NEW MEXICO SEISMIC MONITORING, RESEARCH, AND MITIGATION 2010-2011

New Mexico Bureau of Geology and Mineral Resources and Department of Earth and Environmental Science, New Mexico Institute of Mining and Technology.

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Seismic and geophysical studies

The New Mexico Tech Seismic Observatory located 763 earthquakes during October 1, 2010 – September 30, 2011. For events located in or immediately adjacent to New Mexico, the majority of these events are distributed among three main regions: the northeast border of NM near Raton, NM and Trinidad, CO; the Dagger Draw area in the Delaware Basin, southeastern NM; and the Socorro Magma Body region (SMB, shown in Figure 1 with black outline) in central NM. All of these regions are long-standing loci of prolonged seismicity. Events in the Raton area are part of a continuing swarm that began in 2001, and that, to date, has culminated in a 5.3 earthquake near Trinidad, CO on August 22nd of this year. The Dagger Draw area has produced 13 $M_d > 3.0$ (duration magnitude) earthquakes since 2002, and the Socorro Magma Body region has produced continuing activity since at least the mid 19th century, including earthquakes as large as an estimated magnitude 6 in 1906. In addition to these three areas, we located a number of events near Pie Town, NM and in northern Chihuahua, Mexico near the Rio Grande. The largest events in these regions are the following: M_d 3.7 in Raton/Trinidad region south of the Colorado border, M_d 2.3 near Dagger Draw, M_d 3.9 in northern Chihuahua, Mexico; and M_d 2.3 in the Socorro magma body region.

Following the earthquake catalogs compiled by Al Sanford and colleagues (2002), the Geophysics group at NMT also completed an earthquake catalog through 2004 (Sanford et al., 2006) and is working on the next catalog. This newest catalog will cover 2005-2009, and will be available soon. Data from the catalogs may be downloaded from http://geoinfo.nmt.edu/publications/earthcat. Current efforts at NMT include a focus on continued monitoring and cataloging of local earthquakes in the Socorro and Carlsbad regions. Earthquakes at the New Mexico Tech Seismic Observatory are monitored continuously and are posted regularly at http://www.ees.nmt.edu/outside/Geop/NMTSO/quakelist.html.

Our geodetic monitoring of active deformation in New Mexico during 2010-2011 includes the operation of two continuous GPS stations and a small network of tiltmeters located astride the Socorro magma body to study its ongoing surface uplift. In addition, a network of 12 geodetic stations, originally established in 2002-2006, was reoccupied using survey-mode GPS techniques in spring 2011 in a collaborative effort by researchers and students at the New Mexico Bureau of Geology and Mineral Resources, the Department of Earth and Environmental Science, NMT, the University of New Mexico, and the Georgia Institute of Technology. We are currently analyzing these

measurements, which should provide the first well-resolved estimates of present-day horizontal deformation associated with SMB and better constrain the geometry of the magma body.

Other ongoing SMB research efforts include basic geologic mapping, relocation of small earthquake swarms, analysis to link seismicity to regional fault structures, and investigation of possible non-volcanic tremor signals in the region. In addition, Gary Axen is P.I. (with NMT co-P.I.s Fred Phillips and Bruce Harrison) on a new NSF project to study the long-term uplift history of the Socorro magma body using river terraces.

Mark Murray and Susan Bilek are co-P.I.s on a renewed NSF EarthScope Program seismotectonic project that includes analyzing data from 25 GPS stations in New Mexico and Colorado to assess present-day deformation and seismicity across the Rio Grande rift. Observations from the first 5 years of this project suggest that ~1 mm/yr east-west extension is spread uniformly over a very broad zone from the Colorado Plateau well into the western Great Plains, and is not localized on the surficial expression of the Rio Grande rift.

