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Preliminary Regional Magnitude Results in the Middle East Region Using Narrowband *Lg* Coda Envelopes

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ABSTRACT:

Because many regional seismic discriminants are functions of magnitude, it is important to obtain a stable measurement especially for smaller events that will likely have very limited station coverage. We have collected and analyzed regional broadband waveforms from stations in the middle east region for the purpose of calibrating a stable regional magnitude scale that can be applied to events that are too small to detect teleseismically. Our approach is to obtain frequency-dependent empirical Green's function coda envelopes for narrow frequency bands that can be used to correct for gross path effects. We make the assumption that the moment-rate spectra are generally flat below ~2 Hz for these events smaller than *Mw*~3.5. In a least squares sense, we obtain frequency-dependent corrections to the *Lg* coda measurements to fit the scalar moment estimates. These frequency-dependent corrections remove the effects of the *S*-to-*Lg* coda transfer function, thus correcting back to the *S*-wave source spectra. Due to the averaging nature of *Lg* coda waves we are then able to obtain a stable single-station estimate of the source spectra. To avoid regional biases we tie our coda envelope amplitude measurements to seismic moments obtained from long period 1-D waveform modeling for moderate sized earthquakes (*Mw*~3.5.-4.5). Most importantly, we can now apply the same corrections to significantly smaller events that cannot be observed teleseismically. Our empirical approach takes into account scattering, absorption, and waveguide losses as well as frequency-dependent site effects. Moreover, the use of the coda envelope mitigates the undesirable effects of source anisotropy, random site interference, path variability, and directivity that plague direct wave measurements. This approach was successfully applied to other regions where it was observed that the coda-derived *Mw* estimates showed significantly smaller dependence on lateral path variation and source radiation anisotropy than the more conventional approaches such as $m_b(Pg)$, $m_b(Lg)$, and teleseismic m_b.

Key Words: regional magnitude, *Lg* coda, discrimination

OBJECTIVE:

The goal is to find a method of obtaining a stable magnitude from as few as one station for small-to-moderate sized regional events. Because direct waves are sensitive to geologic structure between source and receiver as well as source radiation pattern, this requires multiple-station averaging to eliminate these undesirable effects. Scattered waves (Coda) average over the lithosphere's small-scale features as well as any source radiation pattern using only one station.

RESEARCH ACCOMPLISHED:

We focused primarily on ABKT recordings of moderated-sized regional events that occurred in the Zagros Range in Iran. The epicentral distances to ABKT were generally around 1000 km. Four of these events were also recorded at station GNI in Armenia, also roughly 1000 km away. All of the events had globally averaged teleseismic m_b values from the USGS NEIC catalog. We first obtained event-averaged empirical Green's function envelopes for the region for narrow frequency bands ranging between 0.05 and 3 Hz (*e.g., Hartse et al.,* 1995). We then corrected for frequency-dependent path and site effects and calibrated against independent moment estimates. (See *Mayeda and Walter*, 1996, for details of the method).

Figure 1 shows coda-derived *S*-wave source spectra for events recorded at ABKT after all path corrections were performed. Estimates of Mw were obtained from the long-period spectral levels and are compared with teleseismic (CMT) and regional waveform modeling results in Figure 2a. As was found for the western United States (*Mayeda and Walter*, 1996), regional coda magnitudes in this region using a single station are in excellent agreement with network-derived estimates. In addition, inter-station variability is also shown to improve when using the coda spectra. Figure 3 shows that $m_b(Pg)$ measured at ABKT and GNI for common events are considerably more variable than Mw (coda), similar to results from the western United States. With these preliminary path and site calibrations we can now obtain stable estimates of moment and m_b for events that are too small to be recorded teleseismically or at multiple regional stations. This will be essential for low magnitude regional monitoring since a number of regional discriminants are functions of magnitude.

