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ARE WE DRYING UP?

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THE object of the present communication is to bring together some of the more striking facts in regard to the desiccation of the earth's surface, — or at least of a considerable portion of it, — which has taken place in the most recent geological period, and to suggest the inquiry, whether we have any proof that this desiccation has been and is continued into the historical period: in short, Are we drying up?

All questions relating to changes, or supposed changes, of climate during the historical period are of the greatest possible interest. Much has been written on this subject, and yet but little has been definitely established. There is a prevailing popular impression that the countries around the Mediterranean are drier than they were two or three thousand years ago, and that this change is due in part, if not wholly, to the cutting down of the forests which are assumed to have once existed there. Yet, when this matter comes to be investigated, it would appear that there is little if any evidence either that there has been any such wholesale stripping of the wooded lands, or that there has been any considerable change in the climate of that region. The question of the influences of forests on the amount of the rainfall has been ably and carefully examined by Mr. G. P. Marsh, and his results are thus summed up: "The scientific reputation of many writers who have maintained that precipitation has been diminished in particular localities by the destruction of the forests or augmented by planting them, has led the public to suppose that these assertions rested on sufficient proof. We cannot affirm that in none of these cases did such proof exist, but I am not aware that it has ever been produced."¹ It ap-

¹ The Earth as Modified by Human Action. New York, 1874. Page 196.

pears to be true, at all events, that exact observations with the rain-gauge have not yet anywhere been kept up for a sufficient time to enable us to speak with certainty with regard to the existence of any secular change in the amount of rain falling at any one place. The length of time during which such observations have been made is but trifling compared with the duration of the historical period, and infinitesimally small when considered with reference to even the most recent of the geological epochs.

We have, however, as will be seen, abundant evidence of a great change over at least a considerable part of the earth's surface, in the amount of water distributed in the lakes or running in the rivers, and it can be shown, beyond a doubt, that this change has been taking place within a very recent period, speaking geologically. Some important evidence can also be adduced to the effect that this change has been continued in the historical epoch, although not yet capable of demonstration by the recorded observations of the rain-gauge.

There are two regions especially where the facts already collected show most clearly, not only a diminution in the amount of water existing on the surface, but a most striking one. In Central Asia and in Western North America, the observations of numerous observers all point unmistakably in this direction. The observations of the Schlagintweits in Thibet and Turkistan may first be mentioned. One or two extracts may be given from H. von Schlagintweit's article entitled, "Investigations on the Salt Lakes in Western Thibet and Turkistan."¹ He writes as follows: "In all portions of High Asia, south and north of the main water-shed, there are numerous places where the former existence of mountain lakes may be recognized." . . . "In Thibet, throughout the entire longitudinal depression between the chain of the Himalaya and the main water-shed of the Karakorum, of the once numerous lakes, but comparatively few are still in existence." . . . "So extreme is the dryness in Western Thibet that, in the case of nearly all the lakes still remaining, the evaporation exceeds the supply of water, so that the prevailing condition is at the present time one of gradual diminution in the area covered by water." There seems to be here, in combining all the results of the Messrs. Schlagintweits' observations, abundant evidence of a marked change of climate in the most

¹ From the Proceedings of the Bavarian Academy of Sciences, Cl. II. Band xi. Abth. 1.

recent geological period, — resulting in the almost entire disappearance of extensive lakes, — and also that this desiccation is still going on.

The observations of Mr. Drew, the author of an elaborate work on the Jummoo and Kashmir territories,¹ fully corroborates the often previously expressed opinion, that the Valley of Kashmir was, in later geological times, completely occupied by a lake. But no evidence has, as yet, been discovered to prove that this desiccation took place during the historical period, although the traditions of the natives point in that direction. There is, however, abundant proof of diminution in the area covered by water in the basin of the Aral and Caspian seas, not only during the latest geological epoch, but also within a comparatively recent period. Those who wish to investigate the matter will find the material in a paper by Major Wood, published in the journal of the Royal Geographical Society for 1875. There is no doubt of the former vastly greater extension of the Caspian and Aral seas. While there has been much discussion with regard to the shifting of the channels of the rivers entering these seas, and their variations of height at various times during the historic period, it seems beyond dispute that a gradual desiccation of the region has been in progress, and that it is still going on. That there once existed here a vast Asiatic Mediterranean which connected by navigable waters with the Northern Ocean is very generally admitted. With reference to the diminution in the water of Lake Aral at present going on, Major Wood says:² “The sand-drives and tracts of hard clay occurring on the low shores of Lake Aral point to the conclusion that extensive areas of country which are now dry land were formerly covered by the water-spread of the lake. It has been remarked that the mouth of the Syr-Daria has become in recent years fordable, and that the depth of water between the island of Tokmak Atta and the south shore of Lake Aral has diminished. It is also an established fact that a minaret, which gray-beards of the Kirghiz state was formerly situated on the edge of the eastern shore, is now at some hours’ walk distant from it; and finally, since 1848, when it was a marshy swamp, Gulf Abougir, at the southwest corner of the Lake, has been entirely dried up, and its bed is now under cultivation. There is no doubt that the cause of this continuous

¹ The Jummoo and Kashmir Territories. A Geographical Account. By Frederic Drew, F. R. G. S., F. G. S., London. 1875.

