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7.1 Analysis of data recorded at the Spitsbergen array

Introduction

This report presents results from analysis of data recorded at the Spitsbergen array (SPITS) from events in the Svalbard region during the period July through December 1994. Through this period 1258 seismic events in the Svalbard region were manually checked and located using data from the SPITS array.

Recording Performance

Since the installation of the Spitsbergen array in 1992, the SPITS data have been processed at NORSAR in the following way:

- From 11 December 1992 data from SPITS were included in the manual Intelligent Monitoring System (IMS) analysis when the data quality allowed for it. During the manual review of the automatic IMS results from the processing of data from the other arrays in the northern European region, the NORSAR analysts manually added the relevant SPITS data for the events already defined by the IMS.
- From 12 January 1994 the SPITS data were fully integrated in the IMS and automatically processed in the same way as the data from the other arrays.

Only data that have been manually checked are included in the analysis and shown in the maps in this report.

As indicated in Fig. 7.1.1 the recording performance from July through December 1994 was very good with no month except August having less than 90% uptime. The low uptime in August reflects the field work performed during 22-31 August, when cables were put in trenches, the S-500 seismometers were replaced with Guralp extended short-period (CMG3ES) seismometers and new batteries were installed. Also, a three-component Guralp broad band instrument (CMG-3T) was installed at site B4.

The gain factor and filtering of the new instrumentation was changed on 19 November. For the short period instruments the gain was changed from 6.1 µV/bit to 0.61 µV/bit, and for the broad band instrument the new gain was set to 1.2 µV/bit. At this visit also the high-pass filter corner frequency was changed from 10 to 2 seconds for the short-period instruments. The effect of this change is that we get better on scale recordings of regional seismic events, as can be seen in the difference between the 8 October and 24 November recordings in Figs. 7.1.8 and 7.1.9.

Detections and Locations

The total number of automatically determined event locations for which data from the SPITS array were used was 1378 events during the 6 months from 1 July through 31 December 1994, whereas the number of manually reviewed locations where SPITS data were used was 1258.

An overview of the Svalbard region is shown in Fig. 7.1.2, showing the location of the SPITS array and the KBS three-component station. In the same figure the four main mining sites (Pyramiden, Barentsburg, Svea and Gruve 3 & 7) are indicated.

Figs. 7.1.3 and 7.1.4 show the locations of reviewed seismic events in the period covered as well as those recorded on the array since the installation. The Mohns Ridge and the Knipovitch Ridge show a relatively high seismic activity as should be expected for these parts of the mid-Atlantic spreading ridge system. Possibly more interesting are the clusters of seismic activity on and off shore Svalbard:

1) In the northeast, Nordaustlandet shows a dispersed seismic activity at a relatively high rate, and with a possible E - W lineation over the central part.
2) In the Heerland area east of the Svea mine the seismic activity is very high and concentrated within a relatively small area.
3) East of the southern tip of Svalbard, in Storfjorden, a high activity seismic cluster in a relatively small area is found. The activity seems to extend in a northeasterly direction from this cluster.
4) Southeast of Egdeøya (in the Barents Sea) a more dispersed seismic activity is seen.

Some of the seismic clusters above have been recognized by earlier investigators (Bungum et al, 1982; Mitchell et al, 1990), notably the Heer Land zone and the Nordaustlandet seismicity, but also the more dispersed seismicity described under 3) above.

It is also of interest to observe that the Barents Sea south and east of the zone described under 4) seems to be void of seismic activity, and this is also the case for the off shore areas east of the Svalbard Archipelago.

The clustering of seismic events was so intriguing that a cluster analysis of the database was performed in terms of location, magnitude and time of day as shown in Fig. 7.1.5. From this figure it can be concluded that the seismicity shows a clear geographic clustering in the areas mentioned above, but that no clear clustering can be observed in the time of day distribution. This lack of time clustering around certain hours is a very good indicator that the data are real earthquakes and not man-made events, that tend to cluster in certain "firing" hours.

