times. If, however, we go back to old historic records, it is a very curious thing that, as far back as I have had access to them or had them quoted to me, everybody writing about the lake of Seistan nearly always describes it as being 100 miles long and about 15 miles wide. This is how one would describe it now, and so it does not seem to have been materially larger than it is now. The old river-beds, the old canals, bear about the same proportion to the river as the present beds and canals do now. As regards other questions, of course we studied Mr. Huntington's paper very carefully. Mr. Huntington was not long enough in this country to give a very definite opinion on the various points, and he ascribes these various phenomena which I am talking of to climatic oscillations, and to glacial and interglacial periods, and he suggested as a possibility that the river itself had oscillated from side to side in Seistan. If I had known his doubt on this point, I could have told him that the Halmand and the Hamun have oscillated time after time from one side of Seistan to the other. The following spelling of the word, "Seistan," is the right one, because the name is a later form of the old "Sejistan," which again comes from the older form "Sakæstan," *i.e.* "land of the Scythians" (Sakæ). The Seistan lake is only known to have completely dried up once. The area of water contracts and expands according to the seasons of high and low river. The suggestion that has just been made, that the wind plays an important part in removing the salt, is a good one.

I think that is all I have to say. I am not in a position, nor would I dare, to give a final verdict as to which is the correct solution of the problem under discussion—subsidence or removal by the wind. I thank you very much for your remarks on my paper.

The CHAIRMAN: I think you will cordially support a vote of thanks to Sir Henry for this very interesting paper.

THE RIVERS OF CHINESE TURKESTAN AND THE DESICCATION OF ASIA.

By ELLSWORTH HUNTINGTON.

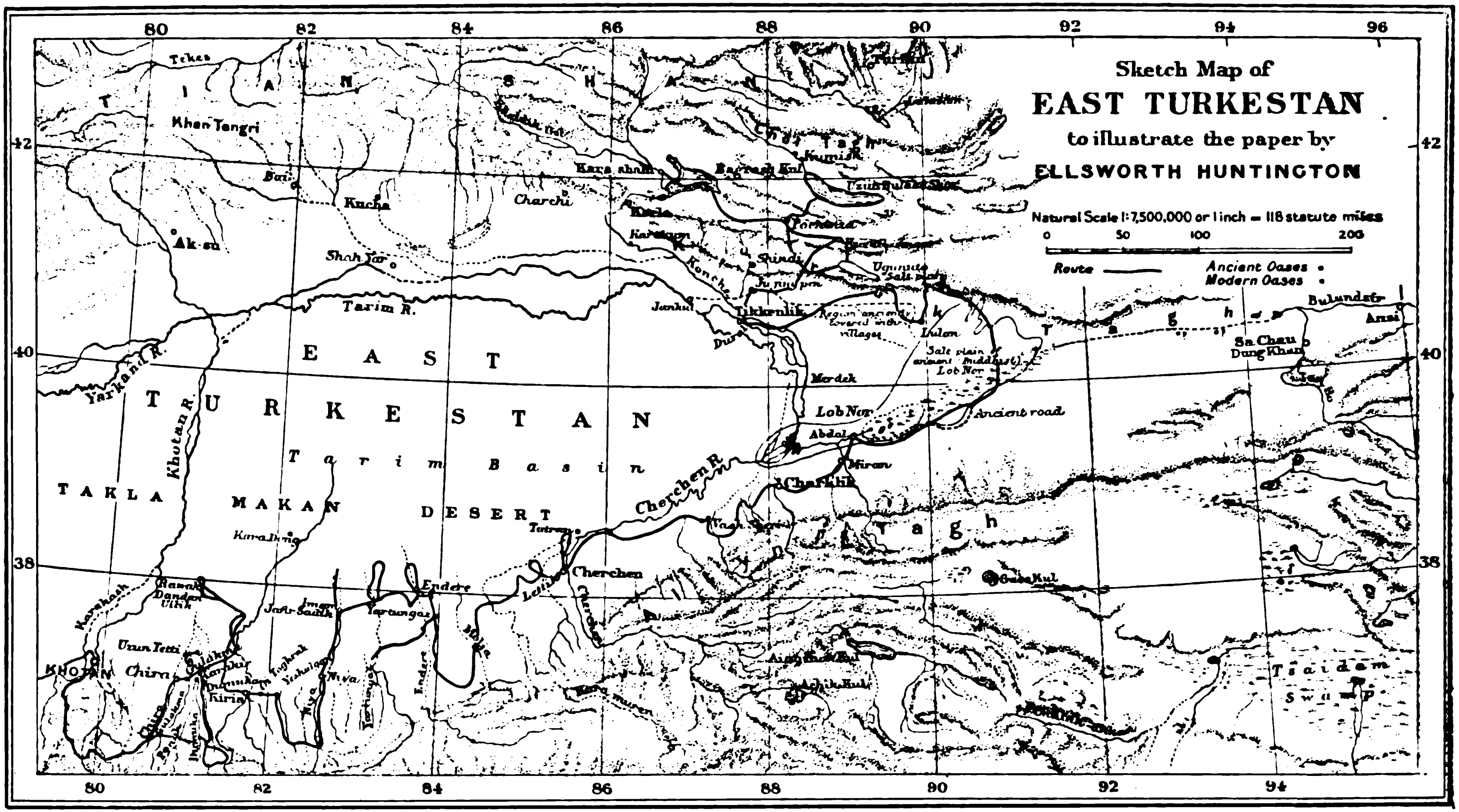
"THE desiccation of Asia" is a phrase frequently used but rarely well defined. With some writers it means the retirement of Tertiary inland seas because of warping of the Earth's crust—a process essentially completed long before the appearance of man; with others, who usually disregard the division of the Glacial Period into alternate cold and warm epochs through several of which man probably existed, it denotes the change from the coldness or moisture of glacial times to the aridity of to-day; while with still a third group it indicates a gradual change of climate, supposed to have taken place during the period covered by history, and to have been a potent factor in causing great human migrations, such as the invasion of Europe by the Huns, or of western Asia by the Turks. The reality of the first two types of desiccation is established almost beyond question by geological evidence; a study of the geography and archæology of eastern Persia, Transcaspia, and Turkestan during the past three years has led me to believe that the third type is equally real, and that during the last two thousand years there has

