RCL	NARS-Baja: A Five-Year Deployment of Broadband Seismic Instruments Around the Gulf of California	
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NARS-Baja fills a gap in broadband station coverage in California and southern Mexico. Pooled with stations from the Berkeley Digital Seismic Network (BDSN), TriNet (Caltech), and the UNAM Array in southern Mexico, it will provide extensive coverage of the entire North American Plate Boundary. NARS-Baja will provide an important seismic data set for RCL research:

- 5+ year operation will ensure collection of a large data base of waveform data, and operation in conjunction with the planned OBS experiment in the Gulf of California (Gaherty and Collins, PIs), and deployment of EarthScope/U.S. Array in the western US.
- Data will be available to any interested researcher through IRIS and the SCEDC Data Centers immediately after the data have been collected and checked.

There are only a few constraints on the role of the mantle in the heterogeneous deformation processes that may be central in the formation of the Gulf of California rift, but there are no models that provide a regional perspective of structural heterogeneity (though recent seismic studies indicate a stark contrast in lithospheric thickness across the eastern Mohave shear zone [Melbourne and Helmberger, 2000], and show deep-seated low velocity structures in parts of the Basin-and-Range [e.g. Song et al., 2003]). Global seismic models indicate anomalously low seismic velocities in the uppermost mantle beneath the East-Pacific Rise, Gulf of California, and the western US (e.g. Grand and Helmberger, 1984; Su et al.,1994; Ritsema et al., 1999; Megnin and Romanowicz, 2000). However, their intrinsic 1000km scale lateral resolution is not high enough to show whether the systematic variation in western North America deformation style (e.g. rapid sea-floor spreading along the EPR, oblique rifting in the Gulf of California, and Basin-and-Range extension in the western US) is due to mantle structure heterogeneity.

- Tomographic and forward modeling studies will use the NARS-Baja network alongside long-term network stations in southern Mexico (UNAM) and California (TriNet and the Berkeley Digital Seismic Network); and the Earth Scope/U.S. Array once available (planned to be within a few years), to attain an order of magnitude increase in model resolution of crust and mantle across the entire North American Plate Boundary region (cf. Fig. 2).
- Distribution of NARS-Baja stations on both sides of the Gulf of California rift (Fig. 1) is ideal for studying seismicity and earthquake faulting processes. Systematic earthquake location allows identification of active faults in the Gulf of California region. Focal mechanisms are pivotal for confirming the direction of plate motion and likely orientation of transform faults.

On average, 6 Mw 4.5+ southern and central (22°N – 28°N) Gulf of California earthquake epicenters are recorded in the NOAA/PDE catalog annually, but only 14 Mw 3+ events. By empirical relationships, at least 60 Mw 3+ events should be expected, but Mw 4- events are poorly recorded by distant (>1000km) seismic stations. Locating these small events is important for identifying active tectonic structures where thick sediment cover masks bathymetric/seismic reflection structure.

- NARS-Baja will detect and locate small earthquakes throughout the Gulf of California region. Experience with the TriNet network in southern California (Kanamori et al., 1997), suggests that we will be able to record all Mw 3.5 earthquakes with high SNR at 5+ stations, giving a 15-km precision. In the northern Gulf of California region, where the seismic station density is highest, relative locations can be estimated to as accurately as within a few kilometers through cluster analysis (e.g. Richards-Dinger and Shearer, 2000).

- Recently, cluster analysis using an E-W profile of seismic stations deployed in northern Baja California (Lewis et al., 2001), showed gradual crustal thickening from 15km in the Gulf of California to ~40km Moho depth beneath the western Peninsular Ranges. NARS-Baja data can constrain Moho depth at each station with comparable vertical accuracy.
- P. Persaud (Persaud et al., 2003; AGU Fall Meeting abstract) has computed receiver functions with the NARS-Baja recorded so far (Fig. 3). Her study indicates that coastward crustal thinning occurs along the entire length of the Baja peninsula, and that the crust beneath the Sonora side of the Gulf of California is as thick as that beneath the Baja-California peninsula. These crustal thickness estimates will get more precise, since more recordings (especially for the recently deployed Sonora stations) are being archived.