A very crude analysis of the Gutenberg-Richter recurrence parameters was attempted with the M_L magnitudes calculated. Most of the events in the area 76^oN - 80^oN and 10^oE - 25^oE had no magnitudes assigned, or had an m_b magnitude assigned. There were 61 earthquakes with M_L magnitudes greater than or equal to 2.0. The regression analysis yielded a relation

$$\log N = 4.06 + 1.25 \cdot M_L \quad (1)$$

which for the area under consideration tentatively would indicate return periods of 9 years for magnitude 4 and above and 150 years for magnitude 5 and above. As seen from Fig. 7.1.6 the b value is stable; however, the small amounts of data and the different tectonic environments covered (spreading ridge, oceanic crust and continental crust) certainly warrants further investigations with more data in order to obtain more reliable return periods.

Data examples

The broad band capability of the new extended short-period Guralp sensors is demonstrated through the records shown in Fig. 7.1.7 of the Chinese nuclear test on 7 October 1994. Figs 7.1.8 and 7.1.9 show SPITS recordings from events on the Knipovitch Ridge and Zone 3 (see list above), respectively. These two events occurred before and after the sensors were changed, and the difference in data quality should be evident. The new Guralp extended short-period sensors provide resolution also of the lower frequencies, where the larger earthquakes are particularly rich in energy. The smaller nearby earthquakes do not have sufficient low frequent energy to exceed the background noise, and hence must be filtered before the signal can be recognized.

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References

Bungum H., B.J. Mitchell and Y. Kristoffersen (1982): Concentrated earthquake zones in Svalbard. *Tectonophysics*, **82**, pp. 175 - 188.

Mitchell B.J., H. Bungum, W.W. Chan and P.B. Mitchell (1990): Seismicity and present day tectonics of the Svalbard region. *Geophys. J. Int.*, **102**, pp. 139 - 149.

