Seber, D., Barazangi, M., Tadili, B., Ramdani, M., Ibenbrahim, A., and Ben-Sari, D., *Three-dimensional upper mantle structure beneath the intraplate Atlas and interplate Rif mountains of Morocco*. Journal of Geophysical Research, 101, 3125-3138, 1996.

Copyright 1996, American Geophysical Union.

Abstract:

We integrate observations based on teleseismic *P* wave travel times and available geologic data to infer that the lithosphere beneath the intraplate Atlas mountains is thin and/or it is characterized by lower *P* wave velocities, while beneath the interplate Rif mountains and the adjacent Alboran Sea a previously thickened lithosphere has been delaminated into the upper mantle. Using surface geology and geochronology data, previous studies have proposed that lithospheric delamination took place in this region. In this study we show through analysis of teleseismic *P* wave residuals the existence of a high velocity (>3%) upper mantle body, which is interpreted to be the delaminated, rigid lithosphere. This high-velocity layer is overlain by a very low velocity uppermost mantle material replacing the delaminated lithosphere. Teleseismic *P* waves recorded by a recently installed digital seismic network and an older analog network in Morocco provide the residuals database. A total of 734 *P* wave residuals from 92 selected teleseismic earthquakes are used to document the spacial pattern of upper mantle velocity structure beneath northern Morocco and the Alboran Sea. Subsequent use of these residuals in a tomographic inversion scheme produced a three-dimensional velocity image of the upper mantle. We infer from the *P* residuals that strong upper mantle velocity anomalies exist beneath both the Rif and Atlas regions. The Rif stations show negative residuals (- 1-1.5s) for ray paths from the east and northeast and show positive residuals (~ 1-1.5s) for raypaths from the northwest and southwest. Tomographic results indicate the existence of a high-velocity body (~ 3% higher velocities) in the upper mantle beneath the eastern Rif and Alboran Sea, extending approximately from subcrustal depths down to a depth of at least 350 km. In the western Rif, however, 1-2% lower velocity material is imaged in the upper mantle. The residuals of the Atlas stations also show azimuthal variations. In general, most of the *P* waves that travel beneath the High and Middle Atlas have about 0.5-1.0s delays. In contrast, the rays that travel beneath the northwestern margin of the Atlas mountains and the adjacent Moroccan Meseta area show negative residuals (~1s), suggesting that higher velocity material exists beneath the platform area adjacent to the Atlas mountains. Tomographic results indicate that beneath most of the Atlas system the uppermost mantle has about 1% lower velocities. Beneath the Alboran Sea region, however, reported low uppermost mantle *P_n* velocities contrast strongly with higher velocity upper mantle velocities obtained by our analysis. Low-velocity uppermost mantle beneath the Alboran Sea underlain by a high-velocity upper mantle material is used to support earlier interpretations of lithospheric delamination beneath the Rif and Alboran Sea Regions. The enigmatic occurrence of subcrustal earthquakes in these regions is also consistent with this active delamination mechanism.

Figure 11. A schematic representation of the interpreted cross section across the Atlas and Rif/Betic regions. This interpretation is meant to show a gross upper mantle structure based on analysis of teleseismic residuals. Lithospheric thinning beneath the Atlas is inferred from the positive residuals. Beneath the Rif and Alboran Sea regions teleseismic P wave residuals and tomographic inversion results show that high-velocity material exists in the upper mantle. Very low P_n velocities in the uppermost mantle are overlain by high-velocity upper mantle material. In a recent study *Seber et al.* [1996] discussed the occurrence of intermediate-depth earthquakes beneath the Alboran Sea and surrounding regions and the presence of a seismic gap in the uppermost mantle beneath the Alboran Sea region.