² Journal of the Royal Geographical Society, vol. xlv. page 403.

shrinking in the area of Lake Aral is that the evaporation from its surface is in excess of the supply received by it from the Amu and from the Syr."

Similar facts in regard to the diminished quantity of water in Arabia are cited by various travelers in that country. Some of them are given in Mr. Marsh's volume, to which reference has already been made.

In Africa the existence of extensive ruins in the Great Libyan Desert, in a region quite destitute of water, and which is now entirely uninhabited, may be taken as a strong indication of great changes since the historic period. Dr. Livingstone, in his travels in southern Central Africa, was again and again much impressed with the proofs presented to him of a rapid and extensive diminution within recent times of the amount of water in the lakes and rivers of that region.¹

But it is not only in the Old World but also within our own territory that a former much greater extension of the water system can be easily demonstrated. The terraced character of the rivers of our northeastern States afford ample proof that these once conveyed a much larger quantity of water than they now do. The facts have been set forth in detail by various geological writers, and especially in President Hitchcock's Surface Geology. It is true that geologists have only lately generally admitted the apparently self-evident fact that the origin of these terraces is due to a diminution in the quantity of water which the streams have conveyed, and not to any sinking or rising of the land.

It is, however, in the region west of the Rocky Mountains, especially in the "Great Basin," that we find a condition of things most strikingly resembling that already noticed as existing in Central Asia. Everywhere, throughout the area occupied by Utah and Nevada and portions at least of the adjacent territories, the evidences of desiccation within the most recent geological period are very striking. These facts were first brought to notice in part in the Geology of California, volume i. (1865), in which the terraces surrounding Mono Lake were described, and the former greater extension of this and the adjacent lakes shown to be beyond doubt. The same thing was also noticed and commented on in the Yosemite Book (1869). The terraces surrounding Great Salt Lake are so conspicuous that no traveler

¹ See Livingstone's Missionary Travels in South Africa. London. 1857. Page 528. He says: "All the African lakes hitherto discovered are shallow in consequence of their being the mere *residua* of very much larger ancient bodies of water."

passing through that region on the railroad could fail to notice them. The publication of the detailed maps of this region by the Fortieth Parallel Survey will, no doubt, furnish data for estimating with considerable precision how large an area was formerly covered with water, and how numerous and extensive the different bodies of water were.

It is not to be expected that in our western territories there should be any proof obtained of a diminution in the quantity of water having taken place during the historic period. The character of the aboriginal inhabitants and the perishable character of their dwellings forbid this. Yet there are traditions pointing in this direction, as noticed in the *Geology of California*, volume i., the mountaineers insisting on the former connection of Mono and Walker's Lakes. However this may be, it is certain that the sharp and well-defined character of the terraces in this region indicates very clearly that the diminution of the volume of the water must have been an extremely recent phenomenon.

It is not possible at this time to enter upon a discussion of the question of the connection of this desiccation with the so-called glacial phenomena. It has seemed natural, of course, for geologists to connect the terraced condition of the rivers in the north-eastern States with the melting of the ice of the glacial period. As far as the problem at present under discussion is concerned, it makes no difference whether we do or do not consider the desiccation in question as one of the sequence of events to which the glaciation of a portion of the northern hemisphere belongs. What we are specially interested in is, whether the desiccation is still going on. If, as seems highly probable from what has been advanced in the previous pages, the quantity of water on the surface, over large areas, has considerably diminished, certainly in the very latest geological times, and also in part within the historic period, then it is not likely that the former glaciation and the present desiccation can be considered as so intimately connected in their general cause that the latter cannot take place except as a sequence of the former. The absence of any very distinct proof of a much greater extension at any time of the ice masses over the ranges of Central Asia must be taken into consideration in connection with the extensive and rapid drying up of what has been and is now going on in that region. The same may be said in reference to the Great Basin and our own western territory. At the time of the greatest extension of the glacial masses in that region, but an insignificant propor-

tion of the surface was thus covered. Only the very summits of the highest ranges had glaciers upon them, and the amount of snow and ice thus stored away would seem to have been far too small to produce by their melting a general filling of all the valleys with water unless we assume — which is certainly not probable — that the change was almost instantaneous.

It is certain that both in Asia and North America the phenomena of desiccation are on too grand a scale by far to be supposed to have anything to do with cutting down of forests. The drying up has been commenced before man interfered with nature, and has been continued without reference to his puny operations.