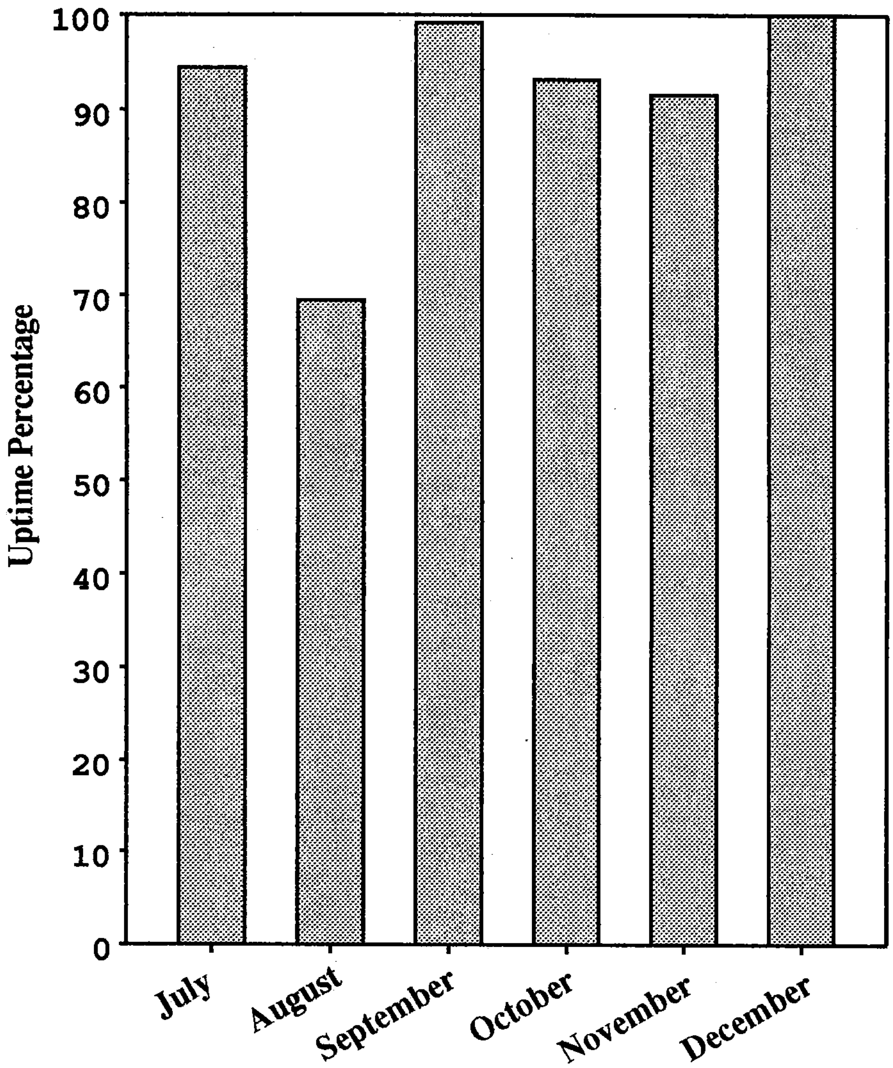

Fig. 7.1.1. Monthly uptime in percent for the SPITS on-line data recording during July-December 1994, taking into account all factors (field installations, transmission line, and data center operation) that affect the recording uptime.

