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THE ALPS OF CHINESE TIBET AND THEIR GEOGRAPHICAL RELATIONS

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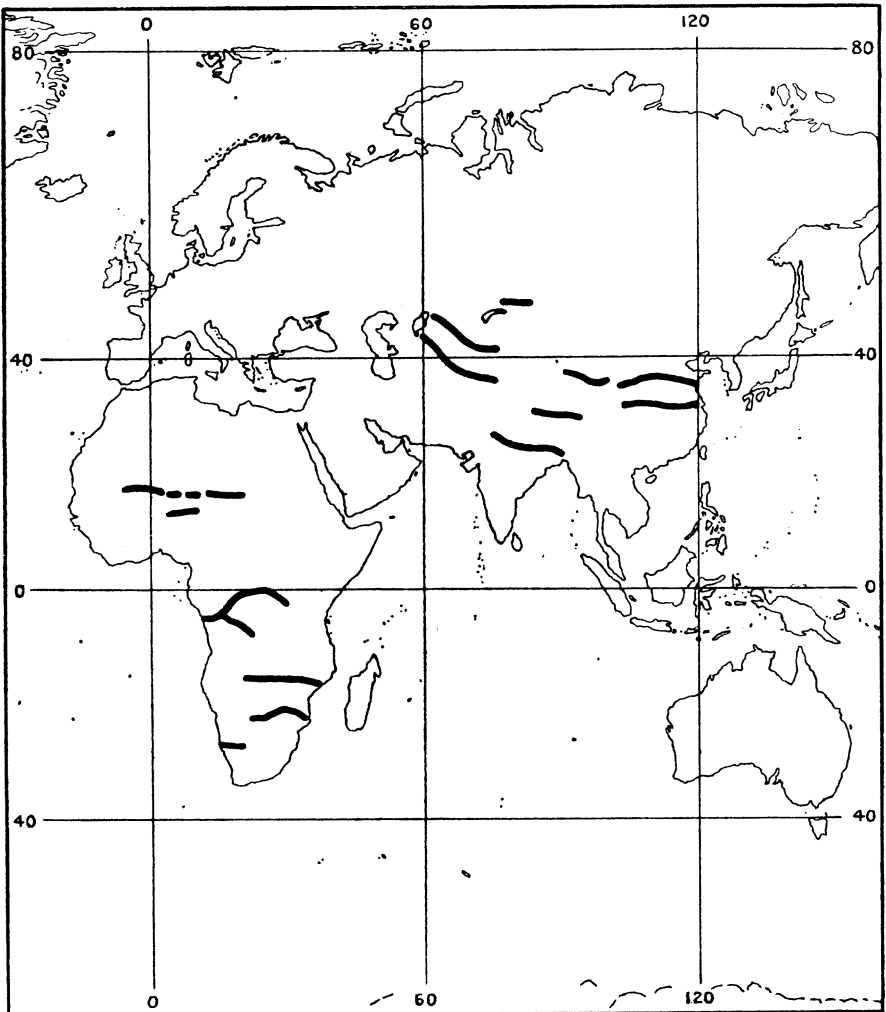
I. Introduction—the Problem of North-west Yunnan.

THE coasts of Burma and West Sumatra separate two areas which present one of the most striking contrasts in the map of the world. West of that line the geographical forms are simple and the units large; the coast-lines are long and straight; the islands are few and their outlines, as of Madagascar and Ceylon, are regular; the lands are vast continental blocks such as the peninsulas of India and Arabia and eastern Tropical Africa. East of Burma and Sumatra, on the contrary, the geographical forms are complex; the arrangement of land and water is exceptionally intricate; the coast-lines are deeply indented, and some of the islands, such as Celebes and Halmahera, are extremely irregular and project in long narrow sinuous peninsulas. The lands vary greatly in structure; some are fragments of a fold-mountain chain; others are relics of an old plateau; some have been piled up by volcanic eruptions; and others built as coral reefs.

This contrast between south-eastern and south-western Asia is dependent on differences in their mountain chains, which there truly answer the description of "the backbones of the lands." The relation between the land-forms and the mountain structure of south-eastern Asia is however obscured by uncertainty as to its mountain plan. The southern border of the Eastern Archipelago consists of fragments of a great chain of fold-mountains, the Malay Arc, which was formed by similar processes and at the same date as the Alps and the Himalaya. The Malay Arc bends northward at its western end, and is continued as the Burmese Arc; it also bends northward at its eastern end off the northern edge of the Australian platform. The combined Burmese-Malay Arcs are, according to one interpretation, the main continuation of that Alpine-Himalayan mountain system which includes the chief mountains of Europe and Asia from the Pyrenees to Assam. Upon this view the further eastward extension of the Alpine-Himalayan line was

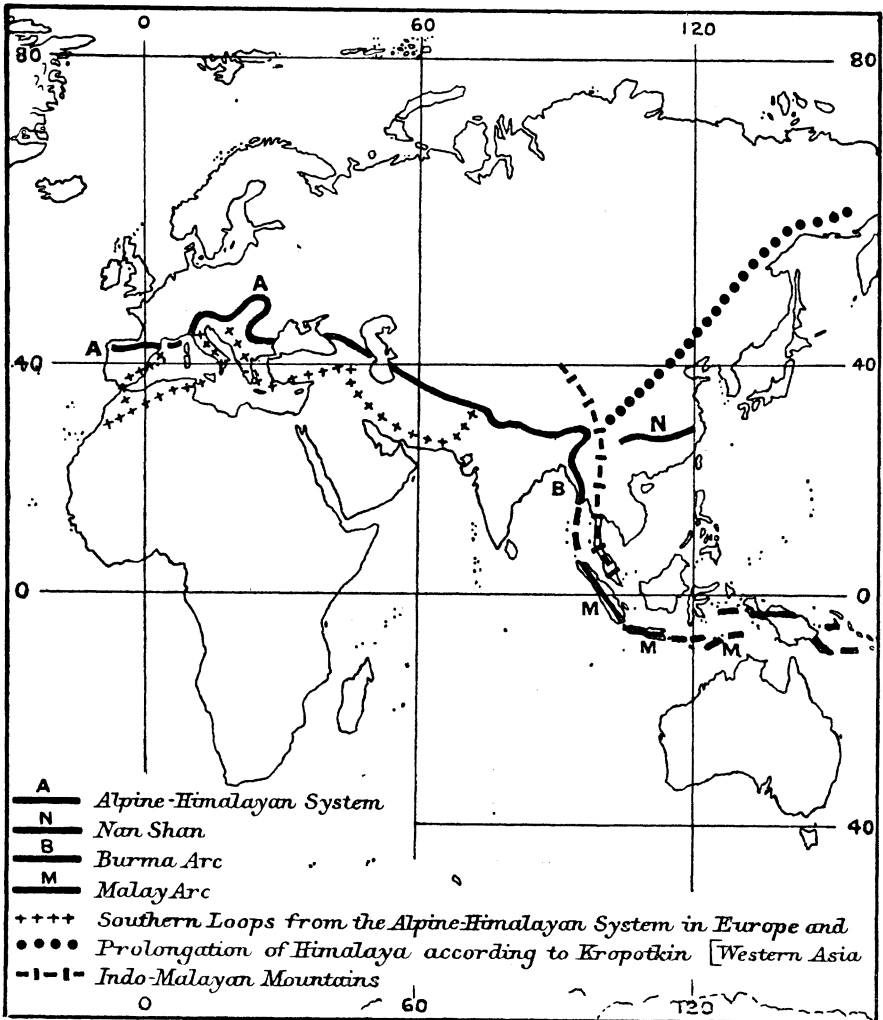
blocked to the east of Assam by the older Indo-Malayan System, which forms the great projection of south-eastern Tibet into Indo-China. This firm mass resisted further crumpling and diverted the later Alpine-Himalayan folding southward, and the surf-line of that crustal storm is preserved as the Burmese and Malay Arcs.

A different interpretation has however been advanced by Kropotkin in his 'Orography of Asia,' and amongst English authorities on western China by Archibald Little. Impressed by the great snow-clad mountains which are known as the Alps of Szechwan, and especially by the range which Little called the "Ta-shüeh Shan" or the Great Snow Mountains, they considered that the Himalaya extend eastward from Assam into



1. East-and-West Valleys due to Early Folds.

Central China ; thence, according to Kropotkin, the line is continued northward as the Great Khingan Mountains, passes into the mountain chains of north-eastern Asia, and, crossing Behring Strait, is continuous with the fold-mountains of western America. This problem is intimately connected with the development of the river system of south-eastern Asia and with the geological history of the Indian Ocean. The evidence of Indo-China and south-western China on the latter question is correlative with that of the African rift-valley system. Hence arose the interest felt by one of us for many years in the geographical and geological investigation of south-eastern Asia ; we were accordingly glad of the opportunity during the present year for a visit to Yunnan in order to