been in progress a desiccation of Asia which is the last faint undulation of the great climatic waves of the Glacial Period. In the reports of the Pumpelly Expedition, I have considered the question as it applies to Persia and Transcaspia. More recently, during 1905, as a member of the Barrett Expedition to Chinese Turkestan, I have been able to carry the investigation into regions where the evidence is more conclusive.

The rivers of East Turkestan fall into two main groups. One, including most of the large streams, comprises those which rise among the lofty mountains on the south-west, west, and north of the Tarim, or Lop, basin, from Khotan around through Kashgar to Korla, and join to form the so-called Tarim terminating in the historic lake of Lob Nor. The other comprises a multitude of smaller streams which rush down from the mountains, chiefly in the southern and eastern parts of the basin, and, for the most part, wither away in the desert. The latter belong to a highly specialized type peculiarly sensitive to changes in the water-supply. In the southern part of the basin, from Khotan eastward to Lob Nor, where the type is most perfectly developed, the larger withering streams, rising among snowy mountains, flow at first in zigzags or in east-and-west courses among the shallow longitudinal troughs of the northern part of the Tibetan plateau, and then, turning northward, break through the great fault-scarp of the Kwen Lun mountains in narrow gorges; while the smaller, rising on the north side of the Kwen Luns, flow down the face of the escarpment as rushing summer torrents. Reaching the sharply defined, squarely cut base of the mountains, all the streams, large or small, enter the zone of Piedmont gravels, a sloping plain from 15 to 50 miles wide. At first they flow in deep terraced trenches cut in their own gravel fans, and often difficult to cross; but soon the fans decrease in size, the terraces die out, and the streams spread into such broad and numerous channels that the water completely disappears, partly by evaporation, and still more by sinking into the gravel. To judge from the map, this is the end of the smaller streams. In reality, they continue underground as a confluent sheet, deeply buried where the gravels prevail, but coming close to the surface where the latter give place to clays and sands. Here water, often saline, can be obtained in wells at a depth of from 3 to 6 feet, and its widespread presence is shown by the abundance of reeds, tamarisks, and poplars which form a zone of vegetation from 1 to 20 miles wide, skirting the northern edge of the gravels for nearly 1000 miles. The larger streams succeed in crossing the Piedmont gravels during the three or four months of the flood season from May to August, and either lose themselves among reed-beds in the zone of vegetation, or pass on and gradually dwindle to nothing in the sand of the Takla-makan desert. The only exceptions are the Cherchen river, which, being diverted eastward along the zone of vegetation,

succeeds in reaching Lob Nor, and the smaller streams farther east which in extreme flood join the Cherchen. During the drier part of the year all the streams, except those of Chira, Keriya, and Charklik, disappear in the gravels, but reappear lower down in springs seeping out in the river-beds. Typically each main stream irrigates an oasis on the southern edge of the zone of vegetation, and formerly irrigated another, which, because of salinity or lack of water, it cannot now support. As a whole, the withering rivers show signs of having decreased in size during the last two or three thousand years, the evidence lying partly in diminished length, as shown by dead vegetation, and partly in diminished volume and increased salinity, as shown by ruins.