In addition to magnitude estimation, the coda derived source spectra can be used to identify very shallow (< ~2 km) and deep (> ~60 km) events. *Mayeda and Walter* (1996) found that NTS explosions, near-surface mine collapses, and very shallow earthquakes exhibited a pronounced spectral peak between ~0.2 to 0.8 Hz (Figure 4). This is likely a result of surface excitation that scatters into the coda in this pass band. For deep earthquakes in the Hindu-Kush region we also found peculiar spectral shapes, where the low frequencies are greatly diminished relative to the high frequencies (> 1 Hz). In this case, due to the large depth, surface wave excitation is diminished rather than enhanced as was found for the case of shallow sources.

CONCLUSIONS:

The coda methodology for source spectra and magnitude estimation has been successfully applied to the western United States as well the Korea/Yellow Sea region. Our preliminary results for the middle east region, specifically Iran, shows that the methodology is transportable, providing a means of obtaining stable, single station estimates of small-to-moderate sized regional events. A stable, accurate magnitude is necessary because some regional discriminants are functions of magnitude (*e.g., Walter et. al.,* 1995; *Hartse et. al.,* 1997).

References

Hartse, H., S.R. Taylor, W.S. Phillips, and G.E. Randall, (1997). A preliminary study of regional seismic discrimination in Central Asia with an emphasis on Western China, *Bull. Seism. Soc. Am.* **87**, 551-568.

Hartse, H., W.S. Phillips, M. C. Fehler, and L.S. House, (1995). Single-station spectral discrimination using coda waves, *Bull. Seism. Soc. Am.* **85**, 1464-1474.

Mayeda, K., and W. R. Walter, (1996). Moment, energy, stress drop, and source spectra of western United States earthquakes from regional coda envelopes, *J. Geophys. Res.,* **101**, 11195-11208.

Walter, W. R., K. Mayeda, and H. J. Patton, (1995). Phase and spectral ratio discrimination between NTS earthquakes and explosions, 1, Empirical observations, *Bull. Seismol. Soc. Am*, *85,* 1050-1067.

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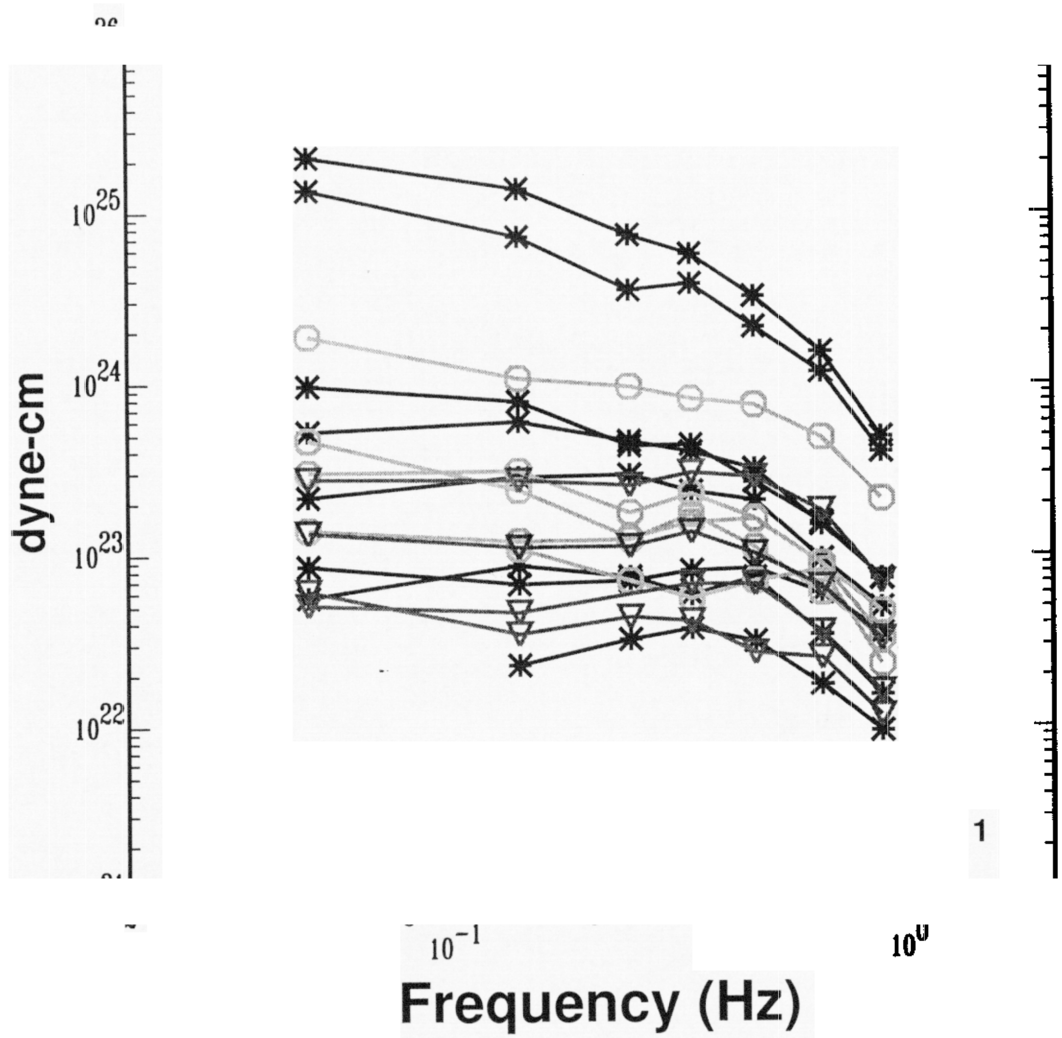


