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DESERTS OF ASIA — THEIR ORIGIN AND GROWTH IN THE LATE PLEISTOCENE TIME

BY

D. N. WADIA

GEOLOGICAL ADVISER
MINISTRY OF NATURAL RESOURCES AND SCIENTIFIC RESEARCH
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YOUR EXCELLENCY, MADAM PRESIDENT, LADIES AND GENTLEMEN

BEFORE I begin the Seward Memorial Lecture, I wish to express my tribute to the workers of the Birbal Sahni Institute of Palaeobotany for the signs of all-round progress disclosed in the Secretary's report of its year's work. The last three or four years' progress of this Institute, especially the increase in the Institute's contacts abroad, are, I have no doubt, due to the devoted efforts of the President and the members of the staff.

I am going to address you this evening on the subject of Desiccation of Central Asia during the late Pleistocene or sub-Recent and prehistoric times, a desiccation that has resulted in the conversion of wide tracts of the Asian continent into barren sandy wastes, stretching from the Mediterranean shores of Asia Minor and Arabia to the Khingan range on the borders of Manchuria. Perhaps, some explanation is due from me for the choice of this subject for a lecture on the Founder's Day of this Palaeobotanical Institute. As deserts denote antithesis and hostility to plant life and imply the very negation of the green mantle on the earth's surface, which forms the main realm of studies of botanists and palaeobotanists, it is of interest to students of these sciences to enquire into the causes which operate periodically in different regions of the earth which bring on desert conditions and leave their mark on the stratigraphic records of succeeding geological ages. It must be clear to all students of palaeobotany that deserts are recurrent, if comparatively evanescent, phenomena. In the geological records of India there are at least five well-marked desert epochs that are easily distinguishable — there must be many more which are not definitely decipherable — of which the long protracted Middle Gondwana (*Mahadevas*), Middle Tertiary (*Murree* and *Sirmur*) and the late Pleistocene are the most prominent. Palaeogeographic studies have shown that in every past geological age there were extensive regions on the land surface of the earth characterized by extremes of aridity and barrenness, as is the case today, though the rock records of the period may not always have preserved characteristic lithological evidence. Our Afro-Asian, Australian and American deserts today had their parallels in every geological age. There are today desert zones in the oceans also — vast tracts totally barren of marine life, both vegetable and animal, and doubtless these conditions prevailed in the seas of past ages. Geologists are well familiar with rock systems containing marine deposits thousands of feet in thickness, but which are completely devoid of traces of fossil marine life; a part at least of this barrenness must be ascribed to the desert conditions existing in the seas of the times in which no life could exist.

I feel I have no reason to offer further explanation for selecting this subject.

DESICCATION OF CENTRAL ASIA

A very well-marked phenomenon of the late Pleistocene and post-Glacial time in the continent of Asia is the conversion of many millions of square miles of its surface into semi-deserts or deserts. The desert belt of Asia extends from the Sahara across Syria and Anatolia, seven-eighths of Arabia, through long stretches of the Iranian plateau, to Baluchistan and the Thar areas of Rajputana in one southern branch, and in the north, right through the basin of Aralo-Caspian seas, the deserts of Kizil Kum and Kara Kum, the Balkash region, thence broadening out in Chinese and Russian Turkistan, into the Takla Makan desert of Tarim basin and the Mongolian desert of Gobi. The aridity of this continental belt has arisen through many causes, but the best understood and the immediate one is defective rainfall — from total absence to scanty, irregular and ill-distributed rain. Annual rainfall statistics of these regions are highly erratic, but the mean yearly rainfall may be stated as 1-3 in. in Arabia, 3-8 in. in Anatolia, Syria, Perso-Caspian and Baluchistan regions and a highly uneven patchy rainfall of 1-7 in. in Tibet, the Tarim and the Gobi regions. There is a body of competent geological, geographical

