yang Hairong and Liu Tieliang
(Northwestern Institute, China Academy of Railway Research)

In this paper, we are trying to make an analysis on some of the seasonal freezing-thawing of the natural ground in the permafrost zone of the Qinghai-Xizang plateau.

1. In the cold seasons, the active layer is frozen in both upward and downward directions, and the depth of downward freezing occupies about 80% of the layer in thickness. The freezing action lasts only in a time range corresponding to 30% of the total cold seasons, and shows a large potential freezing capacity.

2. The migration of the water in the said layer makes the rate of freezing action low at the beginning and in the end but high in the middle stage. Based on the statistics of relation of the frozen depth with the freezing index of clayey soil layer at Fenghuo Shan, it can be assumed that the possible seasonal maximum frozen depth is 5.4m. and 3—4 times as large as the possible seasonal maximum thawing depth in that area.

3. The rate of thawing varies with the initial frost condition of the ground. In the late stage of the thawing season, the active layer holds stationary at 0℃ lasting about one month before a normal freezing action starts.

4. The fluctuation of air temperature will induce a change of the upper limit of permafrost. According to the data observed in a short time, it is calculated that the change of annual mean temperature per 1℃ will result in a change of the upper limit by

7% for the fine-grained soil covered with vegetation and 17% without vegetation. The maximum deviation of annual mean air temperature for 100 years suggests less then 1℃, and so it is believed thet the fluctuation of the upper limit of permafrost in the coming century may attein a depth no more than 10—20%.

5. Calculetion besed on the dete observed et Fenghuo Shan shows that the latent heat loss during the thawing action is about 68% of the thawing index in the surface layer, that the apparent thermal loss amounts to 9%, and that the thermal loss in the permafrost layer above the annual zero amplitude zone is about 23%. The exchange amount of evailable heet in the section between the upper limit of the permafrost and the annual zero amplitude zone (10m in depth) is $+7690 kcal/m^2$ and $-7750 kcal/m^2$, respectively, the absorption capacity being to the exhaustion.

ALPINE PERMAFROST IN CANADA IN COMPARISON WITH TIBET

R.J.E. Brown
(Geotechnical Section, Division of Building Research, National Research Council of Canada)

Alpine permafrost occurs above elevations of 1400 m to 2300 m above sea level in the Western Cordillera and at a few locations in Eastern Canada south of the southern limit of the permafrost region. In China alpine permafrost is found extensively throughout the Tibetan Plateau at an elevations of 4000 m to 5000 m above sea level. Predictions used to estimate the distribution of permafrost in the mountains of the Provinces of Alberta and British Columbia for compiling the original Permafrost Map of Canada assumed the elevation of the lower limit to be about 2200 m at latitude 49°N descending to about 1300m at latitude 55°N. Cooperative investigations by the National Research Council of Canada and the University of Calgary during the past five years have verified the lower limit to be generally 200 to 300 m higher. Since 1974 a network of boreholes to depths of 15 to 30 m (one to 150 m) to measure ground temperatures has been developed in the Rocky Mountains of Southern Alberta from latitude 50°N to latitude 53°N (from 100 km south of Calgary northwestward through Banff to Jasper). The distribution of alpine permafrost in this region is greatly influenced by air temperature, latitude, elevation, slope and aspect, vegetation, snow cover and rock type. Continuous permafrost probably exists above treeline due to elevation, sparse vegetation and thin snow cover. Results of these observations and current knowledge of the distribution of alpine permafrost in Canada in relation to climatic and terrain factors will be discussed. The Tibetan Plateau lies between latitude 30°N and latitude 40°N more than 1000 km south of the Canadian alpine permafrost region but at much higher elevations. Its location north of the Himalaya Mountains contributes to low mean annual air temperatures and thick extensive permafrost. Mean annual air temperatures are below 0℃ with mean annual ground temperatures ranging in some areas from $-20C$ to -50^0C at 4200 m to 4500 m above sea level. Permafrost of 180 m in thickness has been reported.

CALCULATORY STUDY ON THE HISTORY OF DEVELOPMENT OF EXISTING PERMAFROST ON THE QINGHAI-XIZANG PLATEAU

Ding Dewen Guo Dongxing
(Lanzhou Institute of Glaciology and Cryopedology, Academia Sinica)

On the basis of previous works of the authors and of others, we adopt the idea and viewpoint in physics as the guiding principles and use the mathematical methods for the discussion of problems in our study. We attempt to elucidatethe physical nature and signs for the formation and development of permafrost and suggest the principle of time-space correlation of the forms of permafrost on the Plateau.

On this ground we ascertain the temperature prerequisite for the formation of permafrost on the Plateau is -2℃, that for the existence of continuous permafrost, -5℃; the latter in Qinghai, -4.1℃. Moreover, in this article, the superimposed model of climatic process on the Plateau has also been suggested. It is on such basis that the mean temperature within the time-scale of every glacial age (or interglacial) on the Plateau since the Pleistocene has been revised.

Through the temperature index for the existence of permafrost on the Plateau worked out by the authors and the application of analytical equation in terms of the thickness, the thawing districts (talik) and the ground ice of permafrost, the historical process of the development of permafrost since the Pleistocene have been inferred, the periods of respective stages of the existing permafrost since the formation evalurted, and the conditions of thawing discussed.

MUD-FLOWS IN THE QINGHAI-XIZANG PLATEAU

Tang Bangxing, Li Deji, Lü Ruren, Tan Wanpei,
Tien Lianquan, Liu Suqing
(Chengdu Institute of Geography, Academia Sinica)

The Qinghai-Xizang Plateau has undergone strong uplift in separated periods since Pliocene, being the youngest, highest, and the greatest one in the world. It is also, despite its subtropical latitudes, one of the most favourable regions of mudflow development in our country.

Mud-flows are controlled by such factors as geologic structure, landform, drainage, and climate, etc. With respect to the Qinghai-Xizang Plateau, the tectonic movement of differential upheaval, repeated glaciation, frosting and weathering, etc. have provided sufficient solid materials for mud-flows, as do steep landforms and ready water sources for their formation. Since most bursts of mud-flows are caused by rain water or melt water, they may well be grouped under two headings: The rain-induced and the glacier-induced mud-flows. Both types differentiate according to climate. In the interior of the Plateau the mud-flows silter do not exist, or restrict in activity, owing to the arid cold. On the other hand, strong flow activities occur in the south-east and east parts of the Plateau under humid climate rich in rain and melt water. The glacier-induced mud-flows originate in the ice and snow belt, and the rain-induced one in the forest, forming vertical zones. Both types of mud-flows are mainly distributed to the south and southeast of the Gangdese mountains and of the Qinghai-Xizang highways. Two regimes may be recognized: 1) The SE Xizang and the Himalayas with mud-flows of glacial and pluvial origins and 2) . The south Xizang with mud-flows of torrential and lake-overflow origin. It is recognized that periodicity occurs to the mud-flow activities alternating highs and lows, although the duration of a cycle varies in localities.

Regarding the control and prevention of mudflows, the principle of "avoiding the strong and controlling the weak" has been followed. The agency of highway administration, taking into consideration the mudflow characteristics, the nature of their damage, and the prevention capacity against the mud-flow, has adopted the policy of "making the mud-flow detour or draining it over" . In water-passage area, to build bridges is preferable to building culverts as far as draining is concerned. When the road passes through the debris area, a temporary passage or a road passing through the seeping water is advisable. As to the control of mud-flow gullies, engineering measures of draining and damming may be recommanded.

CHARACTERISTICS OF THE MUD-FLOWS JIAMAQIMEI GOU GULLY, BOMI COUNTY, XIZANG

Tian Lianquan, Li Deji, Liu Suqing
(Chengdu Institute of Geography, Academia Sinica)

In the gully of Jiamaqimei Gou, Bomi County, Xizang, where steep slopes and abundant rainfall provide sufficient supply of solid materials for the development of mudflow, the burst of such flows ranks one of the most frequent in the world.

According to the nature of the flow, 3 types have been recognized, e. g. the turbulent, the structural, and the transitional. Of the structural mudflows, the specific weight of the moving mass, which is characterized by a lattice-frame structure, exceeds 2.0 ton/m^3. Unlike an ordinary mass movement, this type of mudflow has its individual enveloped by a glue membrance and may slide forward, so that the surface layers move faster in varying degrees than the ground layer. A turbulent mudflow is originated from a turbid current enlarging gradually its load by eroding the gully sides. The flow does not differ much from a water current, being structureless with an extra-ordinary bed load.

The structural mudflows are by far more important than the other 2 types in the Jiamaqimei Gou. They may be subdivided into 3 groups, i. e. the continuous, the intermittent, and the creeping, in the order of decreasing velocity. The intermittent mudflows are the principal agent that has dug out the gully bed of the Jiamaqimei Gou. For the last 30 years, they have increased in number and size, broadening and deepening the gully, besides threatening to damage the motorable road and its bridges (on the right side). Control measures should have been taken to stabilize the situation by damming, as well draining, the flow.

CHARACTERISTICS OF GLACIAL MUD-FLOWS IN SOUTH-EASTERN QINGHAI-XIZANG PLATEAU

Du Ronghuan, Zhang Shucheng
(Chengdu Institute of Geography, Academia Sinica)

The mountainous regions in south-eastern Qinghai-Xizang Plateau is a region where existing glaciers (especially the monsoon maritime glaciers) are very well developed. The physical geographical environment and glaciation peculiar to this region is the cause for the development of its unique glacial mud-flows.

The distribution of glacial mud-flows is concentrated in the gullies of both sides of Bodou Zangbo, Yigong Zangbo, Polung Zangbo, the Dongjiu He and the Niyang He where lie the big bend of the Yarlung Zangbo Jiang in the south of the eastern section of the Nyainqentanglha Shan, and corresponds to the distribution of the monsoon maritime glaciers. Guxiang Gully on the right bank of Bodou Zangbo may be taken as a typical example of the glacial mud-flows in the region.

Gùxiang Gully is a large-scale glacial mud-flow gulley which is developed in the Amphitheatric Zungenbecken of high mountains.

During the uplift of the Qinghai-Xizang Plateau, accompanied by variations of advances and retreats of the glaciers and the sculpture of the earth's surface, a steep topography with a great difference in relative height as well as corresponding longitudinal profile were developed. It provides plentiful loose solid materials (moraines) as well as various sources of water (meltwater and rainwater) which became the basis for the development of mud-flows. The variations of climate and severe earthquakes are the causes of frequent and intense activities of various types of mud-flows in Guxiang Gully. Since the retreat of the glaciers on the Qinghai-Xizang Plateau in the 30's, the mud-flows in Guxiang Gully have revived once again. They burst out frequently every summer and autumn for the last thirty years or so, thus causing great disasters.

According to the data collected from three surveys and local observations made in the 60's and the 70's, the authors attempt to sum up the modern process of development and the characteristics of glacial mud-flows in Guxiang Gully. The main items are as follows:

1. The analysis of the factors and processes of development of the glacial mud-flows;

2. The characteristics of activity and machanism of the glacial mud-flows;

3. The variations of erosion and silting, the features of accumulation and the trend of development of the glacial mud-flows.

THREE-DIMENSIONAL DISTRIBUTION OF SOIL ON XIZANG PLATEAU

Liu Chaoduan
(Nanjing Institute of Soil Science, Academia Sinica)

On the basis of the vertical differertiation of the soil mantle, appears the succeeding horizontal and vertical differentiation of soil mantle on Xizang Plateau. The soil mantle of the plateau surface (about 4400 m above sea level) may be divided into two parts by the Kangdese-Nyainqentanglha Range, showing latitudinal sequence. Both the north and the south belts further display the longitudinal differentiation from southeast to northwest. The north belt may be subdivided into zones of alpine meadow soils, alpine steppe soils, and alpine desert soils, each of which forms a spectrum with 3 vertical zones. The south belt may be subdivided into subalpine meadow soils, subalpine steppe soils, and subalpine desert soils, forming the base zones of the respective spectra with four vertical zones. In addition, on the border of the plateau. as well as in the valleys dissection the plateau, there exists vertical zones sequences.

Due to the marked multi-interweaving of the latitudinal, longitudinal, and vertical zonalities, the same soils of Xizang belong at the same time to vertical, latitudinal and longitudinal sequences, being a 3-dimensional complex. The vertical belts divided by the snow line and forest line extend horizontally to form the nival belt, the Xizang belt and the "wooded" belt. The word "belt" means an unit of 3-dimensional soil mantle, or a vertical unit with horizontal differentiation, or a horizontal unit with vertical differentiation.

The 3-dimentional distribution (represented by S) may be defined as a function of three variables, namely, the latitude (W) the longitude (J), and the altitude (G) expressed by:

$$S=f(W, J, G).$$

It is clear that any one of the latitudinal, longitudinal, or vertical zonality is only the expression, where the other two variables approach constant. The difference between the mountain soils and the plain soils is only of relative meaning. The correlation of Xizang soils to the tundra soils is undoubtedly logical, while the isolation of the horizontal zonality from the vertical is problematical.

SOIL FORMATION AND DISTRIBUTION OF THE CHANGTANG PLATEAU

Li Mingsen
(Commission for Integrated Survey of Natural Resources, Academia Sinica.)

The Changtang Plateau rises about 5000m in elevation with an area about 600,000km^2, it belongs almost entirely to one single interior drainage system. Cold aridity prevails, more so toward the north, with annual temperature below 0℃ over most of the area and annual precipitation ranging from 300 mm in the south to below 50 mm in the north. Strong cryo-weathering and aeoliation have produced a thick cover of loose but angular materials. The sparse vegetation comprises steppe and desert steppe, besides desert.

The soils developed under such severe environment may be classified into 2 major groups: (1) the steppe soils include alpine steppe soils (saga soils) and alpine desert steppe soils (Morga soils); (2) the desert soils include subalpine desert soils and alpine desert soils. Of the alpine steppe soils, the organic matter amount is 1—2% and the eluviation of $CaCO_3$ is slight. The organic content of the alpine desert soils is below 1% with surface accumulation of $CaSO_4$ and soluble salts. The alpine desert steppe soils are genetically between the alpine steppe soils and alpine desert steppe soils. The subalpine desert soils differ from the alpine desert soils in that the former accumulate in the subsurface horizon of $CaSO_4$ and other easily dissolved salts. Common to these 4 types of soil are the retarded circulation of bio-substance, slight humification, weak seasonal eluviation, strong cryo-weathering, and the significant alternation of freezing and melting.

