THE SECOND DANISH PAMIR EXPEDITION

CONDUCTED

BY

O. OLUFSEN
LIEUTENANT OF THE DANISH ARMY

STUDIES IN THE VEGETATION OF PAMIR

BY

OVE PAULSEN
MEMBER OF THE EXPEDITION

WITH 30 FIGURES AND A MAP

PUBLISHED AT THE EXPENSE OF THE CHURCH- AND SCHOOL DEPARTMENT AND THE CARLSBERG FUND

COPENHAGEN
GYLDENDALSKE BOGHANDEL · NORDISK FORLAG
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. . . . . *Balaxiam, and direct our way towards Cathay, betwixt the east and north-east. Beyond Balaxiam*[1]*) is a certain river, whereon stand many castles and villages belonging to the king of Balaxiam's brother; and after three days journey is the province Vachan, having in length and breath three days' journey, the inhabitants whereof have a peculiar language, and worship Mohammed . . . If you depart thence betwixt the north-east and east, you must ascend for three whole days together, until you come to an exceedingly high mountain, than which there is said to be none higher in the world. There also between two mountains is a great lake, and through a plain runs a very fine river, near which are excellent pastures, so that in them a lean horse or an ox may be fat in ten days. There are also plenty of wild beasts, especially exceeding great wild sheep, having horns, some of them six spans long, of which they make divers kinds of vessels. The plain contains twelve days' journey in length, and is called Pamer; nor is there any habitation there; and travellers must carry victuals with them. No bird also appears there, by reason of the cold; and it is reported that if fire be kindled there it is not so bright nor so effectual to boil anything as in other places . . . .*

MARCO POLO (Voyages and travels, 1307).

[1]) = *Badakshan.*

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INTRODUCTION

The second Danish Pamir Expedition, due to the initiative of Professor O. Olufsen, at that time a lieutenant, and under his leadership, left Copenhagen in March 1898. The route lay across Russia, by steamer over the Caspian Sea, by rail through Transcaspia, stopping at various places underway, to Ferghana. In the little village of Osh which is located in this latter country, our caravan was fitted out, and in the month of June we turned our faces southwards and went over Guldsha, Olgin Lug and the Taldyk Pass to the Alai Plain through which flows the Kisil-Su, a tributary of the Pandsh. South of the Alai Plain the expedition entered Pamir, passed the Sea of Kara-Kul, (about 4,000 mètres above sea level), went over the Ak-Baital Pass and reached the Murghab River on which the Russian fort, Pamirski Post is situated. From this point our way led westward through Tshatir Tash to Alitshur Pamir, and in the neighbourhood of the mighty alpine lake, Jashil Kul, (about 4,000 mètres above sea level), we spent more than a month. This was the most important episode of the period spent in Pamir, especially for a botanist, as leisure was afforded for making excursions far and near. The expedition left this part of the country in September, going South over Tuz Kul and the Chargush Pass (4,240 mètres above sea level), along the Pamir-Daria to Wakhan. The autumn was spent in the southern and western valleys of Pamir, the Wakhan, Goran and Shugnan, and at the end of October we went into winter quarters in Chorock, a little country village situated where the Gund river joins Pandsh. In the beginning of March 1899, we retraced our steps across Pamir, which was now covered with snow, and the first days of April saw us again in Osh.

The summer of 1899 was spent in Transcaspia, September and October in Persia, and in November 1899 the expedition was back in Copenhagen.

The cartographic, topographic and ethnographic results of the expedition have been published by Professor OLUFSEN, while Mr. A. HJULER, senior assistant master at a public school, published the results of measurements of air electricity and studies of the dialects of southern and western Pamir. (See the literature list.) The botanical results have been published by the author of the present article, first in a number of taxonomic papers,[1]) later in a book on the vegetation in the Transcaspian Lowlands. (See the literature list.) The present paper is the last of the articles on the results of the expedition. The manuscript has lain half-completed for a long time and its conclusion has been frequently postponed on account of stress of other work. No one realizes better than the author himself how much this is to be regretted.

[1]) These publications are located as follows: Videnskabelige Meddelelser fra den naturhistoriske Forening i Kbhvn. 1901 — Caryophyllaceae (by H. WINKLER), Ranunculaceae, Phytoplankton from the Caspian Sea (both by OSTENFELD), in the same periodical for 1903 — Cruciferae, Umbelliferae, Valerianaceae, Compositae (by HOFFMANN), Gramineae (by HACKEL), Potamogetonaceae (by BAAGØE), Chenopodiaceae; Botanisk Tidsskrift Vol 24 — Nouvelle espèce de Riella (by PORSILD); Vol 26 — Pteridophyta, Gnetaceae, Cupressaceae, Lemnaceae, Typhaceae, Juncaginaceae, Alismaceae, Typhaceae, Juncaginaceae, Alismaceae, Liliaceae, Convallariaceae, Amaryllidaceae, Iridaceae, Juncaceae, Lichenes (by WAINIO), Orchidaceae, Salicaceae, Cupuliferae, Urticaceae, Cannabaceae, Polygonaceae; in Botanisk Tidsskrift Vol. 27 — Amarantaceae, Phytolaccaceae, Berberidaceae, Ceratophyllaceae, Papaveraceae, Fumariaceae, Resedaceae, Violaceae, Frankeniaceae, Tamaricaceae, Euphorbiaceae, Oxalidaceae, Linaceae, Geraniaceae, Balsaminaceae, Malvaceae, Rutaceae, Zygophyllaceae, Polygalaceae, Ampelidaceae, Rhamnaceae, Thymelaeaceae, Elaeagnaceae, Saxifragaceae, Ribesiaceae, Hamamelidaceae, Rosaceae, Lythraceae, Oenotheraceae, Haloragidaceae, Myrtaceae, Loranthaceae, Primulaceae, Convolvulaceae, Solanaceae, Plantaginaceae, Bignoniaceae, Apocynaceae, Asclepiadaceae, Rubiaceae, Caprifoliaceae, Dipsacaceae, Scrophulariaceae, Selaginaceae, Gentianaceae, Borraginaceae; Botanisk Tidsskrift Vol. 28 — Fungi (by ROSTRUP), Cyperaceae (by OSTENFELD), Labiatae (by BRIQUET); Bulletin de l'Herbier Boissier VI — Papilionaceae (by FREYN); Botanisk Tidsskrift Vol. 29 — Additions and Corrections. — The Algae are still unpublished.

PART I. THE ALAI MOUNTAINS

CHAPTER 1

ALAI is a mountain range lying north of Pamir and stretching from east to west. It is separated from Pamir by the Alai Plain, or the Alai Steppe, as it is often, (incorrectly, it seems to me) called. From an orographical point of view, then, the Alai Range may be considered the northern mountain boundary of Pamir. It slopes toward the north, down to the fertile, densely populated country of Ferghana, at one time the Kingdom of the Khans of Kokan. Ever since olden days important caravan routes have led from this country to western China (Kashgar). These have been enlarged and improved recently by the Russians. Our expedition, after being fitted out at Osh, left that town by one of these routes, going through Gultsha and Sufi Kurgan to the Taldyk Pass, from which we descended to the Alai Plain. This was in the latter half of June, 1898. From richly cultivated country the way now led up into the extreme foothills of the range, fresh green and rounded, covered with a dense carpet of grasses and *Cyperaceae*: *Poa bulbosa*, *Festuca ovina var. sulcata*, *Carex supina*, *C. nitida var. conglobata*, and others, and dotted with flowers in great profusion. Here *Eremurus robustus* bore its crimson clusters two mètres in the air, like burning torches, and the intensely yellow *Eremostachys labiosa* and the white *E. nuda*, large and upright as waxen tapers. The *Trollius*-coloured *Anemone biflora*, *Macrotomia euchromon*, *Erysimum canescens*, and *Euphorbia sub-*

cordata all had yellow blossoms, while *Hedysarum songoricum*, *Onobrychis pulchella*, *Astragalus platyphyllus*, *Cousinia microcarpa* and *Thymus serpyllum* had red, *Geranium collinum var. alpinum* and *Viola silvestris* lilac, *Lappula sp.* and *Myososlis arenaria* blue and *Silene brahuica*, *Astragalus alpinus* and an undetermined lily white

Climbing higher up we entered veritable mountain glens, their sides formed from a blue-black clay-slate and their bottoms filled with the strange conglomerates composed in part of very large stones cemented together with clay, which will be discussed further in Chapter II. Through these conglomerates, which we found in the valleys also in Pamir, the rivers of to-day have forced their beds. High up, at Sufi Kurgan for instance, a little over 2,000 mètres above sea level, we found on the disintegrated surface of the slate mountains, a poor scattered vegetation, with *Ephedra distachya*, green bushes a foot or two high, *Artemisia sp.*, *Umbilicus Lievenii*, *Lagochilus Paulsenii* and *Oryzopsis holciformis var. songorica* as its most important components. *Stipa barbata var platyphylla* which at great altitudes, (2,400 mètres above sea level), is replaced by *Stipa orientalis var. trichoglossa*, was seen occasionally and also the acicular-leafed *Arenaria Ledebouriana*, *Polygonum acerosum*, *Astragalus macrotropis var. robustus*, *A. tibetanus*, *Sisymbrium brassiciforme* and *Sedum sp.* I found *Orchis turcestanicus*, and *Primula sibirica* in the marshes, and in a cold mountain stream submerged mosses, *Bryum Schleicheri var. latifolium* and *Philonotis calcarea.*

It was very striking that throughout lower Alai hardly a tree was to be seen. Near Gultsha, at a great distance up in the mountains a few scattered dark evergreens were discernible, presumably *Juniperus excelsa*, which B. Fedtschenko mentions from here, and which he assumes has been driven out by cultivation. Along the valley trails which we followed, single lonely poplars or willows, (*Salix coerulea*), were to be seen, always with tattered fragments of garments hanging on them. There is a belief current among the Kirghiz, who wander with their herds in these regions, to the effect that single trees, standing free, are sacred and capable of effecting a cure, when a rag, which has been in contact with a

diseased or injured spot is hung upon them. As a consequence every tree fairly bristled with rags of multi-coloured hues. All the trees remaining are now considered sacred. The reason that so few remain must presumably be sought in the fact that they were not always so reverenced. There is no doubt but that under normal conditions these regions would be densely wooded, — at all events the valleys. The nomadic Kirghiz have chopped down tree in great quantities for fuel, and their grazing herds have prevented the subsequent growth of seedlings. Nor did we see any signs of the trees and bushes, poplars, birches, *Rhododendron*, *Berberis*, *Crataegus*, *Rubus fruticosus*, *Hippophaës*, *etc.*, mentioned by GEIGER as found on Alai's northern slope; the reason too is presumably the same, we followed a much travelled caravan route. Almond bushes, (*Amygdalus communis*), alone, were common.

The climate of Alai must be propitious to trees. To my certain knowledge no meteorological observations on this matter exist, with the exception of those published by OLUFSEN, based on the few days of our sojourn in Alai. The Alai mountains indeed act as a screen for Pamir rendering it rain-poor by intercepting moisture coming from the north and condensing in into rain. We experienced several severe thunder showers in these regions, and from these and the accounts of similar storms given by natives it would seem that much rain falls in Alai. The vegetation, expecially on and near Olgin Lug, bears witness to the same. The woods near Olgin Lug prove to what an extent climatic conditions have favoured their growth, and seem too, to indicate that the Alai Range further down might, in fact, become wooded.

Olgin Lug is a grass grown plain in the Alai Mountains, narrow and about 5 kilomètres in length. It lies about 2700 mètres above sea level with its greatest length running from south to north. High mountains, ab. 3,500 mètres above sea level, some with their summits covered with snow, shut it in on every side. It is watered from south to north by the little stream, Kurshab, which, coming from the Taldyk Pass, flows into the Syr Daria. We spent several days on Olgin Lug and very regretfully left the beautiful spot. In brilliant

sunshine, broken by refreshing showers, our excursions on Olgin Lug and up the wooded mountain slopes, where the flora was rich and varied, were a joy.

The plain itself is treeless, but along the banks of the Kurshab a few small junipers, *Juniperus psendosabina*, were growing. It is probable that the plain would by nature be densely forested and that the absence of trees is due to man. Not only is Olgin Lug situated on the caravan route to Kashgar, but it is inhabited as well by a number of Kirghiz. Their dome-shaped Kibitkas may be seen here and there, while their live stock, especially the Yak bulls, graze far and wide. These alone are sufficient to prevent the growth of new forests. They are very amusing, these sturdy diminutive oxen, with their horse's tails and pig-like gruntings. They and their masters, the Kirghiz, the barking dogs and the women, with high turbans, lend to Olgin Lug a populous and picturesque charm, increased by the ever moving caravans on their way to and from China and Pamir. These stop for a night on the plain and are soon off again, a long line of heavily burdened horses and camels, hung with bells and accompanied by drivers, horsemen and dogs. Marmots, *(Arctomys marmotta var. dichroa)* too, were lively. Their burrows were legion, and in riding great care was necessary, lest ones horse should stumble in one of their holes and break a leg. These small animals are both quick and shy, They would squeak as they perched or played about, only to disappear in great haste at one's approach. We saw, too, many small, burrowing rodents, the gray and brownish gray *Arvicola tianschanicus* and the almost tail-less *Ellobius talpinus.*

The plain is covered with grass, but the vegetation, which most closely resembles that of a meadow, as it is principally composed of mesophytic hemicryptophytes, was somewhat trampled down and cropped. I made note of *Atropis convoluta, Festuca ovina var. vallesiaca, Carex stenophylla var. desertorum* (common), *Avena desertorum, Alopecurus pratensis,* as well as *Cerastium falcatum, Lepyrodiclis holosteoides* and the little gray annual *Alyssum desertorum* and very tiny specimens of *Erodium cicutarium, Rumex sp., Poten-*

tilla sp., *Taraxacum sp.* Along the Kurshab River I found *Kobresia Royleana*, *Scirpus pauciflorus and compressus*, *Triglochin palustre*, *Gentiana leucomelaena*, *Taphrospermum altaicum*, *Lappula tenuis*, *Euphrasia Regelii* and *Funaria microstoma* growing, and in the water, *Ranunculus natans* with floating leaves and *Bryum Schleicheri* were swimming.

However conditions changed as soon as we began to

Fig. 1. Forest of *Juniperus pseudosabina* on Olgin Lug, cowering a slope below a steep rock. Drawing after a photograph.

climb up the mountains. We found ourselves at once in woods of juniper, *Juniperus pseudosabina*. This species extended from the plain all the way up to the summits of the adjacent mountains, to an altitude of about 3,300 mètres above sea level. At this height, though, the junipers were but bushes at most 2 mètres tall, far too scattered to be considered a wood. Below on the other hand, the junipers formed, as I have said, a wood. The trees attained 10—12 mètres in height, and many had mighty trunks; a single one which we measured had three trunks, the largest, a mètre

above the ground, was 1,5 mètres in circumference, and at the level of the ground the three together measured about 3 mètres in circumference. *Juniperus pseudosabina* has not a very close crown, the scale-like, or in some cases needle like leaves form foliages far from full or umbrageous. There were many dead limbs, doubtless killed by *Gymnosporangium juniperinum*, for the latter's pale brown spore masses were very common on the branches, which showed swellings on the infected spots.

The wood of the junipers had very narrow annual rings, indicating the great age of the large trees. Unfortunately I had no opportunity to count the rings.

In the lowest, most fertile part of the juniper grove the distance between the trees was 5—7 mètres, thus affording light and room for other plants to grow. The ground was stony, damp and mouldy with fallen branches and needles. It was covered by a somewhat dense herbaceous vegation, while between the junipers various bushes and single small other trees were scattered. Among the latter we saw only one little non-flowering *Sorbus*, under 3 mètres in height, (FEDTSCHENKO mentions *S. thianschanika* from here), while *Berberis*, (FEDTSCHENKO mentions *B. heterophylla* from here), *Rosa*, (both were barren), *Spiraea crenata*, *Ribes triste*, *Lonicera hispida*, *Karelini and microphylla*, all with rather large leaves and growing to an height of 1—3 mètres, and the little fine-leafed *Lonicera Olgae* represented the bushes. I found climbing *Clematis alpina var. sibirica*. There were no other arborescent plants and the species already mentioned were so few and far between that they contributed but little to the general physiognomy of the vegetation.

The herbaceous vegetation was however rich and varied, the profusion of flowers was nothing short of marvelous, dotting a carpet of perennial grasses: *Poa attenuata*, *Festuca ovina var. vallesiaca*, *Koeleria cristata*, the narrow-leafed *Avena desertorum*, the broad-leafed *Poa pratensis*, *Festuca sibirica*, *Carex supina* and *nitida*, and others. Of "flowering" plants the perennials were the most numerous, as a rule 20—30 centimètres tall with broad leaves and large blossoms. To this group belong *Trollius songoricus*, *Ranunculus songoricus*,

(O. Olufsen *fot.*)

Fig. 2.
The northern end of Olgin Lug. The Kurshab river is seen is the foreground, behind is a caravan camp and mountain-slopes with *Juniperus pseudosabina*.

Anemone albana and *narcissiflora*, *Onosma Gmelini*, *Gentiana Olivieri*, *Cerastium dahuricum*, (40 cm tall), *Aquilegia sp.*, *Cortusa Matthioli* with its beautiful foliage and handsome purple clusters, *Linum heterosepalum* and *L. perenne*, *Aster alpinus*, *Crepis multicaulis*, a rosette-plant with a long peduncle, *Lamium album*, the two broad-leafed large *Ligularia*-species, *L. robusta* and *L. altaica*, both with great yellow heads, *Parnassia subacaulis*, *Polygonum rumicifolium and Rheum Webbianum*, *Valeriana caespitosa*, and *Ferula Jaeschkeana*, of which I only saw the leaf-rosettes. The names of these species will give a European reader an idea of the luxuriant growth and abundance of flowers.

The low perennials, 10—20 cm tall, are: *Thymus sp.* (common), *Astragalus alpinus* and *myriophyllus*, *Carex supina* and *nitida*, *Potentilla bifurca*, with subterranean runners, *Polygala comosa*, *Leontopodium alpinum*, *Psychrogeton turcestanicum*, a rosette plant with yellow blossoms, *Saxifraga cernua*, *Stellaria graminea*, *Adoxa moschatellina*, the yellow flowering *Viola uniflora*, *Carum atropurpureum*, *Draba incana* and *media*, the beautiful *Isopyrum anemonoides* and the even more beautiful *I. grandiflorum*, both with low finely pinnatisect foliage and large white or pink blossoms, *Oxytropis humifusa*, *Primula farinosa*, *Botrychium lunaria*, *Cystopteris fragilis*, *Fragaria sp.*, *Pedicularis pycnantha*, *Galium sp.*

Many of the low perennials are more or less cespitose in their growth: the very common *Astragalus pamiro-alaicus*, which has abundant pinnate foliage and yellow stemless blossoms, *Potentilla radiata*, *nivea* and *hypoleuca*, *Androsace villosa*, *Koeleria cristata*, *Festuca ovina var. valesiaca.*

Bulbous plants claim a special place. We found the lovely blue *Ixilirion Pallasii*, *Fritillaria ruthenica*, a common plant, 20—30 cm in height, with narrow leaves and large red and yellow mottled flowers, *Gagea persica*, and the following spring, March 1899, *Crocus alatavicus* was found in blossom.

Finally the juniper woods contained a number of annuals: *Gentiana leucomelaena*, *Lappula tenuis*, *Euphrasia Regelii*, *Valerianella plagiostephana*, *Smelowskia sisymbrioides*, all tiny,

small-leaved, slender, soft plants, among which *Lappula* and *Smelowskia* are covered with hairs.

In the juniper wood the following Cryptogams were found: Mosses, *Distichum capillaceum*, *Orthotrichum anomalum*, *Bryum sp.* (?), *Tortula ruralis*, the three latter on stones, *Timmia bavarica*, *Bryum pendulum*, *Tortula fragilis var. pocillum*, and of lichens *Lecidea candida* and *Dermatocarpon miniatum* on stones, *Lecanora mutabilis* and *L. umbrina var. umbrinofusca*, *Placodium aurantiacum*, *Anaptychia ulotrichoides*, *Lecidea goniophila* and *glomerulosa* on branches of the juniper, and finally *Cladonia pyxidata var. pocillum* and *Lecanora bracteata var. alpina* on the ground.

By glancing at the species it is easy so see that this rich herbaceous vegetation is for the most part composed of mesophytic hemicryptophytes, indeed many of them have rather a hygrophytic character, for instance *Trollius*, *Gentiana*, *Parnassia*, *Saxifraga*, *Adoxa*, *Primula*, *Botrychium* and *Pedicularis*. As far as I have been able to judge *Thymus sp.* and *Androsace villosa* are the only chamaephytes and there are only a few annuals.

That this herbaceous flora depends on the trees for its existence is proved by the fact that where the latter are lacking the former is also. It must therefore be called an under-vegetation. Boris Keller has described similar vegetations from the Altai Mountains, open pine, larch or silver fir forests with vigorous or more or less dense herbaceous vegetation, of which he gives analyses. It appears in looking these over that in Altai, too, hemicryptophytes are most common.

Juniperus pseudosabina does not form a wood everywhere. In many places the trees are scattered or bushlike in form and then the herbaceous vegetation is far less abundant. However under the bushes there is more green to be seen than between them; it grows in a dense verdant carpet of annuals, including *Veronica cardiocarpa*, *Galium songoricum* and *spurium*, grasses (without flowers), and a tiny Borraginaceous. The mountain slopes were covered with stony gravel dotted here and there with plants: *Lagochilus Paulsenii*, *Ixilirion Pallasii*, *Ephedra distachya* 1,5 mètres tall, various barren

grasses, *Artemisia sp.*, *Potentilla bifurca*, *Ferula Jaeschkeana* and a thorny-leaved cushion-plant without blossoms, presumably an *Acantholimon*, *Carex nitida var. conglobata*, the annual *Polygonum acerosum*, *Nepeta satureioides*, *Poa attenuata* and *persica*, *Fumaria Vaillantii*, *Adonis aestivalis var. miniata*, *Callipeltis cucullaria*, *Rhinanthus sp.*, *Arenaria serpyllifolia*, *Asperugo procumbens*, *Bromus tectorum*, *Bromus crinitus*. Nor did this plant community show any signs of xeromorphy. It contained indeed specimens like the labiatous *Lagochilus*, *Artemisia*, and *Ephedra* which are somewhat xerophytic, since *Lagochilus* is thorny and has leathery pinnatisect leaves, while *Artemisia* is silvery haired, and *Ephedra* leafless, yet the majority of the species are tiny, soft, slender annuals, easily destroyed by a short drought. It is possible too, that later in the year they would have been gone, we found them in June. Many of the annuals seem to have been imported, (*Fumaria*, *Adonis*, *Asperugo*, *Bromus*.)

Climbing higher up the mountain side the junipers are more and more bushlike and gradually disappear. Here at an altitude of 3,000—3,300 mètres above sea level, with patches of snow here and there, the vegetation comprises only a few species. I found the lovely borraginaceous *Macrotomia euchromom* with its blue blossoms unfolded and the dainty little *Isopyrum grandiflorum* finding foothold in the cracks of the rocks. The cruciferous *Parrya pinnatifida* and *P. fruticulosa* are also rock plants, as are *Smelowskia calycina* and *Draba fladnizensis*. I found too *Carex macrogyna*, *Lloydia serotina*, *Rhodiola rosea*, *Allium monadelphum*, *Linum perenne* and *Phlomis oreophila*. All these were perennials. The season up here was too short for annuals.

The mountain tops resemble fell fields more closely than anything else, for the vegetation was so sparse that there was more soil bare than covered with plants.

B. Fedtschenko (Pamir i Shugnan) finds 7 formations in Olgin Lug, but in his preliminary articles they are characterized so briefly that it was difficult for me to recognize them. This author states too, that barley fields are to be found on Olgin Lug. In such case it is the highest altitude for the cultivation of cereals.

The forests of Olgin Lug were the only luxuriant forests seen on our expedition in Turkestan, and the sudden transition to the parched, wind-scourged Pamir was striking. Yet of all the 98 species I saw on and near Olgin Lug, about one half (48 %) are also to be found in Pamir, while only 7 % were in common with those of the Transcaspian Lowlands. As both Pamir and Transcaspia have very little rainfall, it must be the conditions on the mountains which are common for Pamir and Alai.

The species common to Olgin Lug and Pamir are the following:

Allium monadelphum
Androsace villosa
Anemone narcissiflora
Aster alpinus
Astragalus pamiro-alaicus
Atropis convoluta
Bromus crinitus
Carex stenophylla
Cortusa Matthioli
Cystopteris fragilis
Draba fladnizensis
— incana
— media
Ephedra distachya
Euphrasia Regelii
Festuca ovina
Gentiana leucomelaena
Isopyrum anemonoides
— grandiflorum
Kobresia Royleana
Leontodon alpinum
Ligularia altaica
Linum perenne
Lloydia serotina
Macrotomia euchromon
Oxytropis humifusa
Parnassia subacaulis
Phlomis oreophila
Poa persica
Polygonum acerosum
— rumicifolium
Potentilla bifurca
— hypoleuca
— nivea
Primula farinosa
Psychrogeton turcestanicum
Ranunculus songoricus
Rhodiola rosea
Saxifraga cernua
Scirpus compressus
Smelowskia calycina
Triglochin palustre
Valeriana caespitosa
Veronica cardiocarpa
Viola uniflora.

The above list is given here because it shows that none of the plant species forming the xerophytic plant communities of Pamir are to be found in Alai at Olgin Lug. The species

in the list grow in Pamir all under especially favourable conditions, in marshes or on shady monntain sides.

The Alai Plain, the summer paradise of the Kirghiz, which forms the southern boundary of the Alai mountains, is watered by the river Kisil Su, (the red stream) whose waters like the soil of the plain are rusty red. The plain near Sary Tash (3,270 mètres above sea level) is flat or slightly rolling and furrowed by many small streams flowing into Kisil Su. On June 27 the soil was dry and dusty when dug, yet the vegetation did not impress one as being xerophytic. It is composed of a short green-sward of grasses and *Cyperaceae* dotted with many gay flowers. The main plants are *Festuca ovina var.. vallesiaca*, *Carex stenophylla var. desertorum* (both cespitose) and the tiny annuals, *Ceratocephalus orthoceras* and *Alyssum desertorum*. Common too were *Avena desertorum* (cespitose), *Anemone Tschernaewi*, a rather low tuberous species, *Astragalus Danieli Kochi*, *A. tibetanus*, *Pulsatilla albana*, *Carex nitida var. conglobata* and *Leptaleum filifolium*. Of these the latter only is an annual. *Alchimilla sp.*, *Draba media* (annual), *Psychrogeton turcestanicum*, *Chorispora macropoda*, and *Sisymbrium mollisimum* (perennials), were found, as well as the following mosses, *Tortula Paulsenii* on a slope near a stream and *Bryum leptoglyphodon* at the mouth of a marmot burrow. The vegetation both in appearance and species composition resembles closely that of Olgin Lug and may best be compared to a meadow. Here, on the Alai Plateau, the plants are smaller and less well developed than on Olgin Lug, and the absence of trees is natural, as Sary Tash lies above the timber line. Near the river or its tributaries on moist ground we found the delicate little *Ranunculus flexicaulis*, *Taraxacum paludosum*, *Carex Regelii*, *Scirpus alpinus* (= *pumilus*), *Erysimum altaicum*, *Polygonum cognatum* and *Primula algida*.

On the southern side of the Alai Plateau, near Bordo-Ba, there was a little pond with *Hippuris vulgaris* and *Potamogeton gramineus*. Here too, in a stony, dried-out river bed, *Rheum rhizostachum*, a species under a foot tall, was growing.

PART II. THE HIGHLAND OF PAMIR[1])

CHAPTER 2

Structure and Geology.

Pamir, the mighty highland, connecting Hindukush and Karakorum in the south with the Alai Mountains and Thian-shan in the north, and forming a sort of natural bridge between these mountain ranges, falls sharply off on the east toward Eastern Turkestan, while toward the west its slope is gradual. The water-shed dividing the rivers flowing east from those flowing west, lies at about the line Rang Kul—Great Kara Kul, so that the larger part of Pamir is watered by streams flowing westward. (See the annexed map).

These conditions, then, determine the eastern border of Pamir, fixing it at the line of the Kashgar chain of mountains, which extend from the north toward the south. The western boundary is not so easily fixed. It may perhaps be most naturally placed where the Pandsh River flows from the north to the south. The northern border is the Alai Plain, which is watered by the Kisil-Su, and the southern, the upper course of the Pandsh and the Hindukush mountains.

Between the rivers, which for the most part flow toward the west, and of which the most important are the Pandsh, the Gund and the Murghab, are high mountain ridges, 5—6,000 mètres above sea level. The greatest altitude is to be found in the East, where Mustagh-ata in the Kashgar chain reaches a height of 8,000 mètres, and in the north-

[1]) The land is often called »The Pamirs«. This name indicates that there are several »Pamirs«, i. e. flat barren valleys. Hower as the name Pamir is ordinarily used, and as it used here, it designates not only the valleys but the mountains between them as well, including also the western part where no flat valleys exist. Thus, when speaking of »The Pamirs« in this treatise we mean the valleys, Pamirs specifically (in the narrow meaning of the word »Pamir«), while »Pamir« includes the entire district.

west, (Darwas), where there are peaks more than 7,000 mètres high.

From a geographical point of view, the Eastern part alone belongs to "Central Asia" as defined by RICHTHOFEN, the drainless water basin of olden days, where all the products of disintegration remain in the land itself. The larger, western section, on the other hand, belongs to RICHTHOFEN'S peripheral regions, — those having outlets into the ocean or its relics, — and the water of the rivers of Pamir flowing west, does empty into the Aral Sea.

However the whole of Pamir may be included in MUSHKETOW'S definition of Asia Media, — that territory with no outlet in the ocean. (See GEIGER, PAULSEN.)

From an orographical point of view there is a difference between eastern, or Pamir proper and western Pamir. We may characterize the former as a complex of flat plains or broad valleys, now divided by high mountains, now succeeding each other, tract on tract, and often watered by rivers. These valleys, which are from 3—4,000 mètres above sea level have separate names, — Little Pamir, Great Pamir, Alitshur Pamir, Rang Kul Pamir. Toward the west, however, in Lower Pamir, which borders High Pamir at ca. 73° W., the valleys are deep and narrow, the rivers flow more swiftly, there are no plateaus, but mountain ravines.

Geologically considered, Pamir, that is Eastern Pamir, is according to IWANOFF one huge mountain mass on a lodgment of granite and gneiss. These rise to the surface, particularly, in the southern part; toward the north they are largely hidden by the metamorphosed deposits of the paleozoic age (Devon?), — by slate, crystalline lime-stone, dolomites, and sandstone. Of upheavals which have formed the mountain ranges, the most important and the oldest is the one running W. S. W., for it is that upheaval, or rather that series of parallel upheavals, which has formed the principal mountain chains and valleys.

The glacial period attained a very high development in Pamir. Many of its traces are still visible. A thick layer of ice once covered the entire country; from this jagged, precipitous, ice-breaking peaks towered, while the lower moun-

tains were polished smooth. The valleys, everywhere, were filled with deep moraine deposits especially of conglomerates, through which the rivers of our age have worn their way. In Pamir of to-day there are no glaciers except in the north and east on the highest mountains, where, indeed, they are very large.

The glacial period was followed by a lake period, during which many lakes, far greater than those of to-day, came into being. In many places, in Alitshur for instance, water washed out all traces of the glacial period, eating away the moraines and depositing the debris in the bottoms of the valleys.

The glacial period and the lake period together, still according to IWANOFF, have given to High Pamir of to-day its orographical characteristic of plateau.

According to another theory, represented among others by MAX FRIEDERICHSEN, conglomerates, the so-called Hanhai formations, are the results of atmospheric disintegration in an arid climate.

From a tectonic point of view, High Pamir is no mountain plateau, but, as has been stated above, a mighty mountainous mass, with deep valleys partly filled with deposits of conglomerates. The valleys are continually being filled today at a lively pace by the help of the atmospheric disintegration, which is very great, on account of the enormous differences in temperature from season to season, and between day and night. Huge stretches of talus at the base of all the mountains bear witness to this.

The deep valleys of Lower Pamir, with their steep slopes are being filled in a similar way. Here, though, no glacial nor lake period has acted as an auxiliary.

Lower Pamir, as its name indicates, does not lie as high as High Pamir. Chorock, located at the junction of the Gund and Pandsh rivers is about 2,100 mètres above sea level, Pamirski Post in High Pamir about 3,600 mètres. The climates of the two localities are very similar, as the curves on Fig. 3 show, but that of Lower Pamir is much milder and has far more rainfall during the winter season (see below). The valleys of Lower Pamir are cultivated for the

most part, and villages are scattered here and there. The population, Iranian by race (Galtshas or Mountain-Tadjiks) has fixed habitations, whereas the population af High Pamir is sparse and of the nomadic Kirghiz. Regular agriculture is practised in the Pandsh valley (Wakhan Daria) to Ssarhad (3,350 mètres above sea level), and in Langarkisht (3,000 mètres), where our expedition made a halt, both cereals and fruit trees (apricots) are grown. Near Shach Daria cultivation extends ud to Sseis (3,160 mètres), along the Gund river up to Ssardym (3,160 mètres), in the Murghab valley to Ssares (3,200 mètres) and on the Alai plateau to 2,740 mètres. (This is according to GEIGER.) In a large part of Lower Pamir then, the valleys are cultivated, and according to GEIGER in early days the cultivation extended even higher up than now. The condition to-day he does not think due to a changed climate, but rather to the lack of energy of the population.

