J. Ind. Geophys. Union (2003)
Vol.7, No.3, pp.155-158

Effective criteria to assess seismic source efficiency in poor signal to noise conditions in a trap covered region – A case study

B.Rajendra Prasad and G.Kesava Rao

National Geophysical Research Institute, Uppal Road, Hyderabad – 500 007

ABSTRACT

It is well known that trap covered areas pose a great challenge for imaging the sedimentary rocks covered by it. Seismic reflection technique suffers most, due to poor source coupling, aggravated by lack of water table conditions. The alternate seismic method, seismic refraction is moderately successful, the basic reason being that the sources can be located in more suitable environment (may be within 5 to 10 km range) as compared to seismic reflection, where depending on the targets / survey requirement, a shot has to be located at every 50 m / 100 m interval along a profile. Source coupling however, is still a problem to be tackled effectively in refraction surveys. Normally a relative topographic low with adequate thickness of weathered layer and good water table condition is chosen for shot location after studying the open wells / tube wells along the profile.

NGRI had taken up an ambitious project for imaging subtrappean sediments in Deccan Syneclise. As a routine, the team had conducted certain experimental recordings in the area. The experiment consisted of shooting different charge sizes (350 and 600 kg) in specially drilled shot holes with charge placed at an average depth of 23 meters. Care has been taken to place the charges in similar geological environments and near by locations.

The seismic records are processed on Promax 2003 with the aim of studying the energy content and the amplitude decay with offset. Even though, it appeared that the quality of seismic monitor record with 350 kg charge size is better than that of 600 kg, the study of average trace amplitude, its decay and amplitude spectrum of noise free traces have shown, as expected, that the record quality of 600 kg charge size stands better. The technique is verified in poor S/N conditions. The misleading impression from monitor record of 350 kg can be attributed to the random noise conditions.

DATA ACQUISITION, PROCESSING AND DISCUSSION

It is usual practice to perform experiments in field to choose suitable geophysical parameters before acquiring seismic data in any geological terrain to meet the task. One such experiment was conducted by CSS Project of NGRI to choose optimum charge size of dynamite source to fire long-range refraction shots, to delineate subtrappean Mesozoic formations and basement structure in Deccan Syneclise. The study was felt essential, since the first arrival data play significant role to arrive at approximate boundary velocities of various refractors in evaluating basic geological model. The amplitude study of later arrivals can definitely improve the basic model especially in basaltic terrain, while following the standard technique of travel time ray tracing (Fhedner & White 1999). Catchings & Mooney (1988) have used charge weights ranging from 900 to 2200 kg for wide-angle reflection / refraction study in a basaltic terrain, Columbia Plateau, USA to identify various seismic events. We felt similar need in our endeavour for delineating basement structure in Deccan Syneclise with seismic refraction with offsets ranging from 0-12 km (50 kg) and 36-48 km (700kg).

Seismic source signatures were generated at an offset of 30 km by firing different charges sizes (350 and 600 kg of dynamite) in trap covered terrain, near Shahada, Maharashtra (north of river Tapati) and recorded 30 channel spread (2.9 km length), using 10 Hz geophones and 24 bit RF Telemetry Seismic Recording System (Eagle-88) in December 2002. Spread and shot point location map is shown in Fig.1.

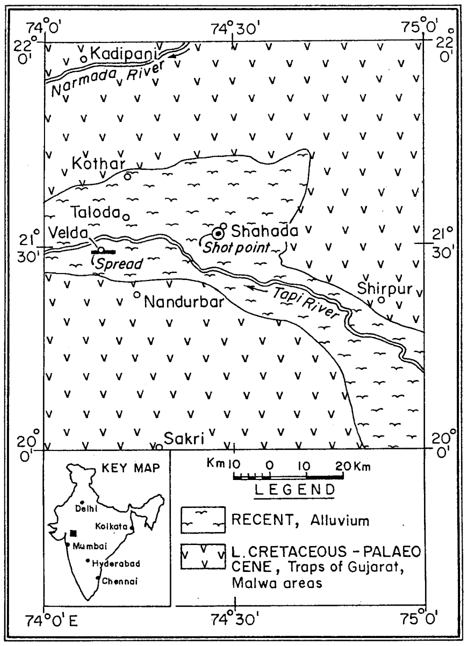

Figure 1. Spread and Shot point location map.

