31. The Younger Dryas Age

By

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In the closing stages of the Upper Pleistocene the Younger Dryas Age was a comparatively cool epoch, the traces of which are the more pronounced, as this epoch appeared between the rather warm parts of the late Quaternary Age, namely the preceding Alleröd Age and the following Sub-Arctic Age.

During the Younger Dryas Age two stages of considerable halts or retardations of the receding land-ice are recorded by the Fennoscandian end moraines represented by the imposing Salpausselkä I and II in Finland and the Raer in Norway. In Sweden, where the land-ice during the time in question had to recede over a broader belt, the corresponding marginal formations are accordingly not so well developed. Thus we only find scattered parts of the first end moraine such as the Örudden in southernmost Södertörn, the Kungshögarna at Mjölby in Östergötland and margin deltas at Dals-Ed. The second stage is represented by a belt of retardation, in places 10–15 km in breadth. A third stage of retardation, Salpausselkä III in Finland, is much more insignificant than the two earlier. The extended eskers such as the Jordbro malm and the Påla malm in Södertörn belong to this stage. The position and duration of these three stages of end moraines in Sweden have been approximately determined by means of a study during the last ten years in connection with a revision of the Swedish time-scale (NILSSON, 1960*a* and *b*). This investigation has been performed thanks to grants from the Naturvetenskapliga Forskningsrådet, Stockholm.

Small corrections only were required in this revision of the time-scale of GERARD DE GEER. Thus the giant varve at Döviken in Ragunda which was chosen by DE GEER to represent "a very proper Zero-year, or limit between the Finiglacial and the Postglacial subdivisions of the late Quaternary stages" (DE GEER, 1940, p. 171) has now been dated to 6923 B.C. instead of earlier 6839 B.C. Also the date of the beginning of the Finiglacial Age had to be altered. A symmict varve just S. of Stockholm which registered the first influx of salt water into the region of Stockholm was deposited the same year, according to DE GEER, as the Baltic Ice Lake was drained at the northern end of Mount Billingen. This year was dated −1073 and determined to mark the beginning of the Finiglacial Age. The length of this age is now found to be 1102 years and the symmict varve in question is dated to 8025 B.C. (=6923+1102).

Now, as it is stated—by means of several connections between gothiglacial varve graphs—that the drainage of the Baltic Ice Lake was not contemporaneous with the varve −1073 but occurred c. 290 years earlier, the question arises which of the two events just mentioned is the most convenient one to chose in marking the boundary between the Gothi- and the Finiglacial Ages? The symmict varve −1073 is not always so easy to distinguish, but so is the giant varve which was deposited in the Tidan Valley during the year when the Baltic Ice Lake was drained to the sea level (CALDENIUS, 1944). This drainage was a very distinct and most remarkable occasion and it would be to take the line of DE GEER, I suppose, to chose its drainage varve to represent the first year of the Finiglacial Age as the drainage varve at Döviken starts the Postglacial Age.

The drainage of the Baltic Ice Lake is stated by SAURAMO to have occurred in Finland the year when the land-ice margin left the second Salpausselkä. In the Finnish time-scale of SAURAMO this year is marked ±0. This year of the drainage of the Baltic Ice Lake or the year 8315 B.C. seems to me to be the most convenient connecting link between the Swedish and the Finnish time-scales. This is indicated by the dotted line marked 8315 between the two parts of the time-scales in Fig. 1, and gives a very good coincidence as to the duration of the Fennoscandian end moraines in Sweden and Finland.

SAURAMO assumed that another drainage of the Baltic Ice Lake occurred 292 years after the above-mentioned. The reason for it was the influx of salt water into Finland that year. With the new dating of the drainage at Billingen to c. 290 years before the arrival of salt water in the region of Stockholm, there remains no reason for this other drainage, neither in Finland nor in Sweden.

The Younger Dryas Age comprises the time of the Fennoscandian end moraines, and in accordance with Fig. 1 can be dated c. 8900–8100 B.C. Of this time 600 years with the two most important end moraines belong to the Gothiglacial Age, while the rest with the smaller third end moraine falls in the first transitional part of the Finiglacial Age.

