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Notes on the Lower Amú-darya, Syr-darya and Lake Aral, in 1874

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The scenery in the Rufiji has little or no variety. The level country which forms the delta is covered with now ripening Indian corn and millet-seed right down to the banks of the river, without a break for the whole distance we ascended, excepting that here and there a coco-nut grove towered above the corn, indicating the locality of a village, or a few mango, pomegranate, and banana-trees, scattered sparingly about, broke the monotony of the scene. We saw but two hippopotami and one crocodile during the time we were in the river, but were informed that, although the former are scarce, the latter are very numerous.

In conclusion, I would observe with what caution reports (however interesting they may be), founded neither on scientific basis, nor having pretensions to any, nor on any reasonable or practical grounds, should be received, more especially when such reports are professedly at variance with the opinions and experiences of scientific and practical men, or other competent authorities.

XV.—*Notes on the Lower Amú-darya, Syr-darya and Lake Aral, in 1874.* By Major HERBERT WOOD, R.E.

The Mouths of the Amú.—THE Amú-darya, Jihoon, or ancient Oxus, takes its rise on the elevated Pamir plateau, and after a course in a general north-west direction, discharges its waters by three mouths into Lake Aral. Commencing on the east and passing to the west, the names of these three branches of the river are, the Yany-Su, the Ulkun, and the Taldyk; the magnitudes, however, of the three different volumes of water contributed to the lake are in the order, Ulkun, Yany-Su, and Taldyk.

Admiral Boutakoff, in his early explorations of the lower courses of the Amú, specified the Loudon Canal, which passed some water into the Abougir Gulf, as a fourth discharging arm of the river. This canal was subsequently closed at its upper end, and whatever water may have entered Abougir from it now passes by the other three arms, but chiefly by the Yany-Su and the Ulkun. It may be doubted whether Loudon was ever more than a large irrigation canal, which passed its superfluous water into Abougir during high floods of the Amú; though it might now have had, had it not been closed, the largest discharging mouth, since it actually ran to the lowest point from where it left the main stream along the shortest line.*

Taldyk is probably the arm by which the Amú-darya first

* These remarks do not apply to what Loudon may have been in the tenth century.

58°

KHANATE

O F

K H I V A

after Russian sources

BY MAJOR HERBERT WOOD, R.E.

Scale of English Miles

60°

159 feet above Mean Sea Level

enote Heights above Aral

Figures denote Heights a

Lenote Heights above Aral

43°

Boukan

D E S E R T

Turya Kasgan

Kuktcha

42°

Taspak-Kasgan

EDW. WELLES, LITHO. RED LION SQUARE.

reached Lake Aral, since the river last ceased to flow to the Caspian Sea. In 1848 the officers of the Aral flotilla found a larger quantity of water passing in it than that flowing at the present day, which is probably scarcely one-fourth of the supply contributed by the Amú to Lake Aral. The diminution may partly be due to an extension of irrigation in its neighbourhood, but is so chiefly to the fact that the Khivans erected several dams across it to prevent its ascent by the Russian steamers. Taldyk, coming from the south-east, turns in a northerly direction, and flows fifty miles past the town of Kungrad to its mouth in an almost straight line, from which circumstance it takes its name (Taldyk = straight). At Kungrad it throws off a branch to the north-east, which joins the Ulkun or central arm of the Amú; this branch is called the Kuldun in the sketch illustrating Boutakoff's paper in the 'Journal of the Royal Geographical Society' (vol. xxiii.), though I believe it is not now distinguished by that name.

The Ulkun-darya, or central branch of the Amú, receives a portion of its waters from the stream just noticed, but is chiefly fed by the remarkable mass of lakes and marshes which are situated on the lower courses of the river. Soon after issuing from these, the Ulkun is joined by the stream from Kungrad, and flows due north a distance of 25 miles. Turning then westwards, and running parallel to, and at a short distance from, the south shore of Lake Aral, it discharges its waters by the Ulkun, and 6 or 7 miles further by two or three mouths, of which the Kichkiné is the largest. The form of this delta seems to be due to the intermittent volume discharged by this arm, acting in combination with sand-ridges or dunes occurring along the shore of the lake. During two-thirds of the year the volume and velocity of the stream is insufficient to pass its waters with ease over the bar at the mouth, and some portion of them consequently find their way along the valley line behind a neighbouring sand-ridge. At the epoch of flood, this subsidiary direction of the stream would be enlarged and continued; and a new mouth into the Lake would be broken through the ridge at any eligible situation. A succession of similar phenomena seems traceable along a line crossing the desiccated country which extends from Fort Peroffsky to Lake Kouktchatengis, near the south-east corner of Lake Aral.

The eastern arm by which the Amú discharges into Lake Aral is the Yany-Su, or *New Water*; and though, as its name implies, it has the most recently-formed outlet, it will soon probably be the principal of the three branches. When ascending it in 1859, Boutakoff (*vide* Diagram No. 6) reached a point some 20 miles distant from the lake, where the further

MOUTHS AND LOWER COURSES OF AMÚ (17th Century & subsequently) *Diagram N° 4* LOWER COURSES OF AMÚ DARYA 1848-59 (after Boutakoff) *Diagram N° 6* Edw^d Weller

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progress of his steamer was arrested by a ridge of sandstone crossing the stream. The depths of water over this rocky barrier were found to vary from $1\frac{1}{2}$ to $2\frac{1}{2}$ feet, those in the lower course of the Yany-Su having been from 5 to 8 feet. Boutakoff left his steamer at the ridge, and continuing his ascent in an open 12 horse-power steam-launch, found the channel to be stony, while sharp rocks rose here and there to nearly the surface of the water. In 1874 the same steamer, the *Peroffsky*, commanded by Captain Bruchoff, ascended the Yany-Su without finding a vestige of the obstruction described; and thus, since 1859, the sandstone-ridge has been entirely swept away by the stream. This arm of the Amú is consequently of very recent formation, and it has not yet, in all probability, reached its full development, though it passes fully three-eighths of the Amú supply into Lake Aral. Yany-Su flows in a N.N.E. direction along a distance of about 65 miles, including meanders, out of Lake Dowkara, which in its turn is fed from the main stream of the Amú by the branch called Kuwan Jerma.

The point where Kuwan Jerma leaves the Amú is situated at about 80 miles in a direct line south of the shore of Lake Aral; and in its course downwards to Kungrad are detached from the Amú several streams towards the north, which feed the lakes and marshes described above as draining in their turn by the Ulkun arm into Aral. It is thus seen that the river reaches the Lake by several branches, and forms in its lower course a triangular space, which presents at first sight a remarkable similarity to the delta of other rivers. The apex however, of this triangle is more than 60 feet above the level of Lake Aral, which is in itself a circumstance sufficient to dispel the notion that the country traversed by the lower courses of the river have been formed by alluvial deposits; and in the usual sense of the word, therefore, the Amú-darya cannot be said to have a "Delta."

The Eastern Arm of the Amú.—The banks of the Kuwan Jerma (*New Cut*) Channel, by which, according to local report, a portion of the waters of the Amú-darya have passed down to Lake Dowkara for about one hundred years, are but little elevated. Towards its commencement they are covered with a tolerably thick growth of jidda (*Eleagnus hortensis*) and a scrubby acacia (*Halimodendron*), in addition to some black poplar and a few oriental planes of small size, which have probably been planted. This vegetation is found only on the firmer ground, for on land situated at a low level and subject to inundation, it is generally replaced by a thick tamarisk jungle. The course of the Kuwan Jerma (Section, *Diagram No. 2*) is somewhat tortuous, and the stream in many places cuts through high sand-

hills, which apparently bordered former river-beds, where water must have flowed, at nearly right angles to the direction in which it runs at the present day. Looking eastwards from the summit of these sandhills is seen an extensive tract of country, disposed in long rolls of sand, in the hollows between which lines of shrubby gloomy-looking trees maintain a struggle for existence. This vegetation is periodically alimmented by the moisture which, percolating during the flood season into these low levels, and collecting near Kuwan Jerma in pools of water, supports a luxuriant and verdant growth of aquatic plants. But as the eye passes from these green masses to the glowing eastern horizon, the tract of country grows more and more sterile, until the sight is blinded by the glare of the desert sands which stretch into the distance.

Fifteen miles below the head of Kuwan Jerma, the irrigation canal called Kegeilee is detached from the left bank, and waters the country on this side. It carries during high floods at least 150 cubic yards per second; and it forms a convenient line of water communication between the Amú and the town of Chimbye, which is situated about midway between Lake Dowkara and the central mass of lakes and marshes from which the Ulkun arm issues.

Chimbye, a little town of some 1500 souls, is on a height of $31\frac{1}{2}$ feet above the level of Lake Aral, and is surrounded by well-planted gardens and fields, which are fertilised by the water of Kegeilee. The streets are mean and narrow, and bordered by low flat-roofed buildings of *pisé*, whose shelter seems, however, less popular than that of numerous *kibitkas* which are pitched about the town. There appears to be a good deal of traffic in the bazaars, and on market days, which take place twice a-week, a very large number of the country population come into Chimbye. Amidst the surrounding cultivation are many *havélis*, or homesteads; and in a garden surrounding one of the largest of these, is a garrison composed of a *sotnia* of Cossacks.

The country falls eastwards from Chimbye to the shore of Lake Dowkara, whose surface is about 20 feet above the level of Aral. After the cultivation in the neighbourhood of the town is passed, the country in this direction is boggy, and covered with a thick tamarisk jungle. It is traversed by numerous channels, some of which (such as Púr Khan) are of considerable size; these inundate their low-lying banks in the flood season with the waters of Kuwan Jerma, from which branch they are detached at points lower down than the head of the Kegeilee. Across this tract of tamarisk jungle-covered swamp are occasional lines of sand-hills, between which are found reed-covered

lagoons, and on whose summits are seen a few *kibitkas*, inhabited by some miserably-poor nomad Kirghiz.

Lake Dowkara, which is fed by Kuwan Jerma, is a large shallow sheet of water and marshes, extending over an area of about 150 square miles; through whose extent many channels, having a greater depth, pass with tortuous courses. The lake occupies a depression lying at the foot of the Belitao Hills, the line of whose bold sandstone cliffs encircle it to a height of 200 or 300 feet on the north and north-east sides, and trends away with diminished height to the east. By the closing of the London Canal in 1857, which has already been alluded to, an increased body of water was thrown into the Kuwan Jerma Channel, and added to the sheet of water, known as Lake Dowkara to-day. Boutakoff described this as being separated from Lake Tampyné Ayagé on the west by a narrow depressed spit of land, through which the waters communicated by a small stream; and during floods these lakes also effected a junction over the low ground lying between them. At the present time they form permanently a single sheet of water, and the name of Tampyné Ayagé has disappeared in that of the larger water-spread, which also includes the lake of Kungrad on its east side.* It is thus seen that since 1859 the level of the water-spread behind the Belitao Hills has been raised by a few feet; and as in addition the level of Lake Aral has fallen probably about two feet, the sum of these additional falls has been acquired by water flowing out of Lake Dowkara to the outlet of Yany-Su, and the disappearance of the natural dam of soft sandstone which formerly existed on this arm, is thus easily explained.

Issuing from Lake Dowkara, Yany-Su flows in a channel of about 500 feet broad, through low sandhills, and passes the cut it has made through an indurated clay-elevation. Here the banks are from 40 to 50 feet in height, and are covered with the usual scrub jungle, which further down in the course of this arm, is replaced with saksaul (*Haloxylon ammodendron*) forests, as the south-east corner of Lake Aral is approached. On the western bank, near the Yany-Su, marshes extend in the direction of the lower course of the Ulkun, from which an old arm, known as Kazzak-darya, formerly entered Aral. The eastern discharging arm of the Amú forms an approximate boundary between the Karakalpaks to the west, and the nomad Kirghiz to the east.

The Central Lakes of the Amú.—The Amú-darya below the head of Kuwan Jerma sweeps round to the west, and turning again north-west, gives off its waters from the right bank by successive channels, which run in a general northerly direction.

* Not to be confounded with the town of Kungrad, on the west bank of Taldyk.

The oldest and most westerly of these is the one known as the Taldyk branch of the Amú; and a few years back, when a greater volume passed in this direction than does so at the present time, Taldyk threw some of its superfluous flood-waters into the now desiccated Gulf Abougir, which formed an appendage to Lake Aral at its south-west corner.

The channels between Kuwan Jerma and Taldyk, which carry the Amú waters into the central lake and marsh district, owe either their existence or their enlargement to the closing of the Loudon Canal in 1857, by which circumstance an increased volume of water was thrown into the lower courses of the Amú. The largest of these channels is Chartambye (Section, *Diagram No. 3*), which commences about 12 miles below Khodjeili (situated at the apex of the lower arms of the Amú), and runs a distance of 25 miles before actually reaching the central lakes, near the Kashkanatao Hills.

Though the right bank of Chartambye—more particularly in its upper course—is tolerably well defined, its left bank and lower course are bordered by marshes, which in the flood season extend to the west, and joining on to the courses of the other channels lying between it and Taldyk, pass insensibly into the region of rush-covered lakes below.

