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Further Exploration in the Tian-Shan Mountains

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Source: *The Geographical Journal*, Vol. 31, No. 4 (Apr., 1908), pp. 395-400

Published by: geographicalj

Stable URL: <http://www.jstor.org/stable/1777843>

Accessed: 27-06-2016 02:26 UTC

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Sikhim Himalayas, namely, the evidence of an elevation of the whole mountain group at a recent date. The rivers here also appear to have received additional erosive power so as to enable them to cut those wonderful gorges, some of which, I think the author said, were 1700 feet deep. The fact that they have not been widened by atmospheric agents points conclusively to their very recent origin. The retreat of the glaciers shown also in this district is another point of great interest. The presence of "hanging" valleys occurring in the main valleys themselves is a most suggestive phenomenon, and one to which I recently called attention in the Alps. It is very instructive to find the same thing here, proving again that glaciers must, till recently, have protected their beds from the downward erosion by water such as took place in the valley below the termination of the glacier. At this late hour I will only once more add my congratulations on this very admirable expedition.

Mr. FRESHFIELD: We have had a very interesting paper, followed by an interesting and important discussion, in which various points of scientific interest have been raised. I have already informally expressed the thanks of the Society to the reader of the paper, Dr. Longstaff.

Dr. LONGSTAFF: I am afraid I have not made it clear that I was not the leader of the expedition. We all three worked together to the best of our abilities, but if any one of us deserves the title it is Bruce. I will only mention one other matter: Graham's reference to the irreconcilability of his maps with the actual configuration of the country applies to the Rishi valley and not to anything that he saw from Kabru. I would add that our largest cameras were quarter-plate size, as every ounce has to be considered when coolies are not available.

FURTHER EXPLORATION IN THE TIAN-SHAN MOUNTAINS.*

By Dr. GOTTFRIED MERZBACHER.

THE rigour of winter has for some time interrupted my scientific pursuits and forced me to take up quarters here. I make use of the opportunity to communicate some particulars respecting the course of my expedition down to date.

My departure from Munich was made on April 17, 1907, in company with H.R.H. Prince Arnulf of Bavaria, who, chiefly for the sake of the big game abounding in their valleys, had determined to travel in the Tian-Shan. The impulse to the journey came chiefly from the Prince. The invitation to join him with which he honoured me was, however, all the more grateful to me inasmuch as I had for some quite considerable time been cherishing the wish to follow up my researches in the Tian-Shan, and as in a most generous manner His Royal Highness rendered the prosecution of my scientific pursuits practicable. Unhappily His Royal Highness, after a happy hunting expedition pursued without adverse incident of any consequence, and after his return in complete health to Europe, succumbed at Venice, on October 18 last year, to inflammation of the lungs. The early and unexpected death

* Dated "Kulja, February 9, 1908."

of my noble patron casts a dark shadow on an expedition which was entered on with such joyful expectations.

His Royal Highness and I passed into the heart of Asia by way of the Caucasus, Transcaspia, and Turkestan. In Tashkent we foregathered with the other partners of the expedition: Dr. Kurt Leichs as geologist; Francis Kostner, from Corvara in Tyrol, as guide, who had already accompanied me on a two years' journey through Tian-Shan; P. Rockinger as taxidermist; Francis Borgar, from Eisenerz in Styria, His Royal Highness's hunter. From Tashkent we travelled together through Semirechensk to Issik Kul lake, and thence to Kulja, where the expedition was organized and whence it took its departure.

The reasons inducing me to make a third journey into the Tian-Shan mountains rest on the consideration that, however rich the booty of observation heretofore gathered by me, it yet, on closer examination, seemed to me to supply but inadequate basis for my investigations into the history of the more recent development of the mountains. On the contrary, urgent necessity rather impelled me to draw within the compass of my observations the eastern parts of the central Tian-Shan, including the chains stretching farther to the east. The past year was devoted to the first part of this my programme. The expedition chiefly occupied itself with the exploration of the river-systems of the two greatest mountain rivers draining the northern slope of the central Tian-Shan,—Kok-Su and Agias. The valleys of these two mountain rivers, both of which, after flowing a very considerable length in longitudinal valleys, suddenly bend round and pass into transverse valleys, delivering their waters into the Tekes, had hitherto fallen more within the scope of sporting circles than within that of scientific explorers. English and more particularly Anglo-Indian hunters, allured by the abundance of game in these valleys, especially by the extraordinary size of the ibex and wild sheep of these regions, had repeatedly picked them out for the arena of their sport.

