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Correlation of late glacial annual clay-varves in North America with the Swedish time scale.

By

Gerard De Geer.

At the meeting of this society on the third of February I presented some diagrams showing the correlation obtained a few days earlier between annual clay-varves [1] at four different localities in Vermont in the United States and corresponding varves of the Swedish time scale.

During an earlier stage of the geochronological investigations I expressed the hope that it would perhaps be possible through comparative studies to find out in Sweden and North America corresponding variations in the rate of recession of the late glacial ice border and thereby to prove that the last deglaciation and probably the last glaciation as well in both regions had been simultanous and due to a common and general cause. [2] This would mean an important step toward a real explanation of the Ice age.

In 1915 I had found that the variation of the single varves could be identified at great distances quite as well as at localities near each other and that the cause of this variation must have been a general one, evidently of climatical nature. Thus I got the hope that such identifications should be performable at least as far as the extension of one and the same climatic zone. The annual means of the temperature of the air nowadays in Northern Europe correspond very well with those of North America east of the Rockies

[1] Compare: varvels. Swedish *varv* (old spelling: hvarf; isl. hwerf) means a circle, a turn as well as a periodical iteration of layers. Proposed as an international term in the Compte Rendu XI Congr. Geol. Int. p. 253.

[2] En förhistorisk tideräkning. Svenska kalendern för 1908; Uppsala 1907, p. 80.

and, the same probably being the case also with respect to those of the warmer melting season, it is obvious that the resemblance must have been much greater still during the late glacial melting epoch, when the land surface was uniformly covered by a great ice sheet. In the glaciated regions of this epoch the amount of heat, radiating from the sun, must have been pretty well registered by the amount of melting water and melting water sediments.

Thus it was to be expected that the annual varves on both sides of the Atlantic ought to show corresponding variations. I also believed to have found some such series which might be identical, though they were too short to be quite reliable. In the case of one, from Essex Junction, on the east side of Lake Champlain, near Burlington, the identity depended upon the assumption that I had, when measuring that series in 1891, at two horizons sprung over together three varves.

During the last five months of 1920, accompanied by my wife and two others of my most experienced assistents, dr R. LIDÉN and dr E. ANTEVS, I went to North America in order to find out how far it was possible to make an international use of the Swedish time scale.

At Essex Junction we found that my first measurement was correct, that no varves were oversprung and thus that the variation of the whole series dit not fit. As the section now exposed at several horizons was folded, we had to measure the undisturbed layers at as many places as possible. Thereby I got a material allowing later on the combination of all the measurements to a composite, well controlled series, which I succeeded with certainty to identify with the Swedish time scale between the years — 1099 and — 1208 before the end of the Ice age. Of those 109 varves 97 — or 89 % — fitted very well, while 11 % were dissimilar or locally developed, as also in Sweden is often the case.

With Essex Junction as starting point I succeeded already the following day in identifying with the Swedish time scale also the varves at three other localities in Vermont, or Waterbury, Woodsville, and Wells River, where dr LIDÉN at my request had executed measurements in order to facilitate and corroborate the definitive correlation of Essex Junction.

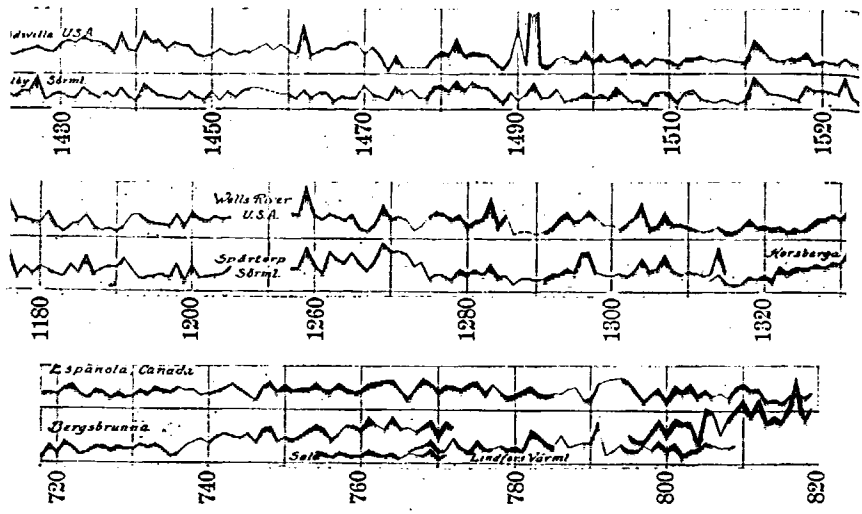
At Waterbury the measured varves were identified with the years — 1178 to — 1440 of the t me scale, 210 varves — or 80 % out of the whole number, or 263 — showing identical variations and only 20 % being local.