CHAPTER 3

The Climate of Pamir.

The climate of Pamir is continental. The winters are cold and the summers, in consideration of the high altitude, hot. The actual summer is short. In High Pamir, July and August are the only summer months in which plants grow and blossom, and even during these months, in which the average temperature is over 13^0, night frosts up to -4^0 are common. At the end of August the minimum-thermometer of the expedition even registered $-10^0{,}_2$.

However the days are for the most part bright and hot. The light is so strong that one is obliged to wear coloured glasses, and the sun burns so fiercely in the thin atmosphere that hands and face become blistered. As we rode horseback hour after hour in this scorching sunlight the upper side of the left hand holding the reins was often covered with great burns; and it has happened that the foot exposed to the sun's rays even though protected by a great boot, was so

scorched that one was obliged to dismount to avoid keeling over in a faint.

In Pamir one is exposed to great changes in temperature. One afternoon in August the thermometer registered 24° an hour before sunset, a few hours later it showed 10° frost.

The summer days, too, contain other surprises than those of changes in temperature. On July 21 for instance. (it was not the only occasion) a very severe snow storm overtook us. Dense clouds of snow were driven hither and yon by a whistling wind and we were unable to see either behind or ahead.

Such gales are frequent in High Pamir. In the evening the wind would often suddenly begin to howl down the mountain sides, carrying stones and gravel in its path. In a short time however all would be quiet. With the exception of these mountain storms Pamir is a country where gentle breezes or total calm are the natural order of events. See OLUFSEN and FICKER on this point.

The canopy of clouds is light. According to FICKER, Pamirski Post has 116 clear days and 55 cloudy. The remaining 194 partly cloudy days have presumably nearly all been bright with scattered cumulus clouds covering the tops of the mountains, for this is the usual condition of affairs. (Compare OLUFSEN.)

In the summer-time Pamir is practically rainless. Both the amount of rainfall (see the Table) and the number of rainy days are very small. Pamirski Post has a rain-probability (KÖPPEN) for the month of July of 0,11, for January of 0,10 and, according to FICKER, three months can pass without a drop of rain falling. The rain-probability for Chorock is 0,04 in July, 0,22 in January, and four months can pass totally without rainfall. In High Pamir our expedition experienced rain a few times in the month af July. In some instances only a few drops fell, but on one occasion a soft rain fell 14 hours in succession, turning to snow on the tops of the mountains. Nor do the winter snows of High Pamir amount to much, as may be seen from the figures of the table. In the month of March, leaving

Shugnan and Wakhan (Langarkisht), our expedition crossed Pamir via Chargush. The heaviest snows were encountered in Goran in the Pandsh valley. Even though most of the valleys of High Pamir were filled with deep snow yet nowhere did it lie in such quantities as to impede passage. In many places near Pamir Daria the Kirghiz had gone into

Table 1.

(Prepared from FICKER's statements.)

1894—1903	Pamirski Post 38° 11′ N. L. 74° 2′ E. Long. 3640 metres above sea-level						Chorock [1] 37° 27′ N. L. 71° 39′ E. L. 2105 m. above sea-level			
	Average temperature (centigrade)	Maximum temperature, absolute	Minimum temperature, absolute	Total precipitation, mm. average	Number of days with precipitation (average)	Relative humidity (average)	Average temperature (centigrade)	Maximum temperature, absolute	Total precipitation, mm. average	Number of days with precipitation (average)
January	— 18,4		— 46,7	7,8	3,0	62	— 8,4		28,2	7,0
February ...	— 16,6			2,5	1,8	49	— 6,6		20,2	4,8
March.....	— 6,7			1,6	2,4	53	1,7		27,8	6,6
April.....	0,2			3,6	2,3	47	7,9		21,4	4,6
May	7,1			8,4	5,6	47	14,3		28,6	5,6
June.....	10,7			15,4	5,4	45	18,5		14,6	4,2
July	13,9	28,0		8,0	3,4	42	22,0	35,0	5,7	1,2
August	13,6			4,4	2,4	42	22,0		0.2	0,4
September ..	7,9			3,9	1,8	39	18,0		0,2	0,2
October	0,0			2,5	2,0	48	9,7		13,2	2,5
November ..	— 8,0			2,1	2,0	54	3,0		43,0	5,7
December...	— 16,8			2,1	1,4	57	— 2,9		24,8	3,7
Year	— 1,1			62,3	33,5	49	8,4		228,5	46,5

[1]) OLUFSEN published as a minimum for Chorock ÷ 24°,8 (winter 1898 - 99).

winter quarters at an altitude of about 3,800 mètres above sea-level. The snow here was not thick enough to prevent the numerous herds of yak, fat-tailed sheep, goats and horses from finding pasturage.

In Lower Pamir, where the summers are even dryer than in High Pamir, much more snow falls during the winter, as the table and curve show. During the winter journey referred to above, the worst obstacle to our pro-

gress through the Pandsh valley in Goran was the enormous masses of snow lying on the mountain sides, often avalanche-snow, in which our horses stuck fast again and again.

The humidity in the air is slight. The table shows the averages for Pamirski Post, those for Chorock have not been given by FICKER. The records made by the expedition (OLUFSEN), show that the average humidity in July was 38 %, in August 21 % — both from High Pamir. The minima recorded for these months were 5 % and 2 %.

There is, then, less humidity in the air of Pamir than in that of the lowlands of Transcaspia, where Tashkent, for instance, shows a yearly average of 63, Petro Alexandrowsk 57. (FICKER, see PAULSEN as well.)

It was unnecessary to read a record of the dryness of the atmosphere in Pamir to become conscious of that condition. It is the most peculiar characteristic of the country, — the clear air (when not filled with dust) and the scorched and desolate appearance of the earth are always reminding one of the fact. It was noticeable too, how quickly one's clothing dried, and too how often it was necessary to dip or refill ones pen.

I have no data to show the amount of evaporation but it stands to reason that it must be very great.

The temperature of the soil was measured by the expedition at Jashil Kul in High Pamir during July and August and at Chorock in Lower Pamir from November to February. The depths at which measurements were made were from 0,40—1,30 mètres. In High Pamir the temperature at the greatest depth varied between 7—8°, and at the smallest depth between 12—17°, while observations of temperature at the surface of the ground varied between 7—33°,5. All records of soil-temperatures were made on horizontal ground. Slopes with southern exposures presumably show higher temperatures. Near Chorock the temperature at the greatest depth (1,3 mètres) lay between 0,6 and 9°,4, at the smallest depth (0,40 mètres) between — 8°,6 and 3°,9. Whereas night frosts became the rule from the middle of November, no negative temperature was observed at 0,4 mètres below ground

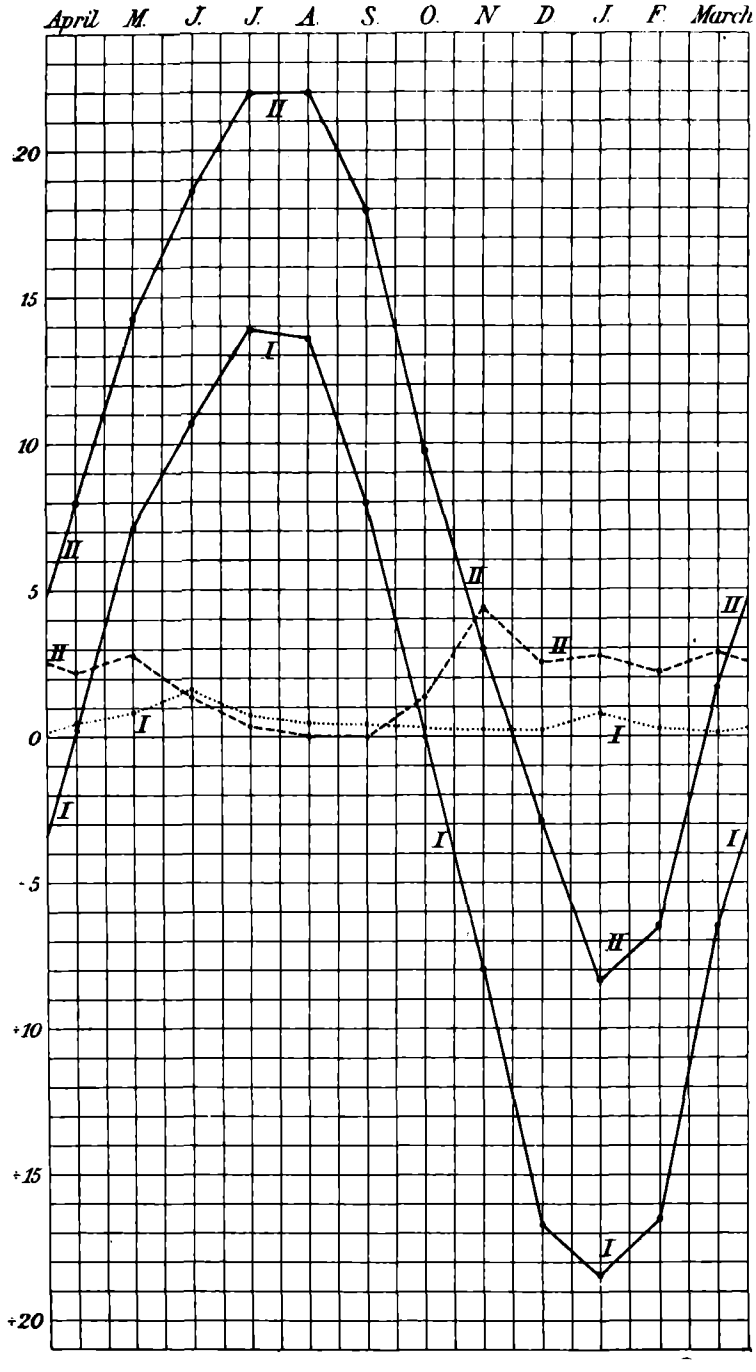


Fig. 3. Hydrothermals for Pamirski Post (I) and Chorock (II). The ordinary lines are temperature-curves, and the figures to the left express degrees Centigrade. The dotted lines give the precipitation in centimeter. (Constructed after the method of RAUNKIAER, 1905, 1907.)

before December 5, at 0,7 mètres before December 23, at 10 mètres before January 6, and, at the end of February at a depth of 1,3 mètres the termometer still showed $1^{0},1$ (OLUFSEN).

Taken all in all, the climate of Pamir is severe but healthy. After an attack of mountain fever, which wakens one at night with a pressure across the chest and a gasping for breath, and after one's skin has become toughened by sun and snow, it is difficult to imagine a healthier place to be in. The sun is always shining, mountains and lakes are bathed in the clearest light. Even though mountain-climbing in this rarified atmosphere is strenuous, the mighty splendours of nature send one sound and rejoicing to the day's work. At night the brezes blow the tent flaps, the candle flickers inside, tired and content we stretch out on the floor and sleep deep and sound. All organs function properly. In Pamir we exuded health and happiness, all three.

CHAPTER 4

General Observations on the Vegetation and Flora of Pamir.

While Alai, low-lying and rainy has her forests of mesophytic herbaceous vegetation, High Pamir is dry and treeless. Only in the valleys with running water and special shelter (deep snow during the winter?) and in certain places along the banks of the lakes can scattered low bushes be found. Narrow green stripes of swamp-meadow or of more scattered mesophytes edge the rivers, when these flow through broader valleys, which is often the case in High Pamir. The northern slopes of the mountains, where the sun's rays cannot penetrate are covered, high up near the snow-line, by a fresh, green mesophytic vegetation. Aside from these few particularly favoured spots, by far the larger part of the mountains and valleys of High Pamir are covered with scattered cespitose hemicryptophytes and suffrutescent chamaephytes.

The intervening distance varies according to the localities, — it is less in more horizontal, damper places, which therefore at a distance assume a strange dotted appearance, — greater on parched southern slopes, which seem at first glance to be entirely bare.

On the whole the vegetation of High Pamir lends only a faint greenish hue to the landscape. Seen from a high altitude, brown seems the colour of the entire country; the mountains are brown, brown too the flat bottoms of the broad valleys, while the talus look like darker brown shadows at the base of the mountains. At the bottom of the furrows on the mountain-sides dark green lines may often be seen; they are narrow stripes of vegetation which only serve to make the furrows appear even deeper, accentuating the picture just as an exaggerated retouch may a photograph. Looking toward the north and east nothing green or only the very faintest green tones are visible, because from that point only the slopes with a southern or south-western exposure are turned toward the spectator, but looking toward the south a greenish shadow seems to rest on those mountain-sides having no western exposure. Exposure, as the following will also prove, plays then a very great part for the vegetation of High Pamir.

I have previously (PAULSEN, 1912) given an account of the biological types (growth-forms, based on RAUNKIAER'S[1]) system), to be found in Pamir. The following statistics give a summary of the facts.

Table 2.

	Number of species	Percentage of species under each growth-form					
		F	Ch	H	G	HH	Th
Pamir.....	514	1	12	63	5	5	14
Normal spectrum[2])	1000	46	9	26	4	2	13

[1]) RAUNKIAER, 1905, 1908. [2]) RAUNKIAER, 1918.

Pamir has, then, a decided hemicryptophytic spectrum with strongly recessive phanerophytes and somewhat pronounced chamaephytes. According to RAUNKIAER the latter are very characteristic for arctic and high alpine districts. In Puschlav, Switzerland, for instance, at an altitude above 2,850 mètres the vegetation contains 35 % chamaephytes[1]). It would seem reasonable, then, to expect to find a larger percentage of chamaephytes in Pamir. However a large number of the Pamir species show a tendency toward chamaephytic growth; they are cespitose and curve upwards more or less. The determinations were made here in Copenhagen, — for when the expedition was in Pamir, RAUNKIAER's system was not yet published — and even so they have shown a percentage of chamaephytes which is higher than the standard spectrum. Chamaephytes are very unevenly distributed among the various vegetation formations. This fact will be discussed later.

Although several Russian botanists had been in Pamir prior to our visit, and although the Englishman, J. F. DUTHIE had published a list of the plants found in those regions, yet previous to our expedition to Asia knowledge of Pamir's flora was but fragmentary. From that time on, however, knowledge of the flora of the country increased rapidly. In 1901 M^me^ OLGA FEDTSCHENKO made a trip to Pamir and published in 1903 in Acta horti Petropolitani, "Flore du Pamir" in which were included all the specimens from Pamir then known. Supplements appeared in 1904, 1905, 1907 and 1909. Here we have a working synopsis of the plants of Pamir, even though the limits of the district could have been better fixed, and even though the interpretation of species and particularly nomenclature may be open to criticism. The main article is illustrated by 8 plates, with characteristic pictures of the landscape, and a map. There is. too, a comparative table showing the distribution of the plants of Pamir in other localities. These other localities are 1.) Tianshan, 2.) Tshungai-Alatan, and Tarbagatai, 3.) Afghanistan, Hindukush and Himalaya, 4.) Thibet, 5.) Chinese

[1]) Counted after BROCKMANN-JEROSCH.

Turkestan and Mongolia, 6.) China, Japan, Korea, 7.) Northern Asia, 8.) The remainder of Turkestan, 9.) Persia, Asia Minor, Caucasus, 10.) Europe and the Ural, 11.) Other countries.

Later, in 1907, M^me^ FEDTSCHENKO published a key for the determination of the plants of Pamir, in Russian. That, as well as the other publications, with which I am familiar, are given in the literature list.

The following description of the vegetation of High Pamir is based in part on notes made on the trip from Transalai to Jashil Kul, and in part on a more complete study of the vegetation near Jashil Kul, where the expedition went into camp from July 19—August 30 1898. Plant growth on a horizontal plain is taken as a starting-point for the description of the vegetation, and we find that that type, the vegetation of the Pamirs i. e. the flat horizontal valleys, is widespread and characteristic. We may call it the Trigonella formation. Next, the vegetation on the mountain slopes with various exposures is described, the Eurotia formation on dry slopes with a southern exposure, Arenaria-Meyeri formation on the northern slopes near the base of the mountains, Poa attenuata formations ("Alpine meadows", of B. FEDTSCHENKO) higher up on the northern slopes watered by melting snow, and finally Talus formations on the mountain sides cowered with great loose rocks. Last of all the hygrophilous formations are mentioned:

Swamp-meadow formation, hot-spring formation, submerged formation, stony river-bed formation, river-bank formation.

Let me explain briefly what is meant by the term "formation" as used in this paper, — an expression applied nowadays to many and various phenomena. The formations to be described here are regarded as plant-communities, belonging to certain growth-forms, — always the same within the same formation, — and these are determined by and adapted to common conditions. I used the same definition in my book on the Lowlands of Transcaspia. WARMING (1909, p. 140, 1918, p. 336) uses the word in the same sense.

DU RIETZ, FRIES und TENGWALL let agreement, (between associations composing the formations) in regard to the dominant growth-forms be the determining factor. I agree with these scientists in believing that inductive research must be based on the vegetation itself and its growth-forms, not on the conditions for growth. The growth-forms used here, are, as has already been stated, the growth-forms of RAUNKIAER'S system, and in this book the formations will be characterized according to the growth-forms of the constituent species, based on RAUNKIAER'S conception. Unfortunately it has been impossible to give any formation-statistics based on the valence[1]) of species, as this method was unknown when the observations were made.

In a high, arid country like Pamir, conditions of growth are as a rule so plain and the differences in plant-growth of the various localities so distinct, that it seems natural to regard the different plant-communities as formations, and the result shows that most of them are rightly regarded as formation. The idea of association, — species-list, to use a single word, — is of less importance in such a country. This is especially true in extensive investigations, where the point in question is to see large tracts of country, and to characterize in general. Of course species-lists have been made from many localities, (they form indeed the basis for our investigations), and many of these lists are given later on to illustrate the formations. The vegetation divisions are based on them.

B. FEDTSCHENKO (1902?) gives the following synopsis of the most characteristic plant formations of Pamir.

1. Aquatic vegetation in fresh water lakes, river-windings, and puddles, composed of very common species, *Caulinia fragilis*, *Ranunculus aquatilis*, *Utricularia vulgaris* (?) and *Ranunculus natans*.

2. Near the river-banks groups of bushes, *Myricaria germanica*, and between these, *Oxytropis glabra*, *Artemisia sp.* etc., are found on sandbanks.

3. On the terrace nearest the rivers there is usually a

[1]) RAUNKIAER, 1909, 1918.

tufted (cespitose) meadow, formed by herbaceous plants, among which *Carex* and poor grasses dominate. Here, too, may be found the white blossoms of *Gentiana leucomelaena* and the red of *Primula sibirica* and others.

4. On the steep slope leading up to the second terrace, which is composed of conglomerates, a very special and characteristic flora is often to be found. Here we may see *Clematis tangutica, Comarum Salessowi, Dracocephalum stamineum*, etc.

5. Terrace No. 2 and the largest part of Pamir, as well, is covered by desert vegetation, scattered low bushes of "Terskén" (*Eurotia ceratoides* C. A. M.), *Artemisia*, species of *Astragalus* and *Oxytropis* (*A. Mushketowi* and others, *O. chiliophilia, Poncinsii* and others).

6. Along the banks of brooks, with their source in the perpetual snows, there is usually a narrow strip of alpine meadow, with a vegetation high-alpine in character.

7. These same alpine meadows are developed on the mountain ridges encircling Pamir. The author has seen them on Kisil-art and Koi-tesek, and there are many other places where they may be found.

8. Finally, in the ravine of Karasu in Jaman-Tal, which is sheltered on all sides, thickets or small groves of willow (*Salix sp.*) are to be found. The trees, however, are not more than 4 mètres high.

To the above detailed report of FEDTSCHENKO's system, (all his statements are included,) his German brief may be added in extenso, as it includes in part new information. (However it does not include all the formations given in the Russian text.)

"Die Vegetation des inneren Pamir ist äusserst arm, (aus etwa 300—350 Pflanzenarten bestehend) und wird folgendermassen gegliedet:

A. Wiesen:

I. Alpenmatten (13—17,000');
II. Feuchte Wiesen;
III. Salzmoorwiesen längs den Flussufern und um den Seen (10—14,000').

B. Steinige Wüste:
IV. Eurotia-Wüste;
V. Abhänge u. s. w.

C. Gehölzformationen:
VI. Myricaria-Gebüsche;
VII. Salix-Gebüsche (im Dschamantal)."

A comparison between FEDTSCHENKO's formations and those described in this article will show that

Alpine meadows = Poa attenuata formation.
Damp meadows } = Swamp-meadow.
Salt-marsch meadows }
Eurotia-desert = Trigonella formation (?).
"Abhänge u. s. w." = Eurotia formation (?).
"Myricaria-Gebüsche" belong to the river-bank formation, and "Salix-Gebüsche" to the stony river-bed formation.

As will be shown in further detail, later, *Eurotia* vegetation should presumably not be classified as desert vegetation.

CHAPTER 5

Notes on vegetation made on the way from Alai to Jashil Kul.

From the fresh and charming Olgin Lug our way leads southwards. It is very steep, and our panting horses crawl slowly zigzagging up over the Taldyk Pass, where in shady places snow lies unmelted on the twenty-sixth of June. Once on the other side, the south side, one may see far across the wide green plain of Alai, stretching from east to west, and forming the boundary between Alai and Pamir.

There lies Pamir! We see a mighty snow covered mountain range, glittering and remote; it is the Trans-Alai Chain, — called Katman Tagh by the natives — the northern mountain boundary of Pamir. Over those mountains lies our path, behind them our goal.

A few days later we rode slowly up over the Kisil Art Pass and found ourselves in Pamir. There we remained nine months. Half of this time, or there abouts, we were snow-bound in our winter quarters in Chorock in Shugnan, while the summer of 1898 was our actual working period in High Pamir.

To attempt to give a general description of our journeyings would lead me too far astray from the matter in hand. In OLUFSEN'S book "Gennem Pamir" experiences and localities are described. HEDIN'S book "En Færd gennem Asien" may likewise be recommended. However, in order to give the reader a general impression of the scenery I will describe very briefly a few of the places which we visited, adding at the same time a short account of the plants found.

Kisil Kul lies at an altitude of 4,000 mètres above sea-level. The name means "red lake". However, there is no lake to be found there to-day, only an arid depression in the landscape. Through this depression the little stream, Markan Su, flows, pouring into the eastern Kisil Su, which in turn empties its waters into the Tarim River. Kisil Kul was the first Pamir landscape seen, and our minds were still filled with the memory of the fertile luxuriance of the Alai Mountains. The contrast was striking. Here at Kisil Kul a cold, dry, biting wind was sweeping over the naked mountains and plains A snow storm followed in its path, but the snow did not remain where in fell, but was whirled away to cracks and corners where it melted until overtaken by night frosts.

The slate mountains here abouts were in an advanced stage of disintegration, those nearest were merely rounded hillocks covered with fragments of slate. Strange hues appeared in this process of decay, red, gray, and poisonous copper green; seen at a distance a wonderfully beautiful play of colour, reminding one weirdly of changeable silk, curious simile indeed, in this dry, lifeless landscape. Far away in the north and west the stony slopes tower up to the snow-covered peaks — Katman Tagh again, seen from the south now, — between the hills the tiny mountain strem glistens, there a little yellowish vegetation is visible, otherwise barren

desolation as far as the eye can pierce, not a tree nor a bush, anywhere. On approaching the stony slopes, however, low green tufts appear about 20—30 steps apart They have long, thick, perpendicular roots and the withered remains of leaves and stalks cling like close tunics below the green. Several have beautiful bright flowers, *Parrya eriocalyx* pink, *Hedysarum pumilum* crimson, *Oxytropis vermicularis* violet, *Smelowskia calycina*, *Sisymbrium Korolkowi* and *pamiricum* and *Chorispora macropoda* yellowish-white or yellow. We found, too, the cushion plant *Androsace villosa var. congesta.* Other species than those mentioned here were not found.

Below, in the river valley, where there is rich black clay between the stones, *Dilophia salsa*, *Primula sibirica*, *Gymnandra Korolkowi*, *Calamagrostis anthoxanthoides*, *Colpodium altaicum*, *Carex pseudofoetida*, *Kobresia stenocarpa* and *Oxygraphis glacialis* are growing. Of these the most common are *Calamagrostis*, *Carex*, and *Kobresia*, and they lend the yellow hue to the river valley.

The lake Kara Kul is situated in northern Pamir south of Kisil Kul, at an altitude of about 4,000 mètres. It is a large lake with colours like the ocean, clear green and deep blue. Promontories of low, dark, rounded mountains put out into its waters at both the northern and southern ends. Its shores are curving and emphasized by a broad margin of snow-white salt, extending the entire circumference of the lake. Absolute quiet and desolation reign, enhanced, perhaps, by the presence of a few small white gulls with brown heads circling above the blue waters. A broad barren plain encompasses the lake, surrounded in turn on all sides by snow-covered mountains. On a clear day, with great white cumulus clouds drifting over the white mountains, Kara Kul possesses a strange weird beauty. The great deserted lake in this dry silent country surrounded by wild mountains forms a picture lacking perhaps in grace, but a picture of greatness and death, — an impression once made, never effaced.

Fig. 4. A view of Kara Kul. The sea is fringed by salt. (O. Olufsen *phot.*)

The plain surrounding the lake is both clayey and sandy with stones everywhere. In many hollows salt has crystallized out on the surface. Skeletons and wind-dried carcasses of scores of horses whiten the ground. There are great stretches where not a single plant is to be seen, but here and there groups of non-flowering cespitose grasses grow stiffly. Otherwise I saw only *Sisymbrium Korolkowii* and the ill-smelling *Oxytropis tibetica* which formed great sand-catching tufts, growing outward in circles and dying in the centre like fairy circles.

The northern peninsula is composed of a gray, glistening argillaceous slate, whose surface is rendered dark, almost black, by disintegration. Fragments of this slate mixed with grayish yellow clay form the soil. In many places plant growth was absolutely lacking, one could search about for hundreds of mètres without finding a plant, not even a lichen. However, after much wandering, 3 species, *Ephedra Fedtschenkoi*, *Christolea crassifolia* and *Acantholimon diapensioides* were revealed. The first is a creeper with long subterranean shoots and small clusters of slender green stems, the second forms fresh green tufts with many leaves and the third is a typical cushion plant; its cushions were up to 1 mètre in diameter and so hard and firm as to be practically unyielding even when trod upon. *Christolea* and *Acantholimon* were common in the bed of a dried-out mountain stream in which the cushion plant formed natural steps. *Ephedra* was apparently best able to endure drought of the three.

In the salt beds along the banks of Kara Kul, yellow *Carex pseudofoetida* and *Polygonum pamiricum* were growing in great masses. Algae and meter-long pieces of *Potamogeton pamiricus* were washed up on the beach. Gazing into the lake from above, the latter was seen forming dense forests of sea-weed on the bottom.

The countries about Kisil Kul and Kara Kul are the most barren I have seen in Pamir. However, a few day's journey further south the landscape sinks slightly and the vegetation

becomes richer. Near Sary Mullah lies a stony gravel plain, surrounded by steep slate mountains. Here plants are growing, separately it is true, so that the ground is visible between, yet abundantly enough that the plain seen from above looks green with only here and there a bare brown spot of hard cracked clay surrounded by white saline crystals. On this plain I found *Artemisia sp.*, *Stipa orientalis var. trichoglossa*, forming tiny fairy circles, *Carex stenophylla*, *Hordeum secalinum var. brevisubulatum*, *Macrotomia euchromon*, *Solenanthus stylosus*, *Oxytropis tibetica*, *Astragalus Muschketowii*, *Eurotia ceratoides*, *Sisymbrium Korolkowii*, *Christolea crassifolia*, *Arnebia guttata*, *Psychrogeton turcestanicum*. In a single locality there was a great mass of *Chenopodium vulvaria*, presumably brought thither by a caravan. *Lappula Myosotis* and *Acantholimon diapensioides* were growing in a dried-up stream.

The vegetation of the plain extends up the lower part of the base of the mountains, (eastern exposure), without great change *Eurotia ceratoides* becomes common here, and we find *Oxytropis humifusa*, *Hedysarum cephalotes*, *Poa attenuata*, and *Veronica biloba*.

Many of the species have gaily coloured blossoms. This quite rich and varied vegetation is made up of cespitose hemicryptophytes and suffrutices, and belongs to the Trigonella-formation which will be discussed further later on.

The Russian fortress, Pamirski Post, lies at the upper course of the Murghab River. This river flows through a valley far broader than itself and composed for the most part of swamp-meadows. North of the river valley is a rather broad rolling plain, its soil of stony clay or sand stained here and there by patches of white salt. Looking at the cliff down to the river with its 4—6 mètres perpendicular drop, we see that the foundation of the plain is a conglomerate. The binding substance is sand or clay and most of the stones are about the size of hens' eggs with occasional great boulders several mètres in diameter. Flat

stones lie almost always with their flat surface upwards, and there are strata of sand and gravel.

Fifteen kilomètres towards the west the same plain is watered by Kara Su, a little river flowing into the Murghab on the left. Here the Kara Su valley is called Jaman Tal. Its sides, 30 mètres high, are perpendicular walls of conglomerate with strata of sand and gravel. 20—30 cm below its surface there is a layer of sand about a mètre thick. Jaman Tal has many lateral valleys, through which an approach to the plain is possible; these are quite dry now. With its perpendicular walls, regular lateral valleys, strata and drought, Jaman Tal resembles the famous Grand Canyon of the Colorado in Arizona. In point of size, however, no resemblance is possible. A photograph of Jaman Tal has been published by M^me^ Olga Fedtschenko in Flore du Pamir (Table 5).

The landscape about Pamirski Post is desolate. The barren, stony, rolling plain is encircled by rounded slate mountains, brown and naked like the plain itself. A clear blue sky arches overhead and the sun beats down on the dry silent country.

On a horizontal section of the plain the vegetation is extremely scattered: *Christolea crassifolia*, dwarf *Ephedra*, *Artemisia*, *Eurotia ceratoides*, *Crepis flexuosa*, *Zygophyllum Fabago*, and a grass with terete slender leaves, are all found in separate tufts. In the direction of some low-lying hills the vegetation becomes somewhat richer with only 1—5 mètres between each plant. Here, in addition to the species already mentioned, we find the hemicryptophyte *Arnebia guttata* and the suffrutex *Sympegma Regelii*.

Westward towards Shatshan, the plain slopes a little and has an eastern exposure. Here the vegetation is relatively rich: *Eurotia ceratoides*, *Stipa orientalis*, *Astragalus Muschketowii*, *Astragalus ophiocarpus*, *Crepis flexuosa*, *Christolea crassifolia*, *Zygophyllum Fabago*, *Arnebia guttata*, *Oxytropis tibetica* (single specimens) and, strangely enough, a smooth little annual *Senecio* (*S. coronopifolius var. parvulus*). With the exception of the latter and of *Crepis* all the plants are short compressed tufts. The same species are to be found on the

mountain-sides sloping towards the east. Further up, another tiny, aromatic and arachnoid hairy labiate (*Nepeta spathulifera*), appears, and still higher *Dracocephalum heterophyllum*, growing in patches on account of its long horizontal rhizomes, *Linaria hepatica* and *Solenanthus stylosus*. The ground of the mountain-slope is of dry gravel with jingling bits of slate and here and there boulders of slate fast embedded. Occasional patches of white salt are visible. At a depth of 10—20 cm the ground is slightly damp.

The vegetation of Jaman Tal is unusual. Here there is a thicket, 4—5 mètres high, of *Salix oxycarpa*, and *Myricaria davurica* and besides *Clematis orientalis* and great tufts of *Scrophularia incisa*, *Calamagrostis compacta*, *Elymus sibiricus* and *Potentilla dealbata*. This vegetation, very little characteristic of Pamir, is presumably due to the sheltered warmth of the deep valley.

Shatyr Tash is situated in the eastern end of Alitshur Pamir at an altitude of about 4,100 mètres. It is a nearly horizontal plain extending on either side of the Alitshur River, which flows westward into the Jashil Kul. Many Kirghiz had pitched their tents on Shatyr Tash and quantities of sheep and yak oxen were grazing on the plain. Mountains tower high into the air on the north and south, and small scattered knolls of rock penetrate here and there the soil of the plain. In some places the ground is dry and covered with fine gravel. Here the vegetation is poor and sparse, composed of *Poa attenuata var. pygmaea*, *Calamagrostis compacta*, *Carex stenophylla*, *Sisymbrium Korolkowii*, *Oxytropis Poncinsii*, *Polygonum paronychioides* and *Chrysanthemum pamiricum*. In a locality with the above flora the ground water was found at a depth of 71 cm. In other places the soil of the plain appeared brown and moist, generally covered with a very thin layer of salt. The dry and wet spots alternate at the same altitude, indicating plainly that they depend on certain subterranean conditions. The surface of the soil in wet places is often rough or lumpy, with quantities of low

irregular flat mounds, 1—2 mètres in diameter and up to 30 cm high. These are either cracked and covered with salt or moist and brown with a surface that is wetter than the ground beneath, but with no salt except on occasional protuberances, like tufts of grass. The cause of these eminences is unknown to me, perhaps it is the action of frost. In any case, the soil in them has apparently considerable capillarity and is able to retain salt water. These mounds are as a rule bare of plants. The salty part of Shatyr Tash is somewhat richer in vegetation than the gravelly part, but mostly the same plants grow in both soils: *Poa*, *Calamagrostis*, *Potentilla polyschista*, *Elymus dasystachys*, *Alopecurus mucronatus* and *Acantholimon diapensioides* are the most important. In some spots the first three named form a thin carpet, and in others, *Acantholimon* usurps all the room there is.