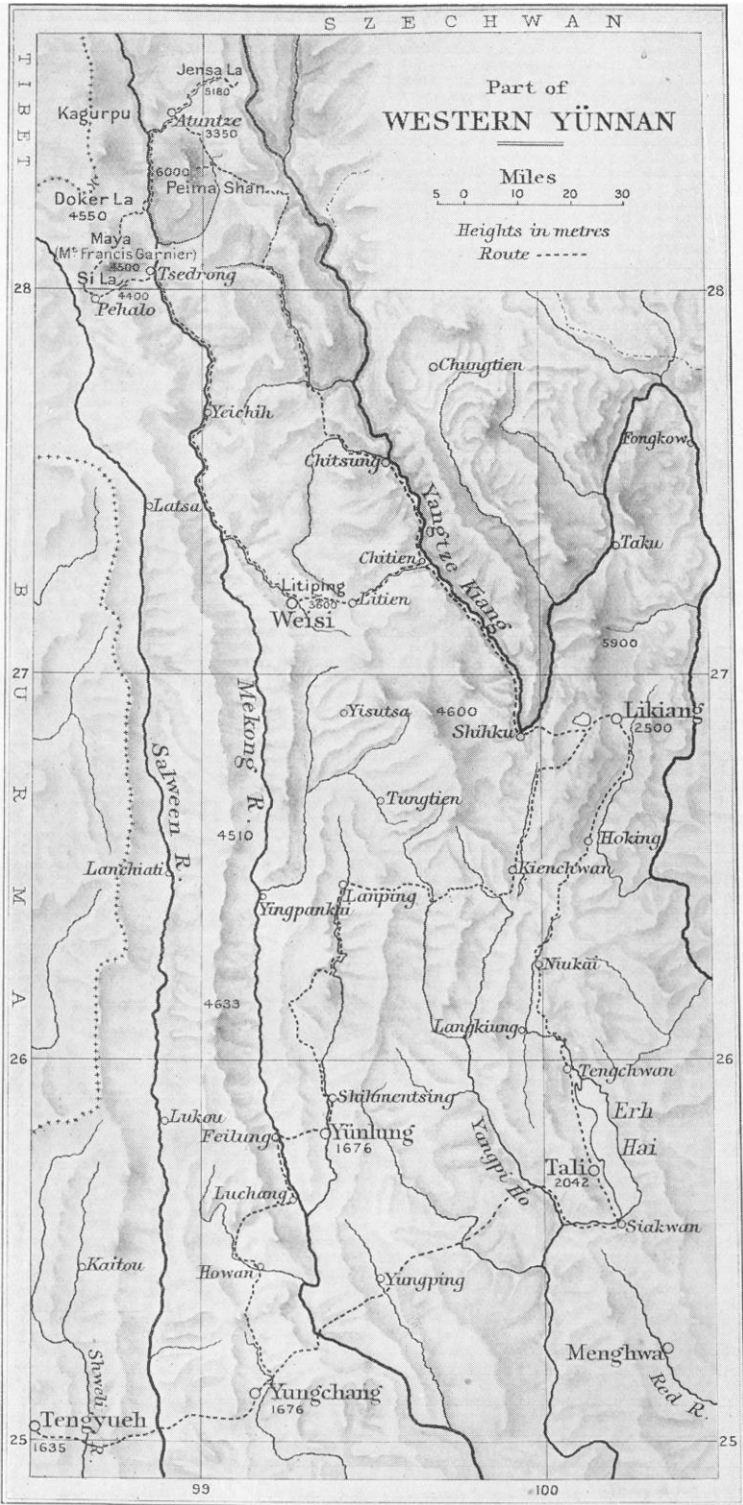
2. The Alpine-Himalayan Systems and their Hypothetical Eastern Connections.

collect further evidence on its geographical problems. The kind support of Sir Francis Younghusband, then the President of the Society, helped to secure the sanction of the Foreign Office for our visit. The Sladen Trustees gave us a generous grant in aid, and our journey was therefore conducted as one of the Percy Sladen Memorial Expeditions.

II. Itinerary.

We reached Bhamo on the Upper Irrawaddy on 7 May 1922. There, owing to the kindness of the District Commissioner, mules were ready for us, and we left the next day. We reached Tengyueh (145 miles) by an eight days' march. As our Indian servants could not accompany us further they were sent back; we engaged a Chinese staff, secured mules that were used to the mountain tracks, and obtained permission from the Chinese authorities to go to Likiang, on the border of Chinese Tibet, where our further movements could be decided. From Tengyueh we proceeded to Yungchang, where we left the main road and turned aside into country which was all geologically, and some of it geographically, unknown. From Yünlung, one of the best known centres of the salt-mining industry, we followed up a river, the Loma Ho, into an area which is represented by a blank on General Davies' map of Yunnan. We reached villages which, according to their headman, had not been previously visited by Europeans. The district was apparently inaccessible until after the revolution of 1911, but since then the people are reported to have become more peaceful and law-abiding. One of the changes produced by the revolution we saw at the salt-mining town of Shihmentsing, where the largest temple has been turned into a school, and owing to its ample endowments education in the town is now free and practically universal. We were allowed to camp in the quadrangle, and delayed our start next morning to see the school at work. Ascending the Loma Ho we passed a series of hot springs, some of which are active and some extinct. They indicate recent earth-movements along the valley. We also passed mines of mercury, silver, and copper.

At Likiang we had to engage fresh mules, secure a new escort, and obtain permission from the magistrate to enter Chinese Tibet. Here we were met by a double check. Our money, which had been forwarded by draft, had not arrived, and the magistrate objected to our going further to the north owing to the disturbed condition of the country. During the discussion it came out that his action was due to peremptory orders from Yunnanfu, the provincial capital, and from Tengyueh, that he was to prevent our going on by all the means in his power. The only policy available was to assure him that these orders could only have been issued by people who were ignorant of the magnificent improvement in the district effected by his administration, and that our inquiries of the local merchants showed that there was no serious risk. He agreed to



TO ILLUSTRATE THE PAPER BY PROFESSOR GREGORY ON THE ALPS OF CHINESE TIBET

let us go on, provided he had no further orders from the capital, if I would sign a letter stating that we went on at our own risk and responsibility. He probably thought we should decline this offer; but we accepted it at once, and as soon as we had secured part of our money, rushed on to reach country where we should be safe from recall. We descended from the plateau of Likiang (8200 feet) into the deep valley of the Yangtze (6200 feet), which though there over 2400 miles from the sea is a great river. It was then in flood owing to the melting of the snows in Tibet. A march of 40 miles up its valley enabled us to confirm Loczy's account of its structure; so we turned westward to the Mekong and crossed the Litiping Pass to the Chinese "western fortress," Weisi. Thence we travelled north up the basin of the Mekong in order to examine its structure. We crossed the Mekong by a rope bridge at Tsedrong, and thence, with three local porters and four of our own men, climbed over the divide into the valley of the Salween. At Pehalo, however, we found that the Salween valley was so smitten with famine that work there was impossible, and we returned to the Mekong over a pass at the northern foot of Mt. Francis Garnier. After rejoining our caravan we resumed the northward journey to Atuntze. Thence in company with M. Peronne, who has long been resident in that town, we made some excursions into the mountains on the Mekong-Yangtze divide, among which we observed remarkable instances of Himalayan earth-movements. From Atuntze we returned past the mountain mass of Peima Shan, to which we made a branch excursion, but bad weather frustrated the attempt to cross its glaciers. The route down the Yangtze being flooded we travelled south by a mountain track and joined the Yangtze road at Chitsung. Thence we returned to Likiang, where, owing to the kindness of the Rev. P. Klaver of the Pentecostal Mission, mules for the journey to Tali were secured without loss of time. We followed the road through Hoking. The return journey was troublesome owing to the flooded condition of the country after the abnormally heavy rains. After Tali we joined the main route across central Yunnan to Tengyueh, where Mr. Houston, the Imperial Commissioner, had engaged mules for the descent to Bhamo, which we reached on September 8.

III. The Mountain System of South-west China.

1. *The Indo-Malayan Mountains.*—South-eastern Asia is one of those regions of which the geography is mainly dependent on the mountain structure. The region has been built up on a foundation due to mountain formation at two different periods. The older mountains are contemporary with the Hercynian System of Europe, which is so named after the Hartz Mountains in central Europe. This Hercynian System also includes the hills of Brittany and the Urals of Russia, and it is represented in the British Isles by the Mendip Hills, the Pennine Range, and the Peak of Derbyshire. Mountains formed at the same date are

extensively developed in Asia, and Suess gave them the somewhat inappropriate name of the Altaids (cf. *Geogr. Journ.*, vol. xlv. p. 503). In south-eastern Asia these Altaids, the Asiatic representatives of the Hercynian System, form the Indo-Malayan Mountains, the significance of which was first appreciated by von Richthofen. They are of primary importance in the geography of south-eastern Asia, although their influence on the present relief is indirect. They were formed at about the age of the Coal Measures, and therefore in an early period of the Earth's history. Their crests have been planed down, and their foundations in some localities lie beneath widespread plains and at others stand up as massive plateaus. When these plateaus are exposed to rain and rivers, deep valleys are cut out along the less resistant rocks; the hard masses form mountain ranges, and fresh earth-movements are often guided by lines of weakness due to the older movements. The later remodelling of south-eastern Asia therefore shows many coincidences with the Hercynian mountain system.

2. *The Himalayan Movements in Yunnan.*—The second great period of mountain formation was modern, and to it are due the main existing mountains of the world. The earth-folding of this period formed, amongst other mountains, the Alps, the Himalaya, and the Burmese-Malay Arc. The mountains then formed can be most easily recognized when they include rocks younger than the Hercynian movements.* The only rocks in western Yunnan deposited between the Hercynian and Himalayan movements are a series of salt-bearing red beds like those of the English Midlands. These rocks have been intensely folded and sometimes even inverted; and these disturbances are necessarily post-Hercynian. Unless there has been a period of mountain formation intermediate between the Hercynian and the Himalayan, the folding of the red beds must be due to the Himalayan movements.

In the case of mountains formed of pre-Hercynian rocks, it is fortunately sometimes possible to determine that their upheaval was due to post-Hercynian disturbances, and must therefore be attributed to the Himalayan movements. For example, the peaks beside the Si La show complex over-folds which are relatively shallow; they rapidly diminish in intensity as they are followed downward, and the lower parts of the mountain do not share in the corrugation. The sudden cessation below of the Si La folds indicates that they were part of a relatively shallow folded layer, and are probably Himalayan in date. The movements that formed the Indo-Malayan mountains gave this area its grain, which lies north and south; hence, as the mountains due to denudation are dependent upon this grain, they also trend in that direction. We found, however, clear evidence of mountain movements of a later date, some of which follow the grain of the area while others go approximately at right angles to it.

* These movements culminated in south-eastern Asia in the Middle Permian.