The central lakes of the lower Amú-darya fill a caldron-like depression, shown roughly on the *Diagram No. 4*, which has been composed from the map annexed to General Ivanien's pamphlet on Khiva. This, the author states, was compiled from observations made by Mouravin, so far back as 1641, and from others of a more recent date; and it is interesting, since it shows that two hundred years ago the great depression which is now filled up with water was, at that day, probably dry. On the east more particularly, but also on the west and south of the lakes, there is rising ground, whose upheaval by a subterranean force may probably have formed the depression now occupied by the lakes. Just at the northern outlet of the lakes is situated a curious physical phenomenon, which may also be, possibly, a trace of that system of subterranean disturbance stated to be recognisable along a line running from the east of Asia, through Lake Aral and the Caspian, to the countries bordering the Black Sea.

The annexed diagram (*No. 5*) shows the phenomenon in question, which occurs at the junction of several channels, draining the central lakes at a point near where the Kuldun stream, flowing from Kungrad, joins the Ulkun branch of the Amú. Here in the stiff clay soil are situated two deep, funnel-shaped cavities, where whirlpools are formed. Quantities of fish of a large size sport and jump in the foaming waters, above whose surface

Edw^d Weller *sc*

numerous gulls and other aquatic birds hover and circle, in search of their prey. There is no reason for supposing that this pair of inverted cones has been excavated by the action of running water; and it seems only possible to class them as craters of extinct mud-volcanoes, like those of the Lussbeyla district, near the mouths of the Indus, or like the circular hollows left by the Calabrian earthquakes at the latter part of the last century, of which a description will be found in Lyell's 'Principles of Geology.'*

To return, however, to the Chartambye Channel. I was informed on the spot (and the statement meets with confirmation by an inspection of the Diagram No. 6, compiled after Boutakoff's sketch) that it had no existence a few years ago; and it has probably been formed by the effort made by the Amú to get rid of the increased discharge caused by the closing of Loudon. While passing on a caïque immediately to the north of the Kashkanatao Hills, I was also told by a Kirghiz moolla, born and bred in the locality, that a dozen years previously he had walked over cultivated fields, which at that moment formed the bed of the stream on whose surface our boat was floating. There is no doubt, also, that Boutakoff in his explorations of the lower Amú passed over dry ground, which was traversed by the writer in a boat in 1874; but Boutakoff himself noted, in 1859, the commencement of the flooding caused by the closing of the Loudon Canal, since in some places he remarked the limpidity of the water (which was consequently almost stationary), and which allowed fields and irrigation channels to be seen through it. Besides Chartambye, the central lakes are fed by two other principal water-courses, called Karabailee and Oguz (Diagram No. 7), of which the last mentioned is the most westerly, and has probably been in existence for at least a century and a half, since on its banks, it is said, the unfortunate Prince Bekovitch was murdered by the Khivan Khan. I noted that this channel was entirely insufficient to carry the volume of water poured into it; and its depth, as the diagram shows, was out of proportion to its small breadth.

The lakes into which the above channels discharge, cover an area in the flood season of about 700 square miles. Individually they are sheets of water, varying in size from a few thousands of square yards, to 10 or 15 square miles, with an average depth of 6 or 7 feet, and a maximum one, in occasional places, of 30 feet. They are frequented by quantities of pelicans and

* It is somewhat remarkable that in many old maps of the Caspian, which include the basin of Lake Aral, two whirlpools are marked in a position approximate to that which would be occupied by the *phenomena* just described in a united Caspian and Aral basin.

other waterfowl, and are separated from each other by dense forests of rushes (*Arundo*), which rise to a height of 15 feet or so. Through this aquatic growth winds a labyrinth of connecting channels, where the water passes occasionally with a high velocity, and carries away the semi-floating islands on which the Karakalpak fishermen establish their temporary resting-places. The beds of the lakes and channels are covered with a thick growth of weeds, where the delicate *Miriophyllum* abounds, and from which the lotus of several colours rises to the surface of the water. On the islands, where a footing is only afforded by the interlaced roots of the rushes and other aquatic plants, may occasionally be found a fern, whose origin must probably have been in the high valleys of Badakshán, at the sources of the Amú, some fifteen hundred miles away.

The Central Arm of the Amú.—At their northern extremity the lakes which have been described, are drained by several large channels into the Ulkun-darya (Diagram No. 8) close to the point where that arm receives the Kuldun stream, coming from the south-west. Immediately below the junction, the Ulkun flows in a channel, having a breadth of about 600 feet, with a maximum depth of 30 feet, and carries in extreme floods a volume of about 1200 cubic yards per second towards Lake Aral. For about 25 miles this arm of the Amú flows due north, through an open country, where the left bank is more elevated than the right, which is swampy. The western bank is occupied by pastoral Karakalpaks in considerable numbers down to the Aral; and these people also occupy the strip of land between the river and the Lake, when the Ulkun turns westwards at Akkala, or the *White Fort*. The firmer ground, on the banks of the Ulkun, is crowded with cattle, grazing on excellent pasturages, which are interspersed with occasional patches of low scrub jungle, where hares and pheasants are plentiful. In the summer season, on the lower course near Aral, are numerous encampments of nomads, who during winter find shelter for themselves and their cattle in *zamoffkas*, or mud-walled enclosures, in which their scanty cereal crops are also stored. The cultivation on the banks of the river in this part is of a poor and limited description, and includes a few patches of rice and wheat, besides melon-grounds, watered by some small cuts from the stream. In addition to the *zamoffkas* mentioned, there are on the banks of the Ulkun a few deserted mud forts, which, with Akkala, formerly belonged to the Khivan Khanate.

The bar on the Kichkiné mouth of the Ulkun (Diagram No. 9) is situated at about 200 yards without the opening, and has a depth of about $6\frac{1}{2}$ feet of water upon it. The mouth itself has a breadth of rather more than 150 yards, with a depth of

water of about 9 feet ; but a quarter of a mile inside the channel narrows somewhat, while the depth begins to increase greatly. From the Lake, the south shore shows a line of low sandhills, and the edge of the water is occupied by broad masses of rushes, frequented by quantities of aquatic fowl. This growth of high rushes extends into the river itself, a distance of a few miles, and then gives way to cleaner cut banks, which rise slightly above the surface of the stream.

The Kuldun.—The Kuldun stream (Diagram No. 10), which joins the Ulkun, runs about 25 miles from Kungrad in a north-easterly direction. It skirts on the right extensive swamps through which the central mass of lakes can be reached ; but its left bank is firm and high, and is usually covered with a thickish jungle, swarming with small game. On its upper course near Kungrad there is a good deal of cultivation, watered by the aid of Persian wheels worked by ponies. The Kuldun was ascended by Boutakoff in his exploration of the Lower Amú, when it carried a much larger body of water to Lake Aral than it does at the present time, which is probably not 100 cubic yards per second, even in high flood. Some six or seven dams were erected across it by the Khivans, and the remains of these are still visible at several points along the course of the stream.

The Elevations of the Lower Amú.—Near Kungrad the Kuldun contours the eastern foot of the Tumulaktao Hill, and has cut into the slope and exposed a soft bed of conglomerate of oyster-shells, cemented together with lime and sand, and coloured with bright red and yellow tints, which are probably due to iron. Among the shells and sand are numerous sharks'-teeth, and what appear to be the seeds of some leguminous plant. Circling round by the south from Tumulaktao, there are a few small eminences bordering the central lakes ; and about 20 miles due east of Tumulaktao are the Kashkanatao Hills. They form an elevated plateau, whose general direction is north-east and south-west, along a distance of about 12 miles, and whose average breadth is about two miles. The hills are of an indurated clay formation of a buff colour, containing numerous fragments of *selenite*, and their slopes are strewn over with sand and small fragments of ferruginous sandstone. On the southern edge of the plateau are many detached hillocks of a regular rounded form, encircled with several parallel and horizontal water-marks, and with occasional narrow beach-like terraces, whose surfaces are of thin sedimentary layers, hardened with iron (?), and bearing very distinct ripple-marks, evidently due to rising and falling waters. The vegetation which occurs on the lower slopes of Kashkanatao is confined to a few prickly plants, such as *Lyceum* and *Haliostachis*, fit only for camels to

feed upon. The greatest elevations of Kashkanatao and of Tumalaktao are probably not more than 100 feet, or a little more, in height. The cliffs of the Belitao range, which shut in Dowkara on the north, appear, however, to be somewhat higher, while their formation apparently contains more compact sandstone than either of those of the other hills which have been referred to. The summits of the elevations of the Lower Amú, as well as those on the banks of the river generally, are all used as cemeteries; a custom which has no doubt been necessitated by the hydrological conditions of the country about the shores of Lake Aral, and the physical phenomena which have attended the flow of the Amú-darya and other neighbouring rivers, since times of great antiquity.

Past and Present Character of the Amú.—In adverting to the changes which have taken place in the direction of the flow of the Oxus since the earliest historical dates, eminent authorities have seen no reason for supposing that the great natural features of the Aralo-Caspian region have so altered as to prevent decided conclusions being arrived at on the subject. Nor is the statement made by Sir Henry Rawlinson as to the recent entire desiccation of Lake Aral to be regarded as an exception to this proposition, for the emptying and filling up of the Lake are circumstances merely dependent on the flow of rivers, the outlets of whose courses have been frequently, and are now, easily modified by the action of man.

From the time of Herodotus (B.C. 458), who gives a short notice of the Araxe and the directions in which its two arms discharged, down to the tenth century of the Christian era, information regarding the Oxus is scanty. There is, however, sufficient to show that, at least as late as three-quarters of a century before Christ, the traffic from India to Europe passed down the river into the Caspian. Subsequently to this, the river seems to have adopted one of the northern channels, and to have entered Lake Aral at its south-eastern corner.* Previous to the fourteenth century the Oxus, or Amú-darya, again changed its course and flowed to the Caspian; and finally, towards the end of the sixteenth century, it abandoned that outlet, and discharged into Lake Aral near its south-western extremity.

The circumstances of this last change in the direction of the flow of the Amú-darya can be traced from the narrative of the English commercial agent, Anthony Jenkinson, which is to be found in Hakluyt; and from the references made by Abulgazee Khan of Khiva, in his 'History of the Mongols and Tartars,' to the old course of the river to the Caspian Sea. In this

* If so, its mouth was near the south-west corner, in the tenth century.

latter work, the country traversed by the Amú, south of Kunya Urgenj, is described as being, in the beginning of the sixteenth century, very fertile and very populous. In 1559 Jenkinson coming from the Caspian struck this old course, which then carried no water to its outlet; and advanced up it, to a point to which water still flowed. Continuing his journey past Kunya-Urgenj to Bokhara, and still ascending the river, he came to where the Amú-darya bifurcated; one branch being the Kunya-daryalik, up which he had travelled, the other being Ardok, the present course of the Amú-darya. Jenkinson arrived at the bifurcation of the Kunya-daryalik and Ardok in the first week of December, *i. e.* at the season of the year when the river carries little or no water, owing to its being ice-bound at its sources. He describes Ardok, however, as being "great and very swift," which under the circumstances can only indicate that the Amú, embarrassed in its flow down Kunya-daryalik, was working to excavate a larger channel for itself in the direction taken by Ardok. That it eventually effected this, is shown by the narrative of Abulgazee Khan, who states that in 1575 the waters permanently changed their flow into Ardok; and that some years subsequently they enlarged a small irrigation canal, passing Túk, sufficiently to find their way by this course into Lake Aral. Before, however, this took place, there is reason for thinking that Ardok, *i. e.* the Amú-darya of to-day, flowed past Khodjeili to the east by Kukuzak (*vide* Diagram No. 4), and flooded the country lying to the south of the Belitao Hills.

Some light may be thrown on the causes of the changes in the course of the Amú-darya, which have been briefly indicated, by a consideration of the use to which the waters of the river are put to, in the Khanate of Khiva at the present day. This tract of country, which is situated on the left bank of the stream, and is watered by several canals flowing from it, measures some 200 miles long by 40 broad, and forms a fertile and highly cultivated oasis in the deserts of the Aralo-Caspian region. On the right bank of the Amú on Russian territory there is also a small strip of ground, about 50 miles in length, and 5 in breadth, which is cultivated in the same way. In about the middle of the month of March the winter begins to break up in the high valleys, where the sources of the Amú-darya are situated, and the melting of snows and of glaciers commences to throw an increased stream of water into the channel. The volume of water continues to augment, until the epoch of maximum summer-heat, after which it gradually decreases again as the winter approaches. The annexed diagram (No. 11) shows the fluctuations in the level of the Amú-darya, which took place between the 23rd of June and the 10th of Sep-

tember, 1874, and indicates the 3rd of August as the day on which the maximum height during that year was attained.*

The results of eight actual measurements of the Amú-darya, collated with the above record of its height during the period specified, have afforded data from which the following Table of the approximate discharges of the river has been compiled. It shows these in cubic feet per second; 1st at Toyuboyin, a point situated above the different positions of the irrigation canals which divert the waters of the river, and 2ndly at Núkús, below the same canals. The difference of the volumes passing these two points, will therefore be an approximation to the quantity used in the agriculture of the Khanate.

DATE.	Volume at Toyuboyin.	Volume at Núkús.	DIFFERENCE.
23 June	101,000	47,800	53,200
29 ,,	97,900	46,300	51,600
11 July	139,800	66,200	73,600
17 ,,	122,600	58,000	64,600
3 August	142,800	67,600	75,200
15 ,,	120,700	57,200	63,500
25 ,,	106,000	50,200	55,800
10 September	93,100	44,100	49,000
Average for 80 days	122,200	59,600	62,600

It results from the foregoing Table that during these 80 days of flood, about one-half of the whole volume of the Amú-darya was diverted by the irrigation canals of Khiva, leaving the other half to pass down towards Lake Aral.