There are swamps too on Statyr Tash; there the soil was very moist but there were no puddles or pools, and practically no change in the vegetation. However in these localities *Alopecurus mucronatus* and the lovely red-flowering *Pedicularis uliginosa* grow.

Mountain-slopes with a southern exposure were extremely dry and there were great spaces between the plants.

Here we found *Eurotia ceratoides*, *Artemisia* and an undetermined grass. On a slope exposed to the northeast and with a subsoil of clay, mixed with small stones, the vegetation was richer and closer: *Artemisia*, *Acantholimon diapensioides*, *Poa attenuata*, *Nepeta daënensis* and *kokanica*, *Erysimum sisymbrioides*. Of these *Nepeta daënensis* and *Erysimum* are annuals. There were stripes and patches of green near the streams coming from melting snow. Here *Bromus crinitus*, *Braya Kizil Arti*, *Ranunculus Aucheri* and *rufosepalus*, a little annual *Veronica*, *Primula sibirica*, and *Pottia latifolia* were growing. The lowest great snow mass lay at an altitude of 4,300 mètres. Just below it was the moss *Eucalypta leptodon*, twenty mètres further down the first phanerogams appeared, and another twenty mètres below them were flowering plants: *Chorispora macropoda*, *Smelowskia calycina*, *Papaver radicatum*, *Poa attenuata*, and *Dracocephalum discolor*.

In Alitshur-Pamir, southeast of the eastern end of Jashil Kul, at an altitude of 4,100 mètres is the little lake, Tuz Kul (the name means salt lake). It is grouped with other tiny lakes on a wide plain which is nearly as barren and desolate as that near Kara Kul. The surface of this plain, brown in colour, and either very stony and gravelly, or clayey, undulates gently and is so destitute of plant life that seen from a neighbouring mountain it appears quite bare. Portions are white with salt. In many places one can go 200 steps without finding a single plant. Vegetation is practically only found in the flat hollows and consists of groups of *Eurotia ceratoides*, *Stipa orientalis*, and *Oxytropis Poncinsii*. Only in the deepest hollows into which sand has drifted are other species to be found; *Solenanthus stylosus*, *Polygonum paronychioides*. *Paracaryum himalayense* (?), *Halogeton glomeratus*, *Christolea crassifolia* (one of the most common), flowering *Linaria hepatica*, *Silene caucasica*, *Atriplex sp.*, *Serratula procumbens*, *Crepis flexuosa*, single specimens of *Acantholimon diapensioides*, *Cousinia rava*, and the little annual, *Senecio coronopifolius*. *Halogeton*, *Christolea* and *Atriplex* would indicate salt in the soil. The plants grow in recesses especially in those on slopes having a northeastern and northern exposure, presumably a question of shade or in any case of shelter, for here sand has formed drifts grayish white and glistening with mica. The plain is swept clean; only stones and gravel remain, or clay in the clayey parts, seeming to indicate that wind is the hindering factor.

In the country about Tuz Kul there were many features of great interest even though they were not of a botanical nature. As the author is no geologist he will not enter into details about these matters but briefly describe conditions as they are.

In a hollow, white with salt, there were pools of water, from these a stripe of damp soil free from salt extended downhill. In a couple of places water oozed slowly up from the ground, which in a circumference of 20—30 cm was a veritable mud-pie. Probably the pools were caused by water oozing up, there is most likely a layer containing

water deep down, from which water rises to the surface as in an artesian spring.

A similar condition on a larger scale was observed south of Tuz Kul, on a clayey plain, lying about 1 mètre below the stony plain described above. On this clayey plain there were twenty-odd unevenly formed clay hillocks, 2 mètres high at the outset. They were quite dry now, but it was easy to see that water had previously flowed out of their tops, where craters 5—10 cm in diameter sealed with clay were formed. The water had poured down the sides forming deep furrows, which radiated from the top forming a star. The rivulets then flowed together into brooks, these in their turn into one larger brook which has worn its way at 2 mètres depth through the clay, flowing at last into Tuz Kul. Here and there the brooks formed small pools which are now dried up and covered on the bottom with white salt.

The clay of which the hills were composed was very hard and firm and free from pebbles; single stones as large as one's fist lay helter skelter on the surface of the ground, looking as if they had been thrown there.

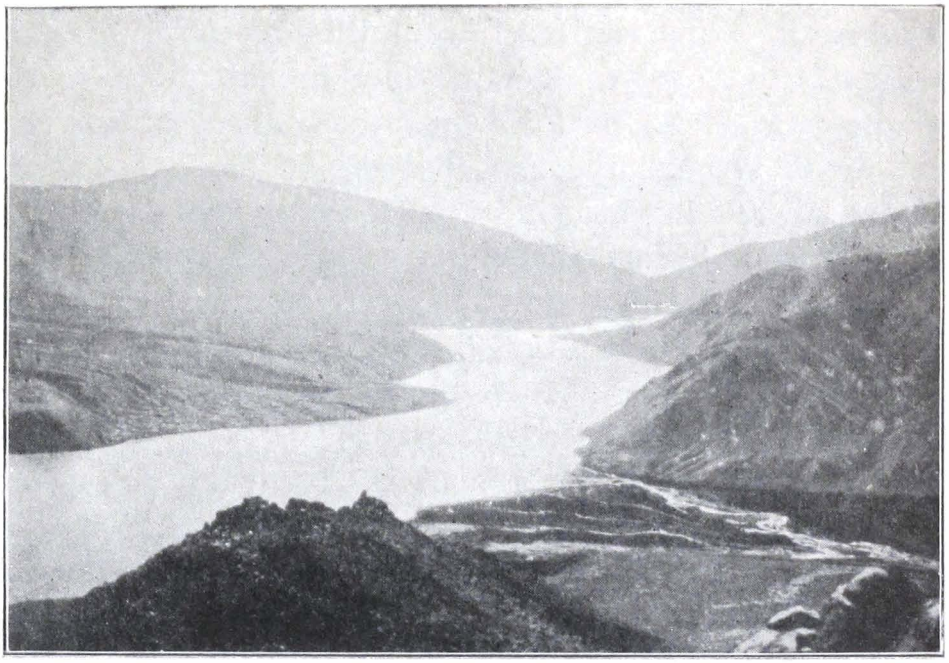
The water must have transported the clay which forms the hills up from the ground; for, inasmuch as the hills are far more worn away by the action of the streams than the outlying plain, they cannot be remains of clay that is washed away everywhere else, but the plain must be the original level. We are thus dealing with mud volcanoes under one form or another.

CHAPTER 6.

Jashil Kul and the Plain near Mardjanaj. (Trigonella-Formation).

Lake Jashil Kul, (the green lake), lies at the western end of Alitshur Pamir, a little less than 4,000 mètres above sea-level. The lake is long drawn-out, being 25 kilomètres at its greatest length, main direction west-east, 3½ kilomètres at

it's greatest breadth, and about 40 mètres at it's greatest depth. The Alitshur River, which flows into the eastern end, is its most important inlet. An outlet from the neigbouring lake Bulung Kul also flows into the eastern end. On the north Jashil Kul receives water from Great and Little Mardjanaj, while from the south countless small streams of minor importance pour into the lake. Jashil Kul has its outlet on the western end. Here the river Gund whirls the waters of

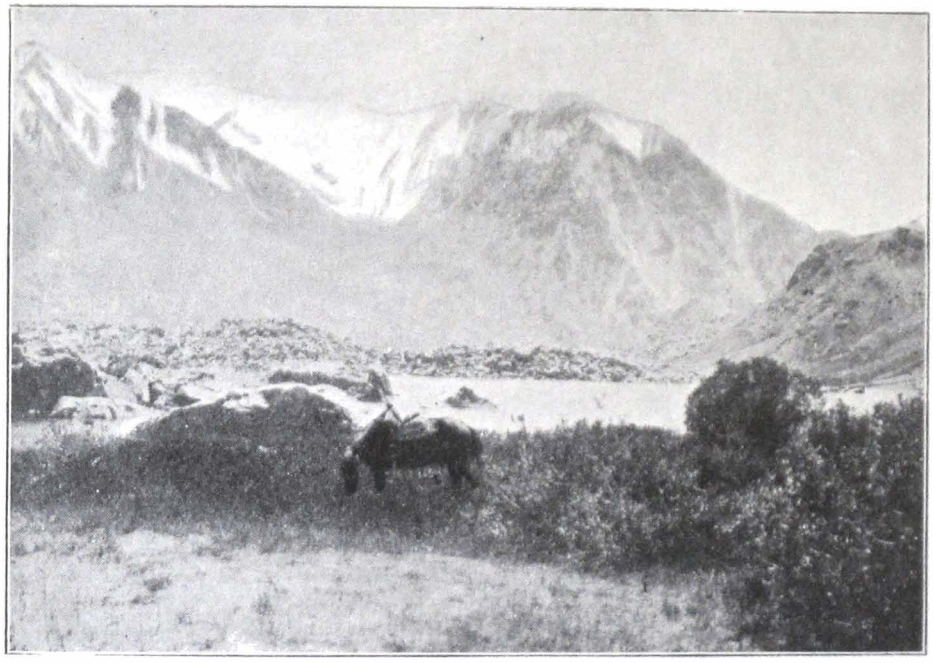


(O. Olufsen *fot.*)

Fig. 5.
Jashil Kul as seen from a mountain-top on its North-Side, east of the Mardjanaj river which is seen running out into the lake. Between the mountain whereupon we stand and the river is seen the plain, whose vegetation is described below.

the lake rapidly down to the Pandsh River. A chain of high mountains lie north of Jashil Kul; their almost naked talus slopes drop precipitously down to the lake. A ride along the western part of the northern shore is a difficult matter; the horse has trouble in picking its way in the loose stony masses, which are apt to glide, carrying both horse and rider with them. A strip along the western edge of the lake is perfectly impassible. Huge piles of gneiss have crashed into the water and lie in a chaos of great boulders.

However almost everywhere from great Mardjanaj toward the east, one may trot if one likes, for here between the lake and the steep mountains, lies an even, horizontal plain, — the remains of one of the usual Pamir plains, — formed by the filling-in of former eroded valleys. The same plain is also to be found at the eastern end of the lake; it is a direct continuation of the plain of Alitshur-Pamir, whose upper portion is Shatyr Tash.



(O. Olufsen *fot.*)

Fig. 6.
The western end of Jashil Kul. In the foreground willows are seen, piles of boulders behind.

The southern shore of Jashil Kul is quite different from the northern shore. Here partially green mountain-sides, with almost no loose talus, slope gradually down to the lake.

The soundings made by the expedition and published by Olufsen in Geografisk Tidsskrift, 1900, Table IV, show that the bottom of the lake drops more precipitously on the south than on the north side. Only 2 of the cuts, (there are 10 in all), are at variance with this and may be explained on topographical grounds, (mouth of a brook on the south side).

The fact that the bottom of the lake slopes more precipi-

tously on the south than on the north side is presumably due to the same causes as the differences in the acclivity and vegetation of the mountains. The slopes with a southern exposure are heated by the sun. This causes great disintegration and lack of vegetation, (the latter may also in part be due to disintegration), and from these barren disintegrated mountain slopes great masses slide down into the lake. Thus the mountains become constantly steeper while the bottom of the lake slopes. The mountain sides with a northern exposure disintegrate far more slowly, and furnish a good locality for plant growth. Practically no landslides occur here and the bottom of the lake is comparatively precipitous, while the mountains slope more gently.

These south-coast mountains are higher than those on the north, their snow-covered summits tower 5—6000 mètres high, and the torrents rushing down to Jashil Kul seem never to dry up.

South of the eastern end of Jashil Kul lies the little shallow lake, Bulung Kul. It is located in a plain sloping gently toward the north, which is watered by the little stream Koi tesek.

Our expedition spent about a month at Jashil Kul. We camped first east of the mouth of the great Mardjanaj on the northern shore of the lake; later on on the eastern shore, and finally near Bulung Kul (see the map).

It was a marvellous experience, a constant succession of sunny days in majestic surroundings which we learned to love. When, after climbing high, high up, one's gaze roamed over this huge silent landscape, — the long, yellowish-green sheet of water nestling shining and still among the lofty brown mountains, crowned with summits of snow, — it seemed as if life no longer existed. Yet nature here was far from dead. The vegetation which I shall soon describe was both beautiful and characteristic. Animal life abounded. A strange tickling sensation comes over one, when for the first time and alone on an excursion, one sees the den of a bear, even though the bear is absent. We had indeed one vain bear-hunt after a huge yellowish-white specimen. There

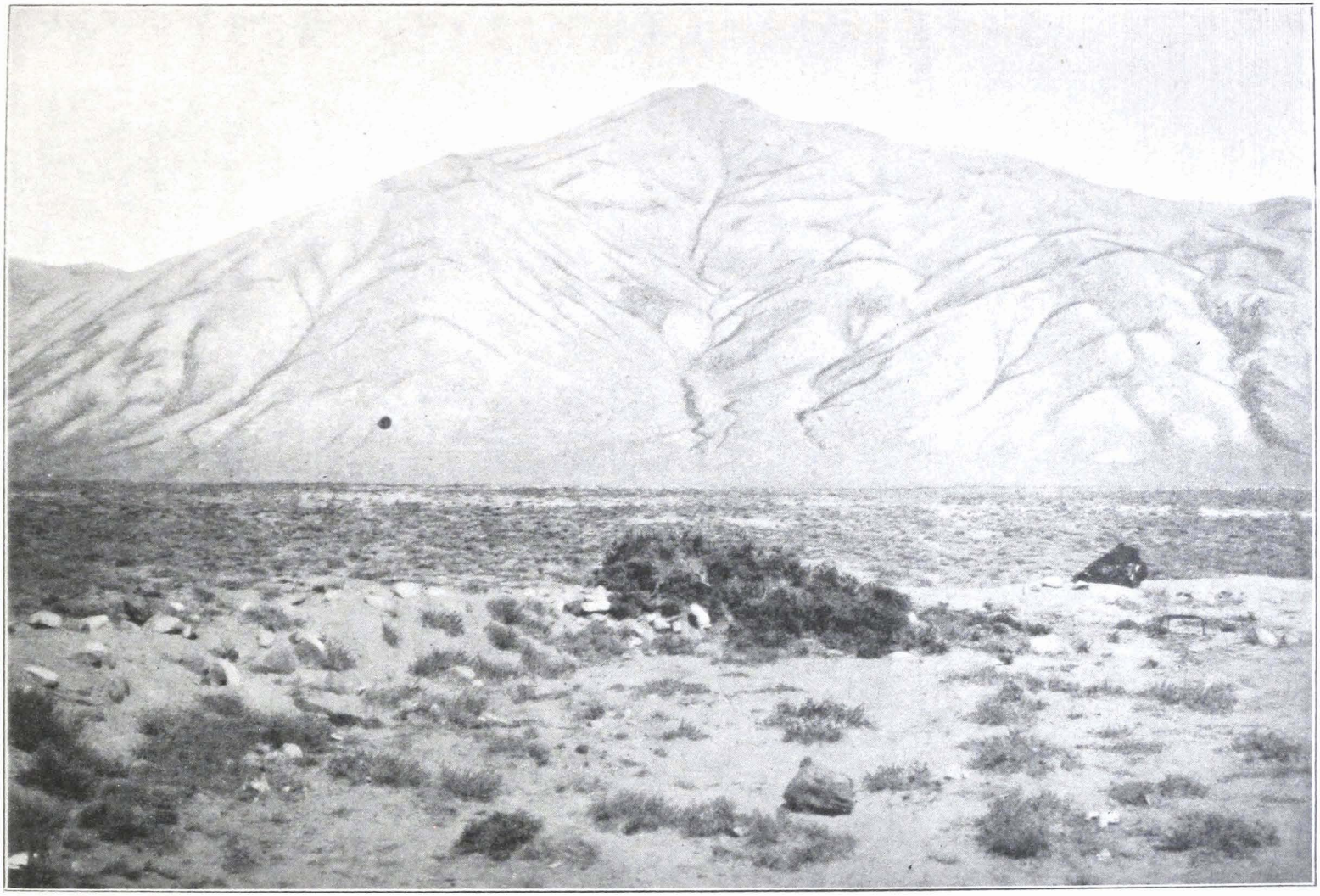
are great mountain-sheep too; *Ovis poli*, whose skulls are scattered by the thousand all over Pamir is one of them. They are very timid and seek refuge on the highest mountains. Besides these we saw goats, *Capra sibirica*, and wolves. Many birds are to be seen near the lakes, doves, sea-swallows, *(Sterna hirudo)*, black cormorants, reddish-brown ducks, *(Tadorna casarea)* while great brown eagles *(Haliaetus leucoryphus)* perch on stones near the shore, darting out into the water after fish, with which the lakes abound. Near the mouths of rivers are snipe, (*Totanus callidris, glareola, glottis*) and wagtails (*Motacilla citreola* and *flava* (?)).

There were many mouse-holes on the flat plains, (*Cricetus arenarius, Arvicola tianschanicus*), but the marmot, so common on Shatyr Tash, was not to be seen.

I have chosen the plain near Mardjanaj as a point of departure for a description of the vegetation about Jashil Kul. Located more exactly this plain lies east of the lower branch of the great Mardjanaj. This river and several tiny, now dry streams, which lead from the east down to the green valley of Mardjanaj, have worn deep into the plain. The plain is bounded on the east by high mountains, on the south east by a low mountain ridge behind which a similar plain stretches. The plain is about 70 mètres above the surface of the lake.

It is horizontal and slightly rolling. As no glacial brooks from the mountains flow through it, the vegetation is forced to depend on precipitation alone. The soil is reddish gray, dry sand, somewhat finer in the hollows, prone to crack on the surface, and mixed here and there with salt. At a depth of 17—20 cm dampness renders it recognizably darker.

The vegetation consists of isolated tufts and cushions. It may be said in general to belong to a poor type, — apparently most nearly a semi-desert type of scattered xerophytic, cespitose plants, with an appendix of cushion plants, — but it is a richly developed form of this poor type.



(O. Olufsen *fot.*)

Fig. 7.
The plain east of Mardjanaj, seen from our camp. In the foregroud a heap of fuel, tufts and stems especially

The distance between the plants varies from one to some footsteps. As the tufts are often large, up to a mètre in diameter, at least half of the ground is covered with vegetation.

The vegetation covering this plain is both characteristic, interesting and beautiful into the bargain, for, as will appear later, many of the flowers are very gaily coloured. There

Fig. 8. The plain at Mardjanaj. The large cushions are *Acantholimon alatavicus*.

are many insects: bees, bumble-bees, butterflies, tiny beetles, grasshoppers and quantities of flies.

Below follows a list of the plant species found on the plain and information as to their growth-forms.

Common, appearing everywhere, were the following species:

Hedysarum cephalotes (Franch). A hemicryptophytic rosette-plant forming large tufts. Among the largest specimens I saw, was one 120 cm in diameter, and another, almost rectangular in form, 2 mètres long and 1 mètre broad. The tufts were usually dead in the centre. The branches were everywhere fastened to the ground by roots. The pinnate leaves, 6—7 cm long, were silver-haired, the leaflets, (about 9—11), as a rule less than 1 cm long, lanceolate,

sulcate and pointed slantingly upward. Peduncles about 12 cm long. Beautiful red flowers.

Oryzopsis molinioides Hack. A hemicryptophytic, cespitose

Fig. 9. *Hedysarum cephalotes* Franch. *subsp. shugnanicum* B. Fedtsch. (ab. 1/2).

grass with close tunics around the base. The leaves convolute, filiform, only 4—6 cm long. Straw about 20 cm long.

Chrysanthemum pamiricum O. Hoffm. A chamaephytic

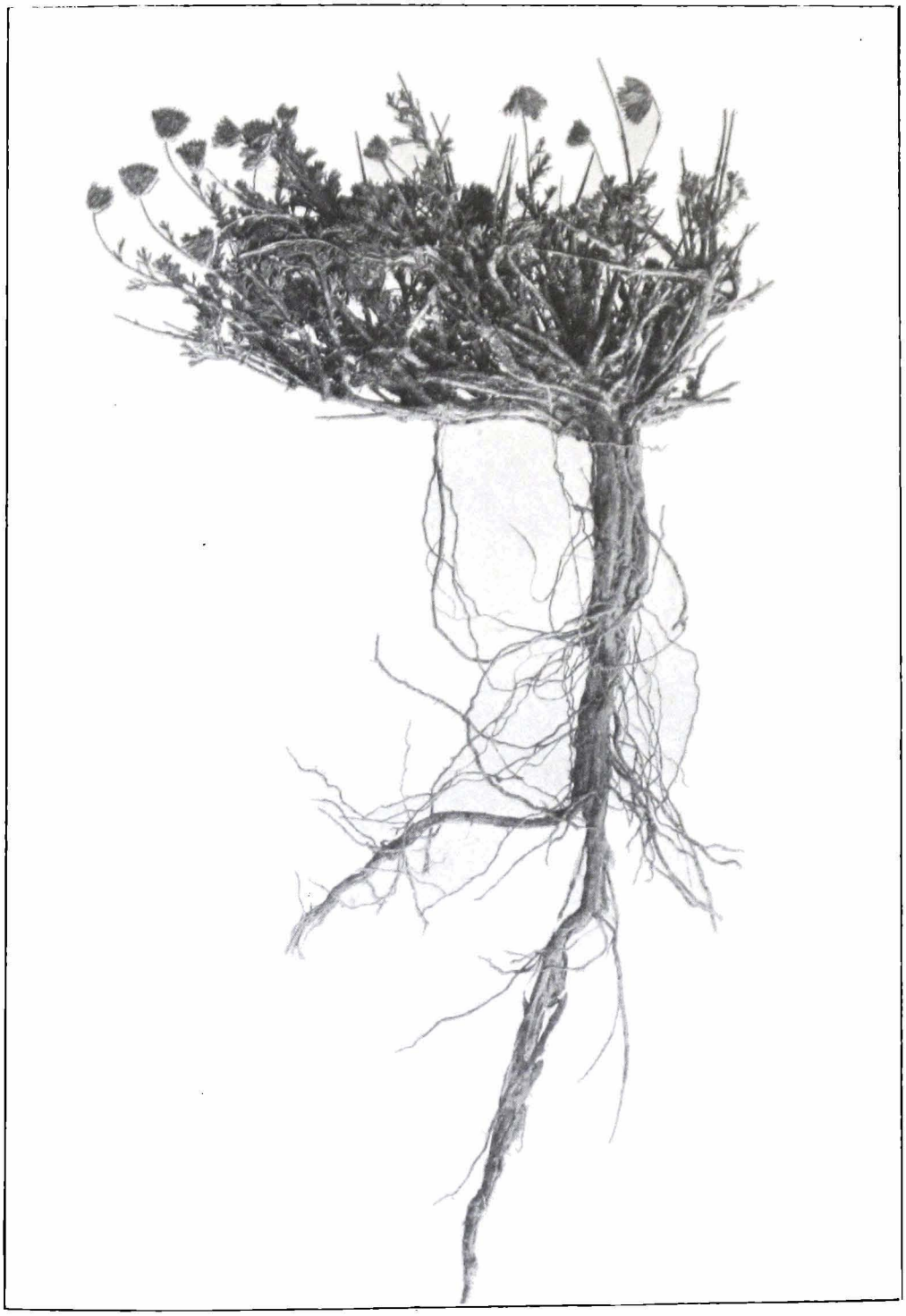


Fig. 10. *Chrysanthemum pamiricum* O. Hoffm. (ab. $^1/_2$).

suffrutex, about 15 cm tall, filled with dead and dried sticks, former shoots. Forms tufts up to 70 cm in diameter, (2 mètre in circumference). Leaves small, about 1 cm long, pinnatisect, stiff, hairy, turned upwards, the lobes revolute. Flowers,

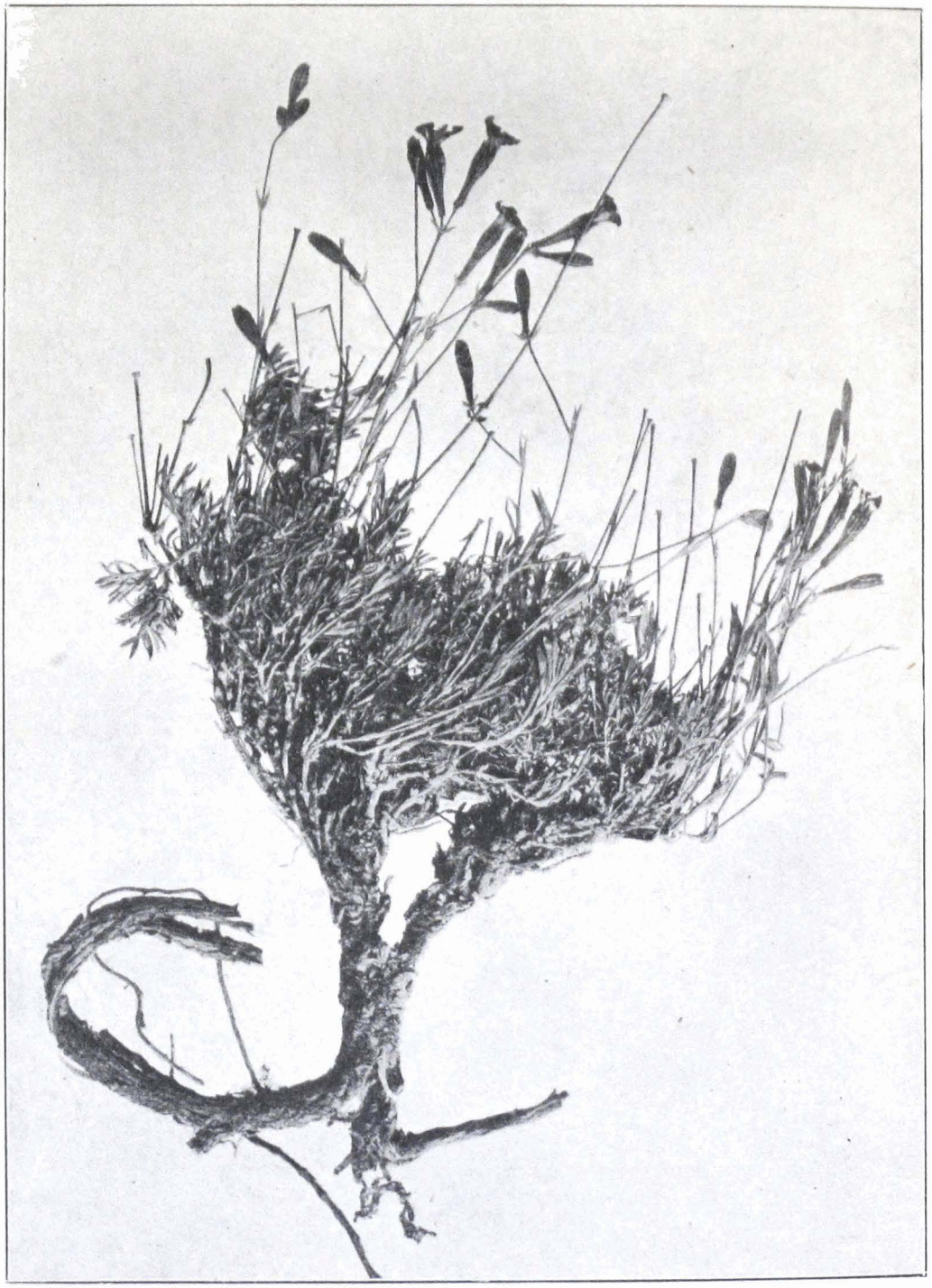


Fig. 11. *Silene caucasica* Bois. *var. pamirensis* H. Winkl. (ab. $^1/_2$).

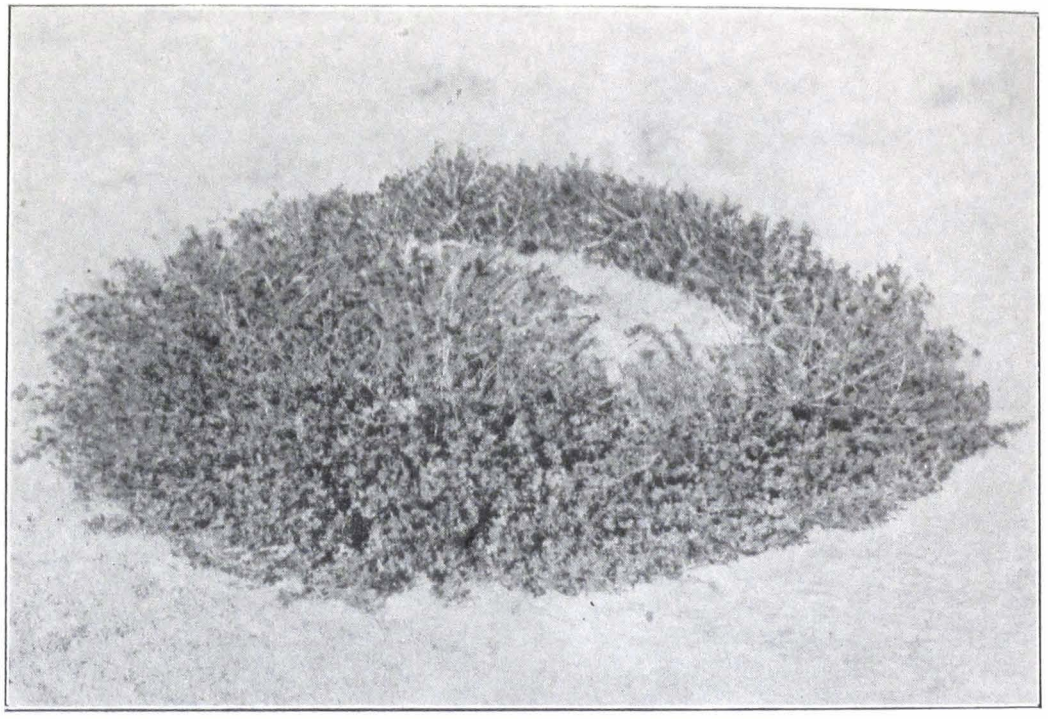
yellow, blossom first on the north side of the tuft. They are not more than 10 cm from the surface of the ground.

Silene caucasica Bois. A hemicryptophyte with a large

Fig. 12. *Oxytropis bella* B. Fedtsch. (ab. $^1/_2$).

"radix multiceps" and many buds on the lower parts. Forms small tufts, up to 25 cm in diameter, often dying away in the centre. The leaves which have the same size on the top and bottom of the stem (a "protohemicryptophyte") are oblong-lanceolate, densely hairy, turned-upwards, about 2 cm long. Flowers, white, with red-striped glandular-hairy calyx, about 15 cm above the ground.

Oxytropis bella B. Fedtsch. A hemicryptophytic rosette



(*Fot. by* O. Olufsen.)

Fig. 13.
A big tuft of *Trigonella Emodi* Benth. on the plain at Mardjanaj.

plant, forming small tufts 10—20 cm in diameter. (Circumference 40—50 cm). Leaves pinnate, almost vertical, 2—3 cm long, have 4—5 pairs of silvery-hairy, lanceolate leaflets about 7 mm long Flowers, violet, growing 6—8 cm above the surface of the ground. (Fig. 12).

Trigonella Emodi Benth. A hemicryptophyte forming large tufts, up to 1 mètre in diameter, on a single thick root. In many cases the entire centre of the tuft is dead and only a circle, 10—15 cm wide, living. Leaves, ternate, with movable leaflets hardly a centimetre long, dentate at the tip, smooth, but with glands secreting an odorous substance. Flowers,

yellow, blossoming first on the north side of the tuft. The flower-stalk is about 30 cm long. (Fig. 13, 14).

Ephedra Fedtschenkoi Pauls. (?) (possibly *E. monosperma*

Fig. 14. *Trigonella Emodi* Benth., part of a tuft. (ab. 1/2.)

Gmel.) A hemicryptophyte with long, horizontal, subterranean rhizomes and light-shoots only 1—3 cm long, cylindrical and leafless. The rhizomes cause many light-shoots to be

Fig. 15. *Astragalus Alitschuri* B. Fedtsch. (ab. $^1/_2$).

found together, but they never form a close growth. The leaves are small scales.