Additional ongoing seismotectonic work includes pursuing improved understanding of mantle anisotropy and small-scale convection at the edges of the Colorado plateau and within the Colorado and northern New Mexico Rockies. An NSF Continental Dynamics and LANL-funded project in which NMT is a major partner, CREST (Colorado Rockies Experiment and Seismic Transects; www.ees.nmt.edu/Geop/CREST), is currently analyzing data from 59 instruments in the Colorado Rockies that were interspersed with 80 instruments in the region from the Earthscope Transportable Array. CREST has revealed a remarkable complex mantle and thin crust underlying the high Colorado Rockies, as well as diapir-like structures that extend as deep as 400 km; indicating a likely active small-scale convection system that has contributed to Neogene epeirogenic uplift of parts of the region.

More generally, New Mexico Tech continues to carry out a wide variety of seismographic research projects, ranging from studies of seismic ocean noise to volcano and mantle imaging seismology in Antarctica. The IRIS PASSCAL Instrument Center and EarthScope USArray Array Operations Facility supported over 65 distinct seismic experiments in 2010-2011. The Instrument Center and New Mexico Tech also served as the site for the IRIS NSF-supported Intern Orientation program in May of 2011, the sixth year of hosting this event.

Relevant New Mexico and regional seismology-related publications and abstracts from 2009-2011 are as follows:

Publications

Aster, R., MacCarthy, J., Heizler, M., Kelley, S., Karlstrom, K., Crossey, L., Dueker, K., and the CREST Team, 2009, CREST probes the roots and geologic history of the

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Abstracts

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Land, L., Aster, R., Seismic recordings of an anthropogenic sinkhole collapse, *Proc. 22nd Syposium on the Application of Geophysics to Engineering and Environmental Problems*, Fort Worth, TX, March 29-April 2, 2009.

Stankova-Pursely, J., Bilek, S., Ruhl, C., Aster, R., Rowe, C., Johnson, J., Characterization of the August 2009 New Mexico earthquake swarm in the central Rio

Grande Rift, *Eos Trans. AGU*, Fall Meet. Suppl., 2009.

Wilson, D., Aster, R., Grand, S., Baldridge, W. S., van Wijk, J., Lithospheric architecture and mantle-supported Topography of the Colorado Plateau constrained by receiver function imaging, *Eos Trans. AGU*, Fall Meet. Suppl., 2009.

Karlstrom, K., Coblentz, D., Ouimet, W., Kirby, E, Van Wijk, J., Schmandt, B., Crossey, L., Crow, R., Kelley, S., McKeon, R., Aslan, A, Darling, A., Dueker, K., Aster, R., Lazear, G., Hilton, D., Dynamic uplift of the Colorado Rockies and western Colorado Plateau in the last 6 Ma driven by mantle flow: Evidence from the Colorado River region, *Eos Trans. AGU*, Fall Meet. Suppl., 2009.

