

ALLEGED CHANGES IN THE CLIMATE OF SOUTHERN
TURKISTAN: *A paper read at the Afternoon Meeting of the Society
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THE aridity of the Tarim basin has been frequently discussed, and the following paper is based on a recent journey, in 1930-31, to the south and south-east of Chinese Turkistan. Conditions in this part of Central Asia have suggested to some geographers a certain abnormality in climate, and they have sought to prove that deserted cities, vanished rivers, and slowly drying lakes are due to a decrease in the water supply of the region.

Before proceeding further it may be well to state that all remarks in this paper refer to conditions in historical times, and it is difficult to understand how the supporters of the theories of climatic changes in this period can invoke the tectonic uplift of the Himalayas during post-glacial times, or connect the dwindling of the ice residue of the glacial period with the gradual disappearance of dead and fossil ice, and the consequent shrinkage of rivers.

The argument in this paper is that no such climatic changes have ever occurred, and that the state of southern Sinkiang gives no basis for the somewhat far-fetched arguments adduced, but is explainable by simple and natural causes. That Professor Penck, at the Society's centenary meetings, denied any such changes encourages the hope that the following observations made in 1930-31 may be of value.

The Tarim basin is a clumsy term, which might well be replaced by the word Kashgaria: but let it stand. Before proceeding farther a brief account of the Tarim basin is desirable. This basin lies between the southern slopes of the Tien Shan and the northern slopes of Kunlun, two ranges which have on these particular slopes a permanent defect in moisture, whether snow or rain, because the Himalayas in the south and the northern Tien Shan to the north impede very considerably the moisture-laden breezes from the Indian Ocean and Siberia respectively, thus limiting precipitation to local condensation for the most part. If this is realized, together with the equally important facts that the chief source of the rivers is the Pamirs and not these two mountain ranges, the problem becomes simple. The Kunlun snow supplies only two important agricultural tracts, Khotan and Keriya, and the Tien Shan only one, Kucha. The belt of cultivation from Qarghaliq westwards *via* Yarkand and Kashgar to Aqsu draws its water from outside the Tarim basin proper; and there is no evidence whatever that there has been a progressive shrinkage of these rivers.

There are three river systems south of the Tien Shan: (1) The Tarim and its tributaries which provide the bulk of the water and drain the area from Qarghaliq to Kurla; (2) the Charchan, in the south-east; (3) the Konche, which, though flowing into the Tarim and exercising a profound influence on the drainage of the basin, rises in the Yulduz valley and is free from any climatic influences of southern Turkistan.

The arguments brought up to support the theory of diminishing water supply are: (1) the drying up of Lop Nor; (2) the disappearance of the Keriya river; (3) the general changes in riverine condition in the south-east; (4) the

evidence of dead forest, dead reed, ruined cities and abandoned towns, derelict cultivation, and, in brief, many signs of lack of water all eloquent of a drier climate.

Now, if all these were really proofs that the climate was becoming more arid, they would only show that certain parts of the Tarim basin, and that not merely the smaller part but the most inaccessible and unattractive part, had been so affected. At the most it would be found that certain rivers have dried up: a very different matter from proving that the whole area had suffered a



Sketch-map of part of Chinese Turkistan

climatic change, and surely an inadequate foundation on which to raise the theory of the impetus of nations. Before dealing with the above arguments it is suggested that some easily explained causes of desiccation be mentioned and also two main characteristics of the Tarim basin.

In a previous paper it was remarked how the great mass of sand that perhaps formed the Taklamakan enabled rivers to wander uncontrolled, and how the rivers themselves were exposed to influences that militated against permanency in their courses. The argument from old sites is far from convincing, and may be most fallacious. Sites are abandoned for many reasons:

(1) disease; (2) war or rebellion, of which many examples are found north of the Tien Shan, especially on the main road from Manass to Ili, and where there has been usually no attempt at re-settlement; (3) excess of water, *e.g.* Qaraqum, south of Kurla; (4) salt in the soil; (5) dispersion, failure, or disappearance of the water, more frequently due to artificial causes than to natural; (6) better land available elsewhere; (7) sand; (8) squatting.

This last is particularly prevalent nowadays, as under present regulations a peasant opening new land is given free seed and pays no taxes for three years; and thus there is a regular practice of squatting on land and at the end of every triennial period moving elsewhere. In a land where building costs almost nothing, and land and wood are free, abandoned houses exist everywhere: so much so that it is easier to build a new house than to repair the old. Settlements are moved also because they are inconvenient. For instance, the people moved from old Domoko in the Khotan district about 120 years ago because the present site of new Domoko proved more convenient. As an old man at Domoko said to me, "We know more than we did then in the old days," referring to irrigation, shelter, soil, and the like.

