NORSAR

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VII.6 Analysis of teleseismic P coda using NORSAR and NORESS

The teleseismic P coda consists of the presumably scattered energy that arrives in the first few minutes following first P from teleseismic events. It has been suggested that it could be used as a yield estimator (see, for example, Ringdal, 1983), and work reported here also suggests that it may also be useful as a discriminant for crustal events. This study examines the problem of the teleseismic P coda from the standpoint of determining the place where the waves in the coda are scattered, with the aim of producing a quantitative model of the coda.

The "starting model" is shown in Fig. VII.6.1. The P coda is considered to be produced by scattering of Lg to P in the crust near the source and by scattering of P to Lg near the receiver. The power spectrum P_c of the coda as a function of time t then has the form, for single scattering,

$$P_c(f,t) = |A|^2 \cdot G \cdot \exp[-2\pi ft/Q] \qquad (1)$$

where f is frequency, A(f) is the Fourier transform of the first P pulse, G is a scattering parameter called the turbidity and Q is the Q. The parameters G and Q will refer only to the receiver site for the case of a deep-focus event and will depend on both the source and receiver sites for the case of explosions and shallow earthquakes.

Fig. VII.6.2 shows a plot of Fourier amplitude against time for a Semipalatinsk explosion for a frequency of 3.6 Hz. At this high frequency the exponential decay model of Eq. (1) seems to fit the data well for the time range 20 sec to 200 sec after first P. For lower frequencies, the influence of PP is important (King et al, 1975). Values for Q of 850 ± 50 (deep-focus events), 1200 ± 150 (Semipalatinsk explosions) and 1200 ± 250 (Semipalatinsk crustal earthquake, March 20, 1976; Pooley et al, 1983) have been obtained. These values suggest Q at both NORSAR and Semipalatinsk is high. Values of G of about 10^{-3} km^{-1} are found for both deep-focus events and Semipalatinsk explosions, suggesting that the size of the coda generated near Semipalatinsk is at most of the same order as that generated near NORSAR. On the other hand, the crustal earthquake near the Semipalatinsk test site gives a value for G of around 5×10^{-2} km^{-1}, considerably larger than the explosion value. This can be explained by efficient generation of Lg by a dislocation source followed by scattering of Lg to teleseismic P.

To try and determine the relative contribution of scattering near the source, near the receiver and from any other mechanism, analysis of NORESS data has begun. NORESS is uniquely capable of determining crustal phase velocities (3.5 - 8 km/sec) and azimuths at high frequencies. From Fig. VII.6.1, the model predicts that a component of the coda should have a phase velocity and azimuth appropriate to teleseismic travel from the source, and another component having phase velocities appropriate to Lg (3.5 - 4.5 km/sec) and random azimuth. Fig. VII.6.3 is a contour plot of a wavenumber spectrum of a 5-second window in the coda of a Semipalatinsk explosion, 5 seconds after P onset. There is indeed evidence of both a high phase velocity peak at the appropriate azimuth, and energy at Lg velocities off azimuth.

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References

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Pooley, C.I., A. Douglas and R.G. Pierce (1983): The seismic disturbance of 1976 March 20, East Kazakhstan: earthquake or explosion? Geophys. J., 74, 621.