In the Changtang plateau, the zonality of soils is clear with the zones changing from east to west in increasing severity of environment. In the southern half of the plateau, alpine steppe soils are in the east and subalpine desert soils in the west. In the northern half, alpine desert steppe soils are in the east and alpine desert soils in the west. The soil distribution reflects the horizontal differentiation of water-heat conditions.

The vertical zonation of soils is simple in structure, being of the arid and semi-arid continental types. The soils are of frozen soil belt with alpine steppe soils, alpine desert steppe soils, subalpine desert soils, and alpine desert soils as the base zone of the respective spectra.

Of the intrazonal soils, the meadow soils, the bog or moor soils or the saline soils occur chiefly in lake basins or valleys.

PALEOSOLS AND THE UPHEAVAL OF THE XIZANG PLATEAU

Gao Yixin Chen Hongzhao Wu Zhidong
(Nanjing Institute of Soil Science, Academia Sinica)

Since Pliocene, the upheaval of the Qinghai-Xizang plateau was accompanied by several periods of glaciation. On the north slopes of the middle Himalayas, paleosols are frequently found interbedded in the glacial debris of different periods, e. g. early-, middle-, late-Pleistocene, and Holocene (high temperature). Based on field observation and laboratory analysis of part of the samples collected, an attempt has been made to investigate the characteristics, classification, and evolution of the paleosols in relation to the uplifting of the plateau.

Soils of red earth-type developed at the end of Pliocene to early Pliestocene indicate the subtropical nature of the climate despite the moderate upheaval. Starting from middle Pleistocene, soil of cinnamon red earth-type developed, when the plateau approached to about 3000 m above sea level resulting in rather arid climate. In late Pleistocene, the soil processes changed to form drab soils. This reflects the increasing cold aridity of the environment following the uplift of the plateau, as well as the shading effect by the Himalayas. Only the south slopes of the range and southeast part of the plateau continued to enjoy the warm moist monsoon and to form red the earth and cinnamon red earth. In Holocene (high temperature), the soil processes in the interior of the plateau then over 4000m in elevation, turned to brown felt soils (subalpine shrubby meadow soils) under mild, cool, and semi-humid climate. The south slopes of the Himalayas and the southeast of the plateau are again the only localities of yellow-brown soils under the influence of the monsoon.

A MICROMORPHOLOGICAL STUDY OF SOIL POLYGENESIS IN XIZANG PLATEAU

Cao Shenggeng Gao Yixin
(Nanjing Institute of Soil Science,
Academia Sinica)

A micromorphological study has been made for some composite soil profiles with paleosol layers in Xizang Plateau. Plate observation indicates that polygenesis is common to all soils in Xizang.

7 kinds of substance may be pointed out as micromorphological evidences for pedorelicts in the soil profiles. They are the ferric oxide and/or hydroxide impregnation matrix, hydrous ferric oxide and/or hydroxide impregnation matrix, fragments of grains of ferruginated minerals, ferric nodules, illuviation cutans, and the carbonate concentrations (a part of the last could have been resulted from recent soil processes).

Two composite profiles have been analysed to trace the polygenetic processes, paleosols of yellow soil have occurred, and the whole evolution may be classified into 5 stages representing respectively the pocessess of: red and yellow soil, brown earths, Arga soils (carbonate arid soils), cold-humid type of soils, and subalpine shrubby meadow soils.

THE QINGHAI-XIZANG PLATEAU AND THE VEGETATION OF CHINA

Chang Hsin shih
(Aug. First Agricultural College, Xinjiang, China.
Cornell University, Ithaca, New York, USA)

The vegetation of continental China going from southeast to northwest grades from "forest" through "steppe" to desert. This special geographic gradient of vegetation should be interpreted in terms of patterns of Quaternary atmospheric circulation which shifted when the Xizang plateau arose. The geographic distribution of vegetation is basically the "projection" of the atmospheric circulation onto the surface of the earth.

The uplift of the Plateau produced the high pressure region called the "Xizang High". Under its control a continental climate and special vegetation developed on the

plateau. The plateau forced the westerlies, which control the "desert zone of cancer" to move to the northward, producing a powerful high pressure system-The Mongolian-Siberian anticyclone. Thereafter, the desert zone was pushed to the north, and a temperate desert formed in central Asia. The expansion of the Xeric steppe zone to the southeastward followed. Meanwhile, the temperate mesic deciduous forest zone of Eastern Asia was compressed and became xeromorphic. While in northeast Asia, there developed a mixed needle-broad leaf forest region under the influence of the moist maritime climate of the "Aleutian Low" being also a consequence of the uplift of the Plateau.

The Plateau prevented the entrance of subtropical desert and savanna into China. In these latitude of continental Eastern Asia, there is a special Eastern Asian subtropical forest of broadleaved evergreens made possible by rains from the Eastern Asian and southwest monsoons. The paths of both monsoons are strongly influenced by the Plateau.

The tropical rainforest and monsoon forest zones extend unusually far to the north (about N 29° lat.) in the western mountain region because of the protection of the Plateau, and the rains from the southwest monsoon. Whereas in the eastern part of China, the winter cold of the Mongolian-Siberian anticyclone prevents their extension even as far as 23°N. Both of these patterns are a direct consequence of the influence of the Plateau on the climate.

ON THE VEGETATION ZONING OF THE QINGHAI-XIZANG PLATEAU

Zhang Jing-wei
(First Bureau, Academia Sinica,
Institute of Botany, Academia Sinica.)
Wang Jin-ting Chen Wei-lie Li Bo-sheng
(Institute of Botany, Academia Sinica.)

Scientists have long been of the opinion that the vegetation zonality of China has been destroyed or interfered by the Qinghai-Xizang plateau which, consequently, has been considered as one unit as a whole, so far as vegetal regionalization is concerned.

The authors, having analysed the vegetation of the Plateau and its peripheries, have come to the idea that vertical spectra of the peripheries, differing significantly from one another, may serve as a basis for horizontal zoning of the Plateau. From the Kunlun-Bayanhar range on the north, the vegetal spectrum is of temperate characteristics; from the Himalaya on the south, it is of tropical; from the Hengduan ranges (Transversal Mountains) on the east to the region between West-Himalaya and Karakorum on the west, both spectra are subtropical.

Hence, the zonalization of the Plateau proper may, based on the spectrum differences, be achieved by dividing into 3 latitudinal zones, i. e. the tropical zone in the south, subtropical zone in the middle and the temperate zone in the north. The tropicel and the subtropical zones may take the east and middle Himalayas as the boundary, while the subtropical and the temperate ones may trke the Kunlun-Bayanhar for the same purpose.

BASIC CHARACTERISTICS OF STEPPE VEGETATION IN THE XIZANG PLATEAU

Wang Jinting
(Institute of Botany, Academia Sinica)

In the interior of cold-arid Xizang Plateau, there develops a vast expanse steppe vegetation including 4 types of communities: the tussock-grass, the rhizome-grass, the rhizome-sedge, and the semi-undershrub steppe. Of these, the widest distributional and the most typical is the tussock-grass steppe. Again, 3 ecological types may be recognized, according to the heat-water relrtion, they are: warm temperate semiarid, cool temperate-strong semiarid, and cold temperate weak semiarid, with the last type being the main one. Steppes of the plateau are somewhat similar to the temperate ones of our country regarding the community aspect, as well as the floristic composition, demonstrating the historic geographic relation between the two regions. However, the endemic species of the Plateau play an important part in the composition of the communities, in addition to the Sino-Himalayan element. There are such communities as dominated by *Stipa purpurea*, *S. subsessiliflora* var. *basiplumosa*, *Orinus thorolii*, and *Carex moorcroftii*, *Artemisia wellbyi* etc. These species are either endemic to the Plateau or taking the Plateau as their chief distribution center. Of the vegetation, the plants are sparse and dwarf, the productivity is extremely low and the ecologicel adaptation to the environment is reflected by such growth form as cushion, rosette, or estalier, velvet cover, strong root system, and so on. In general the floristic composition is poor; there are usually cold-herbaceous synusia and cushion synusia.

It should be remembered that a steppe is but one of the belts of the vertical spectra characterizing the plateau; but the vertical belts in Xizang differ from the ordinary spectra in that the former may turn to form horizontal (latitudinal) zones on outcroping at the plateau surface.

According to the basal belts of the spectra, 3 kinds of vertical belts may be distinguished, i. e. the warm-temperate-semiarid, the cool temperate-strong semiarid, and the cold-temperate-weak semiarid. No forest belts appear in the spectra over the Plateau surface. The upper limit of steppe in Xizang goes as high as 5200 (5400) m, being the highest in the world.

The characteristics of the Xizang steppe result from the combined effect of the latitude, altitude, vast areal expanse, and the juvenescence of the upheaval on the one hand, and the adaptabitity of the plants to the cold-arid environment in the other.

FUNDAMENTAL CHARACTERISTICS OF THE FORESTS IN XIZANG

Li Wenhua Han Yufeng
(Commission for Integrated Survey of Natural Resources, Academia Sinica)
Li Yujiu
(Beijing Forestry College)

The basic features of the Xizang forests may be summarized as follows:

1 . Uneven distribution and high wood production: The upper limit of forest lies at about 4000 m (occasinally 4500m) above sea level, probably coinciding with the isoline of mean annual temperature 2 ℃ and mean temperature 12℃ of July.The forests of Xizang are situated in the region where annual precipitation varies from 600—4000mm, with the annual relative humidity varies from 55%—80%.As a result, the forests are mainly concentrated in south and southeast Xizang, cover an area of 61, 500km^2, i. e. only 5 % of Xizang total area.On the other hand, due to the fact that the yield of timber in Xizang forests are relatively high per heactre, the total timber volume is about 1.4 billion m^3 and ranks second by province in China. From the forest production point of view, the subalpine coniferous forests, the evergreen broad-leaved forest and the pine forests in different vertical belts are the most important resources.

2 . Rich flora: Of the 5000 species of higher plants in Xizang, 90%are found in the forests. One third of them are woody species.There are a large number of endemic trees and shrubs. While the floristic abundance might have been resulted from: (1) the immigration of species from surrounding regions and (2) the great variety of physical conditions, (3) the formation of new species during the successive upheavals of the plateau.

3 . Great variety of forest vegetation. According to the floristic composition, the morphology of forest communities and the ecological factors, a forest vegetation classification system has been established. More than 8 forest vegetation types, 45 forest formations and a still large number of forest associations have been recongnized. A forest map of Xizang with a scale of 1:1,500,000 and a Computerized potential vegetation map have been presented.

4 . Due to the strong intensity of radiation, large daily temperature amplitude and the small annual temperature amplitude in highland, the forest ecosystems in Xizang provide an unusual amount of biomass. On the other hand, the ecological balance of Xizang forests are rather fragile, after deforestation it is very difficult to regenerate. This situation becomes especially serious in the upper limit of the subalpine belt and the semihumid regions, where the struggle for existence between forest and other types of vegetation has been very intense.

THE MAIN TYPES OF FOREST IN XIZANG

Chen Weilie

(Institute of Botany, Academia Sinica)

The forest vegetation in Xizang is on the south side of the Himalayas and to the east of 93°E. Its main types are as follows: 1). Tropical lower montane rain forest, 2). Evergreen broad-leaved forest, 3). Sclerophyllous evergreen broad-leaved forest, 4). Deciduous broad-leaved forest, 5). Coniferous and broad-leaved mixed forest, 6). Coniferous forest, 7). Krummholz etc.

The distribution of forests shows horizontal as well as vertical zonations. The south side of the Himalayas in Xizang, especially in the East Himalaya, because it is affected by the southwest monsoon so its basic belt develops tropical rain forests, where montane vegetation belongs to a montane series of vertical belts of tropical zone. Above it exist evergreen broad-leaved forest, mountain coniferous forest (Tsuga), subalpine coniferous forest (Abies), subalpine krummholz (Rhododendron) etc. The north side of the Himalayas east of longitude 93°E is less affected by the monsoon than is the south side, the basic belt being evergreen broad-leaved forest. This phenomenon indicates that the vegetation is subtropical montane vegetation. Above the basic belt, it develops mountain coniferous forest or coniferous and broad-leaved mixed forest (Tsuga, Pinus, and Quercus), subalpine coniferous forest (Picea, Abies), and subalpine krummholz (Rhododendron).The region of the three rivers is influenced by the warm draw,the thorn bush develops on the lower slopes. Upward of this, is the subalpine coniferous forest. But there is a clear boundary line at about latitude 30°N, the vertical spectrum is complicated in the south but simple in the north. The forest vegetation types of the south and north slopes show striking difference.

AN ECOLOGICAL STUDY OF THE SUBALPINE CONIFEROUS FOREST IN XIZANG

Li Wenhua

(Commission for Integrated Survey of Natural Resources, Academia Sinica)

1. The spruce-fir forest is widely distributed in the subalpine region of Xizang. An analysis of more than 70 sites of the same vegetation in Eurasia Continent reveals that the upper limit reaches the highest in Xizang. By means of regression calculation, a math-

ematical model has been established to show the relation between the altitudinal distribution and the geographical positions of the spruce-fir forest in Eurasia as follows,

$$H = -2695 + 301X - 1.83X^2 + 14Y - 3.8XY + 0.0233X^2Y + 54860\left(\frac{1}{Y-20}\right)$$

$$-1464\left(\frac{X}{Y-20}\right) + 8.09\left(\frac{X^2}{Y-20}\right) \qquad r = 0.98.$$

H = Distribution of spruce-fir forest in Eurasia (altitude of upper limit in m.)

X = Longitude,

Y = Latitude,

r = Coefficient of correlation.

An investigation has been made for study of the relation between thermal factors and the distribution of forests. It has been discovered that the upper limit of subalpine coniferous forest closely corresponds to the isoline of mean temperature of 12℃ in July.

2. Since Tertiary, the Xizang plateau has undergone tremendous geological changes. Every change has added some floristic elements new or exogenic to the plateau. This explains the fact that the coniferous forest in Xizang is more complicated as well as abundant in composition and structure than that in any other places. Endemic elements are also numerous. On the other hand, a comparison between the subalpine coniferous forest in Xizang and those in other places of Eurasia shows that there are a lot of common genera and species in the lower layer of the communities. This shows the intimate relations between the spruce-fir forests in Xizang and in other regions of Eurasia.