It is always argued that old sites are farther from the mountains than present ones (*cf.* old and new Domoko), and consequently that the rivers flow less far than of yore. Yet as a general rule modern sites are far more extensive than the present settlements, and we must bear in mind that without irrigation cultivation in the Tarim basin is not possible, and the maximum is gained close to the skirt of the foothills where sub-surface water wells up.

Another example is that of old Niya. The Niya river supports a flourishing population 60 miles to the south of the old town and near its place of issue from the hills, and the river still flows within 10 miles of the old site, being towards the end considerably canalized. At times however, owing to inadequate snow in the mountains, the river fails to get so far, but there is never a shortage at New Niya, though there may be farther down, and this points to a leakage and loss of water between the two sites. Thus a defective snowfall would prevent cultivation at old Niya but would be enough for the new settlement, and the water supply of the Niya river proves that not a regular but only an occasional defect takes place. It is interesting to note that after old Niya was abandoned there was an interval of many years before the modern town was established, which for many years was a Waqf or charitable endowment for the renowned shrine of Imam Ja'far Sadiq, south of the old town. Why old Niya was abandoned I do not know; but it is absurd to pretend that climatic changes were the cause when at the latter part of the last century the present town was formed. It may have been loss of water, certainly not defect in water.

It is worth noting that the cultivators at the Niya river end complain that a very heavy snowfall prevents the water from reaching them, as the flooded stream breaks down the banks at Toghrasu, 30 miles north of modern Niya, and inundates the country. Signs of such an overflow were very evident in 1931. The people say that they at once go to repair the damage and to coax the river back into its normal channel, but while they are doing this their crops perish from lack of water, as the flooding naturally occurs at the hottest time of the year. Of course the present settlement must affect the supply to the fields at the end of the river. After examining carefully the Niya river I could



Cultivation and houses destroyed by sand at Tashmalik, near Kashgar



Keriya River, east of Tashkalik Chap



Yartungaz or Aqtash River, March 1931



Gorge of the Konche River, between Qara Shahr and Kurla



Junction of Konche and Tarim rivers



Bed of the Tarim River, Lop district, April 1931

find no evidence of climatic change, but considered the behaviour of the river in every way normal.

Another reason why sites in Turkistan are brought nearer the hills is that the people are less pastoral and more agricultural. The ends of rivers in that country are a delta of reed and brushwood, affording admirable grazing grounds, and to this day are so exploited, though in many cases suitable riverine pastures are almost deserted, which in old times carried many flocks, as at Endere.

It is doubtful if old sites prove anything in Kashgaria always excepting difficulties of culture. All the large towns are situated where canalization is possible and the Yarkand, Tarim, Kashgar, and other rivers roll to their death without a single town on their banks, and well-nigh ignorant of mankind. Sometimes, as in the case of Loulan, a town has been abandoned because a river has changed its course, though here again the river is flowing in its former bed; but as a general rule towns in Turkistan are independent of the vagaries of rivers, and the few abandoned sites that have been made to prove so much are the exception. Small isolated settlements, especially if endowed with Buddhist remains, *e.g.* Rawak, near Khotan, have been chosen rather for religious isolation than utilitarian purposes, and undoubtedly in some cases have been abandoned because the water failed.

Mr. P. S. Nazaroff, a capable Russian geologist, well acquainted with Central Asia, and now in Africa, has dealt very curtly with the abandoned sites of Turkistan. He says: "The ancient cities and civilizations of Serindia perished from the destruction of their irrigation system in war" (*Blackwood's Magazine*, June 1931, p. 790, column 2).

The face of Chinese Turkistan is littered with ruined and abandoned settlements, but in a country with a small population compared with the land available there is no incentive to combat the onslaught of nature. It is easier to yield and go elsewhere. If, as at Tashmalik, near Kashgar, a sandstorm destroys the fields and smothers the houses; or if another village taps the water supply; or if the land turns sour from too much salt in the water; or if news comes of better land close at hand; or if a garrison of soldiers is established, the remedy for all these worries is to clear out. It costs nothing, there is no one to prevent it, and so it happens. Thus it is not too much to say that abandoned sites prove next to nothing and seldom what they appear to prove from a casual survey.