Receiver-function analysis can image crust and mantle seismic reflectors (e.g. Owens et al., 1984); especially the Moho depth, where the material contrast is large. Precise depth estimates of deeper discontinuities can be obtained from P-S converted ('P coda') phase arrivals:

- Receiver functions feature large-amplitude P-to-S converted phases that have encountered seismic discontinuities due to the 410km olivine-to-spinel transition and 660km the spinel-to-perovskite transition (Fig. 4; e.g. Vinnik et al., 1983; Gurrola and Minster, 1998). Variation in the depth of these discontinuities is an excellent indicator of mantle transition zone thermal anomalies because the mineralogical phase transition is P and T dependent.
- Figure 4 shows that the Gulf of California uppermost mantle may contain more reflectors. Station NE76 receiver functions, in particular, show high-amplitude arrivals ~20-25s after the direct P phase. While we must fully investigate how significant multiple crustal phases affect the receiver function, it is possible that some of these signals are due to the presence of the Farallon slab in the mantle. We can distinguish crustal multiples from deeper mantle reflections by measuring the slowness of the high amplitude arrivals with high precision (via slant stacking). The relatively large aperture of the NARS-Baja will facilitate this.

Original figures, captions, and narrative by J. Ritsema, Mar. 2004.

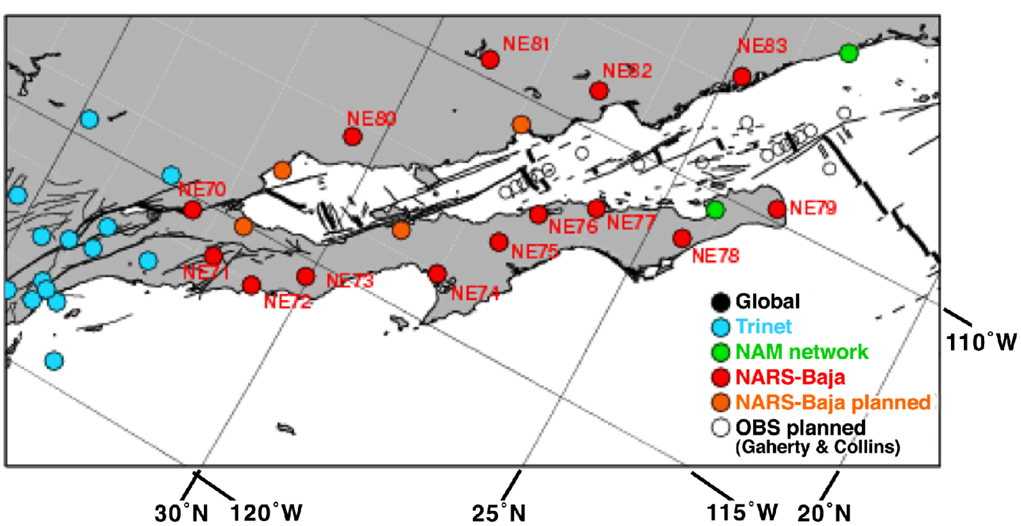

Figure 1. Map of the NARS-Baja seismic network.