3. The subalpine coniferous forest shows a higher productivity and a longer vegetative life in Xizang than in any other place. The more suitable the environment, the greater the biomass. The Xizang coniferous forest experiences a lower rate of disease and rot. Regional or local differentiation of productivity occurs in forest.

4. The Xizang coniferous forest is weak in resisting external disturbance. Once the ecological balance disturbed, the forest is difficult to restore. Hence, arational management of forests must be adopted in order to achieve sustained yield.

GROWTH AND STRESS FACTORS INFLUENCING TREES AT HIGH ALTITUDES ALONG A GRADIENT FROM OCEANIC TO CONTINENTAL INTERIOR

P. Wardle

(Botany Division, Department of Scientific and Industrial Research, Christchurch, New Zealand)

With increase in altitude or latitude, the duration and intensity of temperatures conducive to growth decrease, so that woody plants are less able to withstand stresses of incdepsing severity. The main stress factors are freezing temperatures, drought and mechanical agents (snow, wind, soil movements), each of which has above-and below-ground components.

There are numerous interactions between factors. Wind lowers leaf temperatures or increases transpiration. Snow shortens the growing season but protects plants from cold, dry air. Trees can be inhibited by the interaction between poor aeration and low temperatures in saturated soils or by soil leaching induced by heavy rainfall.

Biotic factors become especially important near the upper treelimit, because forests recover from damage more slowly than at lower altitudes. Time must also be considered, over scales ranging from the seasonal cycle of biological and physical phenomena to the long periods involved in immigration, extinction and evolution of organisms.

High-altitude environments can be arranged along gradients of increasing severity. A logical starting point is the moist, cloudy tropical mountains of New Guinea, where growing temperatures decrease steadily and equably, with little increase in stress factors. Trees become stunted, slow-growing and microsclerophyllous, though even at tree-limit there are "delicate" forms such as epiphytic orchids and treeferns. On other tropical mountains, such as those of East Africa, clear, dry air results in severe frosts, and the evolution of plants such as *Dendrosenecio* with very large leaves that fold inwards at night.

Beyond the tropics, there is the appearance of a winter season when temperatures permit little or no growth, and towards high latitudes and continental interiors frost and drought impose increasingly severe stresses. Trees have evolved two main strategies in these environments. High-altitude conifers benefit from the good water-storage and water-conservation properties of the tracheidal wood and xeromorphic leaves respectively, and develop appropriate seasonal cycles of growth and cold hardiness. Disadvantages are poor ability to recover from fire and other damage, and susceptibility to some forms of winter drought. Deciduous broadleaved trees show a similar cycle of cold-hardiness in their stems and buds, but their annual production of mesomorphic leaves is achieved at the cost of higher water and nutrient demands. However, because they readily produce adventitious buds they are more resilient.

In oceanic or warm temperate regions such as New Zealand and the southern Himalaya, winter stresses are low, and evergreen trees predominate. In the subalpine forests of Japan, conifers and deciduous hardwoods grow intermixed, while the moist summers and deep, reliable winter snow cover allows broadleaved evergreen shrubs and bamboo to thrive despite cold winters. More continental subalpine climates of central Asia, the outposts of tree growth appear to be of small deciduous species growing in favoured localities.

THE VERTICAL ZONATION AND DYNAMICS OF VEGETATION OF THE HUMID HIMALAYAS IN EASTERN NEPAL

Makoto Numata
(Chiba University, Japan)

The ecological expeditions to the Nepal Himalaya in the eastern humid areas have been conducted three times by the Chiba University Himalayan Committee (The leader: M. Numata) in 1963, 1971 and 1977.

The distribution of climax natural vegetation and semi-natural vegetation such as pastures and weed communities in upland and paddy fields, the zonation of climax forests, secondary forests and grasslands, climatic and soil conditions, etc. were our main subjects of study. Our conclusions of ecological studies on Himalayan mountains, particularly the vertical zonation and dynamics of natural and semi-natural vegetation will be proposed and discussed.

A PRELIMINARY STUDY ON THE VERTICAL BELTS OF VEGETATION OF THE EASTERN HIMALAYAS

Zheng Du
(Institute of Geography, Academia Sinica)
Chen Weilie
(Institute of Botany, Academia Sinica)

The horizontal differentiation of vegetation is very conspicuous both on the southern and the northern slopes of the Himalayas. The Eastern Himalayas are the most humid part of the mountain system, being mainly covered by forests. The tropical forest stretches on the southern slope of the mountain as far to the north as 29 °N, much farther beyond the ordinary boundary of tropical forest than those in other parts of the world. On the northern slope, the vegetation shows a transition from forest to steppe.

In general, 4 vertical spectra of vegetation belts may be recognized in the Eastern Himalaya with two on each slope.On the southern slope the basic belts of the spectra are (1) tropical rain forest plus semievergreen rainforest (humid) and (2) tropical rainforest plus monsoonal rain forest (subhumid). On the northern one, the basic belts are (3) montane needle and broad-leaf mixed forest (subhumid) and (4) montane shrubby steppe (semi-arid). The 4 altogether indicate the regional differentiation of vegetation in the Eastern Himalayas, according to different climatic conditions.

THE AEOLIAN REGION OF THE HIMALAYA AND THE TIBETAN PLATEAU

Lawrence W. Swan
(San Francisco State University, U. S. A.)

The Aeolian zone is most apparent above the altitude of flowering plants and the upper limits of the Alpine zone. This highest and coldest region which contains a few simple ecosystems is supported by wind blown organic debris and atmospheric nutrients. The Aeolian zone can be subdi vided into terrestrial nival and aquatic phases and has been identified in high mountain areas in various parts of the world as well as in Polar environments.

The Aeolian zone of the Himalaya is represented at its lowest altitude of approximately 4550m (15,000 ft.) on glaciers (for example *Machilanus swani*, a thysanuran glacier flea), in glacial pools (crustacean fairy shrimps, *Branchinecta* sp., for example) and in glacial torrents (various aquatic insects, Plecoptera, etc.) where nutrients that have been long preserved in snow and ice are finally released. Terrestrial aeolian organisms are best represented above 5500m (18,000 ft.) and are unique above the maximum altitude for flowering plants at around 6100m (20,000 ft.). High altitude lichens and mosses which are found generally below 6100m are aeolian on that they obtain their nutrients from the atmosphere. Terrestrial animals include anthomyid flies, springtails (Collembola) and mites which feed on such organic debris as pollen, dead insects and plant fragments. The salticid spider *Euophnus amnisupenstes* is a predator of these scavenging animals and has been collected as high as 6750m (22,000 ft.), the highest known altitude for a resident animal species.

Microorganisms have been collected in the gravelly substrate near the summit of Mount Everest. Among several species of bacteria obtained at 8306m(27,250 ft.)one organism, apparently a new species tentatively identified as *Geodermatophilus obscurus everesti*,has exhibited a most unusual life cycle in culture. It would appear that living things on this summit of the earth can metabolize and survive since organic nutrients are widely distributed. Soil temperatures in the sun can reach above freezing, and some water is available in favored niches.

The Himalayan Aeolian zone is altitudinally the most extensive and varied in the world and similar conditions may be expected to extend throughout the high ranges of Central Asia. Indeed, the Aeolian region may represent a relatively large fraction of the area of the Tibetan Plateau.

A PRELIMINARY STUDY OF THE SUBNIVAL VEGETATION OF XIZANG

Li Boshing
(Institute of Botany, Academia Sinica)

The subnival vegetation of Xizang represent the uppermost limit reached by world's vegetation. A study of this phenomenon is not only an exploration into the evolution of world's plants, but also an investigation of the tremendous influence of plateau is upheaval on natural environment. An attempt has been made in this paper to describe briefly Xizang's subnival vegetation based on the information collected in the field.

1. This subnival vegetation in Xizang is distributed below the snow-line and above the line of continual plant cover. The climate is severe, the growth is retared, and the vegetation is primitive, being composed here and there of mesophitic herbaceous plant spots plus some lower plant communites. The sparse cover of vegetation is below 5%.

2. Of the subnival vegetation, three belts may be noticed the upper, the middle, and the lower. In the upper belt are some lower plant communites. In the middle, communities of higher plant are found in the slope of rock storm, rock crevices, rock bowls, and on the flats debris of glacial rivers. In the lower belt communities of broken stones are of greater size, usually on stady slopes of glacial debris, silting spots on the valley bottom, and wherever ground water comes out.

3. Microclimate plays a dicisive role in the existence and development of the subnival vegetation. To the severe conditions, plants also wisely adapt, utilizing whatever water and heat available, completing their life in a very short period, and resisting ecologically the cold and other unfavorable factors.

4. The subnival vegetation has evolved since Pliocene from subtropical alpine meadow, enduring all the drastic changes involved in the upheaval and the glaciation of the plateau. Degeneration might have occurred in the course of succession.

MARSHES OF XIZANG PLATEAU

Zhao Kuiyi Wang Debin Song Haiyuan
(Changchun Institute of Geography, Academia Sinica)

Total area of marshes in Xizang is about 11,000 km^2. They spread over the source regions of Nujiang in the Northern Xizang principally, most of them belong to marshes of flood land and shore marshes of the lake; secondly, there are marshes of alluvial fan edges and marshes of valleys in wide upper reaches of Yarlungzangbo jiang, in the moun-

tainous valley zone in the Eastern Xizang and in the Qiangtang plateau of the Northwestern Xizang.

The genesis of marshes in this region depended mainly on the characteristic hydrothermal and geomorphological conditions generated by plateau upheaval, in which the chief factors of marshes generation are steady supply of melt water and *phreatic* water. By C^{14} dating to the peat taken from Wumaqu in Damxung county and Dawalong marshes in Zhongba county, it is known that the absolute ages of the peats are 9,970±135 and 3,985 ±85 years respectively, and it shows that the marshes were generated in the Holocene. According to the analysis of pollen, vegetation remains and clay minerals, it also shows that ancient climates during the Holocene had involved cold, warm, dry and wet changes, while the climates in the Mid-Holocene had been more favourable to the development of marshes.

In accordance with developing of marshes with or without peat accumulations, the Xizang marshes can be classified into two major types and further into 11 subtypes of marshes according to the geomorphologic sitution and the regime of watersupply. Contrast and analysis of geomorphology, hydrologic conditions, soil and vegetation characteristics of the various subtypes of marshes have been presented.

Marshes in this region have possessed following features: the most of them are *gley* fen in the Northern Xizang, while in the Southern are peat moor; the more westwards and northwards they distribute, the higher they locate, the upper limit of marshes location attains to 5,200 m above sea level; but are lacking of *impermeable* clay beds, the decomposition of peat is low; they are herbaceous marshes chiefly, meanwhile the *Kobresia littledalei* is a dominant species and a peculiar plant in plateau marshes; the marshes are under a tendency of natural draining and degeneration at present.

Marshes are an important base of animal husbandry in Xizang whose latent potentialitied of increasing production are high, *and* the management of which should be more effective in order to raise the grass production. Peat is an important natural resources. an agricultural fertilizer already. In accordance with the developmental tendency of marshes in Xizang, approproiate measures should be taken in order to protect them.

PHYSICO-GEOGRAPHICAL DIFFERENTIATION OF THE QINGHAI-XIZANG PLATEAU

Zheng Du, Zhang Yongzu, Yang Qinye
(Institute of Geography, Academia Sinica)

The Qinghai-Xizang plateau is a unique environment in the world due to the combined effect of high altitude, vast expanse of the plateau surface, and its latitudinal position. The physical conditions are further complicated by the dissection of the land surface into deep gorges consequent to the young age of evolution as well as by the integration of horizontal zonation with the vertical, Over the plateau, the horizontal zonation is similar to that over the lowlands, but the altitude distinguishes the zones from what can be expected of lowlands of the same latitudes. Hence, the most southerly zone of the plateau is the montane type of forest and the most northerly zone of the alpine type of steppe or desert, instead of a normal type. Of the vertical zonation, there are mainly 2 groups of spectrum, i. e. the oceanic (humid and subhumid)and the continental (subhumid, semi-arid and arid). It may well be pointed that the upper forest limit in Xizang tops the world, being 4400 m or 4600m above sea level. This probably results from the warming effect of the large landmass. Also the snowline is the highest of the northern hemisphere in central and west Xizang due to dryness.

An important feature in the zonation of the Plateau is the integration of horizontal zones with the vertical. The dissection of the plateau by deep gorges allow the individual vertical zones to outcrop on the land and to extend over the plateau surface as a corresponding horizontal zone. From the southeast including the sharp turn of the low Yarlungzangbo, which is the relatively warm humid part of the Plateau,zones of forest, meadow, steppe, and desert come in succession toward the cold arid northwest.

Based on the horizontal zonation, which reflects the combined effect of all the physico-geographical factors, a tentative scheme of 9 major zones (regions) have been proposed for the Plateau.

THE IMPACT OF UPLIFT OF THE QINGHAI-XIZANG PLATEAU ON THE GEOGRAPHICAL PROCESSES

Zhang Yongzu Li Bingyuan Zheng Du Yang Qinye

(Institute of Geography, Academia Sinica.)

The Qinghai-Xizang plateau is the world's youngest uplifted massif of great area and altitude. Its peripheries show all the phenomena consequent to river rejuvenation. The rejuvenated activity varies in strength and form in different sections. Thus the rejuvenated belt is wide and vigorous in the southeast periphery, but narrow and weak in the northwest. This has been resulted from the fact that the uplift has introduced a contrast in proccess and development between the 2 peripheries concerned. In the interior of the plateau, the deteriorating climate has made most normal streams intermittent or seasonal, as has the retrogression of lakes made the exterior drainage interior. The change of drainage has produced a good number of shallow divides on the old river beds. Some actual processes might have inherited the ancient course; for instance, the plateau has been uplifted to such an elevation that glaciation and periglaciation may continue to work and develop at present.

