

# Arctic geopolitics and the beginning of earthquake monitoring in Denmark and Greenland

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Where there scientific or political reasons behind Denmark's decision to establish its first seismological stations for earthquake monitoring? In a nation where earthquakes are few and of small magnitude, it is remarkable that since 1927 the Geological Survey of Denmark and Greenland (GEUS), and its predecessors back to the Danish Geodetic Institute have recorded seismological events from permanent stations in Denmark and Greenland and shared data through international data centres.

As early as 1907, on private initiative by E.G. Harboe, a seismological station was established in Godhavn, West Greenland (Harboe 1911). However, with time it became clear that the phase readings from the instruments lacked precision (Fig. 1), and in 1912 monitoring was discontinued due to lack of funding (Geodætisk Institut 1978). Having never officially joined the International Seismological Association, or suffered destructive earthquake within their territory, Danish authorities did not at the time have any vested interest in operating expensive seismological stations.

## The origins of Denmark's seismological monitoring programme

Historians of science have argued that scientific knowledge of Greenland equalled sovereignty (Ries 2012; Doel



Fig. 1. Seismograms from the old station in Godhavn kept at GEUS. These seismograms from 1907–1912 are among the oldest seismological records in existence. Photo: Danish National Archives.

*et al.* 2016). Inspired by their approach, I suggest that the formation of a network of Danish and Greenlandic seismological stations could be understood as an expression of national geopolitical strategy rather than a display of scientific vigour. By examining historical records from public institutions like the Ministry of Education, Ministry of Foreign Affairs, Ministry of War and the Danish Geodetic Institute as well as letters from Erik Nørlund and Inge Lehmann, kept at the Danish National Archives and GEUS, it is possible to assess to what degree geopolitical considerations were a factor in establishing a seismological monitoring programme in Denmark.

In 1923, Denmark became a full member of the International Union of Geodesy and Geophysics (IUGG), but it was not until October 1924 after the second IUGG General Assembly in Madrid that (lack of) seismological monitoring from its territory became an issue for Denmark. Before the Assembly, a national committee for seismology had hastily been formed under the leadership of Niels Erik Nørlund, professor of mathematics at Copenhagen University and director of the Danish Geodetic Service (*Den Danske Gradmaaling*). After the Assembly, Nørlund reported to the Ministry of Education that there had been considerable pressure on Denmark to record and share geophysical data from Greenland. So substantial was the pressure that Nørlund warned that unless Denmark initiated a programme of general geodetic research, in particular seismological monitoring and international data sharing, other nations would question Denmark's authority in Greenland (Danish National Archives (DNA) 1).

It was a potent threat, since the Danish government rightfully feared that their claim to sovereignty over Greenland could be contested by their neighbours. For example, a stipulation of the 1917-treaty between Denmark and the USA regarding the sale of the West Indies to the USA was, in addition to paying DKK 25 million, that the USA also acknowledged Denmark's sovereignty over Greenland. Norway on the other hand made counterclaims to parts of eastern Greenland in 1924 and 1931 (Kragh *et al.* 2008).

Over the next months, Nørlund worked on securing support for his envisioned network of seismic stations. As

director of the Danish Geodetic Service, Nørlund was appointed to reorganise national geodesy, including triangulation efforts which traditionally had been a key interest area of the army's Department of Topography (*Generalstabens Topografiske Afdeling*). Using his position, he added seismology to the list of intended activities.

In order to secure the necessary political backing and financial support from private funds, Nørlund employed several different arguments. In addition to demonstrating sovereignty over Greenland, he argued that Denmark needed seismological stations because all cultural and refined nations in Europe had a least one. Also scientifically, seismological data constituted a valuable source of information for geodetic research. Finally, he argued that international data sharing was a means to maintain international peace and collaboration.

During the winter 1924/25, enough political and financial support was mustered that Nørlund and the Danish Geodetic Service could begin building the network.

### Establishing seismological stations from 1925 to 1927

From early on, it was clear that while the Danish government was willing to authorise the construction of seismological stations, much of the funds to build stations and buy scientific instruments had to come from private donations.

