

**Geochemistry of Travertine-depositing Springs of the Rio Grande
Valley, New Mexico**

**Dennis L. Newell
Laura J. Crossey**

Department of Earth and Planetary Sciences, University of New Mexico

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Summary of Results

Travertine-depositing springs and fossil travertine deposits are a poorly understood and underutilized part of the geological record that track the movement and discharge of CO₂ and associated fluids to the Earth's surface. We hypothesize that travertine-depositing springs along the Rio Grande Valley are linked to deeply-circulated fluids associated with mantle magmatism, and that their geochemistry varies systematically among regional tectonic sub-provinces. Additionally, we postulate that poor quality groundwater (e.g., salinity and trace metals) present in aquifers and surface water along the Middle Rio Grande valley is, in part, due to inputs of these fluids along deeply penetrating faults systems related to continental rifting. These hypotheses are testable by examining spring aqueous and gas geochemistry within the five tectonic sub-provinces traversed by the Rio Grande Valley: the Rio Grande rift, Jemez lineament, Valles Caldera, Basin and Range and Colorado Plateau.

Twenty-nine samples were collected and analyzed from spring locations along the Rio Grande Valley from near the Colorado border to just north of Socorro, NM (Fig. 1, 2). The sampled springs were cool to warm (6 - 57°C), and most were located along major faults in the region (Fig. 1). Aqueous chemistry included major, minor and trace-elements, δ¹⁸O, δD, and ⁸⁷Sr/⁸⁶Sr analysis. Gas analysis included major and trace gases (N₂, O₂, Ar, CO₂, CO, CH₄, H₂S, and He), and ³He/⁴He. Results show that travertine-depositing springs range from Ca-Mg-HCO₃ to Na-Cl-SO₄ type waters (Fig. 3) and are moderate to high in dissolved ions. Many springs are elevated in arsenic (8 – 3880 ppb). Spring chemistry roughly groups with the tectonic sub-provinces along the Rio Grande Valley (Rio Grande rift, Jemez lineament, Valles Caldera, Basin and Range, and Colorado Plateau) (Fig. 3). Stable isotopic results are preliminary indicating that spring waters are evolved/mixed meteoric water. Cl/Br ratios require the mixture of different end-member water sources (Fig. 4), and elevated ⁸⁷Sr/⁸⁶Sr (0.7115 to 0.7177) suggests exchange with radiogenic Precambrian basement. Gas results show that springs are charged with CO₂ at levels too great (up to 10^{-0.006} atm) to be derived from atmospheric (~10^{-3.5} atm) or soil sources (~10^{-2.0} atm), and have helium concentrations indicative of a deep crustal or mantle source (Fig. 5). ³He/⁴He ratios (R) range from 0.11 to 0.6 Ra, where Ra is the ³He/⁴He ratio in air (Ra = 1.4 X 10⁻⁶, Hilton et al., 2002). These values exceed the isotopic ratio expected for ground waters found in stable continental crust (~0.02 Ra) (Hilton et al., 2002), requiring the input of primordial ³He from the mantle (Ballentine, 2002; Ballentine et al., 2001). The presence of mantle helium provides strong evidence for a mantle/mantle-derived magmatic source for the excess CO₂ in the spring gases. The gas and water chemistry support the hypothesis of a deep-seated source for Rio Grande Valley travertine depositing spring related to mantle-derived magmatism.

Water quality data from the Albuquerque basin (Bexfield, 1999) shows a wide variety of groundwater types in the Albuquerque basin ranging from Ca-Mg-HCO₃ to Na-Cl-SO₄ type waters, and these data indicate that ~50% of water supply wells in the Albuquerque basin will exceed the new EPA arsenic standard of 10 ppb, once implemented. Additionally, Rio Grande water quality degrades from north to south, marked by an increase in salinity, a trend often attributed to effects of agriculture. But based on Rio Grande water chemistry and Cl/Br trends, some researchers have suggested that the upwelling of rift sedimentary basin brines at the terminus of rift basins is a better explanation for degradation of downstream water quality (Phillips et al., 2003a; Phillips et al., 2003b; Phillips et al., 2002).

Another possibility consistent with the Albuquerque basin and Rio Grande data is that deeply-circulated fluids related to mantle-derived magmatism ('lower-world' waters) are an important contributor to water chemistry and quality in the Rio Grande Valley. The spring results reported here show a similar variation in water types as the Albuquerque basin, with much higher dissolved ions and salinity, and spring waters have arsenic concentrations as high as 3880 ppb. Additionally, the Cl/Br data from springs (Fig. 4) show a similar pattern as the Rio Grande (e.g., Phillips et al. 2003b), requiring mixing of different salt sources. Travertine-depositing springs issuing along rift-related faults are the surface expression of the deep fluid source. However, many rift related faults terminate upwards into rift basin fill, and we propose that the same fluids are conveyed along these faults, leaking 'lower-world' fluids into rift basin aquifers.