Now the natural conditions of the flow of the Amú-darya would be, that the volume and velocity of its waters are such as are sufficient to carry to the outlet of the river, the enormous mass of earthy matter thrown into its channel, at the melting of the snows and glaciers in the spring of the year. It appears, however, that in the Khanate of Khiva, half of the volume of the river is diverted into the irrigation canals, and each separate stream which flows in these, as well as that of the reduced main stream, passes on with a momentum proportionate to these diminished volumes. Some of their power of transporting the earthy matter being thus lost by the several streams of water,

* The lowest level was registered on 22nd March, 1875, at 297 centimètres below height of 3rd August, 1874. Probable low-level volume of Amú, 35,000 cubic feet per second.

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a portion of this burden, which they carried in suspension, must at once be deposited upon the beds of their channels.

General Ivanien states, that the earthy matter deposited in the irrigation canals of Khiva during a single flood season amounts to a depth of $2\frac{1}{2}$ feet; and if this deposit were allowed to remain, it is evident the canals would soon cease to carry sufficient water for cultivating purposes, and would eventually become filled up and entirely useless for their purpose. At the end consequently of each flood season, an earthen dam is built across the head of each canal, to prevent the further entry of any water from the river, and the canal being in this manner run dry, the deposited sand is removed by manual labour from the channels, and heaped up along the banks. The dimensions of the canals are so preserved, and at the advent of the floods of the succeeding year, the dam is removed to allow of that water entering the several channels, which is required for the irrigation of the soil.

It is to be remembered, that while the yearly deposits are cleaned out of the irrigation canals, those in the reduced main stream of the river are left untouched and must accumulate, and this channel must consequently tend to be filled up, and so offer year after year increasing difficulties to the free passage of the floods to an outlet. On the other hand, since in the Khivan deserts no crops can be produced without water, and since a certain *minimum* quantity must be diverted from the river, to ensure the production of sufficient food for the population of the Khanate, it results that the levels of the canals, at the points where they leave the river, are placed at such a height as will ensure the entry of an adequate supply of water even in a year of *minimum* flood. In all other years, consequently, a larger volume of water enters these canals, than is required for the agriculture of the Khanate; and this excess, which would otherwise damage the irrigating works and destroy the crops, must be got rid of by the cultivators as speedily as possible. This is effected by leading or extending the canals into natural drainage channels, which flow down into the deserts westwards of the irrigated tract; and in every year except one of *minimum* flood, the canals thus drain down towards the Uzboy channel of the old Amú-darya, which flows southwards from near Lake Aral. The continued action of these circumstances during a long course of years, would gradually increase the volume of water passing by the irrigation canals, and add to the difficulties of a flow in the lower main channel of the river. This augmented flow would declare itself more particularly by some one canal, whose outlet might be in a more favourable position than those of the others, and the

natural consequence would be, that concurrently with the development of this canal, population and cultivation would increase along its banks. Eventually the flow of water down it, would overcome that down the old embarrassed bed of the main stream, which the river would consequently desert, in order to flow to a new outlet, and in this manner it seems highly probable, that the various past changes in the direction of the Amú-darya have been caused.

A few miles to the south of the point where the old channel Kunya-daryalik leaves the present course of the Amú, is another old dry bed flowing off to the westward through the desert towards Uzboy. Its dimensions are sufficient to justify the tradition, that it was the course in which the Amú-darya waters flowed before they passed by the Kunya-daryalik into Uzboy, and so on to the Caspian in the fifteenth and sixteenth centuries. Considering the previous direction towards the south-east corner of Lake Aral, which an early Arab geographer seems to assign to the Amú-darya, the presumption is suggested, that all the branches of the river, like the one which made its way by Túk into Lake Aral—Ardok, the Kunya-daryalik, the Doudon, and other former courses—were each of them in their turn nothing but an irrigation canal, enlarged and extended in the way which has been detailed. The continued application of this idea while ascending the course of the Amú-darya, would bring us to a point near Tchardjui, from where, the Turkomans living about Merv state that an ancient river-bed runs across the desert westwards to the Caspian. This apparently would be that one whose commencement was seen by Russian officers near Igdy Wells, some 200 miles east of the Caspian, in 1873; and might well be the one also, by which Indian merchandise passed from Balkh into Europe before the Christian era, since in this direction the waters of the Oxus would have run by the shortest line, to an outlet which is situated at the lowest possible point.

The Breadth, Depth, Currents, and Capacity of the Amú for Navigation.—The first sight of the Amú-darya in the flood season is a striking one. The great mass of water, coloured a yellowish-brown with its charge of earthy matter, flows on with scarcely a sign of that human life, which is so inseparably attached to the courses of most great rivers in modern times. The faculties of the spectator seem thus placed at once in sympathy with the legendary attributes of the ancient Oxus; while the mystery which has in times past invested the Khanate of Khiva may well be imagined as embodied behind the thick screen of planes and mulberries, following at no great distance the windings of the river on the western side.

On the bank opposite to the Khivan oasis, the sterility of

the Kizzilkoom desert is shut out from the river by the cultivation in Russian territory, or by the elevations of Shaikjaili and Bishtubye. The clay ridge of Bishtubye commences a little above and opposite to Khodjeili, and continuing some fifty miles along the right bank up the course of the Amú, runs into the lower spurs, of the sombre brown mass of Shaikjaili. These elevations continue about 10 miles further along the Amú, and then turn easterly to lose themselves 50 miles away by a long ridge in the Kizzilkoom. Their place on the river bank is succeeded by the cultivation in Russian territory, while this, in turn, is encroached upon by the desert, which at about 180 miles from Khodjeili touches the bank, and continues up the river. Here also the cultivation of the Khivan oasis ceases, and its place is taken by a high ridge of clay, passing almost into an argillaceous schist, which has been cut away by the stream, into a steep though not lofty precipice. Ten or twelve miles above where cultivation ends, is situated *Toyuboyin*, the "Camel's neck"; where the Amú-darya, flowing for a moment from the north, turns south-west, and rushes through a narrow passage, which the waters have cut through a bed of compact limestone. This dyke of rock has been tilted to a height of more than 20 feet directly across the direction followed by the river; its strike is about north-west and south-east, and the angle of its dip is perhaps 25°.

The breadth of the Amú, which is 1100 feet at this pass, increases along a distance of 20 miles downwards, to about 2500 feet. Here the breadth expands rather suddenly, and attains a maximum of perhaps 10,000 feet at Shurakhan, a distance of 40 miles below. It is along this portion, that the greatest quantity of water is diverted for the irrigation of Khiva; and the great water-spread of the river is here occupied by large alluvial islands, which are covered towards the end of summer with high, golden-eared, waving grass (*Lasiagrostis splendens*).

Continuing down the course of the river, the breadth then decreases, irregularly yet progressively, to about 1500 feet at Khodjeili; and lower down in its course to Kungrad to about 1200 feet.

The depth of the deep-water channel of the river in the flood season varies from 15 to 30 feet in different localities; and its course is usually found either close to, or in the neighbourhood of, the right bank. The truth of this statement is, however, greater in those portions where the stream is not diverted for irrigating purposes. In ascending the Amú, the canals commence to be detached from the left bank at a few miles above Khodjeili; but they are numerous and larger between the 90th and 160th mile above the same place. In that portion, where the *maxi-*

imum breadth is found, the deep-water channel not infrequently abandons the right bank, and winds in and out between the large alluvial islands. Below Khodjeili, where the river in its course to Kungrad takes a decided turn to the west, the deep-water channel passes from one bank to the other; and this is especially noticeable a few miles down, at Shireen Kala, where the ruined fort-wall on the left bank deflects the stream back again to the right bank, which it had previously left. Speaking, however, in general terms, the Amú-darya flowing in a northerly direction in the northern hemisphere, displays its obedience to the great astronomical laws; and its stream acting in conjunction with the earth's axial rotation, erodes its right bank in a very marked manner. Along this bank, consequently, the deep-water channel is usually found, as is exemplified generally by the succeeding diagrams, which represent the cross-sections of the river at several points.

Diagrams Nos. 12 and 13 are cross-sections which were measured at a month's interval, near Khodjeili, a short distance below the branching off of Kuwan Jerma. Their general form is approximately a right-angled triangle, with the deepest part close to the right bank of the river, though in No. 12 the ravine-like portion is more marked than in No. 13; this results from No. 13 being situated nearer than No. 12, to a part where the volume of the stream was commencing to be deflected to the opposite bank. The pronounced form of No. 12 is that, which of necessity followed from the circumstances under which this portion of the Amú originated; it having been in the first instance nothing more than an irrigation canal derived from Ardok, which the yearly floods gradually extended past Túk into Lake Aral. It has been mentioned on a previous page, that before this outlet into Aral was formed, the waters of Ardok probably flowed by the Kukuzak (*vide* Diagram No. 4) into the low ground behind the Belitao. The closing of the Kukuzak at a subsequent date, and the barring of Loudon in 1857, were both circumstances, which at different times threw an augmented stream into the Amú, and caused the deep ravine-like form of the Section No. 12; since with an increased depth a larger volume of water could be passed off to an outlet more speedily than with an increased breadth. The same conditions have already been remarked upon, in reference to the form of the cross-section of the Oguz Channel (*vide* Diagram No. 7). Section No. 13 was measured about one month after the epoch of highest flood, and the depth of its ravine-like portion is probably diminished by deposits; Section No. 12 is, however, entirely free from such deposits, having been measured a few days only before the *maximum* height of the river was reached.

SECTION OF AMU BELOW KUWAN JERMA

27th July

Diagram N^o 12

SECTION OF AMU BELOW KUWAN JERMA

2nd Sept^r

Diagram N^o 13

SECTION OF AMU ABOVE KUWAN JERMA. KHODJEILI

27th July

Diagram N^o 14

SECTION OF AMU ABOVE KUWAN JERMA. KHODJEILI

1st Sept^r

Diagram N^o 15

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SECTION, 15 MILES ABOVE N° 14 AND 15
10th August

to face page 383.
Diagram N° 16

SECTION, 17 MILES ABOVE KHODJEILI
11th August

Diagram N° 17

SECTION, 90 MILES ABOVE KHODJEILI
15th August

Diagram N° 19

SECTION OF AMU DARYA AT TOYUBOYIN
25th August

Diagram N° 20

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Sections Nos. 14 and 15 (*vide* Diagram), which were also measured at a month's interval in the vicinity of Khodjeili, but *above* the heads of the Kukuzak and Kuwan Jerma, show a similar contrast, which is probably due to the deposition of earthy matter by the stream. In these sections the ravine-like parts previously noticed are much modified, owing to the circumstance that this portion of the channel is of older formation than those shown in Nos. 12 and 13. In conformity with the general rule, the deepest part is, however, on the right bank. This also is observable in the cross-section No. 20, through the rock at Toyuboyin, though with some modification, since the course of the river is here temporarily directed to the south-west.

Section No. 16, which is situated 15 miles higher up the river than Nos. 14 and 15, conforms to the general rule, but shows a new modification of form caused by the detachment from its left bank of the irrigation canal Survolee, a short distance below. The stream has thus been divided into two distinct ones, leaving a ridge between them. This section is of interest as showing, in a restricted yet remarkable manner, that form which the bed of the Amú-darya assumes when a great quantity of water is diverted from it by irrigation canals. An excessive cross-section, in such a portion, would have a total breadth of perhaps 10,000 feet from bank to bank, and would be occupied by several islands, with shallow channels flowing between them, and the deepest of these would in general be found in proximity to the right bank of the river.

Section No. 17 is situated at about 17 miles above Khodjeili, and immediately below Bend, at the head of the now closed Loudon Canal. The section is remarkable as showing two distinct portions; one of about 400 feet broad, which is almost certainly still in course of being excavated by the stream, the other of about 950 feet in breadth, which probably represents the old channel while Loudon was still open and carried water from the river. From the circumstance that this section does not seem to have increased its depth notably, since the increased body of water, due to the closing of Loudon, has been poured into it, the inference, perhaps, may be drawn that the channel has excavated itself down to a stratum (of rock) sufficiently hard to cause the stream to act in preference on the indurated clay bank. In type it will be noticed the section approaches to No. 20, though it passes about one-half only of the water which rushes through this latter one.

Diagram 18 represents a section of the Amú below Kipchak, and above where the canal Basoo is detached from the river. In it is noticed the increased breadth taken by the river where irrigation canals occur, though perhaps this breadth is slightly

exaggerated here, in consequence of the stream being deflected directly on to the right bank by some rocks on the opposite side, which act as a groyne.

No. 19 is a cross-section, measured at a point on the Amú, about 90 miles above Khodjeili. It is situated at some distance from irrigation canals, and the abnormal part of the section near the right bank is suggestive of an increased supply of water having been at a previous date turned into the channel at some point above it. It is just possible that the larger part may represent an enlarged section of Jenkinson's Ardok, while the portion nearer to the right bank is that which still remains to be excavated, in order to pass the added Kunya-daryalik stream with sufficient ease.