In the 700 miles eastward from Khotan to the eastern end of Lob Nor, seventeen rivers are worthy of notice by reason of their size or because they support oases. The test of diminished length as measured by vegetation, however, can only be applied to five of the seventeen, or possibly six, since the rest formerly united with one of the other five or with the Cherchen, which reaches Lob Nor. The possible sixth river is the small Yes Yulghun, the lower end of which has never been explored. The Molja is also doubtful. It now terminates in the zone of vegetation, but an old channel suggests that it formerly may have joined the Endere to the west, although now it is too small to flow so far. The Chira, the most westerly to which the test is applicable, appears formerly to have been joined by the three or four streams to the east of it, and to have flowed to the sand-buried towns of Dandan-Uilik and Rawak described by Stein. A strip of dead tamarisks, typical river jungle, extends even beyond Rawak, the northern town, to a point 60 miles from the Chira's present terminus, and over 50 miles from the limit of living vegetation. Farther east the Keriya river is reported by Hedin and Stein to have dead jungle extending 20 miles north of the present end of the stream. On the Niya and Yartungaz rivers I found that similar dead vegetation extends equally far or farther, and on the Endere at least 8 miles and possibly much more. In brief, of the six rivers to which the test of the extent of dead vegetation can be applied, one has not been explored; and the other five all show that within times so recent that the dead reeds, tamarisks, and poplars have not yet disappeared, the rivers flowed from 8 to 60 miles farther than to-day. The Endere and Yartungaz rivers are the most important, for they each support but a handful of farmers, eight or ten families, and the amount of water diverted for irrigation is insignificant. The Yartungaz river is now artificially constrained to flow wholly in one channel, although formerly during floods it spread into two or three. Thus the main stream has been appreciably lengthened. Yet in spite of this, the reeds, the form of vegetation responding most quickly to changes in the water-supply, are dead for a distance of 25 miles along


Sketch Map of
EAST TURKESTAN
to illustrate the paper by
ELLSWORTH HUNTINGTON
Natural Scale 1:7,500,000 or 1 inch = 118 statute miles
0 50 100 200
Route
Ancient Oases
Modern Oases
T I A N S H A N
Khan Tengri
Tekes
Bai
Kucha
Charchi
Ak-su
Shah Yar
Tarim R.
Kara shahr
Bagrash Kul
Kumish
Korla
Shindi
Tikkenlik
Jankul
Lob Nor
Abdal
Miran
Charklik
Merdek
Ancient road
Sa Chau
Dung Khan
Bulundsir
Ansi
E A S T
T U R K E S T A N
Tarim Basin
Yarkand R.
Khotan R.
TAKLA MAKAN DESERT
Cherchen R.
Cherchen
Endere
Yartungas
Niya
Keriya
Khotan
Chira
Dandan Uilik
Rawak
Karakash
Tsaidam Swamp
Tagh
80 82 84 86 88 90 92 94 96
42 40 38

the northward continuation of the main channel, which as yet is buried in sand only in the narrower parts.

The minor streams, wherever I have examined their lower ends in the zone of Piedmont gravel, have old channels never occupied now by running water, and therefore in process of being filled with sand. The channels indicate that the streams were once larger and ran farther, but in the absence of vegetation and ruins, the time of this greater size cannot be determined. The true ends of the small streams, however, as has already been said, are found in the zone of vegetation. If the streams have diminished within recent times, that is, within the period covered by history, the vegetation ought to show it. Between Khotan and Charklik, where the zone of vegetation varies in width from 10 to 20 miles, I crossed it seven times in places several miles from the larger rivers, and therefore dependent on the water coming underground from the smaller streams. In every case the vegetation of parts of the zone—usually the northern parts, more remote from the mountains—is dead or dying; and in some cases half-dead vegetation extends over the whole width of the zone. Frequently for many miles one traverses reed-beds, evidently vigorous and thick at some former time, but now consisting only of a few struggling shoots not a tenth as numerous as those of the past, the rest being mere stubble undermined by the wind. Elsewhere there are large tracts of dead and dying poplars, or of tamarisks, either dead or forming a type of mound characteristic of places where the water-supply is lessened. The death of the vegetation is often attributed to the encroachment of sand, but in the cases under consideration that has little to do with it. Often the ground is almost free from sand, there being only a few inches, or at most scattered dunes a foot or two high. And even this in most cases is not derived from a distance, but is the heavier residue left by the wind as it carries away the soil no longer held in place by living vegetation. The very form of the stems shows that death is not due to sand. In the limited region where sand is manifestly encroaching upon living plants, the reeds and tamarisks shoot up abnormally to two, three, or even four times their usual height, in a vigorous and often successful attempt to keep their heads above the dunes. In the far larger areas of little or no sand the dead tamarisks and reeds show nothing of such tall slender growth, but tend, on the contrary, to become short and stunted. The widespread death in the zone of vegetation seems to be to the smaller streams what the dead channels in the sand are to the larger—an expression of gradual desiccation.

The most unexpected and perhaps the most significant characteristic of the typical river is its ancient towns. Thirteen of the seventeen larger rivers have on their lower courses the ruins of towns dating usually from the Buddhist era, a thousand or more years ago. On six

of the thirteen rivers the ruins appear to be of only one age; on five, the Dumuka, Niya, Cherchen, Vash Sheri, and Miran, of two ages; and on the Chira and Endere rivers, of three ages. In general, the older ruins are the larger, and lie farther down-stream. Also, on the whole the ancient towns were larger than their modern successors, this being notably true of Yartungaz, Endere, Cherchen, Vash Sheri, and Miran. And lastly, with the exception of old Cherchen and Charklik, and possibly of Kara Dong at the end of the Keriya river, which I have not visited, the older ruins are situated so far out in the desert, or upon rivers so small or so saline, that it would be impossible again to locate towns of equal size in the same places, unless a far better system of irrigation were introduced.

