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VI.6 A Microearthquake Survey of the Svalbard Region, Final Results, Phase I

A program for mapping of the seismicity of the Svalbard region was conceived jointly by Norsk Polarinstitutt and NTNF/NORSAR in 1977 as a step by step effort to acquire an improved data base for the seismicity of the area relevant to future evaluation of the related environmental hazard. The objectives of Phase I, the results of which are reported here, were to monitor the frequency of occurrence of microearthquakes and locate the seismic active areas using portable microearthquake instruments operating in the mining settlements between December 1977 and October 1978.

In order to reduce possible biased errors in epicentral locations, crustal models were derived for the Svalbard area. For the continental model we used data from a refraction profiling survey conducted in 1978 by the University of Bergen in cooperation with the University of Hamburg, the Polish Academy of Sciences and the Saint Louis University (M.A. Sellevoll, Bergen, personal communication). We used only data from our stations with travel times as shown in Fig. VI.6.1. The derived model, which explains reasonably well the first arrivals and partly the later ones, has P-velocities of 5.7, 6.7 and 8.2 km/s, with interfaces at 16 and 32 km. For events from the mid-ocean ridge west of Svalbard, a model with a constant P-velocity of 7.5 km/s was derived, based on travel times from teleseismically recorded and located earthquakes.

The Svalbard network has a very good detectability for local events, with most of them coming from the Heer Land earthquake zone. In addition to this zone, a large number of events are recorded from the mid-oceanic ridge west of Svalbard. A total of 1320 events have been analyzed, and of these are about 70% local earthquakes from the Svalbard area. A breakdown of detectability on stations and type of events shows that the three microearthquake stations BBG, PRD and LYR (equipped with Sprengnether MEQ-800 seismographs) are about equal in terms of number of events. Not surprisingly, the WWSSN station KBS is best on teleseismic events, and relatively poor on local events. Epicenters have been estimated for about 75% of the local events, the criterion for locating being that both P- and S-wave readings are available from at least two stations.

Epicenter solutions are presented here in terms of maps in Figs. VI.6.2-3, with data subjected to various precision requirements. In Fig. VI.6.2 the number of locations have been reduced to 339 by requiring at least 3 stations, 4 phases, a 95% error radius of less than 30 km, and a residual Root Mean Square (RMS) level (when calculated) of less than 5.0 seconds. In Fig. VI.6.3 the number of events have been reduced to 241 by the additional requirement that all solutions should involve KBS. It is clear from Figs. VI.6.2-3 that the seismicity in the Svalbard region is dominated by the activity in the Heer Land zone. The size of this zone is only slightly larger than the location uncertainty, so a breakdown of the structure of this zone cannot be obtained from the data at hand. We note from Fig. VI.6.3 that the westernmost epicenters on the map extend out to and beyond the Knipovich Ridge and the Spitsbergen Fracture Zone. Although the location errors remain fairly large, they are certainly not large enough to account for all of the dispersion of the epicenters along the ridge axis.

The complex geologic history of the area around the northern Knipovich Ridge and the Spitsbergen Fracture Zone has probably created large zones of weakness where the present tectonic stress is being released in terms of earthquakes. The most significant factors here are probably (1) the transition from a sheared to a rifted margin with reactivization of old faults, (2) the eastward migration of the spreading axis as late as in early Pliocene, and (3) the unique location of this young spreading center near the passive continental margin north of 77.5^{o}N. With the latter point in mind, we note that this is also the area where the seismicity extends from the rift and more or less continuously into the continental crust. The earthquake activity on the continental shelf north of 77.5^{o}N seems to extend northward to the Yermak Plateau and the northern slope. This feature exhibits some resemblance to what is being observed also further south, i.e., along the Norwegian continental shelf.

