

**Propagation of Regional Phases
in Southern Asia and the Middle East**

B. J. Mitchell and Y. Pan
Department of Earth & Atmospheric Sciences
Saint Louis University

Contract No. F19628-95-K-0004
Sponsored by DOE

ABSTRACT

New Lg coda Q values have been determined for Iran using the stacked spectral ratio method. These, combined with values obtained earlier by Ghalib (1992) in the Arabian peninsula and by John (1983) in India, allow us to extend Lg coda Q coverage through much of southern Asia and the Middle East. With the exception of the Indian shield, Q is low throughout all of the region of study. Lg coda Q in the Indian shield is about 1000 but observed values decrease rapidly with distance to the north and west of the shield, being as low as 200 in Pakistan. Lg coda Q is low throughout all of the Middle East with values ranging between about 150 and 300. That variability may be partly due the lateral structural complexity of the region. Portions of some scattering ellipses for the Lg coda data overlap oceanic regions (the Red Sea and the eastern Mediterranean Sea), a situation that has been shown to systematically affect Lg coda Q measurements. We plan to incorporate these Lg coda Q results into inversions of fundamental-mode Rayleigh wave attenuation to obtain frequency-dependent models of shear-wave internal friction for various regions of the Middle East.

Key words: Lg, Lg coda, Q, attenuation

19960624 115

OBJECTIVE

The overall objective of this project is to characterize the efficiency of propagation of regional seismic phases across a broad region extending from India in the east to Turkey and the eastern Mediterranean in the west. Countries in this region include India, Pakistan, Iran, Iraq, Saudi Arabia, Syria, Jordan, Israel, Lebanon, and Turkey. The efficiency of propagation there is likely to be poor, both because intrinsic anelasticity of the crust is low almost everywhere, and because the structure is laterally complex. The number of published studies on seismic wave propagation in that region are still very few. We are studying attenuation over a broad frequency range between about 0.02 and 20 Hz or higher, thus providing information which can be used to ascertain which frequencies will be best for detection and discrimination of small seismic events. In addition to measuring the attenuation of various seismic phases, we will invert surface wave data (in about the 0.02-0.2 Hz range) in selected sub-regions to obtain models of crustal Q and use those models to predict the attenuation of several regional phases at frequencies between 1 and 20 Hz or more. We will compare the attenuation of those predicted phases with corresponding observed phases to determine if attenuation along various paths is due to intrinsic Q or to damping produced by lateral complexities in crustal structure.

PRELIMINARY RESEARCH RESULTS

In order to complete our map of Lg coda Q for Eurasia (Pan, *et al.*, 1992), we have collected seismograms for several paths across the Middle East. We found that many of the seismograms are unusable because the attenuative properties in this region are so high that Lg coda is almost entirely obliterated before it reaches the recording station. We found, however, well-recorded coda for several relatively short paths across Iran. These produced coda Q values of about 200 using the stacked spectral ratio method of Xie and Nuttli (1988).

We have also incorporated the Lg coda Q values of John (1983), for India, and of Ghalib (1992), for the Arabian Peninsula, into our data base. This has allowed us to expand coverage of Lg coda Q to include those regions. Figure 1 displays the scattering ellipses (for a time window late in the coda) for the coda we have studied. For each source-station pair, the source is at one focus and the recording station is at the other focus of the ellipse. Inversion of the measured Lg coda Q values using the tomographic method of Xie and Mitchell (1990a) leads to a new map of regionalized Lg coda Q for Eurasia. The new results indicate that Lg coda Q is about 1000 in the Indian shield but decreases rapidly to both the north and west of the shield. Lg coda Q is very low throughout all of the Middle East, ranging between about 150 and 300. Individual measurements of Lg coda Q are highly variable, even for nearby paths, probably because of the lateral structural complexity of the region. Both the Red Sea and the western end of the Mediterranean Sea lie near the shield and probably bias the Lg coda Q results for some paths. A similar phenomenon was observed by Xie and Mitchell (1990b) in the western United States for paths in which scattering ellipses significantly overlapped the Pacific basin.

The results obtained in the Middle East are consistent with the conclusion of Mitchell (1995) that the degree of seismic attenuation is proportional to the time which has elapsed since the last period of intense tectonic activity in a region. It does not appear to be affected by the age of formation of continental rock. This is especially well illustrated by the Arabian shield where the rocks are of Precambrian age but the region has undergone extensive recent deformation that causes low Q values.

RECOMMENDATIONS AND FUTURE PLANS

We plan to combine the 1-Hz Lg coda Q results with wave attenuation measured for fundamental-mode Rayleigh waves in various parts of the Middle East. The models that result from this process should provide information on how crustal Q varies with depth and with frequency in this complex region.