Having dealt with the arguments deduced from old settlements, it is well to proceed to other factors that interfere with or menace the water supply of the country. The various "köls," or lagoons, of Turkistan have been ignored as to their influence on the geography of the Tarim basin. The köls are large pans formed either by the overflow of a river or by a change in a river's course. In the former case the river breaks its banks, floods an area, and forms a large shallow lake which persistently draws from the parent stream a large volume of water until the river subsides, when the channel between the river and the lagoon silts up and there is no flow of water except by seepage for perhaps many years.

This was the case of the so-called Lop river (really the Charchan) when in 1930 the river failed to reach the hamlet of Lop, 31 miles north of Charkhliq;

it was said that the whole river turns into a large lagoon west of a line Charkhliq-Lop-ortang, and only when this is filled and the river has parted with the majority of its flow does it resume its channel. If it is asked why the lagoon does not receive merely the surplus water, leaving the normal stream to its appointed course, the answer is that the lagoon is at a lower level than the river, and the increased flow thus diverted from its proper channel causes the latter to be filled up. The above-mentioned case of old Niya shows the damage that this process can cause.

When these lagoons are formed by changes in a river-bed (a regular but less frequent cause than by overflow) two sets of köls are formed. One köl is the old river-bed which becomes a backwater, usually of little breadth, with a tendency to decrease by evaporation and filling up as the steep banks fall in. The second series is caused by the river being unable to carve out its new course quickly enough, so that it overflows and forms new lagoons.

The general influence of these lagoons in the life of the country is considerable. They tend to form smaller subsidiary lagoons, resulting in a dissemination of moisture over a large and often desert area, enabling reed, brushwood, and trees to grow, and adding to the available pasture. At times these lagoons go quite dry, but they are generally damp enough to support acres of reed which present a remarkable prospect like some field of giant corn, swaying rhythmically in the wind, a beautiful sight with the yellow or green sweeping the blue horizon. Old köls are nearly always brackish: new ones are fresh, so that it is easy to distinguish one from the other. Lagoons which are formed by a perennial stream must be excepted from this category. The influence of these pans on the river system is noteworthy, as they are liable to deprive the feeder-river of its flow, curtail its length, and, if not detected, lead to erroneous theories as to the behaviour of the stream.

A reference to the Khotan river will throw some light on the river system that is derived from the snows of the Kunlun. This stream, formed north of the city of Khotan by the confluence of the Yurungqash and Qaraqash rivers, flows due north into the Tarim or Yarkand, but it is by no means a perennial stream, and ceases to flow from October to March inclusive. It is then quite dry beyond the Mazar Tagh ridge, and frequently above it, and the only water found in its bed is in pools close to the bank, where it is frozen hard and so preserved from evaporation.

Of the river's two tributaries, the Qaraqash dries up at the end of autumn, so far as its flow into the Khotan river is concerned. The Yurungqash river provides the water that reaches, and then very precariously, the Mazar Tagh. The difference between these two rivers is caused by the Qaraqash supplying a much larger irrigated area than its neighbour; as its water diminishes, the cultivator takes off for his own use the whole amount.

The Khotan river is thus a purely regional stream, and would never be anything else even if it received the entire flow of its two affluents, which would be unable to furnish a sufficiently strong or abundant current to reach the Tarim. The Khotan river thus exercises little influence on the Taklamakan through which it flows, and hardly anywhere is the riparian vegetation—chiefly reed and thorn with some toghraqs (*populus balsamifera*)—more than 2 or 3 miles in depth: indeed in some places the desert extends along the very

verge of the river bank. The seasonal flow however when the melting snows provide a large surplus of water, even after agricultural needs have been met, is very strong, as is shown by the curious delta at the end of the river. The old river-bed on the east is a broad, desolate, arid channel, filled with hummocks of sand piled up by the wind and bordered with fine toghraqs. No water has flowed, not even a small surplus from the main stream, since 1921, and the old bed is so silted up that even a considerable flood would be impeded in its efforts to enter the old channel.

When, in course of time, cultivation is extended in the Khotan district, there is every likelihood that this river will never, except in years of exceptional snowfall, flow throughout its present course. If it does not so flow for one season its bed will be so affected by aerial action that it will probably furrow a new course in the yielding desert—a much easier task than flowing over sand-dunes.

The reason why the Quruq Darya at Yingpan has again, after a thousand years, become a living stream is that the amount of water far exceeds that which the Khotan could ever conceivably carry.

