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Publisher: Routledge

Informa Ltd Registered in England and Wales Registered Number:
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London W1T 3JH, UK

Scottish Geographical Magazine

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/rsgj19>

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Published online: 27 Feb 2008.

To cite this article: E. Delmar Morgan (1894) The mountain systems of central Asia, Scottish Geographical Magazine, 10:7, 337-352, DOI: [10.1080/00369229408732719](https://doi.org/10.1080/00369229408732719)

To link to this article: <http://dx.doi.org/10.1080/00369229408732719>

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THE SCOTTISH GEOGRAPHICAL MAGAZINE.

THE MOUNTAIN SYSTEMS OF CENTRAL ASIA.

By E. DELMAR MORGAN.

(*With a Map.*)

(*Read at a Meeting of the Society in Edinburgh, April 1894.*)

THE mountains of Inner Asia, though known from remote antiquity, are mentioned by early writers in a vague and legendary way: they were the abode of snow, the seat of the mighty god Indra; their crests were white as swans, their rivers of the purest crystal water in which the gods delighted to bathe; they shone like mirrors and glistened like the flowers of the lotus.¹ Such were some of the earliest notices in literature of the highlands bordering India on the north.

The Chinese, more practical, had accurate surveys made of all the regions brought under their control, and were at a very early date, about the commencement of the Christian era, well acquainted with the "Countries of the West." Orography, however, was never their strong point; and so ignorant were they of the relative heights of these regions, that they believed that the Tarim, or river of Kashgar, after losing itself in Lob-nor, re-appeared again at the sources of the Hwang-ho.²

In the accounts the Buddhist pilgrims of the sixth and seventh centuries have left of their travels, they speak of the mountains in a general way, applying to them the terms "black" and "white," according as the ranges were bare or covered with snow; and it is difficult to trace their routes with certainty.

Turning to the Greeks, we find in Herodotus³ a fabulous tale of a

¹ Carl Ritter, *Erdkunde von Asien*. Russ. ann., ed. by Semeonof, vol. i. p. 28.

² Georg Wegener, *Die Entschleierung der unbekanntesten Teile von Tibet*, p. 6.

³ Canon Rawlinson's *Herodotus*, vol. ii. p. 505.

plain in Asia which is shut in on all sides by a mountain range, and in this mountain range are five openings. A mighty river called the Aces flows from the hills enclosing the plain, and formerly this stream, splitting into five channels, ran through the five openings in the hills and watered the lands of the five nations which dwelt around. The great king of the Persians came and conquered this region, and then it went ill with the people, for the great king blocked up all the passages between the hills with dykes and floodgates, and so prevented the water from flowing out. If the Aces may be identified with the Oxus, as some have conjectured, and the five channels with the five head-streams of this river, the story told by Herodotus, whether founded on fact or not, would serve to illustrate what might happen to the inhabitants of the plains of Turkistan in the event of their water-supply being stopped by the erection of dams at the mouths of the tributary streams of their river.

From Herodotus down to modern times no writer has approached the subject in a scientific spirit, and, with but few exceptions, little information of a precise nature concerning the mountains of Central Asia is to be found in ancient literature. One such exception, however, must be noted in the case of Mirza Haidar, a prince of Kashgaria and a connection of Sultan Baber. His description of the mountainous region round his native place shows, as the late Mr. Robert Shaw remarks,¹ that he was able to rise above details and conceive a general idea—a rare faculty among Orientals. Mirza Haidar's account, written three centuries ago, agrees very well with the explorations of the Forsyth Mission.

The first great impetus to the study of orography was due to Humboldt, who published in 1843 his classical work *Asie Centrale*. It was at his suggestion that the British Government sent the brothers Schlagintweit in 1856 to explore the region north of the Himalayas. In his anniversary address to the Royal Geographical Society,² Sir R. Murchison says of these travellers that they were the only geographers to visit those localities and sustain what Humboldt had affirmed, "that his Kuen Luen presents all the characteristics, relations, and attributes of an independent chain."

Humboldt, whose travels in the cordilleras of the Andes and many years of fruitful study had led him to very advanced views on physical geography, argued by analogy that Asia was filled with a whole system of distinct ranges, four of these—the Altai, the T'ian Shan, the Taurus, and the Himalaya—lying parallel to the Equator, and a fifth, the Bolor-tag, parallel to the meridian; this last continuing the north to south direction of upheaval of the Suliman and Ural chains. Ritter and his school of geographers upheld the theory of great protuberances of the earth's crust, forming wide mountainous tracts in which short ranges held a subordinate place.

¹ *Journal R.G.S.*, vol. xlv. An English translation of Mirza Haidar's work is now in course of preparation.

² *Journal R.G.S.*, vol. xxviii.

These views, founded on an imperfect acquaintance with the physical geography of Central Asia, exercised a great influence on the books and maps of the first half of the present century, and it was not till actual exploration was taken in hand that they were corrected.

Before alluding to the advance in our knowledge of High Asia, mainly due to Russian explorers, let us say a few words on Baron von Richthofen's great work, *China*.

This was the first attempt since Humboldt's time to systematise the geography of Central Asia, and define in a clear and comprehensive way the directions of the principal chains. In the course of his travels in the central provinces of China the author had collected a large number of facts and observations. He found, however, that to explain satisfactorily the physical geography of China it was necessary to extend the scope of his inquiry so as to include Central Asia. Hence the first chapter of *China* is wholly devoted to a masterly treatise on the past and present physical conditions of the interior of the continent.