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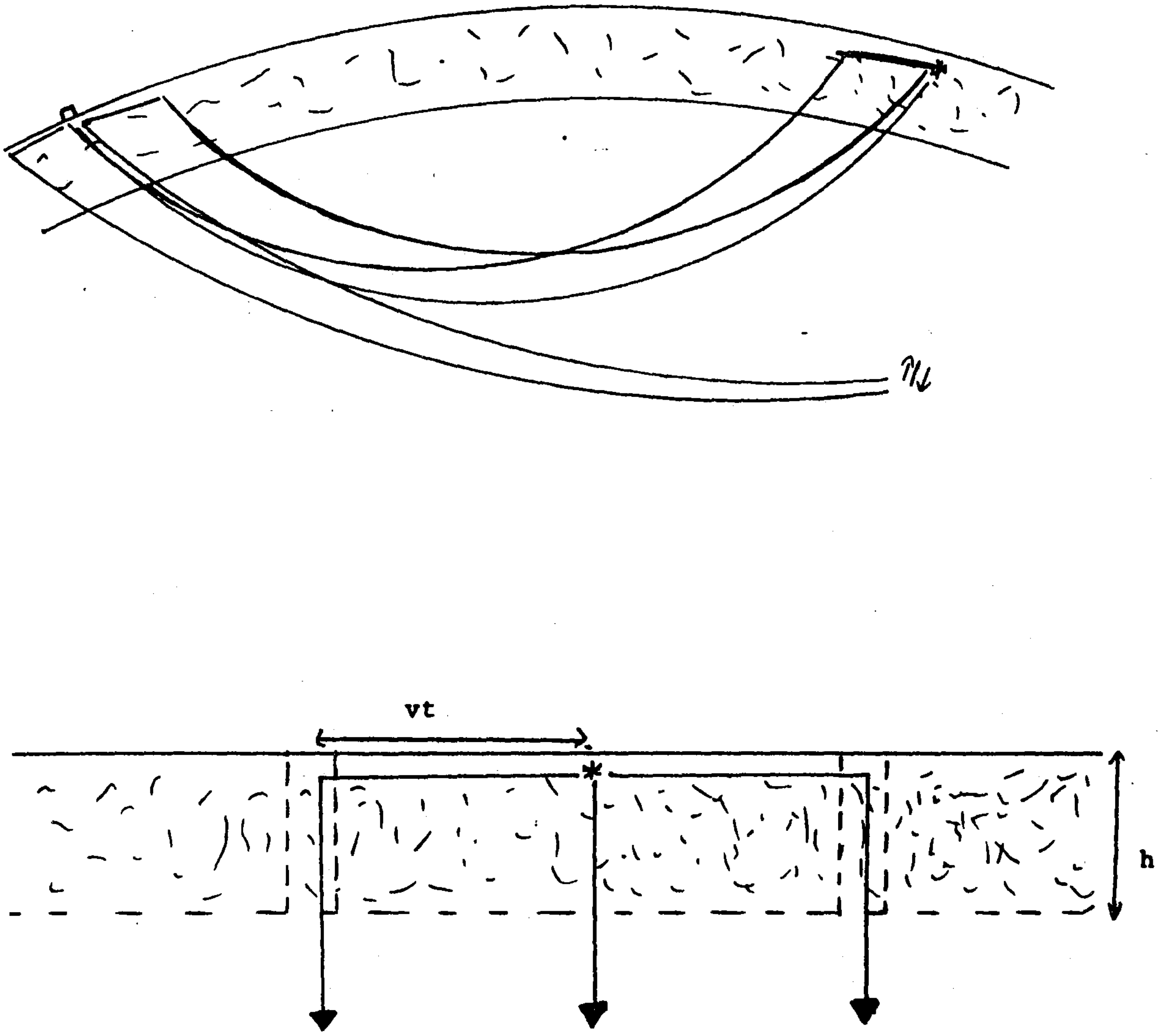


$$P_c(F,T) = A_p^2 \cdot G \cdot \exp(-2\pi FT/Q)$$

$$G = G_{pL} \qquad \text{(DEEP FOCUS)}$$

$$G = (A_L^2/A_{po}^2) \cdot G_{Lp} + G_{pL} \qquad \text{(EXPLOSION)}$$

Fig. VII.6.1 Model of coda (Top). Generation of coda by Lg → P scattering near source, P → Lg scattering near receiver (Middle). Detail of Lg → P scattering near source (Bottom). Formulas for coda power spectrum as a function of time in time range 20 - 200 sec after first P. See text for discussion.