A brief description of the ruins of Niya, Endere, Vash Sheri, and Miran will give a fair idea of the whole. Modern Niya is a town of about three thousand people, located on the southern edge of the zone of vegetation 60 miles east-north-east of Keriya. The town, like all those east of Keriya, is young, having been founded in the early part of the nineteenth century; but though it has been fairly prosperous, decay has already begun. During part of the season of irrigation the water does not come direct from the mountains, but from springs a few miles above the town. Accordingly it is slightly saline, so that the fields farthest down-stream are gradually becoming unfit for cultivation, and are being abandoned a few every year. The cultivated area, according to Stein's map, amounts to 24 square miles, including large lacunæ. Below Niya the river-bed is almost dry, but water seeps in from springs until a good-sized stream is formed, only to disappear again in the course of 20 to 25 miles. Forty miles from Niya, however, at Imam Jafir Sadik, the most famous shrine in Central Asia, the stream once more appears, but soon sinks into the earth again for the fourth and last time. In its lower course the river becomes so saline that permanent cultivation of the land along its banks is impossible. Even if there were no such town as Niya, the water, except during the flood season, would still be saline here at the river's end, and fields would become unfit for use after a short period of irrigation.

Fifty-five miles below Niya, and 4 miles below the present flood limit of the river, one comes upon the first ruins—ancient houses hidden among large tamarisk mounds, poplars, and sand. They belong to the Buddhist epoch, and have been described in part by Stein. I counted over a hundred houses extending northward for nearly 14 miles. There must be many more still to be discovered, for we found a number which were new to the guides, and one can walk within 100 feet of a house and not see it among the tamarisk mounds and sand. There must, too, be many houses buried under the latter, so that the total pretty surely amounts to several hundred. In view of the number of houses and of the large area—about 28 square miles—

apparently under cultivation—which in Chinese Turkestan always means under irrigation—the town can scarcely have been smaller than modern Niya, and must have demanded as abundant a water-supply.

At the northern end of the old town, and overlapping it for about 2 miles, there are traces of a still older ruin. No houses or walls remain, only thickly strewn pottery, bones, and slag, the pottery being of a cruder type than that of the later ruins, and broken into finer fragments. The farthest outlier of this town, so far as I could discover, lies at a distance of 24 miles from the present end of the river. Nothing is known of its history, and there is nothing by which to date it. It may represent an earlier epoch than the ruined houses, or it may merely represent the part of a single long-lived town which was first abandoned.

In either case the question arises whether with the present water-supply, which is completely utilized and is very slightly saline at Niya, it would be possible for an equally large and permanent town to grow up at a distance of from 55 to 70 miles out into the desert, and from 5 to 20 miles beyond the flood limit of to-day. Even if there were no such town as modern Niya, it appears to be impossible. In the first place, if the water at the shrine of Imam Jafir Sadik is to-day too saline to allow of permanent cultivation, it would pretty surely be as bad or worse farther down-stream. A dense population and prolonged intensive culture such as the ruins indicate would hardly be possible. In the second place, it is very doubtful whether the Niya river would reach the lower ruins even if none of the water were diverted for irrigation. A hundred years ago there were no inhabitants along the Niya river, or, at most, only a few shepherds. The river ran freely as far as it would. In the upper ruins the old channel is still visible, and the poplars and tamarisks are only beginning to die. Among the main ruins, however, and still more among the lower ones, the vegetation has been dead hundreds of years, so long that even in this dry climate the poplars are reduced to mere naked trunks, and the tamarisks have either died or grown into mounds 20 to 30 feet high. To put the matter in another way, if the Niya river was as large a hundred years ago as it was at the time of the ruins, it ought at the later epoch to have flowed not only to the ruins, but well on past the most remote of them. Vigorous vegetation ought to have accompanied it to a point at least 30 miles beyond the present end of the river—that is, 5 or 6 miles beyond the most remote ruins. But, as we have already seen, most of the vegetation among the ruins has been deprived of water for much more than one hundred years, and that at the outer limit has not only died and dried to tinder, but has been blown away by the wind so that only the stumps remain, cut off level with the soil.

The weight of the evidence of dead vegetation appears even stronger when the ruins of Niya are compared with those of old Dumuka between

Chira and Keriya. In the early part of the nineteenth century the water-supply of Dumuka gradually diminished, until about 1840 it became so scanty that all the inhabitants moved at once to the present site, 8 or 10 miles farther up-stream. Modern Niya was settled before this, but as the town grew slowly, it is safe to say that the diversion of the Niya river for irrigation did not take place on a large scale till about the time of the abandonment of old Dumuka. Since that time no surface water has reached the old site of the latter, but its vegetation is still fresh and vigorous. If an abundant water-supply was cut off from old Niya at most only twenty or thirty years earlier, it is hard to see why the vegetation should show little or no sign of death in the one case, at Dumuka, and should be completely dead and decayed in the other. It is not probable that the Niya river reached the main ruins a hundred years ago before the founding of the modern town, or that it would do so now if it were not used for irrigation. That a river of the present size could not only reach the ruins, but irrigate an area as large as that now under cultivation is still more improbable. If, however, the climate of antiquity was colder, so that evaporation was less, or moister, so that the rainfall was greater, and if the river was correspondingly larger, not only would this be possible, but the difficulty from salinity would disappear.

