Building and editing 3-D models of lithospheric structure via integrated analysis geological and geophysical data: A scheme for formal integration (data fusion) of geophysical data

G. Randy Keller, Eva-Maria Rumpfhuber, Matthew Averill, Aaron Velasco, Vladik Kreinovich and Ann Gates keller@utep.edu

Departments of Geological Sciences and Computer Science
University of Texas at El Paso

A fundamental goal of studies of the lithosphere is to characterize the 3-D structure of a region of interest in order to address key scientific questions. This could be accomplished by determining physical properties such as Vp, Vs, density, magnetic properties, electrical properties, anisotropy, attenuation (Q), temperature, etc. for volume elements that could take several forms. In addition, interfaces that represent features such as the crust-mantle boundary (Moho), the base of the lithosphere, the bottom of basins, faults, magmatic bodies, etc. must also be mapped in order to properly characterize a region. This goal can only be achieved through a highly integrated approach that takes advantage of all of the geological and geophysical constraints available. However, the building and editing of 3-D models remains a serious challenge, as does the formal integration of differing types of data.

In most cases, seismic methods have the potential for providing the greatest resolution at depth but generally are the mostly costly approaches. Furthermore, many diverse techniques are available for each data type collected. Thus, developing an integration scheme for seismic results is an important first step in reaching our fundamental goal. Each type of seismic has its own sensitivities and resolution, and when used alone can constrain some aspects of the lithospheric structure. However, when used together with other types of data, the integrated data set have the potential the significantly constrain fundamental aspects of the lithospheric structure better and thus advance our understanding the processes at work in the earth, the natural hazards that result, and the natural resources that are produced.

Potential field data can also help constrain 3-D models of the lithosphere. For example, community driven database and standardization efforts have ensured that gravity and magnetic data are available in all of North America. Due to the empirical relationship between density and seismic velocity, gravity data have long been employed as at least as a qualitative checks on seismic results particularly in the lithosphere. Formal integration has been attempted in many ways over the years, but some recent 3-D approaches are ideally suited for at least joint modeling that provides better overall models of lithospheric structure. These approaches are a significant step towards mapping 3-D volumes comprehensively. Also, iterating on the empirical relationship between seismic velocity and density provides a basis for joint analysis and for testing the effects of heat, fluids, and rock composition.

Finally, the need for estimating and visualization of uncertainty in models is very important, and this topic is addressed in a companion paper.