Since Pliocene,the general trend of environmental change has been from warm humid to cold arid. The actual succession of horizontal zones from southeast toward northwest in the plateau is as the following: subtropical forest, temperate forest, cold frutescent meadow, cold steppe, and cold desert. The range of change gradually lessens toward the southeast. The forest retreats from the interior of the plateau toward wherever favrourable, hence It is concentrated in the southeast periphery. The change of the natural zones as a whole including faunal and floristic elements follows similar trend.

As far as soil change is concerned, 3 points of significance stand out; the youthfulness, the polygeneses, and the deterioration of soil processes. The first and the last points are reflected by such phenomena as the weak weathering of the minerals, the low content of clay, the cutan being mainly composed of silt, the presence of regosols in the upper part of the profile, the presence of various microstructure due to cryological phenomena, and the degenerations of bioprocesses. In the cold desert soil the plant residues serve mainly as a frame for cryological processes. The polygeneses of soil may be specified by the composite characteristics in the profile due to the superimposition of ancient process onto the actual, as well as by the soil micro morphology. A steppe soil profile may further reflect the following order of changes: arid temperate, humid temperate, humid-cool, arid cool, and arid cold. The characteristics of the physico-geographical complex in the plateau, as well as the stability, advancement, and retrogression of the characteristics, not only reflects the tri-dimensional changes, but also the consecutive impact of the uplift.

A SYUDY OF LAND TYPES OF THE QINGHAI-XIZANG PLATEAU

Sun Honglei
(Commission for Integrated Survey of Natural Resources, Academia Sinica.)

Land type is a natural complex integrated by such elements as relief, vegetation, soils, and parent materials, climate, hydrography, etc. The character of a land type plays a deciding role in determining the orientation, approaches, and capacity of agricultural development. The tentative classification of the types here presented results from several years of field work (1973—1979).

In the peripheries of the plateau, four spectra of zones have been recognized. They represent the vertical zonations of the surrounding areas up the plateau respectively from Assam in the south, Sichuan in the east, the Tarim basin in the northwest, and the Qaidam basin in the northeast.

In the plateau proper, the land types are more complicated, being the product of the interaction of horizontal and vertical zones. Three series, each with three spectra, have been proposed, The three series respectively belong to the arid, semi-arid, and sub-humid conditions. And the base zones of the nine spectra appear respectively at the elevation of

5000 m, 4500 m, 3000 m, and for one spectrum, at 2500 m. Again, these four base zones respectively belong to the plateau frigid, plateau cold temperate, plateau temperate, and the plateau warm temperated belts.

Also an attempt has been made to classify the land types taxonomically into system, group, subgroup, and species, totally into thirteen systems. The subdivision of a system into group aims at representing the different zones of the spectra, hence a group is such a land unit with similar climate, soil, and vegetation that may determine the orientation of agriculture. Further subdividing a group into subgroups according to land form and hydrography may justify the similarity of land use. Every land unit has been evaluated as to the suitability to agriculture, animal husbandry, or forestry.

APPLICATION OF NATURAL HAZARD MAPPING TO THE SOLUTION OF PRACTICAL PROBLEMS IN THE DEVELOPMENT OF HIGH MOUNTAINS AND PLATEAUS

Jack D. Ives
(University of Colorado, U.S.A. and
Highland-Lowland Interactive Systems
Project Coordinator
United Nations University)

Modern development in high mountain areas is proceeding at many levels and rates depending upon degree of industrialization, mountain populaton pressures, and proximity of large low and population centers, of the countries concerned. At the same time there is growing awareness of the accelerating environmental degradation that results either directly from the technological developments themselves, or, more spontaneously, from indigenous population growth, deforestation and/or overuse and abuse of the basic soil resource, The range of environmental impacts is immense. These include development of a massive tourist infrastructure with financial/economic control frequently exerted from outside the mountain region, as in the European Alps, to rural, agricultural pressures and attendant deforestation and soil losses, as along the southern flanks of the Himalaya, to major mining, hydroelectric engineering, and strategic highway development, in many other areas. Frequently the deleterious impacts in the mountains are transferred downslope and have disastrous consequencies for the neighboring lowlands. Such induces complex feed-back mechanisms in terms of both human and natural processes that are the objects of study of the United Nations University (UNU) Highland-Lowland Interactive Systems Project.

Much of the burgeoning development is proceeding more or less spontaneously, and/ or at a crisis level, with the possibility for adequate, full-scale planning and land-use assessment either unattainable, or unknown. Frequently, the works of man are placed, knowingly or unknowingly, in sites subject to natural catastrophe or slope instability; frequently such works may exacerbate an already potentially or actually unstable site situation. This results in enormous costs in funds, resources, environment, life, limb and human health,

One vital component of land-use planning is the technique of identifying, categorizing, and mapping areas sudject to natural mountain hazards. These are defined as those processes occurring in nature that are a combination of slope, soil, or bedrock instability, with precipitation and gravity, that may come into contact with human activity. In the more recently formed mountain ranges these situations are rendered more complex by tectonic instability and vulcanicity. They range from slow acting processes such as soil and frost creep, expanding and contracting soils, solution and surface collapse and landslides, the results of which are usually cumulative, to debris flows, mountain torrents (German: *wildbach*), rockfalls, and ice and snow avalanches, the responses of which are usually catastrophic and which place human life at risk. Often human activities, such as deforestation and construction of agricultural terraces on steeper and steeper slopes, are so inexticably interwoven with the natural slope processes that the term *natural hazard* would appear inappropriate and is better replaced by the simple, non-specific term *Mountain Hazard*. Such is the situation in the Middle Mountain Zone of Nepal, Sikkim, and West Bengal.

Until very recently the techniques of mountain hazard mapping have been very inadequately developed; even the need for such development has not been widely recognized. Two recent events, however, have served to rapidly improve available techniques and level of expertize, and to provide widespread publicity for the problem. Pioneering efforts in the general field include the Swiss avalanche hazard mapping and zoning plan (Frutiger, 1970), the Austrian combined avalanche and torrent (*wildbach*) mapping and zoning(Aulitzky, 1973), and several comparable projects in France, Bavaria, United States, Canada, and the Soviet Union. Organizationally, the Unesco Earth Sciences Programme, but especially the Unesco Man and the Biosphere (MAB) Programme, and the United Nations University (UNU) Natural Resources Programme, have drawn attention to the need for recognition of both the problem and opportunities for application. Unesco-MAB and UNU have encouraged development of, and experimentation with, combined hazard mapping techniques. Particularly significant progress has been made in Switzerland(Kienholz, 1977; 1978) and in Colorado, USA (Ives *et al.*,1976; Ives and Bovis,1978; Ives and Plam, 1980), and these two efforts have become closely interrelated (Dow, Kienholz and Plam, 1979; Ives, Baumgartner and Plam, 1980). In turn the combination of effort between Boulder, Colorado, Bern, Switzerland, and Vienna, Austria, has been applied to the development of research programmes in Nepal (UNU-Unesco), Northern Thailand (UNU), and in the home countries.

The purposes of this paper are: (1) to detail these developments, (2) to introduce examples of the map products of the various research developmental phases to the participants in the Symposium on Qinghai-Xizang (Tibet) Plateau, (3) to discuss problems and limitations, and (4) to assess ways and means of collaborating with our Chinese hosts in the possible application of this growing awareness and level of expertize to solution of land-use planning problems in the high mountains and plateaus of Western China.

Some details of the current UNU-Unesco applied research programmes in Nepal and Northern Thailand will be given. Finally, cartographic and field identification problems will be discussed. Advantages and limitations of air photointerpretation and satellite imagery/remote-sensing will be outlined.

In conclusion, it is emphasized that some of the major losses of life and property, such as those that have occurred on a catastrophic scale in the European Alps (Aulitzky, 1974), can be avoided by proper planning. The plea is a simple one;it is best to identify hazardous areas prior to development so that, where undeveloped land is available,a passive,zoning approach is taken.The unplanned approach results in constrution taking place in hazardous localities that subsequently necessitate protection by specially engineered structures. This enormously increases costs and contributes to environmental degradation.

PLATEAU, RIVER GORGES AND LOCAL WIND PHENOMENA

U. Schweinfurth
(South Asia Institute, University of Heidelberg, Department of Geography, Fed. Rep. Germany)

The problem discussed derives from the interrelationship of tectonics resp. topography and climate; the local manifestation, especially in the vegetation, results from a combination of these factors. The evidence is based on literature only and it is therefore not surprising, that there are still blank patches in our knowledge of the area.

The writer's interest stems from his thesis on the vegetation of the Himalayas with a vegetation map of the Himalayan system (from Kabul, 70° E to the Yangtsekiang, 100° E scale 1:2,000,000), on which botanically unknown country is left blank. In pursuit of this work, the importance of the river gorges for the vegetation distribution emerged. By comparing the deep gorges which dissect the mountain walls surrounding the Central Asian /Tibetan Plateau certain similarities, but also striking contrasts became evident. The gorges in the southern rampart of the plateau are all under the influence of interchanging airmasses from above the plateau (in the N) and the sea (in the S). This overall constellation is, locally, influenced by the shape of the valleys, the length of straight courses, the height of the slopes resp. the depth of the gorges, the vegetation cover etc. Research deliberately, included the river gorges in the E in a section between 28—30°N,in the hope of finding some clues, if not a solution to the conditions encountered on a minor scale in the Himalayas sensu stricto) As expected, Salween, Mekong and Yangtsekiang, by virtue of their grandiose scale, provide for the most spectacular evidence of the interaction of topography, climate and vegetation. They offer channels to the air masses, winds, and immediately influence them in their behaviour. Lacking yet more detailed evidence from the spot, bservations of winds in the Alps of Europe (WAGNER 1932) and in the Central Andes in South America (TROLL 1952) helped to provide an explanation: an intricate combination of up-and down-valley-winds and up-and down-slope-winds, resp.wind systems, with various interrelationships, seems to establish itself in these gorges. As a result, dry valley bottoms, replaced by wet forests at certain altitudes, a sequence repeated on both sides of the valleys, are met with in all gorges. In addition, tropical influences (from the S) penetrate far up into the continent and temperate influences reach on the upper parts of the ranges far down South, resulting in a complex vegetation arrangement, to which history, in the traces left by the ice age (s) adds still another dimension.

It would be, first of all, of great interest to fill in the blank patches remaining in our knowledge of the veget ation in the river gorges. More local evidence of the wind phenomena and of traces of the ice age (s) are furthermore important desiderata for a better understanding of the country. To learn about research in the river gorge country during the past 30 years, is one of the most exciting attractions to attend this symposium.

AGRICULTURAL DIFFERENTIATION IN THE QINGHAI-XIZANG PLATEAU

Cheng Hong
(Chengdu Institute of Geography, Academia Sinica)
Ni Zubin Sun Shangzhi
(Commission for Integrated Survey of Natural Resources, Academia Sinica)
Yu Xiaogan
(Nanjing Institute of Geography, Academia Sinica)
Chen Douren
(Institute of Agricultural Economics, Chinese Academy of Social Sciences)

The Qinghai-Xizang plateau is a unique in world agricultural geography. High altitudes, complicated landforms, difference in temperature and rainfall, and the historical and economic factors lead to the horizontal and vertical differentiation and to the characteristics adapted to alpine environments of land use and production.

This agricultural peculiarity is best reflected in the structure of land use. The natural grassland makes up 62% of the total land acreage, forests make up 4.1% is being confined in the south and east, and the cultivated land occupies only 0.48%. The cropland is centralized in the river valleys, the five cold-tolerant crops, e.g. highland barley, wheat, peas, potatoes, and rape make up 86% of the total acreage. The alpine forests of mainly darkconiferous trees, and the animal husbandry with the typical yaks and Xizang sheep dominate respectively in their own sectors.

The temperature lowering with the altitude, the agriculture leads to the multizonation in the vertical sense, and the vertical zones, on coming to the land surface, extend to become horizontal zones, as do the physio-geographical zones.

According to these regional differentiation, the Qinghai-Xizang plateau may be divided into three agricultural regions to be subdivided into eleven zones:

The agro-forest region into the Sichuan-Xizang agro-forest zone, South Xizang agro-forest zone, Sichuan-Xizang agro-forest-pastoralzone, and the east Xizang agro-forest zone.

The agro-pastoral region into the east Qinghai agricultural zone, north Qinghai agro-pastcral zone central Xizang agricultural zone, and the south Xizang agro-pastoral zone.

The pastoral region into the east Qinghai-Xizang pastoral zone,the west Qinghai-Xizang pastoral zone, and the west Xizang agro-pastoral zone.

GEO-ECOLOGICAL DIFFERENTIATION OF HIGH-ALTITUDE CULTIVATION IN THE HIMALAYAN-TIBETAN SYSTEM AND SOUTH EAST ASIA

Harald Uhlig
(Geographisches Institut, Justus Liebig-Universität,Giessen,Fed.Rep.Germany)

The paper examines the environmental conditions of the highest cultivation of barley in Tibet (4540 m) and Nepal (4470 m), both irrigated, and of potatoes in Nepal (4690 m). It would be of interest, to discuss with Chinese experts any new results from Tibet and other high mountain regions.

Further, the distribution and types of rice-cultivation are discussed. Its highest altitudes are not found in the tropics, where rice is the staple, but in the subtropical Himalayan system, including the Hindu Kush and the Yulang Shan (Yunnan).Rice cultivation, with old irrigation systems, is found up to 2850m in Jumla Distrct,Western Nepal; in the Yulang Shan it is controversial beween 2475 and 2700 m.Again, the question will be raised about a possible rice cultivation and its environmental conditions in Southern Tibet.

The high sites benefit from the climatclogical effects,which have formerly been summarized under "mass elevation". In contrast to the high interior valleys and intermontane basins with a dry and radiation-rich summer (and ample irrigation from the glaciers), the outer, much lower slopes of the Himalayas are much more cloudcovered, cooler and moister and thus much more unfavorable for rice-cultivation.Irrigated rice achieves much higher altiudes in the high valleys of the Inner Himalayas than does irrigated or even dry-upland rice (so-called "mountain rice") on these outer slopes. The possible and economic cultivation limits drop still much lower in innertropical regions of Indonesia and already of mainland South East Asia. Despite of high population pressure, the geoecological conditions do not allow any rice-cultivation above 1500 m.most fields are much below this, double cropping of rice is replaced above 8—900 m by rotations with cabbage, potatoes etc. Long cloud-cover and high precipitation at the slopes of the isolated volcanoes do not allow any cultivation of other crops (vegetables) above 2250 m at all (Tengger Highlands, East Java), which is already an exception.