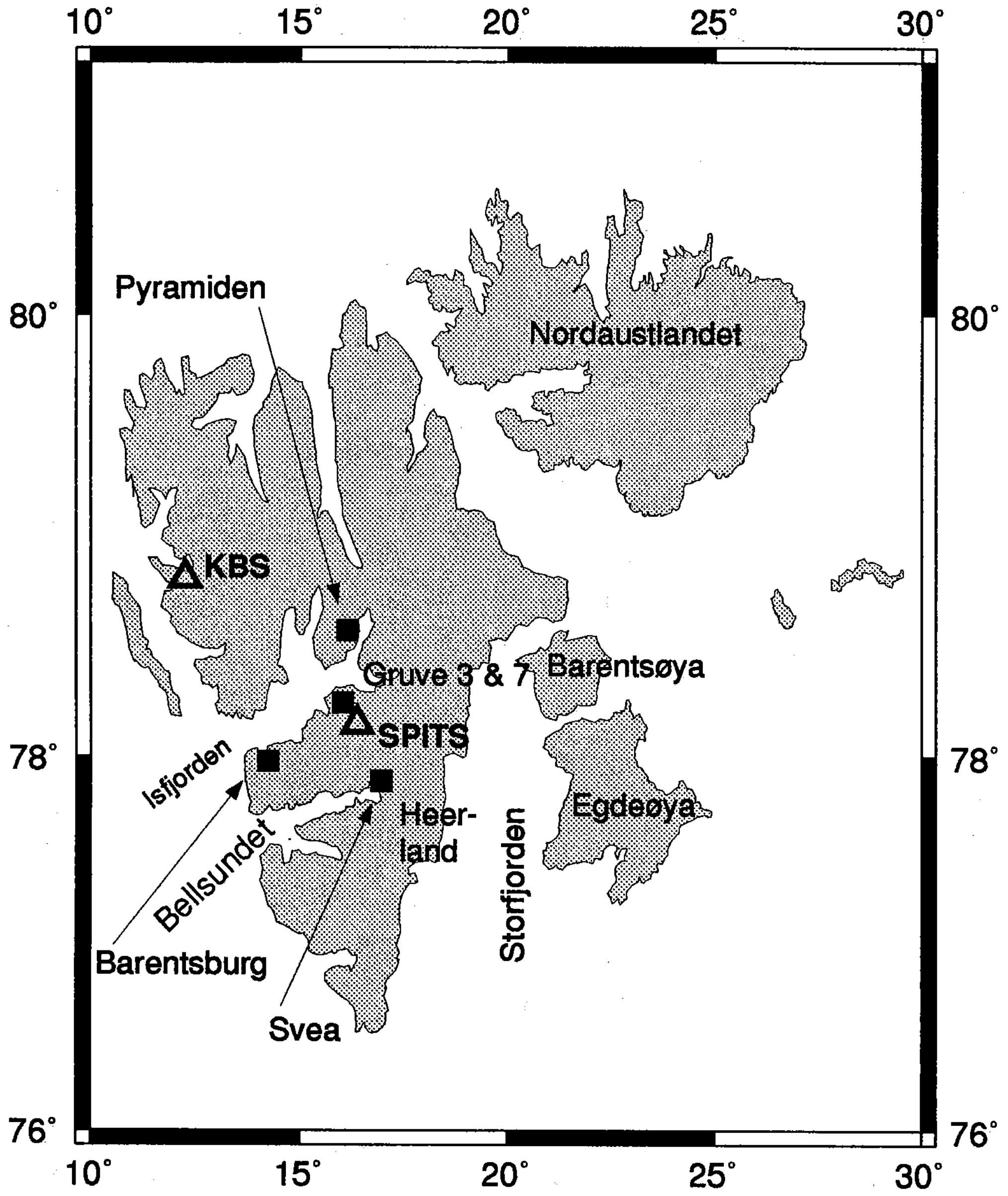

Fig. 7.1.2. Geographic names in the Svalbard region for main sites and areas mentioned in the text.

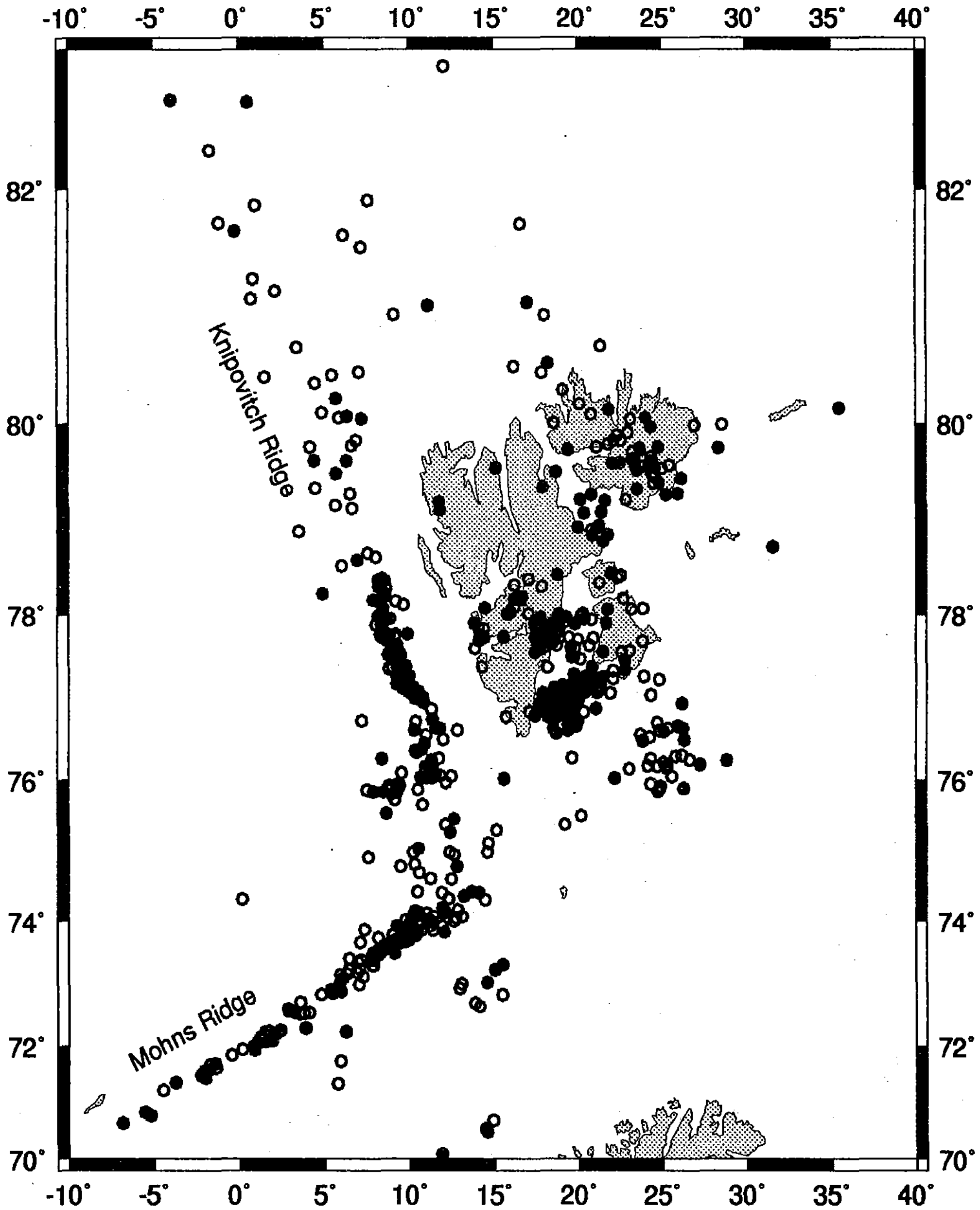

Fig. 7.1.3. Events located with data from the SPITS array in the six month period July through December 1994. Filled symbols represent epicenters within this reporting period, whereas open circles represent epicenters from before this reporting period.

