

## b13 De Geer's test of the Great Ice Age < varve-counting >

Time is now to rescue De Geer from innocuous desuetude. —HR

Agassiz spoke and wrote about his “theory” of an Ice Age but in truth he did not devise a test for the Ice Age that was not just more of the same sort of observations that had led him to the idea in the first place. The Ice Age remained an hypothesis during Agassiz’s lifetime (1807-1873). One of the first tests of the Ice Age that established it as a fact of prehistory was devised by Gerhart De Geer (1858-1943) (**Figure b13.1**) beginning in 1879.

Lakes are called *proglacial* if they are fed directly by the meltwater of glaciers. Working in Sweden, De Geer observed that such lakes accumulate finely laminated deposits that are an alternation of light colored silts and dark colored clays called (in the vernacular) *varved clays* (**Figure b13.2**). During one year, a light bed and a dark bed *couplet* accumulates called a *varve* (*varv* is Swedish for *layer*). How so, can be easily understood: Glaciers are able to grind rock and produce silt and clay-sized material called *rock flour*. As a result, water issuing from a glacier typically looks milky as it carries in suspension triturated (finely ground) rock (common rock minerals have a pale streak). In proglacial lakes during the spring, coarse sediments are deposited recording high glacier meltwater runoff, while sediments finer than silt are kept in suspension by through-lake stream currents and by wind-driven deep stirring when at 4 °C (39.2 °F) lake (fresh) water is at maximum density throughout.<sup>1</sup> This latter changes to shallow stirring of the heated upper portion during summer and early fall. In the late fall, runoff slows as streams freeze and their through-lake currents lessen and stop when lakes freeze across at 0 °C (32 °F). During winter, clay-sized sediment in the still water beneath the lake ice settles out of suspension. So, a pale silty layer records the time when a proglacial lake is free of ice and a dark layer of finest clay-sized sediments records when the lake is icebound in winter.



**Figure b13.1 Gerhart De Geer**

For no sound reason, his accomplishments have been laid aside from mention in other texts even though his work provides for a clear illustration of the full workings of the scientific hypothetico-deductive method.

As varves record annual cycles of sedimentation, they can be used for absolute dating. For the time that a lake was proglacial it will have collected varves. The method is to take a vertical-core sample of the lake sediments. Counting down into the past, each varve can be assigned a calendar year. Short-term climate variations in the past are recorded by varve-thickness variations. *Note:* As the edge of an ice sheet retreats, lakes that become far from its edge cease to be proglacial. However, beneath a thickness of unvarved sediments in a lake now far from a glacier, the presence of varves record, for the time of their accumulation, the nearby edge of a glacier.

Beginning in 1879, De Geer and twenty of his students at the university of Uppsala, Sweden, attempted to match core samples of varve sequences in widely separated glacial-lake sites. Correlation was difficult because each lake has only that part of the record when it was proglacial. Nevertheless, like shingles on a roof, each laid down course (layer) laps over the upper edge of the older layers. In practice, such superposition could mostly not be demonstrated and it was necessary to make judgements to match varve-thickness variation patterns in the lower part of a younger sequence with that in the upper part

of an older sequence. They found that the patterns of thick and thin varves in cores matched quite well from one lake to another as long as no more than 1 km separated the compared lakes.

Mountain glaciers in Scandinavia, De Geer discovered, are remnants of what were two separate ice caps that had existed before the beginning of historical time. The vanishing of these ice caps 8700 varve years before 1910 (when the study was completed), marks the formal end of the Ice Age in Europe. The ice caps themselves were shrunken remnants of a previously existing northern-European ice sheet, the edge of which had begun its retreat 13,500 years ago.

De Geer presented the findings of his varve method at the 1910 International Geological Congress (at Stockholm).<sup>2</sup>

His varve chronology (**Figure b13.3**) extended back for almost 17,000 years. It gives a detailed record of the prehistoric retreat (at some 10 km per century) of the edge of an ice sheet at the end of the Great Ice Age.

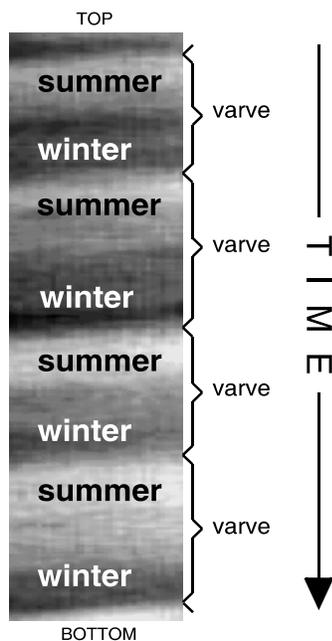
In the United States, similar varve counting studies in 1922 by Ernst Valdemar Antevs (1888-1924) (a pupil of De Geer) showed that the last Pleistocene ice-sheet margin had taken 5000 years to retreat to Canada 250 miles north (4 km per century) of its former terminus across southern New England.<sup>3</sup>

The south to north ice-sheet margin retreat originally plotted by Antevs was challenged 1929 through 1933 by Richard Foster Flint who modeled the deglaciation as of a downwasted ice sheet

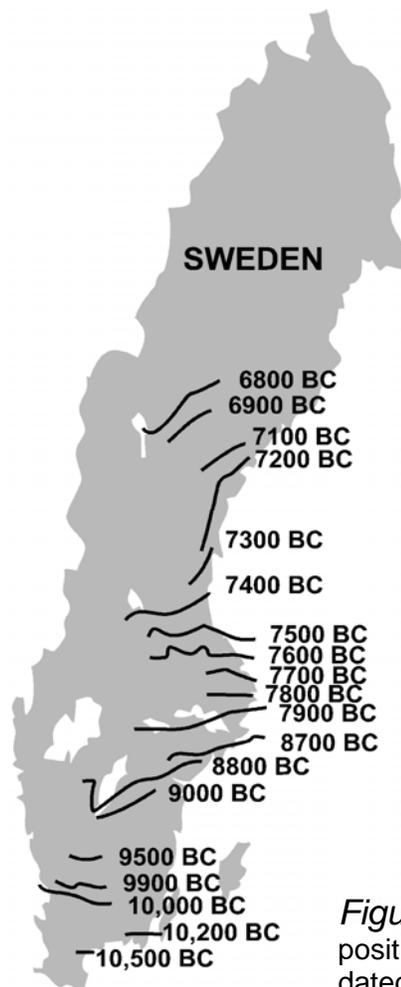
with stagnant ice occupying valley centers. Then in 1956, radiocarbon ages in New England as interpreted Flint were in such discord with varve chronology in North America that Flint chose to omit mention of New England varve work in his comprehensive textbook on *Glacial and Quaternary Geology*, 1957, 1971.<sup>6</sup>

Beginning in 1980, AMS (accelerator mass spectrometry, which can resolve stable nitrogen-14 from radioactive carbon-14) radiocarbon dating has reestablished the validity of Antevs' varve chronology that records a recessional ice-sheet margin.<sup>7</sup>

Modern dating is that from its furthest reach south across North America, the last Pleistocene ice sheet started its final retreat 18,000 years BP (Before Present) which is 16,000 BC (or BCE). □



**Figure b13.2**  
Core of proglacial lake varved sediments showing four varves.<sup>4</sup>



**Figure b13.3** Ice-front retreatal positions in Sweden that De Geer dated by varve counting.<sup>5</sup>