THE AGE OF THE PRESENT DESERTS OVER CENTRAL ASIA*

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IN Central Asia roughly between 37 N and 45 N and from 75 E to 110 E, there are at present vast deserts known as Takla Makan, Lop Nor, the Gobi and a few others (Fig. 4). In this area, the mean annual precipitation, as given by Lu[1], is less than 100 mm. Also, according to Watts[2], the mean maps of the Central Weather Bureau at Peking indicate a large area in Central Asia with less than an annual rainfall of 100 mm. It may also be pointed out that the mean annual precipitation recorded recently at eleven modern meteorological observatories in the Tarim Basin[2] (or Takla Makan) varies between 10 mm and 119 mm. These mean annual values are good enough to give a reasonably good picture of the present highly arid conditions over Central Asia.

From the available literature, one can state that the maximum mean rainfall occurs over these deserts in spring and early in summer. Further, according to Lange *et al.*[3], the infiltration of the rainfall over the mountain valleys in Central Asia is 40–45% in spring and autumn while in winter, most of the precipitation is lost as run-off and in summer, the precipitation evaporates away. This statement by the Russian scientists taken in conjunction with the very low rainfall figures quoted above, leads us to infer that the ground water underneath the Central Asian deserts, which could be attributed to rainfall in modern times, must be extremely small.

While the above climatological facts which are based on data of modern times can be considered as reliable, no meteorological evidence has so far been adduced in support of the following archaeological findings which can also be considered as well-established.

(*a*) There were Palaeolithic and Neolithic settlements[4,6] in these areas.

(*b*) Relics of Chinese art and civilisation in the pre-Buddhist period, dating back to the second century B.C., have also been unearthed[4,5] in these desolate regions.

(*c*) Buddhist frescoes and some of the world's most moving sculptures of the Buddha dating back to the period from the second century A.D. to the eighth or ninth century A.D. have been found[4,5] in these deserts.

(*d*) There are at present numerous dried-up river-beds[4,5] in these deserts. However, "the water table is high and water may often be found within 20 feet of the surface"[6].

(*e*) Archaeologists and others[4,6] have repeatedly stressed that there has been general desiccation over the whole of Central Asia during *historical times.* It has also been established that some of the famous Buddhist sites, *e.g.*, Niya (38° 00′ N, 82° 45′ E) and Miran (38° 16′ N, 89° 00′ E) were abandoned by the inhabitants "about or soon after the close of the third century A.D."[4].

The following paragraphs are a preliminary attempt by the author to adduce meteorological evidence in support of the above findings.

Lamb, Lewis and Woodroffe[7] have recently published the 1000–500 mb. mean thickness patterns** for July around 6500, 4000, 2000 and 500 B.C. epochs and for modern times (1949–1957). The patterns for the pre-historic periods have been derived largely from palaeobotanical and radiocarbon dating evidence. According to Lamb *et al.*[7], the thickness patterns can be taken to determine the shape of the circumpolar vortex of upper westerly winds. In support of this view and of their special usefulness in climatic studies, see Sutcliffe[8] and Lamb[9]. Figs. 1, 2, 3 and 4 show the thickness patterns in July for 6500, 4000, and 500 B.C. epochs and for modern times respectively.

On the diagrams of Lamb *et al.*, the present author has drawn the trough-lines of the major troughs between 30 E and 120 W. The errors in our determination of the positions of the troughs may be five degrees or more in longitude but this degree of accuracy is good enough for the purpose we have in view. The other major troughs seen in the diagrams are obviously too far away from Central Asia to affect directly this area.

A careful examination of the thickness patterns, keeping in view the limitations of our analysis, shows the following:

In all the 4 patterns for the pre-historic epochs 6500, 4000, 2000 (not reproduced here) and 500 B.C.

* Based on a lecture delivered by the author under the auspices of the Indian Meteorological Society, Delhi, on 19th July 1977.

** In the area where the authors have drawn the patterns as dashed lines, we may assume that the lines have been considered by them as tentative.

(*a*) there is a major trough (T_1T_1—see Figs. 1, 2 and 3) with its axis between 60 E and 90 E, *i.e.*, near about 70 E to the west of Lake Balkash.