and archaeological evidences that this desert belt of Asia is the creation of sub-Recent times extending up to prehistoric and even historical times. There are many facts to prove that Asia's continental desiccation is a post-Glacial event. The Pleistocene Ice Age had its seven or eight well-established oscillations of Glacial and inter-Glacial periods, fluctuating from Arctic cold to warm, almost tropical climates, the last phase having ended, according to one belief, only about 15,000-10,000 years ago. In the historical and archaeological records of several Asian countries, e.g. Asia Minor, Iran, Mesopotamia, Seistan, Rajputana and Eastern Turkistan, there are well authenticated facts of pulsation and oscillation of climates, of wet periods marked by a normal or abundant rainfall, punctuated by long dry arid intervals. But eventually these cycles have given place to a period of well-marked and continuous aridity during the last 1,000-2,000 years.

SALT LAKES

Among the most characteristic physical features of a region undergoing progressive aridity are the salt lakes or inland seas, which act as rain-gauges of these regions. The desiccated belt of Asia mentioned above abounds in such inland seas or salt lakes, the most noted of which are the Caspian and the Aral Seas, the Dead Sea, thousands of shrivelling Tibetan salt lakes, the great Lop Nor lake on the east of Takla Makan and the large lake basins of Eastern Turkistan and Mongolia. The Caspian in Glacial periods extended far to the east and west of its present borders and was connected with the Aral Sea on one side and the Black Sea on the other. This connection was severed only in post-Glacial times, since when it has been drying up and today its shrunken surface is 85 ft. below sea level. The Dead Sea in the Palestine-Jordan region is a much smaller body of water, an intensely saline inland sea, six times as salt as the waters of the main ocean; it is 1,292 ft. below the mean sea level, the lowest sheet of water on the surface of our earth, but there are evidences to prove that the waters of the Dead Sea in pre-Pleistocene time filled its basin up to 1,400 ft. above the present level of its waters. The Tibetan lakes, which dot the barren surface of this elevated plateau and are now drying up and turning into salt lakes, were once much larger bodies of fresh water. Their ancient shore-lines were at that time 300-400 ft. above their present level. Exposed to continued evaporation in an arid rainless climate, they are now only a fraction of their original dimensions. The once extensive lake of Seistan on the borders of Afghanistan and Persia has also suffered heavily and shrunk to its present size during the last two millennia. Cultural traditions and megalithic monuments as well as the old irrigation works indicate that the ancient lake of Seistan (the present *Hamun-i-Helmand*), either sympathetically with the Caspian oscillation or independently, occupied an area several times the present lake's size. The high beach-marks preserved round its shores indicate its former level. The hydrography of this region began to change since Herodotus's time and at present the basin has been partly filled by a few small scattered lakes. The Lop Nor basin has suffered still more heavily through the aridity of the last few centuries. Once covering an area several hundred square miles larger than its present extent, it is now surrounded by ruins and remnants of ancient vegetation, villages and irrigation works. It has six distinct wave-cut terraces, as observed by Huntington, a fact which indicates that its water filled the basin to 600 ft. height above the present dry bed. The salinity of this lake receiving the collected drainage of a large river draining an extensive catchment and itself possessing no outlet is easily understood.

Two other Central Asian lakes, viz. the Urumia in north-west Persia and the Shorkul near Kashgar in Sinkiang, may be briefly mentioned. Both were more than twice their present size in the Glacial epoch and have shown extraordinary changes of level since then. The water of Urumia today is much more saline than the sea.