At Woodsville the identified layers pertained to the years —

1413 to — 1556, 125 varves — or 86 % out of 144 — being normal and only 14 % local as to their thickness.

At the town of Wells River, situated at Connecticut River, the varves were fixed to the yeers — 1173 to — 1339 with 129 varves — or 77 % out of 144 — being of normal and 23 % of local thickness.

Thus, at all of those four localities, out of 683 varves no less than 561, or 82 %, show very distinctly the same variations as the Swedish time scale, while only 122, or 18 %, are locally developed.



Correlation of varves in North America with the Swedish time scale (lower linre). Figures = years before the End of the Ice age. Vertical lines up to the curve show the thickness of the varves, 1:5 of natural size. Shadow marks identified varves.

About a week afterwards I succeeded also in identifying with the said time scale a very long series of varves, measured by LIDÉN North of Lake Huron and North Channel at Spanish River and the town Espanola in Ontario, Canada. The whole series comprises 1505 varves, out of which a number of 1117 were measured. At two horizons the layers were disturbed and could thus here not be measured. Near the middle of the section the varves were too thin to show the variations sufficiently well and their number was only estimated at something between 300 and 400. Still a specimen of the whole series thus not measured on the place was secured by dr LIDÉN for the collections of the Stockholm University. Even 165 varves just below those last mentioned were too thin to allow reliable comparisons, but of 952 varves of more favorable

thickness 705 varves or 74 % were found to show the same variations as the Swedish time scale for the following years: the uppermost varves, only 1 *m* below the somewhat river-eroded surface, from the year — 204 to — 437; further on, below a disturbed zone of 34 years, a series from — 472 to — 908. The thin varves not measured showed by the dating of the adjoining ones to be 336. Below those followed the 165 thin varves measured, out of which only 26 % cold be identified. The following, disturbed zone, which by dr LIDÉN was assumed to comprise less than 20 varves, was found to contain 18 and the bottom series was identified with the years — 1420 to — 1708 of the Swedish time scale.

By means of the identification of the varve-series in Vermont and at Espanola all the annual varves of the milder, finiglacial subepoch have thus been recognised also in North America, only with exception of the very last 200 ones, deposited just before the end of the Ice age; and furtheron the same is true of all the varves, corresponding to the stationary stages of the well known Scandinavian terminal moraines, marking the end of the colder, Gotiglacial subepoch.

Espanola is situated about 850 *km* W of Wells River and about 6 250 *km* or nearly 4 000 English miles WSW of Stockholm. This being almost one sixth of the whole circumference of the earth, it seems quite evident that the cause of the variations of the varves must have been a general one and a rapidly working too, just like the radiation of heat from the sun. If this be the case it may also be possible to obtain correlation with the varves in other, formerly glaciated regions, such as the Rockies, Switzerland, Himalaya and Patagonia and thus to extend the use of the time scale all over the earth.

Added during the printing.

Just before the above was going in press I obtained also connection with two localities in Canada, Haileybury and Dickson Creek, Ontario, about 250 *km* NE of Espanola, in the district of Timiskaming. The varves identified pertained to the years + 297 to — 341 from the End of the Ice age.

This means that the ice border at the End of the Ice age was still in this region, a considerable part of the great American glaciation being left on the Laurentian highlands to melt away during the neolithic, postglacial subepoch.