(*b*) there is another major trough (T_2T_2) between 180° and 150 W with its axis running over or near the extreme west of Alaska.

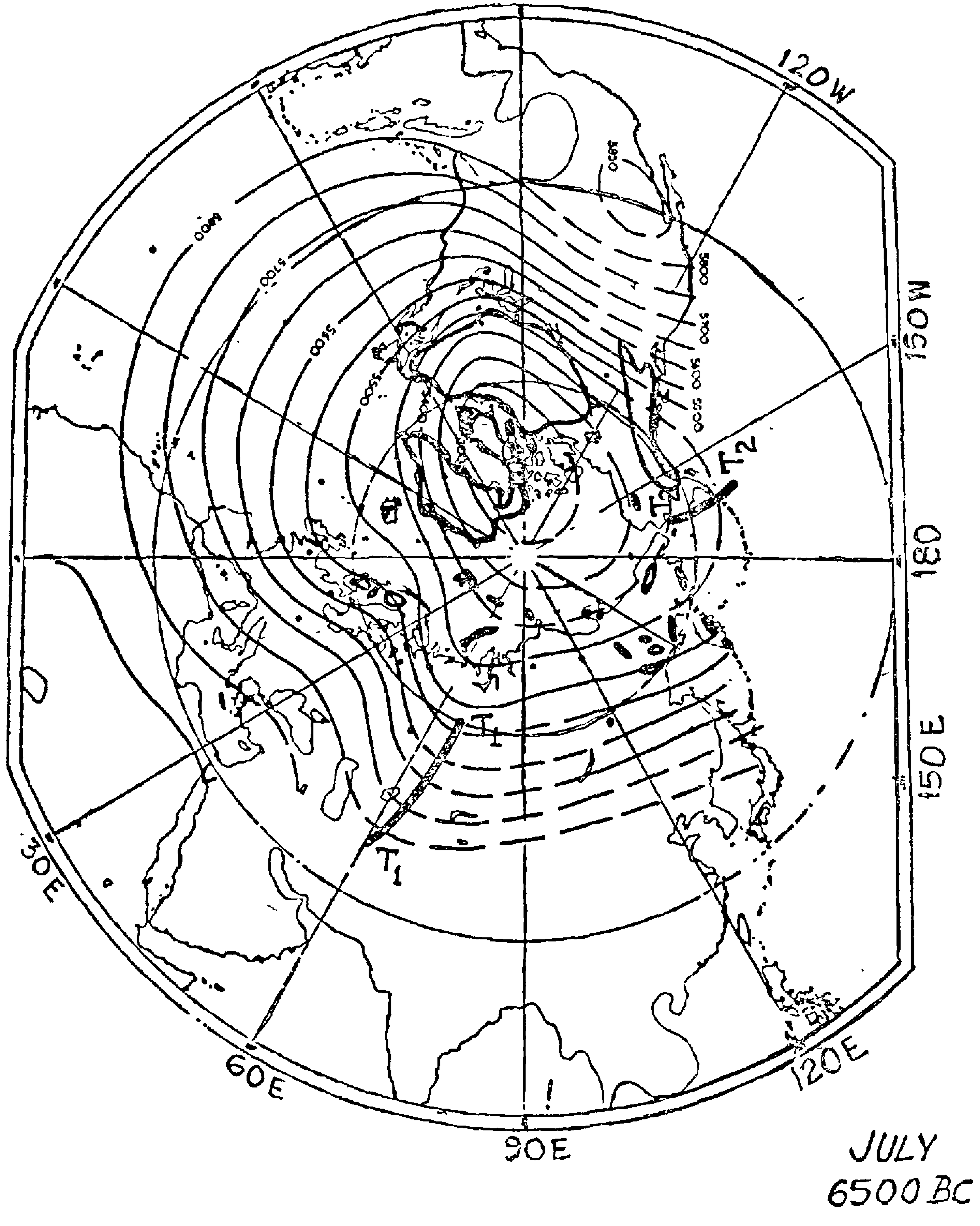

FIG. 1. Mean 1000–500 mb. thickness patterns in July during 6500 B.C. epoch. (Reproduced from the paper by Lamb, Lewis and Woodroffe[7] through the courtesy of the Royal Meteorological Society.) T_1T_1 and T_2T_2 are the axes of the major troughs between 30 E and 120 W, drawn by the present author.

