NORSAR

ROYAL NORWEGIAN COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

Scientific Report No. 2-80/81

SEMIANNUAL TECHNICAL SUMMARY 1 October 1980—31 March 1981

By
Alf Kr. Nilsen (ed.)

Kjeller, June 1981

VI.2 Concentrated Earthquake Zones in Svalbard

An interesting area for the investigation of intraplate seismicity is the Svalbard archipelago. The tectonic setting of this area is unique in that an active spreading ridge (the Knipovich Ridge) lies very near the passive continental margin, and also because the archipelago, as well as the surrounding oceanic areas have a very complex tectonic history. Since 1976, several temporary seismic arrays have been in operation in the area, with the best coverage being obtained in 1979 when a seven-station telemetered network became operational, supplemented by three portable microearthquake stations. The results reported here are based on data recorded between ultimo July and medio September 1979.

Earthquake locations using teleseismic data (Husebye et al, 1975) suggest a diffuse pattern of earthquakes near the east coast of Spitsbergen. Mitchell et al (1979), using data from temporary microearthquake networks, found that the earthquakes are centered in Heer Land and that the active zone, trending east-west, is quite concentrated in extent. Using a network of four stations located in Spitsbergen mining towns, and observing over a period of nine months (Dec 1977 - Oct 1978), Bungum and Kristoffersen (1980) reported an average of several earthquakes a day from the same area, although with considerable variation in the level of activity. The only reliable fault-plane solution for the Heer Land region is for an earthquake in January 1976, with a mainly vertical strike-slip solution in which the planes strike N108°E and N17°E (Bungum and Kristoffersen, 1980). The new data set (shown in Figs. VI.2.1 and VI.2.2) confirms the previously obtained results inasmuch as the lineation of epicenters shown in Fig. VI.2.2 coincides well with the strike direction from the fault-plane solution for the 1976 event. The ISC location for the 1976 earthquake is slightly outside the area of main activity in the Heer Land zone, a difference which probably reflects a bias in the teleseismic location.

In addition to the Heer Land events, Fig. VI.2.1 shows that one earthquake occurred near the west coast and three occurred in Storfjorden. Events in both of

those areas were reported by Bungum and Kristoffersen (1980) as isolated shocks with no sign of clustering in time or space, and they also observed seismic activity along the northern slope of the Barents shelf, with indications of a rough east-west trend from the shelf north of Spitsbergen to the Analysis of the new data set indicates that a relatively large proportion of the recorded earthquakes occurred in Nordaustlandet, spatially concentrated as the Heer Land seismic zone (Fig. VI.2.3). Because the zone is well outside the array, location uncertainties are of course larger than those for the Heer Land events. The Nordaustlandet sequence is quite different from the Heer Land zone in its time-magnitude pattern. Following a 15 day period of complete quiescence, there was an outburst of activity, but without a distinctive main shock. Some decrease in frequency of occurrence seems to occur during the last part of the recording period, and the last shock in the sequence was the largest one, with magnitude 3.9. Before that event, the recorded seismicity had a slope in its frequency-magnitude distribution (b-value) of about 0.5, a value usually associated with a swarm. In contrast the b-value for the Heer Land zone was around 1.4, which is a more typical value.

The Svalbard archipelago is cut by several major Paleozoic faults (Fig. VI.2.1) which trend in a NNW-SSE direction, and these faults were reactivated during Mesozoic and Tertiary times. A fold belt developed along the western coast of Spitsbergen as a part of an extensive early and middle Tertiary deformation. There is little evidence in the surface geology of fracture trends aligned with the strike of the seismic zone in Heer Land. Lineament analysis of Landsat images (Otha, in prep.) show that surface lineaments longer than 2.5 km have dominant strike directions in the sector NW to ENE. In Nordaustlandet late Paleozoic and older rocks are exposed around its north and northwestern perimeter, the rest of the island being covered by a glacier. In the northwest the structure is dominated by a NNW-SSE striking fold system, while farther east a large WNW trending fault extends eastward under the glacier. We therefore find that the activity in Nordaustlandet is aligned with old fault trends, while the correlation is less obvious for the Heer Land area.

The dimensions and orientation of the Nordaustlandet and Heer Land zones are the same, but this does not necessarily imply a similar regional stress field. Although scattered earthquake activity is observed throughout much of Svalbard, the most obvious features are the two concentrated earthquake zones. These intraplate earthquake zones lie only 200-300 km from the obliquely spreading Knipovich Ridge, and somewhere between these two areas a transition from oceanic to continental crust occurs (Sundvor and Eldholm, 1979). Because of the complex tectonic history of the area, it seems reasonable to attribute most of the seismic activity to an interaction between the present tectonic stress field and older zones of weakness (Bungum et al, 1981).

