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By
H. Gjøystdal (ed.)

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VI.3 Classification of Regional Events

Special interest has in this period been focused on the problem related to the discrimination potential of the near-field observations of seismic events. The capabilities of the NORSAR array to detect and locate events at distances smaller than the conventional teleseismic distances has been undertaken and intensive work is now going on upgrading the detection capabilities at regional distances. In this context a preliminary analysis has been initiated to consider the array's capabilities of discriminating between earthquakes and explosions based on events reported at distances smaller than the teleseismic boundaries. A data base of 90 events of which 43 were presumed explosions and the remaining 47 were presumed earthquakes, all with a distance range covering from 10 to 40 degrees, were selected from the data library at NORSAR. The presumed explosions population was mainly located in western or southwestern Russia, while the presumed earthquakes were dominantly restricted to the Mediterranean area and eastwards towards Pakistan. Though it has recently become more popular to include additional near-field phases like the Lg into the discrimination scheme, we have exclusively restricted ourselves to the P-phase observations for our discriminant. The basis for the discriminant is found in the power spectrum of the P phase observations at the different instruments in the array and the energy distribution as a function of time after initial onset. The idea is to assemble optimally all available information in the spectrum in a restricted number of parameters and subsequently design a discriminant which will in an optimal way separate out the major difference in the information contained in the two populations (earthquake or explosion), if there is any significant difference at all. The discriminant to be considered here is identical to the one introduced by Sandvin and Tjøstheim (1978), except that the first step where the initial parameter extraction is performed is technically different but essentially contains the same information, i.e., the reproduction of the power spectrum. The philosophy of the discriminator is based on statistical classification where each data vector which is input to the discriminant is treated within a statistical framework and a distribution is fitted to the data vector belonging to each of the populations. (For references, see Sandvin and Tjøstheim, 1978).

It is surprising that even at frequencies close to the low-pass cut-off frequency installed at the seismometers a considerable portion of energy is observed at some NORSAR registrations from Russian explosions even as far away as Eastern Kazakhstan. It is consequently desirable to have an estimate of the energy distribution over a wide frequency range. The techniques we have adopted for estimating the energy-distribution is simply to apply a series of bandpass filtering with increasing center-frequencies. In this study five bandpass filters were applied with increasing center-frequency. A constant bandwith of 0.8 Hz was selected, starting with the frequency band 0.6-1.4 Hz and ending with the frequency band 3.8-4.6 Hz. A filtered section of the complete 42 traces is demonstrated for an explosion from Western Russia with a distance of $\Delta=15.6^{o}$ in Fig. VI.3.1. The single traces are divided into three subsections; one section contains the noise preceding the signal for an instant indication of the varying noise level; one subsection consists of the P phase itself; and finally the last subsection consists of the coda observations. The coda traces were included due to previous indications that the coda observations contain valuable information for discrimination purposes.

As demonstrated by King & Calcagnile (1976) a rapid change in velocity occurs at a depth of about 420 km in continental Russia resulting in a pronounced later arrival in the approximate distance range $21^{o}\leq\Delta\leq33^{o}$. This feature causes additional complications into the complexity of the P arrivals and the P phase subsection was consequently divided into two sections; one containing the first P onset and the second the later arrival. This leaves us with four subsections. For each frequency band and each subsection a parameter A was estimated, given by

$$A = 20 \log \text{(max. amplitude)}$$

which represents an estimate of the energy restricted to that subsection and that frequency band. The energy estimate of the noise section was subtracted from the remaining three subsections to compensate for the noise level variation.

From the trace with the maximum signal-to-noise ratio, the parameters from the three signal subsections were selected for each frequency band resulting in 3 x 6 = 18 parameters. In addition the average value (averaged over all 42 instruments) of the same parameters were added resulting in a total of 18 + 18 = 36 parameters from each event. These parameters finally enter the discriminant and from this point on the procedure is identical to the one described by Sandvin and Tjøstheim (1978). The number of parameters is significantly reduced by a principal-component analysis and the classification rule is finally based on the reduced data vector. Each event is tested against the remaining events and assigned to the population with the highest classification score.

