

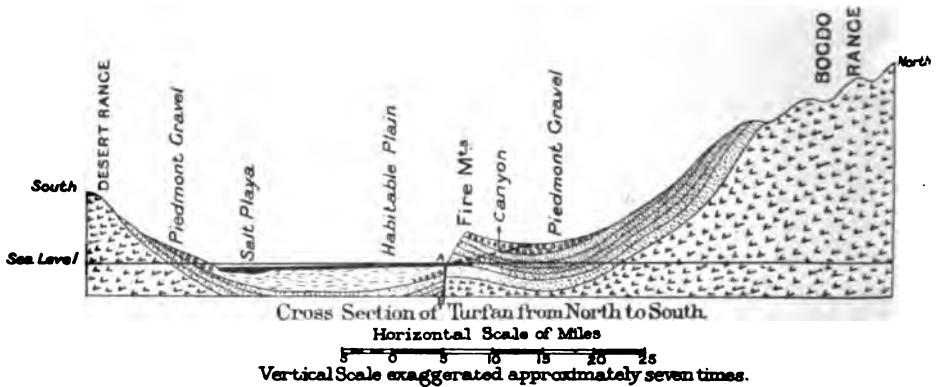
treatment of women. They neither veil them nor impose upon them heavy manual labour. Their women are well clothed, and are free to ride abroad, bully their husbands, and express their opinion in public affairs with as loud a voice as any suffragette could desire. To see a woman of sixty upright as a lance and with a good figure is not uncommon, and that, I think, is a sufficiently striking testimony to any one acquainted with the East.

(To be continued.)

THE DEPRESSION OF TURFAN, IN CENTRAL ASIA.

By ELLSWORTH HUNTINGTON.

THE little basin of Turfan in Chinese Turkestan is of peculiar interest, because, though situated in the very heart of Asia, its lowest portion lies below sea-level. Various travellers have passed through it, and for more than a year it was the headquarters of a Russian scientific expedition. Recently it has been the scene of important archæological



investigations by Grunwedel and Le Coq. The name Turfan is becoming well known; but, so far as I am aware, no one has hitherto published any adequate description of the region from a geographical point of view. The basin of Turfan furnishes an unusually good example of the geographical type characteristic of the arid regions of the world. *Physiographically* it consists of a ring of high mountains surrounding a smooth plain of sediments derived therefrom. The climate is so dry that most of the streams wither to nothing on the basin floor, while the rest terminate in an evanescent salt lake or playa. *Geographically*, the chief features are, first, that the dry climate almost inhibits the growth of vegetation in most places, but causes it to grow luxuriantly in the areas which are watered by the mountain streams; and second, that

man, being able to subsist only in a few limited oases where alone water is found, has developed the form of civilization characteristic of arid regions where irrigation is practised.

Upon reaching Turfan at the end of February, 1906, on my way northward to Siberia from the hitherto unexplored salt desert east of Lob Nor, I was at once impressed by the resemblance of the basin to Persia and other arid regions far to the west. At Doksun, or "Ninety," the first town, the days were so warm that the most pleasant place to sit at noon was on the flat roofs of the mud houses, although the night temperature fell to zero. As I looked abroad one noon over an ornamental parapet of sun-dried brick, a dreamy haze softened but did not blur the rounded outline of the pale blue desert mountains to the south. Far to the north and west the snowy tops of the higher peaks of the Bogdo range, rising 12,000 or 14,000 feet, gleamed fitfully among wisps of cloud. At their foot broad naked slopes of gravel were broken by descending lines of little mounds, the heaps of earth around the mouths of the wells by which the "kariz," or underground canals, are entered and cleaned. Nearer at hand the adobe walls of ruined forts or Buddhist shrines stood white and clear in the bright sunshine, while around them stretched a smooth yellow plain, where the reeds were all dead and broken off even with the ground. Nearest of all, four or five Chantos, or Mohammedans of Aryan race, in sober snuff-coloured gowns, and two women, in picturesque red jackets worn over blue skirts reaching to the knee, were spreading manure on grey fields. Two other Chantos in the same field ploughed up the grey soil with wooden ox-ploughs like those used from time immemorial all over Asia. A Chinese merchant, clad in pale blue, walked across the field toward the walled enclosure of the Chinese town; a high covered cart set on a long axle between two big cogged wheels, lumbered by, with one horse in the shafts and three abreast in front, and as it creaked between the high mud walls protecting precious orchards, the lolling driver encouraged his team with shouts of "Owa, owa, owa, oh!" and a wave of his fish-pole whip. Suddenly not only the distant scene, but the pale grey, almost dazzling prospect of neighbouring walls and fields was swallowed up in dust. A strong north-west wind had sprung up. Soon it increased to a gale, and I had to leave the roof to two gourds rolling merrily amid clouds of blinding dust. By sitting low on the warm mud oven filling half my room, I could have obtained light enough for my work, if the room had not been darkened by the heads of a dozen or twenty Dungans, or Mohammedans of Chinese race, whose eyes were glued to holes torn or sucked in the paper windows.