The distribution of the mountains in this area of 20,000 feet and over is still unknown, and its discovery offers work for many mountaineering expeditions ; but so far as the evidence is known to us these lofty mountains are arranged on two lines which run approximately east and west. The northern of these lines is the Tashuih Shan (*i.e.* the Great Snow Mountains) which rise above the ancient Chinese road to Lhasa between Batang and Tatsienlu ; some of its summits were measured by Kreitner and found to have an elevation of 26,000 feet. West of the Yangtze Kiang are further high mountains, of which the range is little known as they stand on the still forbidden borderland of autonomous Tibet, but Litton, Ward, and others have referred to the existence there of a high mountain wall which runs westward and forms the southern boundary of the Tibetan plateau. South of the Tashuih Shan lies a series of valleys and basins which are lowlying and fertile in comparison with the steppes to the north. South of this line of depressions the mountains rise again to the peaks of Kagurpu, to those near Atuntze, and the numerous snow-clad mountains of southern Szechwan. Their geographical outlier, the snow-capped range of Likiang, has been overthrust from the west, and it appears to be the southernmost mountain directly due to the Himalayan movements. Bacot has remarked ('Tibet Revolté,' 1912, p. 257) that the Salween near Drongneu has cut its way through "a second Himalayan chain," and our observations, on both the geographical and geological structure of the country, support the probability of that identification. The snow-capped peaks rise from a plateau of which the surface is now a peneplane with a general slope downward from north to south ; the level falls from 12,000 feet in parts of northern Yunnan and Szechwan to 7000 feet where remnants of the plateau surface can be recognized between the deep valleys of southern Yunnan. The slope of this surface must have been due either to tilting along an axis trending east and west, or to denudation by rivers flowing from north to south. If the last uplift had been along lines from north to south, then the surface slopes, whether due to tilting or denudation, would have been downward to west or east. The distribution both of the Alpine peaks and of the plateau slopes indicate that the last mountain uplifts in this district were along axes trending east and west. Near Hoking there is an especially striking example of the east and west mountain folds, for in the range west of that city the beds have been flung on end ; instead of their normal course of north and south they suddenly turn east and west. These uplifts happened at about the culmination of the Alpine-Himalayan upheavals, with which they agree both in date and trend. The movements of this epoch were naturally not all on lines trending east and west, for their direction is affected by the grain of the country and by the reaction between the solid plateau of south-western China and the weaker rocks around it. The course of these uplifts agrees in some respects with Deprat's Yunnan Arc, but it

is doubtful whether there are any mountains along the central part of that arc, as marked by Deprat ('Mém. Serv. Géol. Indochine,' vol. i. pt. i. p. 303), due directly to uplift.

The belts in south-eastern Asia affected by the Himalayan movements occur in three different conditions. The first is along the direct continuation of the main line of the Himalaya, and it is still marked by chains of lofty mountains. The second is found on the belt of down-like country and dissected plateaus where once stood the foothills south of the main chain. The third condition is seen in the Burmese-Malay Arcs, with their great loop to the south. The first type includes snow-clad mountains, which rise to between 18,000 feet and 26,000 feet. The second condition is seen in the dissected plateau of western Yunnan along the route from Yunnanfu and Tali to Tengyueh. The third is met with in the highland rim of the Burmese-Malay Arcs. The first and third of these conditions are represented by conspicuous mountain chains which are still important geographical divides; but the second condition occurs in an area which has been levelled to a widespread plain, and its original structure is only shown when deep valleys expose the folds and overfolds in the rocks.

It may be suggested that if these three geographical types were due to movements of the same kind and date, they should not now be in such very different geographical preservation. The explanation of this apparent difficulty is that the movements of the second series occurred in the foothills, which have been planed down by rivers from the adjacent mountains. Moreover, the mountains of both the other types have been subject to enormous denudation. The continuity of the original mountains has been broken by wide gaps which, in the western part of the Burmese-Malay Arcs for example, are larger than the remnants.

There is nothing in the condition of preservation of Kagurpu, or of the Tashuih Shan near Batang or other of the Alps of Chinese Tibet, or of the mountains of the Burmese-Malay Arc, to disprove their formation at the same period as the mountains of the Alpine-Himalayan systems.

3. *The Eastern Continuation of the Himalaya.*—We consider then that the structure of western Yunnan is best explained on the view that the line of the Himalaya is not wholly bent back around Assam, but that one division of it continues eastward into China. Two routes have been suggested as the eastern prolongation of the Himalaya. Kropotkin held that the Great Khingan Mountains are the direct continuation of the Himalaya; but that view seems untenable owing to the essential difference in structure between those two mountain chains. Mr. Kingdon Ward has suggested that the Himalaya are continued as the Tsinling chain, upon which hypothesis no final conclusion is possible until more is known of the Taliang Shan (*i.e.* the Great Ridge Mountains) of southern Szechwan. If their axial lines trend approximately south-south-west to north-north-east and have been caused or renewed by movements of

Himalayan date, they may be a link between the Himalaya and the Tsinling Mountains; but the last contribution to their geology, the memoir by Legendre and Lemoine ('*Massif Sino-Tibetan*,' 1916), though giving no conclusive evidence, indicates that the Taliang Shan are due to the dissection of mountain lines of Hercynian age which had a general trend of east to west.

The evidence renders probable the continuation of the main Himalayan line across southern China through the Nan Shan Mountains which separate the Yangtze Kiang from the Si Kiang (West River). Information as to the geological structure of these Nan Shan is still meagre, but there is evidence that this region was affected by mountain-forming movements at the date of the uplift of the Himalaya. For example, there is a chain of mercury ores in Kweichow, and all the chief mercury mines of the world are in belts that have been intensely compressed by mountain-forming movements of the age of the Alpine and Himalayan systems. The mercury deposits of Kweichow were probably formed at the same time as those of the other chief mercury fields and under similar circumstances; so their occurrence supports the view that southern China was upheaved into a mountain chain at the same date as the Himalaya. This Nan Shan chain was bent northward at its eastern end by the resistant mass of ancient rocks along the coast of south-eastern China.

On this conclusion the continuation of the Himalaya in China follows approximately the course of the eastern end of the Yunnan Arc and "*Sino-Annamitic faisceau*" of Deprat ('*Mém. Serv. Geol. Indochine*,' vol. i. pt. i. 1912; '*Géologie Générale*,' pp. 300-301). Deprat gave the name of the Yunnan Arc to a zone of folding which runs from Tibet parallel to the three rivers and east of the upper part of the Yangtze, where it includes the peak of Likiang; it then widens southward to include the area between the Tsang Shan of Tali and the divide between Tali lake and the Yangtze Kiang; in the longitude of Yunnanfu it ranges southward for 140 miles nearly to Linan in the basin of the Red River. Between Yunnanfu and Linan its trend is west and east, and it butts against the Sino-Annamitic chains; it passes into south-central China on a course to the north-north-east and disappears before reaching the Yangtze, leaving the Nan Shan constituted by the Sino-Annamitic folds which pass on to the Pacific border near Shanghai. The only part of this Yunnan Arc that we crossed was in the region of Tali and Likiang. The country including the essential part of the Yunnan Arc between Tali and Yunnanfu has been well described by Mr. Coggin Brown. Its surface is very irregular; but the undulations appear due to the denudation of an ancient plateau in consequence of the formation of deep basins by subsidence after the mountain-folding had ceased; there is no clear evidence for the survival in this area of any mountain due directly to the Himalayan folding.

According to our interpretation the direct prolongation of the Hima-

layan axis crosses southern China, and the Burmese–Malay Arcs form a loop to the south comparable to the Persian loop in western Asia and the Apennine loop in Europe.

In correlating the mountain lines of Asia and western Europe one important difference must be remembered. In central and western Europe the pressure which crumpled the Earth's crust into the mountain chains of the Atlas and the Alps was exerted from the south. From the Black Sea eastward across Asia the pressure was from the north. Hence in western Europe and northern Africa the mountain chain which is homologous to the Himalaya, as the inner member of the mountain system, is the Atlas ; the Alps are homologous to the outer division and therefore to the Burmese–Malay Arcs.

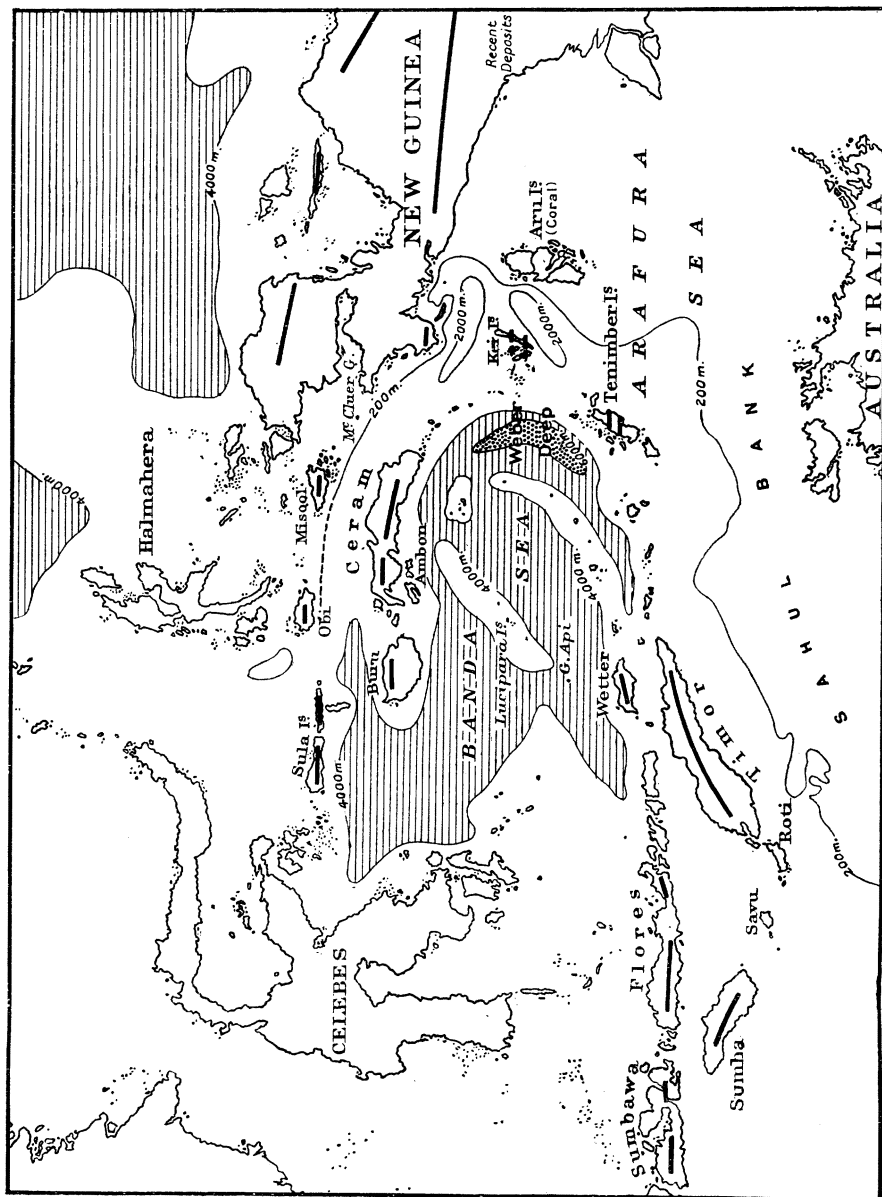
4. *The Subsidences within the Mountain Zone.*—On the relief of the pressure which made the fold-mountains, large areas sank between the outer and the inner series. Thus in Europe were formed the basins of the Mediterranean and the Black Sea, and in eastern Asia the deep basins that broke up the land into the Eastern Archipelago.