The main reason for the present interest in the seismicity of Svalbard has been the Heer Land zone activity. Earthquakes up to m_b 5.5 have been reported from this area, and a recurrence study shows that an m_b 4.2

event occurs roughly every 4 years. A magnitude formula which has been developed for our microearthquake data gives about the same recurrence relationship for the Heer Land earthquakes, and with a b-value of -1.4.

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References

Bungum, H., and Y. Kristoffersen, 1980: A microearthquake survey of the Svalbard region. Final Report, Phase I. NORSAR Technical Rep. No. 1/80, 28 pp.

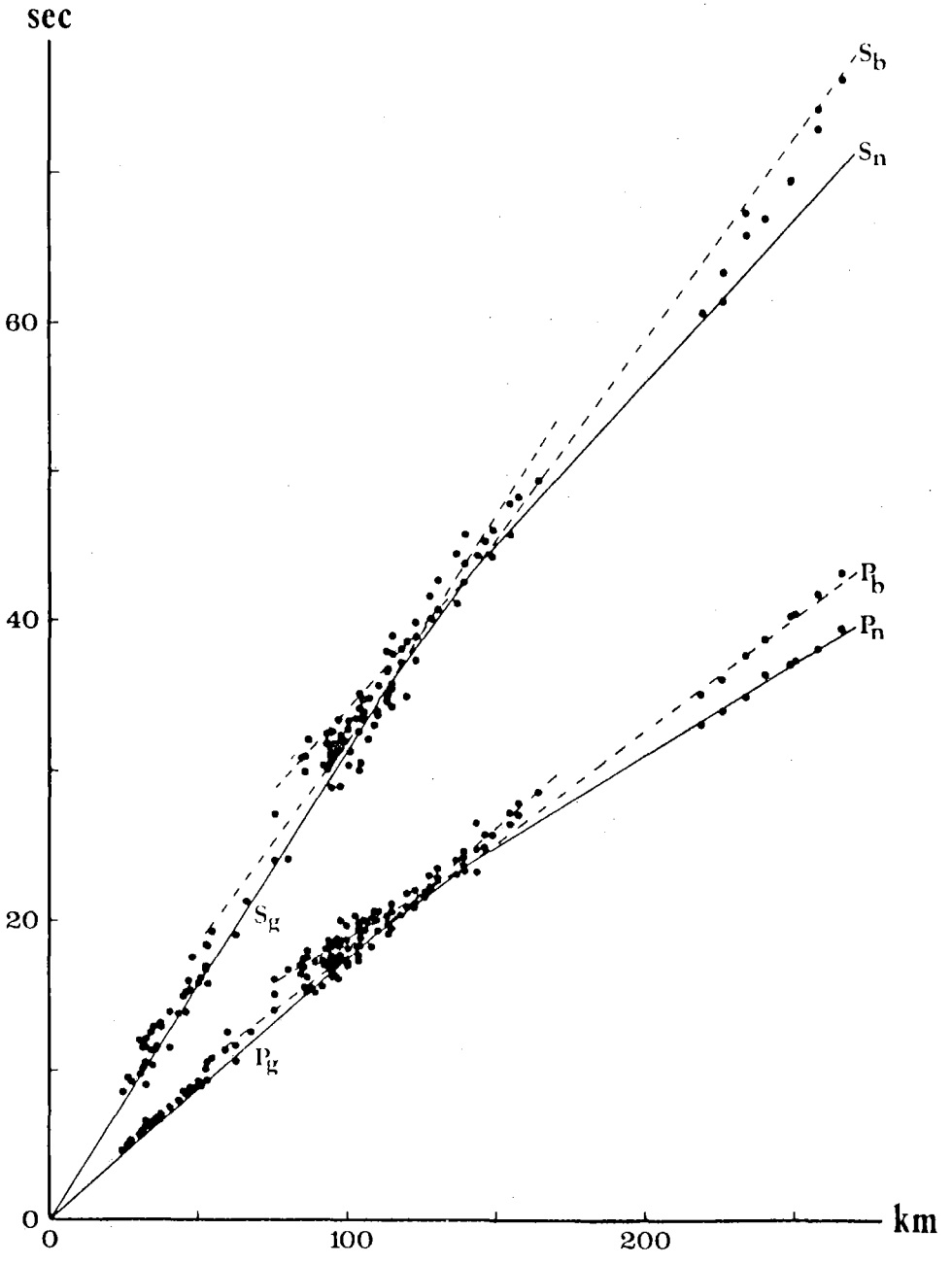