SOME TYPICAL SANDY WASTES OF ASIA

The Arabian, Syrian, Iranian and, nearer home, our Rajputana desert have often been described in books on history and travel. The accounts of Aurel Stein's and Sven Hedin's travels and explorations in Central Asia have brought to light many interesting and valued facts. The latter explorer covered on foot the entire length of the Tarim basin, the Takla Makan desert, Tibet, Mongolia and Gobi, and vividly tells the story of

the sea of sand of this region of the earth's surface, covering an area more than 5,500 miles long and 1,200 miles in maximum width, from Tibet to Dzunguria. This region covers every altitude from mountain ranges of Tibet 17,000 ft. to the lowest point of Tarim depression, 2,200 ft. Though the whole stretch of this ground is not entirely a waste of sand (as for example highlands of Tibet), it has some of the most barren sandy wildernesses of the world. Everywhere in this six million square miles of Middle Asia, the story is of once copious and flowing rivers now struggling against growing sand dunes, of once flourishing human settlements abandoned and their population turned nomad; forests withering and sand-bounded lakes migrating due to encroaching dunes, shrinking in volume and precipitating rock-salt and gypsum deposits in their abandoned beds.

(i) *Takla Makan Desert in the Tarim basin* (Chinese name, *Han-Hai*, meaning 'Dried up Sea') is a vast saucer shaped depression 350,000 square miles in area, traversed by a solitary river a thousand miles long, which empties itself into the Lop Nor Lake at its eastern extremity. All through human history this basin has continued to dry up as the winds bringing moisture from the sea are deprived of it in crossing the mountains that surround it. The rivers from the snow-fed Kuen Lun range struggle through it for some distance, but ultimately succumb and lose themselves in the sand. The only signs of vegetation in Takla Makan are thin bands of drought-resisting tamarisks and some species of poplar and reeds. They have a precarious existence, however, and the vegetation belts shift with the moving sand dunes. The entire expanse is dotted with abandoned remains of human settlements. The temperature in the Tarim has the usual range of desert temperatures, minus 30°F. in winter and up to 125°F. in shade in summer. The diurnal range in summer is up to and more than 100°F. There is often 50°F. of frost.

(ii) *The Gobi Desert* is a physiographic continuation of the Takla Makan east-north-east; it is a thousand miles in length from east to west and approximately 500 miles from north to south in its broadest part, tapering to less than a hundred miles as it approaches Manchuria. There are here numerous desiccated beds and lake basins with elevated shore line surrounding their dry beds and salt-pans. Palaeolithic and neolithic relics point to the presence of abundance of water and of human settlements in this region in the not-too-remote past. The whole of the Gobi region is not entirely waterless, there being several oases with scanty pastures which support the few small wandering tribes of Mongolian nomads. To the west of the Gobi, there is the vast expanse of the Ala Shan Desert, completely devoid of water or oases.

Sven Hedin calculates the volume of drift sand in the dune area of Takla Makan at 370,000 square kilometers. With a mean altitude of 50 meters for the sand ridges and dunes, he gives 4,000 cubic kilometers as quantity of sand in the Takla Makan. This sand is almost wholly of aeolian origin, derived by the action of wind erosion on rocks from the surrounding ring of mountains and from the Mongolian highlands. Only a small part of sand is water-worn and of fluviatile origin. It is in these sands that archaeologists have found evidences of the buried ruins of ancient cities, such as Khotan (Aurel Stein). It is yet doubtful if any water-bearing beds are present in the Tarim or Gobi, storing in them waters of a previous humid period; such 'fossil water' has been discovered at two or three levels in the Sahara.

EVIDENCE OF ARCHAEOLOGY

The evidence of archaeology and history supports the evidence of geology that many of these regions, once well-watered and forested and supporting prosperous agriculture for centuries, are now unfit by reason of their aridity to support any agriculture or human or animal population. Historians and archaeologists and modern explorers and travellers have noted in many parts of Mesopotamia, Syria, Seistan, Rajputana, Khotan, Tarim and Gobi ruins of scores of towns with their irrigation works, signs of agricultural prosperity, forests and other physical evidences of these places having a humid and much moister climate. Ellsworth Huntington in his book "The Pulse of Asia" gives vivid accounts of some of these. Aurel Stein's "Sand Buried Ruins of Khotan" and his discovery of 29 deserted cities on the banks of the now defunct Rajputana river, Ghaggar, the Saraswati of Mahabharat times, are repeated by hundreds of such discoveries in the other parts of the