The Keriya river, which once flowed into the Tarim across the desert, parallel to and east of the Khotan river, provides a constant subject for discussion. How often and how abundantly it flowed is not known. But one thing is certain. The abundant water east of Keriya shows no sign of local desiccation. Beyond Niya the country is dreary in the extreme, but certainly not arid, with its luxuriant reed grazing extending many miles to the north, and enabling the road to Charchan never to traverse the desert. To the south the peneplain is dry and barren, but the water-level is not very deep, and the supply good. From experience it was found that at 3 or 4 feet a newly dug well yielded rapidly a copious flow, and digging such wells satisfied the requirements of a party of ten men and twenty animals. The vegetation was universally abundant, and besides reed, there were tamarisk, toghraq, sarigh buya (*sophora* sp.), and thorns.

To continue the description of the country east of the Keriya river: it was found that the Yartungaz and Endere rivers were considerable streams even during the winter, when springs were frozen and the water supply is at the lowest. The Endere in particular was most impressive, flowing in a bed 80 to 120 yards wide, between cliffs 40 to 50 feet high, at the base of which were frequent springs. At the end of this river is a settlement of two hundred families, whilst at the end of the Yartungaz the houses only number fifty. The truth is that there is no inducement to settle in such out-of-the-way places when there is plenty of more convenient land available, and many well-off farmers have left Endere for this reason. Cultivation higher up the courses of these rivers, especially in the case of the Endere, is not possible as the rivers are too deep for irrigation. Both these rivers provide pasture for many sheep.

The above account of the country east of the Keriya river should be borne in mind when the present state of that river is further discussed.

The Charchan river is remarkable as having a basin of its own, a definite course, and an interesting end in Lop Nor, and is distinct from all other river systems of southern Sinkiang. It was a fine stream, even in March, 1931, and that it had suffered no defect in supply was evident from the abundant lagoons

on both sides. The Chong K l, in particular, was a very large lagoon full of water, and the lesser lagoons showed that they were regularly supplied with water. The Charchan receives hardly any water from its tributaries to the east, for they flow but occasionally when some rainstorm in the hills or the melting of the scanty snow fills them. Still less are the lagoons filled to the river. The river has low banks and irrigation is possible. Indeed, the settlement of Charchan is growing rapidly, and immigrants are attracted by the good land and abundant water.

Although the Toghraq, or Desert poplar, was discussed in a previous paper, it is so constantly invoked in favour of the desiccation theory that a further reference may be pardoned. The more this truly remarkable tree is studied, the more difficult it is to discuss the causes of its growth to maturity and its death, and consequently the more hazardous it is to base any arguments on its condition. There is one thing certain. Dead toghraqs do not imply necessarily a lack of water. They may do so, they often do; but again, toghraqs are found alive where unquestionably there is no water. The explanation escapes me, though the facts are evident enough, and an investigation into the life habits of this tree, and the possibility of its introduction into other countries, would be of great value.

The following examples of its vagaries amplify these remarks. On the Yurungqash, between the Eghriyari and the Qoshlash langars, was a low ridge of sand, on which were dead, dying, and living toghraqs. There were dead toghraqs with living tamarisks growing by them, and the proximity of the Momen K l assured enough moisture. Near Atbash, on the left of the Khotan river, about 18 miles north of the Mazar Tagh, there was a forest of dead toghraqs which have not been smothered by sand, as they were growing on the top of dunes. The water was close by, and there were no signs of flooding. Five miles from the left bank of the Tarim river, between Kunchuk oldi ("the dead bitch") and Rahman K l, is a large forest of dead toghraqs which have a curiously whitish appearance that distinguishes them from trees which have merely lost their leaves. Although 5 miles from water, of which these particular trees need little, tamarisk, saxaul, and sophora were growing, and the neighbouring plain, equally remote from the river, carried numerous though scattered living trees. Many other instances could be given of the death of toghraqs for no apparent reason. There is a Turki saying, not unlike ours of the oak, that toghraqs take a thousand years to grow, and a thousand years to die.

I would hazard, though very dubiously and reluctantly, a few suggestions as to why these trees die. To begin with, toghraqs dislike salt efflorescence, which is often due to excess water. Secondly, the tamarisk by its rapid growth absorbs the scanty water supply, and thus kills the adjacent poplar. Dead toghraqs and living tamarisk are frequently neighbours. Third, maybe sub-soil changes in the water supply, too much or too little; fourth, disease; fifth, human agency. So far the last has had but little effect on the trees, but it is increasing. Poplars are often killed by the shepherds burning off the old reed to hasten the growth of the new. Undoubtedly dead toghraqs often denote lack of water; equally they often do not. The point to bear in mind is that the state of these trees really proves nothing, and as an argument it is worthless.