The coincidence of quite different types of rice cultivation with the eco-climatic division of the Himalayan system by C. Troll will be demonstrated. A classification of the varying altitude- "stratification" of rural settlements and land-use Types is attempted.

ON THE UPPER LLMIT OF AGRICULTURE IN XIZANG

Yu Xiaogan
(Nanjing Institute of Geography, Academia Sinica)
Sun Shangzhi
(Commission for Integrate Survey of Natural Resources, Academia Sinica)

Xizang tops the world in the upper limit of agriculture. Such cold-tolerant crops as highland barley, wheat, rape, potatoes etc. may go up as high as 4600-4750 m, pasture lands 5500 m, herdman's settlements 5000 m. From east to west, the limit increases in elevation as does the intensity of continental climate. The achievements by the Xizang people in promoting the cold tolerance and early maturity of the crops,as well as fighting against the cold, serve the basis of elevating the upper limit.

The higher the elevation, the shorter the growing season, the more frequent the natural hazards,and the lower the economic result. In accord with the principle of economic rationality, it is advisable the upper limit for the near future to set at 4000-4100 m in the east and 4300-4400 m in the west. For the remote future, the limit might well be still lowered for a greater distribution of root and other forage crops, i.e. a better supply of fodder.

RELATIONSHIPS BETWEEN THE CHARACTER OF TEMPERATURE FROM JANUARY TO DECEMBER AND THE UPPER LIMITS OF CROP PLANTING IN XIZANG

Hou Guangliang, Jiang Shikui, Ni Jianhua
(Commission for Integrated Survey of Natural Resources, Academia Sinica.)

1 . Based on the main influential factors of the temperature formation in Xizang—— latitude, altitude, sunshine hours, moisture index and regional physiographics, an estimative formulas of the temperature from January to December, was suggested.

2 . According to relationships between the character of temperature and the upper limits of the crop planting in Xizang, it was pointed out:a). The characteristic temperature conditions of Xizang, is the main factor determining upper limits of the crops planting. This is especially true for the cold resistant crops planting in Xizang.

b). On the surface of same height in the warm season, the mean temperature of western Xizang is higher than that of the eastern Xizang, and the mean temperature of the upper and middle reaches of Yarlungzanbo Jiang is higher than that of the northern Xizang and south slope of Himalayan mountain range.The upper limit of the crop planting is also similar to the temperature conditions.

c). The stronger solar radiations and the regional physiographic factors(such as:microclimate, lakes, vegetations) evidently result the microclimatical difference. In the better microclimatical zone, the upper limit of the crop planting is much higher than that in the other zones. For instance the better microclimatical region near the Shanjian lake side in western Xizang, the upper limit of highland barley planting can reach 4750 m above sea level.

AGROCLIMATIC ANALYSIS OF THE HIGH-YIELD WHEAT CROPS IN QINGHAI-XIZANG PLATEAU

Li Jiyou
(Commission for Integrated of Natural Resources, Academia Sinica)

The yields of wheat crops in Qinghai-Xizang plateau are considerably high. The highest spring wheat crops yield record in experimental field was more than 2000 Jin per Mu, while the winter wheat was 1742 Jin, and highland barley was more than 1200 Jin per Mu. Not only the highest yield record in unit area of chimonophilous wheat crops appeared in this plateau, but also the highest average wheat yield in large area of our country is also over Qinghai-Xizang.

The level of production and agrotechnique condition in the agricultural regions of plateau, especialy in Xizang, are far lower than that of other provinces.Evidently,this high-yield record is close related with the specific climate of the plateau. Mainly: the favourable temperature, the intensive solar radiation, and the adequate cooperation of photophase cause of high-yield wheat corps in Qinghai-Xizang plateau through several years of expedition in Xizang.

From the analogous analysis of crop climate it can be seen that the plateau is of the merit of the temperature of the European high yield wheat region, but without the demerit of rare solar radiation in Europe.Also there are of the merit of intensive or even more intensive solar radiation as main wheat region of middle latitude of north America and North China have, but without the dermerit of short duration of lower temperature in early stage, and excessive high temperature in late stage. In the agricultural region of the plateau, the temperature is optimum for the growing and developing of chimonophilous wheat crops. The suitable low temperature prolongs the growing period of wheat, particularly from turning green to joining stage (for spring wheat it is the stage of tillering to elongation), and also prolongs the heading to maturity period. Therefore it is very favorable for differentiation of ear, filling grains, and accumulation of organic matters. The intensive solar radiations, especially during the period of intensive photosynthesis, provides plenty of energy sources to forming organic matters. The adequate cooperation of photophase and temperature enable to avoid the phenomenon of "napping" during the photosynthesis process and the phenomenon of "foced ripe" during the grain filling and ripening period.Therefore the intensive photosynthesis and rapid accumulation of organic matters would lay a firm foundation for high-yield wheat corps. Those are the basic agroclimatic cause for high-yield wheat crops in Qinghai-Xizang plateau.

During the major period between heading and maturity of wheat crops in Qinghai-Xizang plateau, the daytime is not long, daily mean sunshine(actual sunshine hours) is also not long.It is shorter than middle latitude wheat region of North China,and more shorter than high-yield wheat regions in Europe. During this period, the daily range of temperature on Qinghai-Xizang plateau is also not greater than the wheat region of North China. On Qinghai-Xizang plateau the maximum daily range of temperature appears in winter and spring, that is one of the reasons caused the death of the seedings. Therefore, more annual duration of sunshine and greater daily range of the temperature is not the cause of high yield of wheat crops in the plateau at least in winter and spring times as previously assumed. Conversely, the lower temperature as suggested to be unfavorable factor before, is just the important factor of high-yield chimonophilous wheat crops on Qinghai-Xizang plateau.

THE INFLUENCES OF ECOLOGICAL ENVIRONMENT ON THE WHEAT-LIKE CEREALS' PRODUCTION IN XIZANG

Lu Jimei Yu Binggao
(Nanjing College of Agriculture)

Xizang is a region where the wheat-like crops come to maturity extremely late in China. In recent years, good harvest over 1000 jin per mu has been achieved in Xizang for wheat, barly, and rye, with wheat reaching as much as 1742 jin/mu. Drooping ears with full grains on proper plant shape promise the high yield. A harvest of 1000-1600 jin per mu usually results from ears each with 40-50 grains, of which every thousand grains weight over 45-50 gramme, and the number of ears amounts to 250-470 thousand in one mu. The favorable conditions for crop growth in Xizang are further witnessed by the fact that all the above-mentioned figures would increase, when the ordinary wheat or barley from lowland China is introduced to Xizang.

The yield of a crop reflects the accumulation of organic matter during the growing season. In Xizang, the cool summer with adequate sunshine from intense solar radiation favors the cool tolerant wheat and it's organic accumulation. It is shown that in the milk period of wheat is accompanied by a significant increase in photosynthetic intensity and in organic accumulation. The lengthening of the growing period also counts. The slow warming up in spring and the absence of high temperature over 30℃ in summer definitely tend to prolong the tillering period of the yound plants and the milk period of the grains and these in turn promote the increase in the number of ears and in the weight of grains. During the jointing stage period, the sunshine, radiation, and the cool weather with slight rainfall together help regulate the plant into shape and hence increase the number of ears, as well as the economic coefficient.

ON THE POTENTIAL AGRICULTURAL PRODUCTIVITY IN THE MIDDLE REACHES OF THE YARLUNGZANGBO RIVER

Yang Qinye Zheng Du
(Institute of Geography, Academia Sinica)

Sunlight is the only source of energy of photosynthesis, whence over 90% of the biological production of crops comes. With an adequate supply of heat, water, nutrient, and CO_2, the intensity of photosynthesis is primarily a function of solar radiation. It should be high everywhere in Xizang.

Based on sunlight-temperature conditions, the potential crop productivity has been estimated. It turns out taking 0.4 as economic coefficient, to be as high as 2700 jin per mu for winter wheat. Compared with this, the actual yield of winter wheat by the Agricultural Research Institute in Xigaze, namely 1742 jin per mu (or13566kg per hectare), attains only 65-70%.

An analysis of the ratio of potential evapotranspiration to precipitation shows that 4500 m^3/ha of water is needed to irrigate winter wheat in a normal year. Deficiency of soil fertility is another limiting factor. Both amelioration of soil condition by applying fertilizers and extension of irrigated fields are necessary. For the time being, two measures might be proposed: (1) making denser plantation, (2) keeping a certain amount of spring wheat.

BASIC CHARACTERISTICS OF GRASSLAND RESOURCES IN XIZANG

Deng Liyou
(Institute of Microbiology, Hobei)

The special environment of Xizang bestows on the grassland resources the following characteristics:

1. Vast area and great variety.

2. The grass production per mu is poor, but the grasses are nutritions with high protein content.

3. Marked seasonal difference. This results from the long cold period in the winter half year and the short warm period in the summer half.

4. Marked spacial difference.

5. Insufficient pastureland for grass cutting.

According to the method of biological and climatical composition, 3 classes are assumed for Xizang grassland. The "classes" are divided according to the differences between hydro-thermal composition and vegetation, topographic feature; and "sub-classes" are further divided according to the differences of the ecological type and the community of the grassland. There are different "types" in the "subclasses".

9 classes are divided;

1. Alpine meadow grassland of cold humid.
2. Plateau valley steppe grassland of cold semiarid.
3. Mountain steppe of cool-temperate semiarid.
4. Meadow of moist lowland.
5. Mountain shrub steppe of temperate semiarid.
6. Mountain desert of cool temperate arid.
7. Plateau desert of cold arid.
8. Mountain shrub steppe of cool-temperate humid.
9. Mountain sparse steppe of temperate humid.

AN EVALUATION OF RANGE-LAND IN XIZANG

Mou Xindai
(Department of Grassland Management, Gansu Agricultural College)
Deng Liyou
(Institute of Microbiology, Hobei)

Natural rangeland suitable for pasturage in Xizang covers about 829500 km^2, or 1244 million mu, making up 69.1% of the total area of the Autonomus Region. This is an important resources for agriculture development.

The main types of grassland here are: alpine meadow, plateau valley steppe, alpine desert steppe, lacustrine and riverine meadow, alpine desert steppe, plateau valley desert steppe, subalpine frutescent meadow, montane woodland.

The livestock potential in Xizang is still considerable. However, the growing period for grasses is short, the winter pasture is insufficient, and the livestock may not be increased in great scale.

The glassland of Xizang, according to its stock capability, may be graded as good, medium, low, and poor with respectively the following percentage: 10.09%, 21.39%, 44.23%, 13.84%, and 10.45%.

ON THE GEOGRAPHICAL DISTRIBUTION OF DOMESTIC ANIMALS IN XIZANG

Huang Wenxiu　　Wang Sufang
(Commission for Integrated Survey of Natural Resources, Academia Sinica)

The natural environment differentiates in Xizang domestic animals, because of their distinct adaptability, show a special distribution pattern. Animals of rangeland ecosystem, such as yak, sheep, goat and horse are eurychoric; they are found widely and numerously in the pastoral and semi-pastoral region, and in a certain quantity in the farming regions. Whereas animals of agricultural ecosystem, such as cattle, donkey, and swine are shenochoric; being mainly distributed in agricultual and semi-agricultural regions.

Another characteristic of the distribution reflects the impact of the altitude, i.e. the composition and rates of animals differ in altitude. In southeast Xizang, with elevation below 3500m, animals are of the agricultural ecosystem. But in north Xizang, where the plateau averages over 4500 m in elevation, animals are mainly of the rangeland ecosystem.

For the individual animals, the distribution may be summarized as the following. The Yaks, well adapted to the sub-humid cold, are mainly found in areas over 4500 m in elevation grazing in the over alpine meadow. A formula has been attempted to express its distribution Y as correlated to the temperature T as:

$\hat{Y}=42.7156-3.1614T-0.0227T^2$,

and to precipition P as:

$\hat{Y}=4.1981+0.0662P$.

The sheep are well adapted to the alpine steppe of arid cold over 4500 m above sea level, and their distribution may be expressed as;

$\hat{Y}=48.4440-2.0303T-0.1617T^2$, or as:

$\hat{Y}46.3350+0.0812P-0.0001P^2$.

Goats in arid deserts with sparse vegetation and their distribution conforms to:

$\hat{Y}=26.0708+1.0677T$, or:

$\hat{Y}=265.8244P^{-0.4184}$

Horses are in the warm semi-humid meadows 3500-4500 m above sea level. Their distribution accords with

$\hat{Y}=1.1271+0.0214T$, or:

$\hat{Y}=0.3589+0.0040P$.

THE ADAPTABILITY OF MAN AND ANIMALS ON THE PLATEAU

C. Jest

(C. N. R. S., Paris, France)

A long term field research in the inner valleys of the Himalayan ranges (especially Northern Nepal) gives us the possibility to present the mechanisms of adaptation of Man in difficult conditions.

At an altitude of 4000 meters live small communities in a harsh environment; they have permanent settlements and a twofold activity: agriculture and animal husbandry.

They live at the highest level of an ecological transect which links the Gangetic Plain to the Xizang Plateau. (One must note that differences in ecozones produce different adaptative strategies, and questions of deficits and surpluses must be viewed within the context of the area's ecological structure).

Agriculture practices are limited to the cultivation of one crop of barley in a year. Cattle breeding includes yak, hybrids, sheep and goats. (Cattle breeding is very important as it insures to the community the necessary food supplies and also products for weaving and transport).

The analysis of the type of animal products (horses, yaks and hybrids, sheep, goats), the herding systems show that Man is able to imagine and master difficult environments. The natural-, mineral, fauna and flora-resources, though scarce, are well exploited for building materials, fuel and medicinal purposes.

Survival is assured by a system of barter with the populations living in the Xizang region, People's Republic of China, where grain is exchanged with rock salt. This trade is not only important but vital for the populations of the inner valleys of the Himalayas.

One of the most distinctive features of the life in high altitude is the extreme mobility of the people, this phenomenon being related with the environment.

This contribution should also help comparative studies in the inventory of the existing fauna and flora, its utilization by Man and agricultural and pastoral practices in harsh conditions, as well as the technological inventions Man has made to master the environment.