dry zone of Central Asia. But a much more telling evidence about the deterioration of Central Asia's climate within the last 2,300 years is furnished by the well-authenticated accounts of Alexander the Great's return march after his conquest of the Western Punjab, through Rajputana, Sind and along the Mekran country to Persia, with 110,000 men, elephants and enormous amount of baggage and equipment, without encountering any abnormal difficulties arising through lack of water, fodder for animals and food for his army. This march was through countries which today are so desolate that they cannot support passing caravans of even 100 men and animals. Seistan and Lop Nor 2,000 years ago had extensive bodies of river, ground and lake water and large town-inhabiting populations. The same is true of Rajputana and of cities like Mohenjodaro and Harappa on its borders, whose civilization and prosperity more than 4,000 years ago are well-known historic facts. Within the area of western Rajputana proper, there were large forests and it is a recorded fact that Alexander crossed the Indus in a flotilla constructed of timber derived from these forests. These Central Asian regions now are studded with salt lake basins and ruins of deserted towns and river beds.

METEOROLOGICAL INFLUENCE OF THE HIMALAYAS ON CLIMATE OF ASIA

That the Thar Desert of Rajputana (40,000 square miles) has not expanded and penetrated far to the east or north is due to the meteorological influence of the Himalayas on the atmospheric circulation of India. By reason of its altitude and its situation directly in the path of the monsoons this mountain-chain is most favourably conditioned for the precipitation of much of their moisture either as rain or snow. Glaciers of enormous magnitude are nourished on the higher ranges by this precipitation which, together with the abundant rainfall of the lower ranges, feed a number of rivers which course down to the plains in hundreds of fertilizing streams. In this manner the Himalayas have protected Central India from the gradual desiccation which is overspreading Central Asian continent. To the same cause is ascribed, on the other hand, the conversion of the vast desert tracts of Tibet and the Tarim basin to its north, some of the most desolate regions of the earth today. These once fertile and well-forested regions have been fighting against adverse climatic conditions since the end of the glacial period; they succeeded in preserving the remnants of their forests and cultivation up to the early centuries of the Christian era, but have since steadily succumbed. The desiccation of this area, generally admitted to be in a large measure connected with the interposition of the lofty mountains on the south, has had its full toll on the river system which, once extensive and well developed, has decayed and withered to such an extent that the few existing rivers lose themselves entirely in the growing volume of sands which they are wholly powerless to sweep away. The Kuen Lun glaciers, the survivors of those of the Ice Age, are wasting their vast reservoirs of ice and are retreating. There is no appreciable fresh annual snowfall, as in the case of the Himalayas, to replenish their dwindling snow-fields. In this manner, the immense waterless waste of sand of Takla Makan has replaced the once fertile low-land of Khotan.

CAUSES OF DESERT FORMATION

Theories regarding the causes of desiccation in Asia are rather conflicting. There was once a belief in a uniform world climate persisting through ages. This is disproved by geology, which postulates that every Geological Age has its own geography and climate and there are charts of palaeo-geography and palaeo-climate of different parts of the world for different epochs of geological time. There is no definite evidence that extensive deforestation causes the invasion of deserts. Meteorologists agree that although forests conserve the moisture of rainfall in the soil and keep it more uniformly damp, that they prevent floods and make the rivers and streams more uniform in volume, forests have no appreciable effect on the amount of rainfall or in attracting rainfall. In Syria no forests ever existed and yet it has been overspread by deserts in historic times while parts of Chinese Turkistan have thousands of square miles of forests which have not attracted any rainfall, but which are themselves dying out through continued lack of rainfall. On the whole, there is no certain evidence that during the last two millennia there has been continuous progressive desiccation in the countries we have considered; rather there have been

more or less rhythmic changes and fluctuations of moist climate and aridity, ending with a preponderance of arid conditions causing depletion of sources of surface and ground water.