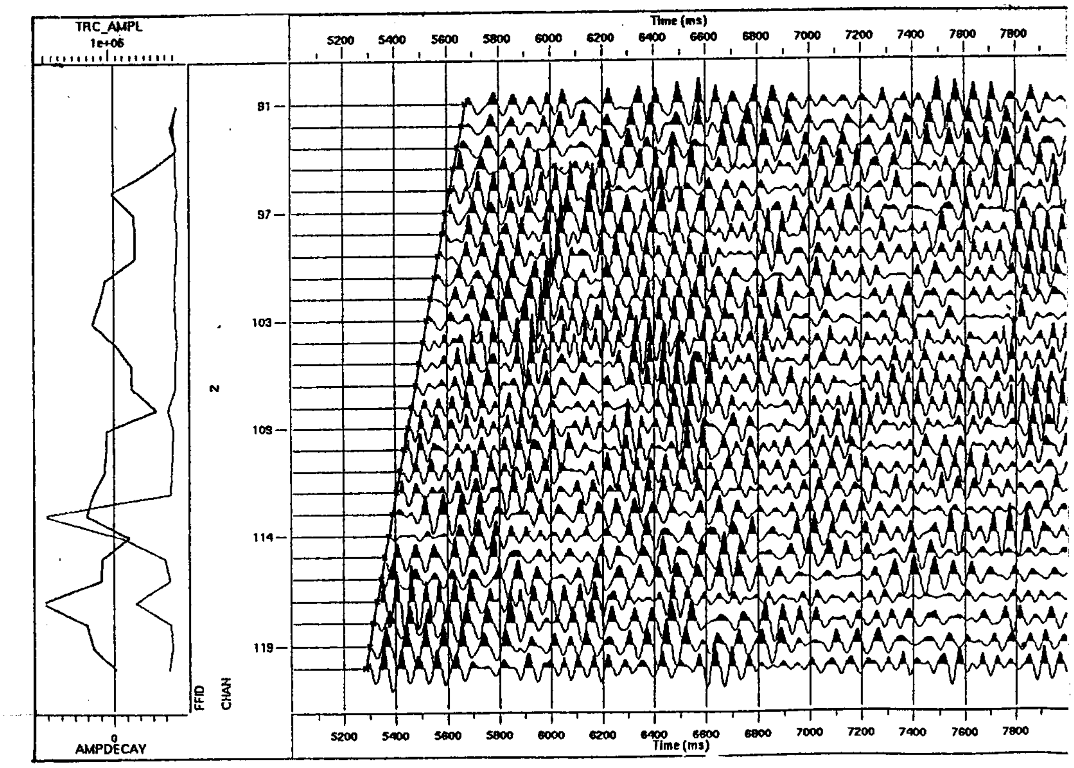

Figure 2. Seismic Record (350 kg charge). Signatures of Amplitude decay and Trace - amplitude.

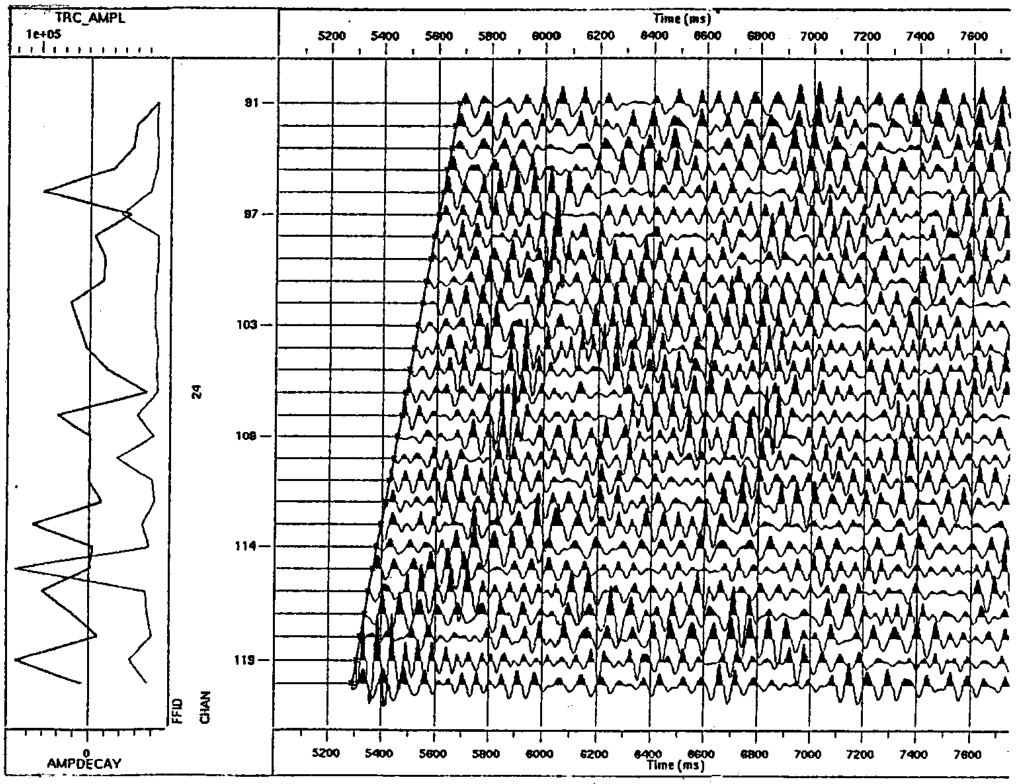

Figure 3. Seismic Record (600 kg charge). Signatures of Amplitude decay and Trace - amplitude.