The velocity of the main stream of the Amú-darya and of its lower branches, in the flood season, attains in some localities to as much as 6 miles an hour, and is very variable. The variations of the current are due to the causes which will now be enumerated:—1. To the irregular slope of the channel, which varies from 11 inches to $3\frac{3}{4}$ inches per mile in its course from Toyuboyin to Lake Aral (Diagram No. 21). 2. To the diversion of a large volume of the river by the irrigation canals of Khiva, and to the consequent variability of the cross-section. In flood the broader reaches of the Amú become reservoirs in which the water is stored up, and in which the velocity is diminished; while that in the narrow reaches, connecting the reservoirs, is greatly increased. On the subsidence of the flood the general velocity of the stream becomes more equalised. To the above causes may be added the circumstance of the Amú-darya, in its passage to Lake Aral, passing through material of all degrees of hardness, from the limestone-rock at Toyuboyin, to clay formations more or less indurated, and interspersed with beds of sandstone. These materials, opposing as they do, different degrees of resistance to the action of the stream, sensibly modify the rate at which the enlargement of the channel is being effected, and consequently affect the velocity of the current. These irregular conditions of flow suffice to establish the conclusion that, even at the present day, more than two and a half centuries since the Amú-darya has passed by its present channel to Lake Aral, the ultimate *régime* of the river has not been attained. The actual amount of work executed by the waters, may be inferred from what has already been said regarding the enlargement of the Yany-Su branch; and will receive still further illustration when the present conditions of the Amú are compared with those obtaining in 1863, as they have been described by M. Vámbéry.

I had the advantage of observing the lower Amú-darya, both at the epoch of high flood and a month subsequently, when the

Diagram N^o 18.

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SECTION, 40 MILES ABOVE KHODJEILI

13th August

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water-level had fallen five feet. At the latter date, in lieu of a single sheet of water, the broader parts of the river were encumbered with numerous exposed sand-banks, between which meandered the several channels, making up the total reduced volume of the Amú. In the narrower connecting reaches the river still flowed in a single unbroken stream, but with a diminished breadth and a moderate current, in place of that powerful body of water against which the Aral flotilla steamer, *Peroffsky*, in her ascent, could occasionally do no more than hold her own. This was more especially observable in the reach below the head of the Loudon Canal, since the closing of which, the necessary time has not elapsed to allow of a sufficient enlargement of the channel of the Amú below it. The inability of this part of the channel to carry the volume of water passing during floods is consequently very remarkable, and recalls the process which must have been in operation in 1559 at the head of Ardok, when Jenkinson found that river "greate and very swifte," at a season of the year when the Amú-darya was carrying its *minimum* discharge.

The foregoing brief description of the strong and variable current of the Amú-darya naturally suggests a reference to its capacities for steam-navigation by the vessels belonging to the Aral flotilla. Up to 1873, these usually entered the Kichkiné mouth of the Ulkun branch, through which a landing-place at the western foot of the Kashkanatao Hills was reached. In 1874 an attempt was made to attain the main channel above, by passing from Kashkanatao up Chartambye, but without success. The *Peroffsky* then steamed out again into Lake Aral and ascended the Yany-Su into Lake Dowkara without much difficulty. She commenced the ascent of Kuwan Jerma, just as the Amú floods of 1874 were reaching their *maximum*; and the velocity of the stream and the numerous bends in the course of this arm of the river, made the ascent troublesome and slow. In the main channel above Khodjeili up to Shurakhan (which was the limit attained by the *Peroffsky*), a deficiency of engine power and of some local knowledge of the stream are the sole difficulties which stand in the way of steam-navigation during the flood season. With these qualifications, there seems no reason why steamers should not ascend, with tolerable ease, as far as Toyuboyin, 190 miles above Khodjeili; though whether the passage of the gap at the former-mentioned place is feasible or not is a question which a specialist only could answer decidedly. In any case, great address and powerful engines would be absolute requirements for the attempt; and even these being granted, a successful issue is doubtful, and I am inclined to hazard the opinion, that some years will elapse

before a steamer *steams* up through the gap at Toyuboyin. In descending the Amú-darya towards the subsidence of the floods, a steamer requires to use her engines chiefly in going astern against the stream, since the rapid deposition of sand and growth of shoals in the channel at this epoch, render it impossible to avoid running aground several times during each hour. Besides this grave inconvenience, the steam-navigation of the Amú has a further difficulty presented to it, by the scarceness and consequent cost of firewood,* which on this river is three times what it can be procured for at Fort Peroffsky on the Syr-darya, where it is most plentiful, and from which place the stores of fuel for the vessels of the Aral flotilla are drawn.

The Amú and Country it traverses for 190 miles above Khodjeili.—On the right bank of the Amú-darya, above the head of Kuwan Jerma, stands the small mud-walled village of Núkús, where there is a ferry by which the scattered population converges on Khodjeili on market days; and two or three miles to the north, on the bank of a channel detached from Kuwan Jerma, is situated the new Russian fort. The surrounding flat country has some little cultivation upon it, but is chiefly covered with tamarisk and other jungle peculiar to the banks of the river. This growth of *Eleagnus* and scrub acacia is especially thick, and of some size, a little to the east, about the old bed and banks of the Kukuzak Channel (*vide* Diagram No. 4); down which some small quantity of water still escapes from the river in the flood season.

In the description of the Amú-darya contained in M. Vámbéry's 'Sketches of Central Asia,' it is stated that a waterfall existed in the neighbourhood of Khodjeili, down which the stream rushed from a height of 3 feet with the swiftness of an arrow; this, the enterprising traveller very naturally thought, would be a great obstacle in the way of the navigation of the stream. It is beyond doubt that in 1863, the date M. Vámbéry refers to, the Amú-darya must have been working to enlarge its channel near Khodjeili, in order to pass off conveniently, the increased volume which had been thrown into it by the barring of the Loudon Canal in 1857. M. Vámbéry's description, however, indicates something more than this; and in another place he speaks of a "dam" at Khodjeili. What the obstruction referred to actually was it is difficult to say, since I could hear nothing regarding it at the locality itself; but it may be conjectured to have been, in all probability, an artificial spur, which had at some previous date been thrown out from the bank in order to shut up the Kukuzak. This channel was closed by the

* Say 17. 10s. per ton.

Diagram N° 21.

SECTION OF THE AMU DARYA FROM LAKE ARAL UP THE EAST ARM BY KHODJELI TO TOYUBOYIN

Edw^d Weller

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Khivan Khan to punish the Nomads living along its course, precisely as Loudon was closed to punish the Turkomans under the Chief Atta Murad Khan; and though I am unable to state the precise date at which the occurrence took place, this was sufficiently near to support the conjecture hazarded. It is certain the flow down Kukuzak has ceased in very recent times, and the work necessary to close this arm would probably have had the dimensions which M. Vámbéry's description of the dam at Khodjeili applies to it. In any case, the river has effectually swept the obstruction away, whatever it may have been, for no vestige of it remains at the present day.

Round the fortress-like village of Núkús, there is some cultivation and timber, but less than on the Khivan side of the river, where continuous groves of trees entirely hide the buildings of Khodjeili. To the south of this place, however, at a mile or two distant, a few scattered homesteads are seen among the crops, which cover the open country to a point opposite to Syed Atta Auliya, and which then give place to a scrub jungle for some miles further up the left bank of the Amú.

Syed Atta Auliya, 6 miles above Núkús, is the hill forming the northern extremity of the Bishtubye ridge, which more or less closely skirts the right bank of the river for 50 miles downwards from Shaikjaili. The ridge is very similar to the elevations of Kashkanatao and Tumulaktao which have already been described, and is of a yellowish-brown indurated clay, sprinkled over with sand and fragments of ferruginous sand-stone, of which thin *strata* still cap the isolated elevations occurring in some few places along it. The average height of Bishtubye is less than 200 feet, and increases towards its southern end, where it is lost in the lower spurs of Shaikjaili. Like most elevations on the banks of the Amú, the summit of Syed Atta Auliya is crowned with a *pisé* mausoleum, surrounded by a cemetery, which presents a curious appearance from the numerous wooden stretchers (used in carrying corpses to their resting-places) being placed vertically in the ground round the graves.

A little higher up the river than Syed Atta Auliya, but opposite to it, the first irrigation canal is detached to water the land round Khodjeili. At this point the river is broader than in the reach below, and the mouth of the canal is hidden among rushes and scrub jungle, a thick growth of which latter vegetation also covers the opposite bank, at the foot of the slope of Syed Atta Auliya.

In the reach immediately above, the river narrows again, and in the floods, the rush of water down this was exceedingly powerful. A month subsequently, the fall in the level of the water exposed a section in the perpendicular right bank, of some

feet of compact clay, which was superposed on a *stratum* of sedimentary rock of no great degree of hardness. About here the Bishtubye ridge retires a little distance from the river, and the flood-waters cover the intervening space with a marsh; which before very long time elapses, will be included in the channel of the Amû. This encroachment of the stream on the Bishtubye ridge is very observable all the way down from Shaikjaili.

Almost 20 miles above Syed Atta Auliya, but on the Khivan bank, is Bend, a fortress which was erected for the protection of the dam placed across the head of the Loudon Canal. Both fort and dam are hidden in the dense but moderately high *eleagnus* jungle, which covers the low left bank from Survoolée upwards, and has obliterated the several old mouths of Loudon, save one, in which a small stream still flows to fertilise a limited area of land lying to the north-west of Kunya Urgenj. Bend is situated at the bottom of a broad reach of the river; and on the opposite bank, upon the Bishtubye ridge, here standing a mile back, is an elevation called Nogay Kala, from the circumstance of its having been occupied by Nogay Tartars, who fled hither after the taking of Kazan by Ivan the Terrible. From its summit the glaring sandy wastes of the Kizzilkoom are seen extending to the eastern horizon; but the eye finds relief to the south, where a sheet of vivid verdure lies between the bare clay slopes of Bishtubye and the river. This belt of jungle is no more than a mile or so wide at its broadest part; it is of a swampy nature, and is scarcely worthy of the name of "forest," which is applied to it in M. Vámbéry's work. Capping the summit of Nogay Kala are *strata* of ferruginous sandstone, between whose under edges, and the clay below, are some caves, haunted by owls of a very large size. On the open ground at the foot of the slope many fossil shells are to be found, including bivalves and *ammonites* of 18 or 20 inches in diameter. These gigantic remains are firmly embedded in the indurated clay soil, which atmospheric action has worn away around them, and so gives them the appearance of being the bases of ruined pillars; a circumstance possibly giving rise to a story current on the spot, that the locality was the site of an ancient city.

From Bend the jungle continues upwards along some 8 miles to a rising ground which the river has cut away into a steep escarpment, of about 30 feet high, on whose top is a small ruined fort. Behind the fort the ground rises to a few graves surrounding the mausoleum of Miskan Atta, a small domed structure in *pisé* work. At this place, close to the head of the broad reach at whose lower end Bend is situated, the river contracts somewhat, and on the right bank, a little above, is seen the fort-like homestead of Nuzr Khan, on some open

swampy ground near the water's edge. It belongs to a Kirghiz family, whose ancestors possessed themselves during a brief space, a century and a half ago, of the Khanate of Khiva, and whose submission at that date to the Czar, is held to have established the right of Russia to the protectorate of the territory at the present time. The head of the family now resides at Kalechkala, among the semi-sedentary Kirghiz established near Lake Dowkara.

Up to the fort of Nuzr Khan the banks of the Amú can scarcely be considered either interesting or picturesque, and the monotony of the sand-charged stream itself is only very occasionally relieved, by the small caique of a solitary Uzbek fisherman. At the point named, however, a change for the better occurs; for on the horizon the broken outlines and summits of the Shaikjaili range begin to declare themselves plainly, and in the middle distance the massive "Tower of the Jinn" frowns over the river from the summit of a low conical hill forming the extremity of a spur running down from Bishtubye. As this is approached, the jungle on the right bank of the river grows higher; while on the opposite side the highly-cultivated and thickly-timbered environs of Kipchak give an earnest of the Khivan oasis, which so far has been looked for in vain. Hereabouts are the heads of some irrigation canals, and opposite to these, upon some open ground south of the "Tower of the Jinn," stand the *madrissa*, built by Hajee Niazbye of Kipchak, and the *mausolea* of his family. These buildings are of a superior stamp of architecture, and, being constructed of burnt brick, must have cost a good deal of money. It is therefore to be hoped some steps may be taken to prevent the low ground they are situated upon being swept away by the stream; a circumstance which threatens to occur before very long.

The small town of Kipchak, with its flat-roofed, rather dilapidated, mud-houses, is surrounded with a high wall, and stands on a point of the left bank of the Amú, about 40 miles above Khodjeili. Under the town wall the river's bank forms a natural quay, whereon are piles of small timber used for building, and stacks of agricultural produce, and alongside which a few caiques float. At the extremity of the point of land are some rocks, deflecting the body of the stream to the opposite bank and cutting it away in the manner which has been mentioned. These rocks do not appear, however, to be now so marked a feature at this point of the course of the Amú-darya, as M. Vámbéry's description of them would lead one to believe. There is not the slightest danger to be apprehended from them by boats; and the inference is, that since 1863 the river at this point has enlarged itself considerably.

The Amú preserves its breadth for 16 miles above Kipchak to the commencement of the Shaikjaili range, and along the same distance the Bishtubye ridge, which, opposite Kipchak, lies perhaps 3 miles back from the river, gradually approaches it again to lose itself in the northern spurs of Shaikjaili. On the crest of the ridge, not far from the hills, stands a large squat *pisé minar*, one of two prominent landmarks, whose erection is attributed to the expedition of Prince Bekovitch; the second *minar* stands some 15 miles further up the river, on some high ground on the same bank.