Within other regions of former glaciation such as in the Himalayas, South America and East Africa there have been found double end moraines very analogous to these two first Fennoscandian end moraines both in mutual appearance and in their position in relation to earlier or later margin formations of similar kind. In several valleys of Kashmir and adjacent districts in the Himalayas ERIK NORIN discovered magnificient double end moraines, which he called the Khapalu moraines (NORIN, 1925, 1927). These moraines appear at distances of 3–5 miles from each other and attained heights of up to 1000 feet or more. They dammed up lakes in which varved clay was deposited. The varved sediments were measured in different valleys and the corresponding varve graphs show that these sediments were deposited contemporaneously in these valleys. DE GEER could also connect these graphs with the Swedish time-scale and found that the series of varves measured by NORIN at the villages Biano and Sesko comprise the time from −1536 to −1180 in the time-scale (DE GEER, 1940) or 463 to 107 years before the above-mentioned symmict varve dated to −1073. As the year of this varve is now dated 8025 B.C. the Biano–Sesko

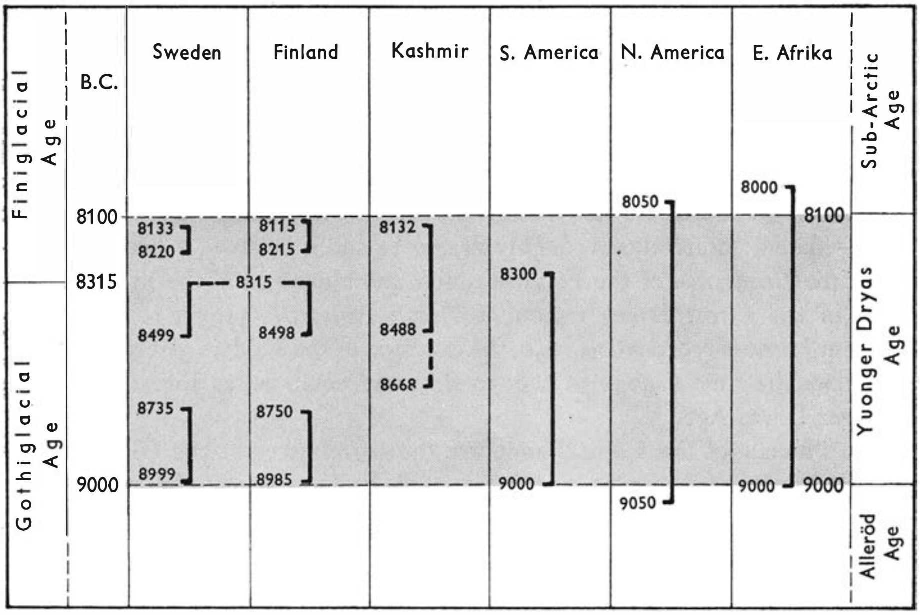

Fig. 1. The Younger Dryas Age comprises the epoch of the three Fennoscandian end moraines (dated in Sweden by the author and in Finland by M. SAURAMO) from c. 9000 B.C. to c. 8100 B.C. The drainage of the Baltic Ice Lake at 8315 B.C. is now used as a connecting link between the time scales of Sweden and Finland, and the figures of the moraines coincide very nearly. To the Younger Dryas Age belong the Khapalu moraines in Himalaya and the Finiglacial moraines in South America investigated by E. NORIN and C. CALDENIUS respectively, and the graphs of the corresponding varved clay was connected with the Swedish time scale by G. DE GEER. The correlative epoch in North America has been determined at c. 9050–8050 B.C. by R. FOSTER FLINT and in East Africa to c. 9000–8000 B.C. by the author.

varves correspond to the time 8488–8132 B.C. Below the measured series at Biano a part of the section had been built up with varves which are now disturbed and no longer measurable, the number of which was estimated to be about 180. This time is marked in Fig. 1 by a dotted line and corresponds to the interval between the first and the second Khapalu moraine.

In South America (Patagonia and Tierra del Fuego) CALDENIUS has studied the traces of former glaciations and he found 4–5 series of end moraines which he referred to the Last Glaciation. The fourth of these series consists of double moraines which he assumed to have been contemporaneous with the Fennoscandian end moraines. CALDENIUS produced comprehensive measurements of varved clay, and graphs of varve series at Laguna Blanca and Rio Corintos were connected with the Swedish time-scale by DE GEER. As a main result of these datings CALDENIUS writes: "The comparison of the Patagonian diagrams with the Swedish time-scale shows that the finiglacial deterioration of the climate has commenced before the year −2040 and the improvement of climate of the same period before the year −1340, to judge from the advance and retrogression from the finiglacial moraines" (CALDENIUS, 1932, p. 156). The two years mentioned fall 967 and 267 years respectively before the symmict varve −1073 or 8025 B.C. The duration of the finiglacial deterioration of Patagonia then is determined from c. 9000 (8992) to c. 8300 (8292) B.C., which is very nearly the same time as that of the two first Fennoscandian end moraines.