Because of the complexity of this broad region, it is likely that we will not be able to obtain a one-dimensional model which satisfies all of the data which we hope to collect. In particular, the margins of the Mediterranean and the Red Sea rift may distort or extinguish seismic phases which traverse them. We have tentative plans to install temporary broad-band seismic stations on Cyprus and near the Red Sea to evaluate the degree to which those features affect regional seismic wave forms.

REFERENCES

- Ghalib, H.A.A., Seismic Velocity Structure and Attenuation of the Arabian Plate, Ph.D. Diss., Saint Louis University, 313 pp., 1992.
- John, V., Coda-Q Studies in the Indian Subcontinent, M.S. Thesis, Saint Louis University, 99 pp., 1983.
- Mitchell, B.J., Anelastic structure and evolution of the continental crust and upper mantle from seismic wave attenuation, *Rev. Geophys.*, in press, 1995.
- Pan, Y., B.J. Mitchell, J. Xie, and J. Ni, Lg coda Q across northern Eurasia, in Proc. 14th Ann. PL/DARPA Seismic Research Symp., Rpt. No. PL-TR-92-2210, 311-317, 1992, ADA256711.
- Xie, J., and O.W. Nuttli, Interpretation of high-frequency coda at large distances: Stochastic modeling and method of inversion, *Geophys. J.*, 95, 579-595, 1988.
- Xie, J., and B.J. Mitchell, A back-projection method for imaging large-scale lateral variations of Lg coda Q with application to continental Africa, *Geophys. J. Int.*, 100, 161-181, 1990a.
- Xie, J., and B.J. Mitchell, Attenuation of multiphase surface waves in the Basin and Range province, Part I: Lg and Lg coda, *Geophys. J. Int.*, 102, 121-137, 1990b.