Richthofen defines the term "Central Asia" to mean that region where the waters collect in inland basins having no outlet to the ocean, and where the long continuation of such waterspreads has given rise to special phenomena. This continental region extends from the highlands of Tibet on the south to the Altai on the north, and from the Pamir watershed on the west to the Khingan range and the great rivers of China on the east. It is connected by the bridge of the Hindu Kush with the Aralo-Caspian basin on the west. But this last, as well as the separate lake basins in other parts of Asia and Asia Minor, are not included in his "Central Asia." Those parts of Asia where the drainage reaches the sea he styles the periphery, and, lastly, between the inner basin and the periphery he distinguishes an intermediate zone in the transitional stage, where in recent times the flow has changed from inwards to outwards, or *vice versa*. The important difference between the central basin and the periphery consists in the fact that, while *there* all the products of the latest geological periods proceeding from chemical decomposition and mechanical disintegration of rocks have remained in the country, *here* they have been carried to the sea; and the deposition of solid matter, *there* sub-aërial, *here* took place with the aid of running water.¹

Richthofen further shows that "Central Asia" formed the bed of an ancient sea in the Cretaceous or Tertiary period. This sea, occupying the whole of what is now known as Chinese Turkistan, part of Mongolia and the Gobi, is the Han-hai (or desiccated sea) of the Chinese, whose traditions speak of a sea having once existed here. Its area, within the limits assigned to it by Richthofen, may be compared with the Mediterranean. M. Mushketof, a Russian geologist, assigns to it an even wider expanse, and would include the so-called Turanian or Turkistan region in the Han-hai; for recent geological researches tend to show that the Aralo-Caspian plains were submerged in Tertiary times, and were connected with the Tarim basin on the one hand by the Straits of Dzungaria and with the Northern Ocean on the other, and that the gradual disappearance of

¹ *China*, i. pp. 7, 8.

both seas and separation into distinct basins in all probability took place contemporaneously. In support of this argument he adduces, besides geological evidence, the similarity of their surface-deposits—loess, drift sands, and saline plains; and the fact that Turkistan is completely land-locked, for most of the rivers discharge into lakes—the Syr Daria and the Amu Daria into the Aral, the Ili into Balkhash, the Tchu into the Saumal-kul; while the rest lose themselves in the sand, *e.g.* the Talas, the Zarafshan, the Tejend, the Murghab, etc., precisely in the same way as the Tarim disappears in Lob-nor.¹

Richthofen classifies the mountains into two principal systems²—those of Eastern Asia with a general north-east trend, and those of Western Asia lying approximately north-west. To the first of these he gives the name of *Sinian* or Chinese, a term originally suggested by Mr. Pampelly, an American geologist; the second he calls *Altai*. His Sinian system begins near the meridian of Lha'sa and stretches to Tokio. His Altai, with an almost constant WNW. to ESE. direction, is continued in the Tangnu-Khangai, Lesser Altai, Tarbagatai, and other chains. It is met with again in Armenia, in the Caucasus, and probably also in the Pyrenees. In the south-east the Altai system is represented by the Himalayas and the mountains of farther India; the last-mentioned, however, lying almost due north and south as far as their intersection with the Sinian system. To the Sinian system, again, belong the T'ian Shan and the Hindu Kush.

THE KUEN LUEN.

But the most remarkable of Richthofen's systems is the Kuen Luen, with its axis almost parallel to the Equator, the "backbone of the continent." Whether viewed in its continuity in one and the same direction for upwards of 2500 miles, or with reference to its average height, this is the most remarkable of the mountain ranges of the world.

To the physical geographer the Kuen Luen offers much that is of interest. It demarcates the low-lying Tarim basin on the north from the Tibetan highlands on the south. As regards its western and central parts it belongs to the drainage system of Central Asia as far as the 103rd meridian east of Greenwich. East of this, its southern slopes supply the headwaters of the great rivers of China, and therefore belong to the periphery of the continent. Though millions of years have disintegrated its rocks, it still rises throughout its whole length to the enormous altitude of 18,000 feet above sea-level, so that, though its summits are lower than those of the Himalayas, its crest is higher. It intercepts the passage of the north-east winds blowing across the plains of Mongolia and the Gobi, just as the Himalayas on the south stop the moisture-laden monsoons of the Indian Ocean. Its characteristics are an extremely scanty flora and an extraordinary abundance of animal life—two conditions at first sight apparently opposed to one another, and, as

¹ Mushketof, *Turkistan*, p. 14.

² Six systems altogether.

regards the second, only to be explained by the absence of human beings. This immense desolate range, extending in almost unbroken continuity through 40 degrees of longitude, from the meridian of Yarkand on the west to that of Hwai-King-fu in the east, has remained almost unknown to Europeans till quite lately, and does not even appear on the maps with any approach to accuracy. In 1856 the brothers Schlagintweit, as already mentioned, first ascertained its independence of the Himalayas. From 1865 to 1873, Messrs. Johnson, Shaw, Hayward, the members of the Forsyth Expedition, and a few others crossed its north-western extremity. Among these Dr. Stoliczka first studied its geology, but was not spared to finish his labours.