This recent journey round the Tarim basin enabled me to realize still more the singularly erratic behaviour of the Tarim and Yangi rivers, but it is not necessary again to discuss this as it was dealt with in a previous paper.

It is now appropriate to deal with the questions mentioned earlier in this paper, questions which are the very life-blood of the theory that Chinese Turkistan is drying up.

Lop Nor is not drying up. I was prevented, owing to political disturbances, from reaching the lake itself, but a casual visit would have proved nothing, as examination of the sources of supply is the more desirable. The Quruq river, flowing by Yingpan and Loulan, was the chief feeder of the lake. When it changed its course and its waters amalgamated with those of the Tarim, Lop Nor did not receive the same share as before. This was because, although the Tarim did and does feed Lop Nor, the intake of the lagoon was diminished because (a) the water reached the west of the lake and failed to reach the part which the Quruq river supplied; (b) cultivated areas increased and so the supply available for the lake correspondingly decreased; (c) extensive lagoons east of a line north and south through Shahyar absorbed much water. In other words, Lop Nor after the defection of the Quruq received a part of that river's water *via* the Tarim, and the normal supply from the Charchan river. The lake thus decreased by the difference between the whole of the Quruq Darya and the proportion that reached it through the Tarim. Climatic influences did not enter at all into the matter.

What is now happening is that in 1931 the Tarim river had lost its fortuitous increase of water which came when the Quruq changed its bed, because that river has returned to its old channel, and is reported to reach Lop Nor in 1932. If this happens Lop Nor will receive its former quota of water. The point to bear in mind, and which seems to dispose of this lake as a factor in the desiccation theory, is that the waxing and waning of Lop Nor have nothing whatever to do, and never could have had, with its three constant sources of supply—the Charchan, Konche, and Tarim rivers. As these have never decreased in volume, and as the lake is only fed by them, how can any alteration in it be due to climatic changes?

I do not believe that the Keriya was ever a perennial river, and the analogy of the Khotan river encourages me to this conclusion regarding a much smaller stream. It flowed for a time, and then dried up, perhaps again flowing in periods of flood. The toghraqs at its northern end are nourished by the seepage from the Tarim river. It has been shown that the rivers and country to the east of the Keriya river show no signs of aridity, and it is difficult to regard the isolated case of this river, which now supplies a large arable district and thus diminishes its available flow north, as a serious contribution to the argument. Its decrease would at the most only afford evidence for a local climatic change, and that hardly a convincing one. So long as its neighbours in the west, and more so those on its east, flow with undiminished vigour, the Keriya river seems to me to prove nothing. Surely the failure of one river is not to be adduced as the proof that a vast area has suffered a climatic change.

There is next the argument of general changes, *i.e.* a diminution in the volume of the rivers of the south-east Tarim basin, but what is produced to support this? The lack of population seems to have provoked this very con-

venient theory, but at no time, past or present, have settlements in that region been other than scanty, sporadic, and insecure. It may have been the old silk route, but where are the settlements along it? Few and scattered are the remains. The reason why south-east Turkistan has been left alone is not lack of water or poorness of the soil, but a lack of amenities. Burans or dust-storms are unusually frequent, insect pests are notorious, the winters are colder and the summers hotter than elsewhere, the sand makes communication difficult, there is ample land in more favoured neighbourhoods, so there is no inducement to settle down in this dreary quarter. In spite of its remoteness, Charchan, Charkhliq, and Vash-shahri are increasing as pressure of population drives out the enterprising and energetic peasants from older settlements. There is nothing, then, in the south-east area of the province to help the desiccation theory.

The evidence of dead vegetation has been dealt with, and generally such evidence seems inconclusive.

It can hardly be hoped that the above remarks will lay, for good and all, the ghost of the desiccation theory, on which arguments and theses of a far-reaching nature have been founded. This ghost still haunts the geographical discussions of Chinese Central Asia and its phantom shrieks have driven off much valuable observation. It has even been alleged that the climatic changes of southern Sinkiang have affected or indeed caused the great human migrations of Central Asia. Both premise and hypothesis seem fantastic. So far as migrations go, if the whole of Turkistan had become as dry as its great desert, the result to mankind would have been quite insignificant.

This country has been called the land of withering rivers, a picturesque but wholly mistaken piece of imagery. There is only one river that is withering, and that is the southern reaches of the Tarim river, because it has had to give up the water that once flowed by the town of Loulan, itself often invoked by the aridity theorists. The rivers of Turkistan are fickle and untrustworthy, two Turki characteristics, but they are not withering. It is likely enough that the Yangi river will, by some caprice, return a second time to the Tarim. It certainly will if the cultivators in the lands of the lower Tarim prevail in the courts of heaven which they are deafening with their appeals for water for the ever-withering fields, just as doubtless a thousand years ago the folk of Loulan prayed for the return of their river.