According to FOSTER FLINT (1957, Table 20B), the Valders glacial maximum falls between 11,000 and 10,000 B.P., which figures are determined by means of radiocarbon dating. He also mentions a moraine maximum in Scotland which "is C^{14} dated, indirectly, at roughly 11,000 Yr and is believed to be an approximate time correlative of the Fennoscandian moraines and of the Valders maximum in the Great Lakes region of North America" (1957, p. 380). If the "present" time is reckoned as 1950, the duration of the Valders glacial maximum comprises the time c. 9050 to c. 8050 B.C. and encloses, as Fig. 1 shows, the Younger Dryas Age.

The Pluvials of the tropical zone are the correlatives of the Glaciations of the two hemispheres, owing to the fact that the Quaternary climatic changes, which caused them all, were contemporaneous all over the world. Also such smaller changes in climate as resulted in the cool Younger Dryas Age have been traced in tropical East Africa. The Last Pluvial also called the Gamblian Pluvial—the traces of which have been studied in British East Africa and in Ethiopia by the present author—is recorded by a more extensive glaciation than the actual one on the highest mountains and by imposing lakes within the basins of the Great Rift Valley. From the arrangement of the investigated series of end moraines and groups of ancient shore-lines, I could distinguish seven wet phases out of which four (A, B, C and D) belonged to the Gamblian Pluvial and three (E, F and G) to the Postpluvial epoch. A transitional epoch, which is now chosen as a limit between the two groups, was a very dry phase during which even desert-like conditions prevailed. Then there followed, during a first part of the Postpluvial time, the Makalian wet phase with two maxima, the lakes of which, E1 and E2, were rather extensive in the basins of the Rift Valley. Then another desert-like epoch broke in followed by a second, longer Postpluvial wet phase, called the Nakuran wet phase (with the lakes E3, E4, F1–5 and G1–3, see Fig. 2).

This course of the postpluvial history of these basins has been built up during the study of the shore lines and sediment of these ancient lakes, especially in the Naivasha and the Nakuru basins. Also an excavation of a prehistoric site in a cave (Gamble's cave II, S. of Lake Nakuru) gave important information. Thus I found that the cave had been formed as a beach cave by the ancient lakes D1 and D2. Varved sediment of the lake D1 was measured and the corresponding graph connected by DE GEER with the Swedish time-scale. This part of the sediment was dated and comprises the time c. 13 000–12,900 B.C. Also varved sediment of the lakes E3 and E4 in the beginning of the Nakuran wet phase were dated. Their graphs represent the time c. 6900–6700 B.C. and c. 6400–6300 B.C. respectively.

The excavated layers of Gamble's cave, reckoned from the bottom, were: beach gravel (lake D2), two occupation levels (Kenya Capsian culture), a third occupation level (Kenya Stillbay culture), a layer of wind-blown sand (the first arid epoch), an occupation level (Elmenteitan culture), a layer of wind-blown sand (the second arid epoch) and then on top sterile layers and modern occupation levels. The three oldest occupation levels belonged to the decline of the Gamblian Pluvial and the fourth one to the Makalian wet phase (LEAKEY, 1947; COLE, 1954).

When placing the first arid phase, the Makalian wet phase, and the second arid phase in the Postpluvial time, they fall in between the above dated wet phases represented by D1 and E3. Then there are, I think, no other possibilities than to refer the first arid phase to the Alleröd Age, the Makalian wet phase to the Younger Dryas Age and the second arid phase to the Sub-Arctic Age. The two lakes of the Makalian wet phase would then be the correlatives to the two Fennoscandian end moraines.

The end moraines of the Gamblian Pluvial are very well developed on the Kilimanjaro, Kenya and Ruwenzori Mountains, but the Postpluvial moraines are small and not yet sufficiently known. I have seen some of them on these mountains, but a comprehensive survey is necessary in order to trace them below the present valley glaciers. In the Ratzel Valley on Kilimanjaro there are, according to KLUTE (1920), a couple of Postpluvial end moraines at the altitudes of 5000 m and 5120 m. The lowest moraine of the pluvial maximum was met at 3800 m, a moraine of recent time at 5280 m and the glacier at 5450 m. On several other mountains such as Mount Elgon, Mount Badda or Kaka (Somaliland Plateau) and the Semien Highland (Ethiopian Plateau), where I was able to establish glaciation during the Gamblian Pluvial, no glaciers prevailed in Postpluvial time.