Further west the great basins of southern China and of Indo-China and Burma as well as the Gulf of Martaban are to be regarded as due to similar subsidences between the direct prolongation of the Himalayan line and its southern loop.

5. *The Malay Arc and its Eastern Termination.*—We have seen therefore that the supposed hairpin bend of the Himalaya around Assam is not a simple loop, but is part of the mountain knot by which the Burmese Arc is joined to the main mountain axis of Asia. At the eastern end of the Malay Arc the same problem arises, since that arc is generally represented, *e.g.* in the instructive lecture delivered to the Society by Dr. Molengraaff in 1921, as ending in a sudden reversed bend around the Banda Sea.

According to Suess ('Antlitz,' 3, 1901, pt. i. pp. 304–307, 331), on the other hand, the Banda Arc is not a chain of fold mountains but an "arc-shaped horst," and the two peninsulas north-west of New Guinea, which are separated by McCluer's Gulf, are the continuation of the Sula–Obi–Misool line on the north and of the Buru–Ceram line on the south, while the Timor Arc continues eastward as part of an east-to-west chain which is independent of the two northern lines. Bohm (1906) has adopted the same general view. The geological evidence appears to us consistent with it. The Tenimber Islands have been shown by Professor Brouwer to include vertical Mesozoic rocks, which he compares to those of east Ceram ; but their strike varies from east and west to 25° N. of W., and is therefore that of the island chain extending westward from Tenimber to Java and is not due to folding on the line of the Banda Arc. In the Kei Islands also the strike of the older and more steeply tilted beds trends east and west (see *Verbeek, Faarb. Mijnw.*, 37, 1908, pl. xv. figs. 421, 431, 440) and is part of the general east-to-west

grain of this region, which is older than the Banda Arc. It is true that in Great Kei there are some shallow folds with gentle dips which trend from south-south-west to north-north-east, parallel to the eastern part of the Banda Arc; but they may be explained by a gentle tilt of the foundation toward the Banda subsidence, and they do not indicate a chain of fold mountains connecting those to the north and south of the Banda Sea.



3. THE BANDA ARC

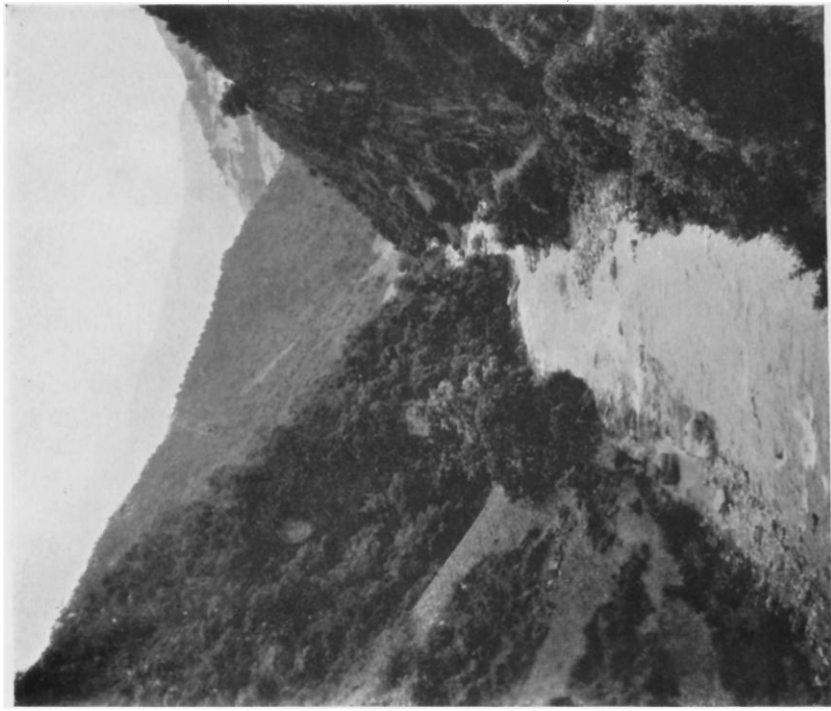
The characteristic rocks of the Ceram-Buru line and of the islands of the eastern end of the Timor chain have not been recorded from the Kei Islands, which form the middle and essential part of the Banda Arc. The geology of the Kei Islands shows that they stand in a long-established valley between the mountain axis of New Guinea, Ceram, and Buru on the north, and the line through Timor and northern Australia on the south. There appears as yet no evidence of the formation of a chain of fold-mountains running north and south to the east of the Banda Sea. The existing evidence is consistent with the conclusions that the Buru-Ceram line is a prolongation of the northern mountain axis of New Guinea; that the Java-Timor series is a prolongation of the mountain lines of south-eastern New Guinea, and that the Kei Islands stand on an intermediate horst.

The Alpine-Himalayan line is therefore recognizable from the Pyrenees to Papua. Both ends appear to be cut off abruptly, the Pyrenean by the Atlantic, the Papuan by the Pacific. There is strong evidence that the line was continued further in both directions, the Pyrenean across the Atlantic, and the Papuan far out into the mid-Pacific. If, as seems probable, the formation of this great fold-mountain chain was due to the pressure of the northern cap of the world against the tropical or subtropical zone, this action should also have affected the floor of the Pacific. That this zone of mountain-folding did affect the Pacific basin is indicated by two lines of evidence. East of New Guinea extends the area of the coral atolls of the Pacific; and according to Darwin's theory, which seems now to be generally accepted, each atoll is a garland of coral marking the site of one of the mountains of a submerged continent. The existence of land extending far out from eastern Asia and northern Australia into the Pacific and possibly connected with America would explain many striking resemblances between the animals and plants of tropical Asia and Australasia and of the opposite regions of America. The remarkable resemblance of the flora of south-eastern Asia to that of the southern parts of the United States, which was recognized by Asa Gray, has been fully confirmed and is supported by the evidence of various groups of animals. Two objections to this view may be taken. One is that all these cases of community were established by the organisms having spread, not across the Pacific, but around it *viâ* Behring Strait or the Antarctic Continent. The second objection is that the evidence is inadequate, since clear evidence of any such Pacific land would have been afforded by such groups as the higher mammals and the birds; but if a land connection had been raised by the earlier uplifts of the Alpine-Himalayan Series and had been broken and parts of it submerged beneath the ocean in the Miocene, that land connection would not have been available to the more recently developed birds and mammals. They could only have passed from Asia to America by the northern route.



THE TWO-SPAN CHAIN BRIDGE ACROSS THE SALWEEN RIVER ON THE ROUTE FROM TENG-YUEH TO TALI

The foothills consist of red sands; the range to the west consists of crystalline limestone, quartzites, and schists.



LOOKING SOUTH-WEST DOWN THE WEISI RIVER AFTER ITS PASSAGE THROUGH A DEEP GORGE

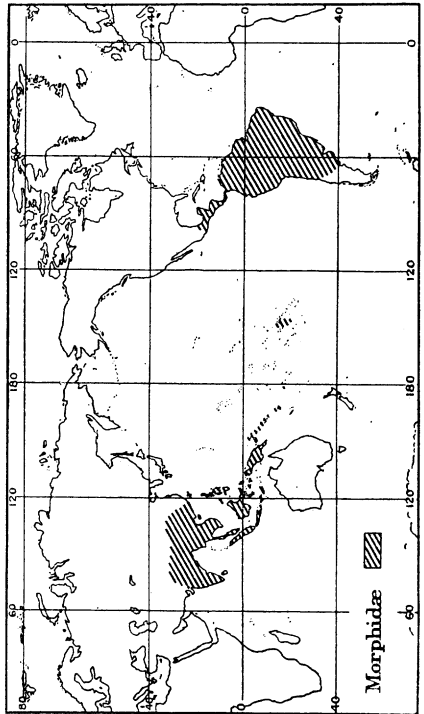
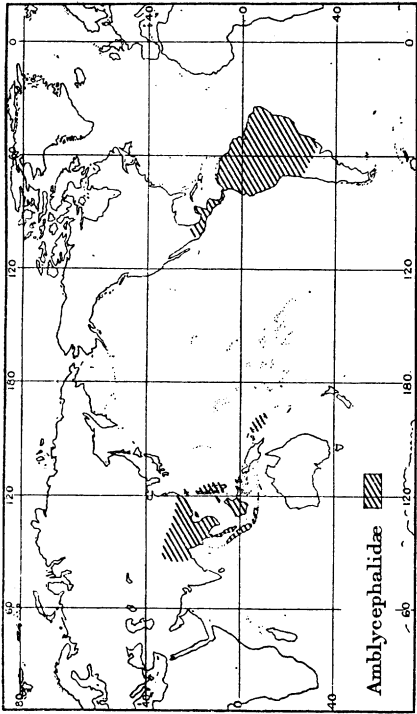
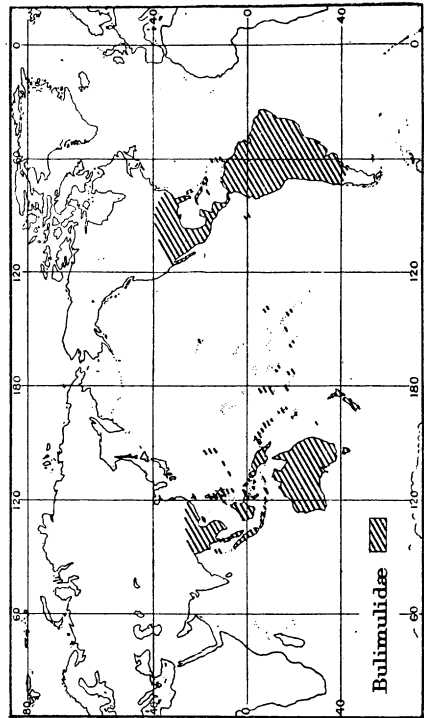
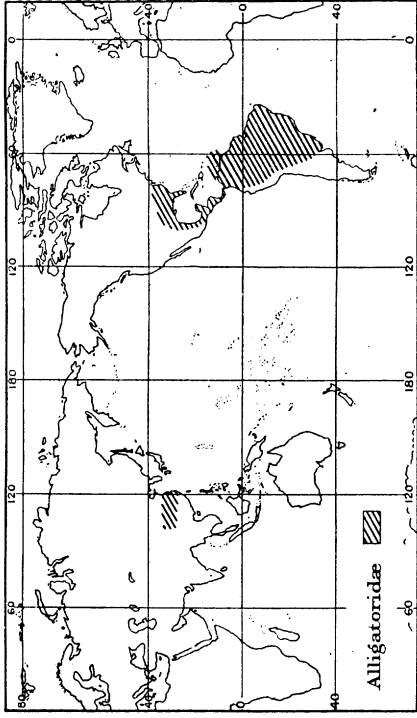


THE GORGE BELOW LONDRE

The ridge is part of the floor of the old high-level valley, dissected by the Mekong and its tributaries.