DISCUSSION

Before the paper the PRESIDENT (Admiral Sir WILLIAM GOODENOUGH) said: Colonel Schomberg spoke to us more than a fortnight ago at an Evening Meeting about his travels in the Far East, and this afternoon he will speak to us of the climate there.

Colonel Schomberg then read the paper printed above, and a discussion followed.

Sir FRANCIS YOUNGHUSBAND: I have not really made a study of this subject, although it is a most interesting one, in spite of what the lecturer has said as regards its dryness. The problem is whether the rivers in Turkistan really do dry up and general desiccation takes place. But all I can say to you this afternoon will be merely observations that occurred to me in the course of the lecture.

Colonel Schomberg seems to be pretty certain that there is not a general

desiccation of that part of Central Asia, but I am wondering whether, although there may not be a steady desiccation going on, as it were, in a straight line, beginning with a very wet period and ending with an extremely dry one, there may not have been fluctuations—whether what is going on in Central Asia is not a fluctuation of dryness and wetness, and whether that may not have been caused by the advance or retreat of the glaciers in the Kunlun range south of Chinese Turkistan. I think all the rivers with which the lecturer dealt were running down from the Kunlun range, and I can recall that Dr. Emil Trinkler, a traveller who lectured to this Society, went up to the Kunlun range for the purpose of studying whether the glaciers were advancing or retreating. The advance or retreat, the diminution or augmentation of the glaciers, would account for the fluctuation in the amount of water in the rivers which come down from the range. Perhaps there may be a fluctuation extending over a period of ten to twenty years. That glaciers do vary is confirmed by one's experience in the Himalaya, the glaciers there advancing and retreating to a considerable extent within our knowledge. I have on various visits seen great fluctuations in the glaciers there; it may be the same in the case of the Kunlun range. It may have been going on for thousands of years and during recent historical times. That may be one cause of the fluctuation in the amount of water in the rivers.

Then, of course, there is the sand problem. The sand, while not retiring, very often advances in strange places; that may also have some effect in damming up the course of a river and turning it off into another direction. That is a point which the lecturer, in his full paper, has taken into consideration. In his recent lecture before the Society Colonel Schomberg cited the case of the forests being attacked, as he thought, by some insect pests which caused their destruction. That may have an effect also on the water supply. Then of course there may be fluctuations of population due to disease, or to war; that may also be a cause of the disappearance of cities.

The above are just a few points that struck me as I listened to the lecture. I think the point about glaciers is one that should be taken into careful consideration.

Major L. V. S. BLACKER: Colonel Schomberg has opened the door to a most interesting subject and one which consideration will show must have had a vital fundamental effect on the history of the movements of the population of the Old World through a number of centuries past. Before going further I venture to make a small contribution to the evidence on the subject, and that is that I observed some years ago coniferous trees in a valley called Bulun between Pokhpu and the Kunlun in a position which is, I think, considerably farther east than they have been observed before, north of the Himalayan axis.

I think that if one looks at the Old World generally one will observe a dry belt running obliquely roughly from north-east to south-west. In the extreme north-east is Outer Mongolia and the Gobi. Tracing it farther along you come to the Taklamakan desert, with which Colonel Schomberg has been dealing; and, still farther, the Qizil Qum, Qara Qum, and Golodni Step of Western Turkistan; and then the arid areas of Baluchistan, South Afghanistan, Persia, 'Iraq, Arabia, Sinai, the Sudan, the Western Sahara right into the Atlantic at Rio de Oro, a vast belt stretching right across two continents which it is impossible to match anywhere else in the world. There is little doubt that the dryness or wetness of the belt as a whole must have been altering during the last few hundred years. There are a number of phenomena for which it would otherwise be impossible to account. It is more than possible that the lowest point, the Nadir of desiccation, had been reached some little time ago in the Taklamakan, and we hear to-day that the humidity of the climate is now on the upward trend. I think Dr. Roy

Chapman Andrews described in Outer Mongolia a spring growth of green grass, something quite different from the scenery of which previous travellers in the last century or the century before gave one any conception.

Another point that has to be accounted for is the change in the course of the Oxus from the Caspian to the Sea of Aral, which I believe is about 150 to 200 years old. Further, there is the decay of the rich and prosperous cities of Maverunnahr and Khorezm, at the present moment sites in the country where the wells are 700 and 800 feet deep. I refer to the deserts south of Merv between Charjui and the Afghan border. I was fortunate enough in 1920 to see the remains of what must have been a section of the Golden Road between Meshed and Samarqand; that ran through what is now completely uninhabited dried-up salt-encrusted country which must in the old days have borne some vegetation and population.