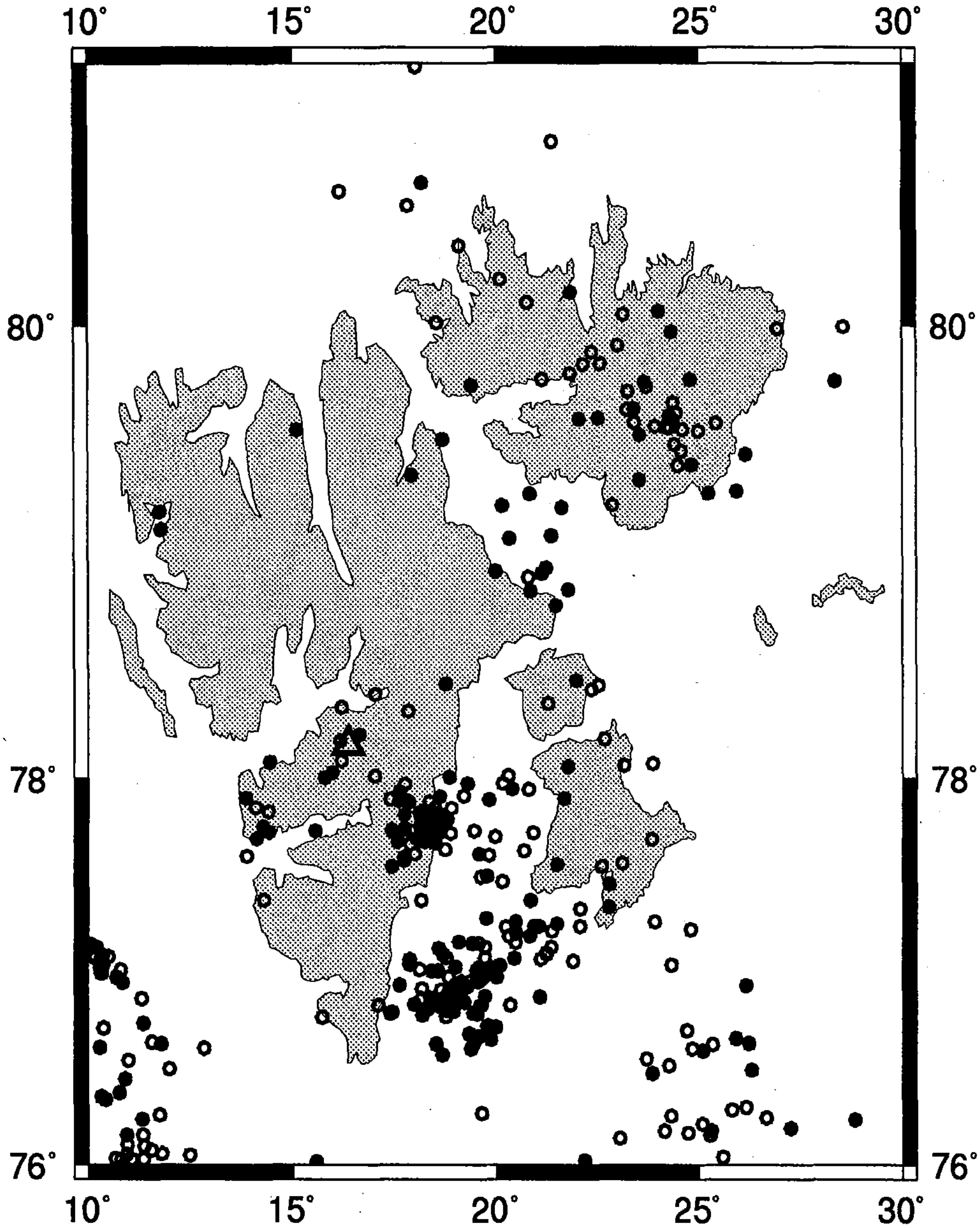

Fig. 7.1.4. Events located with data from the SPITS array in the six month period July through December 1994. Filled symbols represent epicenters within this reporting period, whereas open circles represent epicenters from before this reporting period.