If, as has been suggested, the records of rain-gauge and thermometer are too incomplete and unsatisfactory to throw any light on the question of climatic changes of importance in modern times, the question arises whether there are not other sources of information to which recourse can be had. For instance, records have, in parts of Europe, been kept for many years of the flow of water in some of the principal rivers. Can any results be obtained from a comparison of these records with a view to the settlement of the question, whether the amount of water passing from year to year at certain points has diminished, increased, or remained constant? The eminent geographer, Berghaus, was one of the first to take up this investigation. He worked up the observations of the Rhine made at Emmerich, those of the Elbe at Magdeburg, and those of the Oder at Küstrin, and came to the conclusion that each of these rivers had decreased in volume during the past hundred years, and that there was reason to fear that they would eventually have to disappear from the list of the navigable streams of Germany. Later than this, an eminent hydraulic engineer, Gustav Wex, chief director of the important "Donauregulirung,"¹ and a high government official, undertook the same investigation, but with much more detail. His results, however, are similar in character to those of Berghaus, and seem to demonstrate beyond the possibility of doubt that the principal streams of Middle Europe, namely, the Danube, the Rhine, the Elbe, the Vistula, and the Oder, together draining an area of 570,000 square miles, have for many years been carrying a constantly diminishing quantity of water. The longest series of observations used in coming to this conclusion is that of the Elbe, at Magdeburg, where the records go back for one hundred and

¹ A great work undertaken with a view to the regulation and improvement of the channel of the Danube at and near Vienna.

forty-two years ; but the observations for shorter periods of from fifty to seventy years, which in the case of the other streams are all that are available, seem to leave no doubt as to the character of the result.

The probable causes of this diminution in the quantity of water in the Middle European streams are discussed at some length by Mr. Wex,¹ as also by a committee of the Vienna Academy of Sciences, appointed to report on his communication, and among whom were several eminent meteorologists. The general impression, both of Mr. Wex and the committee, seems to be that the cutting down of the forests is the essential cause of the desiccation. But the number of facts which can be given in support of this hypothesis is quite small. It is, as Mr. Marsh has stated, not so much facts as the general opinion on which reliance is placed in citing the destruction of the forests as the probable principal cause of the difficulty. It is easy to see that stripping the woods from the surface increases the rapidity of the evaporation, and that in consequence of this less water must flow in the streams unless the deficiency is made up by a larger precipitation. It is extremely difficult to prove anything in this connection in a region where so many small patches of forest are mixed up with the cleared land, as is the case in Germany. But it is fair to presume that the moisture taken up in one part of a great river basin must be let fall again in the form of rain somewhere within the limits of the same basin. Hence we should have no difficulty in understanding that stripping the surface of its trees would cause increased and irregular precipitation, which would have injurious and even disastrous effects in mountain regions, where the soil was thus laid bare to be washed away by torrential flows of the streams following on sudden and heavy falls of rain. That this is really the case is well known from experience in the Swiss and French Alps, and elsewhere. But that a positive diminution in the average quantity of water carried down in the streams would necessarily ensue on removing a portion of the forests in any region, we do not consider to have been proved as yet. The commission, in reporting on Mr. Wex's paper, are quite cautious in their expressions of opinion on this subject, showing their uncertainty by even taking into consideration the question whether the progressive hydratation of mineral substances consequent on the cooling down of the crust of the earth,

¹ This paper was published in the *Zeitschrift des öst. Ingenieur und Architekten Vereins* for 1873.

may not, as suggested first by Saemann and afterwards by Delesse, have something to do with the proven desiccation.

In regard to one question this commission of the Vienna Academy is quite unanimous, and this is that great pains should be taken by the different governments of the enlightened states throughout the world to obtain more light and additional data bearing on this subject. If desirable for Europe it is still more so in this country. We need much more numerous and more accurate observations of rain-fall. One cannot but be struck, in examining Mr. Schott's working over of the Smithsonian rain-tables, with the poverty and incompleteness of the data. We need also careful and long-continued measurements of the amount of water flowing in some of our principal rivers. For instance, New York should establish a systematic investigation of the Hudson River, and Massachusetts or Connecticut, or both, should take in hand the river which flows through those two States, and which is of so much importance to their manufacturing and other interests. For California, especially, these investigations are of the greatest importance. If it can be shown that the removal of the forests seriously diminishes the quantity of water running in the streams, then there is yet time to stay the hand of the wood-cutter ere the mischief be consummated. That the stripping of the Sierra Nevada of its timber would be essentially injurious to the State in increasing the already alarming irregularity of the seasons there can be little doubt, even if the average precipitation were to remain the same.

That there has been a very marked decrease in the amount of water on the earth within the most recent geological period is beyond a doubt; and that there is considerable reason to believe that the desiccation is still going on has, we think, been made evident in the above pages, although it has been necessary to handle with extreme brevity the various points advanced. Much might be said with reference to the connection of the so-called "glacial epoch" with the present one of desiccation, but this part of the discussion must be reserved for another occasion.