Per contra, in the patterns for modern times (Fig. 4),

(*a*) there is no trough anywhere between 60 E and 90 E which we had observed in the pre-historic epochs. Instead, we see a major trough T_3T_3 between 150 E and 180°, *i.e.*, near 165 E with its axis to the east of Kamchatka in USSR ;

(*b*) there is also a major trough T_4T_4 between 150 W and 120 W, *i.e.*, off the west coast of Canada and U.S.A.

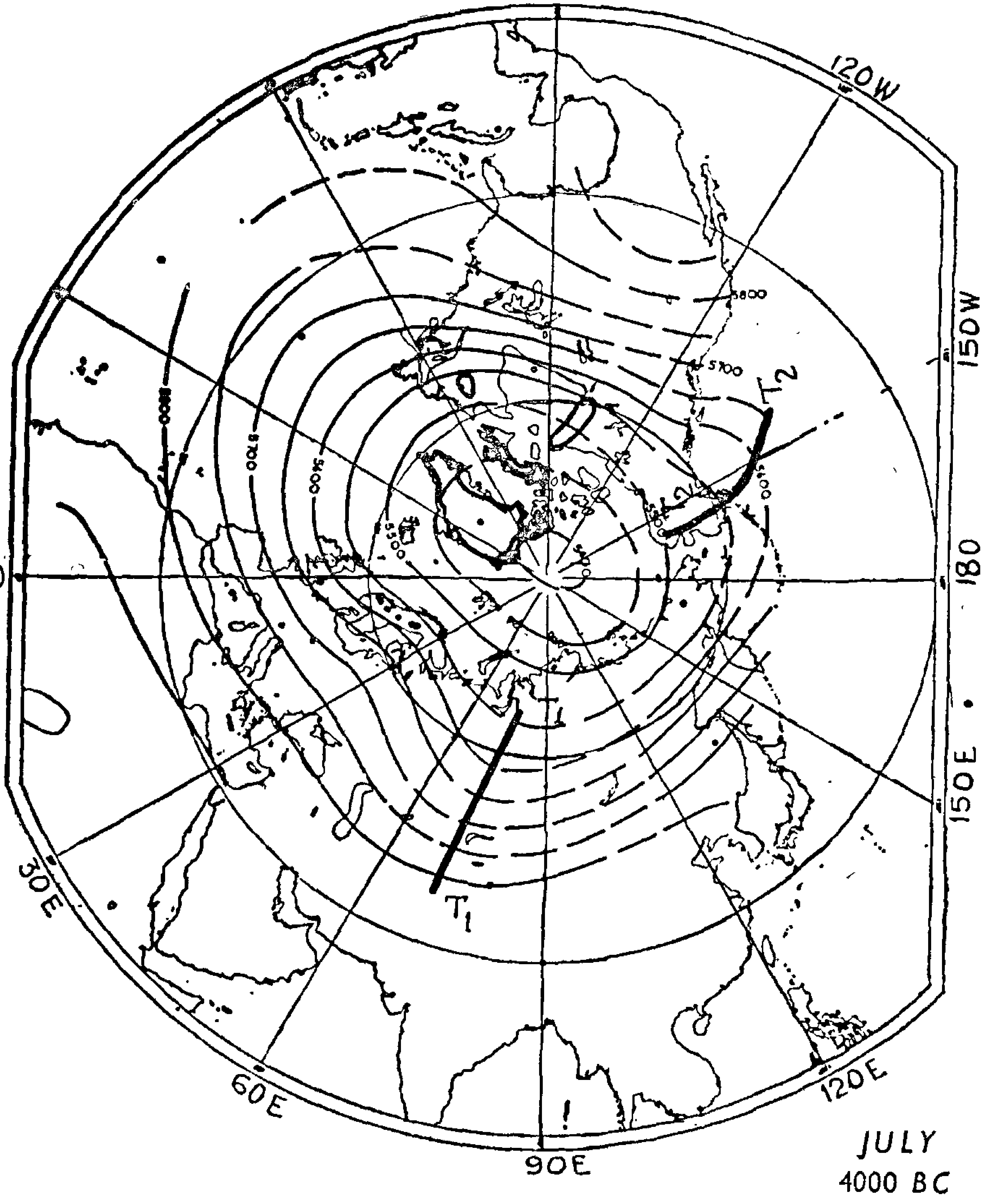

Fig. 2. Mean 1000–500 mb. thickness patterns in July during 4000 B.C. epoch. Otherwise, legend same as for Fig. 1.