That evening, as my Chanto host was entertaining me by playing on a marvellously slender, long-necked tambourine, he remarked, "This wind is nothing. You just wait."

Two days later we were camped in the reedy salt plain 20 miles to

the east, beside a stone wall made of blocks of rock-salt. An evening gale came up, and blew over my tent and that of the men.

"This is nothing," said the host, who had become our guide. "Just wait till April or May. Then the wind takes the roofs off houses, and leaves the young wheat with 2 or 3 inches of its roots swept bare of earth. All this wind comes from a little lake on the way to Urumchi. There is an iron gate in the lake, and it is only half shut. If any one could shut it, the wind would stop."

I visited the lake on the way to Urumchi—the seat of the Chinese viceroy of the "new province"—100 miles north-west of Turfan, and saw the reason of the legend. Two monoliths, about 7 feet high, stand near the shore. Near them there are a number of artificial mounds of various sizes, and several lines composed of groups of stones. Each group consisted originally of about eight boulders from 1 to 3 feet in diameter, arranged in a circle perhaps 6 feet across. The whole aspect of these relics of an unknown race is almost identical with that of the mounds which I saw in 1903 with Prof. Davis, of Harvard, at Son Kul and Issik Kul, 600 miles to the west.

The climate of Turfan is characterized by extremes in other respects as well as in its winds. On March 5, a quiet sunny day, the temperature was 2° below zero Fahrenheit at sunrise, but rose to 54° above zero at noon in the shade of a high cliff. The summer in this mid-continental basin is of necessity very hot, as might be expected in a place 300 feet below sea-level. Horses, cows, sheep, and camels die unless driven to the mountains. Only the hardy donkey can live through many seasons. In 1894, when a Russian expedition spent a year at Lukohun, on the east side of the basin, the mean temperature of June and August was 87° Fahr., and of July 91°, and the absolute maximum 118°. Such temperatures as those of Turfan render exertion of every kind almost impossible in summer, but they make the fruits of the region most luscious. At the beginning of March I found fresh melons, grapes, apples, and pears in the markets, all of them most delicious and perfectly preserved. The only exception was a kind of pear which is never sold until it is rotted, as the flavour is then supposed to be best. In summer the variety of fruits is, of course, greater. The heat is so intense that melons are cut into strips and dried in the sun. In most parts of the world they would rot long before they became dry.

According to the Chinese, the summer is so hot that during the day the birds all gather in the shade of the trees beside the rivers. If one of them flies up he is scorched to a cinder, and falls sizzling into the water. Another Chinese yarn affirms that the heat is so great that after blowing on your rice to cool it, you must ply your chop-sticks as fast as possible. If you do not, the rice will become hot again and burn you. In winter, as might be expected, Turfan is cold. The mean temperature in January, 1894, was 15°, and the minimum

-5° Fahr., which seems high in view of the temperature of -2° which I experienced on March 2, 1906. Snow never falls; at least, my host at Doksun said that during the forty years of his life he had never seen any there, although it falls yearly on the mountains round about. Rain, he added, is almost equally rare. Once or twice each summer it falls in sufficient quantity to wet the ground, though not to run. Once in ten years or so there is a cloud-burst, and raging floods ruin fields and houses.

In order to see as much of Turfan as possible in a short time, I planned to go around the periphery of the basin with horses, sending my camels to the capital, also called Turfan, to be sold. It proved impossible to carry out this plan entirely, because south of the playa of Böjanti there is no water. When we tried to go north of the playa, there was so much water that three horses sank into the mud so deeply that we were obliged to unload them before they could extricate themselves. At Deghar, the most eastern village which I visited, we found a queer anomaly. Although the village lies in an almost rainless region at the foot of some of the highest sand-dunes in the world, it not only has suffered from occasional floods, but the houses have to be rebuilt every five years because they sink into the mud. The plain of Turfan is so flat that in spring underground water from the mountains converts hundreds of square miles into impassable muck. It might be expected that plants would grow abundantly, as in the zone of vegetation of the great Lob basin to the south. So they do, to a certain extent, and have done much more extensively in the past. On the whole, however, the water dries up so early in the season that only camel-thorn and a few reeds can flourish.

The chief physical features of Turfan, aside from its arid climate and strong north-west winds, are illustrated in the accompanying map and section. As is usual in the enclosed basins of arid regions, there are four chief divisions arranged concentrically, namely, the mountains, the Piedmont gravels, the habitable plain of fine soil, and the central lake or playa. The crests of the peripheral ring of mountains form the boundaries of the Turfan drainage area, measuring about 80 miles from north to south, and nearly 200 from east to west. On the north and west the Bogdo and other ranges of the eastern part of the Tian Shan system rise to a height of from 12,000 to 14,000 feet, and, being comparatively well supplied with rain and snow, form the source of the chief streams. In most places the lofty mountains are difficult to traverse, so the roads must follow deep, precipitous gorges; but in the neighbourhood of Davanchin, near the Lake of the Winds, mentioned above, there is a pass only 3700 or 3800 feet above the sea. This is the lowest point in the whole of the vast circuit of mountains and plateaux which hem in the great basin region of Chinese Turkestan, extending nearly 1500 miles from east to west and 500 or 600 from