The Endere river, 60 to 70 miles east of the Niya, though larger, has no proper oasis. At its lower end, eight or ten shepherds have cultivated a little land during the past thirty years; but the river is too saline to admit of permanent irrigation. The shepherds say that even fresh land can only be cultivated once in three years, and any attempt at prolonged cultivation would be futile. Nevertheless, the river has on its right side—first, the ruins of a large Buddhist town of early date; second, of an almost equally large town of later Buddhist times; and third, of a small Mohammedan village; while on the left or west side it once supported a Buddhist hamlet and a fair-sized Mohammedan village. The two larger Buddhist sites resemble those of Niya in relative age and location, but are of greater size and more separated, and the older town appears to have been the more populous. The larger Mohammedan village, a walled enclosure within which the houses are still standing, is much smaller than either Buddhist site, its houses numbering 150. Like the Buddhist towns on the lower Niya and Chira rivers, and the late Mohammedan sites of old Ponak and Dumuka, it appears to have been abandoned deliberately and of set purpose, for the houses and walls were left intact, and everything of value was carried away. Disregarding the two smaller sites, we thus have on the Endere river the ruins of three towns of different ages, which grew up one after the other, the later town in each case being smaller than its predecessor. To-day there is water enough to support a large town, but it cannot be used because of the salt. The uppermost ruins lie only 12 to 15 miles

further up-stream than the present shepherd hamlet, and the lowermost lie quite as far down-stream. Even if the difficulty due to the entrenchment of the river to a depth of 20 or 30 feet could be overcome, and the water could again be brought to the ancient sites, it would be too saline to support such large and permanent towns. If, however, the water-supply was once enough greater so that surface water reached the lower parts of the river three or four months each year instead of only one, the difficulty would be largely obviated, and the conditions would be like those of modern Niya, the fields would gradually become saline, but it would be many years before they would have to be abandoned. On any other supposition the location of the towns and their successive abandonment seem inexplicable.

Still further to the east, 200 miles from Endere, the Vash Sheri river rushes swiftly down from the mountains, and, after losing most of its volume in the Piedmont gravels, supports the thirty people of Vash Sheri. During the months of June, July, and August, the melting snow on the mountains—30 to 40 miles away—increases the river's volume enormously. Hearing of this large amount of water wasted among reed-beds, a considerable number of people have come to Vash Sheri during the thirty years since it was settled, but most have gone away after a year or two. In summer they had more than enough water for their fields, but during the planting season of April and May the supply often ran short. Under the present conditions of climate and irrigation, a population of thirty or forty is all that the river can support. Yet in ancient times the number of people must have been many times as great. Formerly, the river followed a more westerly course. At the end of the old channel, and at the same distance as the modern hamlet from the mountains, the ruins of a Buddhist town cover an area at least $2\frac{1}{2}$ miles long by 1 wide. Here, as at Niya, the ruins consist of two parts. The older village covered the whole area. Its houses have completely disappeared; but if it were settled as densely as the abundant pottery indicates, or as densely as the modern villages, its population must have numbered five hundred or more. The later village, or the later part of the original village, as the case may be, occupied only the upper portions of the ruins. Traces, sometimes very faint, of sixteen houses can be seen, and some must certainly have disappeared or escaped notice. It is safe to say that near the time of its abandonment the village must have had a population of a hundred souls—three times as many as the present hamlet—and that earlier it must have had far more: so large a number of people could not be supported to-day without a radical change in the system of irrigation. Fortunately, the river changed to its new course as soon as the abandonment of the village allowed the rude dam of small boulders at the head of the old channel to fall into decay. Accordingly, the irrigation works have not been subjected to the destructive influence of floods,

and are still almost intact. The difficulty of keeping the river in its old bed may have been the immediate cause of the abandonment of the village, but it had nothing to do with the sufficiency of the water-supply of the past as compared with that of the present. The latter depends upon the character and width of the river-bed, which are essentially the same in both cases, the old channel being the wider, if anything, and upon the nature of the irrigation system, which, again, was precisely the same in the past as it is to-day. Then, as now, the innumerable minor channels into which the river divides were simply dammed with banks of gravel dug up close at hand. Thus all the water was gathered in a single larger channel on one side of the mile-wide flood-plain, and was led off into canals, mere ditches dug in gravel or sandy clay, as the case might be. If the river should again be turned into the old canals, the available supply of water at the ruins would apparently be essentially the same as that at the village to-day.

