Seismic Refraction Tomography Study of the Potrillo Volcanic Field in the Southern Rio Grande Rift: Opportunity for Collaboration Between Geosciences and Computer Science

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INTRODUCTION

On May 16-18, 2003, the geophysics group at the University of Texas at El Paso conducted a 2-D wide-angle seismic refraction/reflection experiment across a portion of the southern Rio Grande Rift centered on the Potrillo Volcanic Field (PVF). The PVF is perhaps best known for its rhyolitic lava flows at two main localities within the field, Hacita Hill and Potrillo Maar. The experiment is part of a joint project to study magmatic contributions to crustal evolution in an intracrustal setting using the southern Rio Grande Rift as a natural laboratory. A part of seismic treatments that were designed and built with funds provided by the Texas Higher Education Coordinating Board and the National Science Foundation were deployed by a team of about 35 student volunteers. The field work and data analysis was funded primarily by a grant from the Texas Higher Education Coordinating Board to UT-EP and Texas Tech University. Additional funding came from the National Science Foundation EAR (Continental Dynamics Group) and The El Paso Water Utilities.

BACKGROUND

The Rio Grande Rift is a major Tertiary tectonic feature that profoundly modifies the lithospheric structure of the southern Rocky Mountains of North America. Patterns of magmatism and deformational structures of the rift both crosscut and recast older structures including those associated with Precambrian continental assembly, late Paleozoic Ancestral Rockies and late Mesozoic to Early Tertiary Laramide tectonism. The region is an excellent place to study magmatic modification because it is a location where comprehensive geophysical data sets and a rich suite of basement samples can be obtained. In fact, all crustal levels are accessible, with (1) shallow basement exposed in nearby mountain ranges, (2) a remarkably diverse deep- and middle-crustal sensitivitiy suite in two Quaternary rhyolite volcanoes, and (3) a middle crustal sensitivitiy suite in Eocene intrusions near El Paso. Thus, these data sets provide a fantastic opportunity to establish the relative importance of magmatic input to formation of the crust by integrating the geophysical structure of the region with detailed geology/chemistry, geothermometry, geochronology, and chemistry of surface and xenolith samples. The modeling of these data with current tomographic inversion algorithms is an opportunity for further interdisciplinary collaboration between our geophysics and computer science groups, because the software is difficult to use, models are hard to edit, and the inversion is inherently unstable.

PVF Experiment Layout and Record Sections

Near-Vertical Reflection Data

PVF Near Vertical Deployment

CHECKERBOARD TESTING

Incorporate expert knowledge:

In order to improve the usability and expand the usefulness of the tomographic inversion code we are combining the knowledge and experiences of our geoscience department with the resources and programming experience of our computer science department. Our goals include development of user interface software designed for both ease of data input, creation of the initial model, and displaying results adapted to needs of the geoscience community, parallelization of the inversion algorithms to better utilize computing capabilities and possible improvement of inversion algorithms to incorporate additional available data and stabilization of the calculations.

Some of the solutions computed by the current methods are mathematically sound, but geophysically unsound. The geophysicist then realizes the source of the error and repeats the process. We plan to incorporate internal uncertainty and other types of uncertainty to use a geophysicist’s knowledge and intuition in the solution process, to produce models which also agree with geophysics.

Use advanced methods:

Fast Marching Method (Sethian, 1999): Unlike typical methods, this method avoids iteration by, among other optimizations, adapting Dijkstra’s shortest path algorithm to the continuous case. It runs in O(n log n), where n is the number of points in the domain.

Level Set Method (Osher and Sethian, 1988): This method avoids iteration by, among other optimizations, adapting the Level Set Method to the continuous case. It runs in O(n log n), where n is the number of points in the domain.

COLLABORATIVE WORK

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