Richthofen's travels in the provinces of Honan and Shensi drew attention to its extension eastwards, and many pages of that author's classical work are devoted to its importance in relation to the vertical configuration of the continent. As other ranges of Central Asia came to be better known, and their geology more studied, the interest attaching to the Kuen Luen increased, for it was important to define what connection there was, if any, between this range and the T'ian Shan on the one hand and the Karakoram on the other.

Richthofen places its limits at the meridians of 76° and 118° ; he divides it into three nearly equal parts—a *western*, composed of a single broad chain; a *central*, consisting of a system of parallel chains; and an *eastern*, where several chains are so closely compressed together as to form but one trunk. Later explorations have shown that the parallelism observed in the central parts extends much farther east and west than Richthofen conjectured; and Dr. Wegener, his pupil, in an admirable essay on the orography of this system, while adopting the method of his master, divides the system at the 82nd and 106th meridians; that is to say, he shows that west of 82° and east of 106° it consists of a single chain, while in the centre is developed the system of great parallel ranges.

THE WESTERN KUEN LUEN.

One of the most interesting questions concerning the Western Kuen Luen is its relation to the Pamir tableland; and here we are again brought face to face with Humboldt's theory of a meridional range. It will doubtless be remembered how much learned controversy this subject called forth some years ago. The Russian geographers claimed to have discovered that there was no such meridional range, and the English geographers set themselves to show how Humboldt's mistake had arisen, in the first place by falsification of documents by Klaproth, and secondly by the turning of a Chinese map through an angle of 90° , so that east became north, north became west, and so on.¹ It was expected that actual exploration would decide the point. But, after all the researches of the past fifteen or twenty years, there yet remain doubts. Shaw, Hayward, and the officers of the Forsyth Expedition were confident that the magnificent snowy mountains they saw to the west of Kashgar, culminat-

¹ *Journal R.G.S.*, vol. xlii. p. 482.

ing in the massive group of Tagharma or Mustagh-ata with its twin-headed peak, 25,900 feet above sea-level, and rising as a long wall from the plain on the east, constituted a meridional chain. Fedchenko, Severtsof, Ivanof, Mushketof, and others, were of the contrary opinion. They attributed the statement of the English explorers to an optical illusion, produced by the appearance of the ends of the Pamir chains, which, when seen in the distance *en face*, gave the impression of a continuous range. This view, however, was not shared by the late Colonel Kostenko, who accompanied General Skobelev's march across the Alai in 1876. He saw these mountains in August from the summit of the Uzel pass, about fifty miles off, and confirmed Humboldt's views of a meridional range.

Dr. Wegener, in discussing the question as to where the Kuen Luen begins, says that in the present state of Pamir research there is hardly room to doubt that the east margin of the highlands is defined by an approximately north and south upheaval of extraordinary height, having the appearance of a mighty range and producing the deepest impression on the beholder, be he even the impassive Chinese.

Eduard Suess in his *Antlitz der Erde* has lately formulated the idea—not his originally, but Stoliczka's—that the Kuen Luen itself, forming a curve towards the north, is continued as the Kizil-art range, and this view, founded on Stoliczka's geological researches, has been adopted by Neumayr and Geiger; the last-mentioned geographer has developed it still further by bringing the Kuen Luen, as the Kizil-art or Kashgar range, to $37\frac{1}{2}^{\circ}$ north latitude as far as the Trans-Alai mountains belonging to the Pamir group.¹ Professor von Loczy, in his work lately published on the scientific results of the Szechenyi expedition, has put forward an entirely new theory, viz., that these marginal ranges of the Tarim basin on the south, as well as of the Pamir region on the east, are quite distinct, and have nothing to do with the Kuen Luen system. These views, however ingenious, are not based on sufficiently well-ascertained facts to be accepted as final, and they certainly do not agree with the latest Russian map of the Pamir region, where ranges running parallel to the Equator cross those having a meridional direction, and where the Tagharma or Mustagh-ata group appears to have an equatorial axis, and is placed at the end of the southern Rang-kul range.

The westernmost parts of the Kuen Luen are the narrowest, and at the same time the loftiest, of the whole system. Peaks of 21,000, 22,000 feet and upwards, though surpassed by many in the Karakoram, Mustagh, and Himalayas, are among the loftiest in the world; and if we consider the great age of their component rocks and the enormous denudation these have undergone through untold ages, it will be safe to conclude, as Wegener does, that they must at one time have been equal to their younger rivals in the Himalayas and Mustagh.

Till within the last few years the only geological observations in this western end of the Kuen Luen were those of Stoliczka and Bellew along the Chang Chenmo and Karakoram routes. Stoliczka found that the

¹ Wegener, *l.c.* p. 19.

whole system of mountain ranges between the Indus and the borders of Turkistan were bounded on the north and south by syenitic rocks, enclosing between them Silurian, Carboniferous, and Triassic formations; and he remarked on the great contrast between these and the mountains south of the Indus, where all the principal sedimentary formations are represented, from the Silurian up to the Eocene, and most of the beds abound in fossils.

Bogdanovitch, the geologist of the Pevtsof Expedition, who crossed the Western Kuen Luen from the upper valley of the Tisnaf in 1890, also found the chains to be built up of granite and syenite, with clay and chloritic schists farther north; and these were followed by sand and limestones with a typical Carboniferous fauna; lastly, at the foot of the mountains opposite Karghalyk he found very recent Tertiary deposits, such as Stoliczka had observed in other parts of the Tarim basin.