The country close to the Amú, on the Khivan side, between Kipchak and a point opposite to Shaikjaili, is uncultivated, but a little way back it is studded with clumps of trees, and home-steads are scattered among fields, covered with crops. On the right bank, above Kipchak, there is a plantation of moderately-sized timber, and farther on some open ground, a part of which is occupied by Lake Karakool. This the river threatens to absorb into its channel, and a small-domed mosque, with its surrounding cemetery, which are situated close by, are likely to share the same fate. At this point the Amú-darya has cut away a low ridge, and has left a bank of about 10 feet high, whose erosion is assisted by the fact of the clay composing it being filled with isolated masses of sand. This the running water washes out and caverns are formed, whose falling in, from time to time, hastens the destruction of the bank. The river acts with great power against its right bank about here, on account of the *momentum* it has acquired in the narrower reach above, which skirts the foot of the Shaikjaili range. The commencement of these hills occurs at about 56 miles above Khodjeili, on the right bank of the Amú, where a small mosque is situated close to the edge of the water.

The Shaikjaili hills, rising rather abruptly a few miles away to the east of the river, receive the Bishtubye ridge among their lower and northern spurs, and then turning with increased height southward, along a distance of 5 miles, skirt the Amú, which at the foot of the slope has a breadth of less than 3000 feet. To the west the hills present a massive group, perhaps 3000 feet high, of a sombre brown colour, which approaches in some parts to deep neutral tint, and has a greenish tinge, as if produced by coal-dust. Their formation is metamorphic, and the rock is sprinkled with glistening points, while larger pieces of the same nature crop out in irregular and tilted *pseudo-strata*, more especially at the rounded shoulders of the ravines, which separate the component buttress-like portions of the central mass. Here and there are light-coloured patches, whose fallen *detritus* forms heaps, at the base of the steep slopes

on the river's bank below. At the southern extremity of their river-face the hills turn eastward again, and stretch into the Kizzilkoom desert by a long ridge, which gradually decreases in height to its termination in the east. A line of clay-elevations, which seem to be the southern prolongation of Bishtubye, and through which perhaps the Shaikjaili group was upheaved, continues along the bank of the Amú, for a distance of 10 miles farther, from where the hills turn eastward. Over these clay ridges are seen the higher ones thrown out from Shaikjaili in a southerly direction; and remarkable contrasts of colour are afforded by the intermingling of the darker spurs with those of the yellow clay, giving the idea of trees and clumps of massive timber. I mention this, since it shows how M. Vámbéry fell into the error of describing these elevations as being thickly covered with forest; and, I may add, some careful use of a field-glass was necessary before I could divest myself of a similar erroneous notion.

At the southern end of the river-face of Shaikjaili, and close to the water's edge, stand the picturesque ruins of an old fort, called Yampuk, and on the opposite bank are some hills of no great height, of apparently the same formation as that of this metamorphic group. In speaking of the Amú at this point, M. Vámbéry states, that here the waters roar as if the Oxus, that unruly son of the desert, were angry at being so imprisoned between the rocks; and the navigation in the reach below is described as being dangerous from the force and rapidity of the current. It is sufficient to note, that this description is by no means applicable to the locality at the present time; its value, however, is great, as it illustrates in a forcible manner the work the Amú has executed in enlarging its channel since 1863.

Up to Yampuk both banks are capable of being examined from the deck of an ascending steamer; but along a distance of 90 miles further to Tunuklu the breadth of the Amú is too great to allow of this being done; and the channel winds in and out between large islands, so that either the one or the other bank only is occasionally seen. Such glimpses are, however, sufficient to show the striking change of physical aspect which has been effected by the waters of the Amú, in transforming the sterile clay desert into a smiling and highly-cultivated garden. In Khiva irrigation is generally employed, and the country is covered with cereal crops, lucerne or cotton, which alternate with melon-grounds and fruit-orchards. Silk-culture is extensively practised, and the mulberry abounds among groves of other cultivated trees, shading the numerous neat homesteads which are scattered along the banks of the irrigation canals. On the more elevated Russian bank irrigation is less extensively

employed, it being in the neighbourhood only of Sháhbázwáli and Shurakhán, that the Khivan standard of fertility is in any way approached. However, the whole of the right bank of the river, for some seventy miles, is also redeemed, by the beneficent waters, from the state of utter sterility it would possess in the absence of such an advantage. On the less cultivated portions and on the alluvial islands numerous flocks of sheep and cattle are grazed and tended by shepherds, who are assisted by crop-eared, short-tailed, European-looking dogs.

On account of the agricultural avocations of the population, the homesteads are scattered over the surface of the country, and villages consequently are unknown, while towns are few and generally undiscernible from the river. At Sháhbázwáli, on the right bank, there is, however, a collection of buildings near a tall *pisé* minar, of the usual massive Khivan form; and a little way off is a large-domed mosque, surrounded with smaller ones. These, together with the town of Kipchak and the *madrissa* opposite to that place, are really the only buildings of which a good view is obtained on the Amú; a few homesteads and ruins being, of course, excepted from this statement.

The Russian territory is situated on the right bank, commencing from the mouth of Taldyk, in Lake Aral, and continuing to Meshekli, more than 200 miles above Khodjeili. Meshekli is on the new frontier-line of Bokhara, and past here, for 40 miles, to Tunuklu, the Amú-darya flows in a narrow valley, into which local tradition says the river was artificially turned by a former ruler of the country. This narrow valley is bordered by low clay (?) hills, up to which, on the right bank, the Kizzilkoom desert extends. Twenty miles below Meshekli is situated Toyuboyin, the "Camel's neck," where the river, with a breadth of 1100 feet, has been already described as bursting through a bed of compact limestone, which is filled with small shells. Ten miles below Toyuboyin the river issues on the open country by the "Lion's mouth;" and here is situated the fort of Tunuklu, upon an elevation forming the northern extremity of the high clay ridge which the stream has cut into a steep escarpment, varying from 10 to 50 feet in height, on its left bank. Between Toyuboyin and Tunuklu the Amú-darya expands in breadth generally in its descent, and 2 or 3 miles below the former place the centre of the stream is occupied by the pretty alluvial island of Aral-chee-bábá Auliya, whose area of some 15 acres is thickly covered with willows and poplars.

Below Toyuboyin, along the right bank, extends the line of low sand-covered hills to a point nearly opposite to Tunuklu, and here a ruined mud-fort also occurs. From this down to

Sháhbázwáli the Amú expands in breadth enormously, and the islands along the same distance increase in size. From the same point the great irrigation canals commence to be diverted from the river on both sides; and the great fertility, which is the characteristic of the Khivan territory, is not without its parallel on the right bank, where a strip of country, some 50 miles long and 5 miles broad, has been reclaimed by irrigation from the sandy desolation lying to its east. In addition to the half-drowned lands traversed by the lower courses of the river, this cultivated area may be said to be the only habitable portion of the Russian possessions on the Amu-darya.

The chief Russian position in the Amú-darya district is at Petro-Alexandrofskiya, a walled garden, near the town of Shurakhan. Petro-Alexandrofskiya is in nearly the same latitude as Khiva, and about 30 miles east of it; and the verdure and leafiness of the place form a wonderful contrast with the sterility which lies at its very postern gates. The country between it and Shurakhan is a tract of desert, across which run what strongly resemble old canals; and some way to the north, at the foot of the slopes of the southern face of Shaikjaili, is an old river-bed of large size, which at some ancient date must also have carried water towards the west.

Notes on the Lower Syr-darya.—The Syr-darya, or ancient Jaxartes, has been described sufficiently on several occasions to make it unnecessary in the present note, to do more than allude in general terms to the direction of its flow and the country it traverses; the chief object in view in what is about to follow being to apply to this river, the principles deducible from the study of the Amú-darya, with the intention eventually of passing on to a consideration of what the state of Lake Aral, the recipient of the waters of the two rivers, may have been at different epochs in past times.

The Syr-darya, flowing in a general direction from east to north-west through 17 degrees of longitude, takes its rise in Russian territory, among the high valleys of the Thian Shan, which lie to the south and south-west of Lake Issik-kul. Nearly 400 miles below its sources it enters the Khanate of Kokand, and crosses that country in a south-westerly direction along a distance of 250 miles. Entering Russian territory again, it soon makes a remarkable turn and flows almost due north through six degrees of latitude, after which it changes direction once more, and flows westerly, with northing, in a rather meandering course, along a distance of more than 400 miles to its mouth in Lake Aral.

The turn taken by the Syr-darya to the north below Khodjend, where it fairly emerges from the hilly country into the

plains, is remarkable for the following reason. Fort Peroffsky being about 239 feet above the level of Lake Aral, and 400 miles distant from the mouth of the river, the fall per mile in this part of its course is $7\frac{1}{4}$ inches. Applying the same rate of fall to 850 miles of the Syr, up to a point somewhere below Khodjend, we find the height of this point to be 580 feet above Lake Aral. From here along a line to the south-east corner of the lake would be a distance of about 600 miles, and a river following this from Khodjend directly westwards, would have a fall per mile of $11\frac{3}{4}$ inches. The actual course of the Syr, which has the lesser slope of $7\frac{1}{4}$ inches per mile, consequently suggests very strongly that it has been artificially produced.

It is to be noted that the fall of $11\frac{3}{4}$ inches per mile which has been indicated for this ancient and natural course of the Syr, is almost identical with that which the Amú possessed when it ran in its most ancient course westwards, from some point near T'chardjui to the Caspian Sea. This identity of fall is what might have been expected, from the similar conditions of the flow of the Amú and of the Syr, which are in flood, from the melting of snows at their sources, during the spring and summer months, and whose small autumn streams are still smaller in winter. The analogy between the rivers might be pursued by considering that the Amú does not at the present time receive affluents such as the Zarafshan and the Murghab, which formerly reached it; while it seems certain that many streams such as the Demus and Baskatis of Ptolemy, which have now disappeared, formerly contributed their waters to the Syr. The changes which we know to have taken place in the flow of the Amú, and the identity of use to which its waters and those of the Syr are applied in countries having a similar geological formation, may reasonably permit us to suppose that similar phenomena are likely to have occurred in the flow of the Syr.

A consideration of the incidents which occurred during the Macedonian expedition on the banks of the Tanais, or Jaxartes, as recounted by Arrian, point to the conclusion that Cyropolis, which was the extreme north-east point reached by Alexander, was not situated on the bank of the present Syr-darya as has hitherto been generally supposed. The position of this city is sufficiently indicated by the circumstance, that Alexander returned from it by forced marches, both with infantry and cavalry, to the relief of Maracanda or Samarcand; and reached the neighbourhood of that city early in the morning of the fourth day after starting. The distance he made with his troops during those three days of forced marching could cer-

tainly have not been more than 100 miles, measured as the crow flies, even over the most favourable ground. But in passing from the valley of the Tanais to that of Politymetos, in which Maracanda was situated, the Macedonian forces would have crossed either the Nouratintao or the Sanzartao range of hills which intervened; and supposing this to have been done at the easiest point, *i. e.* by the pass immediately to the south-west of Djizzak, it is clear that at least three days would have been required to march the distance between Cyropolis and Maracanda, which could not have been equal to less than 120 miles, over level ground. Now it is 140 miles, as the crow flies, between Maracanda and the nearest point of the course of the Syr-darya of to-day, by a line drawn straight across the Sanzartao range; and this distance would be something like 170 miles through the pass which has been mentioned, and which would have been at the same time the easiest and the shortest line to follow. Nearly a week would have been absorbed in marching this distance, a circumstance which at once offers insuperable objections to the supposition that Cyropolis could have been situated upon the present course of the Syr-darya. A further reason indicates that Cyropolis should be placed at the shortest possible distance from Maracanda which Arrian's history will allow of, since we are told that Spitamenes, having broken up his camp before Maracanda at the approach of Alexander, was pursued vigorously by the relieving forces; and this circumstance, however credible it might have been after a forced march of 120 miles in three days, would have been utterly impossible to execute after one of 170 miles in the same space of time. All the considerations which have been detailed afford good reason, consequently, for placing Cyropolis within a curve described from Maracanda as a centre with a radius of 100 miles, and the curve falls short of the present course of the Syr by 40 miles.

Arrian states that the river on which Cyropolis was situated usually ran through it like a torrent, but that when Alexander took the place, this channel was dry. The river might therefore have been either an affluent of the Tanais, which was liable to sudden floods from rains falling in the neighbouring hills, or on a bed of the Tanais, from which at no very distant date previously the flow had changed into another channel. Such a change, it has been established from a study of the Amú-darya, could result from the waters of the Tanais having been employed for irrigation purposes; and since Cyropolis was the greatest and most populous city of those regions, there is reason for assuming that cultivation, aided by irrigation, was extensively practised in its neighbourhood. We know that the

waters of Politymetos in the adjacent valley were largely utilised at that date in the same way; and the ability of raising large supplies of food was the necessary condition of the existence of masses of population.

Arrian further relates, that the European Scyths assembled in large numbers in the neighbourhood of Cyropolis, on the opposite bank of the river, which at this point had no great breadth, and that they threw their javelins across and made insulting speeches to the Macedonians. The temper of Alexander being roused thereby, he ordered the hides which covered the soldiers' tents to be prepared, and used them to ferry his troops over the river, which, though narrow enough to throw a javelin across, was deep enough to be unfordable.