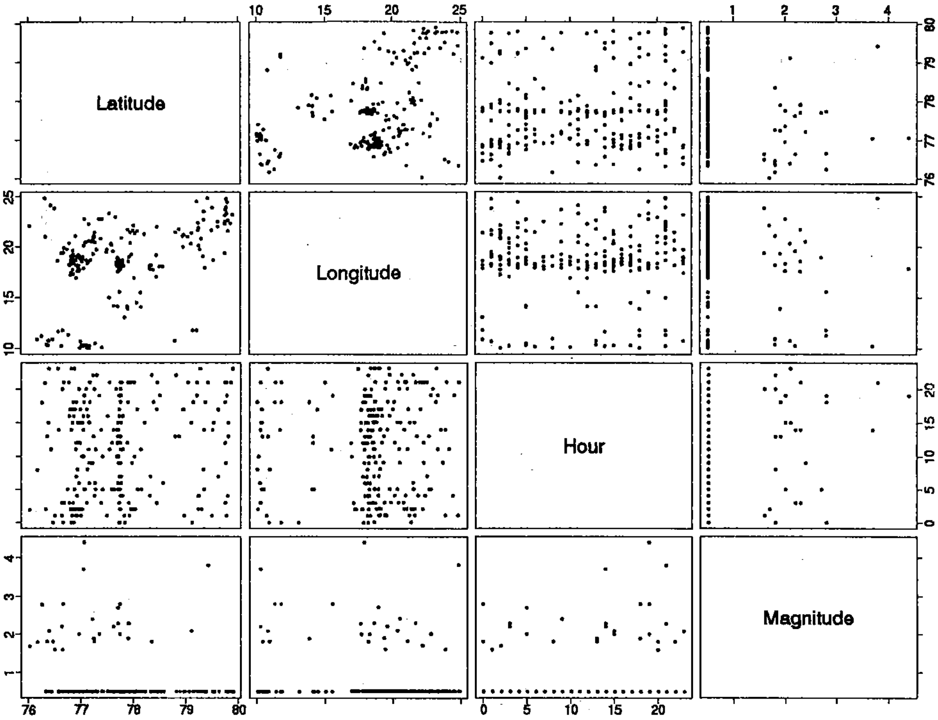

Fig. 7.1.5. Cluster plot of the seismic events in the region 76°N - 80°N and 10°E - 25°E. A strong correlation between any two of the four parameters latitude, longitude, hour of the day and magnitude would have been revealed here.

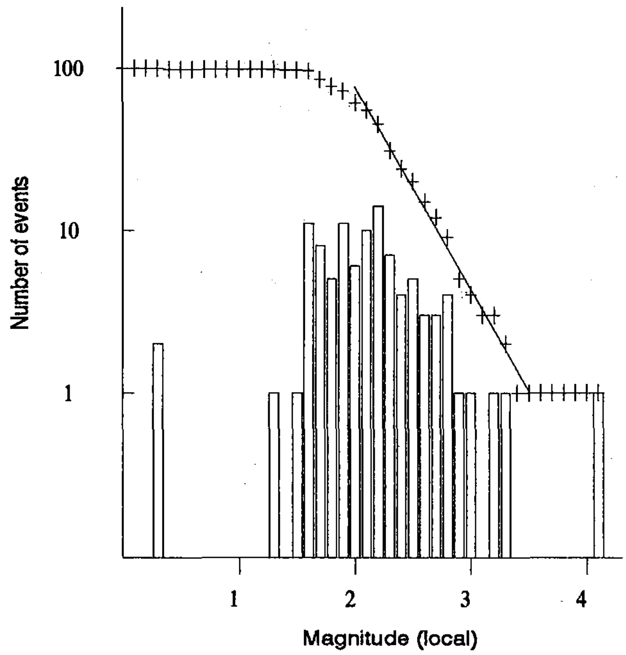

Fig. 7.1.6. Recurrence relation based on M_L magnitudes and a small sample of events (61) from the region 76°N - 80°N and 10°E - 25°E.