THE CENTRAL KUEN LUEN.

Between 82° and 106° E. longitude, or from about the meridian of Keria to that of Sining, the Kuen Luen develops a system of parallel chains trending approximately from east to west or from east-south-east to west-north-west, and sweeping across Northern Tibet in gigantic parallel ridges. Prejevalsky was the first to cross them, on his third expedition, and place them on his map. They begin on the north with the Nan Shan, the Southern Mountains of the Chinese, and east of Shachow (Sand Town) the Altyn-tagh (properly Astyn-tagh or foremost mountains), west of that town the Anembar-ula, Tokus-dawan (or Nine Passes), and Russian range. These form the first line of ascent from the Gobi. Beyond lie five or six more principal chains, divided by broad level valleys, with occasional subsidiary ridges, mostly composed of detritus.

All these mountain groups, whether primary or subsidiary, have the same direction from east to west, and are, therefore, parallel; even the principal ranges, enormous though their absolute elevation, are of comparatively small apparent height; the snowy mountains occur generally in distinct groups, not in lines extending for great distances; the forms of the mountains are mostly rounded, their slopes gradual, and their summits dome-shaped; the ranges are easy of access, and the passes very gradual; there are generally few cliffs, these being replaced by detritus, the product of disintegration of the rocks, which are mostly clay schists, limestones, and sandstones.

The mean level of the snow-line in the Central Kuen Luen, as observed by Pevtsof, is 16,700 feet on the northern slopes, and 17,800 on the southern; perpetual snow is met with only on some of the highest ranges—the Tang-la, Marco Polo, and others; also at the sources of the Hwang-ho and in the Western Nan Shan.

Glaciers occur but seldom in the Kuen Luen, and are not extensive, probably not exceeding four miles in length; and the slopes leading up to them are so gradual that the horseman may ride up to the edge of

them. Besides those of the Mustagh-ata group, Bogdanovitch only observed five glaciers (the principal of which he named Prejevalsky) between the meridian of Yanghi Hissar and Lob-nor, all of these being of the second rank.

The glaciers descend to about 15,000 feet of absolute height. There are no signs of former glaciers, the orographical conditions being unfavourable. If more detailed surveys should bring to light a greater development of glaciers,¹ Bogdanovitch is of opinion that this will not affect his statement that glaciers in the Kuen Luen, at all events as far east as the meridian of Lob-nor, are rare, insignificant in size, and wholly dependent on the accumulation of snow on the northern slopes. Turning to the geognostic character of the Kuen Luen, Bogdanovitch observes that the ranges of the Kuen Luen and the Eastern T'ian Shan are alike in their geognostic features, but that there are few formations of the period when the present gigantic snowy ranges were covered by the sea. The process of the development of the continent began in the earliest Palæozoic epoch.

The least-explored region of the Central Kuen Luen is from Keria to the north-west for 12 degrees westwards.

Pevtsof's Expedition, in 1890-91, supplied many details regarding the submontane region in the meridian of Cherchen, and the mountains rising immediately above it. Five parallel ranges were observed, mostly snow-capped. These, taking them in order from south to north, are: Akka-tagh, Ayalyk-tagh (also known as the Kizil-unguinin-tiure, a continuation of Prejevalsky's Moscow range), Diomnalyk-tagh (a continuation of Prejevalsky's Tsaidam range), Yusup-alyk-tagh (Prejevalsky's Tchamen-tagh), and Astyn-tagh (Prejevalsky's Ältyn-tagh); and this wide system of ranges continues eastwards to Tsaidam and Kuku-nor. With regard to the first of these, the Akka-tagh, Pevtsof reports it to be the same range as that seen by the late General Prejevalsky from Unfreezing Lake, and named after him "Prejevalsky" range. To the north of it is a broad valley, gradually narrowing towards the west. Many of the peaks in this Akka-tagh are 20,000 feet high, and are covered with perpetual snow. Streams fall down its slopes, and join the Tchertchen-daria from the left.

According to hearsay, a lofty hilly region extends to the south of Akka-tagh, but the passes across the latter were blocked with snow, and Pevtsof's Expedition could go no farther. The region to the north is auriferous, and mines are worked here during the summer months by the natives of Keria.

The horizontal structure of the Kuen Luen is thus described by Bogdanovitch:—From the meridian of Polu or Keria to that of Tchertchen the constant direction of the ranges is west-south-west and east-north-east; the chains are all straight, and their ends overlap, and only one is capped with snow. East of the meridian of Tchertchen a succession of

¹ Mr. St. George Littledale saw a very high range of mountains in long. 96° 30' E. (approx.) south of Humboldt range with snowy peaks and large ice-fields. Cf. *Geogr. Journ.* vol. iii. No. 6, p. 462.

distinct snowy chains trends east and west; farther east the direction changes to west-north-west and east-south-east, and finally becomes north-west and south-east. Here, too, the ranges are detached and their ends overlap. It is in this central part of the system that gigantic groups of mountains have been observed (Mt. Jing-ri, Shapka Monomakh, and Mt. Kremlin), and easy passes (Muzluk, Karachuk, leading from the valley of the Tchertchen to that of the Zaisan-saitu).