Again, in Persia there is much evidence in all parts to show that a change of some sort has taken place. In Baluchistan you have, no doubt, evidence from the pages of Arrian to the effect that the Hanna valley was thickly grown over with jungle where the country is now almost waterless; water has been introduced artificially. Five hundred years ago the Emperor Akbar shot rhinoceros in the Yusafzai valley. It is difficult to find rhinoceros there now. Farther southwards and westwards you come to a country once called *Arabia Felix*, a designation hardly appropriate in view of its present state; but even here Bertram Thomas has recently described the fertility in the coastal belt, along what is, in effect, the eastern or southern edge of the great belt.

I suggest with diffidence the possibility that this dry belt is moving, and that the Taklamakan and Qizil Qum mark the eastern confines of it. Lop Nor and Keriya are now benefiting by the swing of the pendulum; the dryness is moving to the south and to the west, whilst the vegetation, which brings with it rainfall, is coming in from the east. Also, it should not be forgotten that during the last half-dozen years the Indian monsoon has regularly crossed the dry belt of the North Punjab to the Peshawar valley.

Another explanation of this cycle of cause and effect is the fact of the growth of Islam which being in its early days a non-materialistic creed undoubtedly led to deforestation, and deforestation possibly led to the diminution of rainfall and the ensuing vicious circle of denudation and destruction of vegetation and movements of population.

Mr. L. C. W. BONACINA: I cannot speak from any personal knowledge, but I would like to say that I have enough faith in the general stability of the climate over long periods to think that Colonel Schomberg is on the right lines in refusing to invoke the aid of climatic change to explain phenomena that can be explained by other factors. And yet there is something to be said for the other side. The evidence is steadily accumulating that climate is really made up of very irregular see-saw fluctuations from one century to another, which may have very important effects—rather longer fluctuations than Sir Francis Younghusband, I think, had in mind. In fact, so much evidence is accumulating to that effect that statistical meteorologists are losing their most cherished possession, that is to say, their standard averages or normals. These really do not exist to-day, and meteorologists are finding themselves in a somewhat awkward predicament, since there is no guarantee that a fifty-years' rainfall average in one century will be the same as that in another. I think there is evidence that the Caspian Sea has gone through many changes of level from century to century, and its last high phase was in the sixteenth and seventeenth centuries. Surely that points to an increase of rainfall in that period which was likely to have been pretty general over Asia. Supposing the rainfall at that period in the dry Tarim basin—where the rainfall is now only

a few inches a year—were 50 per cent. higher; though that is not much in actual quantity of water, the effect is likely to have been magnified on those Pamir mountains where the snow comes down, which is the source of most of the rivers which Colonel Schomberg has been speaking about.

Therefore the conclusion I have come to is that Colonel Schomberg is right as far as he goes, but that he should allow for the possibility of collateral effects due to the probability of the century-wide fluctuations in question.

The PRESIDENT: Colonel Schomberg, I would like to ask you a question which you can answer "Yes" or "No" to, and that is, whether you think the advance of the peak of the glaciers necessarily means fluctuation in the rivers. Perhaps you would like to answer that question now.

Colonel SCHOMBERG: No, I would not like to answer it!

The PRESIDENT: There are many others we would like to have heard to-night—Sir Aurel Stein, Mons. de Margerie, and others—and it is quite possible that on some future occasion we may be able to hear them. There is one we cannot hear, that is the traveller mentioned by Sir Francis Younghusband, Emil Trinkler. He was killed a year ago in a motor accident; a very great loss to science. He was thirty-five years of age and a man who had a power of thought and research which is not given to everybody.

As I have nothing original to add to this most interesting and, indeed, important business I would like, with your permission, to read from the Appendix of Trinkler's book entitled 'The Storm-swept Roof of Asia.' He says: "Much has been written on the subject of the desiccation of Central Asia. There can be no doubt that some two thousand years ago several of the rivers coming down from the high mountains fringing the Tarim basin penetrated farther into the desert. The Niya river was about 70 miles longer, and the Keriya, which is now gradually drying up in the sands, very probably at one time reached the Tarim basin. What was the cause of the decrease in the volume of water which used to flow in these rivers? The best answer to give is that we do not yet know. It will only be possible, with very exact observations covering long periods of time, for us in the future to state whether there has been any substantial decrease in the rainfall or in the size of the glaciers." And a little farther on he says: "The theory has been advanced that, some three thousand years ago, there was still ice left from the last glacial period, especially on the high plateaux and mountain ranges bordering the Tarim basin, and that these ice reserves have now melted. This theory, which has been put forward by Burrard and Rickmers, and which has also been accepted by Sir Aurel Stein, certainly deserves careful consideration. . . . There is no doubt that the desiccation of Central Asia is one of the most difficult problems that awaits solution in this part of the world."