H. Bungum
B.J. Mitchell, Saint Louis Univ.
Y. Kristoffersen, Norwegian Polar Research Institute

References

Bungum, H. and Y. Kristoffersen (1980): A microearthquake survey of the Svalbard region. Final Report, Phase I. NORSAR Tech. Rep. No. 1/80, NTNF/NORSAR, Kjeller, Norway.

Bungum, H., B.J. Mitchell and Y. Kristoffersen (1981): Concentrated earthquake zones in Svalbard. Tectonophysics, in press.

Husebye, E.S., H. Gjoystdal, H. Bungum and O. Eldholm (1975): The seismicity of the Norwegian and Greenland Seas and adjacent continental shelf areas. Tectonophysics, 26:55-70.

Mitchell, B.J., J.E. Zollweg, J.J. Kohsman, C.-C. Cheng. and E. Haug (1979): Intraplate earthquakes in the Svalbard archipelago. J. Geophys. Res., 84: 5620-5626.

Otha, Y., in prep. Fracture and lineament studies in central eastern Spitsbergen.

Sundvor, E. and O. Eldholm (1979): The western and northern margin off Svalbard. Tectonophysics, 59:239-250.

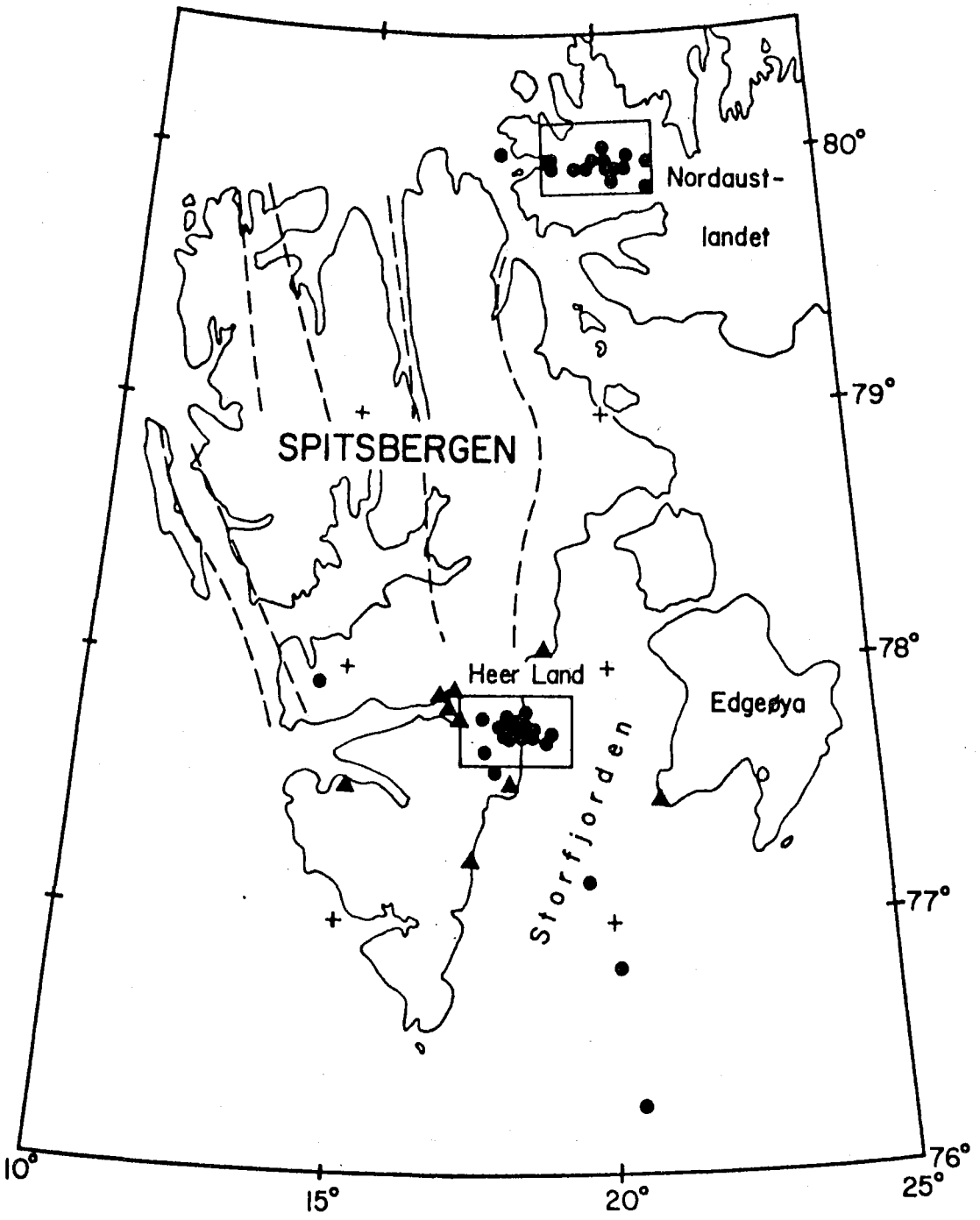

Fig. VI.2.1 Map of Svalbard with locations of recording stations (triangles) and epicenters. One station symbol has been covered by earthquake symbols in the Heer Land zone. The two inserted boxes correspond in size to the areas covered by Figs. VI.2.2 and VI.2.3.