There are certain features of the Kuen Luen system, when viewed as a whole, that cannot fail to arrest our attention. First, the general straight line of the strike of the several chains, as opposed to the usual convexity or undulating course of most mountain ranges. It is the longest straight range in the world. Secondly, the very great vertical development, the more remarkable inasmuch as the chains for the most part rise from a base greatly elevated above the sea; the greatest heights occur in the west and south of the system. The southernmost chain has, according to Wegener, at its west end a height along the crest of more than 18,000 feet. It is unrivalled among the ranges of the world, and preserves a height of 16,400 to 19,600 feet as far as the Tang-la pass. Each of the more northerly chains is, as far as at present known, lower than the one behind it, and the west end of each is higher than the east end. Prejevalsky, however, gives the precedence to the central chain because of its great extent continuing uninterrupted through 40 degrees of longitude; while the southern snowy chain, which branches off near the gorge of the river of Keria, and is probably continued in the Tang-la or the mountains bordering Tengri-nor on the north, terminates much sooner, or loses its equatorial direction on merging with the meridional ranges of Indo-China.

Exploration in the Kuen Luen has made great strides of late years, but there still remain tracts in the north-west where no traveller has ever set foot. Between Bower's route and those of the Russian explorers lies an unvisited part; the sources of the Yangtse-Kiang have not yet been discovered, and there is much detail to fill in. Meanwhile every fresh step in advance brings to light new facts bearing, not only on the geography and geology, but also on the past history of these regions. For we know that what is now a wilderness was formerly the seat of cultivation, and that underneath the sands lie the remains of flourishing cities dating back to Bactrian times, or even earlier.

THE T'IAN SHAN.

The second great mountain system of Inner Asia is the T'ian Shan or the Celestial Mountains (so called because they appeared to the Chinese to reach to heaven). The T'ian Shan rears its mountain masses on the Rubicon between two deserts—the Tarim desert on the east, the Turanian desert on the west. With its snowy crests and peaks, and its glacier-fed streams, it ensures life to the cultivated oases of the plains. Less lofty in elevation above sea-level and less extensive than the Kuen Luen, it is nevertheless one of the greatest mountain masses of the world. It belongs wholly to the interior of Asia, all its drainage finding its way

into lakes, or evaporating before reaching them. Its area has been estimated to be twenty-five times that of the Swiss Alps and thirty-one times that of the Pyrenees.

Beginning about 100 miles east of the meridian of Barkul, the T'ian Shan soon throws out a series of parallel subsidiary chains, and to the west of the sacred peak of Bogdo-ula these rise to a great elevation, and continue in a more or less east and west direction, with a deflection towards the south-west, till they die away in the plains of Turkistan.

The orography is somewhat complicated, and Richthofen's division of the chains into NE. and NW. systems does not include all the several lines of upheaval of which the T'ian Shan is composed. A glance at the map, however, will show that the prevailing direction is north-east by south-west, and that the north-west and south-east strikes are of secondary importance, and serve to connect the principal chains. But besides the continuous parallel ranges of which the T'ian Shan is mainly composed, there are huge masses of mountains, such as Khan Tengri (24,000 feet), the groups of Kok-su, Ak-shirak, and others, where the peaks attain a height of 21,000 to 22,000 feet, and where there are vast accumulations of glaciers. It is near these masses that the principal rivers of Turkistan take their rise, and flow down wide, long valleys in a general north-western direction.

There have been several attempts to classify the T'ian Shan into "Eastern" and "Western," "Northern" and "Southern." Severtsof divides the range at Khan Tengri, and calls the part to the east of this group the T'ian Shan proper, characterised by a simpler relief and a series of longer parallel ranges; all to the west of it he calls the "Western" or "Turkistan" part, with its more complex relief and series of short upheavals with intersecting ranges; he would even make a "Central" division comprising the region between Khan Tengri and the sources of the Tchat-kul.

Mushketof adopts a different division, depending on the hydrography; thus the water-parting between the Amu and Syr-daria discharging into the Aral on the west, and the Chu emptying into marshes, and the Ili into Lake Balkash on the north-west, serves to divide his "Eastern" and "Western" T'ian Shan. All to the north-east of the watershed forms his "Eastern" T'ian Shan.

Mushketof again divides the T'ian Shan into a system of five folds or arcs, with their convexity turned towards the south. The northernmost of these begins on the west with some low hills at the south-western extremity of Lake Balkash, and, rising to a great height in the granite mass of Khan-tau (Royal Mountain), terminates on the east in the meridian of Turfan, with a total length of 1000 miles.

His second fold begins with the Kulja-Bassy hills, and is afterwards known as the Trans-Ili Alatau, a very fine range of mountains attaining a height of rather over 10,000 feet along the crest, and culminating in Mount Talgar (15,353 feet) on the meridian of the town of Verny. Soon after this the range becomes much lower, and, after dividing into a number of secondary ridges, disappears in some hillocks in the Ili valley. In length this range is equal to the Pyrenees, and has a most imposing

appearance when seen from the plain, with its dark wall-like sides and snow-streaked ridge. The Trans-Ili Alatau is the first chain seen by the traveller on approaching the T'ian Shan from the north by the high road.