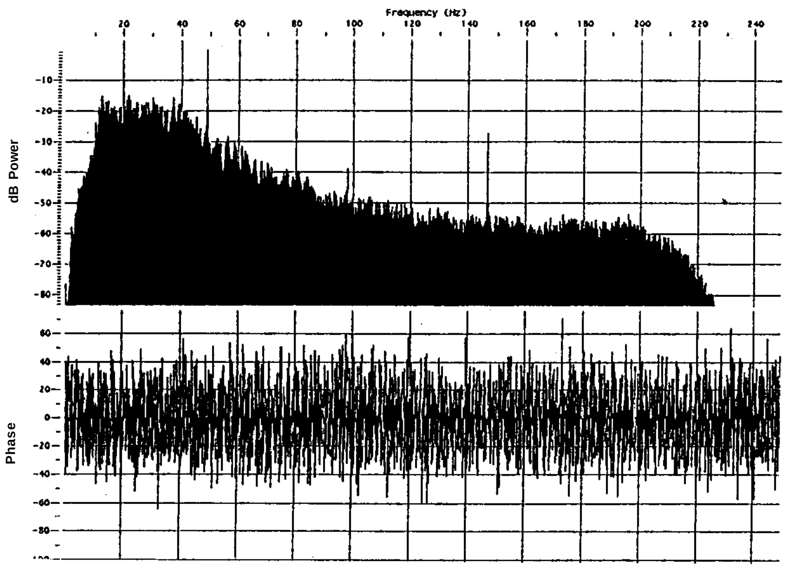

Figure 4. Amplitude and Phase spectrum (Trace 95,350 kg charge).

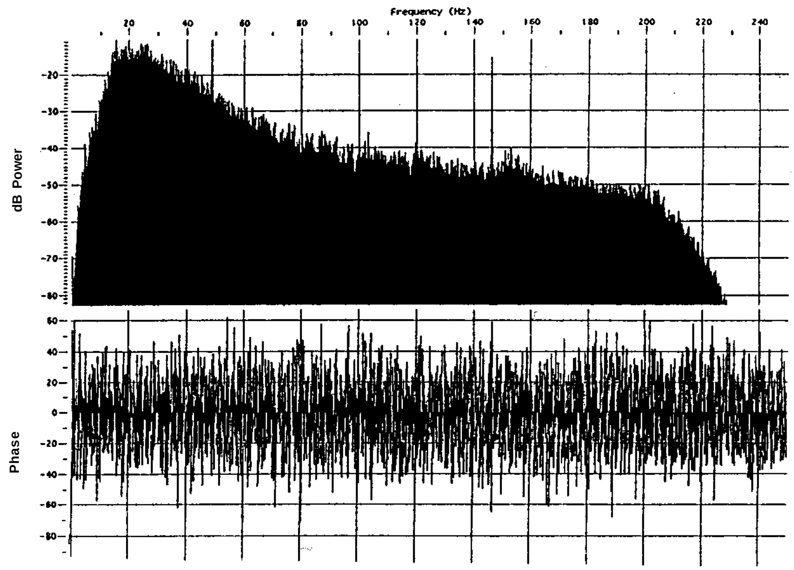

Figure 5. Amplitude and Phase spectrum (Trace 95,600 kg charge).

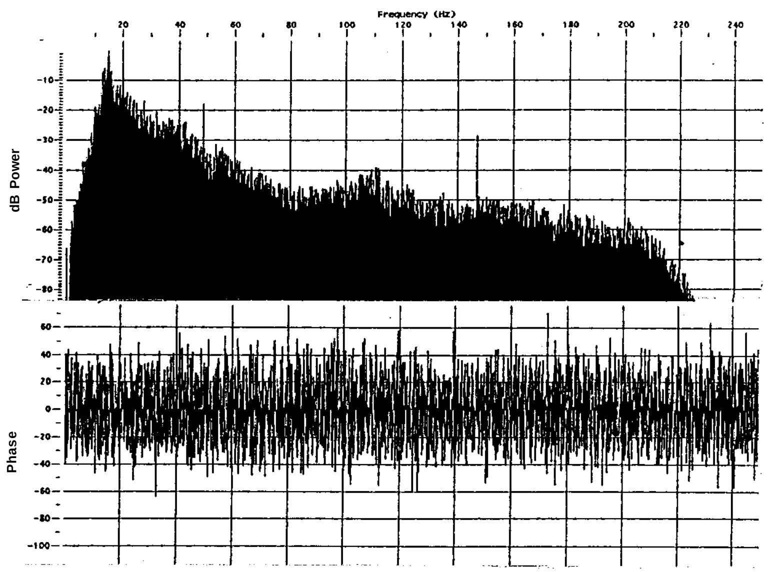

Figure 6. Amplitude and Phase spectrum (Trace 115,350 kg charge).