Astragalus Alitschuri B. Fedtsch. A hemicryptophyte with

Fig 16. *Polygonum paronychioides* C. A. M. (ab. 1/1).

a large "radix multiceps", forming small tufts. Rosette-plant. Leaves, pinnate with about 5 silvery-haired pairs of leaves about 1—2 cm long. The leaflets are elliptical, 4—5 mm

long. The peduncles grows slantingly outwards. The flowers are yellow and only 15 cm above the ground. (Fig. 15).

Polygonum paronychioides C. A. M. A chamaephyte, suffrutex characterized by the whitish sheen emanating from the large membraneous ochreae. A large vertical tap-root bears horizontal woody branches, 5—10 cm long, whose herbaceous tips turn upwards. The whole forms a flat disc resting on the ground; large portions are dead. The revolute

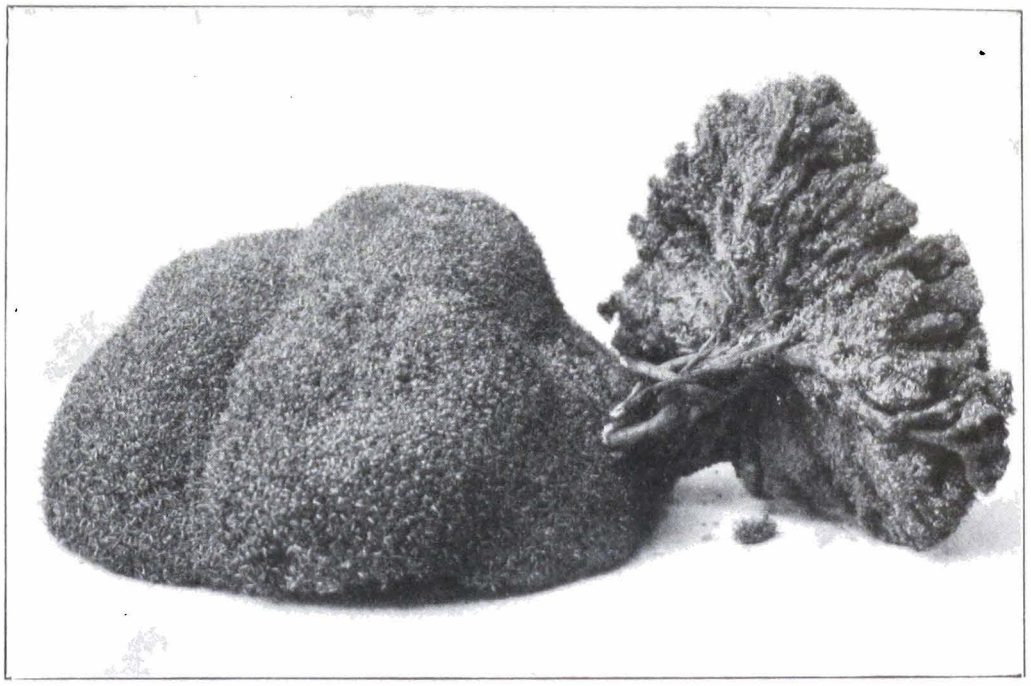


Fig. 17. Two specimens of *Acantholimon diapensioides* Bois., a convex cushion seen from above, and a flat cushion seen from below. (ab. 1/2.)

leaves, a few mm long, are almost hidden among the ochreae. Flowers, small, red. (Fig. 16).

Acantholimon diapensioides Bois. A chamaephyte, cushion plant, which can attain a diameter of more than 1 mètre. ("Radial flach Polster", HAURI-SCHRÖTER). When young it is only attached by the main-root, later many adventitious roots are formed. The cushions are flat as a rule, on the level of the ground, but occasionally (on clay soil?) high bulging specimens are found; these contain air; ("Luftkugelkissen", HAURI-SCHRÖTER), otherwise they are solid, filled with twigs and dead leaves and so firm that one can step on them without injury. In large old specimens the centre

is generally dead, and the growth continues in a fairy ring. The leaves are about 2 mm long, very close together and do not prick. The beautiful sessile pale pink flowers are often seen edging the cushion. (Fig. 17).

Fig. 18. Fasciated stem of *Eurotia ceratoides* C. A. M. (ab. 1/2).

Acantholimon alatavicum Bge. A chamaephyte, cushion-plant belonging to HAURI and SCHRÖTER's "Kugelsträucher" as it is penetrated by both light and air. The cushions can be more than 1 mètre across and may bulge as high as 18 cm over the ground. It rests lightly on the ground

only fastened by a single main-root. The cushion is often higher on the south than on the north side.

Fig. 19. *Astragalus lasiosemius* Bois. Leaflets for the most part fallen off. (ab. $^1/_1$).

It is filled with remains of leaves. The leaves are acicular, 1—1,5 cm long. The beautiful sessile flowers blossom earlier on the north side of the cushion than on the south side. The fruit has a winged calyx.

Eurotia ceratoides C. A. M. A chamaephyte, suffrutex. It has a single large main-root with horizontal lateral roots, bearing many woody stems; these are nearly always flat, firmly fasciated, and on top bear living and dead twigs. The tuft can attain a diameter of 120 cm, when they are so large, the centre is generally dead. The tufts have been figured by SCHIMPER fig. 453, p. 791. The leaves are lanceolate about 1 cm long, stellate-hairy with revolute edges. The plant is 15—20 cm tall. Flowers inconspicuous. (Fig 18).

Solenanthus stylosus (Kar. Kir.) Lipsky, (Lindelofia stylosa). A hemicryptophyte, forming tufts, without centrifugal growth but surrounded by many withered leaves. The ground leaves are about 10—20 cm long, lanceolate, sulcate and velvety-hairy. The stem-leaves are narrow, and about 5 cm long. The flowers, dark-purple, are at the utmost 50 cm above the ground.

Astragalus lasiosemius Bois. A suffrutescent chamaephyte, with a single thick main-root bearing large tufts (one specimen was 90 cm in diameter, another 65 cm long, 35 broad), often dead in the centre; the leaves are pinnate with 3—5 pairs densely sericeous leaflets, 5 mm long. The rachis remains upright like a long pointed thorn. (Fig. 19). Rich florescence of yellow blossoms, not more than 10 cm above the ground.

Serratula procumbens Rgl. A hemicryptophyte with procumbent herbaceous branches of which the older part is covered with remnants of leaves. The leaves are 4—7 cm long, lanceolate-elliptic, glabrous. The great red heads blossom in August.

Artemisia (*herba alba* Asso?). A suffrutescent chamaephyte, having a single vertical root with many lateral roots. The branches diverge on all sides and upwards, and may form great plates, about 1 mètre in diameter. The leaves are bipinnatisect and sericeous. The small yellow flowers blossom in early September.

Stipa orientalis Trin. A hemicryptophyte forming close tufts, which, when old, often wither in the centre and form rings, up to 10 cm in diameter. It is very tunicate. The filiform leaves are up to 8 cm long; the straw up to 20 cm.

In addition to these species found almost everywhere on

the plain, many others are found mixed with the above or growing in single localities:

Macrotomia euchromon (Royle) Pauls. This plant, when young, is a cespitose hemicryptophyte, but will here be considered chamaephyte, because the vertical rhizome grows up over the surface of the ground like a cushion; it can attain

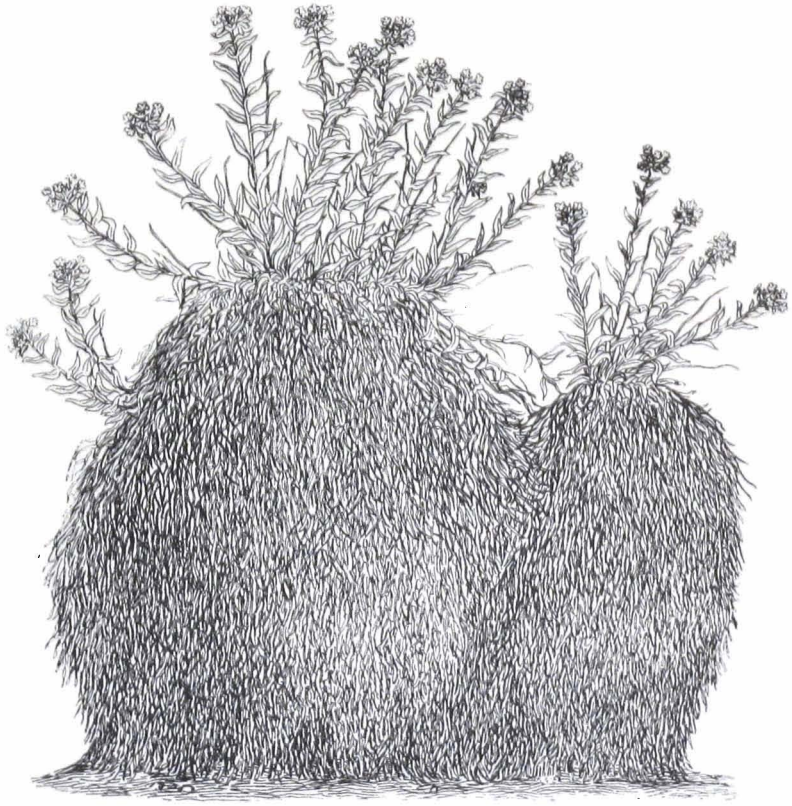


Fig. 20. *Macrotomia euchromon* (Royle) Pauls. Old specimen, which has formed a 30 cm high pillar covered by dead stems, on the top of which fresh shoots appear; they are now flowering. South-side of Jashil Kul. (Drawing after a sketch and measurements by the author). (Ab. 1/6.)

a height of 30 cm, and is closely covered with dead stems (see Fig. 20). This is a phenomen known to us from arctic regions where some species, (*Lesquerella arctica*, *Potentilla pulchella*) form in open places, the so-called "pillars", covered with remains of dead leaves, and bearing a few green leaves on their top (pictured by OSTENFELD and LUNDAGER). In the case of *Macrotomia* both the pillar and the living portions attain greater dimensions than the arctic plants, which are

only a few centimètres high. — The leaves, 5—8 cm long, are ovate-lanceolate, coarsely hispid and covered with many fine hairs, sulcate; the lower leaves are sloping, the stem-leaves horizontal. The flowers at first red and visited by bumble-bees, and later yellowish-white; on specimens born up on large cushions they may be raised up to 70 cm above the ground; on young specimens 30—40 cm.

Astragalus dolichopodus Freyn. A hemicryptophyte with a "radix multiceps". By degrees small tufts are formed about 30 cm in diameter, sometimes ring-shaped. Rosette plant. The leaves are 2—3 cm long, and have 4—5 pairs of leaflets, which are cuneate, 7—9 mm long, sericeous and in the day-time when the sun shines turn their profile to the sunlight. The red flowers are only raised 15 cm from the ground.

Cousinia rava C. Winkl. A hemicryptophyte with "radix multiceps", forming small tufts. The white, prickly-edged, white-villose leaves, which grow all along the stem, are 5—12 cm long; the red heads are about 30 cm above the ground.

Oxytropis Poncinsii Frch. A chamaephyte with a thick "radix multiceps" bearing small very thick tufts of short shoots. The tufts are arched like cushions, and the plant approaches a cushion-plant. The leaves have 4 pairs of lanceolate, densely sericeous leaflets, about 5 mm long placed very close together. The flowers are purple, almost sessile. The swollen, hairy, green or rosy-red pods often encircle the tuft like a hoop. The centre is formed by the many closely packed silvery leaves. The entire effect is strange. (Fig. 21).

Astragalus oophorus Freyn. A hemicryptophyte with thick "radix multiceps" bearing small tufts. The light-shoots are very short, only 2—4 cm long, the leaves are 2—3 cm long and have 2—4 pairs of densely hirsute leaflets, which are obovate and about 7 mm long. The flesh-coloured flowers are only a few cm from the ground.

Carex stenophylla Wahlenb. A hemicryptophyte with subterranean horizontal rhizomes, and tunics of dead leaves about the shoots. The spikes are 7—10 cm above the surface of the ground.

Scorzonera mollis M. B. (*var. cano-velutina* Beauv.) and *Scorzonera pusilla* Pall. are both hemicryptophytes, semi-

rosette-plants with long, narrow more or less villose leaves and yellow flowers which are not more than 8 cm above the ground.

Lappula stricta (Ldb.) Gürke. A therophyte 10—15 cm tall or, as it has a ground-rosette of dead leaves, perhaps better determined as a biennial hemicryptophyte. The leaves

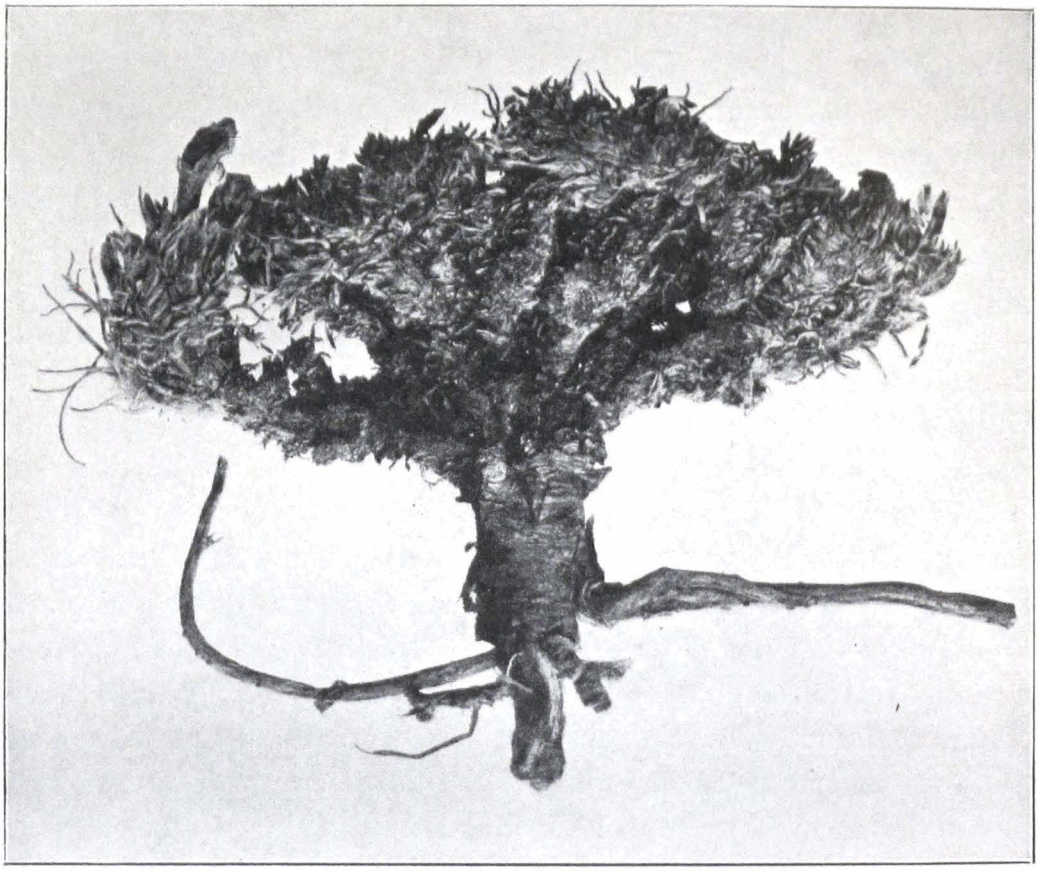


Fig. 21. *Oxytropis Poncinsii.* Frch. (ab. 1/2). Flowers on the left side.

are narrow and hirsute, flowers small and blue. The fruit has hong-looked thorns.

Nepeta daënensis Bois. A therophyte, 5—10 cm tall, slender, upright and for the most part without ramifications, with 2—3 pairs of almost smooth, linear, or linear-lanceolate leaves. Small red flowers. It grows in crevices or similar localities, never, or very rarely, on the flat, arid plain. (Fig. 22).

Polygonum molliaeforme Bois. A therophyte with delicate filiform decumbent stems, and 3—4 mm long, smooth, linear

leaves, half hidden in great white ochreae. Small, red flowers. In crevices and similar favourable places. (Fig. 23).

Elymus dasystachys Trin. (*var. aristatus* Rgl.). A hemicryptophyte, with long, subterranean rhizomes (?), and thick tunics around the base of the light-shoots. The leaves are up to 25 cm long, coarse and convolute. The straw up to 35 cm long.

Halogeton glomeratus. A therophyte with ascending branches, bearing cylindrical, succulent, blunt leaves, 0,5—0,8 cm long. Flower-clusters in almost all the axils. Found only in the hollows of the plain, preferably where there is a little salt.

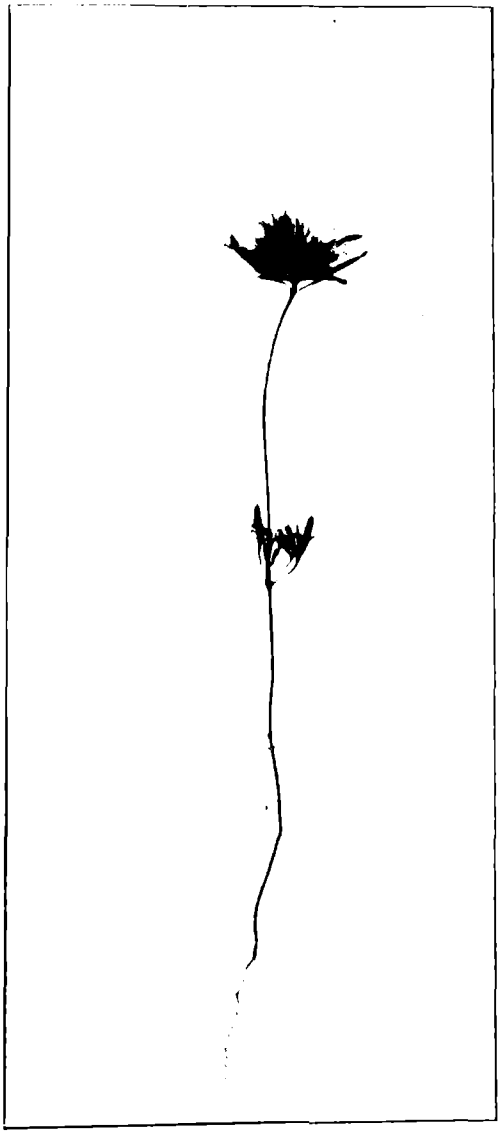


Fig. 22. *Nepeta dačnensis* Bois. (ab 1/1).

Arenaria Meyeri Fzl. A suffrutescent chamaephyte, forming tufts. The largest I saw was 75 cm long, 70 cm wide. The light-shoots emanate not only above ground, from the lower parts of the stems, but also as far as 10 cm underground; some of them are subterranean runners. It is a semi-rosette-plant in that the majority of the leaves are below on the light-shoots. The leaves are acicular, 1 cm long. The white flowers are about 20 cm above the ground. This species is not common on the plain. It is found almost exclusively in hollows and there, together with *Carex stenophylla*, *Hedysarum cephalotes*, and *Acantholimon diapensioides* and others, forms what may be considered a special formation, the Arenaria-Meyeri-formation. (Fig. 24).

As long as the various parts of the plain are horizontal the vegetation found is, in the main, the same. That *Eurotia* and *Acantholimon diapensioides* form associations in some places, *Artemisia* and *Stipa* in others, is presumably due to chance causes; in any case I have no theory as to how it comes about.

The plants growing on the plain do not represent many different growth-forms. Of the total 31 species, 17 are

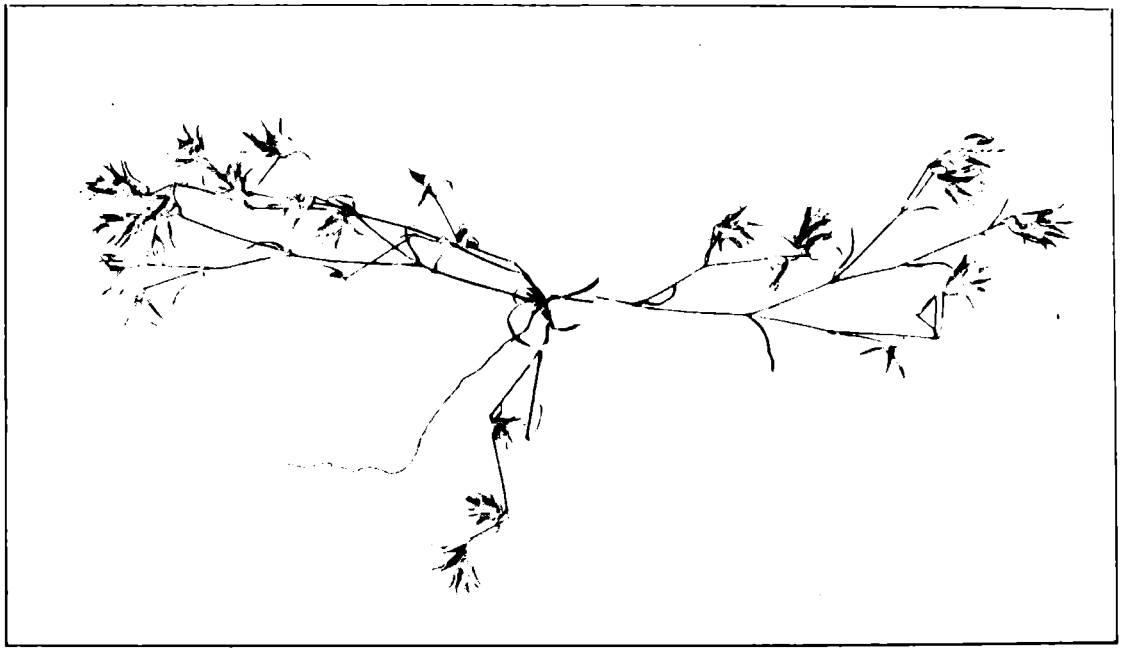


Fig. 23. *Polygonum molliaeforme* Bois. (ab. 1/1))

hemicryptophytes, 10 chamaephytes and 4 therophytes. — Let us first consider the chamaephytes. They belong to two groups, cushion-plants and suffrutices. To the former belong only the two *Acantholimon*-species, of which one, *A. diapensioides* is a true cushion-plant, according to HAURI and SCHRÖTER's definiton of the term, that is to say, its shoots are so closely packed together, that light and air cannot penetrate between; the leaves are very small and stubby. *A. alatavicum* on the other hand is a "spherical bush", "Kugelkissen", far more open in its construction and with long (spinescent) leaves.

There are 6 suffrutices: *Chrysanthemum pamiricum, Po-*

lygonum paronychioides (?), *Eurotia ceratoides*, *Astragalus lasiosemius*, *Artemisia* (*herba alba?*) and *Arenaria Meyeri*. Of these *Polygonum* has short horizontal procumbent shoots, the

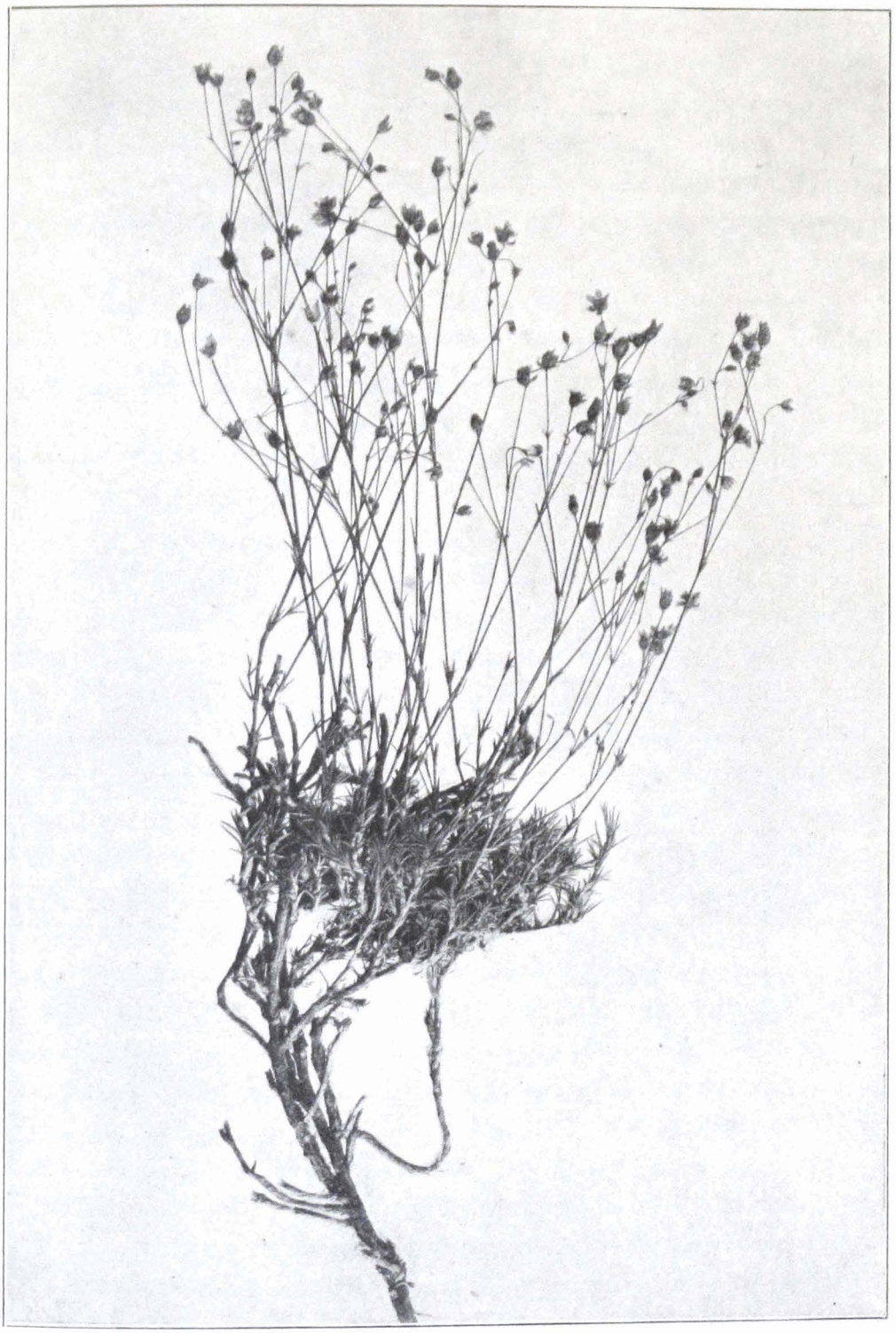


Fig. 24. *Arenaria Meyeri* Fzl. (ab. 1/3).

others have upright shoots, of which the lower parts are permanent. Especially characteristic are *Eurotia* with its broad flat stems, and the spinous *Astragalus lasiosemius*.

The 17 hemicryptophytes belong to two types, spot-bound species, and species having elongated, subterrannean rhizomes. To the latter type belong *Ephedra*, *Carex stenophylla* and *Elymus* (?). The 14 spot-bound species need no repetition here. *Stipa orientalis* is the only monocotyledonous plant among them, and, like most of the others, it forms large close tufts which are born by a huge main-root; radix multiceps. As seen by the figures, the tufts attain great size, and must be very old. Many of them become by degrees so compact and so tall that they approach cushion-plants in form. In the case of others the rhizomes gradually grow high above the ground so that the plants become indubitable chamaephytes. (*Macrotomia*). *Cousinia rava* and the two *Scorzonera* species are the only ones not forming large tufts.

There are only three Therophytes, as *Halogeton* is very rare and confined to single hollows. *Lappula* is, if I may use the expression, a tempered type, upright with rather large leaf-surfaces, while *Nepeta* and *Polygonum* are delicate small-leafed plants mostly found in favourable localities.

Based on the above we may characterize the vegetation of the plain as a richly developed vegetation consisting for the most part of spot-bound hemicryptophytes and chamaephytes, which often form very broad tufts. The plants have no great height as the flowers are usually 20—30 cm from the ground, single exceptions being $^1/_2$ mètre. Among the cespitose plants, the chamaephytes, though the number of the species is few, play a very important part. This is also true of the two species of cushion-plants. Hemicryptophytes with horizontal subterranean shoots are found sporadically. Therophytes are few and of no importance.

This vegetation, or one that is similar, is very common

throughout Pamir, especially in the broad flat valleys, called "Pamirs" in the narrow meaning of the term. It is here considered a special plant-formation, named after one of the most important species, Trigonella-formation.

In localities resembling the plain near Mardjanaj there is a vegetation, similar to that on the plain itself, and the same is the case on many slopes having an eastern exposure. Of these more will be told later. Let me here give two examples of Trigonella-formation on flat soil. On the top of the peninsula lying between the two eastern arms of Jashil Kul there is a horizontal flat or slightly rolling plateau, with many stones and occasional embedded boulders. A scattered vegetation of *Eurotia ceratoides*, *Kochia prostrata* (?) — in some places these two are the only species, — *Stipa orientalis*, *Acantholimon diapensioides* and *alatavicum*, *Ephedra*, *Oxytropis bella*, *Trigonella Emodi*, and *Silene caucasica* are growing on the fine, sandy, brown soil.

A little to the south, east of the outlet of Bulung Kul, on a plain sloping gently toward the north, grow many specimens of *Solenanthus stylosus*, *Oxytropis Poncinsii*, *Cousinia rava*, *Hedysarum cephalotes* besides the same species as are found on the plain near Mardjanaj, with the exception of *Astragalus lasiosemius* and *Alitschuri*.

Reference may also be made to the descriptions, given above, of the plains near Sary Mullah (page 34), Pamirski Post (page 35) and Shatyr Tash (page 36), where similar vegetation is to be found, composed in part of the same species, among which *Eurotia ceratoides* is always found. The plains near Kisil Kul and Kara Kul had a slightly different character; they were almost bare of plants, and those found were of other species. This difference is presumably due to the fact that the climate of northern Pamir is more severe than that of southern Pamir.

Sub-formations and Associations caused by moisture or exposure.

As mentioned before, the plain near Mardjanaj though slightly rolling is practically horizontal, and I have also stated that certain species seek out the depressions between

the mounds. These depressions naturally enough have a finer, more clayey bottom than the surrounding plain. This bottom is often cracked by drought, and sometimes a little salt may be found crystallized out. Most of the plant species, characteristic of the plain, shun these depressions, — however the following are to be found there: *Acantholimon diapensioides*, whose cushions are here often looser and more rounded than on sandy soil, *Solenanthus stylosus* and *Hedysarum cephalotes* of which there were many low, weakly developed specimens with small, scanty flowers. These species are found just as frequently between the depressions, as in them. On the other hand *Carex stenophylla* prefers the depressions, and *Arenaria Meyeri* (and the annual, *Halogeton glomeratus*, which was only found a single time), grows there exclusively. The case of *Arenaria* was very striking. It made a strong impression of not belonging to the Trigonella-formation, but of being fragments forced in from another plant-community. This other plant-community was found later, south of Jashil Kul, — the Arenaria-Meyeri-formation, covering the rather moist northern slopes of the mountains. The *Arenaria-Meyeri* depressions near Jashil Kul are, then, the forced in fragments of this. The vegetation of the plain cannot then then be rightly considered a single association of the Trigonella-formation, but as a "Complex of associations" (DU RIETZ, FRIES und TENGWALL).

The following may be said in regard to the importance of exposure for the vegetation of the Pamirs. On a gently sloping plain east of a low line of hills, and again east of Bulung Kul, I found *Cousinia rava* dominating, a beautiful luxuriant growth, and of other species: *Stipa orientalis*, *Chrysanthemum pamiricum*, *Trigonella Emodi*, *Hedysarum cephalotes* and *Linaria sp.* The latter were scarce. There was far more soil than plants to be seen.

Where this vegetation is to be found, the plain slopes toward E. S. E. Further south the declivity becomes sharper, and the exposure by degrees N. E. At the turning point, where the exposure changes from south to north, *Cousinia*, *Chrysanthemum* and their accompanying plants disappear almost wholly, and a new association of *Acantholimon diapensi-*

oides and *Artemisia* appear. A little further south *Acantholimon alatavicum* appears, *Stipa orientalis* diminishes in quantity and we find large numbers of *Oryzopsis molinioides*. There are single specimens of *Silene caucasica* and *Arenaria Meyeri*.

As the plain forms long flat billows, there is soon a stretch parallel to the first, and here again we find *Cousinia rava* and *Chrysanthemum pamiricum*, but at a new swell of the ground they have once more vanished. We now pass flat stretches with varying exposures and vegetations.

N. W. exposure: Scattered *Eurotia ceratoides*, a few *Acantholimon alatavicum*.

N. E. exposure (decline greater): many *Acantholimon alatavicum* and *Artemisia*, a few *Trigonella Emodi* and *Arenaria Meyeri*.

N. W. exposure: *Eurotia ceratoides*, *Cousinia rava*, *Acantholimon diapensioides* (only a few), *Stipa orientalis*, *Hedysarum cephalotes*.