We have the following two possible explanations for the observed positions of T_1T_1 and T_2T_2 in relation to T_3T_3 and T_4T_4:

Explanation-I: T_1T_1 may have shifted eastwards to the position T_3T_3 between 500 B.C. and the 1950's. Likewise, during the same period, the trough T_2T_2 may have shifted eastwards to the position T_4T_4. Our climatological and synoptic experience suggests that the shifts of these mean troughs must have been gradual and not abrupt.

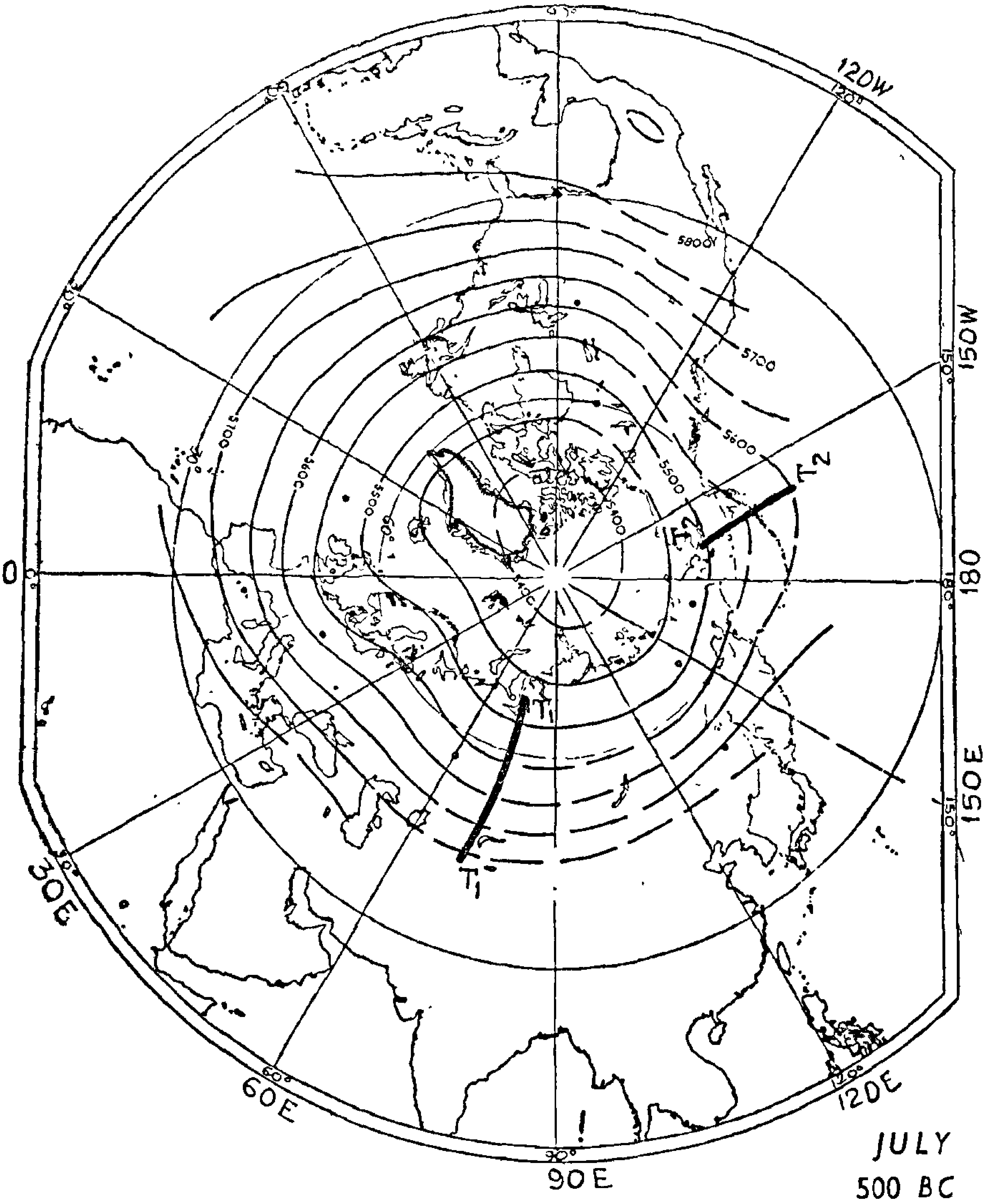

FIG. 3. Mean 1000–500 mb. thickness pattern in July during 500 B.C. epoch. Otherwise, legend same as for Fig. 1.