The third fold is formed by the Alexandroffsky mountains, beginning near the town of Auliye-ata with the lofty peak Mount Semeonof, so named after the first explorer of the T'ian Shan. This range is known farther east as the Kungei Alatau, and borders on the north the magnificent waterspread of the Issyk-kul (5300 feet), rising abruptly from its shore to a height of 10,000 feet of absolute elevation. There are several passes over this range, but the most interesting to the geologist is that known as the Buam gorge, down which the impetuous Tchu pours its stream between steep walls of conglomerate rock. The Kungei Alatau is closely associated with the Trans-Ili Alatau, so much so as to be called its "twin" range. In the meridian of Talgar the two are connected by a transverse granitic ridge known as Almata, and there is a pathway over the two ranges by which the pedestrian, if he be accustomed to mountain climbing, can reach Issyk-kul from Verny in a day. These mountains have delightful grassy valleys, such as the Great and Little Kebin, which are the favourite resort of the nomadising Kirghiz. East of the Almata or Almatinka the Kunge Alatau is much lower and divides into two ridges. These afterwards unite to form the Ak-buran-tau range, known farther east as the Ish-kilik, continuing beyond the Ili till it merges in the mountains of Dzungaria. The peaks of this fold are from 9000 to 10,000 feet of absolute elevation, and the easiest pass (Santas) 5850 feet. Tradition says that Timur, passing through it with a vast host, ordered all his warriors to place a stone on its summit; on his return march, in order to judge of his losses, he bade the men form a second similar heap in the same way. Hence, say the Kirghiz, the name *Santas*, "a million stones."

The fourth fold of Mushketof's system is the longest and most elevated of all, and is in fact the axis of the T'ian Shan. It begins on the west with two parallel ridges which afterwards form one not far from Khan Tengri. The first of these western ramifications is composed of the groups Karakol and Ulakol, uniting in the grand range of the Terskei Alatau aligning the southern shore of Lake Issyk-kul; the position of this lake being approximately central in the system. The Terskei Alatau, running parallel with the Kungei Alatau on the north shore, but surpassing it in elevation, with its long serried crest covered with constant snow and glistening with glaciers, produces an impression not easily rendered in words. Its northern slopes, not exposed to the fierce rays of the sun in these latitudes, are here and there clothed with belts of forest, contrasting with the somewhat monotonous aspect of the mountains on the opposite side of the lake. East of Issyk-kul, near the sources of the Tekes, the range loses its regularity where it rises in the mighty group of Khan Tengri; beyond this again its sides are darkened by trees and whitened by snows as it continues along the Burkhan-tau¹ and Khalyk-bassy to the

¹ According to its petrographical peculiarities this is a distinct range.

Narat range, sending down numerous tributary streams to the Tekes and Kunges.

The scenery here is the finest in the T'ian Shan, especially between the east end of Issyk-kul and the lower valley of the Tekes, affording a variety of hill and dale and effects of colouring worthy to rank with the most beautiful parts of the Alps of Switzerland; while the gloomy recesses of the defiles, with their precipitous cliffs and the snow-clad peaks towering above them, might call to mind parts of the Austrian Tyrol and the Saint Gothard pass. The weather-worn limestones and marbles of its summits have a jagged appearance, and the outcrops of schistose rocks here and there complete a picture which is never wanting in variety.

Very different is the aspect of the southernmost of the two ramifications composing this fold to the west of Khan Tengri. Instead of a wall-like range we observe here, says M. Krasnof, groups of mountains divided by valleys and low passes, apparently so distinct that we are at a loss to know how to classify them. A closer survey, however, of these mountains, and the fact that they all have a granite core margined on north and south by sedimentary rocks with conformable stratification on either side, convinces us that this range belongs to the same fold as the last. It begins at Djitim-tau, continues to the eastward as the Ak-shirak and Kiuli, and unites at the Sari-djas with the Terskei Alatau at Khan Tengri.

The mean height of the range is between 9000 and 10,000 feet, and many of its peaks are between 15,000 and 18,000 feet; many of the passes¹ are above 11,000 feet, *i.e.* higher than any of the passes of the mountains of Europe and approaching those of the Himalayas. These passes are, however, in the summer months free from snow, and, with the exception of those over glaciers, not more difficult than any others.

The fifth and last fold limits the T'ian Shan system on the south. It begins on the south of the river Naryn (headwaters of the Syr-daria) with the Ferghana chain, which under various names borders the plain of Ferghana on the east. This chain has a mean altitude along its crest of 10,000 feet, and is crossed by several easy passes. On the extreme east it attains its greatest height of 12,740 feet at the Col of Suyuk; a range of the same name runs off from it in a direction east-south-east. Farther east are the Kara-teke-tau and Djagaimal, which unite in the great chain of Terek-tyu-tau, trending north-east and crossed by the Turong-art pass. About here are some very high mountains—Mount Nicholas, 17,000 to 19,000 feet, Mount Catherine, and Mount Peter, and the plateau of Ak-sai (about 11,000 feet), watered by a river of the same name, and separated by low rising ground from the alpine lake of Tchatyr-kul (11,050 feet).

South of these five folds or chains begins a succession of ranges

¹ Kyz-art, 8090 feet; Barskoun, 11,810 feet; Turgen-Ak-su, 12,800 feet; Muz-art, 12,000 feet; Besh Mainak, 10,520 feet; Kiuli, 13,570 feet; Kashka-su, 10,918 feet; Narat, 10,200 feet.

known under the generic name of Alai, and belonging to the Pamir system with its higher valleys and different relief.