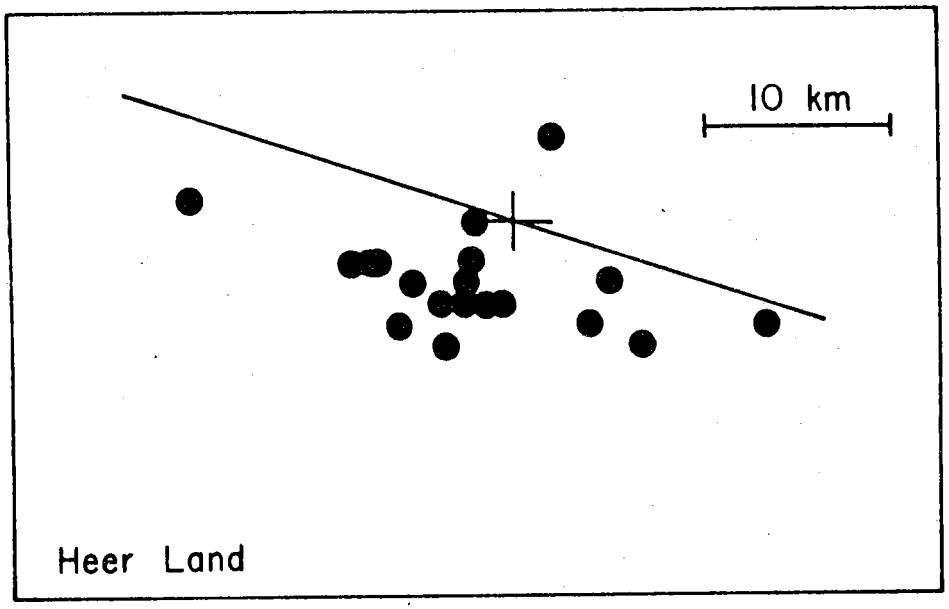

Fig. VI.2.2 Epicenter map for the Heer Land region, covering the area within the southernmost box in Fig. VI.2.1. Also shown is the ISC solution for the epicenter of the January 18, 1976, earthquake (with standard error base), as well as the direction of one of the nodal planes for the same event.

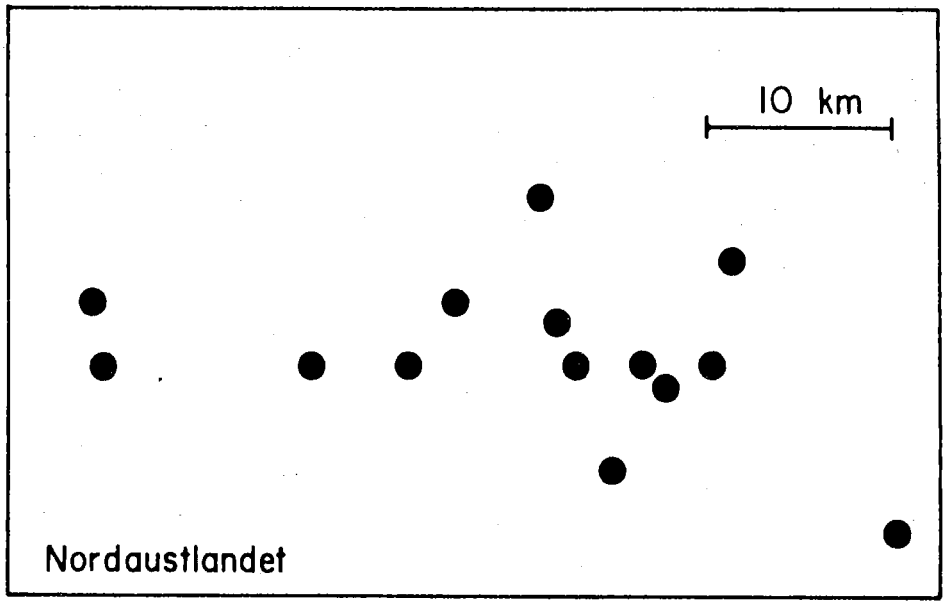

Fig. VI.2.3 Epicenter map for the Nordaustlandet region, covering the area within the northernmost box in Fig. VI.2.1.