S. W. exposure: *Cicer pungens*, *Cousinia rava*, *Eurotia ceratoides*.

Paying no attention to north and south, but grouping the species just mentioned by eastern and western exposures we find: western exposure, (the dryest localities), *Eurotia ceratoides*, *Cicer pungens;* both eastern and western exposures: both *Acantholimon* species, *Hedysarum cephalotes*, *Stipa orientalis* and *Cousinia rava;* eastern exposure alone, (the least dry localities); *Artemisia*, *Chrysanthemum pamiricum*, *Linaria*, *Trigonella Emodi*, *Oryzopsis molinioides*, *Silene caucasica*, *Arenaria Meyeri*. This grouping, in any case the first and last group, corresponds to my own observations of the species most resistant and least resistant to drought. The grouping seems to show how the species are assorted in the various associations. Under definite conditions, (horizontal plains), the species can grow in common, but they are divided into various associations as soon as they are subjected to even a slight degree more or less, of the warmth of the sun and attendant moisture. The differences discussed here are very small; — the slopes are so slight that one cannot feel them when walking. The adjustment between the varieties and their surrounding must be extraordinarily fine.

With what may the Trigonella-formation be most closely compared? In many places its physiognomy resembles a semi-desert, an Artemisia-desert, for instance, or one formed by suffrutescent *Salsola* species, (see PAULSEN, page 69); — and SCHIMPER, who, however, only knew the vegetation of Pamir from photographs (fig. 449—455 in his book), says, (page 792), that the flat valleys have the character of deserts, just as does FEDTSCHENKO, (see above, page 28). Compared with the Transcaspian deserts these differ physiognomically by containing the many large cushions of the two *Acantholimon*-species. Cushion-plants (*Anabasis aretioides*) are, though, to be found in the Sahara. Perhaps another difference is to be found in the fact that hemicryptophytes, and not chamaephytes, play the leading part, in any case in quantity of species, that thus woody shoots are less conspicuous here than in deserts. However this difference is not vital, as Transcaspia has a considerable quantity of xerophytic hemicryptophytes, even though their importance is less than in Pamir.

A third difference is that there are no vernal-flowering species here, while in low deserts the majority of the species flower in the spring; the lateness and coldness of the spring is the reason for this.

A fourth, and in my opinion conclusive difference, is the fact that the Trigonella-formation is poor in therophytes, annual species, while low-lying deserts are characterized just by the large numbers of therophytes found there. Salt-deserts are the single exception; this is due to a special edaphic cause, the soil's content of salt, while in Pamir the cause is doubtless climatic. WARMING, too, (1909, page 251), emphasizes this, and, quoting various authors, shows that the percentage of annuals diminishes with the increased altitude, (also with the geographical latitude), and remarks that the cause of this lies in the shortness of the vegetation-period, and the low temperature, only permitting a few annuals to complete their development and set ripe seed.

The small number of therophytes present is the main reason why the Trigonella-formation may not be considered a desert-formation. When f. inst. SEMENOW says the vegetation of Pamir has steppe-character, and WARMING (1909, page 260)

speaks of "mountain-steppe" or "alpine steppe" on the mountains of High Asia, as "a type of fell-field that approximates to steppe in many respects" he places the vegetation between fell-field and steppe, but gives it the latter name. What WARMING here calls "steppe", is, what I call[1]) semi-desert, and, as has been said before, if plant communities are to be

Table 3.

	Number of species	Percentage of species under each growth-form					
		F	Ch	H	G	HH	Th
East Greenland. Fell-field[1]	72		25	74	1		
Disco. Fell-field[2]	25		36	56	4		4
South-Greenland. Fell-field[3]	61		36	56	3		5
Iceland. Fell-field[4]	71		31	65	1		3
Bernina. "Schuttflur"[5] (ab. 3000 m.)	61		23	71	3		3
Trigonella-Formation	49		29	57	2		12
Transcaspian lowlands[6]	768	11	7	27	9	5	41

[1] N. HARTZ. [2] PORSILD. [3] ROSENVINGE. [4] JÓNSSON, STEFANSSON, OSTENFELD. [5] RÜBEL. [6] PAULSEN.

named according to their growth-forms, it is hardly permissible to give the Trigonella-formation the name of desert. However, as the most important forms are hemicryptophytes and chamaephytes, there seems to be nothing to prevent placing it under the category of fell-fields. In the Table 3 given here the biological spectrum[2]), (after RAUNKIAER), of the

[1]) See PAULSEN, 1912.

[2]) The species-list given above, for the Mardjanaj-plain, + following species from other similar localities: **Ch:** *Astragalus Muschketowii, Cicer pungens, Sympegma Regelii, Kochia prostrata* (?). **H:** *Psychrogeton turcestanicum, Arnebia guttata, Oxytropis tibetica* and *humifusa, Christolea crassifolia, Zygophyllum fabago, Poa attenuta, Hordeum secalinum, Sisymbrium Korolkowii, Crepis glauca, Calamagrostis compacta.* **G:** *Linaria sp.* **Th:** *Astragalus ophiocarpus, Veronica biloba.*

Trigonella-formation is seen, in the line before the last, and in the remaining lines the spectra, (arranged by me after the lists of the named authors), of various arctic and alpine fell-fields, and finally, (last of all), a desert spectrum. The fact might be emphasized that the fell-field spectrum may not specially express the vegetation natural to fell-field formations, but to that of arctic and alpine nature; for, as RAUNKIAER has shown, hemicryptophytes and chamaephytes dominate in just that nature, — the latter thriving the better the poorer the conditions, i. e. the greater the altitude, or the further north. However, this reservation in no way alters the main point that all the spectra given, agree in having a large percentage of hemicryptophytes and chamaephytes, and from this we may conclude that the spectrum both of the Trigonella-formation and of the others is an expression for alpine nature.

In other words the ability of the plants of Pamir to adapt themselves to their surroundings, in so far as this regards the relation of the surviving apices to the crust of the earth, is an adaptation to cold and snow, rather than to heat and drought.

A further comparison between the Trigonella-formation and fell-fields[1]) reveals the following similarities and differences.

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[1]) According to WARMING, 1909, the characteristic of fell-field is the fact that all vegetation is low, and that plants are so far separated from each other that the bare ground is visible between. In arctic fell-fields there are often many mosses and lichens which are either rare or totally wanting in alpine fields from lower latitudes. Fell-fields are to be found on almost all high mountains. "Warming's description of fell-field, (1909, page 256), might have been written on a New Zealand dry mountain". (SPEIGHT & COCKAYNE, 1911.) The conception fell-field includes many various formations, from the arctic fell-field, which is closely related to "Tundra", to the "Gesteinsfluren" of the Alps (SCHRÖTER) and the xerophytic vegetations in the mountains of Pamir, New Zealand, and many other places. They are all rich in chamaephytes, poor in therophytes, and wanting in fanerophytes, however different they may be in other respects. To give them the common name "fell-field", is at present just as permissible as to group many different formations under the term "forest".

1. The vegetation is scattered, does not cover the ground. I have an idea that it is less scattered in the Pamirs than in the fell-field of the Alps and Greenland, where the nudity of the ground is an important character-mark. The poverty of the soil in humus is characteristic for both.

2. An important difference is the fact that the arctic fell-fields are rich in lichens, while these are wanting in the Pamirs (and in the Alps).

3. Shoots are short, and the leaves therefore grow close to the ground, which WARMING, 1888, denotes as a characteristic of fell-field plants. Rosettes of leaves which are common in the Greenland fell-fields are more rare in Pamir (*Scorzonera, Astragalus Alitschuri, Oxytropis Poncinsii*), but the shoots are generally short, so that the leaves are as a rule close to the ground.

4. Cespitose growth, "radix multiceps" is common to both localities.

5. Cushion-plants are common, perhaps not in number of species, but in the number of individuals. (*Silene acaulis, Acantholimon diapensioides.*) These two species belong to the same group of cushion-plants (HAURI u. SCHRÖTER). *Silene*, just like *Acantholimon*, has adventitious roots on the under side of its branches.

6. In arctic fell-fields many procumbent small bushes are found, *Dryas, Arctostaphylos alpina, Cassiope, Rhododendron lapponicum, Salix herbacea*, and *Betula nana*. They are woody chamaephytes, with horizontal branches. There is only one representative for this type in "the Pamirs", *Polygonum paronychioides*, and it is far from attaining the same size and compactness as many of the arctic specimens do.

7. Species having subterranean runners are found in both places, even though their importance is small. *Carex stenophylla* and *Ephedra* in Pamir, *Carex rupestris, rigida* and others in Greenland are examples.

8. As far as I know, no synopsis of the adaptation of arctic fell-fields in respect to xerophytic structure exists. WARMING, KIHLMANN, WAGNER, BONNIER and others have published facta in regard, to the hairiness, leaf-structure etc., of arctic and alpine plants; and the biology of arctic plants

has formed the subject of a special series of articles published by WARMING under the common title "Biology of arctic plants". We see from these studies that arctic plants are generally low in growth, have small leaves which are often evergreen and in that case either leathery or thick and stiff, or hairy, or pinoid, juncoid or cupressoid, or convolute, and that the stomata are either submerged or concealed in some other way.

WARMING (1909, page 254) adds, however, "deciduous foliage shows this xerophytic structure to little or no extent". It seems to me, that in studying a list of fell-field plants, the one from East Greenland given by HARTZ for instance, many species are found, which, externally at all events, do not show xerophytic structure: *Chamaenerium latifolium*, *Pyrola grandiflora*, *Campanula rotundifolia*, *Erigeron*, *Arnica*, *Oxyria* and others, even though these plants hardly belong to the very typical fell-field plants.

However their xerophytic structure seems to me less definitely characterized than in the plants of the Pamirs, which have smaller leaves and are more hairy. There are probably no other evergreen plants among these than the two *Acantholimon* species and *Arenaria Meyeri*; the remainder, which either are, (or appear to be), deciduous, seem to have just as little xerophytic structure, — as what follows will show, — as the arctic deciduous plants.

In order to give as concrete an idea as possible of the xerophytic adaptation of species composing the Trigonella-formation, I have attempted to classify their leaves in the various groups shown below.

There are 11 Astragaleae, with small pinnate, always hairy, often sericeous leaves. 6 other species have pinnatifid or pinnate leaves. To these belong *Zygophyllum Fabago;* (a chance guest!), with smooth succulent leaves, *Trigonella Emodi* with smooth ternate leaves, and *Sisymbrium Korolkowii* with scattered hairy leaves of an almost mesophytic type. *Chrysanthemum pamiricum* and *Artemisia* are very hairy, *Cicer pungens* very glandular-hairy.

There are 7 species with small, (under 2 cm in length) undivided, hairy leaves, which are generally narrow. To

these belong *Eurotia ceratoides*, stellate-hairy, *Silene caucasica* and *Sympegma Regelii*.

There are, too, 7 grasses and cyperaceae, of which the majority have convolute leaves. Among these *Stipa orientalis* is the most important;

5 species with small, narrow, smooth leaves, to which belong the annuals *Veronica biloba* and *Nepeta daënensis*;

6 species with undivided, comparatively large leaves, in any case more than 2 cm long and not linear. The leaves are hairy, (*Solenanthus, Scorzonera*) with the exception of the glabrous *Serratula procumbens*.

There are 3 evergreen species with very small (0,x cm) or acicular leaves, the two *Acantholimon*-species, and *Arenaria-Meyeri*;

2 Polygonum-species with small leaves, for the most part hidden in the large ochreae;

1 hairy succulent, *Halogeton* (a chance guest!), and

1 leafless species, *Ephedra*.

We see from the above, first that the leaves are as a rule small; in the pinnate species the leaflets are small, their measurements are given above. The majority of the leaves are hairy, as a rule closely. Of glabrous-leafed species, not annuals, or having acicular leaves, there are only *Trigonella Emodi* which has movable leaflets, *Serratula procumbens*, whose leaves are sulcate, the *Polygonum*-species, whose leaves are concealed in ochreae, the augusti-foliate *Linaria sp.* and the succulent *Zygophyllum Fabago*.

In order to obtain an idea of the internal structure of the leaves of the plants of the Pamirs, I have dissected several leaves which were brought home in alcohol. They belonged to the following species: *Astragalus Alitschuri, Macrotomia euchromon, Silene caucasica, Acantholimon alatavicum, Oxytropis Poncinsii, O. bella, O. tibetica, Trigonella Emodi, Scorzonera mollis, Serratula procumbens, Sisymbrium Korolkowii, Solenanthus stylosus, Eurotia ceratoides, Arenaria Meyeri*, and *Acantholimon diapensioides*. Other species should have been examined but the necessary material was lacking.

The majority of the species examined, show in the main

the same structure. The leaves are isolateral, with 2—3 layers of palisade-cells on each side and a thin spongy parenchyma in the centre. In some cases there is a band of sclerenchyma over the nerves, but this is by no means always the case. The epidermis has never more than a single layer, is not thick, nor thick walled; there are always stomata on both leaf-surfaces, they are on a level with the epidermis except in the *Oxytropis*-species, where they are depressed to the inner line of the epidermis. *Oxytropis tibetica* has epidermis cells filled with mucus.

The following species have a deviating structure:

Sisymbrium Korolkowii's leaves are dorsiventral with 4 palisade-layers on the upper surface, loose spongy tissue, thin epidermis with stomata on both sides.

Trigonella Emodi has likewise a dorsiventral leaf, yet with palisades on both surfaces. The mesophyllum is loose on the whole; the cells of the epidermis are papillose-curved, very thin walled, and filled with mucus; there are bi-cellular glands and slightly depressed stomata on both sides.

Finally, the winter-green species, *Acantholimon alatavicum* and *diapensioides* and *Arenaria Meyeri* have acicular or scaly leaves with many sclerenchyma-bands and 2—3 layers of palisade-cells the entire way round. The epidermis consists of one layer with a thick outer wall and slightly or non-depressed stomata. In *Acantholimon diapensioides* the cells of the epidermis are papillosely protuberant, in *Arenaria* they have thick walls all the way round.

The leaf anatomy of the majority of the plants of Pamir agrees in the main points with that described by WAGNER and by BONNIER as typical for alpine plants. The great development of palisade-cells is especially striking, and one is apt to assume that the plants of Pamir, like the european alpine plants, are adapted to a powerful assimilation of carbonic acid (cf. BONNIER). In any case the majority of species of deciduous plants in the Pamirs seem to be in coincidence with their surroundings, when they have small, hairy, isolateral leaves with well-developed palisade tissue, thin epidermis and stomata on both sides.

We know from HEINRICHER that isolateral leaf-structure seems to be especially dependent on strong light, and according to BONNIER the characteristic features of alpine plants, — short, hairy stems, small, hairy and relatively thick leaves, well-developed palisade tissue and a large number of stomata — seem to be determined by strong light and dry air, as each of these factors alone can transform a lowland plant in such a way that it is able to assume these characteristics to a greater or lesser extent (A. LOTHELIER). Strong light has, though, a greater effect than dry air.

We may then explain the structure of the plants of the Pamirs as directly or indirectly dependent on the strong light and the dry air.

But even though the dryness of the air is one of the factors influencing the structure of the plants, the latter does not necessarily express a xerophytic adaptation. We know that the summers in Pamir are dry, and the plants must naturally be adapted to drought as well as to other conditions, — otherwise they could not live, — but we find only a few expressions of this adaptation to drought.

We can only point to the small size of the leaves and their almost unfailing hairiness as frequent xerophytic characteristics. The latter is especially striking and important, for both in the Alps, and in arctic fell-fields, many glabrous species are to be found, (the few indigenous to the Pamirs are named above), so that we here presumably have the expression of the growth-forms for the particularly dry climate of Pamir. Added to this is the structure of the evergreen species, which, as mentioned above, are of a different and far more xerophilous type than that of the deciduous plants. Aside from this the plants do not seem to be xerophytically constructed, but both in regard to hibernation, and to the structure of the shoots and to the anatomy of the leaves, to agree in the main with alpine fell-field plants. The arctic species have as a rule, as shown by BÖRGESEN and by BONNIER, weakly developed palisade tissue in the leaves, and in this respect differ from the alpine species.

The supposition emphasized above that the Trigonella-formation is rather to be considered a fell-field than a desert

form, is strengthened by the fact that the species in their outer and inner structure agree most closely with alpine plants, in other words they are more strongly influenced by the altitude above sea-level, than by the dryness of the climate.

CHAPTER 7

The Vegetation of the Mountain-Slopes.

(Eurotia-formation, Arenaria Meyeri-formation, and Poa attenuta-formation.)

In writing of the vegetation (Trigonella-formation) of horizontal flats, attention was called to the fact that other plant species than those of the flats are to be found in depressions, even though these are quite small and shallow. *Arenaria Meyeri* is characteristic of such depressions and is only found there (on flats). An example was given of the vegetation on a flat, mainly horizontal, yet slightly billowed, and we found that the species change according to the different exposures, even though the angle of declivity is extremely small. (Above, page 66.) Thus the adaptability of the plants on flats to the conditions of moisture or of exposure is very great. Exposure should presumably merely be considered as another expression for conditions of moisture, in that it determines the angle at which the sun's rays strike the surface of the ground during the different hours of the day, and the length of the period during which the locality is sunny.

Climbing a mountain in Pamir and going down on the other side, very soon reveals to one the enormous importance of exposure, and one quickly realizes that exposure is, in general, the determining factor for plant growth on a mountain slope. Roughly speaking, a northern and eastern exposure are favourable, a southern and western unfavourable for the appearance of a luxuriant vegetation rich in species; plants on a southern and western exposure are xerophytic, while those on an eastern, and especially a northern exposure are more or less mesophytic.

Exposure, while paramount in importance, is not the only factor to be considered. The nature of the soil plays a part, and is of particular importance when the slopes are covered by talus, — masses of great stones or boulders hurled down the mountain-side, — for these cover the surface of the ground and protect is against the rays of the sun, and it is safe to surmise that much moisture is to be found beneath them. The unusual vegetation characteristic of such places indicates the same. (More of this matter below page 93.) The talus of small stones or gravel, which I have seen in a few places, were either nearly or totally barren, probably because the bottom is constantly changing: the continual great variations in temperature bring about a rapid denudation, followed by a constant supply of new gravel and small stones rolled down from above. On account of the fineness of the material the masses are easily set in motion. In Switzerland such localities have their "Schluttpflanzen", as we know from SCHRÖTER and others.

The importance of exposures may be seen at a distance. On account of the vegetation the bottom of the dry stream clefts appear like dark lines (see fig. 7) on the mountain-sides. On looking more closely, but still a good way off, we see that on a slope with an eastern or western exposure, the dark line of vegetation lies south of the bottom of the cleft and along the southern shore of the bed of the stream; i. e. on the side with a northern exposure, — and, on approaching more closely, we find that not only the bottom of the cleft but the slopes as well have a different vegetation on the north and south side; everywhere the localities with a northern exposure have more luxuriant plant growth, than those exposed to the south. A few examples illustrating this are given below.

Going north on the Mardjanaj-plain, described earlier, along the Mardjanaj River, one finds many larger and smaller clefts cut by small streams now dry, and leading into the river; their main direction is east-west.

The slope toward the north of one of these, was closely grown with *Artemisia sp.*, *Solenanthus stylosus*, *Trigonella Emodi*, *Carex stenophylla*, *Oryzopsis molinioides*, as well as a few spe-

cimens of *Acantholimon diapensioides*, *Hedysarum cephalotes* and *Eurotia ceratoides*. The slope exposed to the south was almost bare; there were only a few scattered specimens of *Eurotia* and *Ephedra Fedtschenkoi*, a very few of *Trigonella*, *Stipa orientalis*, and *Serratula procumbens*. Of these few species, *Ephedra*, *Stipa*, and *Serratula* were lacking on the slope exposed to the north.

Only the lower part of the slope toward the south was more densely covered with species from the other side. In the bottom of the cleft the species from the slope exposed to the north were growing as well as *Arenaria Meyeri*, which was only found here.

Another parallel cleft revealed similar conditions. The slope toward the north has a fine cespitose growth with yellow and red flowers; here were quantities of *Hedysarum cephalotes*, *Trigonella Emodi*, *Oryzopsis molinioides*, *Agropyrum longearistatum*, *Eurotia*, *Solenanthus stylosus*, and further down *Artemisia*. The slope toward the south is rather bare, at the upper part we found only *Eurotia* and *Ephedra*, lower down, in addition to these two, *Stipa orientalis*, *Artemisia sp.*, *Astragalus dolichopodus*, and *Nepeta daënensis*. The bottom of the cleft was broad and flat in some places and has the same vegetation as on the plain above.

The species included in these examples nearly all grow on the above-named plain, but they are distributed in another way, and in the clefts reveal their varying grades of hardiness to drought, *Eurotia*, *Ephedra*, and *Stipa* are the most hardy, *Arenaria Meyeri* the least.

Eurotia and *Stipa* are the chief plants in what I propose calling the Eurotia-formation, which is widely found in Pamir on all mountain slopes with a southern exposure. Although all its species are to be found in the Trigonella-formation, yet the selection is so restricted and so characteristic that it seems to deserve consideration as a separate formation. This will be discussed further, later on.

The most hardy species named occur again and again on the arid slopes exposed to the south or west. Often in such places *Eurotia* is the only plant-species found, and it has a scattered growth. *Stipa* is likewise common, *Cicer*

pungens, a spinous, largely cespitose plant, or *Christolea crassifolia* more rare.

These hardy species, particularly *Eurotia* and *Stipa* are also common on slopes with a western exposure, which, presumably on account of the prevalent western winds, (see OLUFSEN, Met. Obs.), are almost as barren and dry as the slopes exposed to the north. The following is an example illustrating the difference between slopes with an eastern and a western exposure. In a cleft lying N. S. there is a green slope on the western side having an eastern exposure. Here we find *Nepeta podostachya*, *Acantholimon alatavicum*, *Artemisia* (*maritima aff.*), *A. pamirica* and many large tufts of *Arenaria Meyeri*. The slope with a western exposure, however, is bare with green patches formed by *Eurotia*, *Trigonella Emodi* and a few *Cicer pungens*.

On slopes with a northern exposure many different species are to be found, and not always the same. Below are examples taken from different places in Pamir.

1. Plentiful growth of *Chrysanthemum pamiricum* with *Cousinia rava* and large tufts of *Macrotomia euchromon*.

2. A rather steep slope, green in patches, with *Poa attenuata var. versicolor*, in other places covered with many *Eurotia ceratoides*, which do not here shun advantageous localities.

3. A slope with a north-eastern exposure, almost green. There were many large cushions of *Acantholimon diapensioides* and besides *Artemisia herba alba*, *Poa attenuata var. versicolor*, *Solenanthus stylosus*, *Trigonella Emodi*, and *Paracaryum himalayense* (?).

4. South of Jashil Kul. There is an astonishing change when, leaving the gray parched slopes of the north shore, poor in plant growth as they are, one crosses over to the southern shore. Here the slope is quite green, I might say grassy, extending down to the lake (A "Li" in Danish). The soil is the usual rather fine sand, often cracked or lumpy with many pebbles. On the surface were many large disintegrating crumbling boulders. A large, much ramified dwarf-bush, *Ephedra*, (*E. nebrodensis*), is common, and *Arenaria Meyeri*, which on the north side creeps into hollows,

covers the ground here in many places with its fine fresh green acicular foliage and its many white flowers whose odour is plainly detected. There is a profusion of *Astragalus alatavicus*, multipinnate and green-leafed and mostly without blossoms. *Astragalus Alitshuri*, *Stipa orientalis*, *Psychrogeton turcestanicum*, *Trachydium sp.* are common species, and *Festuca ovina var. valesiaca*, *Parrya nudicaulis*, (long vines hanging down a steep slope), *Nepeta kokanica*, *Macrotomia euchromon*, *Cousinia rava*, *Crepis flexuosa*, *Kochia prostrata*, (in places very abundant.), *Artemisia* (*maritima aff.*) *Veronica Hjuleri*, *Sisymbrium heteromallum*, *Bromus crinitus*, *Ligusticum alpinum*, *Geranium collinum*, are likewise found. *Eurotia* is scarce, but on a few slopes exposed to the west or south, that and *Stipa orientalis* are the only plants found. *Acantholimon diapensioides*, one of the most common of the plants of Pamir, is lacking here, but the spinous *A. alatavicum* is common. The lovely red-flowered *Pedicularis pulchra* grows in small, dampish depressions.

Of the last four examples named, — to which many others could have been added, — the first three show a striking resemblance to the vegetation on the horizontal flats, (Trigonella-formation); their species are almost all indigenous to these, which is likewise true of the species characteristic for slopes with a southern exposure.

The last named species, and especially *Eurotia ceratoides*, are characteristic both for the short slopes of clefts and similar places, and for the long mountain declivities exposed to the south, which the strong insolation quickly rids of the dampness coming down from the summits of the mountains.

This is not the case with the species, which from horizontal flats creep up the slopes with a northern exposure, and to which reference was made above. These species seem to be the characteristic for the short slopes of clefts etc. or for the base of the mountains, whereas, on the long main slopes of the mountains exposed to the north, which are shady and watered from above, they resign in favour of communities of other mesophytic plants, (Poa attenuata-formation).

The last of the examples given (4), the one from the

southern shore of Jashil Kul belongs to the first category. The vegetation is mostly composed of the species of the Trigonella-formation, very luxuriantly developed. However there are some species, not seen in "the Pamirs", which belong to a more mesophytic type than these plants. *Ephedra nebrodensis, Astragalus alatavicus, Trachydium sp., Festuca ovina var. valesiaca, Parrya nudicaulis, Pedicularis pulchra* are species showing that this slope is more moist than the others mentioned above. This slope was indeed the end of the main slope of the mountain, exposed to the north; and many rushing torrents indicated how much water came from the summit.

The vegetation south of Jashil Kul forms a transition between the Trigonella-formation, and the mesophytic formation on the mountain-slopes exposed to the north. Yet, differing from them both in the combination of species and conditions of adaptability, it seems to claim consideration as a special formation, with a name borrowed from the dominating species, — Arenaria Meyeri-formation. A typical development of this was seen nowhere else.

I have seen the mesophytic vegetation of mountain slopes, or the Poa attenuata-formation especially well developed in three places in Pamir, — on the two mountains lying east and west of the lower course of the Mardjanaj, (on OLUFSEN'S map in "Geografisk Tidsskrift", the western peak is called "Hens"), and in the Chargush Pass.

The finest development of Poa attenuata-formation was on the north-eastern and northern side of Mt. Hens. Before describing it, I will for the purposes of comparison relate a few facts concerning the vegetation of the adjacent slopes. On the south-western slope, on the ridges between ravines, the usual poor *Eurotia* vegetation, with *Stipa, Cicer pungens, Acantholimon alatavicum, Silene caucasica* and *Astragalus lasiosemius,* was found. In the clefts, which are green, *Arenaria Meyeri, Oryzopsis molinioides* and *Hedysarum cephalotes* dominate. Near the summit the last mentioned species becomes common, and many *Elymus lanatus var. canus* and *Senecio Paulsenii* appear.

Seen from a distance the eastern slope looks green, but

on approaching it, the ground becomes visible between the tufts, which are formed of *Artemisia aff. maritima*, *Trigonella Emodi* *Acantholimon alatavicum*, *Astragalus lasiosemius*, *Stipa*

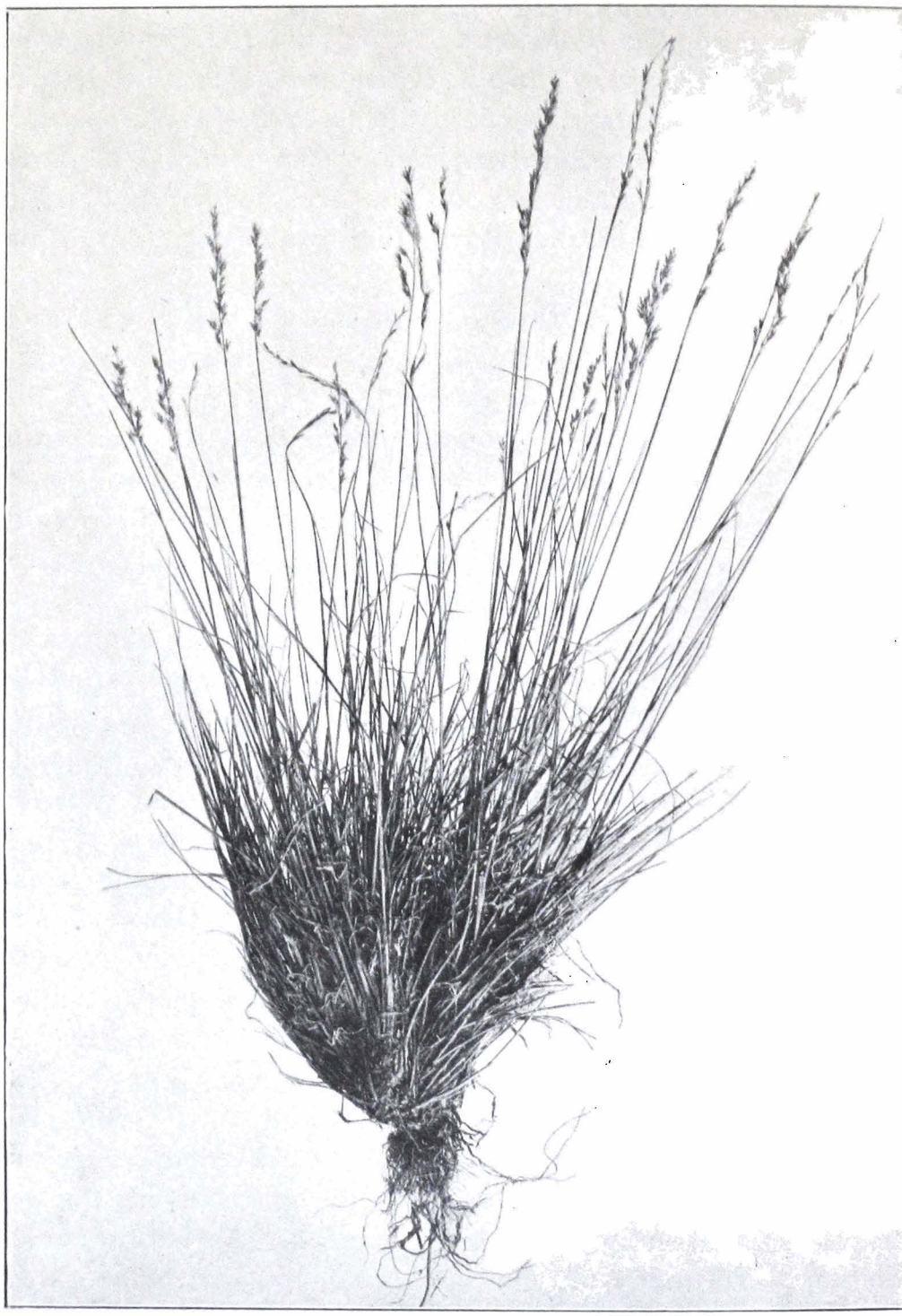


Fig. 25. *Poa attenuata* Trin. (ab. 1/2)

orientalis and *Astragalus Alitschuri*, and in clefts and hollows *Arenaria Meyeri*, — on the whole a less xerophytic vegetation than on the slope with a S.W.-exposure, and corresponding to the Trigonella-formation. The large clefts open to the east bear on the slopes exposed to the north-east an entirely different and totally mesophytic vegetation, in some places dense in others somewhat marshy, growing on moist soil rich in humus. Here we find the Poa attenuata-formation in an association comprising *Carex macrogyna* and *Kobresia schoenoides*, *Gypsophila cephalotes*, *Geranium collinum var. saxatile*, *Myosotis silvatica*, *Primula nivalis*, with beautiful, large, purple blossoms, the white-flowering bulbous plant *Lloydia serotina*, in large quantities, succulent Ranunculi, (*R. rufosepalus* and *rubrocalyx*), *Saxifraga cernua* and *flagellaris*, *Cerastium trigynum var. glandulosum*, *Leontopodium alpinum*, *Sedum gelidum*, *Swertia sp.* Not a single one of these species belongs to the Trigonella-formation.

On the north slope of the mountain a similar vegetation is found on similar soil. In a single locality were included: *Astragalus alatavicus* (mentioned above from the south side of Jashil Kul), *Draba turcestanica*, *Pedicularis dubia*, *P. pulchra*, *P. sp.*, *Isopyrum anemonoides*, a tiny, fine-leafed ranunculacea with white blossoms, *Gypsophila cephalotes*, *Dracocephalum discolor*, and *Nepeta kokanica*, gray-leafed, aromatic labiates with blue flowers, *Artemisia minor*, *Oryzopsis purpurascens*, *Poa attenuata*, *Elymus lanatus*, for the most part without blossoms, *Acantholimon alatavicum*, *Hedysarum cephalotes* and a few barren cushions of mosses. These last named species do not seem to rightly belong in this plant community, and the same is true of *Nepeta* and *Dracocephalum*, which appear to represent another and more xerophytic type, than *Pedicularis* and the others with which, however, they always appear. I have made no notes on this.

On another part of the north slope the vegetation grew in vertical stripes of various combinations. The most xerophytic were represented by low ridges, with a somewhat western exposure, on which *Eurotia ceratoides* was scattered. The slope was dry, and at a depth of 12—14 cm the soil was a little moist. The intervening degree of moisture was

represented by stripes in which *Nepeta kokanica*, and two grasses, *Bromus Paulsenii*, and *Poa attenuata var. versicolor* dominated. Besides these, *Acantholimon alatavicum*, *Psychrogeton turcestanicum*, *Arenaria Meyeri* and *Artemisia minor* were seen. These plants, forming a rather mesophytic community, yet with xerophytic traces, (*Acantholimon*, *Nepeta*), grow on stony brown soil rich in humus, which at a depth of 10—30 cm is dark with moisture. I consider it an association of the Poa attenuata-formation.