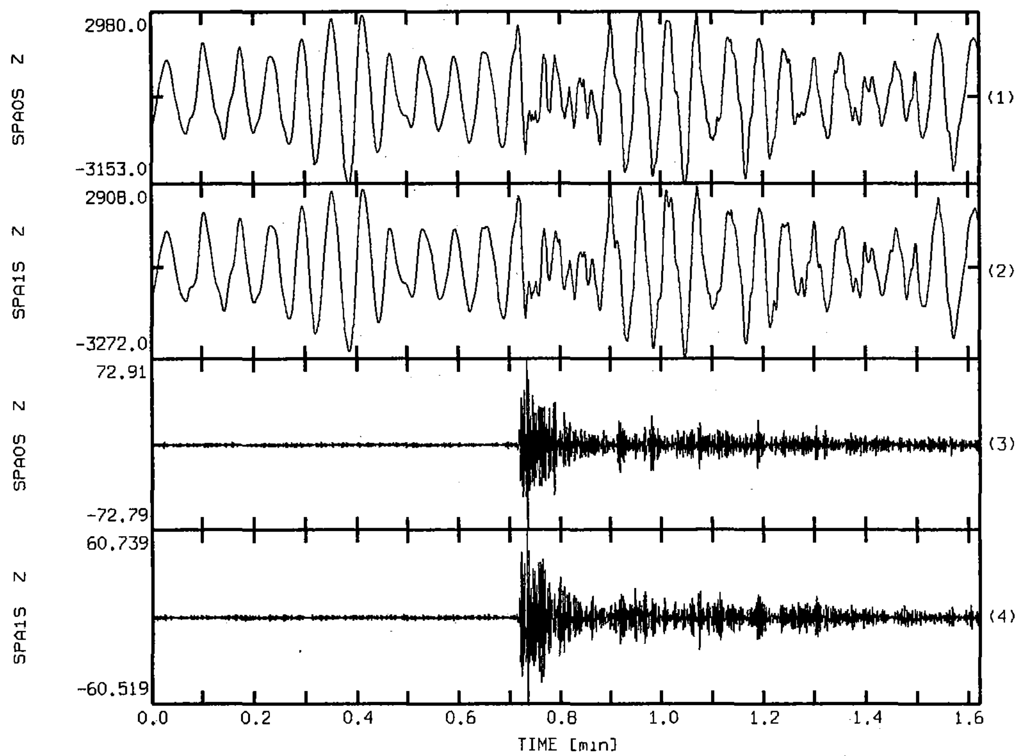

Fig. 7.1.7. Recording of the October 7, 1994, Chinese nuclear test at the SPITS array. The upper two records are unfiltered short-period channels for vertical instruments at sites A0 and A1, and the lower two records are the 4-8 Hz bandpass filtered records for the same two sensors.