By my expedition, the hydrographic system of the two rivers and their most important tributaries were now investigated as far as their highest sources, including the glaciers, hitherto totally unknown, lying in the valleys at their sources. In this investigation special attention was paid to the structure and the composition of the mountains, as also to the causes of the peculiar valley formation. Not wishing to forestall the comprehensive report which is left in abeyance till after the close of the expedition, I should like here, in respect of the two river regions, only to state in brief that in extent they fall short of the glaciers of the great longitudinal valleys, Sary-Dokhas, Inylchek, etc. The biggest of them do not reach beyond $7\frac{1}{2}$ to $12\frac{1}{2}$ miles long. Their number and diffusion, on the other hand, are very great. In particular parts, too, of the region, glaciation is notable. The total extent of territory covered by firn and ice is far larger than I had expected. This covering lies

particularly thick in the upper regions of the headwaters of the Agias, as also in the region of the chains parting the Agias from the winding course of the middle Kok-Su. Some of the glaciers investigated are distinguished by uncommonly complicated structure. Such, *e.g.*, are those of the great valley of the Kopr-Sai, tributary to the Agias, and those of the Khaptu-Su valley belonging to the same river-system.

With respect to the geological structure of the territory examined, I confine myself to the statement that, as might be expected from the already published geological and palæontological results of my former expedition, no fundamental deviations indeed as to structure and geological composition come to light in that part of the Tian-Shan recently brought within the sphere of investigation, as compared with the regions before traversed. Yet withal there do spring into notice substantial differences concerning both the structure of the mountains and the distribution of the different kinds of rock. In this part also of the Tian-Shan the kernel of the mountain chain is a purely sedimentary one, and the highest watershed between north and south is formed by metamorphosed, presumably Lower Carboniferous limestones (marble, dolomite). In the system of the watershed, besides, a striking parallelism of structure becomes more and more evident. There is here, on the other hand, a far thicker distribution of certain eruptive rocks, more particularly of quartz, porphyries, and related rocks, and in part also of the younger porphyries, than in the western central parts of the mountains. Leaving out of account the great part which, in the formation of the thick series of crystalline slates, must be attributed to dynamo-metamorphic processes, the influence of contact-metamorphism exerted by the eruptive rocks on the surrounding masses of rock is, accordingly, beyond comparison more important. The participation, however, of the granite in the structure of the mountains, especially in the interior chains, here falls substantially short of that obtaining in the dominant conditions of the western part. The generally steep uplift of the layers and the predominance of the north-easterly trend constitute here, too, remarkable characteristics of the structure.

An unexpected distribution and uncommon thickness are attained by the recent formations (red conglomerates, clays, marls, and sandstones), characteristic of the Central Asiatic mountains, in the upper Kok-su territory, where they form independent chains rising to over 13,000 feet. Till, however, I have extended still farther east my observations of these sediments, I refrain from hazarding a conclusive judgment respecting the mode of formation. All the same, I should like even here to point out that it seems to me a mistake for any one to generalize too dogmatically in this matter. The more occupied I am in the examination of these formations, the more is borne in on me the conviction that they are not to be explained from a common origin.

On the contrary, the more do I become persuaded in reference to the mode of formation of these deposits, and in the face itself of their very varied character, that the deposits piled up in the interior basins of the mountains must be distinguished from those deposited in the great river-valleys, and these, again, from the recent formations deposited along the edge of the mountain system. Through extension of my observations to the eastern chains, I hope to be in a position to throw more light on this difficult problem.

Of unusual extent and in good preservation are the traces of the diluvial Ice age in many parts, visited by me, of the mountain system. Convincing evidence has also come to hand in favour of the opinion formerly pronounced by me ("An Expedition into the Tian-Shan Mountains"), that, in respect also of these mountains, several larger phases of revolution, with intervals of periods of retrogression, must be assumed. In Mus-tamas valley, *e.g.*, there lies over well-preserved old moraines diluvial grompholite; above this again thick moraine, which in its turn is next covered by more recent grompholite; and above these again are piled masses of moraine of the most recent Ice age. In the Saksan-Teke (tributary to the Kok-su) valley consolidated old moraine was found, ground smooth by advancing ice of a later period. In the Agias valley is seen a beautiful example of the sliding of younger moraine over older, whereby sand-clay deposit, intercepted between them, got dislodged in an extraordinary manner. Similar demonstrations offer themselves in plenty. Altogether, it would not be easy to find a spot where, in a manner more convincing than here, the explorer is, step by step, reminded how in great part the present configuration of the mountain system is due to powerful climatic oscillations, and how periods of great moisture and great drought have repeatedly alternated one with the other. Only under such conditions are to be satisfactorily explained the peculiarities of the valley formation of this region—its diversity, its manifold ramifications. To these conditions my observation was specially directed.

On the conclusion of my labours in the two great river-systems mentioned, I turned anew to the great Musart valley with a view to filling up certain gaps in my knowledge of this region. The more important lateral valleys, whose acquaintance I had missed making on a former occasion, were now looked up. The glacier system, again, of the uppermost basin of the valley enclosing wonderful ice-currents of exceedingly rich articulation, could this time be more minutely examined and sketched. In this way I shall also be enabled to adjust statements made respecting the course of certain glacier valleys radiating from the central massif, embodied in my former report of travels ("An Expedition into the Tian-Shan Mountains") and in the map accompanying it.