Fig. 1 We have collected regional, moderate-sized earthquakes located by the NEIC that were recorded at stations ABKT and GNI. Moments from the Harvard CMT catalog as well as moments derived from long-period regional waveform modeling were used to calibrate the coda-derived S-wave source spectrum. Our single-station moment estimates from our spectra agree very well with network averaged results. In addition, we used the higher frequencies (0.6-0.9 Hz) to derive a regional m_b scale that agrees well with the globally derived teleseismic USGS NEIC m_b. Above are coda-derived source spectra for events in the central Zagros (stars), north Zagros (circles) and Makran (triangles) regions of Iran ranging between m_b 4.3 and 6.0. All are roughly 1000 km from station ABKT.

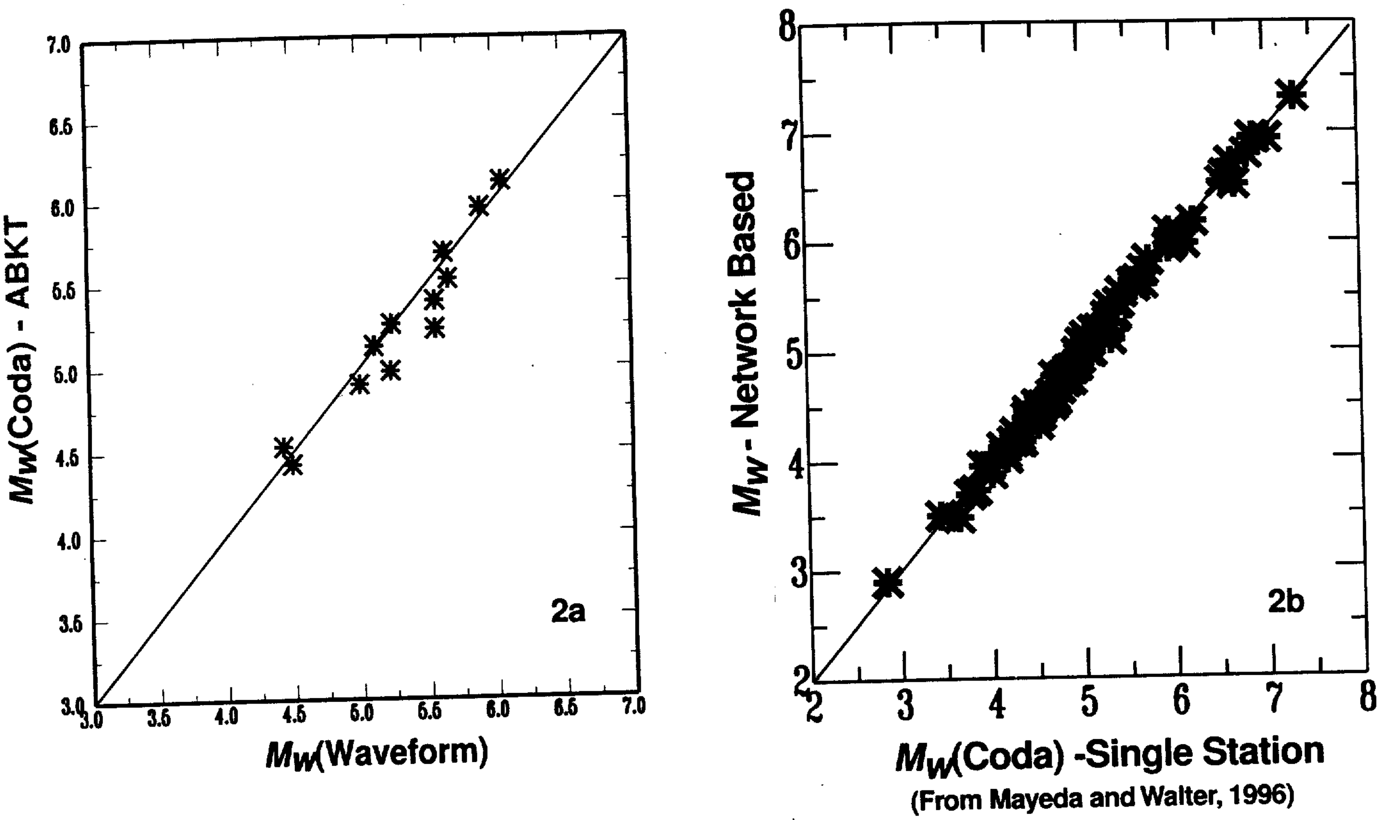


Fig. 2 Single station Mw estimates in Iran (fig. 2a) are comparable to results from the western United States (fig. 2b)