In the spring of 1925, orders for a variety of different seismographs and other instruments were placed at international suppliers in England, Germany, Russia and the USA. Not knowing which seismic frequencies they could expect and at a time where no standards for performance and accuracy existed, orders were for state-of-the-art seismograph models of different mechanical or electrical designs. The costly instruments were all paid for by the Carlsberg Foundation which also made significant contributions towards the construction costs of the stations. In addition, Carlsberg also agreed to provide an annual grant to cover operating costs for two of the three stations, a practice that continued until the 1950s.

Without any practical knowledge about the working of seismological instruments or how they would react to the extreme climate of Greenland, it was decided that a station in Denmark should act as a testing and comparison site for the different instruments. At the same time negotiations began to secure space for stations both in Copenhagen and Greenland. Historical records show that geopolitical and strategic considerations played a significant role in where to locate the three planned stations (e.g. DNA 2).



Fig. 2. In COP's Caponière XIII, the purely mechanical Wiechert Horizontal seismograph is still in its original location. Photo: Casper Brogaard Højer.

Being relatively close to the city, the permanent station in Copenhagen (COP) was the first to be completed. In the spring of 1925, the Army handed over two caponieres located in the old fortifications of Copenhagen (*Vestvolden*) to be used as a seismological station. Still being part of the military defense system, access to the station was restricted until well after the Second World War.

Installations began in the autumn of 1926. By 17 February 1927 all instruments were in place and monitoring began, but due to occasional failure of the timing, the working of the station was not considered satisfactory before March. Hereafter publication of the records began in a seismological bulletin. By then COP was equipped with the following seismographs: A Wiechert 1000 kg Horizontal (Fig. 2), a Wiechert 1300 kg Vertical, three Galitzin instruments (two horizontal and a vertical), a 2-component Milne-Shaw. Later a 2-component Wood-Anderson seismograph was added.

Today historical bulletins and log book from all the stations can be found at [http://seis.geus.net/seismic\\_service.html](http://seis.geus.net/seismic_service.html). As the largest of the three seismological stations in the network, COP had a fulltime caretaker to do daily maintenance and recording, paid by the Carlsberg Foundation and living in a nearby cottage.

Establishing and installing Denmark's first permanent seismological station was not an easy task for the untrained personnel hired by Nørlund, and in recognition of their valuable contribution, Inge Lehmann and two students received a bonus worth nearly two months' salary (DNA 3). By all accounts, this was also the later so famous seismologist Inge Lehmann's first encounter with seismological work, which principles she first began to study in earnest later that year.

The station in Ivittuut (IVI), South West Greenland, was the second to be completed (Fig. 3). With the help



Fig. 3. The entrance to the seismological vault in Ivittuut is next to the old tennis court. Today (2014), the court is unkempt and Ivittuut largely deserted.

of the Danish mining company *Kryolith Mine og Handelselskabet*, a seismological vault was blasted into the bedrock about 250 m from the mine's main blasting sites (!) To determine the effect of blasting on the seismological instruments tests were made with a portable seismograph during the summer of 1926, but it was not before the summer of 1927 that the intended seismographs, a Wiechert Vertical and a Wiechert Horizontal seismograph, were installed (DNA 4). Operated, for an extra fee, by the local radio-telegraphist employed by the mining company, the station began recording on 24 August 1927 (Bulletin Ivigtut 1929).

When the third and final station in the Danish network was constructed, it became clear that that geopolitical arguments worked both ways between Arctic nations.

In September 1925, Nørlund wrote to the Danish Ministry of Foreign Affairs that the Danish Geodetic Service was considering a permanent seismological station on Jan Mayen because the island had an active volcano. It was a delicate subject since Norway's Meteorological Institute had annexed part of the island on behalf of Norway. Denmark had refused to officially state its position on the matter but maintained that some buildings within the Norwegian-claimed area were owned by Denmark. With the aid of the Ministry of Foreign Affairs, an agreement was made with Norway in March 1926 to the effect that the Danish Geodetic Service could place a station on the Norwegian part of Jan Mayen. However, shortly afterwards in July, Norway announced that their Meteorological Institute would expand its activities to the whole island and claim it on behalf of Norway (DNA 5).