In the course and towards the conclusion of the year's expedition,

the opportunity has presented itself several times of turning greater attention than heretofore to the structure of the secondary chains extending from the river Tekes.

Unfortunately, the labours of the expedition were encroached upon and retarded to an uncommon degree by the weather of the past summer and autumn, wet and unfavourable beyond all precedent. Out of four summers passed in Tian-Shan this last was the most unfavourable. It will give a fair idea of the kind of weather dealt out to us if I remark that in the course of six months we had but nine days completely free from precipitation. Under almost exclusively west winds there came almost every day rain or snowfall. The whole period of glacier-melting is to be reckoned at hardly six weeks. Even at the beginning of July most of the glacier currents were readily crossable, and by the middle of August the water from the melted ice no longer offered any obstruction. Frequently in the middle of summer we were transported into truly winter landscape. By the middle of September winter set up in the mountains his stern rule, no longer subject to any relaxation, a rule which extended far down into the foothills.

It will be understood how, under such conditions, there can be no talk of a retreat of the glaciers. Almost everywhere the glaciers betokened stability; in some cases an inclination to advance. It needs but a few more of such years to induce a general advance of the glaciers of the mountain system. Exceptions from these conditions could be observed only in the territories at the upper waters of the Kurtai and the Jirgalan, where the glaciers were in decisively vigorous retreat. Further particulars on this subject I reserve for the later comprehensive report.

The abnormal weather did not rest confined to the high mountains. All over Semirechensk unusually heavy and continuous precipitations were experienced, with markedly lowered temperature. In high situations, as in Varynkol (Okhatnishi) and other places, the corn could not be led in. In many parts of Turkestan, too, an increase of precipitation has for a number of years been observed, especially in the past year. The following data I owe to the kindness of the director of the Tashkent Astronomico-Physical Observatory, Colonel Ossipoff:—

				Mean annual precipitation during the ten years ending Dec. 31, 1906.		In 1907.	
Sarmarkand ...	...	...	...	13·193 inches	...	19·528 inches	
Margelan ...	...	...	...	6·870	„	8·307	„
Aulieata ...	...	...	...	10·992	„	13·152	„
Kerki ...	...	...	...	5·349	„	9·912	„

The figures in the two last entries of the above table cover only eleven months, to the exclusion of December.

As appears from the notable investigations of L. S. Berg, the surface of the Aral, as also of Lake Balkhash, is steadily rising. Further data have since been obtained demonstrating the continuation of this ascending

movement, which involves also the Ala-Kul lake. It may, perhaps, be assumed that for Central Asia there has set in the beginning of a period of great precipitation, of a climatic oscillation, on the duration and importance of which nothing definite can of course yet be said. Here in Kulja, where I am compelled to put up for some time till it is again possible to travel, the course of the winter is abnormal. It began about the middle of October, a full month, namely, before its usual time, and it continues ever since with uninterrupted rigour and with extraordinarily abundant snowfall. The staff of the Belgian Mission Station, which has now been planted here for sixteen years, have no memory of any winter at all approaching this one in magnitude of snowfall. The snowy mantle has now a thickness of 5 feet, and since New Year the temperature oscillates between -4° and -18° Fahr., with extraordinarily violent and frequent barometric oscillations. My meteorological lists ought this time to contain quite peculiarly interesting data.

Dr. Leuchs having, in the beginning of December, begun his return journey, I hope, in the beginning of March, on the arrival of my new geological coadjutor, Dr. P. Groeber, to start once more for the mountains.

ON THE OBSERVATION OF DESERT SAND-DUNES.

By VAUGHAN CORNISH, D.Sc.

THE following suggestions for observations of desert sand-dunes have been formulated in reply to the letter of an intending traveller in North Africa. I have at various times been called upon for such notes by travellers proceeding to Australian, Indian, and other deserts, and it occurred to me, therefore, that such suggestions might be of use to other Fellows of the Society.

1. I think the most pressing thing in dune-study is the measurement transversely of a series of ridges of sufficient size to be called sandhills, *i.e.* such that the lower layers are compacted by weight, and possibly by moisture, although devoid of foreign binding material, such as, *e.g.*, redeposited carbonate of lime. The point is to ascertain if a series comprising many ridges will give an average ratio—

$$\frac{\text{Length from crest to crest}}{\text{Height from trough to crest}} = 18 \text{ (approximately).}$$

In the *Geographical Journal*, January, 1900, it will be seen that I found this to hold for *les dunes elementaires* (as, I think, French observers call them) when averaged up, this being the same ration as for each of the well-known æolian ripples of loose surface sand.

If several such cross-sections can be obtained in different localities,