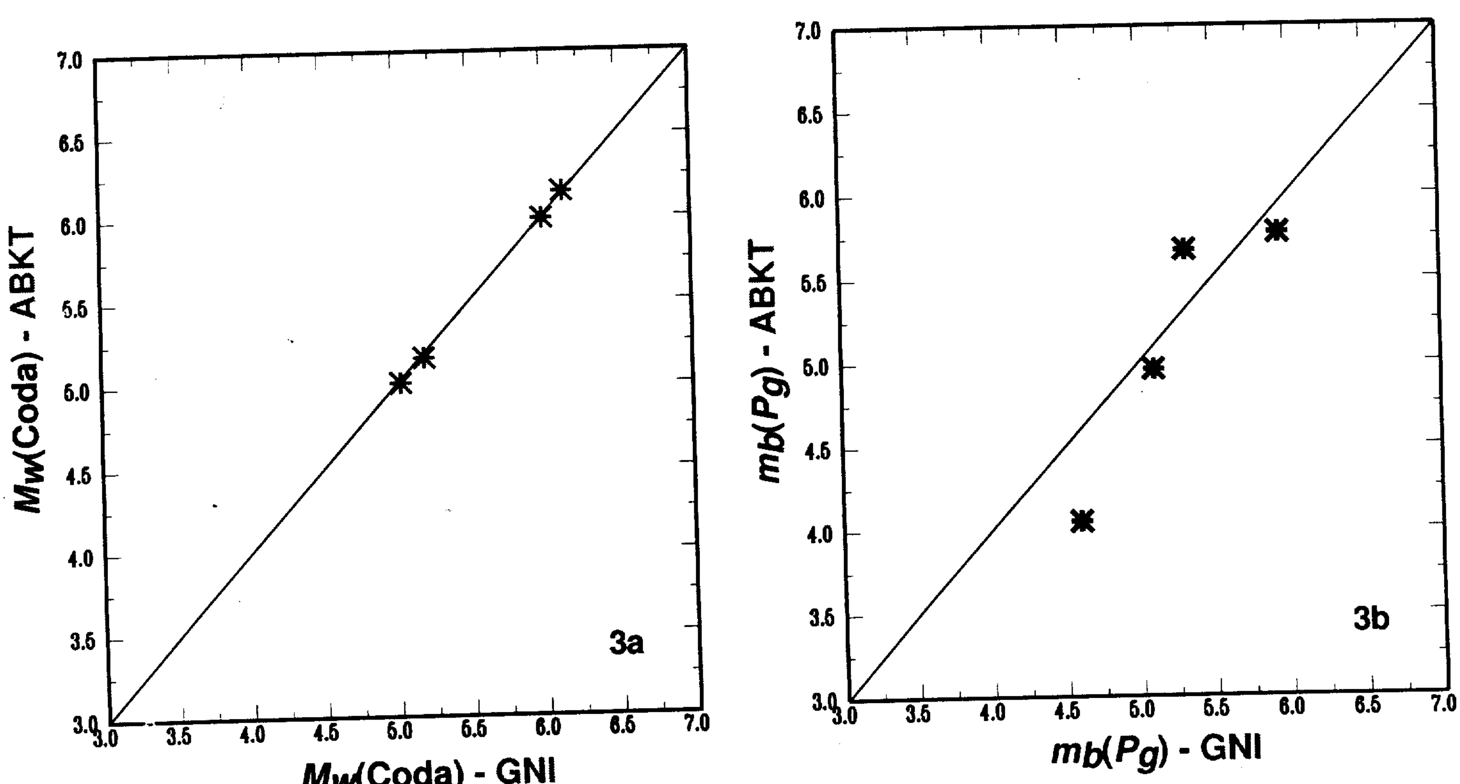
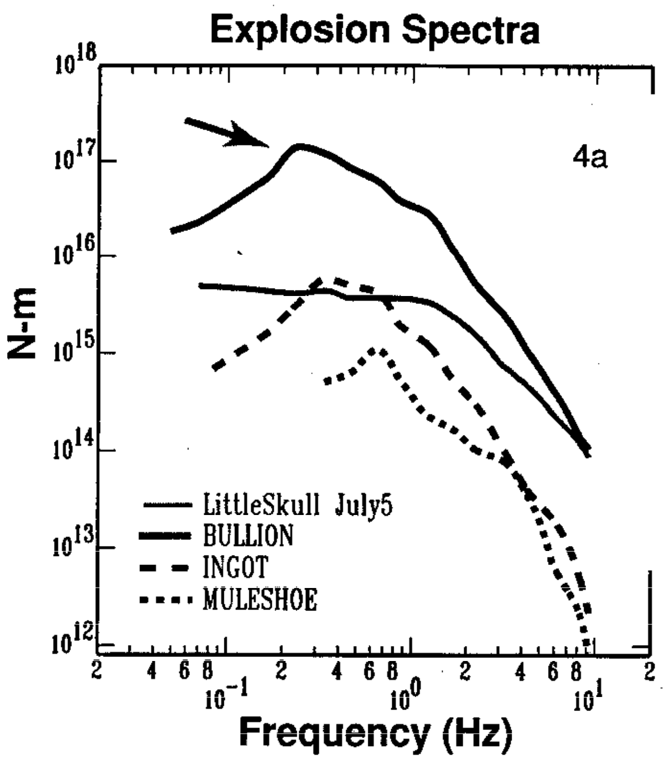


Fig. 3 Interstation variation using the coda (fig. 3a) is much less than magnitudes based on direct phases such as Pg (fig. 3b)