In the summer of 1926, initial seismological tests were carried out on Jan Mayen by the Danish Geodetic Service, but results were poor and it was decided to establish the station at the newly founded colony of Scoresbysund (*It-*



Fig. 4. Inge Lehmann (second from the left) inspects SCO presumably in the summer of 1928. Photo: From Inge Lehmann's private archive at the Danish National Archives.

*toqqortoormiit*). Founded in 1925, one of the colony's purposes was to establish a Danish presence in East Greenland where Norway also had made claims.

Construction of the station (SCO) began in the summer of 1927, also here funded by the Carlsberg Foundation. By then the Danish Geodetic Service had enough experience with construction and installation to proceed relatively quickly. A cellar was blasted into the bedrock, and on top of that a low building was constructed. To protect the instruments from variations in temperature the cellar was covered by 80 tons of rock and access restricted to a low corridor one could only crawl through. A second building housed the radio station and electronic recording instruments (Geodætisk Institut 1930).

The installation of the seismological instruments went smoothly, as the station was equipped with two Galitzin horizontal seismographs and a Galitzin vertical seismograph transferred from COP (Den Danske Gradmaaling 1928). Fully funded by the Carlsberg Foundation the station began operation on 12 January 1928, with the local radio-telegraphists in charge of daily recordings (Fig. 4). In the beginning the paper seismograms were sent annually to the Geodetic Institute by ship, but later it became practice that results from large events were radioed immediately to Copenhagen.

## After 1928

In 1928 the Danish Geodetic Service and the Department of Topography of the Army General Staff (*Generalstabens Topografiske Afdeling*) merged to become the Danish Geodetic Institute (*Danmarks Geodætiske Institut*). Inge Lehmann, who had been the principal figure in setting up the Copenhagen station and analysing data from all the

stations, was appointed chief of the Geodetic Institute's new Seismic Section.

The value of the Greenlandic seismological stations as evidence of sovereignty was soon tested. In 1931, Norway claimed parts of East Greenland, Denmark opposed the claim and the matter was put to the Permanent Court of International Justice in The Hague. In preparation for the trial, the Ministry of Foreign Affairs asked the Danish Geodetic Institute to prepare a series of reports about their scientific activities in Greenland. In July 1932, Inge Lehmann forwarded a special report about the seismological station in Scoresbysund to the Ministry (DNA 5) which was submitted as part of the evidence supporting the Danish claim. In April 1933, the Court decided against Norway, recognising Danish sovereignty over all parts of Greenland.

Scientifically, the three stations also soon proved valuable by providing quality seismic records from remote, low-noise Greenland, with efforts put into timing records and adjustment of instruments in the challenging environment. It was partly data from the seismological stations in Ivittuut and Ittoqqortoormiit that in 1936 enabled Inge Lehmann to deduce the existence of the Earth's inner core (Lehmann 1936).

Today GEUS records seismological data from about 25 locations in Denmark and Greenland, including the original stations in Copenhagen, Ivittuut and Ittoqqortoormiit, now equipped with modern digital instruments.

## Conclusions

Historical documents from the Danish National Archives and GEUS clearly show that international geopolitics and strategic considerations played a significant role in the location of the seismological stations. Especially Denmark's need to express its sovereignty over Greenland played a pivotal role. It was by invoking arguments of power, culture, science and international peace the director of the Danish Geodetic Service, Erik Nørlund, was able to gain the necessary political and financial support for establishing a network of seismological stations, and in 1928 establish a permanent Danish seismological monitoring authority under the Danish Geodetic Institute.

As the Danish government's main interest was the strategic value of the seismological stations, it fell to private

donations to unlock the scientific potential of the stations. It was therefore the logistic support of the *Kryolith Mine og Handelselskabet* and the long-term financial commitment of the Carlsberg Foundation that made it possible to equip and operate the stations at a high scientific standard.

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