Colonel Schomberg spoke of Mr. Nazaroff, and what Mr. Nazaroff said was: "The ancient cities and civilizations of Serindia perished from the destruction of their irrigation system in war." I happened to ask Sir Aurel Stein about that, but I did not use the word "war." I said I had been informed—for my knowledge in these matters is negligible—that it was possible that the water had been cut off by "political action," and there was no doubt about Sir Aurel Stein's reply, for he said: "If anybody told you that, my dear Admiral, he told you wrong," and there was an end of it.

You have opened a very important and interesting subject, Colonel Schomberg, and I ask you, on behalf of this audience and also of all the members of the Royal Geographical Society, who read your articles with great interest, to accept our very best thanks for the care and trouble which you have taken on this and many other occasions.

Professor LYDE, *who was unable to be present, writes*: Colonel Schomberg's treatment of the so-called "evidence" from dead forests and reed-beds and derelict towns and fields seems to me quite admirable. I traced that upstream movement in Western Turkistan forty years ago. There might be political ends in view, but everywhere—*e.g.* along the Kopet Dagh as well as the Hindu Kush—there was an economic retreat upstream for the reasons he gives, *e.g.* excess of water breaching the river-bank higher up, or irrigators there extending their tillage, or the downstream people themselves tending to agriculture and needing six or seven times as much water as before.

The statement that "the chief source of the rivers is the Pamirs" seems an error. The Pamir eastward drainage is almost negligible; even the Taghdumbush "Pamir" does not get its water mainly from the Sarikol. The overwhelming proportion of the Yarkand (Rastram) supply comes from east of the Shimshal Pass; you can call it Karakoram or Kunlun, but not Pamir! So, too, the overwhelming proportion of the Kashgar (Qizil) comes from east of the Qizil Art, *i.e.* from the Trans-Alai and the Terek, not the Pamirs.

I assume that every one accepts the evidence of the retreat of the cover in both regions. If so, its power to supply must be less than it once was; and it seems very probable that it is actually supplying less now, and quite certain that decrease must eventuate. But the proof of this, I agree, is to be found not in the Lop Nor region, but round the sources and in the upper valleys of the Rasham and the Qizil.

Colonel SCHOMBERG *has sent us the following additional note for publication*: Mr. W. B. K. Shaw, late of the Sudan Forest Department, kindly writes to say that he has noted action similar to that described in my paper in the desert vegetation of the Sudan. His letter reads: "I think the enclosed photograph* may be of interest to you in connection with your remarks on p. 319 of the *Geographical Journal* for April 1930. I took it in the Bir Natrun Oasis in the southern part of the Libyan Desert in November 1927. It shows—not very clearly—two groups of 'sellim' trees (*Acacia Ehrenbergiana* Hayne); those in the foreground quite dead while those in the left centre and background are alive. The former are on the lower level where the sand shows dark in places owing to moisture, the latter are raised on low sand mounds. The water-level in an adjacent water-hole is close to the surface, some 6 to 10 feet below the level of the dead trees. There are salt-pans in other parts of the oasis with a vein of salt formed just below ground-level, and it appeared to me that the trees in the foreground had been killed by excessive salinity in the soil brought about by a salt-crust forming there after evaporation of moisture. The loose sand of the mound, on the contrary, formed a 'mulch' which prevented great evaporation and consequent salinity. Under what conditions the now dead trees were once alive is not so clear; possibly the constant wind action had removed the sand from around them and formed the low dunes behind for the now living trees. The water in the well has only a very slight taste and is quite drinkable. Near by, though out of the photo, is tamarisk growing on mounds just like those in the pictures facing p. 317 of your article. I think you are quite right in your reply to Mr. Hinks on p. 322 in saying that this species is reproduced by seed."

Note.—The spelling Kara-Kash in the map was copied from several previous maps of this district in the *Journal*; it seems probable however that the name is better spelled Qaraqash (= black jade) as in the text.—ED. G. J.

*Unfortunately the photograph is not sufficiently clear for reproduction.—ED. G. J.