Summarising the foregoing remarks and comparing the heights of the valleys between the folds of the T'ian Shan, we find that, beginning on the north at the level of Lake Balkash (900 feet), the absolute elevation of the country increases in regular gradations as we proceed southward—the Ili valley (1300 feet), Issyk-kul (5300 feet), Son-kul and the so-called Syrts (9400), forming as it were a succession of three gigantic steps, or terraces, each being raised 4000 feet above the one next below it; and on the margin of each step rise two chains, so joined together as to form the letter x, with peaks at the points of junction rising high above the step. Above all towers the noble mass of Khan Tengri, with its white cap, affording a panorama, when viewed from Lake Boroga-bossun, which dwarfs into insignificance the views from the summit of the Rigi and Mount Pilatus, and may bear some resemblance to that of the Alps as seen from Milan.¹

In order to understand the geography of the T'ian Shan we must learn how it has gradually been built up. When were these mountain ranges raised? Have they always been as they are at present, with their snowy peaks rising up to the vault of heaven? and when did this great mass of mountains dividing the interior of the continent into two basins come into existence? These questions can only be answered by studying the results of long-continued geological observation. In India, where the geological survey has been at work for a series of years, the whole of the peninsular area has been mapped out, and the knowledge of the geological structure is very extensive. In Central Asia geological observations have only been recently undertaken, and wide areas are comparatively unknown. The investigations of Professors Mushketof and Romanofsky during the last decade enable us, however, to form some idea of the changes that have taken place before the surface assumed its present aspect. Mushketof tells us that the core of the principal folds is composed of crystalline rocks, granites or diorites, and these are exposed along the crest of the ranges of the T'ian Shan group. The crystalline rocks are covered conformably by primordial shales, limestones, and sandstones of a white, grey, and red colour. At the point of contact of the shales with the granites the former lose their stratification and partake of a granitic character, with crystals of felspar imbedded in them. The sandstones and limestones belong to the Palæozoic formations, and have been so little disturbed that, even in those places where the topography is a chaos of peaks and defiles, it is easy to make out the orography. With these Palæozoic formations, continues Mushketof, are unconformably stratified later deposits, belonging mostly to the Jurassic series. The Tertiary deposits on both the northern and southern flanks of the T'ian Shan are so closely allied to each other that they may be traced in the passes leading from Ferghana into Kashgaria, and in the so-called Dzungarian strait between the T'ian Shan and Tarbagatai.

¹ Krasnof, *Zapiski, Imp. Geog. Soc. Gen. Geog.*, vol. xix. p. 34.

All these deposits have a marine character. This, and the fact that they stretch round all sides of the T'ian Shan, induces Mushketof to believe that in the Tertiary period the Central and Eastern T'ian Shan formed an archipelago of islands between two extensive seas, now represented by the Turanian depression and the Han-hai or Tarim region, and united by the Dzungarian and the Ferghano-Turkistan straits.

Relying on the unconformable stratification of the younger with the primary rocks, he is also of opinion that in pre-Tertiary times, while this sea was in existence, the summits of the mountain masses of the T'ian Shan, the Pamir, and probably also the Himalayas and Hindu Kush, reaching now to a height of 20,000 to 25,000 feet, had not more than one-third of their present elevation; for the Tertiary strata, as observed by Mushketof at Lake Tchatyr-kul and at Ish-kilik, are, according to Krasnof, not less than 10,000 to 11,000 feet above the actual sea-level. The great mountains were then low heights hardly appearing above the surface of the waters; and, as with the western Alps, so with these ranges of Asia, there were in their stead only groups of small islands.

At the end of the Tertiary period a general upheaval took place, probably extending over millions of years, for the deep-sea deposits are overlaid by shallow-water deposits, and these again by beach deposits, with remarkable regularity. While this change of the surface was in progress, both basins, the Han-hai on the east and the Turkistan basin on the west, gradually receded at the same time and equally, and, owing to the influence of new climatic conditions, lost by evaporation more and more of their waters, till they at length assumed their present condition, which is still one of desiccation.

This picture, drawn for us by the learned Russian geologist, may be compared with one by Mr. Oldham¹ of the geological changes that have taken place in India since Palæozoic times.

He shows that the distribution of land and sea was very different then from what it is now. All the land west of the Aravalli range, says Mr. Oldham, the north-west Himalayas, a great portion of Tibet, and all Upper Burma were then covered by the sea; while dry land spread to the south-west far beyond the present coast. The series of great earth movements which took place in India, and which were ushered in by the greatest series of volcanic eruptions found anywhere in the world—eruptions which covered an area of 200,000 square miles with an accumulation of lavas and tuffs several thousands of feet in thickness—were probably contemporaneous with similar earth-movements in the interior of the continent. But the evidences of volcanic eruption in the T'ian Shan are not at present convincing. Stoliczka, indeed, found basaltic rocks and boulders in the mountains north of Kashgar, and passed through what appeared to be the centre of an extensive volcanic eruption. Mushketof discovered diabase, melaphyre, and more recent volcanic rocks, such as dolerites, in the Borohoro range north of Kulja, and tuffs in the valley of Badam in the Western T'ian Shan. But he is of

¹ *Journal R.G.S.*, vol. iii. No. 3, pp. 169.

opinion that there is no connection between the recession of the sea and the volcanic phenomena, and that volcanic rocks are by no means so widely distributed in Inner Asia as some have supposed, on the basis of Humboldt's theory of the existence of active volcanoes in the T'ian Shan.