north to south. Wright* has recently stated that "all through Tertiary times" this pass served as a connecting channel between the Arctic ocean, which then covered Siberia, and a great interior sea in Western and Central China. He further holds that since man has occupied the Earth there has occurred a brief submergence by which the whole of Northern and Central Asia was covered by the ocean at the time of the Noachian deluge, and the pass near Davanchin was converted into a strait connecting an inner and an outer sea, as the Strait of Gibraltar connects the Mediterranean and the Atlantic. The theory is most interesting; but I found absolutely no evidence to



A VALLEY IN THE CHOL TAGH, OR DESERT MOUNTAINS, SOUTH OF TURFAN.
ICE IN THE FOREGROUND.

support it. Central Asia does not appear to have been covered by the ocean since Eocene times, at the beginning of the Tertiary era millions of years ago.

In contrast to the lofty mountains on the north and west sides of Turfan, those to the south are low, with well-rounded, mature forms. They are intensely dry, and well deserve the name of Choul Tagh—the Desert mountains. The few springs are usually saline, and there are no perennial streams. Nevertheless, during periods of occasional rainfall they are areas of rapid erosion, like all the other mountains.

The other three concentric divisions of Turfan are areas of deposition.

* 'Scientific Confirmations of Old Testament History' (Oberlin, Ohio, 1906), pp. 214, 302, 309-312, 321.

The coarser waste carried by floods is deposited at the base of the mountains as a zone of Piedmont gravel. In the course of ages the gravel has gradually accumulated to great depths, burying the lower slopes of the mountains, and forming a broad barren expanse like a beach of shingle from 5 to 20 miles wide. In its dry porous depths most of the streams, even those from the highest mountains, gradually lose themselves, disappearing completely. At the inner edge of the zone of Piedmont gravel—that is, at the edge farthest removed from the mountains—pebbles give place to fine clayey deposits forming a smooth plain. The plain is covered with reeds and camel-thorn, half of which are dead. Villages dot it here and there where water can be procured for irrigation. As one approaches the centre of the basin, the plain becomes more or less saline, and the clumps of trees characteristic of villages give place to grey towers of adobe, marking sites once occupied by man, but now no longer habitable for lack of water. Finally, in the lowest part of Turfan, 300 feet below sea-level, the saline plain gives place to a still more saline playa, the central reservoir toward which flow all the centripetal streams from the mountains, though only the one from Davanchin is able to reach it for more than a few days at a time.

The peripheral upland, the Piedmont gravel zone, the inhabited plain of fine soil, and the salt lake or playa fed by withering centripetal streams,—all these are typical features of the basins of arid regions. Two features of Turfan, however, are peculiar: the vast accumulations of sand at the eastern end of the plain, and the little range of the Fire mountains on its northern border. The sand has been taken from the plain and from the gravel zone by the prevailing north-west gales, and has been piled into enormous dunes 500 or 600 feet high. It is dark in colour, because the mountains from which it was originally derived are composed largely of basaltic lava. It forms an absolutely desert region, into the centre of which the natives never penetrate, so far as I could ascertain. They speak of the "Sand mountains" as an unknown region into which they dare not venture far, the home of goblins and demons dwelling in ruined cities which were buried in sand because of the gross immorality of the inhabitants.

The Fire mountains are not volcanic, although their name has given rise to the oft-repeated fiction that an active volcano exists in Central Asia. There is nothing of the sort. The name was given to them by the Chinese because of the brick-red colour of the sandstone of which they are composed. The sandstone is largely of Tertiary age, but part of it perhaps dates back as far as the Cretaceous. It varies from very coarse to very fine in texture, and is often interrupted by bands of light-coloured clayey shale or of gypsum. Everywhere it is full of ripple-marks, raindrop prints, mud cracks, and the like. These features, together with the absence of fossils, the inconstancy of individual

layers, and the prevailing red colour, show that the strata were deposited sub-aërially, and that the Turfan basin has not been submerged beneath the sea during recent geological times. They also prove that throughout the Tertiary period the climate was, for the most part, as dry as it now is.