As a methodological addition to this paper we would like to present the extensive documentation work done from 1965 onwards to collect data, publications and reports on the High Altitude of the Himalaya-Central Asian regions by the Centre National de la Recherche Scientifique multidisciplinary team, and the results of the International Symposium "Himalaya" organized by C. N. R. S. in December 1976. We believe that a network of information is necessary to promote further researches and comparative studies with Chinese scientists.

ZONATION OF ANIMAL HUSBANDRY IN THE QINGHAI-XIZANG PLATEAU

Ni Zubin
(Commission For Integrated Survey of Natural Resources, Academia Sinica.)

The Qinghai-Xizang plateau is unique both in physical and human respects. It is vast in expanse partially complicate in landforms, and hence clearly differentiated in latitudinal position and in elevation. From southeast to northwest over the plateau, the changing of climate from warm humid (semihumid) to cold arid (semi-arid) is accompanied by an alternation in vegetation as well as in pasture, e.g. forest—meadow—steppe desert. In addition, the difference in animal's adaptability to the cold aridity and oxygen insufficiency of weather complicates the zonal differentiation of animal husbandry in altitude, from south to north, and from west to east.

According to the pastoral differentiation, a scheme of zonation into 3 zones has been proposed. And They are subdivided into 15 regions according to the combination of animals, as following:

1. The yak zone in southwest Xizang with its 5 regions:
   a). The region of yak and sheep of northeast Xizang, south Qinghai, and west of Sichuan,
   b). The region of yak, cattle, sheep, goat, and swine in east Xizang and northwest Yunnan,
   c). The region of yak, sheep, cattle, and goat in west Sichuan and south Gansu,
   d). The region of cattle, swine, and goat in south slope of the Himalayas,
   e). The region of swine, cattle, and goat in west Sichuan.
2. The yak and sheep zone of central Qinghai-Xizang, of which the 3 regions are:
   a). The region of yak and sheep of Nagqu and Marxin plateau,
   b). The region of yak, sheep, cattle and goat of south Gangdis slope and the Lhasa valley,
   c). The region of yak, sheep and cattle of Tanggula zone and south Qinghai,
3. The sheep zone of west and north Xizang, of which the 7 regions are:
   a). The region of sheep, yak, and goat of the Changtang plateau,
   b). The region of sheep, yak, and goat f south Xizang,
   c). The region of sheep, yak, cattle and goat of the Yarlungzangbo valley,
   d). The region of sheep, goat, and yak of west Ngari,
   e). The region of sheep, cattle and goat of Qaidam,
   f). The region of sheep, cattle, and yak of the Qilian mountain and south Qinghai,
   g). The region of cattle, sheep, swine, and horse of east Qinghai.

THE PROBLEMS OF DISEASES AND INSECTS IN THE HIMALAYAS' FOREST ECOSYSTEM

Chen Momei
(Chinese Acadamy of Foreat Science)
Huang Fusheng
(Institute of Zoology, Academia Sinica)

Being a natural region with unique forest ecosystem, S. E. Xizang is one of the treasuries in natural resourres of our country. Inside several forest communities, insects and fungi are small and minute, living intricately and often undiscernible, but amongst themselves and the forest ecosystem as a whole there are certain organic and complicated relationships. This forest ecosystem not only determined ecological equilibrium and instant for this region but also effected to other regions.

This paper mainly deals with the distribution, composition and succession of insect fauna and fungal flora before and after the exploitation of forest resources and their influences upon the present and future of different kinds of forest. The aim is to find a way to promote the benefit and to rid of harmness.

I. The fungal flora and insect fauna under the condition of the ecological equilibrium in forests.

Through the nature selection, competition and adaptation of fungi and insects to the environment for a long time,a special Himalayan's fungal flora and insects fauna of various virgin forest communities has been formed. They effect on the formation and exchange of biomass in different way. Generally, the amount of fungi and insects is definitely limited. There is a equilibrium among the species of fungi and insects. These are II orders, 30 families and 85 generas of fungi.Among them 80 % of the fungi are belong to *Bidiomycetes* (*Polyporaceae*, *Uredinales*). More than half of the insect specimans were collected in forests. The main species of insects are *Orthopter*. *Lepidopter*, *Coleoptera*, *Hymenoptira*, etc.

As soon as the forest ecosystem is interfered, some general species of fungi and insects may replace the dominate species' communities, that may be more injurious to the forests and their regeneration.

II. The increasing of fungal diseases and pests after the forest ecosystem are interfered.

As a result of unproper and inplaned harvest of the forest, unsuitable reforestation and introdution of tree species in the past twenty years, the forest ecosystem was interfered. Thus the composition of fungi and insects species and their distribution in the virgin forests were greatly changed. This made the damage done by fungi and insects in more serious condition and there was a tendency in quickly spreading of these diseases and pests.

III. The Himalayan forest ecosystem is a healthly one and was strong and long-living in its major past.

The pathology of the main Himalayan's forest communities are analyzed in detail. The decay of these forest communities have compared with other forests in our country. Results demonstrate that Himalayan forests have a healthly ecosystem. Most of the dominate tree species are thriving and good shaped. The decay rate of the forests are low. All this reflects that the beneficial ecological conditions by the zonation of plateau to a great extent favour the growth of plateau forests. They provide the forests not only a long life age but also provide extremly high yield, It is seldom in the world.

Ⅳ. To maintain the ecological equilibrium in order to control the development of forest pests.

We have found out the rules in succession of forest disasters in exploitation forest resources. In order to restore the ecological equilibrium, we should manage cutting correctly, determine the proper silviculture treatment, set aside those diseased regions and keep natural reserved forests, thu, control the occurence of disasters.

Abstracts of Papers Submitted Late

THE INFLUENCE OF QINGHAI-XIZANG PLATEAU UPLIFT ON SOIL GENESIS AND EVOLUTION

Chen Hongzhao, Gao Yizin, Wu Zhidong
(Nanjing Institute of Soil Science, Academia Sinica)

According to a lot of data in the field investigations with soil physical and chemical analysis, micro-morphological and electron-microscopical identification in the laboratory, as well the researched accomplishment in other disciplines, from the view point of soil genesis, the influence of plateau uplift on soil-forming envirorments in Qinghai-Xizarg region is discussed. It shows that since Pliocere, the most noticeable changes of soil-forming environments in this area were the raising of the altitude of land surface and the increasing of the complexity of geomorphology, rebuilding the situation of atmospheric circulation to make specific climatic characteristics of plateau, the gradual decreasing of the forest coverage which has beer replaced by the alpine meadow, alpire steppe and high-frigorideserta, changing the scil-forming weathered crusts into a great variety of kinds, so that there has become a particular soil region.

In this paper the discussion about the influence of plateau uplift on the development of soil forming processes recently is accentuated. It is suggested that the influence was chiefly shown as in the following five points: the strengthening of soil-freezing process, expansion of the formation to make the increasing of soil coarse particles, the development of soil de-swamp process, the occurerce of soil salinization, and the remaining of soil polygenetic characteristics. Every description is combined the macroscopic with the microscopic characteristics.

The relationship between plateau uplift and soil historical evolution is approached from the data of paleopedlogy and others. It is considered that soil-forming processes of Qinghai-Xizang plateau were begun one after another between late Cretaceous period and middle Eocene epoch. In the historical evolution, two periods were presented, which are moist heat soil-forming period and arid cold soil-forming period. Because the influence of neotectonic uplift and glaciatior had the regional difference, the way of soil historical evolution in different parts of the plateau was not the same. Concerning the soils of Qinghai-Xizang plateau and their regularly distributioral patterns in three dimensional space of today, four fundamental patterns can be divided roughly, i. e., moist, semi-moist, semi-arid, and arid.

GENESIS AND EVOLUTION OF BORON-BEARING SOLONCHAKS IN ALI AREA, XIZANG

Gao Yixin Zhang Liandi
(Nanjing Institute of Soil Science, Academia Sinica)

Most of the lakes in Ali area, Xizang, belongs to the tectonic faulted ones. At the end of the middle Pleistocene, the violent tectonic movement caused faulted zone accompanied with hydrothermal activity. The spring water abounding with boron and lithium continuously flowed into the lakes. With uplifting of the plateau, the drier climate within the plateau leaded to shrinking of the water level of the lakes. Up to the early Holocene, the climate became more and more drier. The concentration of the lacustrine water brought about the enrichment of soluble salts. The solonchaks in this area are developed from the deposits of the lake terraces I and II formed in Holocene.

Due to the climatic and regional differentiations in the Ali area, the salt composition of the lacustrine water and the ground water in the southern part differs from that in the northern part. In correspondence with the salt status in the ground water, the solonchaks in the southern part of Ali area mainly contains soda (the source of the soda is closely related to igneous rocks), while the solonchaks in the northern part are chiefly composed of sulphate-chloride or sulphate.

At present, the hydrothermal activity still remains vigorous. Nearby the lakes can often be found thermopegics. The substances such as boron, lithium, etc. from the spring water, together with other salt-bearing elements derived from eroded places and subjected to weathering and percolating, continuously move into the lakes. Therefore, the enrichment of boron in the lacustrine water provides the salt marsh, solonchaks and the plants with the source of boron. The salt marsh as soil-forming material of solonchaks contains boron as high as 1,000 ppm. The contents of boron (230—490ppm) and soluble boron (30—200ppm) in surface soil are 2—5 and 29—100 times larger than those in the coastal solonchaks in our country respectively.

PRINCIPLE AND BASIS OF SOIL CLASSIFICATION OF XIZANG

Gao Yi-xin
(Nanjing Institute of Soil Science, Academia Sinica)

The soils of Xizang are classified on the basis of pedogeneses, diagnostic horizons and its characteristics. First, edaphic condition, the soil forming processes, and the characteristics of pedogenic horizons and their relationship are considered for the classification of diagnostic pedogenesis. Secondly, according to the characters and morphological reflection determined in the soil forming processes, the types of pedogenic horizons and their diagnostic marks are establied. Then, the soils may be classified by the association of different pedogenic horizons and their differentiation.

According to the relationship between the bioclimatic condition and soils, there are 14 climatic types and 23 types of vegetation in the area. Under the influence of diverse soil forming conditions, there appeared ten types of soil formations such as accumulation of organic matter, oxidaticn-reduction, calcification, action of the crust, salification, bleaching podzolization, leached brown earthening, argillic weathering, allitic weathering and anthropogenic process. The effect of these soil formations on soils reflects mainly in different morphological characteristics of soils, i. e. in the differentiation of podogenic horizons, which are the essential basis of the classification at high level.

Consequently, the genetic horizons may fall into three classes as genetic section, genetic horizon and genetic subhorizon. In all the area, there are 5 genetic sections, 19 genetic horizons and 33 genetic sub-horizons, which are the major components of constituting the soil classification system at high level. From the above mentioned, in the high level classification system have been established three soil classes such as soil order, great soil group and soil subgroup. The soil order is set according to the association, comprehensive manifestation or common characteristics of the major soil formations. The great soil group is divided on the basis of different developmental stages of soil formation and the differentiation in the structural pattern of pedogenic horizons. The subgroup is divided on the basis of developmental sections, additional soil formation and the structural subpattern of pedogenic horizons. Finally, in the tentative scheme of soil classification in Xizang have suggested 12 soil orders, 22 soil great groups and 54 soil subgroups.

SALIENT CHARACTERISTICS OF SOIL FORMING PROCESSES IN XIZANG

Gao Yi-xin Chen Hongzhao Wu Zhidong
(Nanjing Institute of Soil Science,
Academia Sinica)

Diversity of soil forming processes, multifariousness of soil types as well as the simultaneous presence of both modern and old features are all due to the complicacy and peculiarity of the conditions of soil formation. Various type of soils are not isolated but are linked with each other. Each of them has individuality, while among them exists interrelated commonness. The commonness is shown in following respects:

Ⅰ. Various geochemical types of the weathering crusts of soil formation. From the viewpoint of the effect of weathering crusts on the soil formation, the weathering crusts can be divided into two series, i.e.one of oxidation and the other of reduction. Based on the genetic characteristics of the weathering crusts and the stages at which the weathering crusts occur, the oxidation series are further divided into five kinds of weathering crusts, namely, the debris, the salty, the carbonate, the siallitic and the allitic weathering crusts. The reduction series covers four kinds of weathering crusts, i. e. the salty, the carbonate, the siallitic and the allitic weathering crusts. They are not only genetically associated with the corresponding weathering crusts of the oxidation series, but also have the inherent properties of the reduction process.

The characteristics of the weathering crust of the soil formation as well as their effect on the soils are shown in that the frost weathering is so strong, the chemical weathering so weak, and some types of the weathering crusts so thin and full of gravel that the soils possess primitive characters. Most of the weathering crusts are young, but under the influence of uplifting of the plateau and many times of climatic alternations of the glacial epoch of Quaternary, some of the weathering crusts leaded to the ancient weathering crust which was formed under the conditions of humid and hot climate of the interglacial epoch of Pleistocene and underwent the process from a low altitude to a high one. As a result, the soil forming processes of modern times, to a considerable degree, are disturbed by the ancient weathering crust.

Ⅱ. Peculiar Cycle of the Biomass. Apparent accumulation and slow decomposition of organism is another characteristic of soil forming process of Xizang.The biomass of grass plant is considerably little. The surface amounts to about 1.3—4.1 q./ha. of dry matter per year. Due to a small amount of microorganism in soil, the organic residue of plant is accumulated heavily and decomposed weakly. Ranging from Black felty soils and Felty sod soils to Arga soils, Baga soils, Saga soils, Cold desert soils and Frosty desert soils, the contents of organic matter and nitrogen tend to reduce. The composition of humus is characterized by weakened humification, smaller molecular weight, dominant fulvic acid and the ratio of humofulvic acid less than 1.0.

The amount of litter on the mountain forest soil bordering on the plateau is smaller than that on the forest soil of low plain in tropical, subtropical and temperate regions. However, the contents of organic matter and nitrogen in the surface soil are higher than the latter. The forest plant with its special ash composition affects on the soils. The ash contents and the ash composition of a number of forest varieties on the mountain land which borders on the plateau are intermediate between the tropical rainy forest and the dark coniferous forest of the frigid-temperate zones.