A hundred miles east of Vash Sheri the Miran or Miyan river rises in typical fashion in the main snowy range of Kwen Lun, breaks through the front range in a deep gorge, traverses the Piedmont gravels in a terraced trench, and disappears during much of the year in a broad gravel flood-plain. Geographically Miran closely resembles Vash Sheri, and the reasoning applied to the latter holds good with increased emphasis for the former. Archæologically Miran is more important, for the ruins are not only far larger, but a new type of architecture is developed, the chief structures being elevated 10 or 20 feet on solid pedestals of sun-dried bricks. At present Miran is not permanently inhabited, though the fisherfolk of Abdal, on Lob Nor, 20 miles to the north, come in summer to cultivate the reedy fields, and, by using all the water available in spring, raise grain for about fifteen families. The fields can only be cultivated once in three years, for in a single season of irrigation a cake of clay 2 or 3 inches thick is deposited, a cake so stiff that crops cannot grow in it till it has been softened by two years of sun and rain. The natives think that the clay is gathered after the river begins to spread over the huge gravel flood-plain, 10 miles long and 1 or 2 wide. In reality the river is charged with fine clay when it leaves the mountains, where it is said to be equal to the river which supports the large village of Charklik. On reaching the flood-plain the water sinks rapidly into the coarse gravel, but as the current is swift, the fine clay is all borne along, until at Miran the river is literally a stream of mud.

Anciently, conditions must have been far different. The old Buddhist Miran was neither a hamlet, such as to-day might be located here, nor a village like old Vash Sheri, but a large and important town. It covered an area of at least 5 square miles, all of which, judging from the canals and pottery, and still more from the number and location of public and religious structures, must have been thickly populated. The

houses, being made of clay apparently, have disappeared, with two exceptions. Thirteen other structures remain, of which one is a fort, 400 feet square; one a lamasery, the outer walls of which are adorned with clay reliefs of Buddha; two are stupas, or shrines; and the other nine are solid rectangular masses of sun-dried brick, capped in most cases by the walls of what may, perhaps, have been monastic dwellings or Buddhist temples. These establishments appear to have been kept up after the rest of the town had become depopulated, or else were re-occupied after a period of abandonment, during which the fort fell into ruin, as is suggested by the flimsy repairs superposed upon the solid older structure.

Ancient Miran, in its prime, must have required a water-supply almost scores of times as large as that now available. It is reasonable to suppose that, being the most important place for hundreds of miles both from a religious and a military point of view, Miran had an irrigation system as good as the country afforded. The water at first came from an old river-channel east of the town, and later, apparently, from the present channel on the west. The dams and canals are preserved just as at Vash Sheri, and do not differ from those of to-day. The main older dam is composed of tamarisks and small boulders thrown loosely together; and there is said to be another, which I could not find, composed of boulders alone. The canals are either simple ditches, or are raised a few feet on banks; but in every case the material is that which happened to lie close at hand. On the upper Miran river there are no inhabitants, and no opportunity for the diversion of part of the water. The present supply, sufficient for fifteen or twenty families, is all that the river is capable of furnishing under the system of irrigation which prevails now, and prevailed in Buddhist times a millennium or more ago. If, however, the rainfall were increased, say, a third, the amount of water reaching Miran would be multiplied vastly. Being confined to a single channel, the water would suffer scarcely more loss from evaporation and from sinking into the ground than it now does, and all the extra supply would be available at Miran. The difficulty from the excessive amount of sediment would vanish, for though the absolute quantity might conceivably be more than now, it would be diluted with a far greater amount of water, and spread over a much larger area. The hard cake would be reduced from 2 or 3 inches to perhaps a quarter of an inch, not enough to interfere with cultivation. Miran, even more than the other ruins, seems to verify the hypothesis of a change of climate during the historic era.

The ruins of Miran, Vash Sheri, Endere, and Niya are typical of many others. Charklik and Cherchen belong to the same class as Miran and Vash Sheri, the old towns having been located at nearly the same place as the new, and having covered a larger area. This is especially the case at Cherchen, where Lellik, the southern and

apparently older ancient site, covered an area three times as large as the modern town, and the northern later site may have been as large. Neither Charklik nor Cherchen is conclusive, however, for the size of the ruins at the former cannot be determined, and the whole water-supply at the latter is not now utilized. Yartungaz resembles Endere, but the river is much more saline. Accordingly, as might be expected, the ruins are old and rather small, and lie at the highest possible point, like most of the modern oases. The remaining ruins, lying west of Niya, belong to the same type as the latter. Rawak, Dandan-Uilik, and Uzun Tetti were successive towns on what appears to have been the ancient extension of the Chira river, aided more or less by the smaller streams to the east. The pottery-strewn site of Lachinata lies beyond the end of the Gulakhma river; the Buddhist ruins of Payet Beg and Khadaluck and the recently abandoned towns of old Dumuka and old Ponak indicate the former greater length of the Dumuka and Ponak rivers, and an unnamed site in the sand shows that the Karakir stream once extended 15 miles beyond its present limit.

On the northern border of the Tarim basin there is less opportunity for the occurrence of ruins of the kind described above, for most of the streams are either very small, or else, uniting in the highlands, issue from behind the mountains as large rivers which join the Tarim, and will be considered later. At Ying-pen, however, north-west of Lop-Nor, the ruins of a small fort and village described by Hedin are now waterless. I followed the old canal northward for over 3 miles to its head, and found that it was a simple ditch with two small ponds or reservoirs, into which the water was turned from the little Shindi brook, the largest stream in the Kuruk Tagh, or "Dry mountains." To-day no water reaches the ruins during the greater part of the year, and the place cannot be inhabited, yet formerly the water-supply sufficed to support a small village.