The structure of the Fire mountains will be readily understood from the cross-section on p. 254. At a very recent date, geologically speaking, a fault or dislocation (A-B in the cross-section) took place along an east-and-west line parallel to the Bogdo range and about 40 miles from the main crest. North of the fault a long narrow strip of the Earth's crust about 5 miles wide was uplifted and tilted so that it dipped northward. To the south the plain of fine soil dropped to a lower level, and the



YOUNG MEN OF TURFAN DIGGING THE STALKS OF REEDS WHICH DIED CENTURIES AGO AND ARE NOW TO BE USED AS FUEL. THE FEATHERY WEEDS ARE CAMEL-THORN.

front of the tilted strip was left as a steep, inaccessible red escarpment about 2000 feet high. At its western end, beyond the low place in the mountains where, as the map shows, Turfan is located, the fault splits into two parts, giving rise to two steep southward-facing escarpments. The recency of the Turfan faults is proved by their relation to alluvial terraces. In Turfan, as in the other arid regions of Central Asia, the alternating moist and dry climates of glacial and interglacial epochs caused the streams to form five terraces. The oldest is large and much dissected, the youngest very small and fresh. All five of the terraces are found in the valleys which cut across the Fire mountains, but only the two lower ones are continuous on both sides of the fault line. The

other three were cut off by the fault, and end in mid-air where they reach the escarpment. On the downthrown side south of the fault they have been completely buried in more recent deposits. Evidently the little red range of the Fire mountains did not come into existence until the three major glacial epochs had passed away. By that time man certainly existed in Europe and probably in Asia.

The occurrence of the Fire mountain fault was most fortunate for man. If the inner edge of the zone of Piedmont gravel merged everywhere into the finer deposits of the central plain, most of the water from the mountains would be irrecoverably lost. Part, perhaps, would reappear in the form of a zone of vegetation, as it does in the Lob basin, but, nevertheless, Turfan would be almost uninhabitable. While the red range was being uplifted, floods from the Bogdo range cut gashes across it—narrow red canyons with wonderful scenery. A glance at the section on p. 254 shows that the heads of the canyons penetrate into the very heart of the gravel deposits which deeply fill the hollow between the Bogdo range and the Fire mountains. Thus most of the water, which seems to have been lost at the base of the higher range, is brought to light again. It wells out in springs at the upper ends of the canyons, where it supports a few villages upon the narrow terraces; then, with ever-increasing volume, it dashes down the steep red gorges and emerges upon the central plain, where it supports the largest among the flourishing oases of Turfan. Farther south and on either side of the main streams from the canyons, no surface water is available for irrigation. Hence the people have adopted the Persian device of the "kariz." This is an artificial scheme for doing what the red canyons do—that is, for tapping the water stored deep underground. Along the line of greatest slope of the central plain a tunnel is dug. It slopes at a less angle than the surface of the ground. Thus, beginning as an open ditch, it soon assumes the form of an underground tunnel, reached by wells from the plain above, and lying farther and farther below the surface as it is followed mountainward. Near its head it reaches layers of gravel or earth which are saturated with water. This flows down the gently sloping "kariz" until it reaches the mouth of the tunnel, and then comes to the light to support a village. Unfortunately, "kariz" water is more or less saline, and soon ruins the fields, unless they are very heavily manured. The lines of wells by which the "kariz" are entered and cleaned form one of the most unique features of Turfan. Everywhere one sees them by the score, each consisting of a mile or two of crater-shaped piles of gravel surrounding the closed mouths of the wells, which lie a few hundred feet apart. An imaginative Chinese told Sir Frank Younghusband that the hundreds of wells were the work of an invading army of his fellow-Celestials, who found that the heat of Turfan made water scarce. Every spring each "kariz" is cleaned. Professional "kariz"-men go

down the wells and clean out the year's accumulation of mud, together with a vast number of water-snakes, so I was told.

Looking at Turfan as a whole, the scenery of the basin is uninteresting. The lake is a mere mucky salt swamp; the plain, except where there are villages, is a monotonous expanse of reedy stubble and clay, with a little camel-thorn; the gravel slopes are dreary wastes of barrenness; the Sand mountains, though striking, are peculiarly sombre, by reason of the dark grey and deep purple shades of the long slopes. They lack the delicate details so beautiful in sand deposits of lighter weight and colour. The Desert mountains on the south are so flat-topped and subdued in general outline that one gladly turns from them;



OLD BUDDHIST MONASTERY EXCAVATED ON THE SOFT ALLUVIAL TERRACES OF THE UPPER END OF THE MURTUKEH CAÑON NORTH OF KARA KHOJA, IN THE FIRE MOUNTAINS.

even the high Bogdo range on the north arouses enthusiasm only when one approaches it much more closely than the ordinary traveller or inhabitant of Turfan is likely to do. One feature alone, the little red range along the fault-line, redeems Turfan from being utterly commonplace and almost uninhabitable.

I first traversed the Fire mountains north of Lukchun, at the western end of the great sand area. As our caravan approached the mountains, the way led beside a swift brook, bordered by rows of willow, eleagnus, and poplar trees, and by orchards full of fruit-trees. A mile from the centre of Lukchun the guide—by order of the wang,

or native prince, a friendly boy of seventeen—led us to a large mud structure, that we might see a wonderful innovation. It proved to be a little cotton-gin, made within a dozen miles of my home in Massachusetts. It had been exported to Russia, taken to Siberia, and then carried 1000 miles on camels to Turfan. The fact that my people could make such a marvellous machine raised me greatly in the esteem of the natives, and seemed to make them think that the Russians had wronged them by saying that it had come from Russia.