Fig. VI.6.1 Continental travel times for Svalbard, with dots giving travel times (vs distance) for explosions, and straight lines travel times computed from the derived model. Most of the readings are from PRD, some from KBS and a few from SWE.

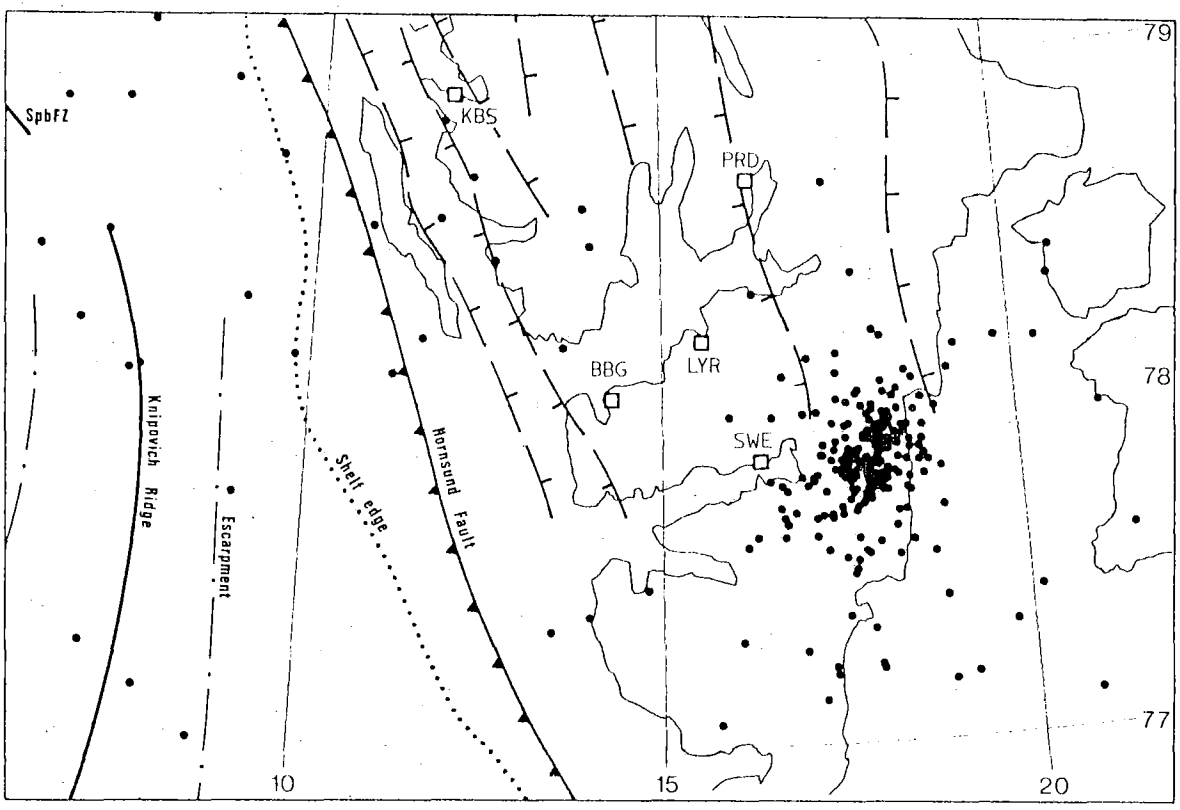

Fig. VI.6.2 Epicentral distribution for earthquakes recorded at 3 stations or more, with a minimum of 4 phases. Each epicentral solution has a 95% error radius of less than 30 km and an RMS error of less than 5.0 sec (if the latter estimate is available). 339 events satisfied these criteria, with 290 inside the area covered by the map. The station locations are shown as squares.