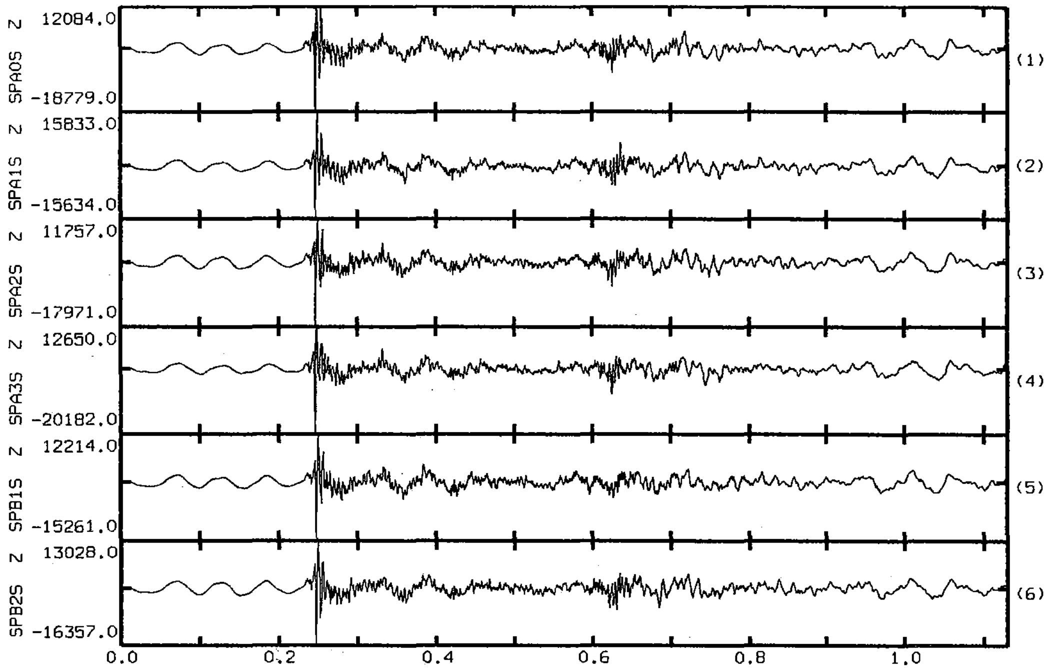

Fig. 7.1.8. Recording at SPITS of the 8 October 1994, 3.5 m_b earthquake on the Knipovitch Ridge (78.2°N, 7.8°E)

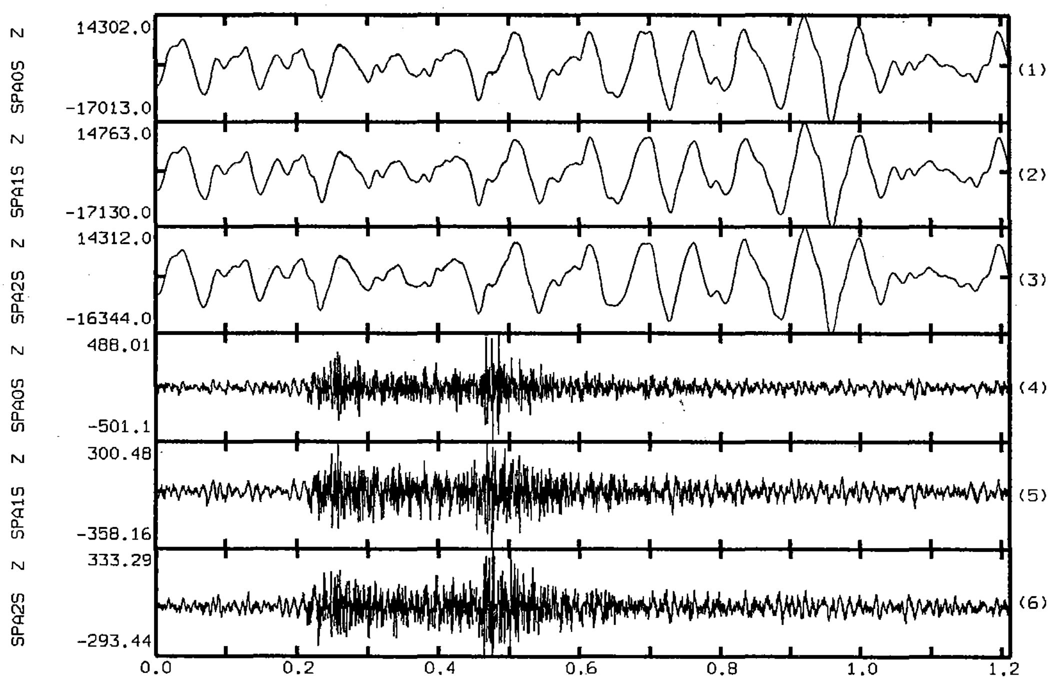

Fig. 7.1.9. Recording at SPITS of a 24 November 1994 earthquake off shore and south of the Heer Land Zone (77.1°N, 17.9°E). The upper three channels are raw short-period recordings, whereas the lower three traces are 2 - 15 Hz band pass filtered data for the same three instruments.