DESERTS LARGELY THE SEQUEL OF GLACIATION OF THE NORTHERN WORLD

The consensus of opinion regards geographical changes such as elevation and depression of large land masses, inducing changes in air and water currents, changes in circulation of ocean currents, etc., to be competent to bring about climatic vicissitudes on a scale that affects continents. Such geographical changes, probably in conjunction with some astronomical causes, brought about the last great refrigeration of the earth, the Ice Age. Desiccation of the earth and deserts may be regarded as a reaction from this freezing and humidity, which came over the region immediately to the south after the final retreat of the ice, an event which may be roughly dated about 20,000 to 10,000 years ago. The Ice Age of the northern latitudes corresponded with the *Pluvial Age*— an age of excessive rainfall — in the semi-tropical and tropical latitudes. While the former region lay buried under several thousand feet thick ice sheets, the moisture-laden atmosphere over it must have engendered widespread storms and cyclonic depressions bringing heavy rains to the latter climes. The regions of the pluvial belt could not but have suffered deep decomposition in the warm humid climate producing a cap of rotted rock, mostly composed of clay and sand. With the disappearance of ice sheets of the north, the highly developed drainage systems of the pluvial belt in the semi-tropics and tropics began to wither and ultimately died out with accentuating desiccation. The land surface was left under a deep cover of decomposed rock, turning into loess and sand. The desiccation, no doubt, may not have been one persistent or continuous process; there may have been oscillations and pulsations, and there may have been minor contributory causes, such as man's interference, wars, overgrazing, cutting down of forests, etc., but their influence would be local and not continental. The main cause of desiccation was secular and terrestrial, affecting pre-eminently the air and water circulation of a whole continent.

There is a parallelism and more or less close correspondence between the arid zone crossing Eurasia and the southern limit of the main European and Siberian glaciation. The latter starts from Lat. 49°, below London and runs across Europe along the 50th parallel but suddenly ascends to 60° after crossing the Urals, further rising to 62° across Siberia. The inner margin of the desert belt follows a similar trend from west to east, from the middle of Spain along the Mediterranean coast of Europe to the south shores of Black Sea; here it trends steeply northwards, corresponding to the similar bend of the ice-line at the Urals. Then the belt trends eastwards along the 50° parallel, descending to 48° in Mongolia. At its maximum width the desert zone is 23° broad. The correspondence in trend and widening and narrowing of the arid belt with the dimensions of the ice-cap over Europe and Siberia is highly significant. The arid zone encompassing as many as 23° of Lat. below Europe is probably related to the intensity and the vast thickness of ice over northern Europe. The greatly diminished area of glaciation in Siberia is reflected in the attenuation of the arid zone east of Long. 90°.

THE FUTURE

Whether and for how long the desiccation of Asia will persist or grow in extent is an interesting speculation. The expression ' The Desert on the March ' is often heard, but there are no complete or reliable data to support this assertion. The dictum of geology that the hearts of ancient continental land masses are fated to turn into deserts has been exemplified in many regions of the world, but this inexorable operation of natural laws is not a lasting feature. Principles of geology also suggest that deserts cannot remain permanent features of a region, but they disappear by a reversal of the processes by which they came into being in the constantly changing geography of our mobile earth.

CONCLUSION

This is a brief abstract of my thoughts on a subject in which I have been long interested. I have given here a résumé of the main outlines of the subject and of my hypothesis that the Deserts of Asia are

caused as a reaction from the Ice Age of the northern world. I have propounded this hypothesis more fully in a report contributed to the UNESCO for their Arid Zone Research Programme on the evolution of the deserts of Asia.

PLATE I

Sketch showing the course of the desert zone of Central Asia from the Red Sea to the Khingan range in China. It shows the physical and regional unity with the Sahara Desert belt of N. Africa. The true deserts are surrounded by semi-deserts and steppe lands. The banding within the zone indicates the gradation in amount of rainfall correlated to the degree of aridity witnessed in the different parts of the zone.

The dotted line to the north of the desert belt denotes the limit of glacial ice during the Ice Age.