Ⅲ. Soils of Modern Times Comprising the Characteristics of Old Soils. Another major characteristic of the soil forming process is that the soils of modern times comprise the characteristics of old soils. In the profiles of modern soils can often be found the relic features of old soils. According to the observation of soil micromorphology, the developmental youthfulness of plateau soils is shown as follows: 1. In the development of soils, the dominant function is performed by physical weathering, which leads to the appearance of the freeze-thaw micromorphology (including three morphological features, i.e. the exfoliation of minerals by freezing-thawing, the micro-rolled distribution of skeleton grains, and the evident scaly-filbriform of optical orientated clays) in soils, and to the presence of much large skeleton material. 2. The intensity of soil leaching is low. The pedological features (shown as two patterns; one is humicans, and the other is calcans, carbonate nodules including normal and abnormal) are weakly developed. The paleosols have a series of relic features of soil micromorphology: ferruginated mineral grain debris, ferruginous matrix, ferri-nodules, alga, illuviation cutans, etc.

ASPECTS OF THE TROPOSPHERIC CIRCULATION OVER TIBET DURING THE SEASON OF THE INDIAN SUMMER MONSOON

M. G. Hamilton
The University of Birmingham

During summer in most years the fully-developed monsoon circulation over India exhibits at least three synoptic patterns, namely, 'moderate', 'active', and 'break' phases. The moderate phase is typified by weak, short-lived and slow-moving cyclones and ridges in the middle and lower troposphere over India. Monsoon depressions are absent. During the active phase, at least one monsoon depression develops over the north Bay of Bengal at the eastern end of the seasonal trough which spans India and moves west-north-westwards for 3—10 days. When a break occurs, the axis of the seasonal (monsoon) trough over a wide longitudinal belt either shifts polewards to the Himalayan foothills or disappears below 500 mb as ridge develops near 20°N. No monsoon depressions form during this phase. Breaks usually persist for 3—7 days. Therefore the active and break phases represent synoptic extremes. This account compares aspects of the dynamical and thermodynamic structure of the troposphere over Tibet and adjacent ares as during the active and break phases.

Manually-derived averages of cloud data obtained from scene-corrected digitised visible and infrared imagery from United States meteorological satellites for selected periods during 1967—1974 and 1977 (timing is approximately 02 GMT near 100°E) and radiosonde and radiowind observations for 00 GMT have been used. Since data from states which employ different radiosonde systems and different schemes of correction for lag and radiation effects were used simple quality control procedures were employed in an attempt to produce reasonably consistent analyses.

Attention is focussed on differences in alrge-scale features of average cloud cover over Tibet and north India between each phase. Contrasts iu the strength of the tropospheric zonal currents and in the thermodynamic characteristics of airstreams over China and India are discussed also. Greatest contrasts are observed over eastern Tibet; contrasts farther west are difficult to quantify because of scanty aerological data.

GEOLOGICAL UNIQUENESS OF PAKISTAN

Abul Farah

(Geological Survey of Pakistan, Quetta)

The geological setting of Pakistan in the framework of the modern concept of Plate Tectonics is unique. It is in the sense that within an area of about 800,000 sq. km. critical tectonic junctions of different interacting plates and microplates are present in an environment where field exposures are excellent. Two types of active plate boundaries are conspicuous: (i) Convergent boundaries: characterised by continent-continent collision, obduction and thrusting in the Himalayan region and by oceanic crust subduction with a volcanic arc and a wide trench gap and thrusting in the southern region of Chagai arc and Makran margin (ii) Transform boundary of Chaman Transform Zone characterised by mega-strike slip and obduction. The Chaman Transform Zone connects the Makran convergence zone where oceanic lithosphere is being subducted beneath the Lut and Afghan microplates and the Himalayan convergence zone where the Indian lithosphere is under-thrusting Eurasia. The available geological and geophysical evidences of the development and demeanour of these plate boundaries have briefly been presented and discussed in this paper. Conclusion is reached that in Pakistan Atlantic type (Spreading) plate boundaries have been present since the Early Mesozoic until the late Cretaceous and as Andean type (subduction, collision, obduction, convergence) boundaries from the late Cretaceous to the present with the Transform Zone (Early Eocene-Oligocene?) connecting the Makran and Himalayan convergence zones.

OUTLINES OF TETHYAN EVOLUTION IN THE TIBETAN/ HIMALAYAN SEGMENT OF THE EURASIATIC ALPIDES

A.M.Celal Sengör
(Department of Geological Sciences, State University of New York at Albany, U.S.A.)

Since the last quarter of the nineteenth century it has been known that the Alpine-Himalayan system of Eurasia formed as a result of the late Mesozoic-Cenozoic demise of an oceanic realm-Tethys. Although Tethys was originally defined on the basis of Mesozoic faunal and lithofacies distributions, it has been recently shown that the evolution of the "Alpides" represents the demise of two distinct oceanic areas: a Permo-Triassic Palaeo-Tethys and a Triassic to Tertiary Neo-Tethys. The Palaeo-Tethys, which shared the Permo-Triassic world with Pangaea, closed durng a late Triassic to late Jurassic interval along a suture zone that extends from northern Greece and Bulgaria through northern Turkey, Greater Caucasus, northern Iran, Hindu Kush, the central Pamirs, Tibet, to the Red River and the Dien Bien Phu sutures. In the Hindu Kush and the Pamirs the Wanch/Akbaytal Lineament separates the southern "Gondwana" elements from the northern "Laurasia" elements. How this line continues into Tibet is not exactly clear, but two regions in Tibet record medial Mesozoic ocean closure. One is the northern Arka Tagh region where thick Permo-Triassic melange and flysch lithologies with Indosinian and some Yengshanian intrusive/extrusive rocks indicate the existence of island arcs and melange wedges of these ages. The other one is the Tanglha Mountains where ultramafics and blueshists (isotopic ages from 210 to 107 m. y.) have been observed. As both north and south of the Tanglha mountains Gondwana affinities are known, I believe the Arka Tagh suture represents the direct continuation of the Wanch/Akbaytal Lineament as the main Palaeo-Tethyan suture. It probably closed during the late Triassic-late Jurassic and remained as a high region since. The Tanglha suture, on the other hand, represents an intra-Gondwana suture, much like the Farah Zone in Afghanistan, and may represent a marginal basin opened over the south-dipping main Palaeo-Tethyan subduction zone. Its final elimination may have been delayed until the late Jurassic-another parallel with the Farah Zone.

The ocean, the Eocene closure of which led to the formation of the present Himalaya, is a part of the Neo-Tethys. In the Himalayan segment the opening of the Neo-Tethys began during the early to medial Triassic. Its closure began during the late Cretaceous by north-dipping subduction and gave rise to the Andean-type continental margin orogen of the Nyen-Chen-Tang-La.

The continental pieces bounded by the main Palaeo-and Neo-Tethyan sutures make up the Cimmerian continent showing a remarkable stratigraphic continuity from northern Turkey to eastern Tibet and perhaps to Burma. This Cimmerian continent has played a key role in the Tethyan evolution, as its anti-clockwise rotation closed the Palaeo-Tethys while opening the Neo-Tethys in its wake. Irregular closure and subduction activity led to the generation of many mini-oceans within it (e. g. the "Flysch Zone" of eastern Iran or the Tanglha suture) that greatly complicate palaeogeographic interpretation. But its recognition greatly facilitates the delineation of the outlines of the main palaeogeographic elements of the Asiatic "Alpides" *sensu lato.*

THE GREAT FUNDAMENTAL FAULTS AS FEATURES IN CRUSTAL EVOLUTION

John Vord, Hepworth
(Institute of Geological Sciences, London)

The "fundamental faults", "great shear zones" or "straightening zones" of the eastern hemisphere are examined with regard to their age of initiation and termination and their structural depth characteristics.

Such features in the Precambrian shields are compared with their possible equivalents in the Phanerozoic crust, e. g. Limpopo, Ubendian, Aswa, Hoggar, Zambesi, Great Glen, S. Armorican, W. Greenland, chanam, N. Zealand, Sumatra.

While it is evident that in the Phanerozoic some of the great fundamental faults constituted plate boundaries it is also apparent that, like the Precambrian features, they do not always belong to a single evolutonary type. They may be features of rupture and incipient separation, or large trunscurrent fault plate margins.and some are zones of shear collision, and others may be compound features. They may or may not be transforms.

Older features, such as the Red River Line, can be recognized partly as depositional sites, partly as fault features, and they also may be sutured plate margins, having played more than one role through time.

It appears that the emplacement of some dismembered ophiolites is related to great fundamental faults or straightening zones and it is possible that the "obduction" of some ophioltes is better explained by "transduction".

An attempt is made to trace plate evolution through time using these features as a guide.

DINARIC KARST AND ITS PECULIARITIES

Josip Roglic,
(Jugoslav Academy of Sciences and Arts, Zagreb)

The first scientific notions and general views on water circulation, and relief's evolution on soluble rocks, were gained in Dinaric karst. Afterwards, as the result of research in different parts of world, some popularized views are modified or abandoned. During the last decades also in Dinaric karst the new notions are acquired and old views were changed.

Deepness of the Karst in the large sequence/up to 5000m/of pure limestone is the peculiarity of Dinaric karst. The cyclic evolution of karst features cannot be proved.

Lithological differences modify water circulation and influence the relief's moudling and, besides a deep karst in the coastal zone, there is a fluviokarstic belt on the continental side.

In the impermeable rocks, surrounded by the karst, the basins of poljes are hollowed out in which during the Pleistocene climamorphogenetic processes, alluvial deposits,or poljes, were laid down.

In stable and favorable ecological conditions corrosional plains originated from contact between impermeable rocks and limestones. Diversity of Dinaric karst results from lithological differences and climatic changes. Scientific research and technical works contribute mutually to a better notion of that classic karst.

ULTRABASIC ROCKS AND MANTLE EVOLUTION

Asish R. Basu
(Department of Geological Sciences,
University of Rochester, New York, U. S. A.)

The Sm-Nd systematics in a variety of mantle-derived samples, including kimberlites, alnoite, carbonatite, pyroxene and amphibole inclusions in alkali basalts and xenolithic eclogites, granulites and pyroxene megacrust in kimberlites are reported. The additional data on kimberlites strengthen our earlier conclusions that kimberlites are derived from a relatively undifferentiated chondritic mantle source. This conclusion is based on the observation that the ε_{Nd}^{I} values of most of the kimberlites are near zero. In contrast with the kimberlites, their garnet lherzolite inclusions show both time-averaged Nd enrichment and depletion with respect to Sm. Separated clinopyroxenes from eclogite xenoliths in the Roberts Victor kimberlite pipe show both positive and negative ε values suggesting different genetic history. A whole rock lower crustal scapolite granulite xenolith from the Matsoku kimberlite pipe shows a negative ε value of −4.2, possibly representative of the base of the crust in Lesotho. It appears that all inclusions, mafic and ultramafic, in kimberlites are unrelated to their kimberlite mantle layer with a chondritic Sm/Nd signature.

The above data and additional Sm-Nd data on xenoliths in alkali basalts, alpine peridotite and alnoite-carbonatites are used to construct a model for the upper 200 km of the earth's mantle—both oceanic and continental. The essential feature of this model is the increasing degree of fertility of the mantle with depth. The kimberlite's source at depths below 200 km is the most primitive in this model, and this primitive layer is considered to be ubiquitous beneath continents and ocean basins.

SOME CLAVARIOID AND CANTHARELLOID FUNGI FROM CHINA—REPORTED AND EXPECTED

Ronald H. Petersen
(Botany Department, University
of Tennessee, U.S.A.)

Records of taxa of fleshy Basidiomycetes from China generally are either from an era when modern taxonomic techniques were not available, and names coined for European or North American taxa were applied to too many Chinese organisms, or too recent to be universally available and cataloged. Nevertheless, from meager personal observations and historical clues, thoughts on distribution of some fleshy fungi belonging to the clavarioid and cantharelloid groups can be offered. Examples used to describe such distribution patterns are *Gomphus szechwanensis*, *G.glutinosus* and *G. floccosus* var. *olivaceus*, the *Ramaria echinovirens* complex and *R.mutabilis*. Other fungal groups expected from mountainous southern China but not yet reported are also discussed.

BREATHING IN SHERPAS OF NEPAL AT HIGH AND LOW ALTITUDE

John T. Reeves, Robert F. Grover,
Peter H. Hackett and Drummond Rennie
(University of Colorado, U. S. A.)

Since the advent of Himalayan mountaineering, the Sherpas of Nepal, by repeatedly carrying heavy loads to altitudes of 7000—8000 m, have established themselves as the "gold standard" of human performance at high altitude. Furthermore, Sherpas (as well as Europeans) have recently attained the summit of Mt. Everest, where the atmospheric pressure is assumed to be 250 torr, without supplemental oxygen. To accomplish this remarkable feat must require extreme hyperventilation; West and Wagner have estimated that the alveolar CO_2 tension must have been reduced to only 10 torr. However, the physiological adaptations of Sherpas to high altitude are relatively unexplored. A previous study of only three Sherpas showed them to have blunted ventilatory responses to acute hypoxia and, during exercise at high altitude, they appeared to ventilate less than acclimatized lowlanders. It seemed to us paradoxical that persons with such unusual abilities at high altitude should have blunted ventilatory drives, and possibly hypoventilation. We thus felt further investigation was indicated and set out to study the control of breathing in the Sherpa by making ventilatory measurements at both low altitude (Kathmandu, elev. 1377 m) and at high altitude (Pherich, elev. 4243 m) in Nepal. For comparison, we used low altitude natives (Western tourists) who were trekking to Mt. Everest Base Camp.

Low Altitude Studies (Kathmandu, elev. 1377 m)

Twenty-five male Sherpas, age 18 to 48 years, born at or above 2200 m were studied. They gave remarkable histories of 47 cumulative expeditions to extreme altitudes, all of which involved multiple carries to over 7000 m. Three had been to the summit of Everest (8848 m). They reported almost complete absence of symptoms of acute mountain sickness, even at extreme altitude. Twenty-five Caucasian males of similar age and from altitudes below 1600 m were studied. Resting minute ventilation was larger in Sherpas (7.37 ± 0.34 l/min per m^2) than in trekkers (5.94 ± 0.37 l/min per m^2).