RAPIDS OF THE MEKONG AT NANTAO



4. TRANS-PACIFIC BIOLOGICAL RANGES

[Redrawn from Bartholomew's Atlas.

The danger of trusting to one or two of the highest and most recently developed groups is shown by the fate of the famous "Wallace's Line," which was drawn to separate the Asiatic and Australasian sections of the Eastern Archipelago. When the distribution of some older forms of life was duly considered that line disappeared and it has been replaced by Weber's line across the Sunda Sea, on a route much farther to the east.

This biological evidence is attended by the drawback that as only those animals and plants that were in existence in the Oligocene or Miocene could have used a trans-Pacific route, their ancestors may have crossed by a northern Pacific land bridge and have been exterminated from the northern lands. When however representatives of these groups are found living on the islands far out in the tropical Pacific, and there is no evidence of their occurrence in northern Asia or America, a mid-Pacific route would appear more probable. This conclusion is especially probable for those Asiatic and American forms that are so similar that they have been regarded as almost specifically identical; they are more likely due to survival, under unchanging climatic conditions, from a once continuous tropical or subtropical habitat than that the species should have wandered for so great a distance and across different climatic zones without having undergone greater change.

There is much biological evidence consistent with the physical evidence for a great land in the tropical Pacific in continuation of the Asiatic mountain lines.

IV. The Parallel River System of Chinese Tibet.

1. *The Parallel Courses of the Three Rivers.*—The other main geographical problem on which we hoped to obtain further information deals with the parallel course of the upper parts of the three great rivers of south-eastern Asia. Eastern Tibet is drained by the Yangtze Kiang, the Mekong, and the Salween; they converge as if they were about to unite, but instead of joining they run parallel across the high platform of Chinese Tibet, for a distance of about 170 miles, for 130 of which they are in a belt about 50 miles wide. Then they suddenly diverge. At Shihku the Yangtze starts to the east-north-east on an extraordinarily zigzag course until, after leaving the western mountains, it flows in broad curves across eastern China to the Pacific. The Mekong further south is diverted to the south-east; the Salween, by a series of jerks to the west, reaches the Bay of Bengal. The Salween and the Yangtze, in places only 42 miles apart, have their mouths separated by a distance measured in a straight line of 2000 miles.

This behaviour is unique in the river systems of the world. Yule compared the approach and divergence of these rivers to a fascis of thunderbolts in the hand of Jove. Sir Sidney Burrard and Sir H. Hayden in the 'Geography and Geology of the Himalaya' (1908, p. 127), say that "The parallelism and proximity of the Yangtze,

the Mekong, and the Salween in their exits from Tibet are amongst the most extraordinary features of the Earth's land surface." "Cette région tibétaine," says Bacot ('Le Tibet Révolté,' 1912, p. 166), "des grands fleuves est unique; quatre gorges parallèles, démesurées, absolument pareilles. Ils n'est rien, je crois, de si géométrique ailleurs dans le monde." Forrest, Bouterwek, Kingdon Ward, Bailey Willis, Deprat, L. Darwin, and others have referred to this question or discussed it.

The explanation of the anomalous feature of this river system is possible on two lines. They may be gutters excavated as overflow channels by the rivers that discharge through them. Tibet is "the roof of the world," and the drainage on a roof is often along parallel lines between the ridges, and the gutters may discharge into different water-butts or on to different slopes around the house. This hypothesis, or some form of it, is favoured by Bailey Willis, amongst other authorities. A second possible line of explanation is that the south-eastern rim of Tibet was once a continuous band of mountains which turned the drainage into central China, whence it discharged to the Pacific; that, this rim having been cleft by earth-movements, the rivers from Tibet flowed southward through the clefts until they reached old valleys to the south of the mountain rim and were diverted by them to east or west.

That the valleys are tectonic, that is are due to earth-movements and not to excavation by rivers, has been advocated by Deprat ('Mém. Serv. Géol. Indochine,' vol. i. 1912, p. 300), who has shown that the great lakes and valleys in south-eastern Yunnan are due to subsidences on lines which run generally from north to south.

2. *The Structure and Relative Age of the Three Valleys.*—In considering the history of these three rivers it must be remembered that their valleys have one important feature in common. Each of the three valleys was formed in two stages. A high-level valley, which was broad and relatively shallow, was first formed; subsequently, along its floor was cut a deep trough, which has been either left as a narrow canyon or enlarged into a broad valley.

The canyon parts of these valleys are due to corrosion, as Mr. Kingdon Ward has clearly shown; for though they are in general straight and direct, when examined in detail they have the sinuous course and overlapping profiles characteristic of river-cut valleys. But these canyons occur on the floors of old straight valleys the position and courses of which may have been determined by earth-movements.

The most significant fact as to the origin of the parallel sections of the Yangtze and the Mekong is that they both have essentially the same structure in spite of the great difference in the rocks they traverse. In both cases the rocks on each side slope downwards away from the valley. The essential structure is that of a trough along the middle line of a broken arch; the valleys of the Mekong, the Upper Yangtze, and other rivers in Chinese Tibet were formed as tension clefts by the rupture of

hard rocks which were pulled apart on the stretched upper side of an arch. They have an origin similar to that of fiord valleys, to which they have many resemblances in plan and form.

Of the upper Salween we did not see enough to determine its structure; and where that river is crossed by the road from Tengyueh to Tali it flows through a broad valley along a band of limestone which is easily worn away; it also is parallel to lines of fracture, for the range that forms the western side of the Salween ends to the west in the weathered fault scarp which forms the eastern wall of the Shweli valley. The Salween valley, owing to its greater breadth and depth and the gentler slope of its sides as seen from the Tengyueh-Tali road, appears much older than that of the Mekong, which there flows at the bottom of a narrow canyon, 2000 feet higher than the level of the Salween.* The form of these valleys is so inconstant that it gives no certain evidence of their relative ages; in some localities the conditions described are reversed. Thus at Luchang, where we descended to the Mekong south of Feilung bridge, the valley is a deep narrow cleft with no room for extensive alluvial deposits; but a few miles further upstream the valley broadens out and has vast drift deposits upon its floor, and it then presents an aspect of much greater age than does its gorge at Luchang. The part of the Yangtze parallel to the Mekong shows the same variations.

Similarly, although the Salween valley south of the bridge has comparatively gentle slopes, a short distance to the north the valley narrows, and the walls are described by E. C. Young (*Geogr. Journ.*, 30, 1907, p. 160) as "extraordinarily precipitous"; it has there the characters of a relatively young valley. Where each of the three rivers crosses old depressions or belts of soft rock, their valleys may be wide with sloping banks and may contain enormous deposits of sand and gravel. Where they cross harder rocks their valleys contract into narrow cleft-like canyons.

The larger size and greater depth of the Salween valley and the lower level of its floor are explicable by the meteorological conditions. Most of the rain in that part of Asia comes from the west, and the western rivers receive a larger water-supply from an equal area of land than those further to the east. Hence it is only natural that the level of the Salween should be lower than that of the Mekong. The fallacious conclusions as to the sources of the Irrawaddy based on its unexpectedly large volume illustrate the heavy rainfall in Upper Burma.† The fact that

* The suggestion that the Salween is the oldest of the three rivers was made by De La Touche (*Mem. Geol. Surv. India*, 39, 1913, p. 20), and also by Mr. Kingdon Ward.

† The measurements by E. C. Young (*Geogr. Journ.*, 30, 1907, p. 179) show that at the date of his observations (December 1905), the Nmai Hka, the main eastern branch of the Irrawaddy, had a larger discharge than the Salween in spite of its much smaller collecting ground.