(Map reproduced from J Bartholomew, Advanced Atlas, 1950.)

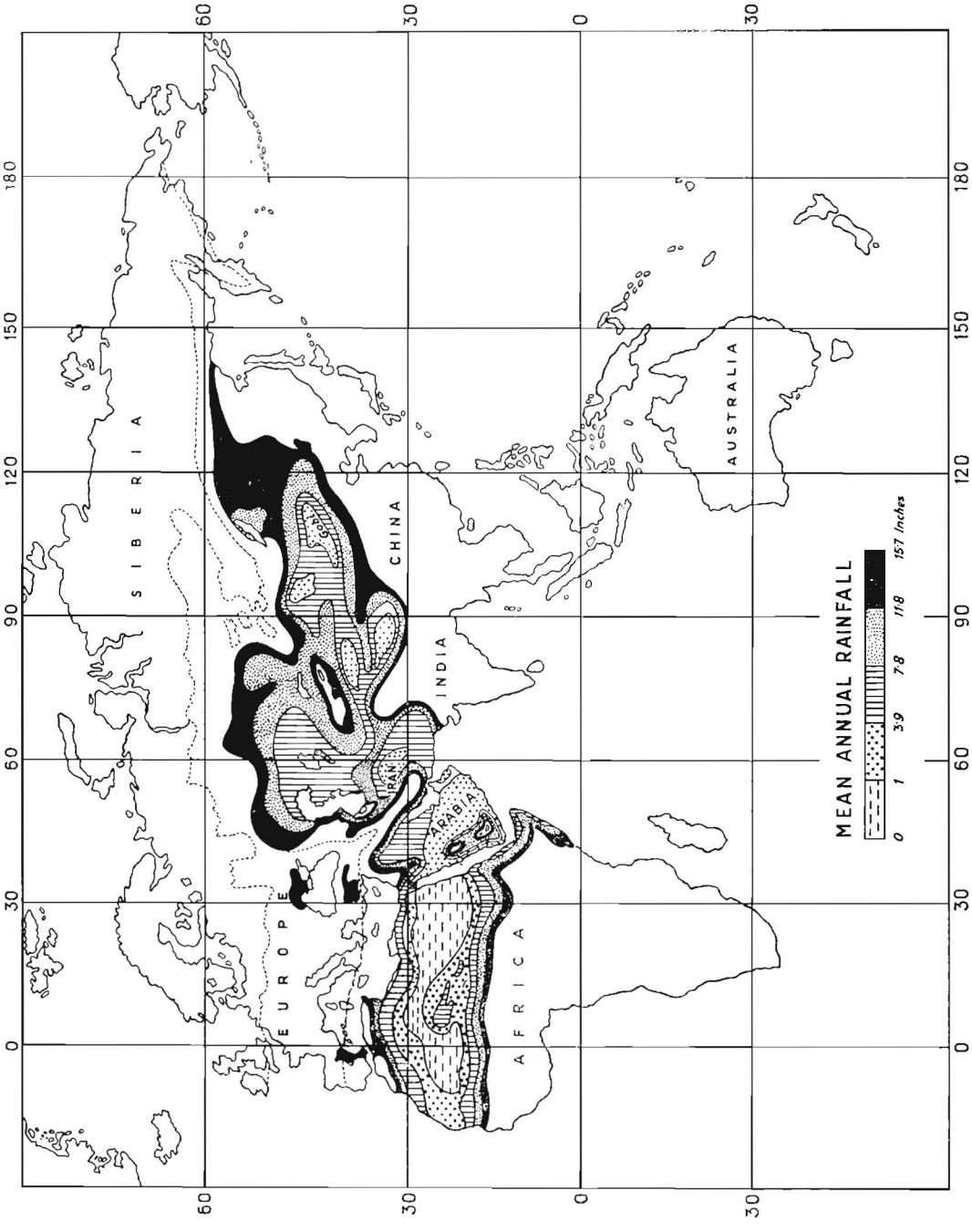
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PLATE I