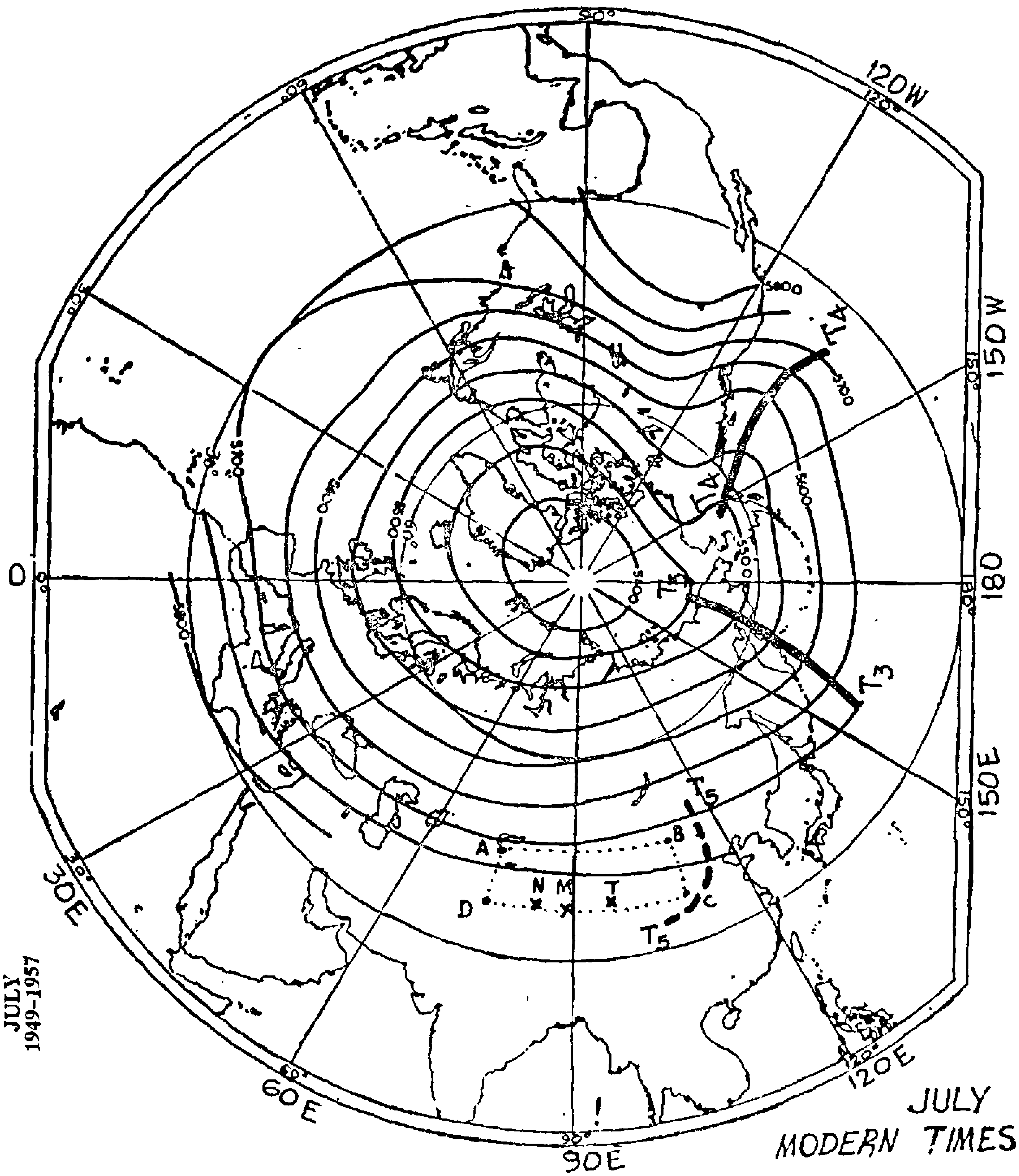

FIG. 4. Mean 1000–500 mb. thickness patterns in July in modern times (1949–1957), reproduced from the paper by Lamb, Lewis, and Woodroffe[7]. The area enclosed by letters A, B, C, D has been demarcated by the present writer. It shows roughly the area covered by the deserts over Central Asia. Letter N stands for Niya and M stands for Miran, the two famous Buddhist sites referred to in the text. 'T' stands for Tun-Huang where the Caves of the Thousand Buddhas are situated. Trough lines T_3T_3, T_4T_4 and T_5T_5 have been drawn by the present author. Note that the trough T_1T_1 which is so conspicuous in Figs. 1, 2 and 3 between 60 E and 90 E is completely absent in this diagram. T_5T_5 (thick dashed line) is the axis of the trough south of 50 N in the mean 500 mb. chart in modern times for July as published by Academia Sinica, Peking[10]. Note that the Central Asian deserts lie "in the rear" of the modern trough T_5T_5.

Explanation–2: T_1T_1 and T_2T_2 may not be related in any way to T_3T_3 and T_4T_4. The former may have disappeared after the pre-historic period and T_3T_3 and T_4T_4 may have developed *in situ* in modern times.

Of the above two explanations, No. 1 seems to be much more plausible as T_1T_1 and T_2T_2 have both shown an eastward shift although the eastward shift of T_1T_1 is rather high compared to that of T_2T_2. But irrespective of explanation–1 or explanation–2, *an irrefutable fact emerges from our analysis*, viz., *the regions which are now deserts in Central Asia lay "ahead of" the trough T_1T_1* (i.e., *to the east of the trough*) *in the pre-historic epochs but they are not so in modern times.