A histogram presentation of the final discrimination score is depicted in Fig. VI.3.2. From this figure it may be inferred that of the total data base of 90 events included, 4 earthquakes and 2 explosions were misclassified. This is a result that is comparable with discrimination performed on a data base consisting of teleseismic events.

O.A. Sandvin

References

King, D.W., and G. Calcagnile, 1976: P-wave velocities in the upper mantle beneath Fennoscandia and western Russia, Geophys. J.R.Astr. Soc., 46, 407-432.

Sandvin, O.A., and D. Tjøstheim, 1978: Mutlivariate autoregressive presentation of seismic P-wave signals with application to short period discrimination. Bull. Seism. Soc. Amer., 68, 735-756.

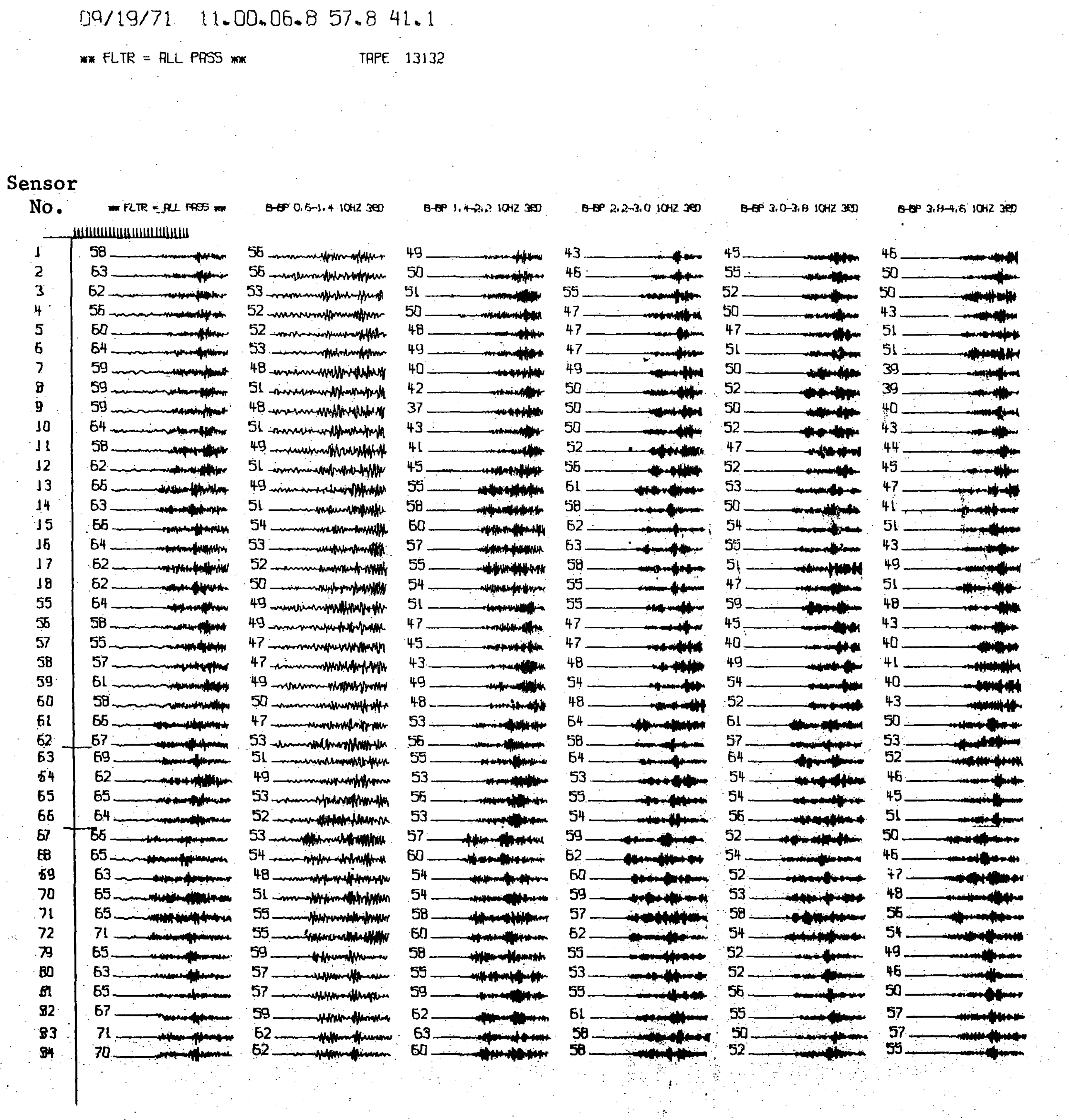

Fig. VI.3.1 Energy distribution as function of frequency for presumed explosion from western Russia with m_b=4.5 and epicentral distance Δ=15.6°. For each NORSAR SP instrument, the figure displays an unfiltered trace and five bandpass filtered traces. The number in front of each trace represents amplitudes in dB relative to 1 quantum unit.

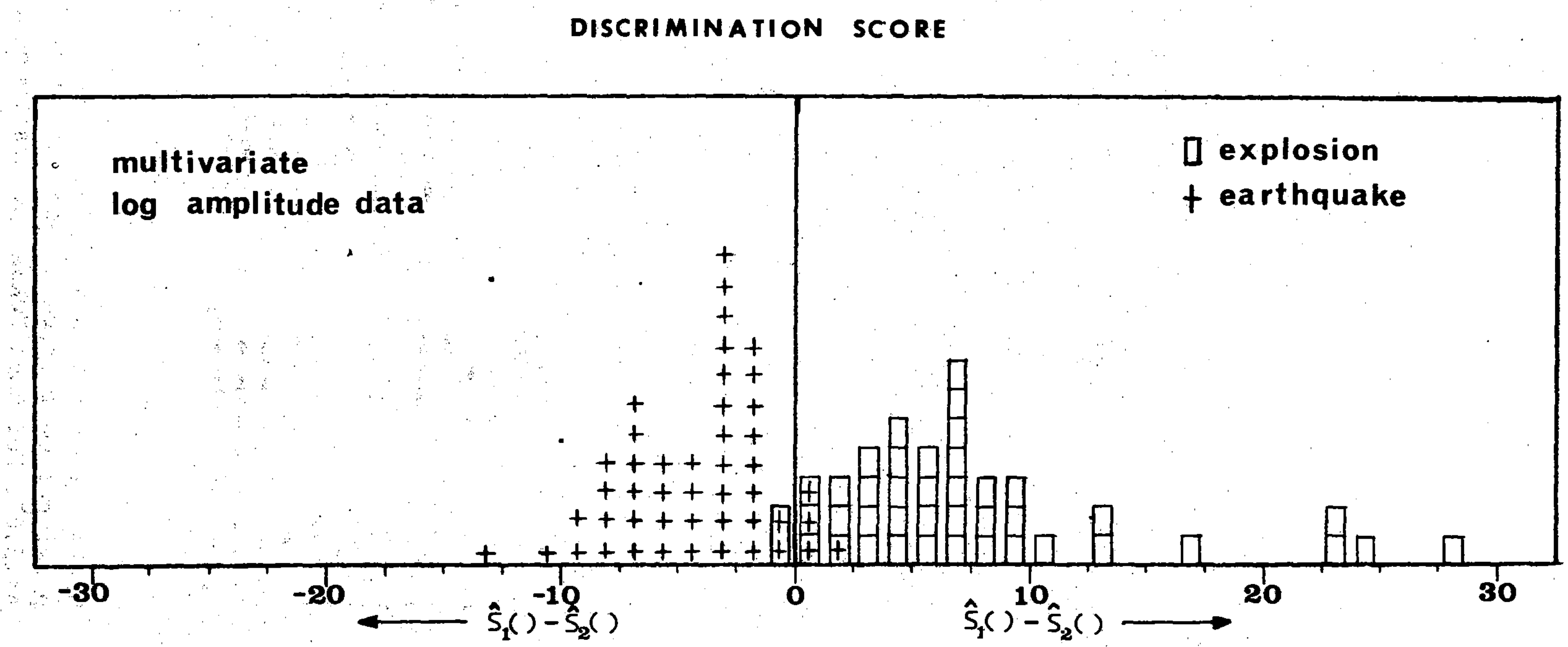

Fig. VI.3.2 Histogram of discrimination score obtained for our data base consisting of 43 explosions and 47 earthquakes.