Similar instances of ancient towns located where there is now no sufficient water-supply are described by Stein as far west as Kashgar; and I found others as far north as the depression of Turfan. Eastward beyond the end of Lob Nor, on the course which the united Bulundsir and Tan-ho rivers once followed on their way to the lake, two other ruined sites of the same sort are described by the natives. The Chinese of Dung Khan (Sa Chau), higher up on the Tan Ho, say that the ruins were abandoned by their ancestors long ago because the water of the rivers would no longer reach them.

In the case of the rivers of the Tarim system, the evidence of desiccation is less clear than among those of the withering type, for the streams are so large that they still support extensive oases and terminate at a fixed point in Lob Nor. Still, the increasing salinity of the lower Tarim, and the decreasing size of the terminal lake, seem to show

that the rivers of this group, like those of the other, have suffered desiccation. The region along the lower Tarim or Yarkand river for 400 miles, and along its parallel tributary, the Konche, for 250 miles above the mouth of the united streams in Lob Nor, is to-day practically uninhabited. The scattered little settlement of Tikkenlik is the only real village, and almost the only place where agriculture of any sort is practised; and even its five hundred inhabitants could not subsist, so they say, if it were not for their flocks and for the fish which they eat in summer with young reeds and rushes. The great difficulty is salinity in both soil and water. Indian corn, one of the great staples of Chinese Turkestan, will scarcely grow at all, and is replaced by millet. Wheat fares better, but only the first year. If a field is cultivated several years in succession, the crops rapidly dwindle just as at Endere and Yartungaz.

The same difficulty prevails all along the lower course of the Tarim and Konche rivers, and several recent attempts of the Chinese to found towns have proved abortive. About 1889 some colonists settled at Jan Kul, 30 miles west-north-west of Tikkenlik, on the Tarim. Next year the population increased to over 2000, and Jan Kul, as the people say, "became a town;" that is, a bazaar was established, and an "amban," or local governor, was installed. But the fields quickly became saline, and after two years, in 1892, the place was abandoned, most of the settlers returning whence they came. Meanwhile, however, in 1891, about 1000 people had come from Turfan to Dural, 8 miles south of Tikkenlik, and had begun to raise wheat. Accordingly a large fort was built there, and in 1893 the amban of Jan Kul was removed to Dural, which in turn "became a town." For three years the population increased, but by 1897 the soil had become so salt and the crops so poor that the colonists began to move away. In 1898 over 2000 rebellious Dungans or Mohammedan Chinese were induced, or forced, to come from Shi-ning, 800 miles to the east, and settle at Dural, but the land and water were so bad that in 1900 they migrated 90 miles north-west to Karakum, on the Konche, another site which had just been opened. Thereupon, in 1901, the amban was removed to Karakum, and in 1904 the last of the people of Dural came to Tikkenlik. Karakum became even larger than its predecessor, and from 1901 to 1903 had a population of nearly 5000, but the salt was as bad as elsewhere, and in 1904 it too was abandoned, though the amban and forty or fifty people still remain. Jan Kul, Dural, Karakum, and Tikkenlik represent four abortive attempts during sixteen years to utilize the water of the lower Tarim and Konche rivers for irrigation. Tikkenlik, being but three or four years old, still survives, but its people are moving away or else are abandoning agriculture and betaking themselves to sheep-raising and fishing, the means of livelihood of the former hamlet before the attempt to establish a town.

Turning now to the past, we find a wholly different state of affairs. In Buddhist times the Tarim and Konche rivers were deflected eastward in whole or in part between Karakum and Tikkenlik, and flowed to the ancient ruins of Lulan, discovered by Hedin. In approaching Lulan from the north-east, and in leaving toward the north-west, I rode 15 miles each way through a region where houses, pottery, and other evidences of human occupation show that the whole area was once thickly settled by an agricultural population. Farther west, on again entering the broad zone of dead vegetation which accompanies the old river-courses, I found pottery, beads, slag, and bits of iron, for a distance of nearly 40 miles, and there was a little ancient pottery in a strip of dead vegetation between two arms of the Konche only 25 miles east of Tikkenlik. It looks as though in ancient times an area 100 miles east and west, by 10 or 15 miles north and south, was thickly dotted with villages irrigated by the Tarim and Konche rivers. Even if the present water-supply would suffice for so large an area, a densely populated, flourishing district like the Lulan of history would be impossible because of the water's salinity. Here, as in so many other cases, the phenomena are easily explicable if the rivers have decreased in size.

The lake of Lob Nor agrees with the rivers, for it shows signs of having been larger at no very distant date. In this article it is not possible to consider the controverted history of the "Great Salt Lake," as the ancient Chinese called it. It must suffice to say that in travelling around it, and crossing the unexplored salt desert at its eastern end, the presence of five, or possibly six, old shore-lines at altitudes of from 12 to 600 feet above the present level, and of a thick series of lacustrine deposits, indicates that the lake has passed through a succession of epochs of expansion and contraction corresponding to those of the lake of Sistan in Eastern Persia, and less closely of Great Salt lake in North America, and to the epochs of the Glacial Period all over the world. The freshness of the dry lake-bed and bluffs, the distribution of vegetation, the presence of an ancient road, now unused and unknown, which makes a long *détour* around a bay of the old lake-bed instead of crossing it as the modern road does, and the well-known fact that the present lake or swamp has diminished in size during the past century, seem to indicate that the last notable expansion of the lake took place, or at least had not yet passed away, when historic man occupied the surrounding region.

