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THE EMERGENCE OF THE GLACIAL THEORY: A SCANDINAVIAN ASPECT

As in many other countries the science of geology developed very slowly in Sweden. Many geological questions were treated in what was called general geography, *geographia generalis*. But in a country like Sweden there were too many questions specific to geology to be solved by the geographers. The way was open for natural historians and scientists of all kinds to speculate and give their opinions about these phenomena.

The geological problems in the Swedish (and Scandinavian) landscape were obvious to everyone interested: the marks after the land elevation, the scratches on primary polished rocks and the long ridges of deposits, "eskers" (which all seemed to have different directions), the huge erratic boulders and the great number of morain-formations.

The question of the land elevation was evoked already in the 1690s by the physician and chemist Urban Hiärne, who is also with good reasons called "the father of Swedish geology". Hiärne noticed that the level between land and water at the coast of the Baltic had changed, and he believed that a diminution of water was the cause. So was also the opinion of many of his followers, Emanuel Swedenborg, Anders Celsius, and Carolus Linnaeus, even if they delivered different explanations. Celsius made measurements and found that the difference in level was about one centimeter per year, which makes one meter in hundred years, a result that came very close to the actual one.

But the problem was not only a scientific one, it also aroused a cultural battle. It was taken up in the Swedish Parliament, and the clerical order expressed its strong condemnation over all these scientific explanations. If there had been any discernible fall of waters, it must have been caused by the retiring of the biblical Flood.

Not until the 1760s a new opinion was formed, and it said that the phenomenon was caused by a land elevation, not by a diminution of

waters. At the turn of the 19th century the general opinion among geologists was that the reason to changes in the water level was a land elevation, but still they could not explain the cause of the phenomenon. At this time many attempts were made to explain other geological processes. Nils Gustaf Sefström delivered a hypothesis in 1838 about a "petridelaunic" flood, which had inundated the Scandinavian countries and caused the scratches as well as the "eskers" and also transported the erratic boulders far away. This hypothesis was very close to Charles Lyell's drift theory. Lyell himself did not from the beginning believe in the phenomenon of the land elevation, but after his visit to Sweden in 1834 he somewhat changed his mind. But still he stuck to his own theory about a gigantic inundation with ice-bergs floating around the whole of Scandinavia.

Then came, as we all know, Louis Agassiz' glacial theory, the idea that most of the northern hemisphere had been covered by an enormous ice sheet. This theory about an ice age in the history of the earth, first delivered as a speech in Neuchatel in 1837, and after that carried out in more detail in the book *Études sur les glaciers* (1840), was a kind of threshold of the modern geological research. At the same time it became a start for the discipline of quaternary geology.

Agassiz was without doubt a highly qualified scientist of his time, because he could combine scientific phantasy with small empirical findings. From general observations, obvious to everyone interested, he had imagination enough to draw far-reaching conclusions. But he also had to face a strong opposition from most of his colleagues. In his principal opinion he was right, but of course he could not deal with all details and solve every problem. He saw that the ice age originated from several different centra, even outside the realm of the Alps. He could explain the localization of the erratic boulders as transported upon—and not under—the ice-sheets. Further on he described the moraines and their origins as well as the scratches on polished rocks.

But Agassiz was after all concentrated on the Alps and consequently he could not—or did not even try to—explain some phenomena typical of Scandinavia: the eskers, the land elevation, the movements of the ice. Most of these problems were left to Scandinavian geologists to be solved.

At first Agassiz' theory aroused opposition even in Sweden. Jacob Berzelius, the famous chemist, did not accept it, because he was bound to his colleague Sefström's idea of a "petridelaunic" flood. But the new generation, coming up around 1850, had another interest for new ideas and new theories. I will concentrate on one of them, Otto Torell, the most important. From the beginning a medical student he became more and more fascinated by zoology and geology. His teacher, Professor Sven Lovén, had found a fossil arctic fauna in Sweden and Finland, and Torell himself made as a twenty-year-old student the historical finding of *Yoldia arctica*, a fossil arctic mollusc. This indicated that Sweden and Scandinavia must have had an arctic climate in an earlier period. But Torell could not simply accept Agassiz' theory, because

the opposition from all leading geologists was so strong; he had himself to find evidence for the theory.

Between 1855 and 1858 Torell travelled on private money—he spent the money his father left him on his scientific interest—to do his own field works. He went to Switzerland, to Iceland, Norway and the Spitzbergen, and to Greenland. Everywhere he saw the effects of an ice age, and these observations were similar to those made in Sweden. In 1859 he took his doctor's degree by a thesis on the mollusc fauna of the Spitzbergen, but his conclusions were of a much wider range, because he applied the glacial theory to the whole of Scandinavia; he was convinced not only of the real existence of an ice age but also glacial erosion and its dominant influence on the landscape in Scandinavia.