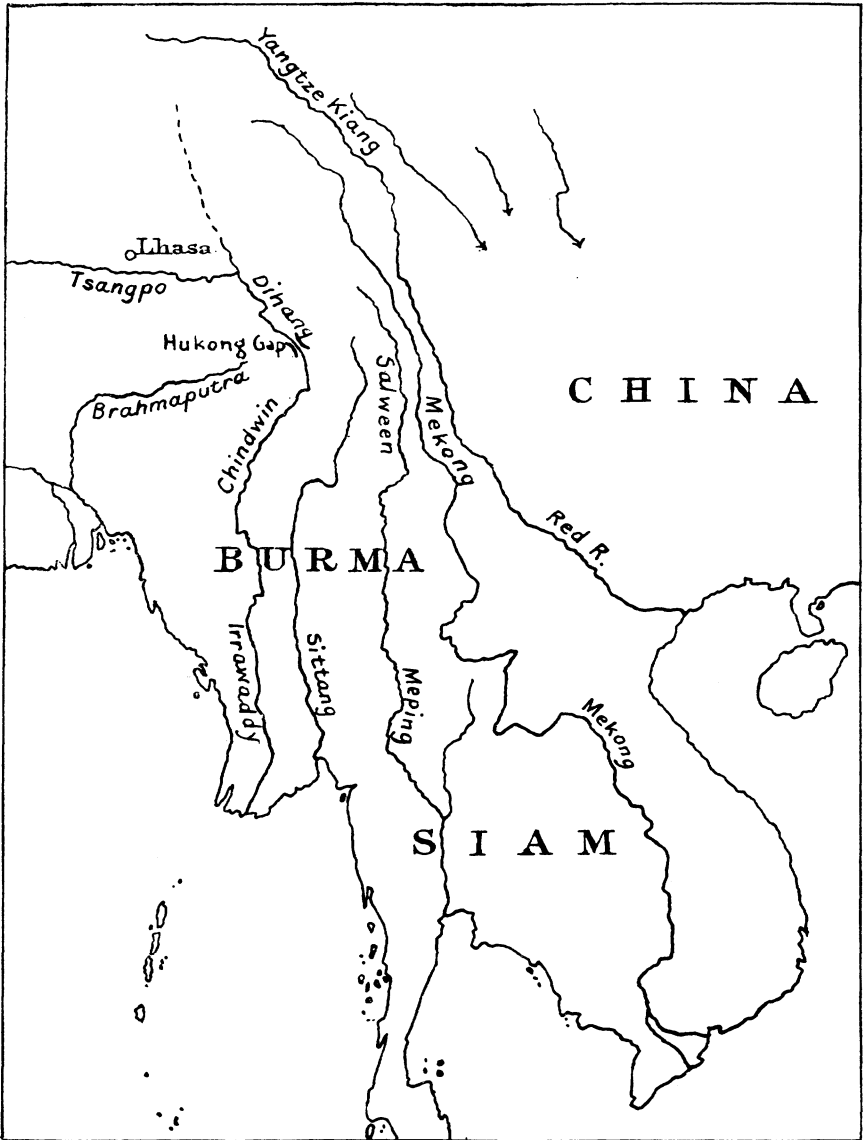
the Yangtze has a larger discharge in the spring than the Mekong is apparently inconsistent with the western source of the rain; but the Yangtze receives the drainage from larger snowfields in Tibet. The three valleys seem approximately of the same age. Their differences in size, form, and level are due to the unequal volumes of the three rivers, resulting from the irregular distribution of rainfall and snowfall, and to the varying durability of the rocks in which the valleys have been cut.

3. *Comparison of South-east Asia and East Africa.*—To understand the origin of the river system of Chinese Tibet it is necessary to consider the geographical history of the region, and as it is so little known much light is thrown on the subject by the comparison of south-eastern Asia with East Africa.

The geological history of East Africa has many features in common with Indo-China, though with some striking differences. The features in common are due to the fact that both East Africa and south-eastern Asia were formerly parts of one continent. They have been severed by the foundering of the Indian Ocean. The collapse of the crust over that great area weakened the lands that were left upstanding beside it. East Africa was split by the Great Rift Valley, and the sinking of large earth-blocks formed the African lake basins, their associated valleys, and the basin of the Red Sea. These subsidences were accompanied by vast volcanic eruptions which covered tens of thousands of square miles with thick sheets of lava. The breaking up of the old continent enabled the sea in Eocene times to invade the Gulf of Aden; the basins of the Red Sea and Lake Nyasa were formed by the Oligocene, and their formation was followed by a general uplift, the recession of the sea, the development of great lakes, and the occurrence of more rifts and renewed volcanic eruptions. Finally, a series of earth-movements made the walls that are still existing in some parts of the valley.

South-eastern Asia has had a similar sequence of geographical events. It was part of the same continent as East Africa and was broken up by subsidences on north and south lines, which allowed the Eocene sea to submerge the coast-lands and extend up the valley of the Irrawaddy. Then followed an uplift that expelled the sea, fractured the crust, and occasioned a series of volcanic eruptions the last of which happened in historic times. The volcanoes were isolated vents and did not build up vast lava plateaus as in East Africa. The east Asiatic fractures moreover, though very numerous, are less regular and less continuous than in East Africa. These two great differences are intelligible when it is remembered that the north-and-south fracturing of the crust in East Africa operated upon a rising broad dome or arch, the surface of which was therefore under tension and was being pulled apart; in south-eastern Asia the fractures cut across an area which had undergone intense lateral compression. Mountain chains of the Alpine type, which

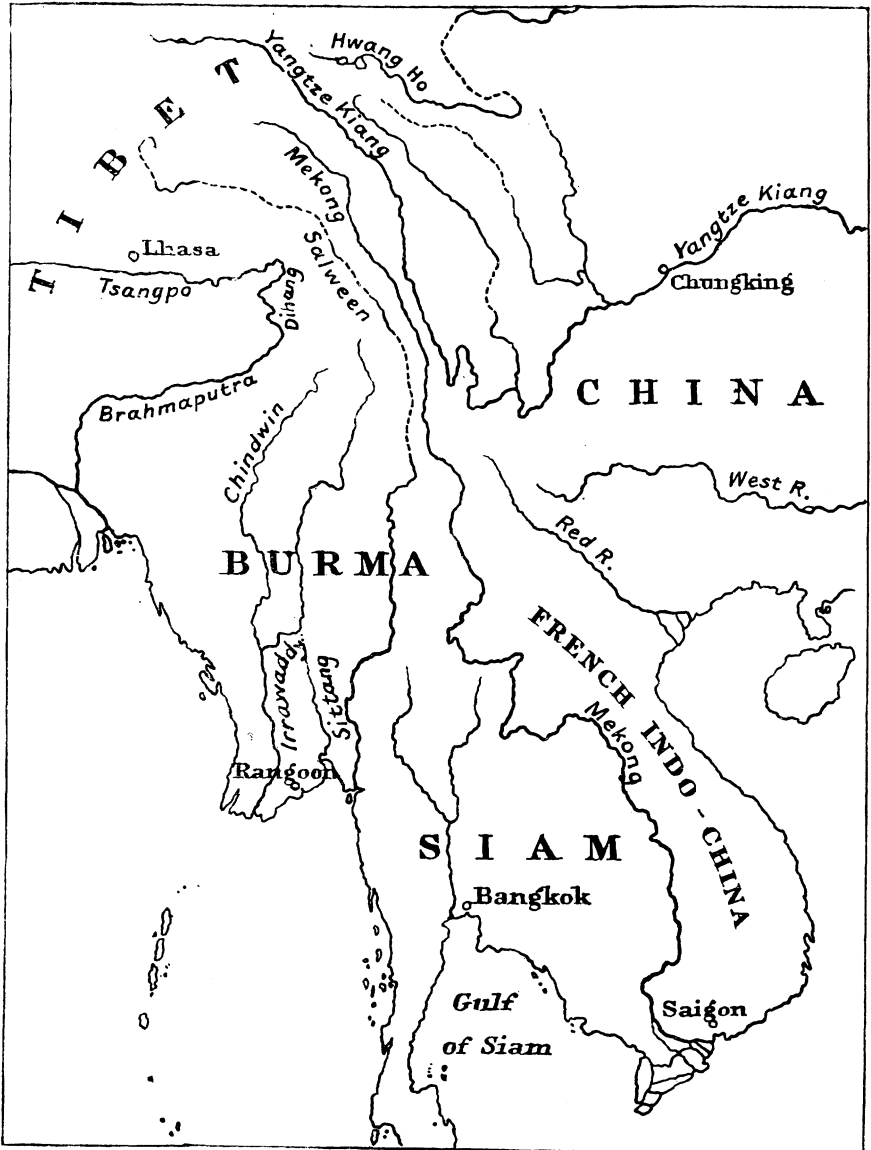
are due to compression, are not as a rule the seat of great volcanic eruptions; where, as in the Caucasus, volcanoes stand upon such fold-mountains they occur where the folds have been broken by subsequent cross fractures. The absence of volcanic activity is one of the characteristic features of mountains formed by intense folding. Hence the essential difference between the topographical features of East Africa



5.—THE POST-HIMALAYAN RIVER SYSTEM OF SOUTH EAST ASIA

and of south-eastern Asia related to these north-and-south fractures is that in East Africa these features have been developed in an old plateau which was under tension, and in south-eastern Asia they have been developed in a folded area that was then recovering from intense compression.

4. *Evolution of the River System of South-east Asia.*—The stages



6.—THE EXISTING RIVER SYSTEM OF SOUTH-EAST ASIA

in the geographical development of southern Asia summarized in the previous section have guided the evolution of the river system. In the middle period of the Earth's history, when India and East Africa were parts of a single continent, the Earth underwent a slow gentle buckling of the crust which produced a series of east-and-west valleys ; they are shown in Africa, for example, along positions still occupied by the Congo, the Zambezi, and the older parts of the Niger. At the end of that period intense folding of the crust accompanied the upheaval of the Alpine System ; that period of mountain formation was followed by movements on lines trending north and south, and they led in East Africa to the formation of the Nile by the union of the upper parts of three of the east-to-west river basins. In Asia there is evidence of great east-to-west valleys which were probably contemporary with those of tropical Africa ; the Tsangpo (the Upper Brahmaputra), the Hwang Ho, the Yangtze Kiang, and the Si Kiang (West River) are probably the modern survivals of these ancient rivers. The Himalayan upheaval confirmed some of these valleys, such as the Ganges and the Upper Brahmaputra ; but it fundamentally altered the general drainage from Tibet, for it left Central Asia upraised as a vast block with long slopes downward to the east and south. The southern drainage after the close of the Himalayan movements was discharged by four main rivers : (1) the Dihang, which carried the drainage from the Tsangpo and much of western Tibet southward, through the broad Hukong Gap, into north-western Burma ; there it formed the Chindwin, which continued southward as the Lower Irrawaddy ; (2) the Upper Irrawaddy in north-eastern Burma, which was probably not then connected to the Lower Irrawaddy but discharged to the sea as the Sittang River near Pegu through the broad valley between the Shan Plateau and the Lower Irrawaddy ; (3) the Salween, which then probably continued through the Meping and Menam rivers to the Gulf of Siam at Bangkok ; (4) the Mekong, which doubtless discharged, as at present, across Tongking, though not along its present course ; and (5) the Yangtze, which was probably continued from its great bend at Shihku through the valley of Kienchwan (Chien-chuan Chou) past Tali and through the Red River to the Gulf of Tongking near Hanoi. This simple river system was broken up by subsidences probably consequent on the reaction from the Himalayan compression. One subsidence made the valley of Assam which diverted the Dihang through the Lower Brahmaputra to the Ganges ; this change beheaded the Chindwin, which till then had been the main stream of the Irrawaddy. That river, however, was compensated for the loss of its Tibetan head streams by capturing the drainage of north-eastern Burma, by beheading the Sittang river, through the reach around the end of the Sagaing range. The Salween was diverted by the formation of a series of young gorges westward to the Gulf of Martaban. The development of the Yangtze



THE PLATEAU OF YUNNAN DISSECTED BY THE VALLEYS OF THE SHUNPI-HO AND ITS TRIBUTARIES



RIVER YANGTZE KIANG FROM A PASS SOUTH OF CHI-T'SUNG
The level spurs on each side are remains of the old high-level valley.