On leaving the cotton-mill we soon came to the base of the steep red escarpment. The form is enough to prove its youth. It rises precipitately from a smooth base-line, which stretches away in an almost straight line far to the east and west. There are no projecting spurs, no retreating valleys. The canyons do not widen at their mouths, but end abruptly at the escarpment. The transition from the canyons to the plain is so sudden that later, after having come down a gorge to the escarpment, I felt as one does when he turns an angle in a narrow path in a dense forest, and unexpectedly finds himself looking out over the unbounded sea. On entering the canyon above Lukchun we found ourselves beside a rushing brook, plunging over naked red rock between high cliffs of gravel forming terraces, or of sandstone forming the main mass of the mountains. The wildness of the scenery set my Ladakhi servants from Northern India to talking merrily of their far-away gorges in the lofty Himalayas. At the end of 4 or 5 miles we emerged from the canyon at the village of Lemjin, lying on the terraces a little downstream from the springs in the Piedmont gravel. As we rode westward along the northern base of the Fire mountains, an utterly different type of scenery prevailed—a vast expanse of naked gravel, stretching northward for mile after mile to the base of the Bogdo range, and rising gently southward toward the top of the low featureless back slope of the red range. Then we turned south again into the narrow canyon of Tuyok, and at once were in another world.

When we came upon the huge ancient monastery or Buddhist lamasery of Tuyok, built largely in caves dug in the terraces, we felt as if we had suddenly been transported to Ladakh and the Himalayas. The village of Tuyok, itself a mere strip on the narrow terraces at the mouth of the canyon, might well have been in the Indus valley. Turfan is crowded with the ruins of Buddhist temples and lamaseries. Each of the ancient holy places has retained its character in spite of the change from Buddhism to Mohammedanism, and the shrines of the past are the shrines of to-day. The chief of them is here at Tuyok. The head sheikh entertained me in his own house. With the freedom from fanaticism characteristic of the Chantos, he took me into the inner shrine, where ordinary pilgrims are not permitted to enter. I fear it was a case of the power of the purse. He supposed that boundless wealth must belong to a man who travelled with a caravan costing

twelve or fifteen shillings a day—as much as the wages of a labouring man for a month. When the sheikh first heard of my approach, he sent a hasty messenger to recall his mother, who had started that morning for Lukchun to attend the wedding of the boy Wang. I remonstrated on hearing of this, but the sheikh answered—

“ If the Wang should see her at the wedding, and know that she had



SACRED BUDDHIST TOWER AT SIRKIP, AT THE FOOT OF THE FIRE MOUNTAINS NEAR LUKCHUN. EACH NICHE CONTAINED A LIFE-SIZE FIGURE OF BUDDHA IN HIGH RELIEF. FANATICAL MOBLEMS HAVE DESTROYED AT LEAST THE HEADS OF ALL THE FIGURES.

left great guests at home uncared for, he would be very angry. He sent a special message that we were to show you every honour.”

Etiquette obliged the sheikh's wife to mortify her curiosity, and hide her face and run away whenever she saw me; but his mother, simply because she was his mother, could not only speak to me, but could bring meals to my room, though her son must set them before me.

Tuyok is a peculiar town. All of its two hundred and fifty families live by grape culture. They say that they raise absolutely nothing

else, except a little fruit and a few vegetables for their own consumption. Their grapes, a small, seedless, green variety, are taken to Peking for the emperor's table. The raisins made from them are the best that I have ever tasted.

In connection with Tuyok and its special industry, it would be of great interest to attempt a study of the influence of physical environment in moulding the habits and character of the people of Turfan, and of the results of the commingling of Chantos, Chinese, and Mongols in this somewhat cosmopolitan basin. It must suffice, however, to say that most of the inhabitants are Chantos belonging to the same somewhat mixed Aryan race as the rest of the people of Chinese Turkestan. Their ancestors came to Turfan a century or two ago from Kashgar, Khotan, Ak Su, and other parts of the Lob (Tarim) basin.

Archæologically and historically Turfan is of unusual interest, because of the abundant evidence that a great physical change has come over the country during the Christian era. The number of ruins is extraordinary. Most of them date from the Middle Ages. A few of the ruins have been investigated by Russian travellers, whose reports are for the most part inaccessible; but it remained for the recent German expedition under Le Coq to study the archæology of Turfan for the first time with any great degree of thoroughness and scientific method. The reports of this expedition may be expected to throw a flood of light on the history of Central Asia, and especially upon the climatic changes to which the country has been subject. Turfan must be peculiarly sensitive to changes of climate because of its complete isolation from the rest of the world by high mountains, its extreme mid-continental position, and the almost rainless character of the basin floor as contrasted with the more ample precipitation of the surrounding mountains. Hence, if changes of climate have occurred in Asia during historic times, and if they have exerted an appreciable influence upon human history, the relation between climate and history ought to be peculiarly manifest in Turfan.

