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Research Overview

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My academic training and current research lies primarily in the application of controlled-source seismology to studying the origin, structure, and evolution of the continents. Because they are relatively light continents are rarely recycled back into the Earth's interior as part of the plate tectonic process. Instead, they grows progressively outward by addition of new material over billions of years. As a result, continents contain the historical record of the geologic events that shaped them. Seismic methods provide a means for illuminating the interior of the continents at a range of scales, including 1) the near-surface, which is important, to environmental-scale questions, 2) the basin-scale, which is important to petroleum exploration and production, and 3) the lithosphere, which is important to furthering our knowledge of the origin and evolution of the continent as well as to understanding and mitigating earthquake and volcano hazards. The rugged mountainous landscape of the El Paso region tells us that our local piece of North America is still evolving and changing. With seismic methods, we can look deep beneath our feet and ask questions such as: 1) where are our freshwater resources? 2) Are nearby volcanoes likely to erupt in the future? 3) How did our mountains form? 4) Is the continent likely to break apart along the trace of the Rio Grande? 5) How are the processes that shape our piece of North America similar or different from those at work on the other six continents?

The processes that form and modify the continents are most active today at plate boundaries and are manifested in part by earthquakes and volcanic eruptions. Many human population centers (e.g. Los Angles, San Francisco, Seattle, and Tokyo) are found at plate boundaries despite the geologic hazards, because of their physical beauty, temperate climate, and access to the sea. A significant portion of my research has always involved multi-institutional collaborative seismic studies to understand the evolution of the Pacific-North America plate boundary and to assess and mitigate geologic hazards in population centers. It is for this work that I am most widely known.

My dissertation work was the first to demonstrate that a portion of oceanic crust underlies much of coastal "continental" California, an observation that has since been confirmed by many other surveys. A 2002 publication on southern California crustal structure presents data and modeling results that has caused the community of seismologists there to question many of its assumptions about the evolution of the plate boundary in that region. Work with students and university and USGS colleagues in the Seattle area has led to a new understanding of the structure that underlies the Cascades volcanic chain and to new models which help predict where ground shaking will be most severe during earthquakes in this highly urbanized region. An upcoming project, "Batholiths", will examine the question of how important magmatic processes beneath volcanic arcs are to continental growth in British Columbia and globally. I am also interested in comparing process at other plate boundaries to North America. Three years ago, I led an effort to collect the first earthquake seismic data ever in Bhutan, which lies astride the India-Asia plate boundary. Those data are currently being analyzed by our group at UTEP. A

Ph.D. student and I have also been working with colleagues at the Earthquake Research Institute in Tokyo to study the Japanese subduction zones, which have many similarities with Cascadia.

While the "action" is primarily at present-day plate boundaries, the stable interior of continents contains an important record of the array of tectonic processes that led to the continents we see today. Interestingly, once formed, continents often undergo further modification as a result of far-field plate boundary processes. Together, colleagues, students, and I, as part of another multi-institutional, collaborative project in the Rocky Mountains, have produced the first image of a 1650 million year old plate suture zone beneath central New Mexico. This ancient boundary appears to be a long-lived zone of weakness within the continent and controls the location of modern volcanic fields, including those at Mt. Taylor, Jemez, and Ocate in northern New Mexico. Gravity modeling of other seismic results from this project provides the first definitive explanation for the isostatic compensation of the Rockies Mountains, and answers the question of why the range has such high elevations. With seismic data donated by the petroleum industry students and I have also gathered new information on the magmatic evolution of eastern New Mexico and the Texas Panhandle 1300-1100 million years ago. In an ongoing project, analysis of a 2002 UTEP seismic survey across southern New Mexico and El Paso is helping us to understand how the Rio Grande Rift, in which we live, formed. Finally, collaboration with colleagues at UTEP and in Europe on seismic surveys collected in central Europe has led to a new understanding of how that continent formed and to new knowledge of similarities and differences between Europe and North America.

Because seismic methods can produce images of the shallow subsurface, they are essential tools in environmental site investigations and water resource assessment. Work of this kind with students and colleagues at UTEP has led to new knowledge of importance to the environment at a number of sites around El Paso, including Ft. Bliss, White Sands Test Facility, Holloman Air Force Base, and the former Texas Low Level Site near Sierra Blanca. For example, at Ft. Bliss we imaged the water table and hot-water filled caves within bedrock in our seismic data. The image of the caves is helping guide design plans for reinjection wells at the desalination plant now under construction. Our seismic images from the White Sands Test Facilities have helped with defining patterns of subsurface contaminant transport there. Seismic images are also helping with the search for new freshwater resources on Holloman Air Force Base.

Many of the seismic surveys mentioned above would not have been possible had it not been for the UTEP geophysics group's leadership in technological innovation that led to the design and purchase of hundreds of new (relatively) inexpensive lightweight portable seismographs for use by the seismological community, beginning in 1996. These instruments, originally built through grants from the Texas Advanced Technology Program, the National Science Foundation and the Department of Defense, are now the world-wide recorder of choice among scientists seeking to record seismic waves from explosives and some short-term earthquake studies. This effort has made UTEP a national and international leader in seismic data acquisition on the continents and has provided many unique research opportunities for our students across the globe. For example, 2000 of the "Texan" instruments are being purchased for the new NSF Earthscope facility.