Diagrams of ancient shore lines within the investigated lake-basins in Kenya (Nakuru and Naivasha) and in Ethiopia (Zwai-Shala and Tana) show a very high degree of similarity as the variations in height of the lake-levels during the Gamblian Pluvial and the Postpluvial time were dependent on the same climatic changes. In this respect there is an especially good conformity between curves from the Nakuru and the Tana Basins.

The successive lowering within these different basins of the ancient lakes representing the pluvial phases from the highest one (A1) of the maximum of the Gamblian Pluvial down to the G lakes is of a striking agreement. This accordance appears very pronounced in the curves which connect the height figures of these lakes, marked on verticals at equal distances from each other (NILSSON, 1940, Fig. 44). This similarity is yet more distinctly visible in another graph of curves (NILSSON, 1940, Fig. 45), where the differences in height between two successive lakes in each series (A1–B1, B1–C1, etc.) are placed as such verticals in the same way as are the thicknesses of the varves in an ordinary varve graph. The very great conformity of these curves must depend, I suppose, on simultaneous climatic changes.

Within the Faiyum Depression SW. of Cairo a similar sequence of shore lines of ancient lakes has been measured and a curve shows the same successive lowering of the lakes (CATON-THOMPSON *et al.*, 1937, Fig. 1, graph reconstructed from Survey's data). From finds of artefacts in the shore line of the highest and oldest lake, this lake must represent the maixmum of the Last Pluvial. If the height figures of the Faiyum lakes are used to build up curves like the above-mentioned, the four highest lakes correspond to the lakes A, B, C and D of East Africa. As the Tana Basin is one of the most important sources of the Nile and the lakes of the Faiyum Depression were fed by the Nile, the similarity of the mutual height positions of the sequences of the lakes in the two basins is only natural. Even such small variations as the yearly ones of the precipitation in Ethiopia are clearly marked and measurable in Egypt.

Another interesting record in Egypt of pluvial conditions in Ethiopia is stated by SANDFORD: "By the time the Mousterian culture had become locally evolved to such an extent that it is called by another name (older Sebelian) the gravel was all but past, and the Nile from the Second Cataract northward was overwhelmed by vast quantities of silt" (SANDFORD, 1933, pp. 36–37). A later occurrence of the same kind is stated by AMER BEY and HUZAYYIN in their investigation of the Nile Valley and the Ma'adi Predynastic site south of Cairo. They traced a phase of unusually high floods in the Lower Nile and suggest linking this phase "with a postpluvial wet phase in E. Africa and—of necessity—Abyssinia. ... But this process of aggradation in the North was not a simple one, as the silts there were deposited in two groups separated by a phase of local lateral erosion ... Could this be an indication that the Makalian wet phase in the upper Nile had two sub-maxima?" (HUZZAYIN, 1947, p. 78). These two events are dated by means of archaeological findings and it seems to me that these unusually high floods reached the Nile during the maximum of the Gamblian Pluvial (phase A) and during the Makalian wet phase or the Younger Dryas Age. And here the statement of the two sub-maxima is noteworthy.

The curves of Fig. 2 show in a schematic way the changes of levels of the ancient lakes in the basins of Nakuru and Faiyum from the end of the Gamblian Pluvial up to the present time. Those lakes which, according to the above-mentioned special curves, are assumed to be contemporaneous are placed on the same verticals. Certain datings anchor the curves to the time-scale. Thus varved sediments of the lakes D1, E3 and E4 are dated by DE GEER by means of the Swedish time-scale (DE GEER, 1934). The Faiyum lakes 10 m and −2 m are C^{14} dated and the dates of the lakes −11 m and −13 m are given in historical documents (BUTZER, 1957). The curves are drawn on the assumption that the climatic changes during the time in question were contemporaneous all over East Africa, as they were during the Gamblian Pluvial. Below the time-scale of the curves the limit between this pluvial and the Postpluvial Age is marked at 10,000 B.C. In the Scandinavian subdivisions of time at the base, uncertain limits are dotted. The lengths of the Alleröd and Younger Dryas are determined