After the long Tertiary era of dry climate, of which we have seen evidence in the red strata of the Fire mountains, Turfan, in common with the rest of the world, experienced the climatic vicissitudes of the Glacial period. There were no glaciers in the region, except in the higher mountain valleys, but the moister or cooler state of the atmosphere caused the rivers and lakes to increase greatly in size. Hence, the term "fluvial" may properly be substituted for "glacial" in order to avoid the implication of glaciation when speaking of non-glaciated regions like Turfan. In Europe and America it is now generally agreed that the Glacial period consisted of several glacial epochs of ice-advance separated by interglacial epochs of warmer or drier climate, during which the ice retreated. In Turfan river-terraces and old shore-lines show that at the same time there was a similar series of cool or moist

fluvial epochs of river and lake expansion alternating with dry inter-fluvial epochs of river and lake contraction. Each succeeding epoch was less severe than its predecessor, just as successive glacial epochs in Europe were less and less severe.

At Turfan, however, there is a series of alternating lacustrine and non-lacustrine deposits, which indicate that previous to the series of *decreasingly* severe fluvial epochs mentioned in the last paragraph, there was a similar series of *increasingly* severe epochs. The deposits consist in part of pale greenish strata of solid clay, which was evidently deposited in the deep water of a large lake, the expansion of the present plays of Böjanti. At top and bottom these typical lacustrine strata pass into



VIEW LOOKING WESTWARD IN THE INNER FORT OF THE RUINS OF CHOUG ASSA (LARGE ASSA). THE HOUSES, LIKE THOSE OF EASTERN PERSIA, ARE MADE ENTIRELY OF ADOBE BRICKS WITHOUT THE USE OF WOOD EVEN IN THE DOMED ROOFS.

others, which were clearly laid down subaërially or in water so shallow that plants throve vigorously. Part of the non-lacustrine strata are composed of sand; others consist of clay full either of the fossil roots of reeds, or of black carbonaceous matter derived from plants of unknown species; still others take the form of bog iron ore, and some of genuine coal. Here and there in the non-lacustrine beds petrified trees are found. The number of alternations between lacustrine and non-lacustrine strata amounts to at least five, and probably more. All of the strata were probably deposited previous to the beginning of the *decreasingly* severe series of climatic oscillations recorded in the terraces

and beaches, and corresponding to the oscillations of the Glacial period in colder, moister lands. Two hundred miles south of Turfan on the borders of the enclosed lake of Lob Nor, and 1700 miles to the south-east around the similar shallow lake of Seistan, in eastern Persia, alternating lacustrine and non-lacustrine strata are found of essentially the same nature as those just described. The chief difference is that at Lob and Seistan there is no coal. The layers full of reeds are succeeded by distinctly subaërial strata of a pinkish colour, full of little stream-channels and other marks of running water, and sometimes showing rain-prints and mud-cracks, which could only be formed when the surface was exposed to the air. From the evidence of these three places it seems safe to conclude that, in central Asia at least, the Glacial or Fluvial period consisted of a long series of climatic changes involving ten, and probably more, complete cycles, during each of which the climatic passed from warm or dry to cold or wet and back again. At first the extremes of a given cycle were mild, but gradually they increased in severity until a maximum was reached, since which time they have decreased.

In many parts of Asia there is evidence—some of which has already been set forth in the *Journal*—that the last faint climatic pulsations of the Fluvial period are still in progress. Apparently two thousand years ago the country was decidedly cooler and moister than it now is. The early centuries of the Christian era, the Dark Ages, appear, however, to have been characterized by great aridity culminating approximately in the seventh or eighth century. Since that time there seems to have been a complete, though mild climatic cycle; that is, during the Middle Ages there was a partial return to the moister conditions of earlier times, while now the country has again become almost as arid as it was during the Dark Ages. There are many reasons for believing that this conclusion applies to Turfan. Unfortunately, we know but little as yet of the conditions prevailing in Turfan previous to about 800 A.D., but since that time there seems to have been a great climatic change. Grum-Grshimailo, a Russian explorer, visited Turfan in 1889. He says that though the swamp or playsa was then, as now, very small and almost dry, Chinese records and an old Turfan song seems to indicate that formerly there was at least a large reed-swamp, if not a lake. The ruins of the town of Chong Assa and of the lamasery of Kichik Assa, at the east end of the swamp near a river-bed which is now dry, point, he thinks, to desiccation. "It would be of uncommon interest," he says, "if one could somehow know when this river existed. The well-preserved river-bed, the finely marked terraces, the ruins of the monastery of Assa on the bank, and a great number of isolated walls which are now half buried in sand—all these indicate that the river decreased in size comparatively recently."