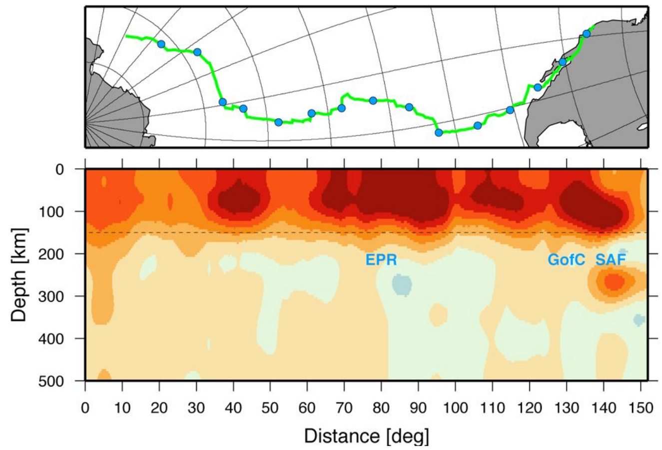

Figure 2. Shear velocity perturbation from PREM in the mantle according to global model S20RTS beneath the East Pacific Rise (EPR), the Gulf of California rift (GofC), and the San Andreas Fault (SAF). The cross-section follows the green line shown in the map. While the model indicates that the uppermost velocities are anomalously low in the uppermost mantle of western North America, its inherent 1000km (~10 deg) lateral resolution is too poor to elucidate changes in mantle structure that can be related to variable deformation processes.

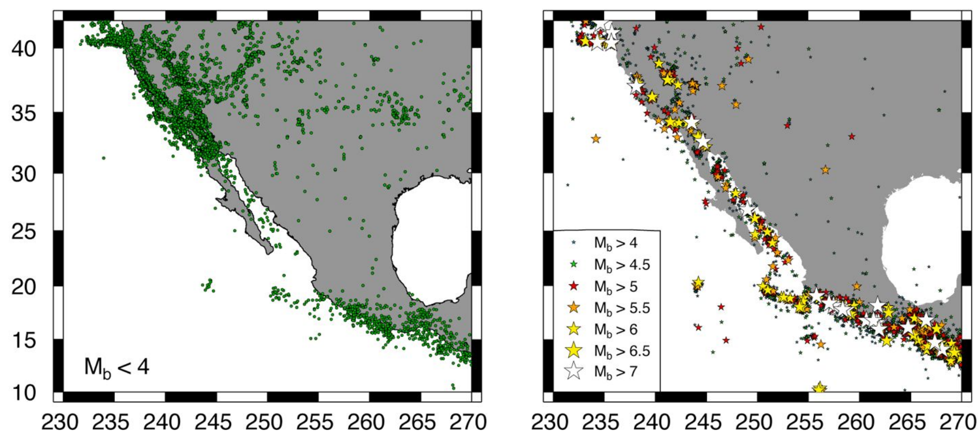

Figure 3. 1978-1999 earthquake epicenters from NOAA/PDE earthquake location bulletins. Shown on the left are <Mw 4 events; on the right are >Mw 4 events. The apparent low number of Gulf of California region moderate-size events is likely due to the lack of seismic instruments in this region.

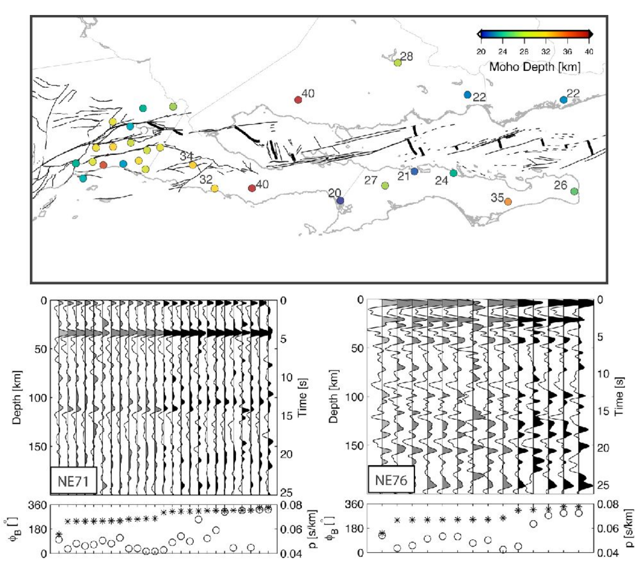

Figure 4. (Top) Crustal thickness estimates at each of the NARS-Baja stations inferred from receiver function analysis (Persaud et al., 2003). (Bottom) Receiver functions at stations NE71 (~34km thick crust) and NE76 (~21km thick crust) demonstrate that the difference in crustal thickness at these stations can readily be inferred from the travel times of the high-amplitude P-to-S signal that arrives within 5s after the main P pulse. The receiver functions clearly show that the mantle beneath these stations has a different reflectivity. (courtesy of P. Persaud, Caltech)