It is impossible in this paper to deal with the intricate question of the origin and age of the mountain ranges of Central Asia. Moreover, there are not sufficient data to enable us to do more than speculate on the ancient relief or contour of the land. Actual observations have been limited to lines of route, leaving wide intermediate spaces unsurveyed. The filling-in of these, and the making of a detailed geological map on the same scale as that of India, would allow of a theoretical reconstruction of the primeval continent. For the present we must be content to leave the orography a little indefinite, and turn our attention rather to those other changes now moulding the face of this part of the world—changes due not so much to water or to subterranean forces as to air. Sub-aërial deposits are distributed widely over the whole of Inner Asia; they may be seen along the foot of the hills and all over the plains. Loess and drift-sands, the products of the disintegration of the rocks by violent winds, are deposited in every hollow and slope, and produce that monotony of landscape which is a special feature. The natives have a saying that where there is *turpak*, or loam, and *su*, water, there you will find a settler. And this is true in more senses than one, for all the buildings are of this material; the mosques, minarets, and tombs are all made of it.

This loess, or loam, mixed with water, and sometimes with a little straw, makes the most durable bricks, whether dried in the sun or in kilns, and resists admirably the action of time and weather.

Not less valuable are the loess deposits to the agriculturist. The fertilising properties of this argillaceous soil when deposited on the fields by plentiful irrigation have been shown by Richthofen in his great work in relation to China. In Central Asia, according to a recent writer, M. Moser, its adaptation to the wants of the inhabitants is equally remarkable, enabling them to cultivate land and produce good crops in localities where this would be otherwise impossible.

Central Asia, it has been said, is the land of contrasts, for side by side with the beneficent loess is the all-destroying sand. Taking its origin in the sandstone rocks of the mountains and the arenaceous deposits of the rivers, this sand is driven by the wind over the plains, invading the fertile oases and burying towns, villages, and fields in its march. Enormous areas are covered by this drift-sand, and its approach is dreaded as much as an earthquake or a flood.

We find, then, the T'ian Shan, the great mountain system of Central Asia, rising in the heart of the continent, united by the Pamirs with the Kuen Luen and the ranges bordering India and the Iranian plateaux, and connected by a system of north-western upheavals with the Altai and the mountains of Siberia. Dividing, as a gigantic wall, the plains to the east and west of it, the T'ian Shan plays an important part in the economy of this region. It is at the same time the source of prosperity and

the cause of misery to the inhabitants, whose future must depend in a great measure on the development of all those undertakings which, under British rule, have assured to the people of India their present well-being.¹

A REVIEW OF SWEDISH HYDROGRAPHIC RESEARCH IN THE BALTIC AND THE NORTH SEAS.

By OTTO PETTERSSON.

(*With Plates.*)

II.

Explanatory Remarks—The Baltic Current in the Skagerack and North Sea—The Salinity of the inflowing and outflowing waters—Different Conditions of the Surface Water in winter and summer respectively, and the Meteorological Consequences.

A FEW explanatory remarks about the symbols, colours, etc., used in the following maps and diagrams may perhaps be useful to the reader. The configuration of the bottom of the North Sea and part of the Northern Atlantic will be seen from the isobathic curves (coloured black) in the maps, Plates II., III., and IV. The positions of the Swedish sounding-stations from February 1890 are denoted on Plates IV. and V. by letters with Roman ciphers. Thus, for example, C_i, C_{ii}, C_{iii}, . . . C_{vi} indicate the sounding-places on the section Christiansand—Skagen, etc. On subsequent

¹ In endeavouring to treat of so wide a subject as that covered by the title of my paper, I have been obliged to omit much that is interesting and suggestive in the reports of recent travellers. Among these, Professor Milne in his "Journey across Europe and Asia" (see *Geol. Mag.* 1877, Decade ii. vol. iv.) makes an observation here and there, touching on some of the points raised in the preceding remarks. Thus, at p. 565, he speaks of the Lake Baikal seal, a species of *Callocephalus*, and its similarity with that of the Caspian and Sea of Aral; also of a seal inhabiting Lake Kozo-gol farther south, evidencing the probable way in which these lakes were formed. All this tends to strengthen the theory of Von Richthofen, Mushketof, and others, of a *former large inland sea* in Central Asia; and my friend Dr. H. Woodward, President of the Geological Society, thinks it highly probable that such a sea once existed.

With reference to the immense thickness and extent of the loess, some interesting remarks are contained in Von Richthofen's original article (*Geol. Mag.* 1882, Decade ii. vol. ix. pp. 293-305), where the question of the origin of this deposit is fully discussed. Similar sub-aërial deposits are very well described by Israel C. Russell, of the U.S. Geol. Survey, in the Arid Region of N. America—Colorado, New Mexico, W. Texas, Arizona, S. California, Nevada, Utah, S. Oregon, etc., and he adopts the desiccated lake theory (see *Geol. Mag.* Decade iii. vol. vi. 1839, pp. 239, 242). The observations of Mr. St. George Littledale (see *Geogr. Journ.* June 1894), and of the Russian traveller, M. Potanin, in his journeys across the Gobi, are of special interest as showing the extraordinary accumulations of this fine dust or sand, in which mountains appear completely immersed, only the rocky crests emerging here and there above the level expanse.