My own observations agree with this on the whole, although I should judge that the ancient water-supply of Assa came from the

north rather than from the east. The largest of all the ruins, Grum-Grshimailo proceeds, are those of Kara-Khoja, a town which was founded between 874 and 913 A.D. After existing through mediæval times, it was finally abandoned at some time after 1644 A.D. The existence of this town coincides with the period of comparative recovery and slightly greater water-supply, which we have inferred during the Middle Ages. In the days of Kara-Khoja, Turfan was renowned for its library, its art, and its craft, as well as its might in war. To-day nothing of this remains. Formerly the region was so thickly populated that the chief of Gaochau, an unidentified town, could put ten thousand men in the field. "If," to quote the Russian explorer once more, "the land was so fruit-



THE OLD BUDDHIST MONASTERY OF KUHIK ASSA (LITTLE ASSA), SHOWING THE TURFAN PLAIN DOTTED WITH CAMEL-THORN. SAND HAS HALF BURIED SOME OF THE BUILDING.

ful, and the population so dense, the question naturally arises, whence came the necessary water for the irrigation of the fields, and for the support of the inhabitants." Grum-Grshimailo hints that the "kariz" may formerly have been more abundant than now, but his main conclusion is that a change of climate has taken place. He does not, however, attempt to decide whether the change was of local or of wide-spread occurrence.

The correctness of Grum-Grshimailo's conclusion as to the density of the ancient population is fully borne out by the vast number of ruins. They dot the plain, not only in districts which are now inhabited, but in more remote regions where no surface water is now available, and where

the underground supply is saline. Ten such places (Cholak, Assa Mazar, Pokluk, Bøjanti, Olpang, Tura Kariz, Kakshal, Chong Assa, Kichik Assa, and Kosh-Dung) appear on the map on p. 257, and I heard of others. They form a well-defined zone which was once habitable, but is now too dry and saline for human occupation. In some cases the only relics of man's former presence are adobe "turas," as Buddhist stupas, or shrines, are called in this region, and a few bits of pottery. Elsewhere, as at Cholak, Chong Assa, and Kichik Assa, there are ruins of forts, houses, and lamaseries. The stupas appear to indicate the sites of villages, for they are on the prolongations of watercourses in places where agriculture would be possible if the streams were larger. Moreover, in Lulan and elsewhere, such stupas are the characteristic mark of villages. The forts mark the sites of larger villages or towns. At Chong Assa the pottery-strewn space included within the low outer wall is about three-quarters of a mile in diameter, indicating a considerable population. In addition to the main villages and towns there were probably smaller settlements of some sort. I found relics of these in the shape of forty or more stone graves on the edge of the southern zone of Piedmont gravel between Pokluk and Bøjanti. Perhaps they belonged to shepherds, though now none come to the region, so far as my guide knew, because the water is saline.

Outside the zone of ruins located in places where no water-supply is now available, there is, as the map shows, a zone where practically the whole of the present water-supply comes from the "kariz," although formerly a population as dense or denser than that of to-day appears to have subsisted without its aid. During my stay in Turfan I visited all the chief towns, and made careful inquiries as to the total population, the proportion of the total supported by "kariz," the origin of the "kariz," and the location and age of abandoned "kariz." So far as I could learn, the "kariz" was introduced into Turfan from Persia, or Transcaspia at a comparatively recent date. The "kariz" is unknown in the Lob basin except at Imamla, where a Turfanik introduced it a few years ago. It has also been recently introduced at Hami, east of Turfan, but otherwise it appears to be unknown in Chinese Turkestan.

My most intelligent informants were the Beg of Lukchun and a learned mullah of the same place. They both said that the "kariz" was introduced about 1780 A.D., in the days of the Wangs Skender (Alexander) and Yunus (Jonah) of Lukchun, and Suliman (Solomon) who built the great brick tower at Turfan. Previously the people relied on surface water and wells. When I asked if there were no traces of abandoned "kariz" of an earlier time, they said, "No, none except those whose history is known. Among the ruins there are many old wells, half filled with rubbish, but no one has ever found any trace of a 'kariz.' There are some old ones which are now dry, but they were all dug since 1780 or thereabouts. At Assa about fifteen [two of which I saw] were dug sixty years ago

[about 1845], but the water proved so saline that the diggers gave them up without even building houses."

All the people with whom I talked said substantially the same thing, provided they had any idea at all about the matter. On the whole, it seems safe to conclude that the "kariz" is, comparatively speaking, an innovation in Turfan, and that the greater density of population in ancient times was not made possible by its more general use. On the contrary, under its stimulus there has been a marked increase in population during the last century, as I was told again and again. As nearly as I could ascertain, the population of the entire Turfan basin consists of 9500 families, or 50,000 souls. Of these, 5400 families are supported by



SCENE IN THE RUINS OF KARA KHOJA. IN THE NEAR BACKGROUND RISES THE RED ESCARPMENT OF THE FIRE MOUNTAINS, BEHIND WHICH CAN BE SEEN THE SNOW-CAPPED BOGDO RANGE.

surface water, and 4100 by "kariz" water. If it were not for the "kariz" the population of Turfan would be only 60 per cent. as great as at present, and would not number more than 30,000. Only the towns of an outer zone close to the Fire mountains, and at the east and west ends of the basin, would be habitable. There would be nothing to represent the ancient towns, which, though they had merely surface water to rely upon, once dotted not only the zone of the "kariz" villages, but also the still drier, more saline zone farther toward the plays.

