Pn tomography at the intersection of the Rio Grande rift and Jemez Lineament

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Introduction

Geologic Setting

The Rio Grande rift is one of the major active continental rift zones in the world and exists between two tectonic provinces of the US; the Great Plains and the Colorado Plateau. It extends from central Colorado, through New Mexico, and into northern Mexico. The rift has been spreading intermittently for 36 m.y. and has produced several types of volcanism. In the past 5 m.y. most volcanism has occurred along a north-east trending lineation referred to as the Jemez Volcanic Lineament.

Project

Between 1999 and 2001, two separate regional teleseismic studies were carried out in the southwest US. The LA RISTRA and CD-ROM projects each included a linear array of several hundred kilometers across or adjacent to the Rio Grande rift. The deployments overlapped by 9 months. The synthesis of these data provides a unique opportunity to investigate the state of the mantle beneath the north-central rift.

Method

Inversion method

A total of 104 raypaths were measured between and along the two arrays. Though this is a relatively sparse collection of rays, the inter-station approach eliminates errors related to the earthquake source. After correcting for crustal structure, the traveltimes were inverted for isotropic P-wave velocity structure using a damped least-squares technique. Laplacian smoothing was used to force a smooth result. Damping and smoothing were adjusted to retrieve only the minimum detail necessary to satisfy the data.

Results

- Observed average Colorado Plateau Pn velocity exceeds 8.0 km/s.
- North-central Rio Grande rift is underlain by low velocity mantle: 7.6 - 7.8 km/s.
- Pn velocities of 8.1 km/s flank both sides of northern Rio Grande rift.
- Lowest observed Pn velocities in vicinity of Valles Caldera - the site of catastrophic caldera-forming silicic eruptions at 1.2 and 1.6 Ma.
- Mantle signature of rift widens considerably south of Albuquerque. This widening occurs in roughly the same location where the rift bifurcates into two rift valleys.
- Observed average Colorado Plateau Pn velocity exceeds 8.0 km/s.

Conclusions

- Colorado Plateau is underlain by high velocity mantle (>8.0 km/s). This supports other observations of a substantial cool lithosphere beneath the plateau.
- The Valles Caldera and vicinity appears to sit atop a region of mantle that is warmer than the adjacent rift. Velocities as low as 7.6 km/s are difficult to explain without the presence of small amounts of melt.
- The abrupt widening of the rift south of 34.5 degrees is mirrored by an increase in the width of the uppermost mantle low velocity zone. This suggests a correlation between the size of the mantle anomaly and the extent of rifting.
- Throughout the central and northern portions of the rift, the low velocity zone is wider than the surface manifestation of the rift, suggesting that the deformation in the mantle is broader than in the crust. Prior results in the south-central rift suggest this pattern continues into the southern rift as well.
- Our results are dominated by a low velocity region roughly coincident with the rift. No mantle feature traverses the rift beneath the Jemez Volcanic Lineament. The lowest velocities are found beneath the Valles Caldera.