* On the contrary, they are situated to the west of a trough (T_3T_3) during the latter period. T_3T_3 is however rather far away from the Central Asian deserts to justify the statement in meteorological parlance that they lie "in the rear" of the trough. The reason for this rather distant position of T_3T_3 will be explained in a later paragraph. We would merely state at this stage that the mean 500 mb. chart for July (the complete diagram is not reproduced here due to considerations of economy of space) published by the Staff Members of Academia Sinica, Peking, shows two troughs. One of these lies with its axis between 110 E and 115 E. This has been shown as a thick dashed line T_5T_5 in Fig. 4. The second trough in the Peking charts lies close to Kamchatka, *i.e.*, almost along the same longitude as T_3T_3 published by Lamb *et al.*, and as seen in Fig. 4. The mean 500 mb. chart of Academia Sinica, according to the Chinese authors, is based on a very large number of modern upper air stations and is therefore considered as very reliable. We are aware that we are comparing a mean 500 mb. contour chart with a mean 1000–500 mb. thickness chart. This does not however introduce any major error in our analysis as we are dealing with broad climatic features of the general circulation of the atmosphere. The fact that both the 1000–500 mb. thickness chart of Lamb *et al.*, and the 500 mb. contour chart of Academia Sinica show the Kamchatka trough almost in an identical position, lends further support to our view. We can therefore legitimately infer that the diagram published by Lamb *et al.*, does not show T_5T_5 because their mean was based on inadequate data over Central Asia which was not the case with the chart published by Academia Sinica. We can accordingly accept that T_5T_5 is a genuine mean 500 mb. trough over Central Asia in modern times. If we accept this view, we immediately see that there is a greater consistency in the amount of eastward shift of the troughs T_1T_1 and T_2T_2 from 500 B.C. to modern times. It also becomes obvious that the Central Asian deserts *lie in modern times "in the rear" of trough T_5T_5 (Fig. 4) in modern times.*