THE DISSECTED PLATEAU OF YUNNAN NEAR YUNG-PING



LOOKING FROM THE JENSA LA DOWN A GLACIATED VALLEY AND ACROSS THE MEKONG VALLEY TO KAGURPU

gorges enlarged that river by the capture of the former Tibetan tributaries to the Red River.

It is only with the three eastern of these five rivers that we are here especially concerned. That they have undergone some such changes is shown by the structure of their valleys. Each of them lies on the floor of a broad shallow valley, which was certainly formed after the Himalayan folding and is probably Pliocene. No deposits have yet been found in the upper parts of these valleys which demonstrate their age; until fossils are obtained the date of their formation can only be given as lower Pliocene or possibly a little earlier. On the floors of these old valleys deep basins and valleys have been formed by subsidence along faults or excavation by rivers; the majority of these basins trend north and south, though some curve round to a course of approximately east and west. Analogy with adjoining areas indicates that the basins had been formed by the late Pliocene, and their formation enabled the rivers to cut deep canyons on the floors of the old valleys connected with these basins.

5. *The Supposed Recent Regional Uplift of Central and West China.*—The agency which enabled the rivers of Yunnan and of western China to cut their canyons, has been generally regarded as a regional uplift. All that part of East Central Asia has been represented as having been upraised at least 6000 or 10,000 feet in very recent geological times; but the evidence for so great an uplift at so recent a date seems inadequate, and a simpler explanation of the facts is possible. The uplift has been introduced to explain the formation of the deep valleys in a country that was formerly a level plateau.* It is often assumed that such level surfaces can only be formed at a low elevation; and, if that were so, uplift would be necessary before they could be dissected by deep valleys. If a wide uplift had occurred in this region marine beds of a recent age would be expected on the borders of the upraised area, and especially where it is nearest the sea as in Burma. One of the striking features in the Burmese coast of the Indian Ocean is the poverty of raised beaches. There are many recent deposits on the surface of the plateau, but they were formed on land or in fresh water. We know no direct evidence of any post-Pliocene high regional uplift of this area, but of weighty evidence against it. The evidence of the glaciers of Chinese Tibet is rather in favour of a subsidence of the area than of its uplift. If the country had been uplifted at the date assumed, the glaciers should have recently increased in size, whereas on the contrary they have become smaller. The decrease in the glaciers appears, however, to have been due rather to variations in the local snowfall than in the level of the land. The physiography of central and south-western China appears intelligible without the assumption of a recent regional uplift, for the formation of wide

* This view is due in the main to Messrs. Bailey Willis and Blackwelder for the Yangtze Kiang basin, and it has been supported by Deprat for Tongking and eastern Yunnan.

plains at high elevations above the sea is shown to be possible by western Australia and the eastern Sudan. In both countries the wind and sluggish streams have developed high-level plains. Any change in rivers by which their currents become swifter and their fall steeper enables them to wear away their beds. This change may be produced on a high plain by the subsidence of the surrounding country or of deep internal basins. The formation of the Irrawaddy valley and the foundering of the deep basins which are so important in south-eastern Asia would have turned previously quiet rivers into cataracts, which would wear away their beds and break up the original plateau by corroding deep valleys into it. Subsidence and not regional uplift appears the cause of the deep canyons which are the predominant feature in the topography of south-western China and its high borderlands.

V. Summary of Conclusions.

These geographical problems depend for final solution on the structure of Chinese Tibet and of adjacent countries of which our geological knowledge is still rudimentary. The full discussion of the problems involves evidence too exclusively geological for statement in this *Journal*, and our collections have not yet been studied. All we have been able to attempt in this paper is to state the general conclusions as to the mountain structure and evolution of the river system of western Yunnan indicated by our field observations. They show evidence that the Alps of Chinese Tibet have been uplifted by earth-movements belonging to the Himalayan series and are a continuation of the main line of the Himalaya; that the anomalous features of the river system are due to meridional ruptures which enabled the drainage from south-eastern Tibet to escape over the platform of western Yunnan through parallel valleys; and that on the floor of each valley a deep canyon has been excavated in consequence of the foundering in recent geological times of areas within or adjacent to the plateau of south-western China and of the neighbouring territories.

Before the paper the PRESIDENT said: It is my privilege and my great pleasure to ask His Excellency the French Ambassador to present to Professor Gregory the Gold Medal which has been awarded to him by the Société Géographique de Paris.

H.E. the COMTE DE SAINT AULAIRE (French Ambassador): Je suis très reconnaissant à Monsieur le Président de la Royal Geographical Society d'avoir bien voulu m'inviter à remettre la Médaille d'Or de la Société de Géographie de Paris à M. le Professeur Gregory. C'est pour moi l'occasion de rendre hommage à l'œuvre admirable accomplie par votre Société pour le progrès de la Science et l'honneur de l'humanité. C'est aussi pour moi une agréable occasion de me féliciter des excellents rapports qui existent entre nos deux Sociétés sœurs. Leur collaboration dans l'étude de notre planète est un excellent exemple pour nos deux Gouvernements. Puissent-ils s'en inspirer et collaborer, avec la même cordialité, sur les points de cette planète où leurs intérêts sont les mêmes et, plus particulièrement, sur les points où leurs intérêts semblent différents, ce qui certainement provient d'une erreur d'optique.

Quant à M. le Professeur Gregory, je le prie de m'excuser si je suis mal qualifié pour louer ses travaux comme ils le méritent et dire la haute estime qu'ils inspirent à vos collègues de Paris. J'aurais voulu qu'un des membres les plus autorisés de notre Société de Géographie fut ici ce soir à ma place. Les diplomates sont bien des voyageurs ; mais ce ne sont pas des explorateurs et encore moins des savants. Pour bien des raisons quand ils parcourent le monde, ils voient, à peu près exclusivement, un horizon qui est le même sous toutes les latitudes, l'horizon d'un sleeping-car ou d'un salon de paquebot. Cependant, comme ils sont pleins de cette présomption qui est l'inséparable compagne de l'ignorance ils refont de temps en temps la carte du monde. Espérons du moins qu'avant de la refaire, ils tachent de la comprendre en consultant les géographes, afin de ne pas avoir à la refaire trop souvent et que, grâce à vous ils tiennent compte des réalités. C'est à cette condition seulement que leur travail sera une garantie de paix et non un germe de guerre.

Je n'aurai donc pas la témérité de rechercher pourquoi le choix de la Société de Géographie s'est porté sur M. le Professeur Gregory. Je crois cependant ne pas me tromper en supposant que si ses explorations dans l'Afrique Orientale lui ont valu d'être considéré en France et dans le monde entier, selon l'expression de M. Grandidier, Secrétaire Général de notre Société de Géographie, "comme l'un des plus éminents voyageurs scientifiques contemporains," c'est parce qu'il étudie notre planète d'un point de vue à la fois très large, très haut et très profond. Le Professeur Gregory est habitué à voir au-delà de la surface des choses car il est un maître de la géologie. Or, selon l'expression de votre éminent Président la géologie est indispensable au géographe comme l'anatomie est indispensable au peintre. Si nous suivons le Professeur Gregory il nous emène très loin dans le temps et dans l'espace. En ce qui concerne le temps, bien qu'il soit très prudent sur l'âge de la Great Rift Valley, il nous donne à entendre, je crois, qu'elle est moins récente que certaines formations qui, pour les géologues ne date que d'hier comme l'Himalaya par exemple, c'est-à-dire, qui n'ont que quelques millions d'années d'existence. Quant à l'espace le Professeur Gregory nous fait aussi la mesure large. Non seulement il a pris pour sujet un phénomène qui s'étend de la Palestine à l'Afrique du Sud, cette série d'antailles dans l'écorce terrestre qui sont comme de formidables coups d'épée de quelque géant préhistorique au temps où les mondes se battaient entre eux, un temps relativement éloigné peut-être, quelques milliards d'années par exemple ; mais sa science déjà planétaire devient cosmique et nous montre dans la lune exactement les mêmes blessures, de sorte que s'il y a eu duel entre la terre et la lune nous constatons—et c'est bien réconfortant pour un pays aussi sportif que l'Angleterre—que la terre n'a pas reçu les coups sans lui rendre.

Cette observation suffit à démontrer que M. le Professeur Gregory possède aussi un mérite que je mentionnerai parce que c'est le seul que je sois capable d'apprécier pleinement et qui justifie un peu mon rôle ce soir : il intéresse à la fois des savants comme vous et des ignorants comme moi. C'est là je crois le signe de la vraie science qui est humaine et universelle, qui satisfait la raison des hommes et enchante l'imagination des enfants ou même de ces vieux enfants que sont souvent les diplomates.

Je prie M. le Professeur Gregory de vouloir bien accepter cet hommage d'un ignorant à un savant en même temps que la Médaille d'or qui lui est décernée par la Société de Géographie de Paris et que j'ai l'honneur de lui remettre.

His Excellency then presented the Medal, and

Professor J. W. GREGORY, in returning thanks, said : It is impossible

adequately to express my thanks for the high honour which is conferred upon me by this award of the Geographical Society of Paris and its presentation this evening by His Excellency the French Ambassador. My gratitude is none the less deep because I feel that this award is less to me individually than as a representative of those British geographers who have been working on the mainland of East Africa in the same spirit and with the same ideals as the French geographers who have done so much for the advancement of geography by their magnificent work in Madagascar. The award is a further sign of that close intellectual sympathy and that constant interchange of thought and knowledge between France and Britain which has been the most long-continued and most fruitful example of the international fraternity which your people, Your Excellency, first embodied as an ideal for the whole world. I feel particular pleasure at receiving this award at this time as I have so recently had the opportunity of seeing some of the great work, both scientific and religious, of the French Mission to Tibet which has been carried through to success, in spite of difficulties and dangers which make the story of that Mission one of the noblest as well as one of the most tragic in the adventurous history of missionary enterprise. I must again express my profound thanks both to His Excellency and to the Geographical Society of Paris for the high distinction of this award.