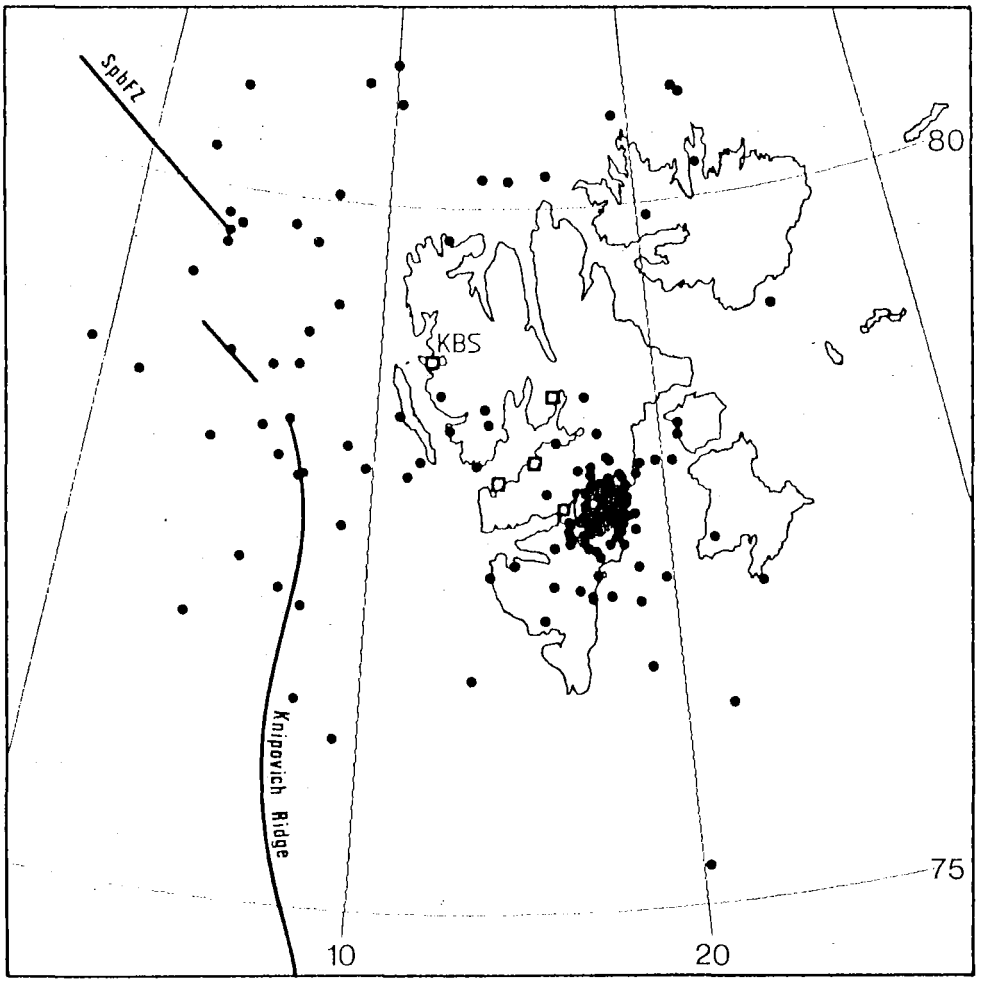

Fig. VI.6.3 Epicentral distribution of earthquakes with acceptance criteria identical to those for Fig. VII.xx.2, but with the additional requirement that station KBS is used in all the solutions. 241 events satisfied these criteria, with 237 inside the area covered by the map.