This greater ventilation in the Sherpas was associated with lover alveolar pCO_2 (29 ± 0.9 vs 33 ± 0.7 torr) and higher alveolar pO_2 (99 ± 1.2 vs 93 ± 1.2 torr). Respiratory pattern also differed between the two groups with the Sherpas tending to have smaller tidal volume-vital capacity ratios (0.123 vs 0.142, $p=0.07$) and notably higher frequencies (20 ± 1.1 vs 14 ± 0.7 breaths per minute, $p<0.001$). This difference in frequency was present not only during measurement with the mouthpiece in place, but also during observation of quiet breathing without the mouthpiece and with the subject distracted.

High Altitude Studies (Pheriche, 4243 m)

Eight other male Sherpas, aged 19 to 35, born and living above 3400 m were studied. as well as the same 25 male Caucasian trekkers previously studied in Kathmandu. All the trekkers had been above an altitude of 3500 m from 4 to 12 days.

Again, resting minute ventilation was larger in Sherpas than in trekkers (9.8 ± 1.0 vs 7.7 ± 0.5 l/min m^2, $p=0.05$). Arterial oxygen saturations also tended to be higher in the Sherpas and showed less scatter (88.0 ± 0.7 vs $85.6\pm1.0\%$).

The basis of the present study was the paradox that persons who have the reputation of being unusually capable of physical exertion at high altitude also are reported to have small ventilatory responses to acute hypoxia. The results, taken together, indicats that Sherpas, compared to Western trekkers, have high resting ventilations both at low and high altitude, and that their responses to acute hypoxia are, in fact, not, blunted. In these respects, the Sherpas may differ from high altitude residents in other regions of the world.

PLATE TECTONICS, GLOBAL SEA LEVEL CHANGES, AND THE SEDIMENTARY RECORD: EXAMPLES FROM THE CRETACEOUS

Erle G. Kauffman

(Department of Paleobiology, U. S. National Museum of Natural History, Smithsonian Institution, Washington, United States of America)

During the Mesozoic-Early Cenozoic eras, intense global tectonics caused the breakup of Pangea and initiated a series of plate tectonic movements that led to the present configuration of continents and ocean basins. The Cretaceous Period was a particularly active plate tectonic interval, and serves as an example of the complex interactions between global tectonics, eustatic sea level changes, and the sedimentologic, biologic, and oceanographic histories of the marine realm. The greatest Mesozoic changes involved the position, size, and volume of ocean basins. New oceans and seas formed (e.g. the Atlantic, Caribbean, ? the Arctic), and others were diminished (e. g. Pacific, Mediterranean) in size. Large topographic features were intermittently built and destroyed on the ocean floor: (oceanic ridges at spreading centers, island arc systems, large elevated tectonic blocks, doming of the crust over hot spots, etc). These events caused major volumetric changes in the world ocean system, and changes in relative sea level that reached hundreds of meters during the Cretaceous. Such eustatic changes had a profound effect on Cretaceous paleoceanography, sedimentation patterns, and biologic history. In most cases they were large enough to overprint the effects of local and regional tectonics, resultant sedimentation patterns (especially in epicontinental sites), and geoidal eustacy. Tectono-eustatic events should be clearly distinguishable in the Mesozoic stratigraphic record all over the world.

Detection of global sea level changes is most obvious in the marines tratigraphic record of epicontinental seas; the transgression and regression of the strand facies along the shallow margins of large water bodies is the most sensitive indicator of change in relative in relative sea level. Two kinds of evidence are used to detect sea level changes in cratonic and continental margin facies: (1) Correlative regional migrations of the strand and marginal marine facies, depicting transgressions (marine advance)and regressions(strand retreat); (2) Vertical deepening-shallowing stratigraphic sequences offshore from the strand line. Both phenomena can be produced by local tectonic and sedimentologic factors; the proof that such events represent eustatic fluctuations lies in the precise correlation of transgressive and regressive peaks in diverse parts of the world, utilizing biostratigraphic zones and geochronology. Different tectonic settings produce different global patterns of eustatically generated transgressions and regressions so that such correlations in proof of eustacy must be made between tectonically similar settings.

The eustatic theory has been tested against Cretaceous sequences in many parts of the world, but predominantly North America, Central America, northern South America, Africa, Europe, Japan and Australia, Nearly 75 percent of the sections tested in these regions show evidence for nearly synchronous transgressive-regressive peaks which broadly overprint local tectonic and sedimentologic effects. Epicontinental transgressive peaks which are broadly correlative in some or all of these areas occur in the Upper Valanginian, Upper Hauterivian, Middle Barremian, Upper Aptian, Upper Albian, Lower Tuconian, Coniacian-Santonian, Lower Campanian, Upper Campanian, and Middle to Upper Maastrichtian. Of these, the Aptian, Albian, Turonian, Coniacian-Santonian, Upper Campanian, and Maastrichtian events are the most widespread. The periodicity and duration of these eustatically generated events is irregular, with transgressions generally longer than regressions, but shorter than would be predicted from simple geophysical causes. They were produced by complex interaction of numerous plate tectonic events, in some cases enhanced by large scale continental events, Evidence strongly suggests that similar tectono-eustatic events dominate earlier Mesozoic and Paleogene marine sedimentation patterns on a smaller scale. Neogene sedimentation shows a stronger glacio-eustatic effect.

Throughout Mesozoic and Cenozoic history, the Asian Subcontinent acted as an unusually stable, elevated tectonic block, Continental sedimentation dominates the central cratonic area, and marine sediments are mostly limited to isolated basins, and in general the coastal margins of the Asian block. But although data is sparse at present, and marine sediments more restricted, there is strong evidence for the global eustatic pattern along the margins of the Asian Subcontinent. The Cretaceous history will be discussed as an example.

SINO-SWISS RESEARCH PROJECTS OF INTEREST

Peter Schindler

(Swiss Federal Institute of Technology in Zürich)

Sino-Swiss scientific contacts have increased significantly during the last months and years. The comparatively large number of Chinese scientists and engineers in Swiss.

Universities reflect a strong demand for formal education. The Swiss Federal Institute of Technology (SFIT) in Zürich proposes the establishment of common research projects with both Chinese and Swiss participants that could prove even more successful. Some projects related to Qinghai-Xizang are discussed.

One important field of mutual research interest but at this time still without formal interaction is the extension of the geological and petrographic work of Gansser et. al.

On the Himalayas, other projects to be proposed come from such fields as geography, glaciology, hydraulic engineering, animal and plant production in mountainous regions and dairy technology. Possible models for such types of cooperation are discussed.

ADAPTABILITY OF MAN TO HIGH ALTITUDE AND MICROCIRCULATION

R. A. Zink, W. Schaffert
(University of Munich, The Federal Republic of Germany)

Red blood cell counts as high as possible were supposed for many decades to be a basic requirement of good high altitude adaptability or tolerance. By isotope techniques it could be shown under these conditions that very high hematocrit values are to a far extent due to a rapid dehydration. Up to 7 liters of water may be lost through the respiratory tract per day during heavy exercise in high altitude regions. Hematocrit values up to 0.55 or a maximum of 0.60 can be considered as physiological and they are undoubtedly advantageous, if water balance is well equilibrated.

As we know from theoretical considerations, experimental studies, clinical findings and scientific expedition reports, is the oxygen transport, the tissue perfusion including the heat supply and the cardiovascular performance severely impaired by the flow patterns of the concentrated blood.

Retinal hemorrhages, thromb-embolic events frostbites and probably pulmonal as well as cerebral edema are some of the pathophysiological results of hemoconcentration. In Peruvian altitude dwellers these microcirculatory disturbances are not rarely fatal in those who suffer from chronic poliglobulinemia, if they do not subside phlebotomy or hemodilution in regular intervals.

We started in 1975 to hemodilute expedition climbers after adequate acclimatisation between 5400 m and 7200 m. 500—700 ml of stabilised human serum[2] were infused in 14 cases just before the climbers ascended to the summits higher than 8000 m, (I-Group). In 9 other climbers 500—700 ml of blood were withdrawn and replaced isovolemically by the same amount of stabilized serum preparation[2] (D-Group). 12 more climbers without infusions or forced fluid intake were used as controls.

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1) Supported Gy the German Research Society

2) Biseko, Biotest Institute, Frankfurt, W-Germany

Hematocrit values:

	n	before	after	after return from summit
		treatment		
I-Group	14	0.58	0.56	0.58
D-Group	19	0.59	0.51	0.53
Controls	12	0.59	—	0.64

It should be emphasized that one climber ascended to 8511 m without additional oxygen isovolemic hemodilution and he returned to the base camp with a hematocrit of 0.47 only.

NO FROSTBITES occured in the I-Group and in the D-Group, though 1,3 man-years were observed with minimum temperatures of −36℃. Whereas several of the untreated members and Sherpas suffered from congelations up to grade II.

RETTINAL HEMORRHAGES were seen in 4 out of 13 fundoscoped climbers before hemodilution. 3 weeks after this treatment no residues of the bleedings could be detected.

HIGH ALTITUDE PULMONARY EDEMA was successfully attended by hemodilution in one case. After the descent from 7200 m to 5400 m the therapy started with human serum infusions[2] plus diuretics and thereafter the patient was isovolemically hemodiluted. No additional oxygen was needed and the patient has recovered completely after 2 days rest.

Conclusions:

High altitude hemoconcentration is to a large extent due to dehydration and should be avoided by any means. The easiest way is a high fluid intake. This however may be difficult in advanced camps of expeditions and the effect of this rehydration lasts only a short time since the body-water-binding-capacity is reduced in chronically catabolic climbers. Isovolemic hemodilution according to our scheme is significantly longer effective and restores the protein depots partially. It seems to be a save and feasable procedure to reduce the risks of exposure to high altitude and to treat acute or chronic high altitude complications.

PRECAMBRIAN TECTONICS, VIEWED FROM THE HIMALAYAS AND THE QINGHAI-XIZANG PLATEAU

K. A. Plumb
(Bureau of Mineral Resources, Geology and Geophysics, Australia)

Although some Precambrian mobile belts may be interpreted as continental margin structures, the origin of many of the polymetamorphic belts within the Precambrian Shields remains an enigma. Their characteristics seem, at first, to differ from those of modern fold belts, and they appear to defy explanations in terms of plate tectonics. They are commonly explained by hypotheses involving high heat flow, thin crust, basement reactivation, and intracontinental rifting, but modern examples cannot be found for many of these processes.

A review of examples of intracontinental mobile belts from the Australian Precambrian Shield reveals the following characteristics:

1) The mobile belts separate major cratons with distinctly different geological histories.

2) The mobile belts were the sites of high-grade metamorphism, abundant acid and basic igneous activity and plutonism, intense folding, and major faulting, repeated many times over long periods of time.

3) Deep-seated faults separate blocks of distinctly different intensity and age of metamorphism and deformation, and different igneous and sedimentary assemblages, etc.

4) The largest gravity anomalies in Australia lie over these belts.

5) Geophysical modelling suggests that there must be major structures extending to at least the base of the crust.

6) Blocks of deep crustal material are now exposed at the surface.

7) Rock units from adjacent cratons extend into and are reworked by the mobile belts.

8) Many of the metamorphic rocks are derived from platform-type sediments.

9) There is no direct evidence of subduction, in the form of ophiolites, deep-ocean sediments, island arc volcanic suites, melanges, or blueschists.

10) It is disputed whether some belts represent distinct geosynclines, or whether all the metamorphic rocks have been derived from reworking of adjacent cratons.

11) Palaeomagnetic data suggest that the adjacent cratons were not displaced, relative to each other. However, data are still sparse, and the accuracy of determinations certainly cannot exclude the former existerce of rifted oceans 1000 km or so wide.

These characteristics resemble many of those which typify the Himalayas and Qinghai-Xizang Plateau. Continent-continent collisions represent another model to be considered when interpreting intracontinental mobile belts, although the Precambrian continental blocks and intervening oceans were smaller in the Australian case than in the Himalayan, and multiple collisions may have occurred.

Continued study of the Himalayas and Qinghai-Xizang Plateau provides a valuable model for the analysis of ancient mobile belts, particularly in view of the range of depth zones exposed by the great uplift.

ON THE GALLIFORMES OF THE QINGHAI-XIZANG (TIBET) PLATEAU

Christopher Savage
(The World Pheasant Association)

The Galliformes of Qinghai-Xizang (Tibet) are of interest and importance to the world (and in particular to the World Pheasant Association) for three main reasons: -

- the Galliformes are important sources of protein in many parts of the world for human consumption and are increasingly important for cancer research; in terms of the World Conservation Strategy, preservation of genetic diversity of such species is of high priority, nearly all the wild forms are now rare in the wild if not endangered with extinction;
- the Galliformes of Xizang, their evolution and ecology, are as yet little known and clearly very different from those of species which have been studied intensely elsewhere;
- the Galliformes of Xizang are birds of great beauty which till now have been known in most cases mainly from Chinese art and from a few birds introduced to zoos mostly in the XIXth Century.

Recent work in the Himalayas and discussions at the First International Symposium on Pheasants held in Kathmandu, November 1979, throw some light on the Galliformes of the Outer Plateau of Qinghai, the characteristics of which are distinct from those of the moister Eastern Plateau. The species of particular interest were: -

- the snowcocks-Genus *Tetraogallus*
- the blood pheasants-Genus *Ithaginis*
- the tragopans-Genus *Tragopan*
- the monals-Genus *Lophophorus*
- the eared pheasants-Genus *Crossoptilon*

The ecology, distribution and evolution of these species can now be pieced together as will be shown, but much more needs to be known of the climate, geology and vegetation of the region before conclusions can be drawn. It may be noticed for example that in the Western Himalayas the genera *Tragopan* and *Lophophorus* are restricted to the southern (moist) side of the mountain chain except where the great rivers have allowed penetration such as up the Sutlej Valley. Further east near the start of the Eastern Plateau, the pattern is reversed and the moister slopes where the pheasants are to be found are north facing. The genus *Crossoptilon* is to be found only to the north of the mountain chain.

The conditions of the region have resulted in very considerable geographical variation within species. This is not unusual and can give clues to differences in ecology which may be important when consideration has to be given to relocations or reintroductions. The experience of the World Pheasant Association suggests however that the study of living birds in the wild and in captivity, can quickly produce information of practical value for conservation. The World Pheasant Association is ready to collaborate in any way possible to advance such research.