The third kind of stripe (another association of Poa attenuata-formation), is the most luxuriant, and the soil is dark with moisture a few centimètres below the surface. The vegetation is green and dense and formed by *Geranium collinum*, *Cerastium trigynum*, *Swertia marginata*, a white-flowering Gentianacea, *Pedicularis*, *Kobresia schoenoides*, *Isopyrum anemonoides*, and *Nepeta kokanica*.

These vertical stripes alternate with each other many times; *Eurotia*-stripes are always on the dry ridges, and *Geranium*-stripes in the flat furrows. In one of these was a spring now dry. Water wearing down through a subterranean $^1/_2$ mètre thick layer of stones about as large as one's fist, had washed away the plant-bearing layer of soil (about 30 cm thick) lying on top, and then continued its course carrying stones, plants and soil in its way. At the mouth of the spring there was a hollow in the mountain-side about 7 mètres broad with a perpendicular wall about 1 mètre high. The soil strata were visible in this wall. Highest up the brown soil in which plants grow, then a layer of stones, from which most of the soil was washed out, and where there were many fine well-rinsed roots, and lowest a very moist, soft, brown layer of soil. This profile is interesting, showing that the mesophytic vegetation is apparently due to the stony layer containing water close below the surface of the ground. The moist soil, rich in humus, above the stones seemed to contain much nourishment.

This vegetation, somewhat dense and surprisingly abundant in a country like Pamir, must then be due to glacial water, which from above oozes through the layer of stones and is

here protected from evaporation by the overlying stratum of soil and the vegetation.

On the mountain lying east of Mardjanaj a similar condition to that on Mt. Hens was found. The vegetation on the north slope was rather dense, in some places close, and comprised *Dracocephalum discolor*, *Nepeta kokanica*, *Oryzopzis purpurascens*, *Draba turcestanica*, *D. fladnizensis aff.*, *Astragalus alatavicus*, *Isopyrum anemonoides*, *Potentilla sericea*, *Oxytropis immersa*, *Psychrogeton turcestanicum*, *Elymus sibiricus*, *Chrysanthemum Richteria*, *Gagea stipitata*, *Festuca ovina var. valesiaca*, *Poa attenuata*, *Artemisia macrocephala*, *Hedysarum cephalotes*, and *Sedum Rhodiola*. Of these species only *Psychrogeton* and *Hedysarum* grew on the south side of the mountain too; they are moreover to be found in "the Pamirs" (the flats). This north-side vegetation does not cover the entire north side of the mountain, but apparently only those places where the exposure is somewhat eastern. — Only here are marmots found, which was likewise the case on the mountain described above. There were also places with a slight western exposure and which were covered with Eurotia-formation *(Eurotia* and *Stipa orientalis)*.

On the summit of the mountain, about 4,300 mètres above sea-level, in the pass between too peaks lying east and west of each other, the following characteristic plants were gathered.

On the south side of the pass, widely separated, *Hedysarum cephalotes* and *Oxytropis Poncinsii*.

On the north side, *Sedum Rhodiola*, *Nepeta kokanica*, *Draba fladnizensis aff.*, *Hedysarum cephalotes*, grasses and single specimens of *Solenanthus stylosus*, forming a luxuriant if not close vegetation.

Under the boulders lying on the summit of the mountain, large tufts of the interesting cruciferous *Didymophysa Fedtschenkoana*, with fresh, succulent leaves, small white flowers, and puffy bladder-shaped fruits were growing. *Smelowskia annua* was likewise found here.

For the sake of comparison with the vegetation of the northern slopes, lists of plants from the eastern and southern

slopes are given. Trigonella-formation dominated on the eastern slope. Here *Stipa orientalis, Eurotia, Astragalus lasiosemius, Artemisia aff. maritima, Acantholimon alatavicum, Polygonum paronychioides, Chrysanthemum pamiricum* were common; *Trigonella Emodi, Cicer pungens, Crepis flexuosa* more rare, while *Arenaria Meyeri* was to be found in clefts. These plants formed a very dense vegetation, from a distance lending a greenish hue to the mountain-side.

On the southern slope the following species were noted: *Stipa orientalis, Hedysarum cephalotes, Lappula microcarpa* (very scattered), and *Psychrogeton turcestanicum.* The plants were so far apart that from a distance the slope looked quite brown.

We see, then, that the vegetation on both the eastern and southern slopes is formed by the species of the Trigonella-formation, while on the northern slopes these were almost totally wanting.

West of the Chargush Pass (height of the pass, about 4,200 mètres), two totally green slopes with a northern exposure were examined. They were both bounded on the south by steep talus slopes, under whose stones, the water poured down from the mountain tops. From the talus it sifts in under the green slopes, presumably flowing under the ground through a layer of stones as described above. The soil is humous, almost black, and moist a few centimètres under the surface. I did not see the substratum of stones, but its presence must be inferred from the fact that not a particle of water flows on the surface of the slopes. On these was a close vegetation of the following species: *Ranunculus sp., Cerastium trigynum, Saxifraga hirculus, Swertia marginata, Primula nivalis var. macrocarpa, Carex sp., Aster flaccidus (= tibeticus), Delphinium cachemirianum, Lagotis borealis, Parnassia subacaulis, Myosotis silvatica, Isopyrum anemonoides, Papaver radicatum, Gentiana falcata, Hymenolaena Lindleyana var. bucharica, Melandrium triste, Draba alpina* and *media, Astragalus tianschanicus var. pamiricus, Poa persica var. alpina, P.*

attenuata var. versicolor, Tragopogon parvifolium, Calamagrostis anthoxanthoides, Bromus erectus f.

As on the northern slopes near Jashil Kul, described earlier, this is a close or nearly close vegetation composed almost entirely of hemicryptophytes. The remaining plants are a few therophytes, chamaephytes and a geophyte (*Gagea*).

As a main result of the above descriptions we may conclude that mountain slopes of Pamir with a northern exposure have a vegetation more os less dense, often close, formed of mesophytically adapted species, while the slopes with a southern exposure have an open, poor vegetation of xerophytes. To obtain a synopsis of the ecology of these vegetations, lists are given of the species on slopes with a northern and southern exposure and information of their biological types (growth-forms), — just as was done in the case of the horizontal flats.

List of plants growing on slopes with northern or northeastern exposure (Poa attenuata-Formation).

Cyperaceae.

Carex macrogyna H
— sp. H
Kobresia schoenoides H

Gramineae.

Agropyrum longearistatum H
Bromus erectus H
— Paulsenii H
Calamagrostis anthoxanthoides H
Elymus lanatus H
— sibiricus H
Festuca ovina H
Oryzopsis purpurascens H
Poa attenuata H
— persica H

Liliaceae.

Gagea stipitata G
Lloydia serotina G

Borraginaceae.

Myosotis silvatica H
Paracaryum himalayense H

Caryophyllaceae.

Arenaria Meyeri Ch

Cerastium trigynum H
Gypsophila cephalotes H
Melandrium triste H

Compositae.

Artemisia macrocephala Th
— minor H
— rupestris Ch
Aster flaccidus H
Chrysanthemum Richteria H
Leontodon alpinus H
Psychrogeton turcestanicum H
Senecio Paulsenii H
Tragopogon parvifolium H

Crassulaceae.

Sedum gelidum H
— Rhodiola H

Cruciferae.

Draba alpina H
— fladnizensis Ch
— media Th
— turcestanica Ch

Gentianaceae.

Gentiana falcata H
Swertia marginata H

Geraniaceae.

Geranium collinum H

Labiatae.

Dracocephalum discolor H
Nepeta kokanica H

Papaveraceae.

Papaver radicatum H

Papilionaceae.

Astragalus alatavicus H
— nivalis Ch
— tianschanicus H
Hedysarum cephalotes H
Oxytropis immersa H

Plumbaginaceae.

Acantholimon alatavicum Ch

Primulaceae.

Primula nivalis H

Ranuculaceae.

Delphinium cachemirianum H
Ranunculus rubrocalyx H
— rufosepalus H
— sp. H?
Isopyrum anemonoides H

Rosaceae.

Potentilla sericea H

Saxifragaceae.

Parnassia subacaulis H
Saxifraga cernua H
— flagellaris Ch
— hirculus H

Scrophulariaceae.

Pedicularis dubia H
— pulchra H
— sp. H

Selaginaceae.

Lagotis borealis H

Umbelliferae.

Hymenolaena Lindleyana H
Trachydium sp. H

Of these 65 species 54 are hemicryptophytes (H), 7 chamaephytes (Ch), 2 geophytes (G), and 2 therophytes (Th). The percentages are given in table 4. Compared with the plants of "the Pamirs" those of the northern slopes show a greater preponderance of hemicryptophytes and much fewer chamaephytes (11 % compared with 29 %).

List of plants growing on slopes with southern or southeastern exposure (Eurotia Formation).

Gnetaceae.

Ephedra Fedtschenkoi H

Gramineae.

Elymus sp. H
Stipa orientalis H

Borraginaceae.

Lappula microcarpa H

Chenopodiaceae.

Eurotia ceratoides Ch.

Compositae.

Artemisia maritima aff. Ch
Chrysanthemum pamiricum Ch
Crepis flexuosa H
Psychrogeton turcestanicum H
Serratula procumbens H

Cruciferae.

Sisymbrium brassiciforme Th

Papilionaceae.

Astragalus dolichopodus H
— lasiosemius Ch
Cicer pungens H
Hedysarum cephalotes H
Oxytropis Poncinsii Ch
Trigonella Emodi H

Plumbaginaceae.

Acantholimon alatavicum Ch

Polygonaceae.

Polygonum paronychioides Ch

Table 4.

	Number of species	Percentage of species under each growth-form			
		Ch	H	G	Th
Northern exposure (Poa att. Formation)	65	11	83	3	3
Horizontal (Trigonella Format.).....	49	29	57	2	12
Southern Exposure (Eurotia Format.)	19	37	58		5

Of the 19 species listed, 11 are hemicryptophytes, 7 chamaephytes and 1 therophyte. The percentages are given in table 4.

Leaving out of consideration the one therophyte, (*Sisymbrium brassiforme*) which was found only a single time, and is not characteristic for these localities, this last spectrum is remarkable for the number of chamaephytes it contains, even more than in the horizontal flats of "the Pamirs".

From the above we see, first that exposure influences the number of the species. This is greatest on slopes with a northern exposure, (65), smaller on horizontal flats, (49) and smallest on slopes with a southern exposure (19). That is to say, that under increasing insolation and resulting drought, fewer and fewer species can exist. We may expect, then, to find xerophytic adaptation least developed on the slopes with northern exposure, and best developed on those with southern exposure.

Next, in regard to the growth-forms, I regret that I have not been able on the spot to make a formation-statistical examination with a computation of the valence of the species. (compare RAUNKIAER.) Instead I must repeat what was stated above, namely, that *Eurotia ceratoides* is by far the most common species to be found on slopes with a southern exposure, and *Stipa orientalis* next. In many instances these two are the only species to be found. If we consider them equally common, we obtain (as valence of growth-form) 50 % chamaephytes and 50 % hemicryptophytes. As a matter of a fact *Eurotia* should have a higher number than *Stipa*.

On slopes with a northern exposure the most common species are hemicryptophytes: *Poa*, *Kobresia*, *Astragalus alatavicus*, *Oryzopsis*, *Isopyrum* etc. *Arenaria Meyeri* is however a chamaephyte.

Table 4 shows that when all species are considered equally common the number of chamaephytes increases with the amount of insolation, but according to what I have just stated, if the species, and thereby the growth-forms, had frequency-valences, the figures would show still greater differences.

In any case, according to the above, we may consider it

a fact that in Pamir the localities with a southern exposure, (the driest), have the greatest number of chamaephytes, those with a northern exposure the smallest number; while horizontal flats lie between the two, both in regard to insolation and to number of chamaephytes.

How the species on the southern slopes adapt themselves in other respects to their surroundings, may be judged by comparing them with the flats described above. The species on slopes with a southern exposure are no other than a selection of the species growing on the flat "Pamirs", a selection made by nature herself. If we try to catalogue them according to leaves and covering, as was done with the plants of the flats, we find among these plants growing on slopes with a southern exposure, 5 pinnate Astragaleae as compared with 11 on the flats, — 3 other species with pinnate or pinnatifid leaves, as compared with 6 on the flats, — 3 species with undivided small, hairy leaves, as compared with 7, — 2 Gramineae and Cyperaceae, as compared with 7, — 2 species with small, narrow, glabrous leaves, as compared with 5, — 1 species with large entire, glabrous leaves, as compared with 6, — 1 evergreen as compared with 3, — 1 Polygonacea as compared with 2, — and 1 leafless Ephedra as compared with 1.

The reduction has, as we see, especially hit the groups Gramineae + Cyperaceae, and the two groups with entire and glabrous leaves. These 3 groups contain, I suppose, the least xerophytic plants. The plants on southern exposures in the remaining larger groups number about the half or a little less, of the species of the same groups on the flats, corresponding to some extent to the total number of species in the two localities: 19—49.

That the least xerophytic species of the flats are preferably the ones wanting on the southern slopes confirms that the former are drier than the latter.

The plants on slopes with a northern exposure do not, as so often stated, belong to the xerophytic type. A glance at the list, page 87, will confirm the impression that the species are, on the average, mesophytic in their structure. Only a few species (*Psychrogeton*, *Hedysarum*, *Acantholimon*) are found again on the slopes with a southern exposure, and

with these are a very few, especially *Dracocephalum* and *Nepeta* which, on account of their xerophytic character (small, hairy leaves) seem strangers to the plant community in which they are found.

Among mesophytic traits we may mention that the grasses, except *Festuca ovina* and *Poa attenuata*, are broad-leafed, as are Liliaceae, that there are many glabrous species, (*Gypsophila*, *Melandrium*, *Senecio*, *Gentiana*, *Swertia*, *Geranium*, *Primula*, *Ranunculus*, *Parnassia*, *Saxifraga*, *Pedicularis*, *Lagotis*, *Hymenolaena*; *Trachydium*) and that these species have also brittle leaves, — that is to say the mechanical tissue is slightly developed. More or less hairy species are also found: *Myosotis*, *Paracargum*, *Artemisia*, *Chrysanthemum*, *Leontodon*, *Draba*, *Dracocephalum*, *Nepeta*, *Papaver*, *Astragalus*, and *Potentilla* belong here, but these can not be called xerophytic. *Papaver radicatum* and *Myosotis silvatica* are mesophytically adapted; the same is perhaps true of the others. Cyperaceae and the bulbiferous Liliaceae, of which there are respectively 3 and 2 species, are not usually found in very dry localities. This is likewise the case with species with horizontal and rootstriking shoots of which *Leontodon*, *Draba fladnizensis* and *turcestanica*, as well as *Saxifraga flagellaris*, were found on slopes with a northern exposure. Only the few species mentioned above, which are also found on slopes with a southern exposure, and perhaps to some extent *Arenaria Meyeri* can be called xerophytes.

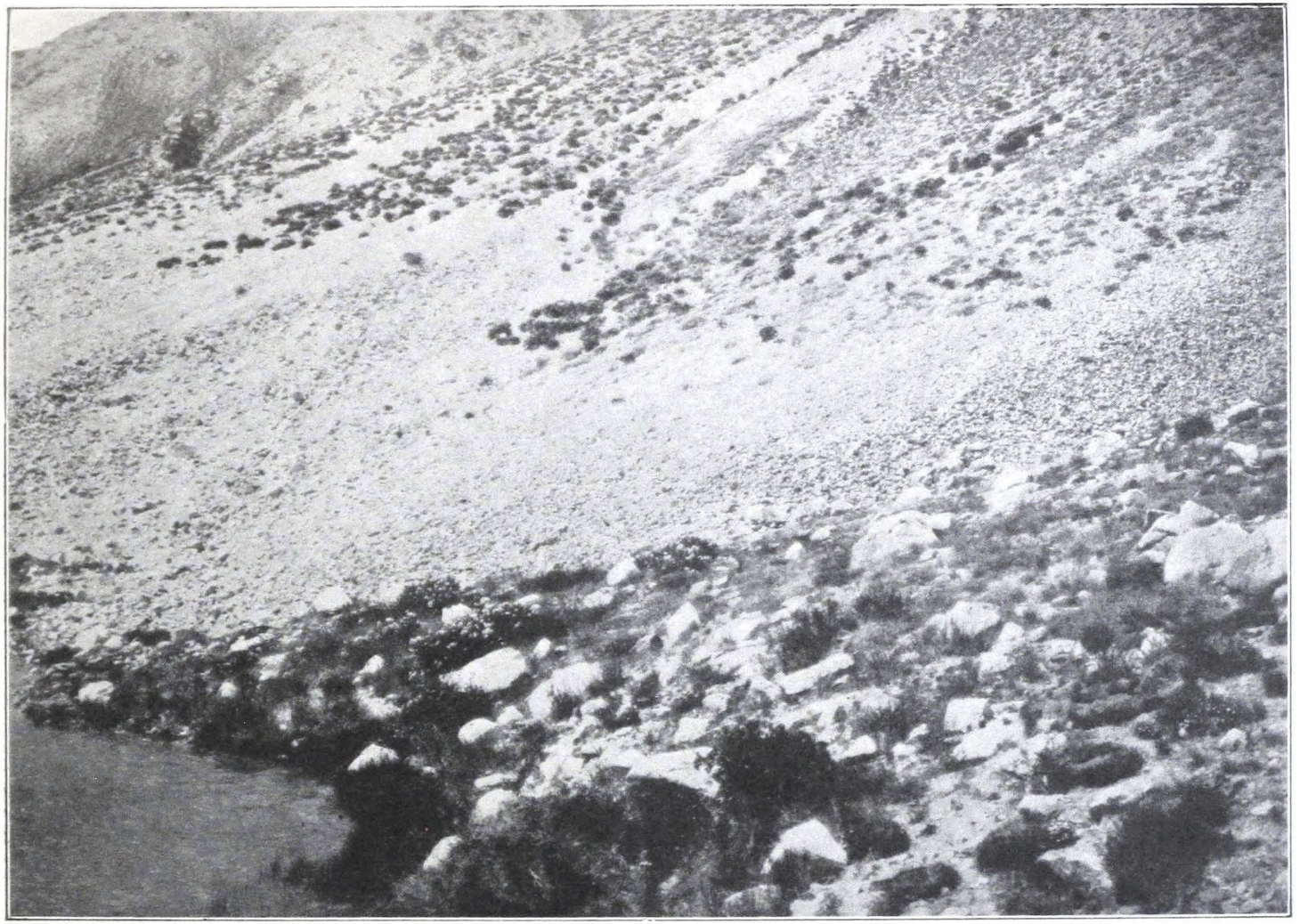
On the whole, one may be justified in calling the vegetation on the slopes with a northern exposure, mesophytic, and, as a comparison with what is to follow will show, this vegetation is most closely related to the vegetation of the river-banks.

The Formation on the Talus Slopes.

As was stated on page 77 talus with large stones reveal other conditions than those usually found on mountain-sides. The great stones and boulders cover protectingly the finer soil beneath, so that even on slopes exposed to the south it does not dry totally out. The vegetation is influenced by this condition, as will be shown in the following.

The western part of the northern shore of Jashil Kul is formed, as described on page 40, by a talus slope stretching, from the almost perpendicular wall of the mountain, straight down to the lake. This slope is continued along the west shore as well.

In many places the talus of the north shore is totally without plant life; seen from a distance no green is visible, only gray-brown stones. Even in the most fertile spots there is a distance of at least a mètre, and some time many mètres, between each plant. The common species are: *Eurotia ceratoides, Cicer pungens, Lagochilus diacanthophyllus, Ligusticum alpinum, Nepeta podostachys, Elymus lanatus var. canus, Artemisia maritima aff., Astragalus lasiosemius,* huge cushions of *Acantholimon alatavicum, Zozimia tragioides, Rubia tibetica, Heracleum Olgae var. virens.* The latter is very noticeable, even though most of the specimens have only rosettes of leaves. The leaves are green and about ½ mètre long; yet high inflorescences both green and dry are to be seen also in quantities. We found too, *Erigeron acer var. droebachensis, Sisymbrium Sophia var. nana, Astragalus tibetanus, Linaria sp., Silene caucasica,* and on the western part, with partly eastern exposure, were *Artemisia pamirica, Allium sp. Trigonella Emodi, Crepis flexuosa, Cousinia rava, Astragalus Alitschuri, Ephedra distachya, Chrysanthemum Richteria, Stipa orientalis* (scanty), *Elymus sibiricus, Agropyrum longearistatum, Polygonum alpinum* with its large white spiraea-like flowers, in great quantities; *Arenaria Meyeri, Ziziphora clinopodioides var. dasyantha, Hymenolaena darvasica, Sedum Rhodiola, S. sp., Ribes heterotri-*



(O. OLUFSEN *fot.*)

Fig. 26. Talus slope with vegetation, at the western end of Jashil Kul.

chum with long crooked stems clambering between the stones, while growing sporadically on the lower part of the talus was a large quantity of *Chamaenerium angustifolium*, and single low bushes of *Hippophaës rhamnoides*.

At the western end of Jashil Kul the talus vegetation was strikingly abundant; particularly on slopes with an eastern exposure. The illustration fig. 26 shows this. It is so unusually rich for conditions in Pamir that Mme Olga Fedtschenko has omitted the western end of Jashil Kul from "the true Pamir" (Flore du Pamir, map) On the slope with an eastern exposure the vegetation is most abundant, but there is no qualitative difference of importance between that and the vegetation on the neighbouring talus slope with a southern exposure. *Polygonum alpinum*, *Chamaenerium* and *Hippophaës* are found only on the western part of the lake (on both shores), I have in fact never found them in any other places in High Pamir. Mme Fedtschenko does not mention them from Pamir. Later on, I found *Polygonum* and *Hippophaës* in Goran, in the valley of the river Pändsh, and it is reasonable to surmise that they have migrated from the west toward the east along the Gund river, and have not yet come further in their journeyings. However there is no information at hand at present as to whether they are to be found in the valley of the Gund. It is possible that they are only to be found at the western end of Jashil Kul, because only there are conditions sufficiently favourable, — the place is comparatively warm and sheltered. Yet *Polygonum* was so luxuriant and abundant in its growth that it did not appear to be at its extreme boundaries. This might be true of *Hippophaës*. The latter has juicy fruit and might have been transported by birds; the former has rather heavy nuts.

CHAPTER 9

Formations Confined to Water

(Hygrophilous and mesophilous).

A. The Formation of swamp-meadows.

Along the shores of lakes, and in particular in many places along the banks of slowly flowing rivers, and in deltas, stretch green flats, which, at a distance, look like meadows but which are better described as marshes or swamp-meadows. Their most characteristic feature is the great cyperacea-tufts, broad, and up to almost a mètre in height, and doubtlessly very old. They are formed by the species, *Kobresia Bellardi*, *Royleana*, *schoenoides*, *stenocarpa*, *Carex orbicularis* and often *Triglochin maritimum*. *Carex pseudofoetida*, which is a subterranean runner, is also common. Between the tufts, there are either open pools, of gently moving or stagnant water, or bare, water-sooked, stinking mire. In these stagnant pools, and where the water moves but gently, salt is crystallized out, lying like hoar frost on the tufts, or, — when the water has evaporated, forming centimeter-thick crusts between them, and looking like solid frozen pools. Some marshes are quite white with salt.

In regard to vegetation non-saline marshes resemble in the main salt-marshes, if the amount of salt in these is not particularly great, as is the case near Tuz Kul. The cyperaceous tufts in particular are the same. In regard to the other flora, many species are found here, which I never found in salt-marshes, others which only seem to appear in non-saline marshes, and a third group, which is common to both localities.

Among halophilous species *Saussurea crassifolia* and *Polygonum pamiricum* occupy the first rank, in the second are *Potentilla dealbata*, which was common in some localities, *Atriplex crassa* and *rosea*, *Suaeda setigera* each of which, however, was only found in a single locality, *Carex pseudofoetida* and *microglochin*, *Alopecurus mucronatus*, *Calamagrostis stricta*, and *Scirpus compressus*, all with subterranean or ground-run-

ners, *Calamagrostis compacta* and *Atropis tenuiflora* in tufts, and lastly *Taraxacum bicolor* and *T. officinalis var. Steveni*, *Oxytropis glabra var. pamiricum*, *Capsella draboides*, *Erysimum pamiricum*, the latter having only been seen a single time in Pamir, and then in a salt marsh. *Atropis convoluta*, a cespitose grass, and *Elymus dasystachys*, with runners, belong most nearly to salt-marshes, though I have seen them in other localities. *Carex vesicaria var. alpigena*, *Triglochin maritimum* and *palustre*, *Poa pratensis*, *Hordeum secalinum var. brevisubulatum*, *Pedicularis uliginosa* and *Primula sibirica*, both with beautiful red blossoms, *Swertia marginata*, and *Gentiana prostrata* have all been found both in non-saline and very salty swamp-meadows. I saw *Heleocharis palustris* and barren *Phragmites* a single time in a salt marsh with an inlet of warm, sulphurous water.

The following species are only seen in non-saline marshes: *Polygonum viviparum* which here is a substitute for *P. pamiricum*, *Ranunculus pulchellus var. pseudohirculus*, *Astragalus brachytropis*, *Gentiana leucomelaena*, and *barbata*, *Pleurogyne carinthiaca*, *Plantago major*, *Pedicularis rhinanthoides*, *Saxifraga hirculus*, *Euphrasia hirta*, *Melandrium triste*, *Capsella procumbens*, *Rheum spiciforme*, *Juncus triglumis*, *Carex parva*, *Stellaria brachypetata*, and *Salix repens var. rosmarinifolia*, which is sometimes seen on the edge of the swamp-meadows as low bushes.

As a rule the species found in swamp-meadows are hemicryptophytes and, as one might expect, they have no xerophytic traits; a few, (*Saussurea* and the Chenopodiaceae), are thick-leafed halophytes. The majority and the dominating species are cespitose plants or spot-bound species, yet a few species with runners are also found. There are hardly any other annuals than *Atriplex* and *Suaeda*. There are several plants with beautiful blossoms, as the following examples will show:

Examples of Marsh-Vegetation.

1. The little lake, Bulung Kul, is shallow, its shores flat and almost encircled by a rather broad belt of marsh-vegetation. Salt is present nearly everywhere, and on mounds

or other protuberances, especially old cyperaceae-tufts, is crystallized out. These latter are formed by *Carex orbicularis var. bulungensis* and *Kobresia schoenoides; Carex pseudofoetida* is especially halophilous. In very moist places *Carex vesicaria var. alpigena* with runners and the cespitose *Calamagrostis compacta* are seen. *Atropis convoluta var. subscariosa* colours some spots with its crimsom panicles, in others, *Alopecurus mucronatus* and *Atropis tenuiflora* are found. Between the tufts in the most saline places are the red-flowering *Saussurea crassifolia*, and *Polygonum pamiricum; Pedicularis uliginosa* flaunts its flaming red clusters of flowers, while the slender, graceful little *Primula sibirica* often finds fast ground on the large cyperaceae-tufts. Here and there, where there is not too much moisture, the greenish white blossom of *Swertia marginata* alternate with the tiny *Gentiana prostrata*, and, as occasional guests, we notice *Mulgedium tataricum*, *Taraxacum officinale var. Steveni*, *Lepidium latifolium*, *Capsella draboides*, *Erysimum pamiricum*, and *Oxytropis glabra var. pamirica*. *Potamogeton Friesii* is seen in the pools of water, with *Batrachium paucistamineum* f. *Drouetii*, as white islands.

On the southwestern shore of the lake the vegetation is somewhat different. Here, a 3—4 mètre high slope confines the lake-basin. At the foot, numerous small springs gush forth, and their fresh water slowly oozes over a narrow beach. Here too, are cyperaceae-tufts, with *Desmatodon cernuus* and *Pottia Heimii* growing on top, and between them sterile moss-cushions and spikeless grasses. We find, too, *Cerastium trigynum*, *Ranunculus pulchellus var. pseudohirculus*, *Saxifraga hirculus* and *Pleurogyne carinthiaca*.

2. In the valley of the Murghab near Pamirski Post broad green swamp-meadows[1]) stretched away on either side of the river. Great tufts were formed by *Carex orbicularis*, *Kobresia Royleana* and *Bellardi* and *Triglochin maritima*. Between the tufts was shallow water, stagnant, near the edge of the marsh, running, further out. On the tufts and along the edge were *Taraxacum bicolor*, *Pedicularis uliginosa*, *Ra-*

[1]) Pictured by Mme Fedtschenko, Flore du Pamir, Table 3.

nunculus pulchellus, Carex microglochin, Triglochin palustre, Primula sibirica, Hordeum secalinum var. brevisubulatum, Colpodium sp., Poa pratensisa var., Poa tibetica var., Bryum subacutum, and the water plants *Potamogeton amblyophyllus,* and *Hippuris vulgaris.*

Where the marshes are drier, they are white with salt, which enshrouds the tufts and encircles the pools. At the bottom of dried-out water-basins is a 3 cm thick salt crust over the mire. Here *Carex orbicularis* and *Kobresia Bellardi* are the main elements of the vegetation, while *Potentilla dealbata* is also common.

3. Near the little lake of Tuz-Kul, — (the name means 'salt-lake'), and near other lakes in its vicinity, considerable quantities of salt have been deposited on the surface of the ground, along the banks of the lakes and on the intervening stretches. It is apparent that water containing salt must ooze up from under the ground. (See above page 38.) Although it was in the midst of a dry season several small springs were observed, in which water gushed slowly and perpendicularly up from the ground. The miry springs, described above, seem to indicate the same.

The belt of salt encircling the lake of Tuz Kul varies in breadth according to the declivity of the slopes. On one side, where they are comparatively steep, it is only ½ mètre broad, but in other places it is about 100 mètres broad. The salt is glistening white with a loose dusty surface. Underneath is a moist greenish brown layer of clay, with coal-black stripes and clumps. In dry places, where the salt was almost like dust, the thickness of it all was about 10 cm; where the salt was darker, wetter and more coherent, it was about 20 cm. Below the clay was sand. A blue-green alga was found everywhere underneath the wet salt.

On a broad salt stretch, east of the lake, practically nothing was growing, — only very sporadic specimens of a little grass, *Atropis convoluta var. subscariosa* and of *Suaeda setigera.* Near the north shore of the lake there was a tussock-salt-marsh stretch, where *Carex pseudofoetida* was the most important species; and besides *Carex orbicularis var. bulun-*

gensis, *Atropis convoluta*, *Primula sibirica*, *Triglochin maritimum*, and upon the Carex-tufts or along the edge of the salty stretch, *Sausurea crassifolia* and *Calamagrostis compacta*. Where the surface of the ground is even and less moist *Polygonum pamiricum* appears; that plant and *Carex pseudofoetida* seem almost to exclude each other. *Senecio coronopifolius* grows on the extreme edge, where there is very little salt.

A little salt-hole, a short distance away, was composed for the most part of a very moist plantless salt surface. There was only a little water in the centre. Around the salt surface the following vegetation belts were found: Nearest the lake a 5—6 mètre broad belt of *Atropis convoluta var. subscariosa*, then an 8—20 mètre broad belt of *Carex pseudofoetida* and finally a 20—25 mètre broad belt of *Saussurea crassifolia* and *Elymus dasystachys*, mixed with *Polygonum pamiricum*, *Suaeda setigera* and *Atriplex rosea*. These belts show us the varying grades of halophilia of the halophilous plants of Pamir.

4. Where the Mardjanaj River flows into Jashil Kul it forms a rather broad delta, which, at a distance, resembles a green meadow. This contains but a small amount of salt. Near its banks low bushes, (about 1,5 mètres high), of *Salix repens. var. rosmarinifolia* are growing. The main part of the plant growth here consists of large tufts of *Carex orbicularis*, *Kobresia Bellardi* and *Royleana*. Large tufts of *Triglochin maritimum* are likewise seen, as well as *Carex parva*, *C. vesicaria var. alpigena*, *Juncus triglumis*, *Poa pratensis*, *Pedicularis rhinanthoides*, *Saxifraga Hirculus*, *Swertia sp.*, *Gentiana barbata* and *prostrata*, *Primula sibirica*, *Polygonum viviparum*, *Euphrasia hirtella*, and the lovely little *Rheum spiciforme* with red peduncles and red fruits. A moss, *Bryum leptoglyphodon* is rather common here.

B. The Hot Springs' Formation.

Very near Jashil Kul two hot springs are to be found. One of them lies north of the lake just north of the outlet of the Alitshur River. The other lies south of the lake.

The first, which is really a group, comprises 2 large and 23 smaller springs, and, in earlier days, similar springs have been found above them in a higher level in at least two places. The openings can still be seen and there are lime deposits below them where the water must have flowed.