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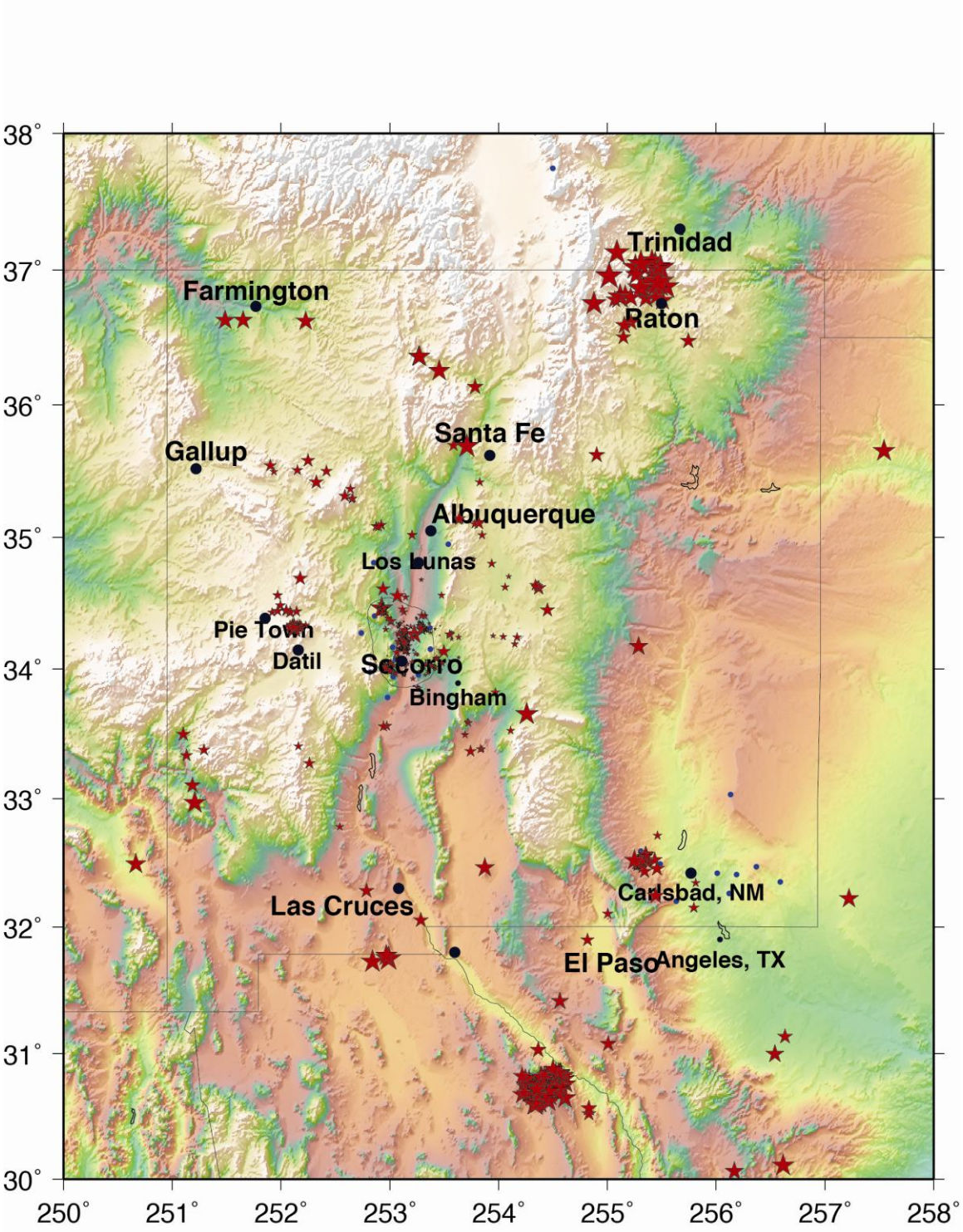

Figure 1: Earthquakes in and near New Mexico from October 1, 2010 to September 30, 2011 (Morton and Pursley, unpublished data from the New Mexico Tech network).

New Mexico Department of Homeland Security and Emergency Management, Mitigation

Statewide efforts continue in the development of local hazard mitigation plans that will meet the Federal Emergency Management Agency's (FEMA) Disaster Mitigation Act requirements. These mitigation plans are assessing risk from various hazards, including earthquakes, and studying ways to reduce that risk. At this time 24 local mitigation plans have been approved by FEMA. One plan is FEMA approvable, pending its adoption. Ten plans are under development and another four are in application stages. The new plans will all address the same hazards as were profiled in the 2008 State Hazard Mitigation Plan update, which include seismic and geologic hazards across the state.

Cooperation between the Department of Homeland Security and Emergency Management (OEM), the New Mexico Bureau of Geology and Mineral Resources, and professors from New Mexico Tech resulted in another successful "Rockin' Around New Mexico" for 35 teachers from throughout New Mexico. The three-day workshop in Jemez Springs, New Mexico, featured on-going forest fire, volcanic, and earthquake hazards and local geologic history and processes.