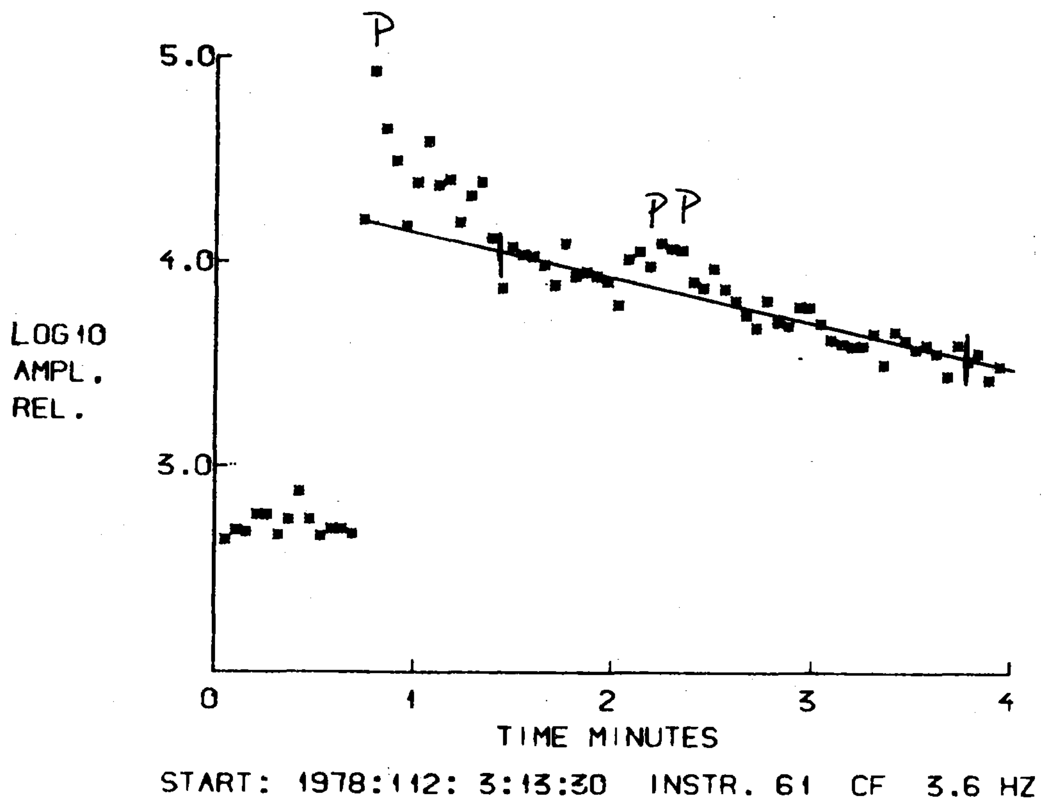
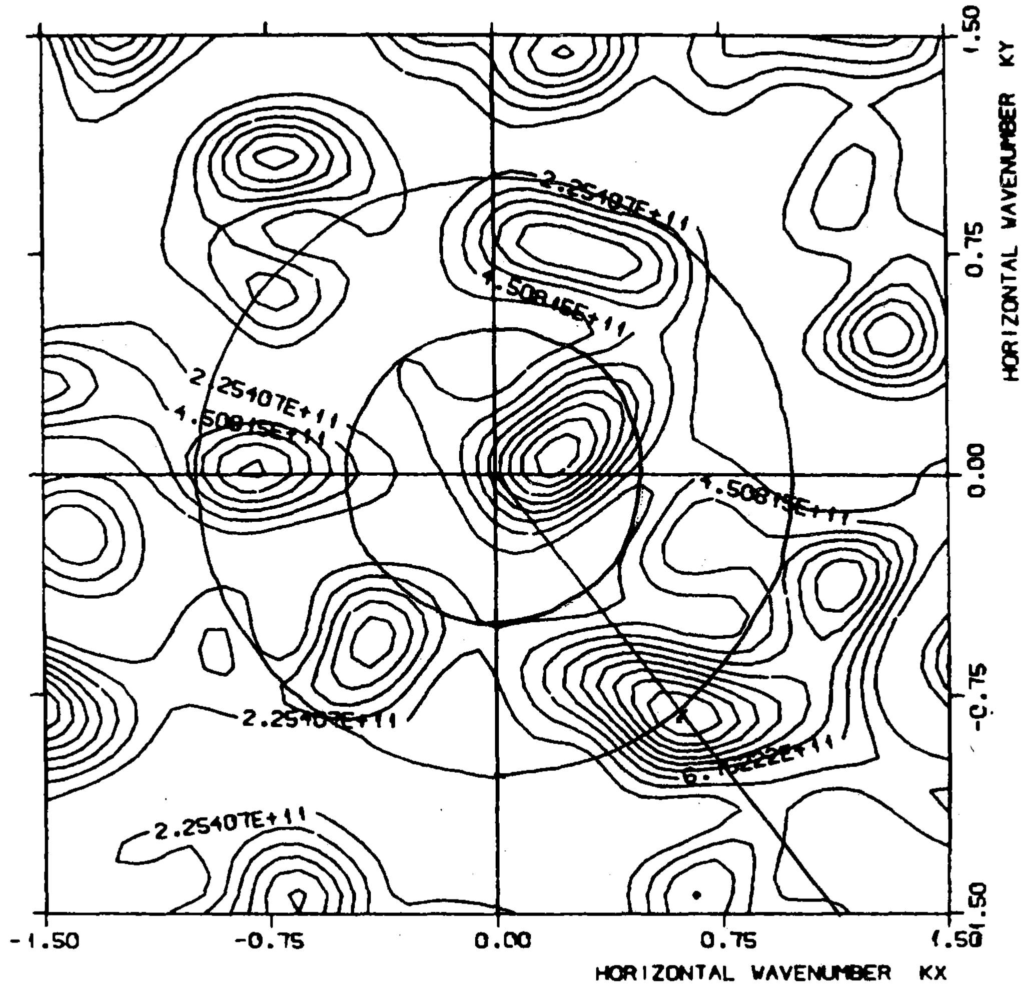


Fig. VII.6.2 Fourier amplitude as a function of time for a Semipalatinsk explosion, April 22, 1978. Line indicating fit of equation (1), ticks indicate range over which fit is taken. Analysis frequency, 3.6 Hz. Note contamination of coda by PP.

MONOCHROMATIC F-K ANALYSIS
CONVENTIONAL RESOLUTION
LINEAR DEPENDENCY BETWEEN CONTOURS



VEL = 3.53 KM/S AZ = 142.9 DEG PWR =***** DB
PREFILTER FREQUENCY INTERVAL: 0.0 - 0.0 HZ ANALYSIS FRQUENCY: 3.6 HZ

CODA

Fig. VII.6.3 Contour plot of wavenumber spectrum, KX linear wavenumber East, KY linear wavenumber North, for a 5-second coda window 60 sec after 1st P. Analysis frequency is 3.6 Hz, linear wavenumber is (1/wavelength). Circles are at phase velocities of 8 km/sec (inner) and 3.6 km/sec (outer).