The warm water gushes vertically up from the ground at no great speed, into a basin of at calcareous tuff, about 1 mètre in diameter, with yellow sulphurous deposits around its edge. The temperature of the water when it gushes out of the ground is 78° C. That the temperature was high was indicated by the clouds of vapour seen arising, and from the quantities of small frogs, which lay, scalded to death, in the basin. Algae-crusts were seen in the basin and its outlet. Along the outlet a dense vegetation of *Heleocharis palustris* (*subsp. eupalustris*), stretched in a fresh green stripe from the hot regions all the way out to the marsh of the Alitshur River. Here, too, were many low, barren *Phragmites communis*, a very rare plant in Pamir[1]).

The other hot-spring was far more interesting. It lies south of Jashil Kul, about 30 mètres above the surface of the lake on an exposure sloping north. This one, too, had several sources, five in all. The water in the largest had a temperature of 32° C, the others 26°, 26°, 22° and 19° respectively. The last could hardly be called a source, but the water oozed up out of the ground in a circle about 1 mètre in diameter. These hot sulphurous streams soon united and flowed in a warm but quickly cooling brook down into the lake.

From the opposite shore the crevice in which these springs are found appears like a fresh green stripe on the brown mountain-side. The vegetation is luxuriant with *Scirpus compressus* dominating. This plant covers the wettest parts of the ground, but does not seem to depend on the temperature of the water for it was just as abundant in the vicinity of a cold spring. At the basins themselves and along the warmer courses *Veronica oxycarpa* and *Epilobium thermo-*

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[1]) It is presumably introduced. In this neighbourhood is an ancient Chinese fort and a sepulchre, (Gumbas), for Abdullah Chan.

philum thrive. These depend both on moisture and warmth. They grow only in the immediate neighbourhood of water, their size and quantity diminishing the further they are removed from this element. Furthest away, where the brook flows into the lake and the temperature of the water was 20°, there were only a few small specimens to be found. Near the spring *Veronica* was 1 mètre high and *Epilobium* 30—40 cm. I have not seen these two species, which are both marsh perennials, anywhere else in Pamir. However *Veronica oxycarpa* is noted by M^me^ FEDTSCHENKO from other localities.

Other plant species are *Juncus lamprocarpus*, growing in the water near the main spring, *Geranium collinum var. candidum*, which was common beside the spring and all along the brook, and the following which grew in the hollow glen, but seemingly independent of the influence of the brook, *Carum Carvi*, *Agrostis alba*, *Ligusticum alpinum*, *Sisymbrium Sophia*, and *S. heteromallum*, *Potentilla bifurca*.

C. The Submerse Formation.

I am best acquainted with this vegetation from the eastern end of Jashil Kul, a large shallow bay, 1—2 mètres deep, and from the equally shallow waters of Bulung Kul. These two places, which are very near each other, and connected by the outlet from Bulung Kul to Jashil Kul, have an identical plant-growth. In both places there is a rich, quite homelike vegetation, composed of *Potamogeton perfoliatus*, and *Friesii* (?) very luxuriant in their growth, and having long upper leaf-bearing stems floating on the surface of the water, combined with *Myriophyllum spicatum*. Farthest in the bay, this latter species dominated, almost filling the water. Scattered here and there were dense groups of *Potamogeton crispus* and dark green masses of *Ceratophyllum demersum*. *Batrachium paucistamineum f. Drouetii* formed submerse cushions, *Ranunculus natans*, *Potamogeton filiformis* and *Zanichellia pedicellata* were also to be found.

Potamogeton amblyophyllus has been seen both in stagnant and running water in the Murghab River near Pamirski Post; and the Zostera-like *Potamogeton pamiricus* formed dense woods at the bottom of Kara Kul.

There is nothing specially characteristic in the submerse vegetation of Pamir. *Potamogeton pamiricus*, alone, seems to be characteristic of High Asia.

D. Stony River-Bed Formation.

Stony river beds, in which at certain seasons there must be much water, but which are almost dry in the summer, have a special characteristic vegetation. Here, as along lake-shores, willows are often growing, and in the Jaman Tal valley, (near Pamirski-post), which is a chasm, 30 mètres or more in depth, with perpendicular walls, I have seen willows, (*Salix oxycarpa*) attain a height of 4—5 mètres. *Myricaria squamosa* (= *davurica*) forms bushes $^1/_2$—1 mètre tall, and, like *M. germanica* in Norway, seems to cling to such localities. The same is true of *Clematis orientalis var. tangutica*, for the most part procumbent, *Scrophularia incisa var. pamirica*, which forms great tufts, and the lovely white-flowering bush, *Potentilla Salessowii*, whose stiff, upright stems grow 20—40 cm tall. The following species are also found: *Glaux maritima*, *Calamagrostis compacta*, *Poa compressa*, *Potentilla dealbata* and *polyschista*, cespitose species with white-hairy leaves, *Carex macrogyna* and *pseudofoetida*, *Kobresia Royleana*, and, too, the delicate little *Parnassia subacaulis*, *Swertia marginata*, *Lappula sp.*, *Crepis tenuifolia* and *flexuosa*, both cespitose with narrow leaf-lobes. *Gypsophila cephalotes*, *Ligularia altaica*, with its broad blue-green leaves and close yellow flower-heads, *Scutellaria filicaulis*, *Astragalus nivalis*, *Sisymbrium humile*, and *S. Korolkowii*, *Tanacetum tibeticum*, *Allium odorum*, *Rheum spiciforme*, the beautiful *Delphinium cachemirianum*, $^1/_2$ mètre tall, with its large pale blue flowers and broad leaves, and *Trigonella Emodi*. The majority of the herbaceous plants named here are cespitose in growth, only *Carex pseudofoetida* and *Glaux* have subterranean runners. All species are perennial and more or less mesophytic in structure, often broad-leafed and smooth. Only a few emigrants from dry localities (*Trigonella*) or from saline soil, (*Carex pseudofoetida*) have mixed in this characteristic, beautiful, luxuriant plant community. On the stony bottom there is space between the plants, the tufts are far apart, well developed and with no

dead leaves, but often with beautiful blossoms. There are none of the poor procumbent plant-tufts so common in Pamir.

Examples:

1. Jaman Tal; a flat valley-bottom filled with large stones and sheltered by perpendicular walls[1]). Here were *Salix oxycarpa* 4—5 mètres tall, and *Myricaria squamosa* 1 mètre in height. We found, too, *Scrophularia incisa*, *Glaux maritima*, *Calamagrostis compressa*, *Poa compacta*, *Elymus sibiricus*, *Potentilla dealbata*.

2. Bos-tjilgá, a little tributary of Kara Su. Stony river-bed with the following species: *Potentilla Salessowii*, 20—40 cm tall, *Clematis orientalis var. tangutica*, *Swertia marginata*, *Lappula sp.*, *Parnassia subacaulis*, *Carex macrogyna*, (tufts 60 cm, in diameter at the root,) *Kobresia Royleana*, *Calamagrostis compacta*, *Poa compressa*, *Elymus sibiricus*. These were common; less common were *Potentilla dealbata*, *Dracocephalum heterophyllum*, *Myricaria squamosa*, *Crepis tenuifolia*, and *flexuosa*, *Trigonella Emodi*, *Gypsophila cephalotes*, *Ligularia altaica*, *Scutellaria filicaulis*, *Astragalus nivalis*, *Tanacetum tibeticum*, *Allium odorum*.

E. The River-banks Formation.

Along the banks of rivers and lakes, when no marshes are present, there is a stripe of close vegetation on firm, moist ground. This is sometimes accompanied by bushes which grow at the edge of the water: *Myricaria*, *Salix repens var. rosmarinifolia* and a larger species, (*S. glauca?*), *Tamarix sp.*, *Lonicera coerulea*. The willows never grow higher than 2 mètres, the tamarisks, and *Lonicera* about $^1/_2$ mètre. The vegetation is of a meadow-like character. Grasses and cyperaceae play an important part. The following were observed: *Trisetum subspicatum*, *Carex orbicularis* and *gracilis*, *Festuca rubra* (*var.*), *Bromus crinitus*, *Kobresia Royleana*, and *Bellardi*, *Poa attenuata var. versicolor*, *P. persica var. soongoria*, — all cespitose. Among these, many other plants were scattered: *Astragalus brachytropis*, *Beketowii*, and *tibetanus*, *Oxytropis glabra*, all long-stalked richly foliate cespitose plants, *Cerastium trigynum*, *Stellaria brachypetala*, *Gymnandra Korolkowii*, and

[1]) Pictured by Mme Fedtschenko in "Flore du Pamir" tab. 5.

Plantago gentianoides, the two latter with undivided, broad leaves, *Saxifraga hirculus*, the smooth low creeping *Potentilla bifurca*, and *P. hypoleuca*, whose leaves are white underneath, the green Anthriscus-like *Selinum papyraceum*, *Gentiana prostrata* and *barbata*, *Pedicularis cheilanthifolia* and *uliginosa*, *Scrophularia incisa*, *Taraxacum bicolor*, *Erigeron uniflorus*, *Artemisia rupestris* (glabrous), and *A. macrocephala* (sericeous), *Crepis multicaulis*, *Tragopogon sp.*, *Delphinium speciosum* with gorgeous blue flowers and broad, smooth leaves, the glabrous *Geranium collinum* and the white-hairy *Tanacetum tibeticum*, *Ziziphorum clinopodioides var. dasyantha*, and finally the annuals *Pleurogyne carinthiaca*, glabrous and delicate, *Euphrasia hirtella*, the glabrous yellow-flowering *Erysimum sisymbrioides* and *Tauscheria lasiocarpa*. Of mosses, *Bryum leptoglyphodon* and *B. pamirio-mucronatum* were found.

This is a community for the most part of cespitose hemicryptophytes. Not a single species has runners. There are no chamaephytes, and only 3 therophytic species were observed. This is moreover a community of mesophytically adapted species. The majority are smooth and many have broad leaves. It seems most reasonable to compare this close vegetation (greensward) with a meadow, which is also characterized by mesophilous, cespitose hemicryptophytes.

Examples:

1. Bosala, near the Alitshur River, a narrow strip of meadow widening out between the windings of the river. There is a close, green meadow-vegetation formed largely of *Carex pseudofoetida* and *Poa pratensis var. subcoerulea*; scattered in between were *Primula sibirica*, *Pedicularis uliginosa*, *Crepis sp.*, *Polygonum viviparum*, *Stellaria brachypetala*, *Ranunculus pulchellus var. pseudo-hirculus*, *Astragalus brachytropis*, and *Gentiana leucomelaena*.

2. Along the little stream, Su Birgöt, near Bulung Kul. A thick green carpet of *Trisetum subspicatum var. glabrescens*, *Poa persica var. songorica*, *Bromus crinitus*, *Potentilla bifurca*, *Crepis sp.*, *Artemisia macrocephala*, *Primula sibirica*, *Tragopogon sp.*, *Cerastium trigynum*, *Selinum papyraceum*, *Astragalus brachytropis* and *tibetanus*, *Plantago gentianoides*, *Oxytropis glabra*, *Gentiana barbata*.

3. On a little peninsula, in Jashil Kul, formed by soil washed out by a stream now dry, we found growing along the waters edge willow bushes, (*Salix glauca?*) and *Tamarix sp.* Behind these was a close green carpet, formed mostly of Cyperaceae: *Kobresia Bellardi* and *Carex gracilis*; *Bromus crinitus* was very common. Beyond these was a quantity of red flowering *Allium (polyphyllum?)*, and still higher up, I found a curious mixture of mesophilous and xerophilous plants forming a rather dense vegetation. Among the mesophilous plants were *Potentilla bifurca*, by whose subterranean runners patches of ground, a mètre or so, in size were covered with its low smooth-leafed shoots, the annual, *Tauscheria lasiocarpa*, in great quantities, *Poa compressa var. tereliuscula* and *Astragalus scheremetewianus*. Among the xerophilous species were both *Acantholimon* species, *Artemisia maritima aff.*, *Hedysarum cephalotes*, *Solenanthus stylosus*, *Cousinia rava*, *Trigonella Emodi*, *Stipa orientalis*, *Scorzonera mollis*, *Polygonum paronychioides*, *Macrotomia euchromon*, *Elymus lanatus var. canus*, — species of the Trigonella-formation, that is to say not those belonging to the driest localities.

PART III
THE SOUTHERN VALLEYS OF PAMIR

CHAPTER 10

Wakhan.

Leaving the Chargush Pass the expedition went to the south and southwest following the river Pamir Daria to Wakhan. As soon as we descended to that river, which rushed along in a foaming torrent, we found thickets of willows both along the banks and in the deep valleys furrowed by its tributaries. The lower down we came the greater the

number and the more luxuriant the thickets. The willow, forming them, is probably *Salix zygostemon* Bois. It generally grows to a height of 3—4 mètres, and occassionally 6—7 mètres. Further down the river other and large arborescent plants appear and small woods are formed in which the *Salix* mentioned still occupies the first place, but where a *Betula*, (*B. odorata?*)[1]), is likewise found, attaining a height of 10—12 m. Here, too are *Ribes*, (*aff. nigrum*), *Hippophaës rhamnoides* and *Rosa sp.* Between small woods are the great umbelliferous: *Archangelica songorica* and *Heracleum Olgae*, as well as *Artemisia aff. maritima*, *Elymus*, *Ephedra*, *Acantholimon alatavicum*, *Stipa orientalis*, *Astragalus lasiosemius*, *Trigonella Emodi*, *Arenaria Meyeri*, *Lactuca orientalis*, *Cousinia nemesskyana*, all known from up in Pamir, and the crisp thin-leafed *Saponaria Griffithiana*. Near springs *Veronica oxycarpa*, *Agrostis Paulsenii* and *Carex gracilis* were noted.

Salt-fields, whose existence is doubtless due to the evaporation of water oozing up from below, lay stretched in many places along the banks of Pamir Daria. Here we found *Saussurea crassifolia* in great quantities.

From Djangarlik our path led up and down along the river, through deep valleys worn by the tributaries of the Pamir Daria, — and high up, at a sudden turning the whole valley of the Pändsh spread out before us. Here lay a wide wooded plain, surrounded by high mountains, with the foaming Pamir Daria in a glistening white stripe among the trees. Still farther south, from the top of the next height, after many months spent in the barren mountains, we again saw cultivated land On the washed-out terraces north of the river lay the yellow squares of fields in green frames, with houses, smoke and tall pyramidical poplars. Down through small groves we rode, fording gurgling brooks, where the red wildbriar hung like fuchsias, and at a quick trot, reached Langarkish, and were at the same moment in Wakhan. It was September 7, and our first thought was, what a paradise of beauty and fertility. But after a short time in the narrow valleys with their fields,

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[1] The appearance of birch in these localities has already been shown by TROTTER (1878) and quoted by GEIGER, page 55.

dirty dwellings and cowed, primitive inhabitants we remembered with regret the lofty, barren, inspiring Pamir.

The remainder of September was spent in Wakhan, and the larger part of October in Goran and Shugnan, which lies at the due S. N. course of the Pänsh river. On October 27 we went into winter quarters in Chorock, which is in Shugnan at the outlet of the Gund into the Pändsh. In March we retraced our steps the same way we came and rode from Langarkish across Pamir back to Ferghana.

In the following pages are notes of scattered observations made during the autumn and winter spent in the southern and western valleys of Pamir.

Wakhan is the name given to the valley of the Pändsh river from Ishkashim toward the east. Its direction is mainly east-west. The highest point in the valley visited by the expedition, Langarkish, lies, according to OLUFSEN, 3,029 mètres above sea-level, while Rang, near where the Pändsh turns toward the north, is 2,702 mètres above the sea. As the distance between the two is about 100 km, the fall of the river during this stretch is only about 327 mètres, which does not occasion any great speed. The river does indeed flow quietly, at times almost forming lakes. In many places gravel and sand are deposited. The latter is dried by the prevailing western winds and tossed hither and thither, forming stretches of drift-sand. According to OLUFSEN's map the valley is 2—3 km broad in the eastern part, in the western end it is narrower, often hardly more than 1 km across. Yet it is wide enough everywhere to permit our riding on the bottom of the valley, without making it necessary to climb over the bordering mountains. However it seemed narrow enough to us journeying in it on its north side, where we had the mighty peaks of the Hindukush[1]) chain constantly before our eyes. These pinnacles of the Hindukush tower about 7,000 mètres high, according to OLUFSEN, and

[1]) In geographies of to-day we often find Hindu-Kooh (Kooh = mountain). The natives say Hindu-Kush (Kush = destroyer).

are for the most part covered with snow. During our stay in Wakhan, blizzards often raged up on the mountain-tops, hiding the summits from us for days at a time. — In several places glaciers are seen, from which many water-courses pour, more and larger than on the north side, but — as there — short.

According to OLUFSEN the climate of Wakhan is dry, almost rainless, with hot summers and cold winters. There is a great difference between the temperature of day and night. In September we sometimes found the thermometer registering over 20° C. at noon and we experienced several night frosts. Western winds prevail, warm, dry, often filled with sand in summer, cold and dry in winter.

Only twice, while the expedition was in Wakhan, were there many clouds to be seen, the usual condition was clear blue sky or a small percentage of cumulus clouds.

We saw no rain whatever, and in March the covering of snow was slight or totally lacking.

In such a climate agriculture must depend on irrigation, and villages were only found where streams rushed down the mountain-side. Agriculture indeed depended on one other factor. Only where the disintegration of material brought down in land-slides had formed terraces along the river, was arable soil to be found. To these the mountain streams were conducted, often with great difficulty and labour. The country villages consisted of clay hovels, with flat roofs, built of clay and dung, and often so close together that it was possible to walk around the entire village stepping from roof to roof, and, at the same time peeping through the hatches, open by to emit smoke and admit air, witness the poverty-stricken, primitive lives of the inhabitants. Many fortified towers on the roofs of the houses, and caves, or other places of refuge in the mountains, bore witness to the sufferings endured by the inhabitants, — mountain-Tadshiks or Galtshas of Iranian origin, — prior to the Russian occupation, at the hands of the plundering bands of the Afghans, their neighbours. In many villages fruit-trees and pyramidical poplars were planted, and contributed no small degree of beauty.

Very curious were the huge fortresses found in many

places in Wakhan, and built formerly by the Siaposhes, a tribe from Kafiristan.

But for this matter as well as for the geography of Wakhan, reference may be made to OLUFSEN, who in "The unknown Pamirs" has given a detailed description of the country. A map is published by him in "Geografisk Tidsskrift" vol. 14.

On the mountain-sides in Wakhan the vegetation was just as poor and dry as we had found it in High Pamir. However, in Wakhan we could study only the vegetation of southern slopes, because the expedition only followed the right bank, or north side, of the Pändsh River.

On these slopes, exposed to the south, *Anabasis wakhanica*, a low leafless suffrutex, usually having many dead twigs among the green, was the most common plant. *Peganum Harmala*, a hemicryptophytic Zygophyllacea, with deeply cleft leaves and thick narrow lobes, was likewise common, as were *Andropogon Ishaemum*, forming small tunicate tufts and having short gray hairy leaves, *Eurotia ceratoides*, *Artemisia fragans*, *Centaurea repens*, the annuals *Kochia stellaris*, *Bassia hyssopifolia*, both with narrow hairy leaves, and *Salsola collina* which has hard, very woody stems, and small, almost squamate leaves.

In a few places, on dry mountain slopes, I found *Astragalus lasiosemius*, on September 11, with its leaves quite withered and the rhachides, alone, sticking out like thorns; and near Dershai I found a very few specimens of *Acatholimon alatavicum*.

This vegetation can best be compared to the Eurotia-formation of Pamir. Like that, it is a chamaephyte formation, in that 5 out of 11 species (46 %) are chamaephytes. It differs from the Eurotia-formation in containing 3 therophytes, (27 %), all Chenopodiaceae belonging to the long-lived type, (summer-annuals, PAULSEN), with xerophytic anatomy. I will not carry my comparison between the rocky vegetation of Wakhan and the Eurotia-formation further, as my acquaintance with the former is too slight, based only on observations made during one autumn and winter.

As in Pamir, green stripes follow the river-courses, and

here we find thickets of *Hippophaës*, willows, and *Rosa*-species. Here, too, are *Glycyrrhiza glabra*, *Geranium collinum v. wakhanicum*, *Agrostis alba*, *Artemisia Tournefortiana*, *Mulgedium tataricum*, *Calamagrostis emodensis var. breviseta*, *Stipa splendens*, *Bassia hyssopifolia*, *Mentha longifolia subsp. modesta*, *Thalictrum minus var. elata*, *Hordeum secalium*, *Elymus sibiricus*, *Sonchus oleraceus*, *Dracocephalum moldavicum*, *Senecio sp.*, *Scirpus setaceus*, *Gentiana umbellata* and *barbata*, in fact a mixture of xerophytes and mesophytes, many of the latter seeming to originate from cultivated soil, — but one and all hemicryptophytes or therophytes.

I have seen hydrophyte-vegetation in two places in Wakhan. The first was a little marsh near Sermut. The vegetation was closely cropped by cattle; green tufts were formed by an undetermined *Carex* and by *Triglochin palustre*. Flowerless *Phragmites* were also present, as well as *Glaux maritima* and a *Plantago*. In pools of water between the tufts were *Heleocharis palustris* (subsp. *eupalustris*) and *Scirpus Tabernaemontanus*, and of submerse plants, a little *Batrachium*, *Ceratophyllum demersum*, *Hippuris vulgaris* and *Chara sp.*

Two tiny shallow lakes near Rang, (in the neighbourhood of Ishkashim), were quite covered with *Heleocharis palustris*, 25—30 cm high, with an occasional *Phragmites* dotted here and there. Many *Polygonum amphibium* were floating on the surface of the water; *Limosella aquatica var. tenuifolia* was growing in the shallowest water, together with *Tillaea aquatica* and *Elatine hydropiper*[1]). In somewhat deeper water I found *Chara*, *Ruppia*, *Potamogeton perfoliatus*. Algae were very common in the lakes.

Potamogeton amblyophyllus and *Batrachium paucistamineum* were found in running water near Nut.

The vegetation of the Pändsh River Valley in Wakhan.

In most places in Wakhan, the Pändsh River flows quietly along, with no great hurry, branching to embrace

[1] The discovery of these two plants here, is surprising, as the place lies far from the localities, where they have hitherto been found.

small islands and uniting again as it continues its course. On these islands, and along the river-banks, where now, in September, there were broad dry strips — the river-bed being far wider than the river, — the soil was sandy or gravelled. Here a characteristic thicket of small trees or large bushes was found. In some places it was so dense as to be almost impenetrable. This was often the condition along the arms of the river, which were like winding streets leading from one open square to another. Wild boars were common; we found many tracks, but caught not a single glimpse of the animal itself. The main plant in the thicket was *Hippophaës rhamnoides*, which grew 2—4 mètres tall, (greatest height 5 mètres,) bore ripe fruit, and, with its dense thorny branches, was the cause of the density of the thicket. Here, too, was *Salix angustifolia var. carmanica*, a tall narrow-leafed willow, bushlike in form, and about as tall as *Hippophaës*, or perhaps slightly taller. *Tamarix sp.*, about 2 mètres tall, were also common.

Climbing over these plants was *Clematis orientalis var. acutifolia*, very common. It was in fruit now, and the great masses of long white hairy styles covered the tops of the trees or bushes like a thick overhanging roof.

The bottom of the thicket was almost bare. Only a few scattered species of herbaceous plants were observed: *Crepis corniculata*, *Arnebia guttata*, *Salsola Kali*, *Polypogon monspeliensis*, *Senecio pedunculatus*, *Artemisia sacrorum* and *Tournefortiana*, *Elymus dasystachys*, *Calamagrostis Epigejos*, *emodensis* and *pseudophragmites*, *Scirpus setaceus*, *Chenopodium glaucum* and *Botrys*. — These were mostly annuals but with no specially common characteristic, and presumably chance guests. *Crepis corniculata* is a sparsely-leafed hemicryptophyte, the *Calamagrostis*-species and *Elymus dasystachys* are large thriving grasses with horizontal runners.

In the river valley in Wakhan there are many places with drifting sand. This was very fine and contained mica. There was not much of it, so the dunes were usually small, but were found in many places. Stones, worn by sand, were likewise common. After the plants growing in the sand and contributing to the formation of the dunes,

four different forms of dunes could be distinguished in Wakhan.

1. Hippophaës-dunes. These are small, not more than 2—3 mètres high, rounded, without distinct windward or leeside. This is probably due to the fact that they are so closely covered with *Hippophaës* bushes, which, in some places are ½ mètre, in others 3 mètres tall. Between these grows *Inula ammophila*, a fresh green innerasiatic sand-plant with small perfoliate leaves, hairy on the under side.

Phragmites, too, grows here, — often 2—3 mètres tall, with its top waving like a flag above the bushes, — and *Salix angustifolia* and *Clematis*. All three, like *Hippophaës*, were probably indigenous to the locality before the sand came and drifted over them. They are what Cowles calls "antecedent", in contrast to *Inula ammophila* which must have come after the soil had been covered by sand.

2. Willow-dunes. These are formed by *Salix angustifolia* (?). Near Sermut they were 3—4 mètres high, while the willows, grouped close together, forming thickets up to 100 mètres in diameter, rose 4—5 mètres above the sand. Willows are probably "antecedent" here too, and were present before the sand came, but now continually gather it around them in the shelter found between their trunks. Between these the sand was bare or dotted with an occasional annual.

3. Eurotia-dunes. These were the most common and also the smallest. The largest were 2 mètres high, but as a rule they were not over 1 mètre. They were sometimes circular, but most often rectangular with the longest axis west-east. A crest of sand lay often east of the plant indicating that the prevailing winds were westerly. This was also shown by *Eurotia*-plants, which only had an all around development in places sheltered from wind, but which otherwise stretched their shoots slantingly upwards toward the east. The main-stem, which, as in Pamir, was fasciated, was furthest to the west and turned the sharp edge toward the direction from which the wind blew. It was often sanded over, and beneath the sand the entire system of ramification might be found, dead. New shoots had pushed their way upwards, but the

internodes were no longer than usual. *Eurotia* is a suffrutex, or here, under milder climatic conditions, preferably, a dwarf-bush, whose branches for the most part survive the winter.

On *Eurotia*-dunes I have found *Phragmites communis var. pumila*, a cespitose dwarf-form, with short closely-packed leaves. It contributed but little to the formation of the dune. There were also *Inula ammophila*, *Cirsium arvense*, *Calamagrostis pseudophragmites* and small tamarisks and willows about $^1/_2$ mètre tall.

The latter was perhaps "antecedent", possibly *Cirsium* also, — there may have been fields here, formerly, but they are just as apt to have been brought out with seeds from the open country. I am inclined to believe that *Eurotia*, too, was "antecedent", for it is by no means rare in the Wakhan-valley. It is difficult to imagine that, after germinating in the sand dunes, it would be able to live in the dunes and attain any great age, — for the broad totally woody stems must be several years old, — without being overcome by the sand and killed, while yet young and weak. It is probable that old *Eurotia* growths have recently been covered with sand which they have only partially resisted.

With the exception of the fact that fewer of the shoots above ground were dead, — those sanded over are not counted in this connection, — and that the plants were one-sided in their growth, *Eurotia* looked here very much as up in Pamir. One would fancy that its short shoots and the limited possibilities for growth would make it but little adapted to dune-vegetation; yet it is a remarkably plastic species. I saw a specimen near Langarkish in the form of a bush 1 mètre tall, with branches bent and twisted, climbing about a rose-bush almost as if it were a semi-liana. Near Sermut it appeared as a little tree with a crown and a cylindrical trunk, about one inch in diameter.

4. Tamarisk-dunes. These have been seen in many places in Wakhan. They attain a height of 4—6 mètres; they are circular or elongated with the longest axis east-west, — the direction of the river valley. They were rather closely covered with tamarisks 1—2 mètres tall; *Calamagrostis*

pseudophragmites, *Hippophaës*, *Inula ammophila*, *Salsola Kali* and *Cirsium arvense* were likewise seen.

The characteristic feature of Tamarisk-dunes is the fact that the sand lies in strata. These are about 2 cm thick and separated by dark layers of dead, half-disintegrated inflorescence-axes, flowers and other deciduous parts of the Tamarisk (sticks etc.). These layers are further divided into layers parallel with the thicker layers, but here no dark stripes intervene.

The dunes were completely rounded off on the top and covered by fine, constantly drifting sand.

How have these stratified Tamarisk-dunes been formed? The expedition found similar dunes in the lowlands of Transcaspia (PAULSEN, 1912, p. 96), which are described as "Tamarisk-knolls" and we read, — "they are presumbably remains of a former continuous tract of a sandy soil now blown away except where the roots and shoots of the Tamarisks have kept the sand at the old level. MAC DOUGAL has pictured sand-knolls formed in the same way by a *Rhus*-species."

It is possible that the Tamarisk-dunes of Wakhan have been formed in the same manner, but it is more probable that they have been formed free and that their growth continues, until they are finally blown out; for on our return to Wakhan in the winter (March), we revisited the Tamarisk-dunes examined in September, and which at that time had pure sandy surfaces, and found them covered with fallen twigs and inflorescence-axes.

It was impossible to tell the origin of the fine stripes in the strata. It may be that on calm days the sand is puttied fast (with rain?) and that every additional drift of sand contributes a layer (stripe).

Cultivated land i Wakhan lies on the terraces above the river as was stated above. It is irrigated by means of the brooks streaming down the mountain-sides. The method is as follows. From the point at which the brook flows out on to the terrace, a main canal with a slight fall is conducted above the town and its fields. From this main con-

duit the water is led out over the fields at different points and times. Stones and dirt act as sluices, which may be opened or shut at will. The Kasi (judge), makes it his business to see that the water is justly distributed. The fields are irrigated by means of flat parallel furrows terminating at

Fig. 28. A load of cereals in Wakhan.

each end in a cross furrow. When all the furrows are filled, the water is turned off. Before beginning to irrigate, the fields are fertilized and ploughed. The plough used is primitive indeed. It consist of a drawing-rod and a bent piece of wood, whose pointed end loosens up the soil. Harrowing is unknown as are fallow-fields.

The soil is stony but fertile. Wheat sometimes grows $1^1/_2$ mètres high. In upper Wakhan the following cultivated plants are grown:

"Gedim", wheat — (*Triticum sativum*).
Triticum durum.
"Zyrk", rye — (*Secale cereale*).
Naked barley — (*Hordeum himalayense Rtt.*).
"Zyrz", millet — (*Panicum miliaceum*).
"Shatrá", rape — (*Brassica napus*). Oil is pressed from the seeds and used for lighting.
"Sach", *Lathyrus sativus*. Fodder-plant.
"Bakla", horse-beans — *Vicia Faba*.
Alfalfa — *Medicago sativa*.

In the western part of the country, the province of Ishkashim, the following were also found:

"Sedörklang", peas (*Pisum sativum*).
"Saghér", flax (*Linum usitatissimum*), found also wild in upper Wakhan.
"Misfar", *Carthamus tinctorius*, an oleaginous plant.

In gardens or small fields the following plants are likewise grown, for the production of stimulants.

Tobacco (*Nicotiana rustica*), poppy (*Papaver somniferum*), and in Ishkashim the thorn-apple (*Datura stramonium*). No small percentage of the population is addicted to opium, and it is said that an intoxicating drink is distilled from the thorn-apple.

The sickle is used in harvesting. By the middle of September, when our expedition reached Wakhan, rye and barley were in, and the wheat and millet harvest begun. The sheaves are stacked for drying in curiously shaped shocks, and born home on the backs of men or donkeys. Carts are unknown, and only the wealthy own horses. The old primitive method of threshing is used. The cereal to be threshed is spread out on a flat place. Oxen or donkeys, which have been muzzled, are driven round a pole in the middle, and in this way the kernels are trampled or shaken out. A winnowing-shovel is used to separate the chaff from the grain. It is tossed into the air on a windy day. The chaff is blown out, and the grain falls to the ground.

Cereals are ground in an old-fashioned way, between two stones or in a hollow in the rock where a large stone is rolled over and over the kernels. Sometimes the inhabitants have a little water-mill, located where the brook leaves the mountains, and driving an horizontal mill-stone.

Further information on agriculture cattle-breeding, tools, utensils, etc., may be found in OLUFSEN's book, "Through the unknown Pamirs".

Among the trees growing in the cultivated part of the country, the apricot, (*Armeniaca vulgaris*), is the most important. The fruit is not only eaten in the autumn, but dried for winter use. The white mulberry, (*Morus alba*), is also common in the western part. This fruit is dried and ground to powder which is used as sugar. *Populus balsamifera*, and *Salix alba* are also seen. Rose-bushes and *Hippophaës* grow between the houses and the gardens. Flowers are sometimes cultivated. I have seen *Callistephus chinensis*, *Tagetes erectus*, *Ipomaea purpurea*, *Chrysanthemum coronarium*, *Calendula officinalis*, *Malva mauritanica*, *Amarantus sp.*, and *Dracocephalum moldavica*. Weeds abound everywhere in the cultivated land. The fields present a sorry spectacle indeed. The common corn-thistle, *Cirsium arvense*, is the commonest and most harmful weed, but beside this there was a quantity of weeds, mostly European: *Chenopodium Botrys* and *album*, *Capsella Bursa Pastoris*, *Polygonum aviculare* and *lapathifolium*, *Setaria viridis*, *Malva verticillata*, *Lepyrodiclis holosteoides*, *Lepidium latifolium*, *Centaurea repens*, *Bromus tectorum*, *Anchusa arvensis*, *Melilotus officinalis*, *Crepis corniculata*, *Eragrostis minor*, *Elsholtzia densa*, *Sonchus oleraceus*, *Mulgedium tataricum*, *Hordeum secalinum*, *Lycopus europaeus*, *Medicago lupulina*, *Salsola collina*, *Euphorbia Esula*, *Solanum nigrum*, *Phragmites communis*, *Vaccaria segetalis*.