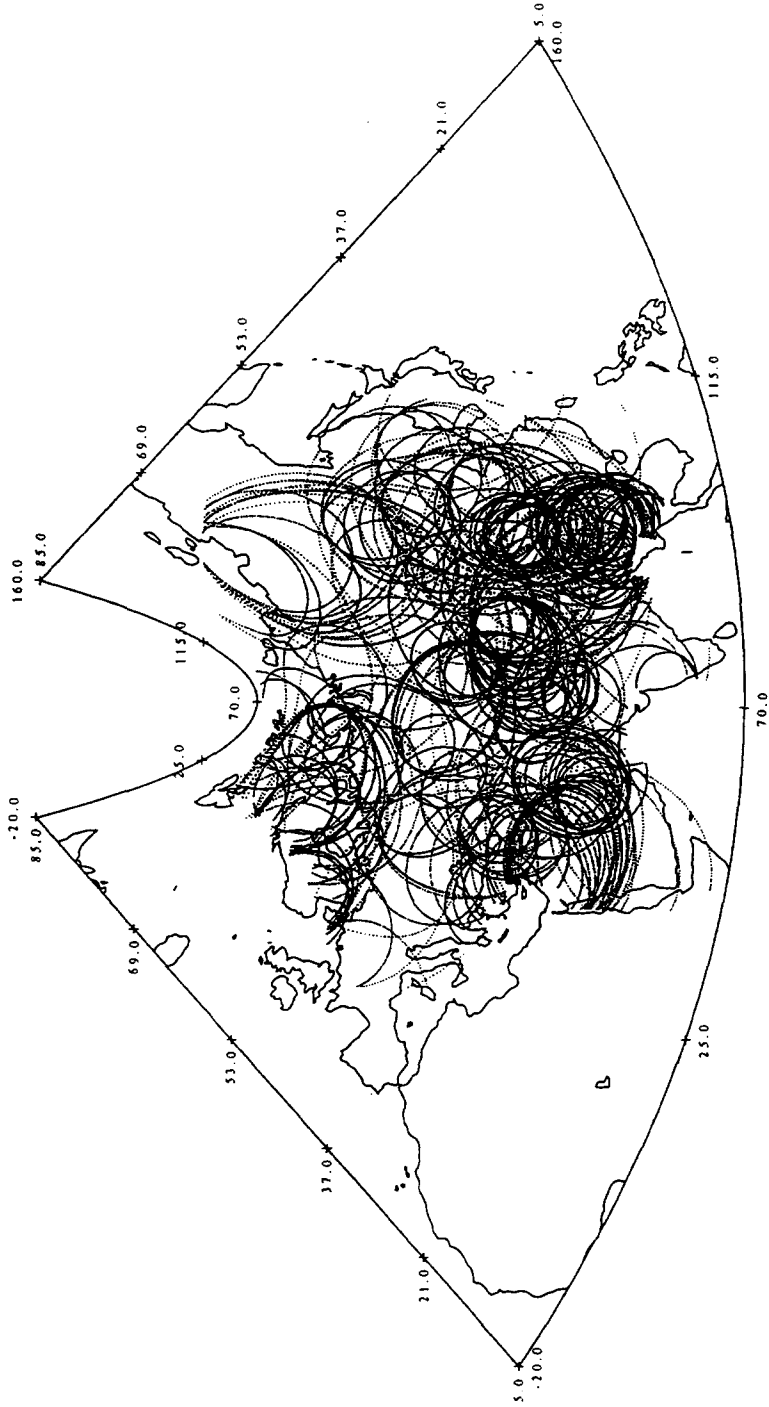


Figure 1. Scattering ellipses for all source-station pairs used to construct the Lg coda map in Figure 2.

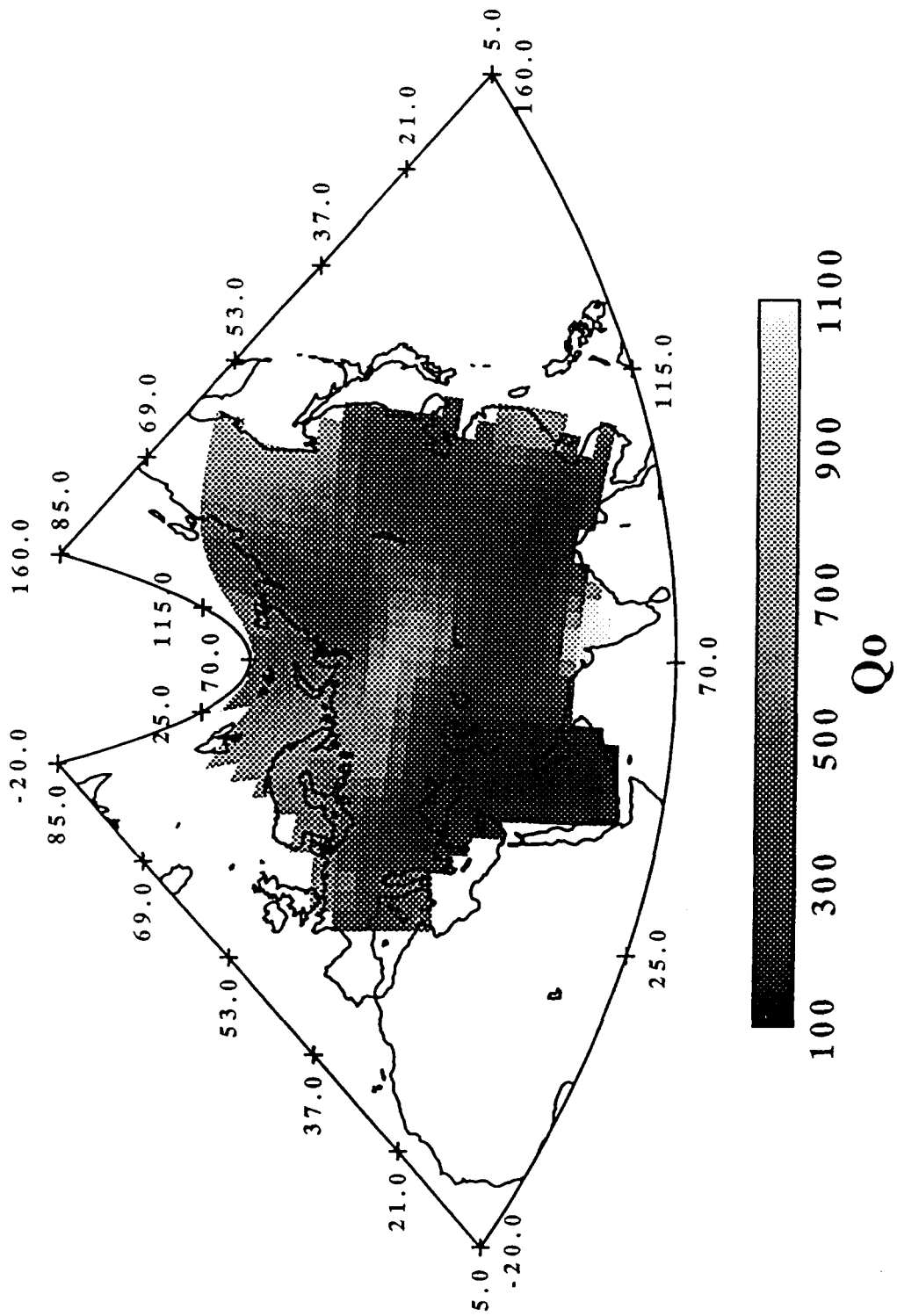


Figure 2. New Lg coda Q map of Eurasia at frequencies near 1 Hz.