The present Syr-darya, at its entry into the plain west of Khodjend, has a minimum breadth of 300 yards, which would be a great deal too broad for javelins to be thrown across. And this narrowness which was possessed by the Tanais of Arrian, in conjunction with the fact that it was not fordable, seems to indicate that it was an artificial channel carrying a deepish body of water. The characteristic conditions of the natural main channel of the Syr-darya would be precisely the opposite of those of the Tanais. Wherever the Syr of the plains might be narrow enough to allow of a javelin being thrown across, it would be fordable; but if it was not fordable it would be so broad that javelins could not be thrown across it. The various considerations which have been specified, all point to the conclusion that Cyropolis was not situated on any point of the present course of the Syr-darya, but that it was either on or in close proximity to, a course which must have passed along the line I have suggested as the ancient line of the river to the south-east corner of Lake Aral. A reference to the map will show that the small affluents of the Syr-darya, flowing from the hills above Tashkend, would have reached this ancient course in a much more natural manner than by the acute angle which they make with the direction in which the river flows to-day. And it may be mentioned, before leaving this part of the Syr, that in the end of 1874 the excavation of a large canal was commenced, in view to the fertilisation of the steppe lying between Chinaz and Djizzak; this canal must have approximately, the direction of the old line which has been assigned for the Syr-darya, and its operation may not improbably influence the present flow of the river in an important manner.

The physical details which have been described as governing the flow of the Amú apply in all their extent to that of the Syr, since this latter river also carries during the spring and summer months a volume of water which is very greatly in

excess of the quantity flowing in the autumn and winter of the year. During the latter period the river runs in a channel, by which probably a volume four times greater has recently been passing; the stream is consequently embarrassed with shoals, while its velocity is low and its depth is small. During this epoch canals can be excavated in such positions as would, on the advent of the floods of the succeeding year, ensure the passage of a large body of water into them, and the set of the stream having been thus influenced, no long time would elapse before the entire volume of the river might be compelled, with no great difficulty, to take the new direction of flow. It is by these artificial means that the flow of the Syr, by the Jani-darya and by the Kuwan-darya, as well as that by the Karauzak, have in all probability been caused; and the ease also with which a dam can generally be constructed across the Syr at low water, enables the flow by most of such channels to be stopped at will. In this way, both the Jani-darya and the Kuwan-darya have been barred at their heads, though an attempt to close the flow by Karauzak in the manner usually resorted to, has failed of success in this case.

I am not aware that the limited number of irrigation canals which exist on the lower courses of the Syr have their heads dammed and their beds cleared of deposit, in the manner those operations are annually carried out in the Khivan Khanate. The difference of treatment probably results from the irrigation on the lower Syr being on a very much less extensive scale and unmethodical; and is also perhaps due to the different ethnic characters of the respective populations, who have inherited different traditions from their ancestors. If the laborious system followed in Khiva had been in use in the valleys of the Talass, of the Tchui, and of the Sary-Su, it is probable that those streams might flow to definite outlets in the Syr-darya, instead of being dispersed and terminating in the sand. The Kenderlik, a river which has entirely disappeared, though it is expressly mentioned in Russian information of the 16th century, and many streams from the northern slopes of the Karatao range whose waters are lost in the steppes, would also under different conditions have swelled the volume of the Syr-darya. And, speaking roughly, it seems probable that in ancient times the drainage of these regions might have been double that of the volume of the present Syr-darya. The water so carried westwards to Lake Aral seems, according to the theory propounded in this note, to have passed by two rivers;* one of which flowed from the present sources of the Syr past Khodjend, and which, in its passage directly westwards below that

* Early Arab geographers specify three rivers, as entering Aral from the east.

place to the south-east corner of Lake Aral, would have received the waters of the Demus, the Baskatis, and other streams mentioned by classical geographers. The second river would have been formed by the confluence of the Arys, the Talass, the Tchui, and the Sary-Su ; and probably had its mouth somewhere about the Kuwan-darya, in a Lake Aral, whose height would have been higher than that of to-day. Such an increased water-spread as is here mentioned, would have included in its perimeter all the salt lakes, great and small, which at the present time are scattered over the country north of Lake Aral, and which are fed by the Irgeez and numerous water-courses from the eastern slopes of the Mougojar Hills, and by the Tourgai, and many other streams which run down the southern and south-western slopes of the low watershed at the sources of the Tobol, of the Ubagan, and of the Ischim. Such supplies would have more than met the evaporation from so large an extent of water-spread, more especially if it be considered that these different physical aspects would probably have been accompanied by a diminished dryness of climate, and an increased vegetation upon these now bare and desolate regions.

At the present day the Syr at Fort Peroffsky has a breadth of about 500 yards, which is diminished to about 300 yards at Cazalinsk ; and the depth, which is usually 20 feet in the channel between Chinaz and Peroffsky, lessens to about 6 feet at a *maximum* at the mouth of the river in Lake Aral. Here, also, the breadth is much diminished, and an estuary is occupied by marshes, which have been formed by the earthy deposits of the stream and by the desiccation and consequent retreat of the limits of Aral.

I had no opportunity of measuring the discharge of the Syr, but I estimate roughly, that it contributes to Lake Aral a volume of about one-half that supplied by the Amú-darya. From Fort Peroffsky downwards (and in addition, I believe, upwards to Chinaz) the banks of the Syr-darya are low, and the river frequently inundates large stretches of the neighbouring country. The greatest quantity of water thus lost by the Syr, occurs in the marshes formed after the division of the river, which takes place at about 10 miles below Fort Peroffsky. Here the Syr-darya forms two branches, the left of which, the Jaman-darya, was formerly the main stream ; the other and right branch, the Karauzak, was accidentally formed, some fifty years ago, from the enlargement of an irrigation canal by the flood of the river. Before uniting again with the Jaman-darya, at about 100 miles further westwards, the Karauzak forms extensive marshes, the evaporation from whose area, alone, probably absorbs a volume of 200 cubic yards per second throughout the year. At a few miles below this division of the Syr the Jaman-darya gives off

the Kuwan-darya from the left bank, and this old arm of the river runs parallel to and some few miles south of the present course, towards Lake Aral. At this day the Kuwan-darya carries little water, and such as enters it is lost on marshy ground near its commencement and in a salt lagoon, which is situated in the country east of Lake Aral.

At 7 miles below Fort Peroffsky the old Jani-darya course leaves the left bank of the Syr, and runs south-west to the dry Lake Kouktchatengis along a distance of more than 200 miles. Towards its commencement its dimensions are not very much less than those of the present Syr-darya; but near Kouktchatengis it gives off one or more branches to the right towards Lake Aral. East of the meridian of Kouktchatengis a large dry river-bed can be traced, running towards Lake Dowkara, along the depressed country situated to the south of the Belitao range of hills; and this river-bed also throws one or more arms towards Lake Aral, at its south-east corner.

The Jani-darya from the Syr to the meridian of Kouktchatengis has a slope of about $8\frac{1}{2}$ inches per mile, and eastwards from this to Lake Dowkara of about 6 inches per mile. At the present day a little water, which passes probably by the overflow of the Syr, is found in the upper course of the Jani-darya; but no regular discharge takes place by it, as its head was dammed subsequently to 1816, in which year Mouravieff says it carried a stream of water. This, however, was probably not a permanent state of things, since Mouravin had seen no water in the Jani-darya in 1740; and it is generally stated that the flow of the Syr by this bed ceased about a century and three-quarters ago, at which time its head was probably situated some distance eastwards of Fort Peroffsky. It seems indeed certain that, in the fourteenth century, the Syr flowed along this line from somewhere near Otrar, at the mouth of the Arys, since the route from Kunya-Urgenj passed in a north-east direction from the south shore of Lake Aral to that emporium of trade.

At its upper end the banks of the Jani-darya are clothed with a tolerable quantity of pasturages and scrubby jungle growths; and extensive stretches of country, liable to inundation, are thickly covered with rushes. Signs of desiccation, however, become rapidly more and more apparent, as the course of the dry river is descended, until, in the neighbourhood of Lake Kouktchatengis, the large saksaul trees which cover extensive tracts of country, are all either dead or in a dying state. From about here the country eastwards begins to present the aspect of a tumbled mass of low sand-hills, of which the lines can be distinguished, running in a general northerly direction. Between these, bare tracts of hard clay occur, which seem formerly to have been covered by floods from the Jani-darya, or are the dry

beds of shallow bays and lagoons which appertained to Lake Aral at a high level of about 50 feet above that of to-day. The desiccation of the country reaches a maximum near the meridian of Lake Kouktchatengis, and the country situated between this dry lake and Aral presents great difficulties to the student of physical geography. For besides the dry bed of Lake Aral, with different water-spreads, the ground is cut up by the channels through which the Oxus, the Jaxartes, and the Syr emptied themselves into their receiving basin at various epochs; and from some neighbouring point, probably at the south end of Lake Kouktchatengis, the Kizzil-darya (*vide* Diagram, No. 22) must have passed across this country which is situated on the right bank of Kuwan Jerma,* and the aspects of which are described in the Notes on the Amú-darya. The Kizzil-darya course could not, however, have remained long in existence, since, owing to the small slope of $2\frac{1}{2}$ inches a mile, which it could at the most have possessed between Kouktchatengis and Kunya-Urgenj, it would have been speedily choked up with sand, unless it was kept open artificially. This desiccation of the Kizzil-darya course agrees, it may be remarked, with the statement in Baber's 'Memoirs,' that the Syr in his day, terminated in the sands of the desert; and the well-defined river-bed which traverses the country immediately to the south of the Belitao Hills is suggestive of the idea that this is the last channel which carried the waters of the Syr westwards, from the north end of Kouktchatengis, before the river had its present outlet on the north-east coast of Lake Aral.

The waterless steppe which lies along the 120 miles of country separating the meridian of the dry Lake Kouktchatengis from Lake Dowkara, on the lower courses of the Amú-darya, presents the extremest degree of desolation. Its surface is for the most part a bare and glazed clay plain, which is evidently the dry bed of a former shallow sea; over this there are occasional tumbled masses of low sand-hills, and across it runs a deep, large dry river-bed, possessing well-defined banks, which must have carried a body of water nearly equal to that of the whole volume of the Syr. The northern limit of the steppe is a regular and continuous line of low hills, which form little more than a high bank of indurated clay at the eastern end, but which, towards the west, become more variable in direction and in appearance, and more elevated until, on the north of Lake Dowkara, they present a sandstone cliff of some two hundred feet in height on their southern face.

From Kaleech-kala, which is situated just on the south of Lake Dowkara, a channel, called Karakool, flows from Kuwan Jerma

* That is, if the Syr water ever passed into Uzboy.

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in a north-easterly direction and loses itself in the sand, after a course of about 20 miles. The moisture carried by this channel feeds a certain limited amount of vegetation along this distance; but eastwards from its termination, to where the main Jani-darya bed is met near Kouktchatengis, there are scarcely enough scattered prickly shrubs to support even the camels passing by this route, or the few goats of the occasional Kirghiz who wander in these regions.

Notes on Lake Aral.—The annexed chart of Lake Aral which is a reduction of that compiled from the surveys made by Admiral Boutakoff in 1848, has traced on it approximately, the several contour lines of 4, 8, and 12 fathoms below the surface. By a careful transfer of the outline of the lake and of these contour lines, from the Russian Admiralty Chart, I have calculated the various quantities, which I shall give in this note, and which I procured in the following manner. First cutting out all the islands included by the water-spread of Lake Aral, I weighed that sheet of paper in a delicate balance, and went through a similar process for each water-spread included by the contour lines drawn at the several depths. Comparing these weights with the known areas and weights of two bands of paper cut from the whole water-spread of the lake, one from north to south, the other from east to west, I found the area of Lake Aral included on the chart of 1848 to be 24,536 square miles. This quantity is in agreement with Colonel Veniukoff (whom M. Elisée Reclus has followed), and who gives 1207 German geographical miles, or 25,540 square English miles, as the water-spread of Lake Aral; but it differs from that of Malte-Brun, who states the area at 1280 leagues, or 17,000 square English miles. The areas included by the 4 and 8 fathom contour-lines were found to be 18,304 and 13,297 square miles; while the water-spread below 12 fathoms of depth was made up of five portions, having a total area of 5010 square miles; the largest of these five portions being the band lying immediately under the cliffs of the Ust-Urt plateau, and having an area of 2152 square miles. It is to be noted, however, that the water-spread of Lake Aral on the chart of 1848 does not include the area of the Abougir Gulf, for which 700 square miles must be added; and this will make the area of Aral in that year to be 25,236 square miles.

Lake Aral occupies the deepest part of that depression in the north-west of Asia, which Humboldt has described as being due to a rupture and subsequent sinking down of the crust of the globe. It is the recipient of the waters of the Amú-darya and of the Syr-darya, whose united volumes afford to it an average supply of about 2000 yards per second throughout the year.

Its waters, though sensibly salt to the taste, are under necessity potable by the wild animals (antelope) and domestic cattle which are found upon the larger islands, and the degree of saltiness seems to be considerably modified by winds, which drive before them the streams delivered to the Lake by the mouths of the Amú and of the Syr.

The deepest part of Lake Aral is found in the western band lying immediately under the cliffs of Ust-Urt, and in this the maximum depth is 222 feet, while the minimum is 84 feet. From the western to the eastern shore the depth diminishes, but not very regularly, until the water-spread is lost in shallow bays and rush-covered lagoons, from which the waters retire during the prevalence of east winds.