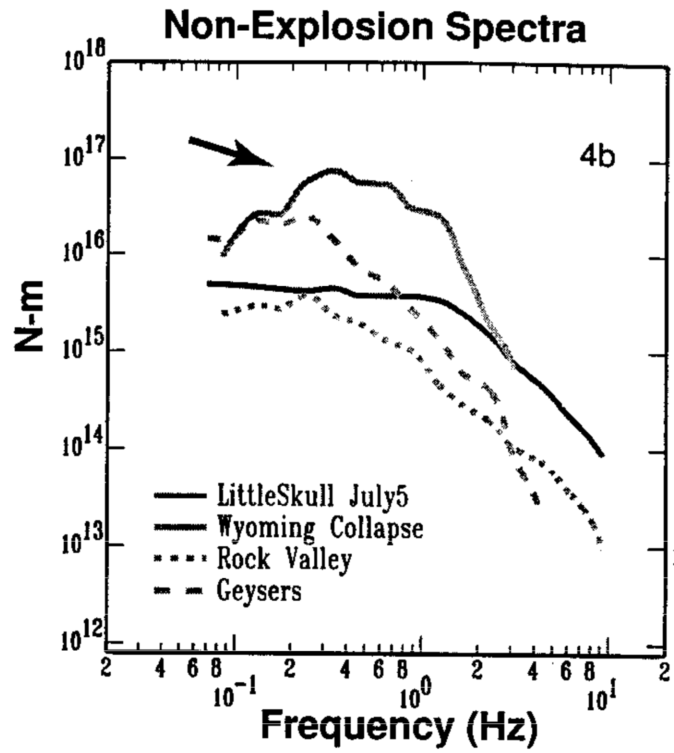


Fig. 4a. NTS explosions have a pronounced spectra peak relative to an NTS earthquake.

Fig. 4b. Minining collapse events and shallow earthquakes also exhibit peaking.

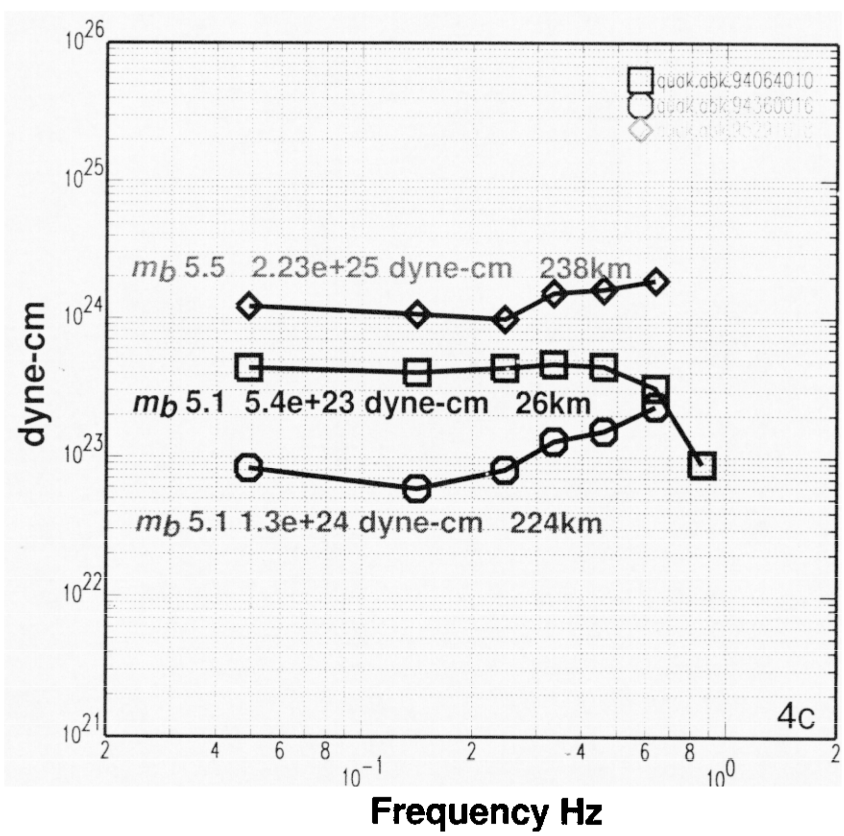


Fig. 4c. Two deep Hindu-Kush events are compared with a normal depth event from the same region(□). The two deep events are deficient in low-frequency energy.

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