The PRESIDENT: Professor Gregory does, indeed, require no introduction, for his contributions to human knowledge in geology and geography are well known. Further recognition has been given to his services to science by the award which has just been presented to him so gracefully by His Excellency the Ambassador of France, a graceful act which you and I appreciate as much as does Professor Gregory himself. Moreover, Professor Gregory is a man of many interests. I have myself been brought into close personal contact with him in another sphere of human activity, namely that of education, for he was a brilliant and most useful member of an important Commission which inquired into the working of the greatest of the Indian Universities, that of Calcutta, and which issued a monumental—I know, for I had to read it—and what may be described as an almost encyclopædic report upon the whole question of higher education in that vast continent. The labours of that Commission had hardly come to an end when Professor Gregory hurried off to a part of the world to which he had been attracted more than a quarter of a century before, namely, East Africa; and the results of his labours there were given to the world early in 1921 in a book entitled ‘The Great Rift Valleys and the Geology of East Africa,’ an account which the author himself described as “A narrative of the origin and history of the great rift valleys of that country and of their relation to the contemporary Earth-movements which transformed the geography of the world.”

At first sight one would not imagine that there was any very direct connection between East Africa and Western China, the country to which Professor Gregory is going to conduct us this evening. Nevertheless, as he will no doubt explain to us in the course of his lecture, there is a very direct connection between the two, for it was not until the crust of the Earth in that part of the globe fell in and the Indian Ocean took its place that East Africa and South-East Asia, which were then part of one continent, became separated by a great ocean. It is true that this happened a longish time ago; at any rate what would be regarded by those of you who are not geologists as a longish time, for it took place, I believe, in the early Eocene period; and when a few moments ago I suggested to Professor Gregory that that meant a matter of some two million

years ago he rather snorted and said, "Well, some people might say so, but it was really from fifteen to twenty million years ago." But in spite of this long lapse of time it is an undoubted fact, as he will explain to us, that the subsidence of the Earth's crust in that region did leave an abiding and a very distinctive character upon the land upon each side of it, with the result that Professor Gregory, with his great knowledge of East African geology and geography has been able to throw a great deal of light upon one of the outstanding geographical features of Western China, namely, its river system.

The journey which is to form the subject of his paper to us this evening was undertaken last summer, and in calling upon Professor Gregory to give us his paper I venture to congratulate him, upon your behalf, upon his recent safe return from that country.

Professor Gregory and Mr. C. J. Gregory then read the paper printed above, and a discussion followed.

Dr. EVANS: I am afraid I am scarcely qualified to speak about Western China, because I have not been nearer to it than Calcutta, which for all practical purposes is quite as far away as Bond Street. But as an old friend of Professor Gregory I have been intensely interested in the story that he has had to tell us to-night. I do not know whether I admire more his courage or the wonderful tact and patience and perseverance with which he met the difficulties he had to meet. There are few parts of the world in which one takes one's life in one's hand more deliberately than on the borders of India and China. The inhabitants, like other people, are good-hearted enough, but they are mostly agriculturists, and with an agriculturist the success of his crops comes before everything else. There are certain things that augur badly for crops, at any rate in uncivilized regions. One of those is the presence of foreigners at unsuitable times, and if you happen to venture that way in an unsuitable time, so much the worse for you.

I was also greatly pleased with all that Mr. Gregory, the son of the great geologist and explorer who has read the paper to-night, told us. I have never heard a more charming account of adventures in a strange land or one which showed a more sympathetic understanding of the good points of the people with whom he came into contact.

I suppose I ought to say something as to the great problems which Professor Gregory has placed before us, the problems of the structure of the world and the history of the changes that have taken place in the past. There are few problems that are more difficult than these. The world is a great palimpsest manuscript on which story after story has been written in the course of the ages, and it is very difficult indeed for us, at the present time, to interpret even the latest of those writings. All over the world we have a series of foldings and faults, crumplings and fractures, which have occurred at different times, and it is very hard to find any system amongst them. My own interpretation of these scars, the traces of past convulsions, in the history of the world is not quite identical with that of Professor Gregory. There are two tendencies, it seems to me, which we find, at any rate in the later changes in the Earth's crust. I say "later changes" because it is difficult for us to know anything very definite of those that occurred before the Carboniferous period. But in these later changes there appear, as I have said, to be two tendencies. In the first place, there are a series of foldings with an east-and-west direction, that is to say, for one reason or other the Earth tends to close like a Chinese lantern from north to south. Whether that is due to a movement from the equator towards

the poles resulting from the slowing down of the Earth's rotation or the contraction of the interior of the earth, or, as Wegener contends, to a movement ("Pol-flucht") from the poles towards the equator, I am not at present prepared to say.

In addition to that, as Professor Sollas told the Geological Society nearly twenty years ago, there is a kind of symmetry in the Earth's crust which has one pole in the centre of the Pacific and the other in the centre of Africa. This symmetry is in my opinion the expression of a general tendency for the great earth blocks of the Earth's crust to slide away from Africa towards the centre of the Pacific, and by the compression which results to form round the Pacific a great chain of foldings which is one of the most striking features of the Earth's surface. I would suggest that the various phenomena we have had described this evening are the result of the interference between these two series of foldings, those round the Pacific and the east-and-west foldings which are manifested better than in any other part of the world in the great ranges of the Himalayas and the Alps.

What are the causes of these various movements it would take us too long to discuss to-night, but I cannot resume my seat without heartily congratulating Professor Gregory on the information which he has brought us for the consideration of these questions from regions in which we still had so much to learn.

The PRESIDENT: Professor Gregory has placed before us a vivid picture of Western China. It certainly recalls to my mind the most vivid recollections of my own sojourn in that part of the world some fifteen years ago. I was much interested in Professor Gregory's description of his entry to the town of Tali-fu. Personally, when I was at Tali-fu I entered through the gateway and not over the wall, but Professor Gregory explained the reason why he found it necessary to enter by climbing over the wall. That recalled a similar state of affairs which I found in existence in another town in Western China, the town of Chung-king, some 1500 miles up the Yangtze from its mouth in the Pacific. On this occasion the gates at Chung-king were closed, not in order to keep out the evil spirits who brought the flood, but in order to keep out the evil spirits who prevented the flood from rising, because the country had been suffering from drought. The magistrate of the city was ordered to repair to the various temples and to pray for rain. He prayed in one of the temples on August 5 in the year 1906 and he prayed with prodigious effect. It began to rain, and a waterspout within twelve hours burst a little higher up the river. The result was disastrous. The river at Chung-king rose to the almost unprecedented height of 108 feet. Houses, coffins, corpses, and live freight on various forms of support were seen racing down the river and were watched in their mad career by the inhabitants on the city wall.

Then again the descriptive pictures which Professor Gregory gave us of those wonderful rivers, the Yangtze, the Mekong, and the Salween, brought back to my mind most vivid recollections of the time when I went across them. There is nothing more striking in the whole of that part of Asia than the regularity with which, day after day, if one is travelling from east to west, or west to east, one finds one has to drop two or three thousand feet to the bottom of a huge valley, and climb up again, say two, three, four or five thousand feet on the other side.

Professor Gregory has given us his view as to the cause of this peculiar formation. From what Dr. Evans said, I gather that there may be some differences of opinion amongst geologists as to the actual cause. But whatever may be the cause, from the point of view of the traveller who is interested in scenic effects rather than in the causes which produce them, the West of China

is certainly one of the most delightful and attractive countries that I have ever struck in any part of the world.

Professor Gregory also told us something about the internal discomfort—I forget exactly what the cause was—which he and his party suffered, or were threatened with suffering, in one part of the journey. That recalled a story of which I myself was the central figure in that very part of the world. I had just eaten breakfast one morning when my Chinese interpreter came to me and said, “Sir, may I speak?” I said, “Yes, Mr. Chu, you may speak.” “Sir, I hear very funny story.” “Yes, Mr. Chu, let’s have it.” He went on, “Sir, they say that the people who eat eggs of this village suffer very terrible pain and sometimes die.” I replied, “Mr. Chu, that would be a funnier story if it was not for the fact that I have just eaten three eggs myself!” I am happy to say that the prophecies of ill effect from the eggs of that particular village were not, at any rate in my case, fulfilled. These stories probably arise from the unhealthiness of some of the valley bottoms where fever, particularly malarial fever, is extremely prevalent. In fact, as we know from the stories told by Marco Polo himself in his great journey across Asia, many of these valleys were said, in those days at any rate, to be impassable by man for that very reason.

Nothing remains now except for me to express, on your behalf, your appreciation of Professor Gregory’s admirable paper and of the most excellent postscript which was added to it by his son.

WEGENER'S HYPOTHESIS OF CONTINENTAL DRIFT

Philip Lake

Read at the Afternoon Meeting of the Society 22 January 1923.

WEGENER'S views are now so widely known that a very brief introduction will be sufficient. He imagines that the continental masses are patches of lighter rock floating and moving in a layer of denser rock, of unknown thickness; and this denser rock forms the floor of the oceans. Following, with a slight alteration, the terminology of Suess he calls the lighter material the Sial and the denser layer the Sima. Suess's words are Sal and Sima, and there is no advantage in the change. Suess thinks, however, that the Sal is continuous, covering the globe completely, and this is a fundamental difference.

Wegener does not suppose the Sima to be actually liquid, but he believes it to be plastic enough to yield slowly under the strains to which it is subjected, much as a stick of sealing-wax supported at its ends will gradually bend without ever losing its apparent rigidity.

In this paper I shall not discuss the possibility of Wegener's conception. He does not profess to explain completely why the continents should move, but he claims to have proved conclusively that such movement has taken place. It is the evidence on which he relies, and more particularly the geological evidence, that I propose to examine.