By his travelling Torell also became a pioneer for Swedish Polar expeditions. His expedition to the Spitzbergen in 1858 was in fact the first one, and among his assistants was Adolf Erik Nordenskiöld, later on famous as the first one to pass the North-East Passage. In 1861 Torell was the leader of an "official" Swedish expedition to the North Polar Sea, paid for by the Parliament and the Crown Prince. We can hereby notice a difference between other European expeditions to the same area, caused by patriotic and economic reasons, and the Swedish expeditions, which were wholly organized by scientific reasons.

During the 1860s Torell was teaching geology at Lund University, and he was also doing a lot of research. But he was a complicated person. Always active, with a brilliant mind of combining theories with empirical facts, he had at the same time difficulties in finishing his writings and having them printed. One example may illustrate this dilemma. In 1865 the scientific society of Haarlem in Holland, La Société Hollandaise des Sciences, announced a competition of how to explain the origin and the transport of the huge erratic boulders spread out in the North of Holland. Torell sent in a manuscript of 383 pages in French and won the first prize, a gold medal and 150 "Gulden". But as he wanted to correct some small details he asked to have the manuscript back, and unfortunately he never finished this last version, and so it was never printed. Now it seems to be lost, but we know the main ideas, because his biographer had the manuscript in his hands when he wrote the memorial article after Torell's death in 1900.

In 1871 Torell was appointed director of the Swedish Geological Survey, and after that he was very much occupied with his practical every-day work and economic projects like ore-prospecting and so on. Still he did not leave his former interest, and in three extensive articles, published in the *Proceedings of the Swedish Academy of Sciences*, he gave a detailed report of his studies on the Ice Age and its effects in Scandinavia. After a long historical introduction he explained how all these different strata of sand, clay and morain had originated as a result of the work of the ice, and how the melting of the ice-sheet had caused these long "eskers" with their round

stones and pebbles. Furthermore he showed how the different ice-streams had moved from the Scandinavian mountains down in West-East direction, then in North-South flowing the Baltic basin. On the West coast there had been a similar movement, in a North-South and East-West direction. By that he could also explain the direction of the scratches on polished rocks and the "eskers". Since he maintained that there had been a land bridge between Sweden and Denmark, he could also tell how the erratic boulders had been transported inside or lying on the ice-sheets down to Holland and North Germany.

From our point of view Torell was not right in every detail and he did not give the final solution to the land elevation question (this was done by Thomas Jamieson and Torell's student Gerard De Geer in the 1880s, who showed that the crust of the earth was rising after having been pressed down by the ice). But in principle Torell gave the right explanation and saw the effect of the ice in its whole extent. He argued against Lyell's drift theory and against Sefström's idea of a "petridelaunic" flood. Instead he accepted Agassiz' glacial theory and made it more complete through his thoroughgoing studies of the Scandinavian landscape.

Torell is not known in an international aspect of the history of geology; still he was not only a provincial figure. At a geological conference in Essex in England in 1865 he was elected to a commission together with Andrew C. Ramsay and Henry Blumenbach in order to give a judgment about glacial phenomena. He corresponded with many of the leading geologists of his time and met some of them for discussion. Before he got a tenure position in Sweden, he had plans for going abroad permanently, to England or to the United States. For a while he wanted to go to Agassiz in the States; especially California had a great appeal to him. In 1875 he visited North America and found many similar effects of the ice. He thought it plausible that Greenland had been the origin of an ice-sheet of even larger extension than that in Europe. The late Georges W. White concluded in an article some years ago that three men had been of the greatest importance for the emergence of the glacial theory in the United States: James Geikie, Thomas Chamberlain, and Otto Torell.

In a way Torell could also be seen as an international pioneer. At a geological conference in Berlin in 1875 he delivered a talk on the glacial phenomena. The audience did not accept his standpoint and showed openly their dislike. An eye-witness described how upset those leading German geologists were; the idea of an ice age was for them "ganz ungeheuerlich", and they regarded Torell's theories as total madness, "Barer Unsinn". But soon the Germans changed their mind; they began to reflect and to see the geological formations from a new angle. Within a few years the glacial theory was accepted. At the German geological conference in 1880 Torell was elected chairman, and this time the participants listened to him with great attention. Some years later he was elected an honorary member of Die Gesellschaft

für Erdkunde, and in Rüdersdorf—where Torell had found so many flat rocks polished by the ice—a memorial stone was raised with Torell's name and the year 1875 engraved.

So it took at least 35 years before the glacial theory was accepted in general by the geologists, but certainly Torell made *his* contribution for this scientific event.

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