In view of what has been stated above, we can confidently say that the ancient trough T_1T_1 around 6500 B.C., 4000 B.C., 2000 B.C and 500 B.C., would have, in individual synoptic situations, caused frequent and fairly large amount of rainfall over Central Asia between 6500 and 500 B.C., *Per contra* in the same area of Central Asia, in modern times, there would be subsidence, inhibition of convection and development of arid conditions in the rear of trough T_5T_5 (Fig. 4). If our above line of reasoning is correct, we should also expect a sharp increase in normal rainfall, "ahead of" trough T_5T_5 which, it may be recalled, relates to modern times. That it is actually so can be seen from the normal rainfall in modern times published by Watts[2]. For instance, along the latitude range 39 N–40 N, the annual rainfall increases from 204 mm at Patou (110 E) to 623 mm at Peking (116 E) and to 1308 mm at Wonsan (127 E). Similar increase takes place in rainfall in July also.

Now, if we accept that explanation No. 1 given in an earlier paragraph is much more plausible, the progressive eastward movement of T_1T_1 would lead to a corresponding progressive eastward extension of the desert area in the rear of trough T_1T_1 (due to subsidence, inhibition of convection and consequent absence of rainfall) as we approached modern times. Such gradual eastward extension of the desert (*i.e.*, of the area where human habitation would have become progressively more and more difficult), is supported by the archaeological evidence pointed out by us earlier about the abandonment of the Buddhist sites at Niya (83 E) and Miran (89 E) "about or soon after the close of the 3rd century A.D."[4]. Likewise, it would be supported by the archaeological evidence regarding the cave-sculptures of the Thousand Buddhas near Tun–Huang (95 E), carved out during the T'ang Dynasty[4] (618 A.D. to 907 A.D.[11]). It is unthinkable that the T'ang emperors would have created such wonderful sculptures of the Buddha in a lifeless desert. In other words, the axis of the mean trough T_1T_1 would have been to the *west* of Tun–Huang (95 E) when the Thousand Buddhas were carved out by the T'ang emperors.

The frequent and fairly large amount of rainfall over Central Asia ahead of the Trough T_1T_1 between 6500 and 500 B.C. would have infiltrated into the soil for about six thousand years. As the ground water would not have been exploited during this long period, it is not unreasonable to expect that it would have gone on accumulating underground.

As we do not however have an idea of the geological formation underneath these deserts, we are unable to state how much of the accumulated ground water would have flowed away. Nevertheless, one could broadly expect from our line of reasoning that the pre-historic ground water is still underneath these deserts and that consequently, the water table is high as we see it today[6].

On the basis of the above facts and arguments the author would put forward a tentative hypothesis *that Central Asia was not a desert region between 6500 B.C. and 500 B.C. and that deserts began to develop only after 500 B.C.* Thereafter, they gradually extended eastwards. This eastward extension would have continued at least upto the end of the T'ang Dynasty. The water table must therefore have risen nearly to its present height by the end of the T'ang Dynasty. The subsequent accumulation of ground water must have been small. The correctness of this statement about the age of the ground water can be checked by C_{14} tests as in the case of the ground water reserves underneath the Thar Desert[12] in India. It is relevant to add that the age of the ground water determined by C_{14} tests may be out by about one thousand† years, but even then, the upper limit of the age of the ground water underneath the Central Asian deserts would be at least six thousand years.

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STUDIES ON THE RELATIONSHIP OF CINEOLE CONTENT AND REFRACTIVE INDEX OF *EUCALYPTUS* HYBRID OIL

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Abstract

An attempt to establish a relationship between refractive index and cineole content of the essential oil of *Eucalyptus* hybrid (Mysore gum; mainly *E. tereticornis*) was made. It was observed that oil samples having refractive indices less than 1·4700 were rich in cineole.

Introduction

LARGE scale plantations of *Eucalyptus* hybrid (Mysore gum; mainly *E. tereticornis*) have been undertaken in Karnataka and other States as a raw material for pulp industry. The leaves go to waste when the tree is extracted. Some of the *Eucalyptus* hybrid trees yield oil comparable in cineole content to the oil obtained from *Eucalyptus globulus* (Blue gum) and the significance of *Eucalyptus* hybrid as an alternative source of cineole was suggested earlier[1]. A screening of these trees was taken up with a view to identifying cineole-rich trees, which are morphologically