CHAPTER 11

Goran and Shugnan.

At Ishkashim the Pändsh river changes its direction and makes a bend toward the north. The southern portion of the country through which it flows is known as Goran, the more northern, Shugnan. Our way led in September—October to Chorock, a village near the outlet of the Gund into the Pändsh. Here we went into winter quarters. The northern section of the Pändsh valley, as far as Kala-i-Wamar in Roshan, we have only seen at Christmas time, 1898, when everything was covered with deep snow.

The following remarks apply only to the Pändsh valley from Ishkashim to Chorock, a distance a little under 100 km. My notes are scanty and insufficient, for the journey — I was alone on this stretch, — was made in haste and the autumn was well advanced.

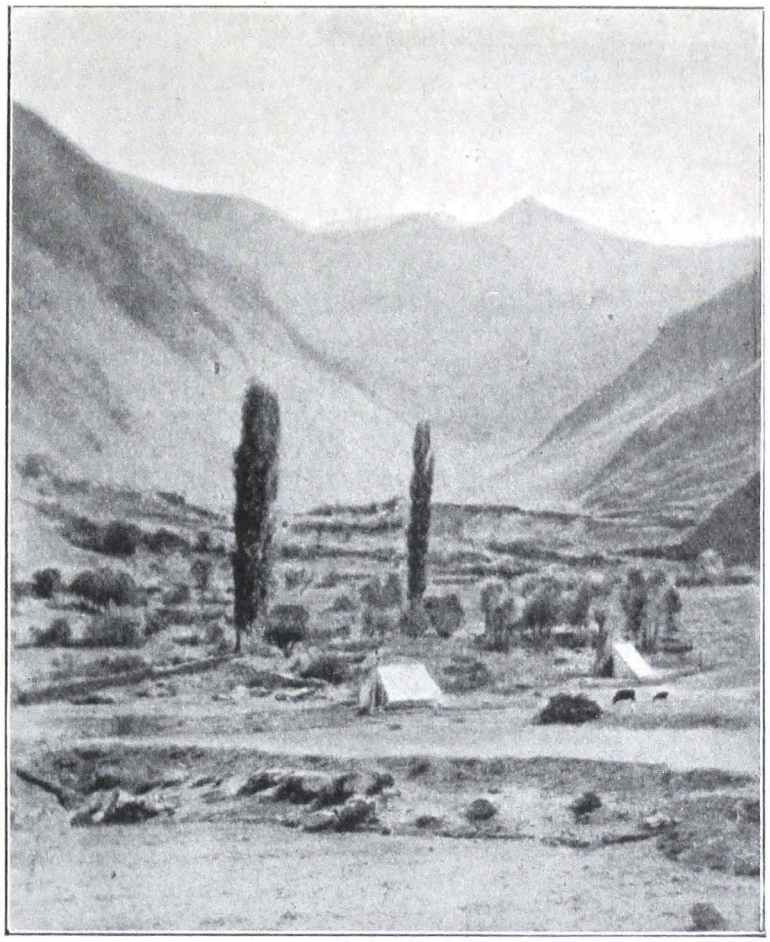
Between Ishkashim, where the Hindu-Kush chain turns off toward the south, and Chorock, which lies 2047 mètres above sea-level, the Pändsh river falls 702 m per 100 km. The fall is here more than twice the fall between Langarkish and Ishkashim, and, following the river, one is immediately aware that the stream is far swifter than in Wakhan. Most of the way here are rapids churning and foaming along between high, precipitous wall of rock. The valley, which according to Olufsen is about 2,500 mètres deep, is rather broad in the south but becomes very narrow toward the north. Here and there in the southern part thickets are seen, but no drifting-sand. Passage was often difficult, the paths were narrow, leading up and down steep slopes. North of Anderab it was either necessary to cross a high steep pass, — this was the only way for the horses, — or let one's self down through an aperture between a fallen boulder and the mountain-side, and then on all-fours crawl down an almost perpendicular wall where cracks afforded a slight foothold, and the river foamed below. Since then the Russians have built a bridle-path.

Along this stretch the river has but few tributaries, only one of any great size, Garm Chasma Daria, coming from the east.

The change from Wakhan to Goran was very great; — also from a botanical point of view. In the first place the altitude constantly diminishes, but, even more important, — there is a different exposure. The direction of the valley is now south-north, the western wind is shut off, the weather is almost calm, — and travelling along the right bank of the river, we have mountains with a western exposure. As far as we could tell the vegetation on these slopes was fare more abundant than in Wakhan, and comprised for the most part quite other species.

The extremely scanty, dry vegetation of the mountain-slopes in Wakhan is replaced here in Goran, by a more vigorous growth of denser and greener plants. In some places there were small thickets of wonderfully luxuriant, almost sub-tropical vegetation. The most common species of plants in the drier parts of the mountain-slopes are, *Artemisia herba alba*, a close bushy green *Ephedra* (*nebrodensis?*), *Cousinia Nemesskyana*, a tall *Echinops* (*xanthacanthum?*), *Lindelofia anchusoides*, and *Astragalus lasiosemius*. The latter is a spinous dwarf-bush; the others are hemicryptophytes with no decided xerophilous character. *Arenaria Meyeri*, known from up in Pamir, was found high up in the mountains near Kuh-i-lal. In wetter localities the beautiful hemicryptophyte, *Incarvillea Olgae*, 2 mètres high, bearing ripe fruit, a *Verbascum*-species, the recumbent, broad-leafed *Cissus aegirophylla, Impatiens parviflora, Geranium collinum, Mentha longifolia, Arctium Lappa*, large, 2—3 mètres tall, Umbelliferae, quite withered, and many bushes, were all common. These latter were mostly to be found in the river-valley or its neighbourhood or near brooks, and included: *Colutea persica, Halimodendron argenteum, Crataegus pinnatifida var. garanica, Cotoneaster multiflora, Lonicera Xylosteum, Hippophaës, Berberis sp., Rosa sp.*, and willows. In the northern part of Goran, near Anderab, the higher slopes of the mountains are dotted with dark patches, formed by small trees or bushes of *Juni-*

perus chinensis, standing apart from each other. I have never seen them close enough together to warrant calling them a thicket or wood. The thickets along the river-valley resemble those in Wakhan: *Hippophaës*, willows and *Clematis* are the most important species found in them, but in many places



(O. Olufsen *fot.*

Fig. 29. The camp of the expedition at Kuh-i-lal.

Cynanchum acutum and *Cuscuta reflexa var. grandiflora* are common.

In so far as the advanced season of the year permitted us to judge, the plants cultivated near the villages were the same as in Wakhan. By degrees others appeared, Cotton, (*Gossypium herbaceum*) was only cultivated in northern Goran, the village of Piesh is the highest point, where I have seen it growing. "Misfar", *Carthamus tinctorius* was cultivated here and there, all the way from Ishkashim, whereas "Kindjit", (*Sesamum indicum*), and "Mash", (*Phaseolus Mungo*), were only

grown in northern Goran and in Shugnan. The fruit-trees cultivated, included white mulberries, apricots, peaches, apples, walnuts and "Sisd", *Elaeagnus hortensis*, whose mealy fruit is much eaten. In Shugnan, (Chorock), there were cherry-trees.

CHAPTER 12

Hot Springs in Goran.

While in Wakhan we visited the hot springs near Zunk, Sirgyn and Barshar. These have been described by OLUFSEN. The algae found in them and in fact all algae collected on the expedition, were in the hands of a specialist for a long time without being determined, when finally sent to another, the war came and interfered. I am sorry to say that at the present time therefore I am unable, to give facts concerning the algae-vegetation of the hot springs.

In October, the expedition visited Garm tshasma (= hot spring), which lies east of Anderab in Goran. Here are enormous hot well-springs, likewise described by OLUFSEN, and after him by SCHULTZ who visited them in 1909. This latter scientist discovered that many changes had taken place in the 10 years which had elapsed since the Danish expedition visited the springs. This is why my notes, which were made on the spot are given here. They supplement those of OLUFSEN, and are being published, so that in time they may serve as a basis for comparison.

The springs lay on the north side of Garm-tshasma river-valley, which has its main direction, east-west. They were visible at a great distance by the white masses of sinter, (calcareous tuff), which sloped down toward the west. Their basins were filled with blueish water. Steam and penetrating fumes of sulphur revealed the presence of the springs. SCHULTZ has published a good photograph of them.

There were at least 10 well-springs lying in a straight line (see the chart fig. 30) with direction east-west, and nearly parallel with the southern border mountains of the Garm-

tshasma River valley, which had the direction N. 65° V.[1]) The description begins from the east.

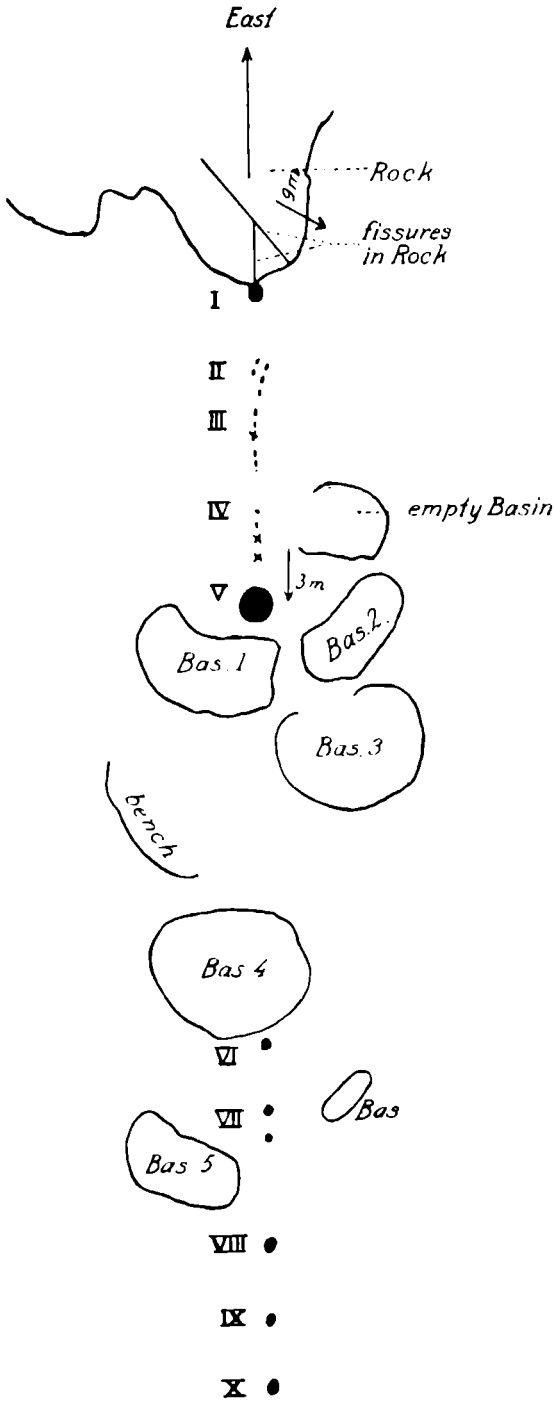


Fig. 30.

Northeast of the present springs, with their glittering white and yellow sinter deposits, lie 3 distinct, ancient disintegrated, sinter cliffs. I estimated the one furthest to the rear to be about 30 mètres in height and 150 mètres in length. The most eastern of the springs now active (I), gushes out of the western slope of a sinter cliff, whose upper edge was about 9 mètres above the enclosed "yard" (see below), at a height of 1—5 mètres above the bottom of the "yard". The spring was plainly seen issuing from a crack in the sinter, having the direction east-west, and this crack was contiguous with another, having a northwesterly direction. The temperature of the spring was 53° C; there was plenty of water but it did not bubble. The water had formed a white sinter shelf, which sloped toward the west, and had worn a furrow in the upper end. Further down it branched out in several arms and flowed down to the "yard", constantly depositing white sinter and a little yellow sulphur.

[1]) Olufsen, through an error in print, gives N. 35° V.

The "yard" is thus called, because enclosed by the natives with a stone-wall. Within this was (II) 8 or 9 small springs, (each one might gush forth at several points; only a few millimètres distant from each other). They are merely small holes but there were also the remains of an old crater, 16 cm in diameter, 4 cm high. Several sources are now dry. The temperature of these small springs was $54^{0}.9$, $46^{0}.0$, $45^{0}.8$, $46^{0}.0$, $55^{0}.0$, $55^{0}.5$, $56^{0}.0$, $55^{0}.0$, $53^{0}.0$, $53^{0}.0$, $53^{0}.0$. They all deposit sulphur and white stone "petrified water", as the natives call it.

III (on the chart) consists of three large bubbling springs with 10—15 cm between each, and 2—3 very small springs which also bubble. They are located on the ridge of a sinter hill with steep slopes on both sides. The middle one of the three larger springs has a crater 6 cm high and 8 cm in diameter, open toward the west. This spring works less regularly than the others. It bubbles for a while, rests, begins again etc. The others bubble continually; the temperature of the large springs was $47^{0}.0$, $52^{0}.0$, $49^{0}.0$, of the small $49^{0}.0$, $39^{0}.0$.

IV is located on the ridge of the same hill. It comprises two rather small, irregularly bubbling springs; their temperature was $31^{0}.0$, $31^{0}.5$, but in a little by-hole near one of them, it was 45^{0}. Just westward lay two dried out holes.

V is a large well-spring, the largest of all the springs. The water spouts straight up into the air about 12 cm. It gushes out 3 mètres deeper down than IV and lies at the foot of a steep sinter slope. There are four source-openings with about 10 cm between each. Each of these openings comprises several smaller ones with only a few cm between. The temperature is $58^{0}.2$, $57^{0}.5$, $58^{0}.8$, $59^{0}.2$. The water flows down over a billow-furrowed shelf, whose upper edge was above 2 mètres above the surface of basin 1, and into 4 basins (1—4) with lovely billowy edges. The water in the basins, when seen from above, had a wonderful clear greenish-blue colour. 1. was 30 cm deep; there was white mire at the bottom. The temperature of the water was 41^{0}, that of 2. was 42^{0}, of 3. 35^{0}, of 4. 25^{0}, of 5. 25^{0}. Between basin 3 and 4 there was a crack in which water with a tempera-

ture of 40°, was bubbling. An outlet drain was cut into the edge of 1 and the groove between 3 and 4 was artificial. The natives used the springs for bathing and attributed healing powers to the water.

VI was a little spring on the slope from basin 4. It was inacessible.

VII had two source-holes, with a temperature of 37° and 58°. There was white sand in the latter and sulphur in the former. The spring bubbles and scolds; rising perpendicularly a slight distance. The water flows into basin 5, which lies about 3 mètres below basin 4. Between VII and VIII there are many minor springs on a straight line.

VIII is a well-spring, sending streams of water, 30 cm long, horizontally out of the side of a hill. Its temperature is 59°.0. It is larger than IX and X which are also well-springs. They were inacessible.

LITERATURE

BONNIER, GASTON: Recherches expérimentales sur l'adaptation des plantes au climat alpín. (Annales des sc. nat. Bot. 7 sér. 20.) 1894.

—: Les plantes arctiques comparées aux mêmes espèces des Alpes et des Pyrenées. (Rev. gén. de bot. 6.) 1894.

BØRGESEN, F.: Bidrag til Kundskaben om arktiske Planters Bladbygning. (Bot. Tidsskrift 19.) Kjøbenhavn 1895.

COWLES, H. C.: The ecological relations of the vegetation of the sand-dunes of lake Michigan. (Bot. Gazette 27.) Chicago 1899.

DU RIETZ, G. E., FRIES, TH. C. E., TENGWALL, T. Å.: Vorschlag zur Nomenklatur der sociologischen Pflanzengeographie. (Svensk botanisk Tidsskrift 12.) 1918.

DUTHIE, J. F.: A list of the plants collected on the Pamirs. (in Alcock, A. W.: Rep. on the natural history results of the Pamir boundary commission). Calcutta 1898.

FEDTSHENKO, B. A.: Sketch of the vegetation of the Pamirs, Shugnan and Alai. (In Russian with German resumé.) (Trudy Imp. St. Petersb. Obsh. Jestestvopit. 33.) 1902 (?).

—: Pamir i Shugnan (P. and S.) (In Russian). (Imp. Russk. geogr. Obsh.) St. Petersburg 1902.

—: Contributions to the flora of Shugnan (In Russian). (Trav. du musée bot. de l'ac. Imp. des Sc. de St. Pb. I.) 1902.

—: Letters from Pamir and Shugnan. (Bull. du jard. Imp. bot. de St. Pb. IV.) 1905.

—: Second voyage au Pamir (Lettres de voyage). (Bull. Herb. Boissier 2. sér. VI.) 1906.

FEDTSHENKO, OLGA: Pamir plants, collected in 1901 by B. A. and O. A. Fedtshenko (In Russian). (Mat. k. posnan. fauni i flori Rossijskago Imp., otd. botan. No. 5.) Moskva 1903.

—: Flore du Pamir (Acta horti Petrop. 21). 1903. — Supplem. I (ibid. 24), 1904; II (ibid. 24), 1905; III (ibid. 28), 1907; IV (ibid. 28), 1909.

—: A key to Pamir plants (in Russian) (ibid. 28). 1907.

FICKER, H. v.: Zur Meteorologie von West-Turkestan. (Denkschr. d. kais. Akad. d. Wiss., math.-nat. Cl. 81.) Wien 1908.

Friederichsen, M.: Forschungsreise in den zentralen Thiën-schan und Dsungarischen Ala-tau im Sommer 1902. (Mittheill. d. geogr. Gesellsch. Hamburg XX.) 1904.

—: Russich Zentralasien. (Peterm. Mitth. 61.) 1915.

Geiger, W.: Die Pamir-Gebiete. (Geogr. Abhandl., herausgeg. von A. Penck. Bd. II H. 1.) Wien 1887.

Hartz, N.: Østgrønlands Vegetationsforhold. (Medd. om Grønland 18.) Kjøbenhavn 1895.

Hauri, Hans: Anabasis aretioides Maq. et Coss., eine Polsterpflanze der algerischen Sahara. (Beih. zum Bot. Centralbl. 28. Abt. 1.) 1911.

Hauri, Hans, u. Schröter, C.: Versuch einer Übersicht der siphonogamen Polsterpflanzen. (Bot. Jahrb., herausgeg. v. A. Engler, 50.) 1914.

Hjuler, A.: Measurements of the electric tension of the air. (The second danish Pamir Exp. conducted by Olufsen.) Copenhagen 1903.

—: The languages spoken in the western Pamir (Shugnan and Wakhan). (ibid.) Copenhagen 1912.

Iwanow, D. L.: A short account of geological researches in Pamir. (In Russian.) (Isvestija imp. geogr. obs.) 1884 (?).

—: Orographischer Charakter des Pamir. (Peterm. Mittheil. 31.) 1885.

Jónsson, Helgi: Floraen paa Snæfellsnæs og Omegn. (Bot. Tidsskrift 22.) København 1899.

—: Vegetationen paa Snæfellsnæs. (Vidensk. Medd. naturh. Forening.) Kjøbenhavn 1900.

Keller, B. A.: In Berg und Thal des Altai. I. (In Russian, w. German resumé.) Kasan 1914.

Korshinsky, S: Sketches of the vegetation of Turkestan. (In Russian.) (Mém. Ac. Imp. Sc. St. Pétersbourg 8. sér. 4). 1896.

Köppen, W.: Versuch einer Klassifikation der Klimate. (Geogr. Zeitschr. 61.) 1901.

Lipsky, W. J.: Mountain-Bokhara. Results of 3 years travellings in Inner Asia. I—III. (In Russian.) St. Petersbourg 1902—1905.

—: In the mountain regions of Russian Turkestan (In Russian.) Iswest. Imp. russkago geogr. obs. 42). 1906.

Lothelier, A.: Recherches sur les plantes à piquants. (Rev. gén. de bot. 5.) 1893.

Mac Dougal, D. T.: Botanical features of North American deserts. (Carnegie Inst. publ. No. 99.) Washington 1908.

Mushketow, J. W.: Turkestan I. (In Russian.) St. Petersburg 1886.

Olufsen, O.: Den danske Pamir-Expedition. (Geogr. Tidsskrift 14.) Kjøbenhavn 1898.

—: Über die dänische Pamir-Expedition im Jahr 1896. (Verhandl. d. Ges. f. Erdk. z. Berlin.) 1897.

—, with Hjuler, A., and Paulsen, O.: Den anden danske Pamirexpeditions Vinterstation 1898—99. (Geogr. Tidsskrift 15.) 1899.

—: Den anden danske Pamir-Expedition. Foreløbig Beretning om nogle Arbejder foretagne i Alitshurpamir (ibid.) 1900.

OLUFSEN, O.: Die zweite Dänische Pamir-Expedition. (Verhandl. d. Ges. f. Erdk. z. Berlin.) 1900.

—: Pamir. Alaisteppen, den afløbsløse Sø Kara Kul i det øde Ørken-Pamir og Ruten over Bjærgene mod Syd til Murghabfloden. (Geogr. Tidsskr.) 1902?

—: Meteorological observations from Pamir 1898—99. (The second Danish Pamir expedition.) Copenhagen 1903.

—: Through the unknown Pamirs. The second danish Pamir expedition 1898—99. London 1904.

—: A vocabulary of the dialect of Bokhara. (ibid.) Copenhagen 1905.

—: Gennem Pamir. Rejser i Verdens mægtigste Bjærglande. København 1905.

—: The Emir of Bokhara and his country. Copenhagen & London 1911.

OSTENFELD, C. H.: Skildringer af Vegetationen i Island. III—IV. (Bot. Tidsskr. 27.) 1905.

—, og LUNDAGER: List of vascular plants from North-east Greenland (N. of 76° N. Lat.). (Danmarks-Exp. til Grønlands Nordøstkyst.) (Medd. om Grønland 43.) København 1910.

PAULSEN, OVE: Træk af Vegetationen i Transkaspiens Lavland (Thesis). (Bot. Tidsskrift 32.) København 1911.

—: Studies on the vegetation of the Transcapian lowlands. (The second Danish Pamir exp.) Copenhagen 1912.

—: Systematic papers, see the introduction.

PORSILD, M. P.: Bidrag til en Skildring af Vegetationen paa Øen Disko (Résumé en français). (Medd. om Grønland 25.) København 1902.

RAUNKIAER, C.: Types biologiques pour la géographie botanique. (Bull. Acad. sc. & lettres de Danemark 1905.) Copenhague 1905.

—: Livsformernes Statistik som Grundlag for biologisk Plantegeografi. (Bot. Tidsskr. 29.) København 1908. Translated in Beih. Bot. Centralbl. 87. 1910 ("Statistik der Lebensformen als Grundlage für die biologische Pflanzengeographie").

—: Formationsundersøgelse og Formationsstatistik. (Bot. Tidsskr. 30.) København 1909.

—: Recherches statistiques sur les formations végétales. (Kgl. danske Vidensk. Selsk. Biol. Medd. I.3). København 1918.

—: Über das biologische Normalspektrum (ibid. I.4). 1918.

RICHTHOFEN, FREIHERR. VON: China. Berlin 1877—1883.

ROMANOWSKI, G., et MOUCHKETOW, J.: Carte géologique du Turkestan russe, dressée en 1881. St. Pétersbourg 1886.

ROSENVINGE, L. KOLDERUP: Det sydligste Grønlands Vegetation (Résumé en français). (Medd. om Grønland 15.) Kjøbenhavn 1897.

RÜBEL, E.: Pflanzengeographische Monographie des Berninagebietes. (Englers bot. Jahrbücher 49). Berlin 1913.

SCHRÖTER, C.: Das Pflanzenleben der Alpen. Zürich 1904—08.

SCHULTZ, ARNOLD: Landeskundliche Forschungen in Pamir. (Abh. d. Hamburg. Kolonialinst. 33, Reihe C.) Hamburg 1916.

SEMENOW, M. P. DE: La Russie extraeuropéenne et polaire. (Commission imp. de Russie à l'expos. univ. de 1900.) Paris 1900.

SPEIGHT, R., COCKAYNE, L., and LAING, R. M.: The mount Arrowsmith district; a study in physiography and plant ecology. (Transact. N. Zealand inst. 43, 1910.) Wellington 1911.

STEFANSSON, ST.: Fra Islands Vækstrige. II. (Vidensk. Medd. fra d. naturhist. Foren. i Kjøbenhavn 1894). Kjøbenhavn 1895.

WAGNER, A.: Zur Kenntniss des Blattbaues der Alpenpflanzen und dessen biologischer Bedeutung. (Sitzungsber. d. kais. Akad. d. Wiss. in Wien, Math.-Nat. Cl. 101.) Wien 1892.

WARMING, EUG.: Om Grønlands Vegetation (Résumé en français). (Medd. om Grønland 12.) Kjøbenhavn 1888. Abridged in Englers Jahrb. 10. 1889 ("Über Grönlands Vegetation").

—: Plantesamfund. Grundtræk af den økologiske Plantegeografi. Kjøbenhavn 1895.

—, assisted by M. WAHL: Oecology of plants. Oxford 1909.

— und P. GRÄBNER: Eug. Warmings Lehrbuch der ökologischen Pflanzengeographie. Dritte umgearb. Ausgabe. Berlin 1918.

—: The structure and biology of arctic flowering plants, edited by (Medd. om Grønland 36, 37). Copenhagen 1905—16.

SOME OF THE ANIMALS COLLECTED BY THE EXPEDITION IN PAMIR

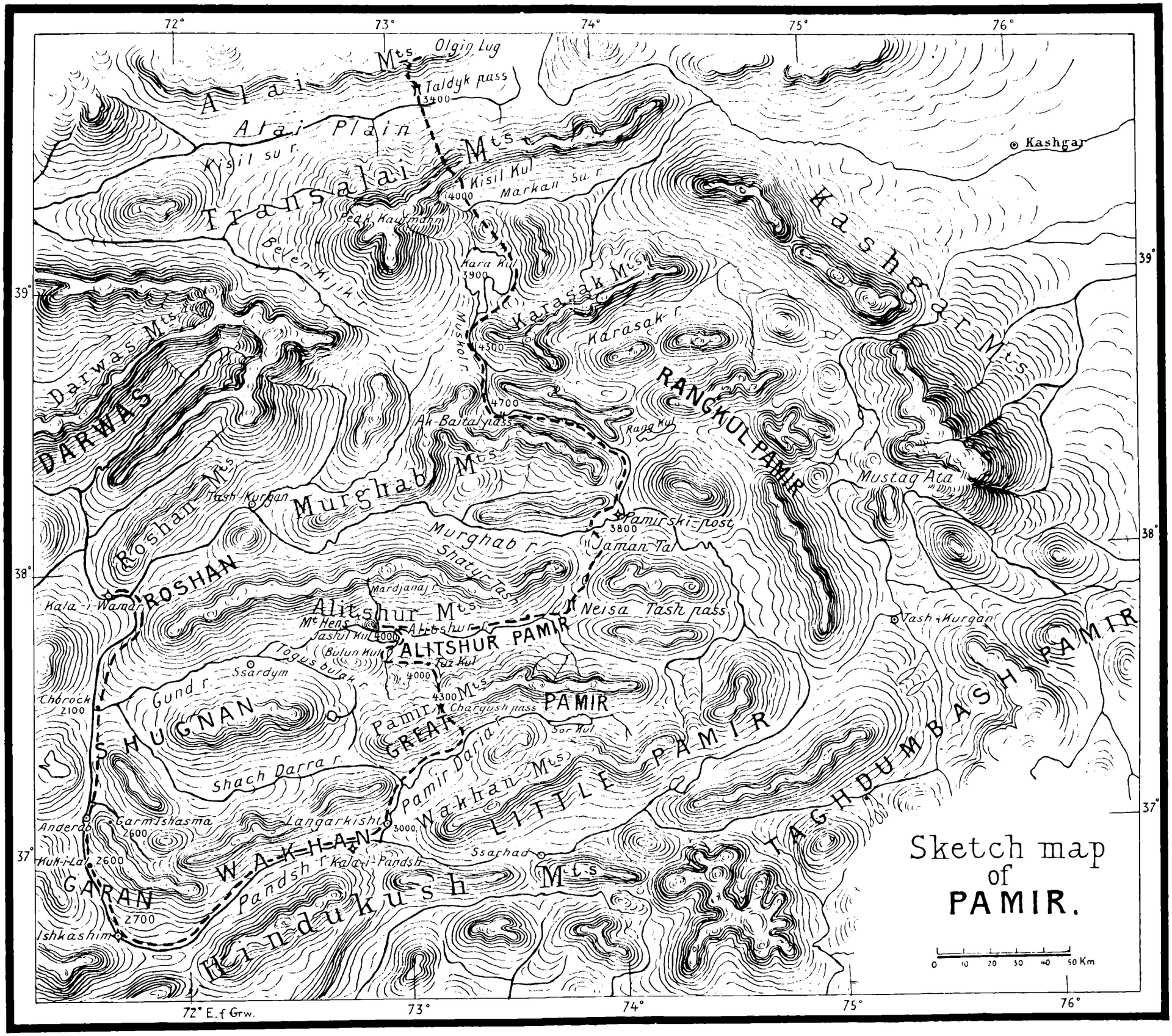
(Identified by the zoological museum of Copenhagen.)

Crocidura aranea (Schreb.)	Shugnan.
Mustela erminea L.	Shugnan.
— alpina Gebler	Shugnan.
Lepus tolai Pall.	Shugnan.
Capra sibirica Meyer	Jashil Kul.
Ovis poli Blyth	Murghab.
Canis vulpes L.	Shugnan.
Cricetus arenarius (Pall.)	Jashil Kul, Wakhan.
Arvicola tiauschanicus (Büchner)	Jashil Kul.
Ellobius talpinus (Pall.)	Sary Tash.
Mus musculus L. (wild-coloured)	Shugnan.
— sylvaticus L. (yellowish)	Wakhan.
— — (typical)	Shugnan.

Anas querquedula L.	Goran.
Tadorna casarca (L.)	Jashil Kul.
Caccabis saxatilis (Meyer)	Shugnan.
Totanus glareola (Gmel.)	Jashil Kul.
— glottis (L.)	Jashil Kul.
— calidris (L.)	Jashil Kul.
Sterna hirundo L.	Jashil Kul.
Phalacrocorax carbo (L.)	Bulung Kul.
Haliaëtus leucoryphus (Pall.)	Jashil Kul.
Circus aeruginosus (L.)	Wakhan.

Motacilla citreola Pall.	Jashil Kul.
— flava L. (?)	Jashil Kul.
Passer domesticus (L.)	Shugnan.
Tropidonotus tessellatus (Laur.)	Shugnan.
Bufo vividis Laur	Jashil Kul.
Schizothorax	Jashil Kul.
Schizopygopsis	Murghab.
—	Jashil Kul.
Nemachilus stoliczkae (Steind.)	Jashil Kul.
Gymnocypris	Jashil Kul.
Cyprinoid	Jashil Kul.

The lower animals have not been determined. They are in the possession of the zoological museum.


72°
73°
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76°
39°
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37°
Alai Mts
Olgin Lug
Taldyk pass
3400
Alai Plain
Kysil sur r.
Transalai Mts
Kisil Kul
4000
Markan sur r.
Peak Kaufmann
Beleu Kul r.
Kara Kul
3900
Muskol r.
Karasak Mts
Karasak r.
4300
4700
Ak-Baital pass
Rang Kul
RANGKUL PAMIR
KASHGARIA Mts
Kashgar
Darwas Mts
DARWAS
Roshan Mts
Tash-Kurgan
Murghab Mts
Murghab r.
Shatyr Tash
Pamirski-post
3800
Jaman Tal
Mustag Ata
ROSHAN
Kala-i-Wamar
Mardjanaj r.
Alitshur Mts
Mt Hens
Alitshur r.
Neisa Tash pass
Tash-Kurgan
Jashil Kul
4000
ALITSHUR PAMIR
Bulun Kul
Tuz Kul
4000
Togus bulak r.
Ssardym
Gund r.
Chorock
2100
SHUGNAN
4300
Mts
Pamir r.
Chargush pass
PAMIR
GREAT
Sor Kul
Shach Darra r.
Pamir Daria
Wakhan Mts
LITTLE PAMIR
TAGHDUMBASH PAMIR
Anderab
Garmtshasma
2600
Langarkisht
3000
W-A-K-H-A-N
Kala-i-Pandsh
Pandsh r.
Kuh-i-Lal
2600
GARAN
2700
Ssarhad
Hindukush Mts
Ishkashim
0 10 20 30 40 50 Km
Sketch map
of
PAMIR.
72° E.f Grw.