The perpendicular cliffs bounding the western coast of Lake Aral have on their summits the Ust-Urt plateau; their line continues with diminished height to the north, and terminates in that direction; but they reappear in lat. $47^{\circ} 15'$, at about 20 miles to the south of the Mougojar Hills in a steep escarpment, which continues with increasing height in a south-westerly direction to the Caspian Sea. This escarpment, which is locally called the Tchink, is also the continuation of the cliffs in a south-westerly direction from the south-west corner of Lake Aral, and it thus forms the northern and southern boundaries of the Ust-Urt plateau. The line of the Tchink is not a regular one, but juts out into bold promontories over the lower ground, and is broken by deep ravines which enter the central mass of the plateau, and probably communicate with numerous deep bowl-shaped depressions occurring upon its surface. Upon the Ust-Urt, between lats. 45° and 46° , the map shows a chain of salt-lakes running across it, besides several extensive tracts of sand; and at about lat. $43^{\circ} 20'$ a cleft or depression on the edge of the Tchink seems to have admitted an overflow from Lake Aral at a higher level, into a large low-lying tract of ground, which is now occupied by the salt-tract and sands of Barsakilmass, under lat. 44° . On the south, the Tchink is continued into the high ground which encircles the eastern shore of the Karaboogas Gulf of the Caspian, and which joins on to the mountains lying to the north of Krasnovodsk and the great Balkan. On the west, Ust-Urt is bounded by the Karasu inlet of the Caspian, the low peninsula of Buzachi, and by that of Mangishlak, with its parallel ridges of Aktao. Immediately to the south of this, again, lies a depressed crescent-shaped tract, having its concavity to the west, and bounded on that side by a small plateau similar to Ust-Urt; while to the west and south of this smaller plateau are the Caspian and Karaboogas Gulf respectively. The

whole of the low-lying sandy portions near the Caspian must have been covered at a former historical epoch by the waters of that sea when it had a higher level than that of to-day.

The country round the northern edge of the Ust-Urt plateau is covered with salt-tracts, quagmires, and stretches of sand, which continue to characterise the region lying immediately to the north of Lake Aral. Colonel Veniukoff states, that a comparison of Gladychef's map of Aral, made more than 100 years ago, with that of Admiral Boutakoff, shows that the country near the Tchibass Gulf must have been under water in the last century. The Irgeez and Tourgai rivers, and the various other streams descending into this depressed region, are lost in salt-lakes and quagmires, of which a considerable number are dotted along the surface of the steppe in a northerly direction into the drainage valleys of the Ubagan and of the Tobol, which flow into the Obi. The south-east shores of the Lake resemble those on the east, and the country on the south has been sufficiently described in the Notes on the Amú-darya.

The sand-dunes and tracts of hard clay occurring on the low shores of Lake Aral point to the conclusion, that extensive areas of country which are now dry land were formerly covered by the water-spread of the Lake. It has been remarked that the mouth of the Syr-darya has become, in recent years, fordable; and that the depth of water between the island of Tokmak Atta and the south shore of Lake Aral has diminished. It is also an established fact that a minaret, which grey-beards of the Kirghiz state was formerly situated on the edge of the eastern shore, is now at some hours' walk distant from it; and finally, since 1848, when it was a marshy swamp, Gulf Abougir, at the south-west corner of the lake, has been entirely dried up, and its bed is now under cultivation. There is no doubt that the cause of this continuous shrinking in the area of Lake Aral is, that the evaporation from its surface is in excess of the supply received by it from the Amú and from the Syr; and an attempt will now be made to approximate to the rate of evaporation which takes place in the basin of Aral, from such measurements as are available for the purpose.

Since in 1848 the area of the water-spread of Aral was 25,236 square miles, and the area of its water-spread at a depth of 24 feet is 18,304 square miles, it follows that the water-spread diminishes by about 866 square miles for the loss of each yard of depth down to 24 feet. The only rough observation of the actual decrease of depth in Lake Aral that I can find, is one made by Boutakoff, who noted that at the entrance of the Abougir Gulf the depth of water had decreased 18 inches

2 D 2

between the years 1848 and 1858, and in this period, therefore, the lake lost 0·05 yards per annum in depth, and had in 1858 an area of 24,803 square miles. During the ten years in question there is no reason for supposing that any extraordinary cause affected the quantities of water discharged into the Lake by the Amú and by the Syr; and I shall therefore assume that the receipt of the lake was constant. A question arises, however, as to what this receipt might actually have been; for the closing of the Loudon Canal on the lower course of the Amú in 1857 has, subsequently to that date, caused all that water to be poured into Lake Aral which formerly flowed to irrigate the lands of Atta Murad Khan, and to alimēt the Lake Sarakamish on the Uzboy course of the old Oxus. This quantity of water can only be roughly estimated from the dimensions which Loudon is stated to have possessed, and from the flooding of the lower courses of the Amú-darya which has taken place since 1857, and from these I am inclined to think that Loudon must have carried not less than 1500 cubic yards per second during a high flood of the Amú, or say 450 cubic yards per second during the whole year. From the 2000 cubic yards per second, therefore, which I have stated as being received by Aral at the present day, this quantity must be deducted, leaving 1550 cubic yards per second for the receipt of the lake between 1848 and 1858. The water-spread of Lake Aral would also be influenced by the rainfall it received, and by the quantity of earthy matters carried into its basin by the waters of the alimēting rivers. Since the earthy matter would be but $\frac{1}{1000}$ th, roughly, of the water received by the Lake, into which but little is carried during high floods, since the marshes act as settling grounds; this cause of variation of level may safely be neglected in a calculation having for its object the rate of annual evaporation. No data exist from which the annual receipt of the lake from rainfall can be stated with certainty, but we may, however, with M. Elisée Reclus, assume it to be 23 centimètres, or 0·25 yards per annum, which is a mean of the amount of registered rainfall at the two nearest stations, Ashtrakhan and Uralsk. The rate of evaporation yearly from the surface of Lake Aral will then follow from the following equation:—

Volume evaporated = volume received, plus volume actually lost, plus rainfall received. And for the period 1848 and 1858 the rate of evaporation will be found to amount to 0·906 yards per annum, say one yard per annum, allowing something for earthy deposit in the basin of Aral.

It is a curious coincidence, that, taking the barometric observations of the height of Lake Aral made in 1826 by Anjou and Duhamel, and by Struve in 1858, the rate of evaporation

obtained for the basin is almost precisely the same as that found from Boutakoff's soundings. In 1826 the level was found to be 36·2 feet above mean sea-level, and in 1858, 24·9 feet; giving a fall of 11·3 feet, or 3·76 yards, in the thirty-two years. The area of Aral in 1826 would therefore have been 26,405 square miles; and by using the same equation as before, the rate of evaporation will be found to be 0·95 yards per annum. We may hence assume, that the rate of evaporation of one yard per annum which has been found, approximates sufficiently to the true rate, to allow of some speculations being hazarded regarding the physical aspects Lake Aral may have presented under different conditions of supply from the rivers feeding it.

Taking first the case that Lake Aral received no supply whatever—a circumstance which may have occurred if both the Amú and the Syr flowed to an outlet in the Caspian Sea—we shall find that down to 72 feet in depth below the present level, twenty-four years only would be required to dry up Lake Aral into the five separate portions which have already been mentioned, and of which the largest and deepest has an area of 2152 square miles, and contains 62,380,000,000 cubic yards of water. If the non-receipt of water continued, less than fifty years would elapse for the *entire* desiccation of this deepest remaining part, and a very much less time, of course, for that of the other four shallower portions; and Lake Aral would consequently disappear in less than three-quarters of a century from the present date, if the waters of the Amú and of the Syr were otherwise disposed of than at present.

At the level of 1848 Lake Aral contained 1,233,434,000,000 cubic yards of water—a quantity which is equal to a supply of 2000 cubic yards per second (the present contribution of the Amú and of the Syr), taking place during $19\frac{1}{2}$ years; but since evaporation would be going on from the moment it is supposed such a supply to the dry basin of the Lake recommences, it is manifest that to bring the water-spread again to its present area would require more time than that number of years.

The time required for this operation can be found from the following equation:—

Content of lake equals supply during the time from Syr and Amú, plus supply from rainfall, minus evaporation during the time; and with the supply of 2000 cubic yards per second and a rainfall of 0·25 yards per annum, and an evaporation of one yard, it will be found $40\frac{3}{4}$ years only would be required to restore Lake Aral to the size it had in 1848. Less than a century and a quarter only would consequently be required to dry up the Lake *entirely* and bring it again to the level it

possessed in 1848, if it subsequently received, again, a supply equal to that of to-day.

At the present time about one-half of the flood-discharge of the Amú-darya is absorbed in the irrigation of Khiva, and probably the same, if not a greater proportion, of that of the Syrdarya is diverted for the cultivation of the Khanate of Kokand. From these two rivers alone, therefore, Lake Aral might, at some particular epoch, have received double the supply which it receives to-day; to say nothing regarding the probability, that the Rivers Tchuy, Sary-Su, Talass, Irgeez, Turgai, &c., which now end in the sand, and that many other rivers, such as the Kunderlik, Demus, Baskatis, Jastus, &c., which have disappeared altogether, in the regions round Lake Aral, formerly contributed their waters to aliment its water-spread. Under such circumstances the lacustrine basin of Aral would have continually filled up, until either the surface assumed such dimensions that the evaporation from it equalled the supply, and so arrested its further increase; or until it reached some point, over which the waters could escape and flow away over the adjacent country on a lower level.

Now, since the Caspian level of 1875 was ascertained to be 243 feet below that of Aral, the description which has been given of the country shows, that the waters of Lake Aral could have escaped at some particular point, and so have limited the water-spread to a determinate area, beyond which it could not have increased.

The accompanying diagram (No. 22) portrays, in a sufficiently approximate degree, the ground which is situated at the south-west corner of the lake; and the mere inspection of it will show that when Aral attained to a level of about 51 feet higher than that of to-day, its waters would have flowed over a spur (which runs out from Ust-Urt in a south-easterly direction) and into the Uzboy Channel, by which the Kunya-daryalik arm of the Oxus formerly flowed down to the Caspian Sea. A reference also to the Notes on the Amú-darya, where a description is given of the watermarks seen upon the sides of the Kashkanatao Hills, will afford confirmation, if any is needed, of this additional depth which Lake Aral certainly possessed, at a former and recent epoch.

With this additional depth of 17 yards the water-spread of the Lake would have had an area of 39,258 square miles at a height of about 208 feet above mean sea-level, and the evaporation taking place from this surface, would have absorbed a supply of about 3850 cubic yards per second. Assuming the Lake to have received the same rainfall as that which has been supposed in the previous cases discussed, the united volumes contributed by the Amú and by the Syr, for the permanence of such a high-

to face base 406
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Diagram No 22

SURVEY OF 1873

Figures give heights above Aral in feet.
Fished line Kizildarya bed. ---

level Aral, would require to be about 3000 cubic yards per second, or half as much again as the quantity those rivers bring down into the Lake at the present time.

Besides the point where the overflow of Lake Aral could take place at the south-west corner, and in all probability did take place up to a very recent period, since Russian information of the sixteenth century states that from the Blue Sea (Aral) the River Arzass flowed to the Sea Khvalim (Caspian);* a depression in the edge of the Tchink, in lat. $43^{\circ} 20'$, has been indicated, by which the waters of the Lake flowed to flood the salt-tract and sands of Barsakilmas. The height of this cleft is stated upon the Austrian Staff-map of Central Asia to be 244 feet, though future observation may make it lower. From Barsakilmas, again, they would very probably have flowed to fill other depressions, situated at lower levels, on their progress westwards to the depressed basin of the Caspian, and the surface of Ust-Urt would have been so covered by a series of lagoons and connecting channels, and have presented the appearance of a sea full of islands.

As far as present information shows, there would not appear to exist any other depressed points in the high cliffs forming the western limit of Lake Aral by which a similar overflow could have taken place; but it is not improbable that such may yet be found. Humboldt imagined that these cliffs above lat. 42° would have prevented any communication between the waters of the Aral and of the Caspian; since he supposed the line of their declivity to join on to the Mougojar chain of hills on the north. More accurate observation shows, however, that this is an error, and that the line of the Tchink which forms the northern limit of the Ust-Urt plateau commences under lat. $47\frac{1}{4}^{\circ}$, about 20 miles south of the Mougojars. The 'Catalogue of Trigonometrical and Astronomical Points in the Russian Empire,' compiled by the Geodesical Department of the Military Staff, states the ground about the head of the Tchagan stream, in lat. $47^{\circ} 7' 27''$ and long. $58^{\circ} 17' 41''$ [Green], to be 257 above mean sea-level. The difference between this and the height of 210 feet, at which Lake Aral overflowed at its south-west corner, is sufficiently small to suggest a probability that more accurate levelling will correct the barometrical height given for the ground over which an overflow from the north-west corner of Aral would require to have taken place, to cause the physical aspects which characterise the country stretching from there to the Caspian Sea. It is also to be noted, that the Ust-Urt spur, at the south-west corner of Lake Aral, would have in all proba-

* Since writing this, I am inclined to think that by Arzass was meant the branch of the Syr from below Otrar, along the Janidarya and Uzboy to the Caspian.

bility had its surface somewhat worn away by the action of overflowing water, driven forcibly over it by the northerly gales which distinguish Lake Aral; and this circumstance would account for some feet of the existing difference between 257 and 210 feet, which requires reconciliation.* If this should eventually be effected, Lake Aral would have overflowed both at the north-west and the south-west corners, as well as by the depression described as existing in the Tchink; and the aspect presented by the country subjected to this inundation would be similar to that possessed at the present day by the central regions of the lower Amú, which have already been described in detail in the Notes on that river. Escaping from the higher basin, with no momentum, over the smooth compact clay country, the waters would have spread laterally, and have alimented those rush-covered marshes which were spoken of by the Chinese when they advanced to the Caspian as conquerors under Pantchao, at the end of the first century of our era, and in which the nomad Kirghiz at the present day find shelter during the winter, though the ground they cover is almost entirely dried up. Here and there, at intervals, the waters would have formerly filled up depressions and swept sand into them, which at the present day remains on the tracts characterising these regions. It seems not impossible, besides, that they might have penetrated and flooded portions of the Ust-Urt plateau by the deep ravines which break the line of the Tchink escarpment, and have so entered into the central mass intervening between the Aral and the Caspian Seas.

