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M. A KIRNOS SEISMOGRAPH IN THE NORSAR SEISMIC ARRAY

The differences in earthquake magnitudes measured from wide band (Kirnos) seismographs, such as are widely installed in the USSR ('East') and narrow band seismographs used in 'Western' installations have been discussed at great lengths in the Geneva test ban negotiations (CCD). The displacement response for the two instrument types are shown in Fig. M.1. Operation of Hall-Sears (U.S.A.) and Kirnos (U.S.S.R.) seismometers at the same site suggests itself as a useful experiment directed to clarifying the discrepancies between 'Eastern' and 'Western' body wave magnitudes.

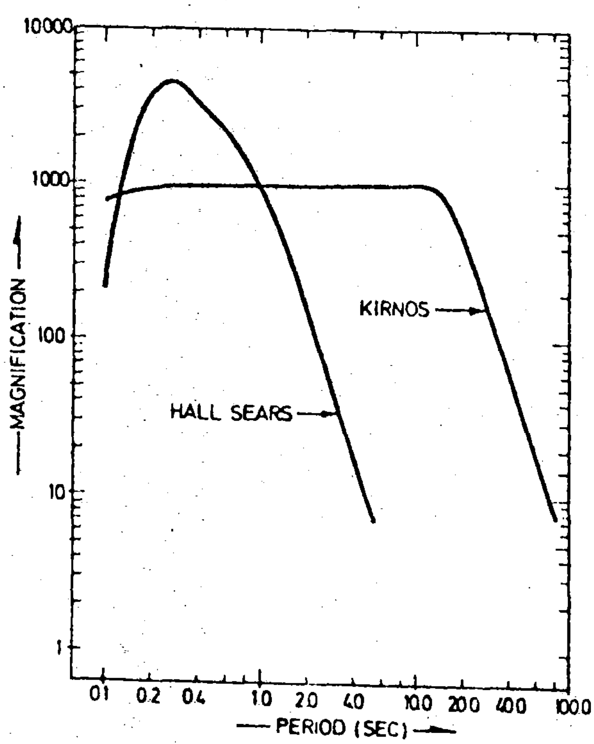
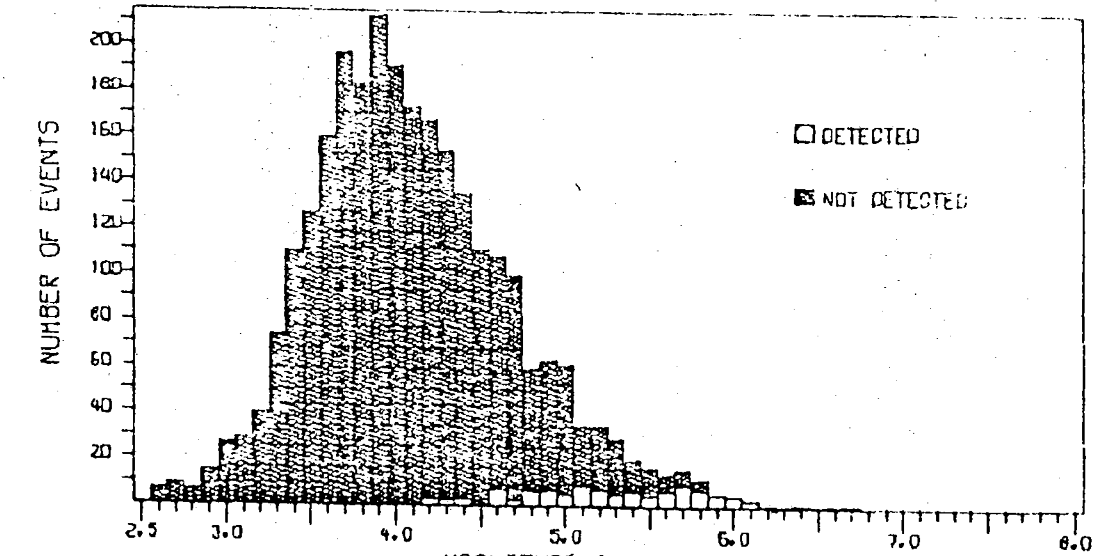


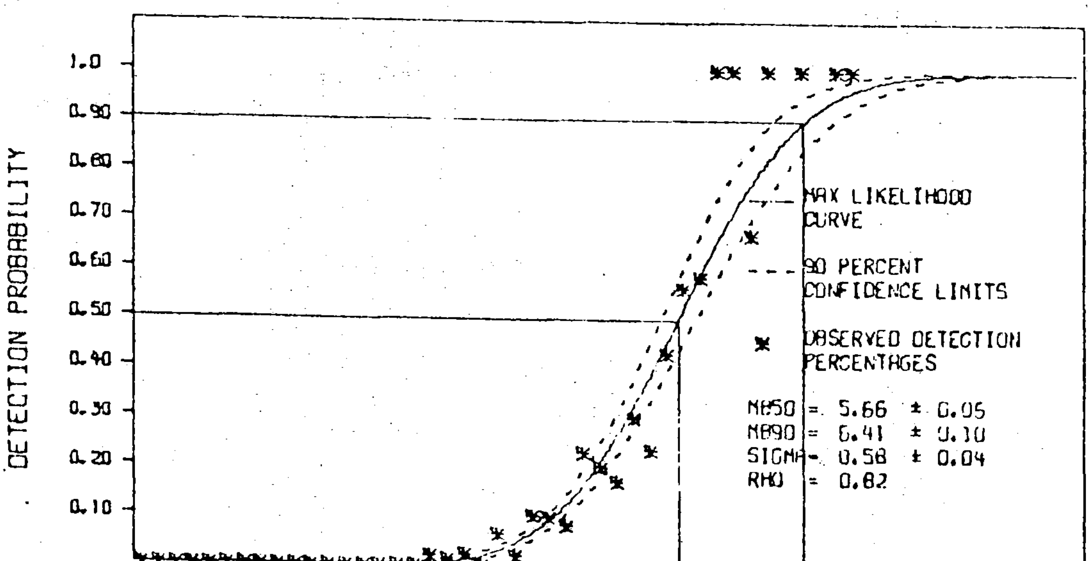
Fig. M.1 Displacement response for Kirnos SVK-2 compared to the NORSAR seismometer response (Hall-Sears). Equal magnification at 1 sec period.

