NORSAR

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NORSAR PHASE 3

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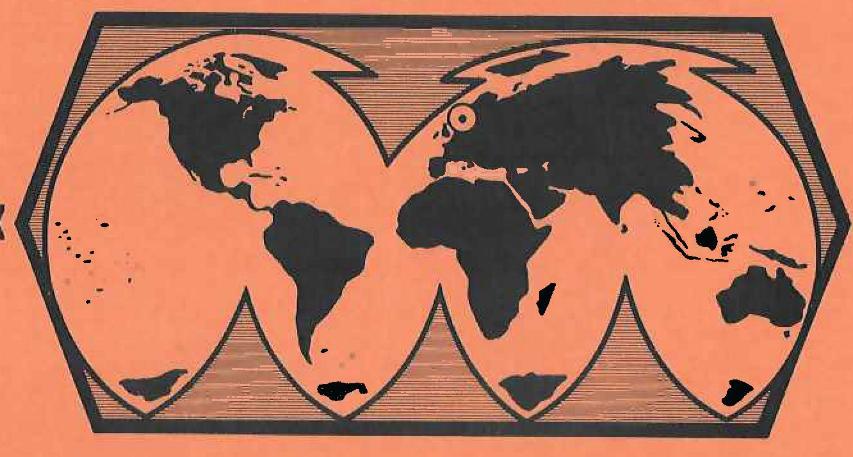

J. m_b:M_s AT NORSAR

The full NORSAR array has now operated for about 3½ years, during which time more than 50 events have been recorded which we presume to be underground nuclear explosions. This is enough data to facilitate a more detailed study (see also Filson and Bungum 1972) of the discrimination capability of NORSAR in various regions, and emphasis is put on the m_b:M_s method which is generally accepted as being the best discriminant available. The region for which most data have been accumulated is Central Asia, from where an m_b:M_s plot is shown in Figure J.1. The distribution includes 44 earthquakes and 26 presumed explosions, and linear regression lines have been estimated

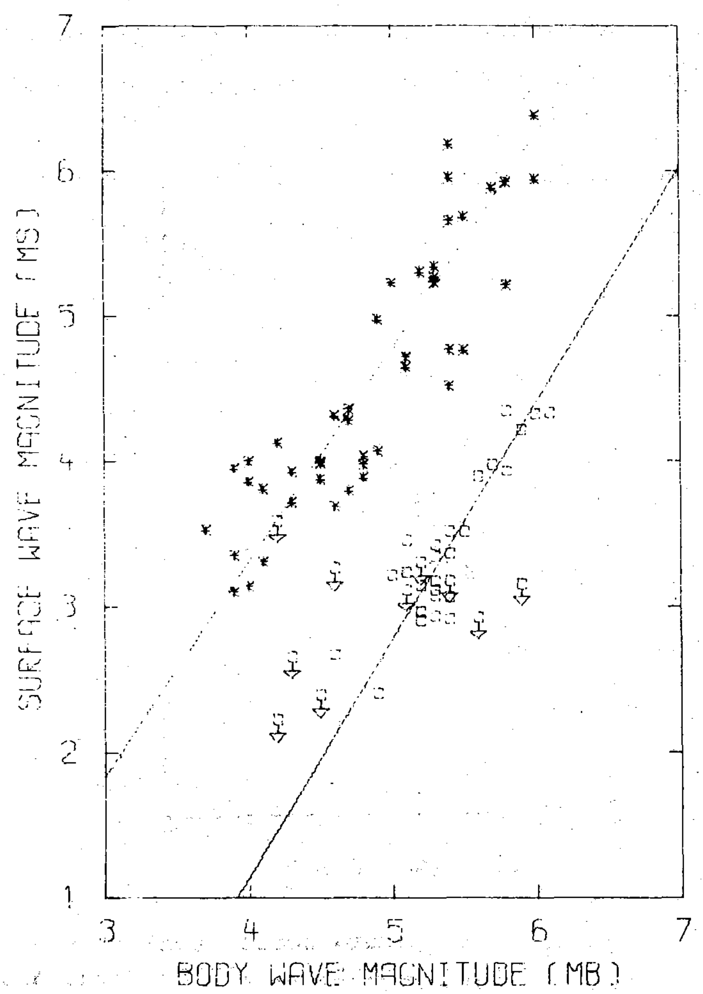

Figure J.1 NORSAR m_b versus M_s for events from Central Asia. Squares and asterisks denote presumed explosions and earthquakes, respectively. The straight lines are maximum likelihood linear regression lines. Arrows denote events for which no surface waves are found, the value being the upper boundary for M_s.

using a maximum likelihood method. A certain clustering of the presumed explosions make an estimation of identification threshold difficult, but from a brief look at the plot it seems to be difficult to get below m_b=5.0 with the requirement that the m_b:M_s method be used as a positive identifier. Using lack of surface waves as negative evidence, identification may be possible down to at least m_b=4.5. It is obvious from Figure J.1 that the main limiting factor is the noise level on the long period records; it is seen that in the 10 cases where no Rayleigh waves are found from presumed nuclear explosions, the M_s level of the noise (measured on a filtered beam) ranges from 2.2 to 3.6, or more than one magnitude. This is consistent with the long term distribution of the long period noise presented in Figure J.2, where on year of data has been accumulated. Although large short term (= a few days)