The rivers which wither in the desert, together with those which join the Tarim and terminate in Lob Nor, drain most of the mountains around the Tarim basin, but there is one part so extremely dry that there are practically no running streams whatever, only a few scattered springs, mostly salt. This inhospitable district, as large as Great Britain, lies between Lob Nor on the south, Bagrash Kul on the

west, and Turfan on the north, and stretches eastward 400 or 500 miles toward the desert of Gobi. It is a desolate region of naked mountains half buried in plains of gravel, and is well named the "Dry mountains" ("Kuruk Tagh") on the south, and the "Desert mountains" ("Chol Tagh") on the north. It is so little known that the best I can do is to quote what was said by my guide, a remarkably intelligent camel-hunter of Kuzzil Singer, the only inhabited place, who knows every spring and mountain for 100 miles in every direction. I asked him whether there was more or less water now than in the past, or just the same. In reply he told of the drought during the last four or five years which every one speaks of, and then went on, "And long, long ago, in the days of which neither my grandfathers nor their grandfathers ever heard, there must have been much more water. In the high mountains there are many places where little stone shepherd's houses, with the roofs all fallen in, stand in valleys where nobody has ever known of there being any water. The nearest water is sometimes 5 or 10 miles away. Surely no one would have built houses and kept flocks and herds in those places unless there had been water. How many such houses have I seen? Oh, many; I never counted, but the mountains are full of them. In other places, away from the higher mountains, one often finds salty deposits and a few reeds where once there must have been springs, and on every side there are old paths coming in where once the wild camels and antelopes used to come regularly to drink. Now, as there is no water and only a very few reeds, scarcely two or three animals come in a year. There were men here then, for near almost all of the dry springs there are old shelters of rocks and pieces of tamarisk, just such as we make now when we lie in wait for game. I never talked to any one about this before, and I do not know whether I am right, but I have seen these things when I have been hunting, and," as the Turki idiom puts it, "that is what I know in my stomach." My own limited observation agrees with that of the camel-hunter. Moreover, I found traces of ancient roads and of villages where there is now no water, and the basin of the Turfan, near by to the north, is full of evidences of an historic decrease in the water-supply.

The phenomena of rivers, large and small, of springs, lakes, ruins, and vegetation, all seem to point to a gradual desiccation of Chinese Turkestan for nearly 1500 miles east and west, and 500 north and south. The records of antiquity indicate that the Caspian and Aral seas were once more extensive than now, and presumably that the tributary rivers were much larger. Transcaspia, Eastern Persia, and the neighbouring regions appear to have been subject to a desiccation similar to that of Turkestan, and indicated by similar phenomena. Thus all the more arid part of Asia, from the Caspian sea eastward for over 2500 miles, appears to have been subject to a climatic

change whereby it has been growing less and less habitable for the last two or three thousand years. Such a change, embracing Persia, Baluchistan, Afghanistan, Russian Turkestan, and Chinese Turkestan, and probably an even larger area, and converting thousands of square miles of habitable country into desert, can hardly fail to have had some effect upon human distribution and history. In Chinese Turkestan part, at least, of the ancient towns described above appear to have been abandoned deliberately, presumably because the water-supply became limited. Movements of the same sort are to-day taking place on a small scale all over the arid parts of Asia; as, for example, in the cases already cited of the inhabitants of Dumuka and other villages who moved in a body to a new location, or of the Dungans and people from Turfan, who wandered here and there along the lower Tarim. In 1904, 500 Kossack nomads, with their flocks and herds, came to Lob Nor, and would have settled among the reeds of the lower Cherchen river if Chinese soldiers had not driven them out with bloodshed. The nomads had come from the Altai mountains, where pasture had become too scanty either because of increasing drought or increasing population, or more probably both. Such movements only need to be magnified to cause invasions like those of the Dark Ages. That they were magnified in Turkestan when the Buddhist towns were abandoned appears highly probable. The abandonment took place in the early centuries of the Christian era, and for most of the time from that day to this the whole country from Keriya eastward for 600 miles, almost to China Proper, remained practically uninhabited, even more so than to-day. Not only the inhabitants of the towns disappeared, but also the shepherd tribes among the mountains, who, judging from names, traditions, and ancient roads and dwellings, were formerly numerous, and who would feel the pinch of aridity more quickly and keenly than the townspeople. Part of the population may have been killed in war, or have died in the epidemics which rage when a country is over-populated, but the rest must have migrated. If, though only in bands of a few thousands, they invaded regions already well populated, where the means of livelihood were growing less because of desiccation, distress and wars would ensue, and the only relief would lie in further and greater migrations. And thus, all Central Asia being under the same ever-increasing stress, a succession of dry years, or a change such as has taken place in Chinese Turkestan since 1900 from an increasing to a decreasing quantity of water in the rivers, might cause migrations equal to the greatest recorded in history.