As a part of a Nordic project on detection seismology, a Kirnos vertical broadband instrument was installed at NORSAR subarray 04B and operated over a period of about nine months. During the period of operation (Jan-Sep 1974) the seismograms from the Kirnos instrumentation have been read in comparison with the NORSAR bulletin. On an average some twelve events have been identified every month, with more events detected in summer than in winter. Fig. M.2 shows the decision histogram together with the maximum likelihood estimated thresholds of 5.7 and 6.4 body wave magnitude for 50 and 90 per cent probability of detection, respectively. All wave modes are included in the detection decision in this case. When only body waves (P, PP, PcP, PKP) are considered, the results are even more modest for the Kirnos seismograph detectability, namely, 5.9 and 6.5 m_b units. However, it has to be pointed out that the reliability of the estimates decreases when sample size is significantly less than one hundred.

Due to poor detectability, the Kirnos seismograph system would need years of operation in Norway in order to establish a reasonable data base suitable for statistical magnitude studies. However, it might be interesting to see if the limited data available follow the general trend that would be expected from a broadband instrument of the SVK-2 type. Due to the paucity of observations, no regionalization was attempted, and, moreover, core phases are excluded from the magnitude considerations in the following. Altogether 25 events in the distance range 18-91 degrees were jointly recorded as P-waves by the Kirnos and the NORSAR Hall-Sears instrument at subarray site 04B00, the two instruments being separated physically by only 2 meters. The body wave magnitude m_b^E computed by the 'Eastern' broadband instrument versus m_b^W computed by the 'Western' SP instrument is shown in Fig. M.3. According to Davies (1968), the difference $m_b^E - m_b^W$ should be around 0.5 magnitude units, while Marshall et al (1972)



MB DISTRIBUTION OF PROCESSED EVENTS
KIRNOS-NORSAR COMPARISON



MAXIMUM LIKELIHOOD DETECTABILITY CURVE
KIRNOS-NORSAR COMPARISON

Fig. M.2 Kirnos detection statistics for the total number of events identified (all phases included).

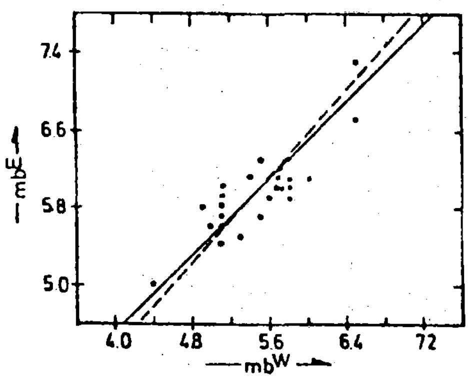


Fig. M.3 Kirnos m_b^E versus Hall-Sears m_b^W. Dotted line: 'Eastern'-'Western' magnitude relationship by Marshall et al (1972). Solid line: E-W magnitude relationship by Davies (1968).

found this relationship to be magnitude dependent, yielding

$$m_b^E = 1.12\ m_b^W - 0.15$$

Both these curves are given in Fig. M.3, and the data is not inconsistent with either.

The results obtained in this study support the conclusion that the main cause of the discrepancy between 'Eastern' and 'Western' measurements of magnitude is the difference in frequency responses of the seismographs employed. A rough estimate of the slope b of the frequency-magnitude relationship for the Kirnos gives a much lower value than reported for 'Western' narrowband instrumentation (Richter, 1958; Marshall et al, 1972). Thus by extrapolation, 'Western' data predicts more small shocks and fewer great shocks than 'Eastern' broadband data collected by Kirnos instruments. The Kirnos event detectability is poor, as the noise level imposes a serious limitation on this broadband system. In conclusion, it should be stressed that in the present context a minimum requirement for a useful broadband seismograph system should include magnetic tape recording to permit such operations as frequency filtering.

More details from this project are to be found in the report of Dahle (1975).

A. Dahle

REFERENCES

Dahle, A. (1975): A Kirnos seismograph in the NORSAR Seismic Array, Internal Report No. 4-74/75, NTNF/NORSAR, Kjeller, Norway.

Davies, D. (1968): Seismic methods for monitoring underground explosions, Almquist & Wiksell, Sweden.

Marshall, P.D., R.F. Burch and A. Douglas (1972): How and why to record broadband seismic signals, Nature, 239, No. 5368, 154-155.

Richter, C.F. (1958): Elementary Seismology, W.H. Freeman & Company, San Francisco and London.