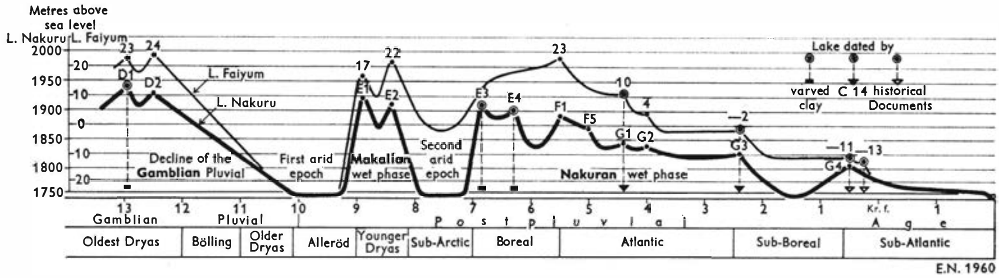

Fig. 2. Curves showing the changes of levels of ancient lakes in the basins of Nakuru and Faiyum from the decline of the Gamblian Pluvial to the present time. The heights of the beaches in the two sequences of lakes are correlated by means of special diagrams (NILSSON, 1940, Figs. 44 and 45). Certain lakes, D1, E3 etc. are anchored to the time scale according to different kinds of dating. The maximum of the Makalian wet phase must fall, I suppose, in the Younger Dryas Age, but its length may be subject to further determinations. On archaeological assumptions, the Makalian phase should begin at 10,000 B.C. or 5500 B.C. and last until 3000–2500 B.C. (COLE, 1954; DESMOND CLARK, 1959).

by means of the study of varved clay in southern Sweden (NILSSON, 1960*a*, Fig. 4). Younger limits are from the data of G. LUNDQVIST (1957, p. 484–485). As mentioned above, the double lakes E1–E2 and 17–22 m of the Makalian wet phase ought to be placed in the Younger Dryas Age. The longer Nakuran wet phase starts with the lake E3 in the beginning of the Boreal Age and extends to the end of the Atlantic time. The places of the Faiyum lakes, 10 m and −2 m, are given by radiocarbon dating to c. 4440 B.C. and c. 2400 B.C. (BUTZER, 1957) and their correlatives should be the lakes G2 and G3. During the Sub-Boreal Age the Faiyum lake was lowered to −11 m, while the Nakuru lake probably dried up for a while but rose again when the "Fimbulwinter" of the Sub-Atlantic set in, as the lake G4 perhaps may be contemporaneous with the lake −11 m. This lake was lowered to −13 m "at the time when PTOLEMY PHILADELPHUS (285–247 B.C.) began the systematic project of reducing the lake to its present low level at −45 m" (BUTZER, 1957, p. 29). The details of the curves are not yet sufficiently known. For this reason straight lines had to be drawn just before and after the two arid phases. The ages of the lakes 23–24 m and 17–22 m of Faiyum are estimated to be about 15,000 B.C. and 7500 B.C. respectively on the basis of archaeological finds. Although these figures must be corrected a great deal, they confirm the mutual date in Fig. 2 of these lakes.

Another example of insertion into the East African time-scale of archaeological finds by means of radiocarbon dating is chosen from the opposite end of Africa. On the southernmost coast of the continent in the Matjes River Cave (c. 300 miles E. of Cape Town) finds of a crude industry have been dated to the age between 9293 ± 400 B.C. and 8543 ± 400 B.C. Whether this industry is of Smithfield type or not seems to be uncertain. However, this dating places the culture exactly in the Makalian wet phase, and in this time at the very beginning of the Post-Gamblian immediately after a dry phase it is also placed by DESMOND CLARK (1959, Table 7 and p. 188).

For the Near East BUTZER has elaborated a detailed division of the Late Glacial and Post Glacial time. His "Subpluvial I" extends from c. 9000 B.C. to c. 8000 B.C. and I agree with him in the following statement about this Subpluvial: "From all indications we believe an identification with the Makalian phase of East Africa may one day be possible" (BUTZER, 1957, p. 26).

When tracing the late Quaternary events we will find that the Younger Dryas holds a key position. Its two maxima of moister and cooler climate have given rise to the mighty Fennoscandian moraines, the Khapalu moraines in Himalaya, the double Finiglacial moraines in Patagonia, the two aggradation phases at Ma'adi in Egypt and to the two lakes of the Makalian wet phase in Equatorial Africa. The list of such examples in nature can certainly be increased in the future. Radiocarbon dating will surely be an invaluable help in establishing reliable time-determinations, and varved clay in giving a real and most detailed time-scale.

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