In confirmation of the evidence of desiccation furnished by the ruins, the condition of vegetation deserves to be noted. The plain is covered

with beds of dead reeds. Evidently the region was once densely clothed with reeds which have died long since, and have now been broken off level with the ground by the wind. The dead reeds are so abundant that people from the towns dig out the stalks for fuel. Every morning one sees donkeys with bulky loads of ancient reed-stems brought into the bazar from distances of from 5 to 15 miles. The reeds are sold for five-pence a load. The price made a great impression upon my men, for at Tikkenlik, near Lob Nor, a month earlier, we had paid a halfpenny a load for the very best poplar or tamarisk wood. The death of the vegetation may be due in part to the increased use of the streams for irrigation, and to the lowering of the water-level by the digging of "kariz." It is so universal, however, that it is doubtful whether it can all be due to man's agency. Dead reeds occur not only near the villages, but far from them; not only between the "kariz," but below their mouths where the level of ground water has been raised instead of lowered so far as man's action is concerned. Altogether it seems reasonable to suppose that the death of the reeds and the decrease of the population are both due to desiccation.

The history of Turfan, so far as it is known, agrees with what one would expect if the preceding conclusions as to changes of climate are correct. In the earliest Chinese records, dating back nearly two thousand years to the first historical fluvial epoch, Turfan is spoken of as highly prosperous. During the succeeding interfluvial, or dry epoch, embracing roughly the third to the eighth centuries, it almost disappears from history, and seems to have suffered great misfortunes and depopulation. In Asia and Europe alike the Dark Ages appear to have been darkened by the same cause, namely, the distress and migrations caused by adverse climatic conditions in arid regions. The Mediæval fluvial epoch, as we have seen in the case of Kara Khoja, was a time of great prosperity. People flocked into Turfan from every direction, as is evident from the manuscripts in *ten* different languages which Le Coq has found. Aryans appear to have come north-eastward from India; Tibetans northward from their plateau, which was growing cooler and moister and less habitable; Chinese from the east; Mongols and Turkish races from the north; and Syrians—probably Nestorian Christians—from the west.

The prosperity of Turfan came to an end at the close of the seventeenth or early in the eighteenth century. The basin was left almost without inhabitants. At first sight such complete depopulation seemed anomalous. That is, it is anomalous in the sense that so far as climate is concerned there seems to be no direct reason why Turfan should not then have been at least as populous as it was before the introduction of the "kariz," and possibly more so. On closer examination, however, it seems probable that the extreme depopulation of two hundred years ago was due indirectly to the influence of climate. The direct cause

of the disappearance of the people from the villages of Turfan was the raids of plundering Mongol nomads from the surrounding mountains. To-day there are no Mongols in the mountains; the country is too dry. The nearest are at Kara-Sher, 150 miles away. In mediæval times, however, when there was more moisture and vegetation, the mountains are said to have afforded homes to bands of Mongol nomads. So long as they prospered, they lived, we suppose, on terms of comparative peace with their neighbours in the plain. When the change from the mediæval climate to that of to-day began to take place, the nomads must have been the first to feel the pinch. Life, we may suppose, became hard as their cattle and flocks began to dwindle. For this reason, presumably, the bold mountaineers began to plunder their weaker neighbours in the villages. The plain gradually lost a large part of its settled inhabitants, and there was no chance for it to recover while the Mongols remained. The Mongols, more than almost any other race, despise agriculture. Therefore, though they occupied the plain, they did not cultivate it. They still presumably migrated from the plain to the mountains in summer, and ceased to do so only when the mountains became so dry as to be useless for flocks. Then they migrated farther, perhaps dispossessing some other tribe, and Turfan was left open once more to settlement by Chanto immigrants from the Lob basin. The depopulation was merely an episode accompanying the reduction of the mountains to a state where they were too dry to be inhabited by nomads. As an historic incident, it is scarcely worth recording. It may, however, typify events which have taken place on a scale involving continents. If so, it illustrates a great factor which has been neglected in the study of history.

During the last century Turfan has again enjoyed a period of comparative prosperity by reason of the "kariz." The "kariz" has nothing to do with changes of climate directly, but it illustrates how the pressure of difficulties stimulates human inventiveness. The increase in population and in prosperity since its introduction affords an admirable example of man's ability, not only to neutralize, but even to overbalance adverse changes in physical environment.

ON THE INFLUENCE OF ICE-MELTING UPON OCEANIC CIRCULATION.*

By Dr. OTTO PËTTERSSON.

(SECOND PAPER.†)

By evaporation of 1 kilogram of sea-water under due precautions we obtain a residue consisting of the solid saline matter dissolved in the water. If we, for example, suppose the weight of this residue to be 35.04 grams, hydrographers in our countries

* Read at the Royal Geographical Society, June 10, 1907.

† See *Geographical Journal*, vol. 24, p. 285.