A remarkable confirmation of the state of things which has been supposed to have existed, is afforded by the circumstance that not until the commencement of the fourteenth century does any European map of these regions hint at the separation of the basins of the Caspian and of the Aral. On the other hand, the Arabs who conquered Khwarezm were acquainted with the fact that Lake Aral had a distinct basin, and this knowledge, however much in contradiction it may appear to be with the ignorance which existed among Europeans on the subject, is, on consideration, entirely susceptible of a reasonable explanation; for these must have been prevented by the actual physical aspects from examining into the swamp-laden intervening tract, and from so becoming acquainted with the isolation of the upper reservoir, which was evident to those living along its shores. Still more if it is considered that the junction was formed by an intermittent overflow, which depended upon the quantity of water used for irrigation and upon the varying volumes of the alimenting rivers during floods, it is evident

* The required point I have since found at Kazar Chakan, lat. $46^{\circ} 25' 4''$, long. $58^{\circ} 34' 33''$, whose height is 210 feet.

that the Arabs must have had precisely the sort of information regarding the water-spread of Lake Aral, which was unattainable by the Europeans of the Caspian; and the mystery with which this ignorance has hitherto invested the state of this Sea since the earliest times is in this manner explained.

It has been stated that one European map hints at the isolation of Lake Aral, and it is remarkable that the confused information which has hitherto been attributed to this, affords in itself some confirmation of those appearances which the Aralo-Caspian region would present when subjected to the intermittent overflow which has been described. The late Sir Roderick Murchison, in his address to the Royal Geographical Society for 1867, in quoting from some notes drawn up by Colonel Yule upon the mediæval maps of these localities, stated that the map of the Venetian Marino Sanudo (which was submitted in the year 1325 to the Pope and to the King of France, with a project for the destruction of the Muhammedan power) bears strong testimony to the existence of Lake Aral. It clearly shows *Mare Yrcanum*, *Caspis*, or *de Sara*, in the proper position of the Caspian, which is connected by a river with another sea further to the east, and full of islands. This sea Colonel Yule thought to be, in a startling degree, suggestive of Aral; and further to the east of it, towards Sara, appears a third and smaller sea, without a name, into which Gyon (*i.e.* Jihoon or Oxus) flows. The map is engraved in Bongarsius' 'Gesta Dei per Francos,' vol. ii., and there is a *quasi facsimile* of it in the second volume of Vincent; but in this the third sea is scarcely to be recognised. Such a map as this would not very untruthfully represent the Aralo-Caspian country, at a date not long after the cessation of an overflow of the kind which has been suggested. The sea full of islands would be the surface of Ust-Urt, studded over with lagoons and lakes in a half dried-up state; while the more pronounced cliffs of the plateau would distinctly isolate the third sea into which the Jihoon flowed, and which would occupy the position relatively of Lake Aral itself.

On three sides the isolated basin of Aral is now divested of very much of the difficulty which formerly attached to speculations on its probable past aspects; but on the north, *i.e.* on the fourth side, there is still an obscurity, which can only be cleared up by future accurate levelling. In this direction there exists a transverse ridge which divides the drainage flowing southwards by the Tourgai and its affluents towards Lake Aral, and northwards by the Ubagan and the Tobol into the River Obi, and so on to the Frozen Ocean. If the height of this ridge be about 210 feet above mean sea-level, it is evident that the waters of a high-level Aral might have escaped in this direction also, and

that the Lake, along the water-course lines which have been mentioned, would have formed a junction with the Frozen Ocean.

In 'Asie Centrale' Humboldt expresses himself very decidedly regarding the low elevation possessed by this dividing ridge, and speaks of the ground it crosses as the great depression by which the waters of Lake Aral formerly communicated with the Frozen Ocean. He states the height of Oorsk to be 52 toises, and that of the town of Tobolsk to be 18 toises; but as the correct figure for the bank of the Ural River at Oorsk is really 590 feet, that for Tobolsk is probably some few feet less than 200, and the height of the dividing ridge at the sources of the Ubagan might thus be about 210 feet, allowing a small slope for the water-course-line down to the last town named. This rough approximation to the height of the ridge agrees pretty well with that at which Aral is shown to have overflowed both at the north-west and south-west corners, and affords some presumption that the ground about here has undergone no change in historic times.

On the other hand, the height of the church at Oorsk is about 690 feet, and the country east of that place is thus described in 'The Kirghiz Steppe of Orenburg,' by Lieutenant-Colonel of the Staff, L. Meyer:—"From Oorsk there stretches, in an easterly direction, a flat elevation, with very gentle declivities, noticeable on the map only from the direction of the streams, but in nature seeming quite flat. This elevation, the absolute height of which is about 1100 English feet, abounds in lakes along its slopes, and serves as a water-shed for the rivers running north and south, but in no way deserves the name of mountains; on the contrary, it belongs to one of the level places of the steppes, and therefore has no special name."

On this I would remark, that if the ground east of Oorsk continued in that direction, with the very small decrease of height which the above passage indicates, the southern slope of the dividing ridge towards the low ground north of Lake Aral would be a very steep one; which is not actually the case. But besides this, the height of 1100 feet, assigned by Colonel Meyer to this ground, is probably somewhat exaggerated. He describes the country as if it was either level or fell away gently from Oorsk eastwards, though it actually rises along a distance of 90 miles in this direction by a gentle slope; and if we give this, 3 feet per mile, the height of the ground at the point where it actually commences to fall to the east again (*i.e.* in lat. $51\frac{1}{4}^{\circ}$, long. $58\frac{1}{3}^{\circ}$) would be 900 feet at the most. From here the country continually falls to the east, along a distance of 180 miles, to the sources of the Tourgai flowing south, and of the Ubagan flowing north; and if Lake Aral ever did flow over the ridge, the point where the waters passed should be 210 feet, about,

above mean sea-level. The fall, therefore, along the 180 miles would be $900 - 210 = 690$ feet, or less than 4 feet per mile; a slope which is gentle enough to be in agreement with the general idea of the flatness of the country as described by Colonel Meyer: but even if the maximum height was 1100, instead of 900 feet, the slope to the east along the 180 miles would not be 5 feet per mile, and there is nothing, therefore, *primâ facie*, against the probability of the overflow having taken place, as far as the actual physical features of ground have been described.

That this overflow of Lake Aral actually did take place over the dividing ridge on the north in very recent times, there is a mass of indirect evidence to show. Baron de Herberstein, who was sent twice during the sixteenth century from the Court of Vienna on diplomatic missions into Russia, wrote an account of the country, entitled 'Rerum Moscovitar. Commentarii, Russiæ breviss. Descriptio. 1549. In fo.' The map attached to this, M. Vivien St. Martin describes as the first attempt at a graphic representation of the Muscovite Empire in its modern aspect, and shows the River Obi running from the Lake of Kitay into the Frozen Ocean. In Bergeron's work, 'Voyages faits principalement en Asie dans le 12^e, 13^e, 14^e, 15^e siècles, &c., La Haye, 1735,' there is a curious letter, which is stated to be written by Jean Balasch, of Arnsberg, to Gerard Mercator in Cleves, under date 1581. The writer, knowing that the geographer was interested in the route to Cathay, sends his letter by the hand of a Flemish traveller, a soldier by profession, who, having been some years a prisoner in Russia, had been sent to Antwerp to engage artisans for the purpose of constructing vessels for the navigation of the Dwina. This Flemish soldier is stated to have related, that when in northern Russia he travelled to the River Obi, partly by land and by the country of the Samoiedes and Siberians, and partly by the River Petchora. That he equipped a ship full of merchandise, whose draft was small, and took with him everything necessary for the voyage, besides several men of the country who could speak the language, and who knew the River Obi, where they went every year. That he started by the way of Ugoria, Petchora, &c., in surveying and examining the route. . . . That when he arrived at the Obi, which was said by the Samoiedes to have seventy mouths . . . he determined to examine three or four only of them, so as not to lose time . . . That from there one can ascend the Obi . . . to a place which he himself had reached by land from the country of Siberia, and which was only twelve days' journey from the mouth of the river . . . and is called Jaka Olgush, from the name of a second river which joins the Obi.

That when one has arrived there the greatest difficulties are past, for the people of the country say, that after three days of navigation (which is a sufficiently rare thing for them to perform, since several who had only proceeded one day's distance had there perished with their leather boats in a tempest), one finds on the water-spread of this great River Obi many vessels laden with precious merchandise, and manned by black people, coming by a great river called Ardok, which enters the Lake of Kitay.

Jenkinson, travelling through Khiva in 1559, states in his narrative, which will be found in Hakluyt, that "the great river Oxus falleth into another great river called Ardok, which runneth toward the north, and consumeth himself in the ground, passing underground above 500 miles, and there issueth out again and falleth into the Lake of Kitay." The Swedish ambassador Olearius also states, and gives a map which shows, the Obi to flow from the Kitay Lake, in 1636. The passages which have been given from Bergeron and Jenkinson, as well as the maps from Herberstein and from Olearius, all go to show that in the sixteenth century Lake Aral overflowed the transverse ridge on the north, which divides its basin from the drainage passing into the Obi. In the fifteenth century the Cardinal d'Ailly (Petrus Alliatus) thought there were two Caspian Seas,—one isolated and surrounded by land on all sides, and the other communicating with the Northern Ocean, a belief which is strongly presumptive of the present Caspian and of the overflow of Lake Aral to the north.* Passing over the Arabian geographers, in whose writings it certainly might be expected that some mention of the overflow would have been made, if it had been in operation at their day (a circumstance which, however, should not be taken for granted, since it was an intermittent overflow dependent upon the supply of the rivers feeding Aral), we find that every geographer and writer up to the fifth century B.C., with the exception of Ptolemy, Diodorus the Sicilian, Aristotle, and Herodotus, affirms the junction of Aral with the Frozen Ocean. Notwithstanding Ptolemy's great authority in such matters, we find Quintus Curtius and Agathemerus, who came immediately after him, contradicting his assertion regarding the isolation of the Caspian. Nor were the Greeks satisfied with the information given by Herodotus, since Alexander fitted out an expedition, whose researches on the Caspian expressly contradicted that state of isolation which the Father of History assigned to it, in such terms as suggest the idea of still more

* It may possibly be that the basin of Chelkar-tengis might overflow to the north while remaining distinct from Aral.

ancient discussion of the same question having taken place, regarding perhaps the expedition of the Argonauts.

Among the descriptions of the Aralo-Caspian Sea which have been handed down to us, those of Strabo, Pomponius Mela, and Pliny are especially remarkable, both from the similarity of the aspects described and the light which the information afforded by one writer sheds upon what is obscure in another. The nearness of the date at which these three authors wrote offers a strong presumption against plagiarism, and is good evidence that in their day Lake Aral overflowed to the south, to the west, and to the north; though they supposed that the ocean made an irruption into the land in a southerly direction. Nor are the contrary assertions made by the four exceptional classical authorities, nor is even the silence of the Arab geographers, regarding this overflow of Aral, any evidence against the occurrence of the fact for which there is such strong evidence at other epochs. The figures which I have submitted in previous parts of this paper (making allowances for all possible incorrectness which may result from deficient knowledge) afford very strong grounds for asserting that the level of Lake Aral might have fluctuated in a degree enormously greater, during short spaces of time, than that which has hitherto been generally supposed, and much of the obscurity which has attached to the aspect of the Aralo-Caspian Sea in past historical times, is cleared up by the very simple explanation submitted for consideration in these Notes.

NOTE.

TABLE OF DIMENSIONS OF LAKE ARAL.

	Square Miles.
Area of water-spread of 1848	25,236
Area of water-spread of 1858	24,803
Area of water-spread at 24 feet depth below level of 1848	18,304
Area of water-spread at 48 feet depth below level of 1848	13,297
Collective area of five portions at 72 feet depth below level of 1848	5,010
	Cubic Yards.
Content of lake from level of 1848 down to 24 feet in depth	530,805,000,000
Content of lake between depths of 24 and 48 feet ..	391,537,000,000
Content of lake between depths of 48 and 72 feet ..	226,905,000,000
Content below 72 feet of depth	84,188,000,000
Content of Aral in 1848 Cub. yds.	1,233,435,000,000

The three or four hundred millions of cubic yards, which Abougir probably contained in 1848, are not included in the above figures.