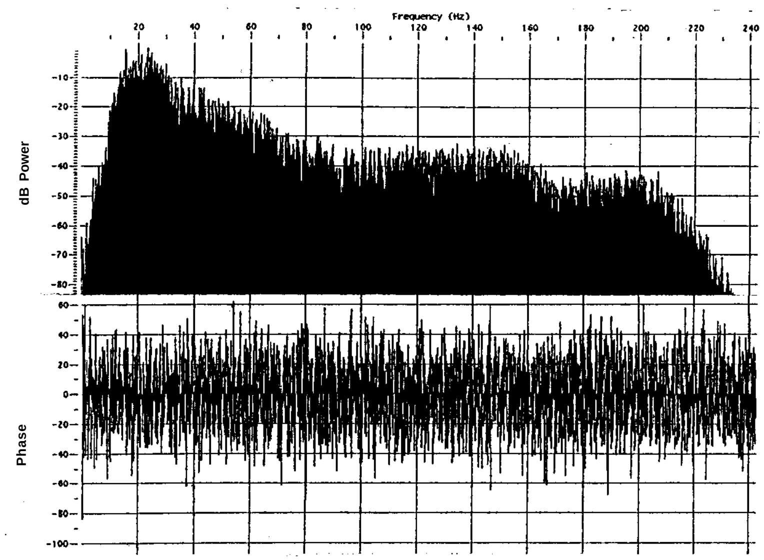

Figure 7. Amplitude and Phase spectrum (Trace 115,600 kg charge).

The shots were fired almost at same location and at an average depth of 23 mts below the weathered layer and water table, to place the source at similar geological environments. In both the cases, the trace signatures correspond to each geophone station are different due to different source volume injection functions, inspite of having similar impulse response (Figs 2 and 3). The seismograms are processed on Promax 2003 for the study.

It is a known fact that at a given receiver, the response to a particular shot is convolution of source signature with the impulse response of the earth, plus noise. To maintain the cultural noise minimal, relatively noise free traces are considered for the amplitude study by applying band pass filter (5 -25 Hz).

The signatures of average trace amplitude and its decay (Figs 2 and 3) show that the amplitude attenuation is relatively high towards farther traces in the record corresponds to 350 kg charge size.

Two noise free and unfiltered traces, 95 and 115 are considered for comparative amplitude and phase spectra study (Figs 4 to 7). Attenuation upto 10 to 20 db in the band of 10-30 Hz is evident and it is almost maintained towards high frequency range in the record corresponding to 350 kg charge. However in both the cases, the significant phase variation is within the tolerance limits (0^0 to $\pm 20^0$).

CONCLUSIONS

The amplitude standout of seismic events generated by different charge sizes of dynamite looks almost alike for naked eye. However the spectral study indicates trace amplitude of 600 kg shot is considerably high and it is maintained for farther traces as well. The frequency spectrum shows attenuation in range of prime frequency components (10-30 Hz), in the record of 300 kg charge.

These observations clearly bring out that, detonating considerably higher charges generate seismic signatures with clear amplitude standout especially in trap-covered areas. Spectral studies of such experimental records / record sections can be used as decisive tool for selecting the parameters of any seismic survey.

ACKNOWLEDGEMENTS

We thank Dr.V.P.Dimri, Director, NGRI, for his constant encouragement and guidance and for permitting this publication. We also thank Mr.S.Raju, Scientist for his involvement and other colleagues for help in acquiring the data. Thanks are due to Mr. Shankaraih, T.O. for preparing the drawings.

REFERENCES

Catchings, R.D. & Mooney, W.D., 1988. Crustal structure of the Columbia Plateau: Evidence for Continental Rifting, J.Geophy.Res. 93 (B1),459-474.

Fhedner, M.M. & White, R.S., 1999. Using wide - angle seismic data for basalt and subbasalt imaging, Abstract presented in 1999 "Society of Exploration Geophysicists", Tulsa, Oklahoma, USA.

(Accepted 2003 June 10. Received 2003 June 8; in original form 2003 May 30)