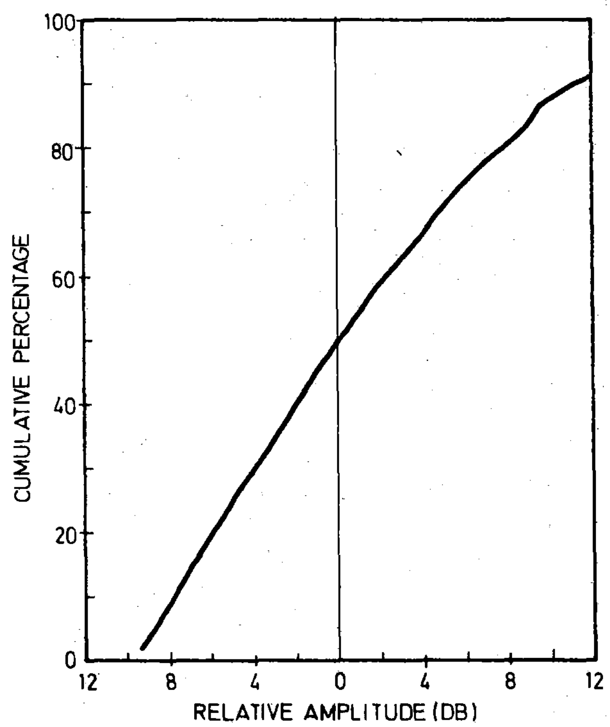

Figure J.2 The distribution of average noise level at the 22 long period vertical seismometers at NORSAR. The averaging is done over one year of data, from September 73 to August 74.

variations are observed, the dominating factor behind Figure J.2 is the yearly variation, with an average noise level during the winter months being almost 10 times that of the summer (which means that so far as NORSAR is concerned, the cheapest evasion technique is obtained by calling the meteorologist).

Figure J.3 shows the difference $m_b - M_s$ plotted against m_b For earthquakes $m_b - M_s$ is clearly correlated with m_b. Using the spectral theory of seismic sources (Aki 1972, Randall 1973), it is possible to estimate approximately how $m_b - M_s$ changes with m_b. As described by Noponen (1974), it can be written

$$m_b - M_s = K + \log_{10}\{f_m F(f_m)\} - 1.36t^*f_m \qquad (1)$$

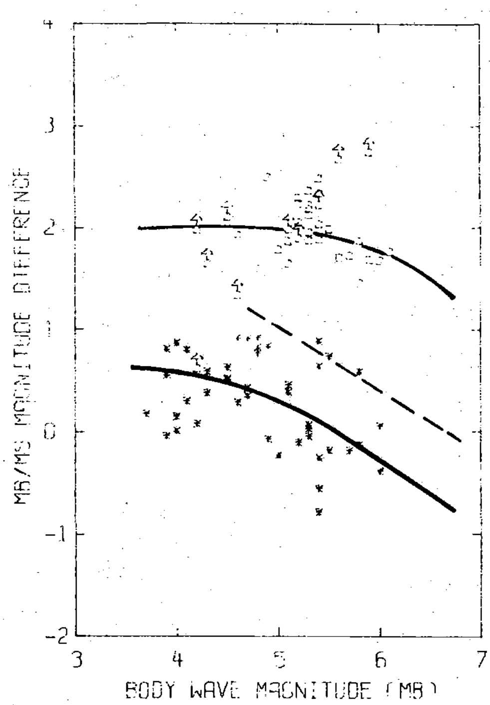

Figure J.3 $m_b - M_s$ of events in Central Asia plotted against m_b. Squares and asterisks denote presumed explosions and earthquakes respectively. The continuous lines indicate predicted change of $m_b - M_s$ as a function of m_b for both types of events. The broken line is the Gutenberg-Richter relationship.

K is a constant independent of m_b, f_m is the apparent frequency of P-wave used in computing m_b, it can be taken to correspond to the frequency of the spectral maximum of recorded P-wave. $F(f_m)$ is the ratio of the P-wave source spectral amplitude at frequency f_m to amplitude at zero frequency. t* is the ray path anelastic attenuation parameter. The values of equation (1) were evaluated for both earthquakes and explosions, using m_b-dependent P-wave source spectral shapes derived by Aki (1967) and by von Seggern and Blandford (1972), complemented with NORSAR observations on corner frequencies. f was estimated by synthesizing the recorded signal spectrum, taking into account the effects of signal absorption and instrument response. $F(f_m)$ could then be computed from the source spectral shape. t* was given the value 0.25. The values of K were estimated in that the levels of the computed m_b-M_s curves were fitted to the observations. Extrapolation of the curves to very low magnitudes suggests that although m_b-M_s decreases with magnitude, a residual difference of approx. 0.5 magnitude units remains between m_b and M_s, apparently caused by the different Rayleigh wave generation capacity of dilatational and shear sources. The slope of the derived m_b-M_s as a function of m_b agrees roughly with observations and at $m_b>5$ with the Gutenberg-Richter m_b:M_s relationship.

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REFERENCES

Aki, K. (1967): Scaling law of seismic spectrum, J. Geophys. Res., 72, 1217-1231.

Aki, K. (1972): Scaling law of earthquake source time-function, Geophys. J.R. Astr. Soc., 31, 3-25.

Filson, J., and H. Bungum (1972): Initial discrimination results from the Norwegian Seismic Array, Geophys. J.R. Astr. Soc., 31, 315-328.

Noponen, I. (1974): Event identification capabilities of NORSAR, Proc. NATO A.S.I. "Exploitation of Seismograph Networks", Sandefjord, Norway, 1974.

Randall, M.J. (1973): The spectral theory of seismic sources, Bull. Seism. Soc. Am., 63, 1133.

Seggern, D. von, and R. Blandford (1972): Source time functions and spectra for underground nuclear explosions, Geophys. J. R. Astr. Soc., 31, 83-97.