Acknowledgements

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- Phillips, F.M., Mills, S.K., and Hogan, J., 2002, Salinization of the Rio Grande: Young water, old salts: *Geochimica et Cosmochimica Acta*, v. 66, p. A598.

Figures

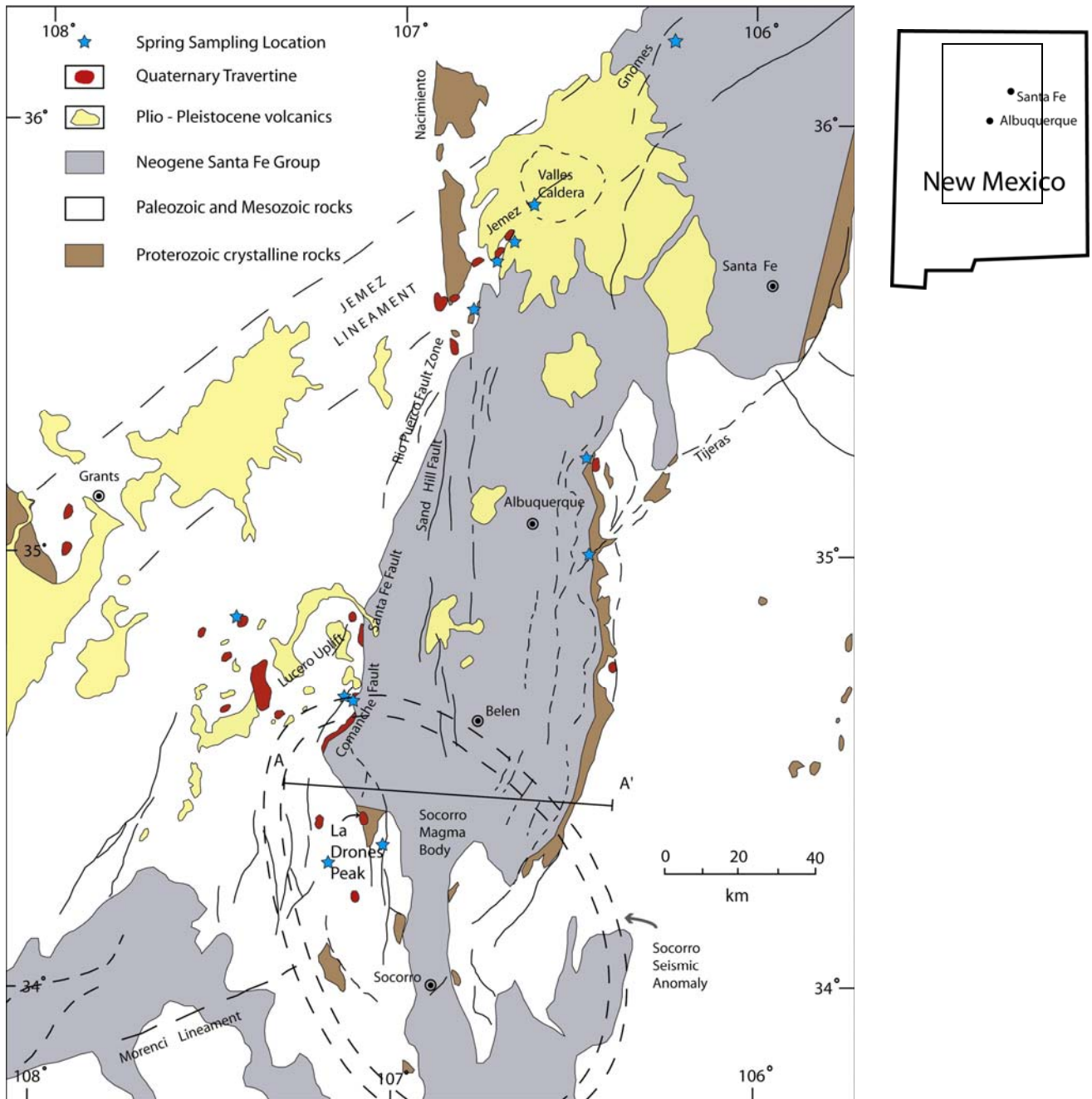


Figure 1. The Rio Grande rift region of New Mexico showing major tectonic features, volcanics, faults, the major Quaternary travertine deposits, the outline of the Socorro magma body (seismic anomaly), and the general location of spring systems investigated to date.

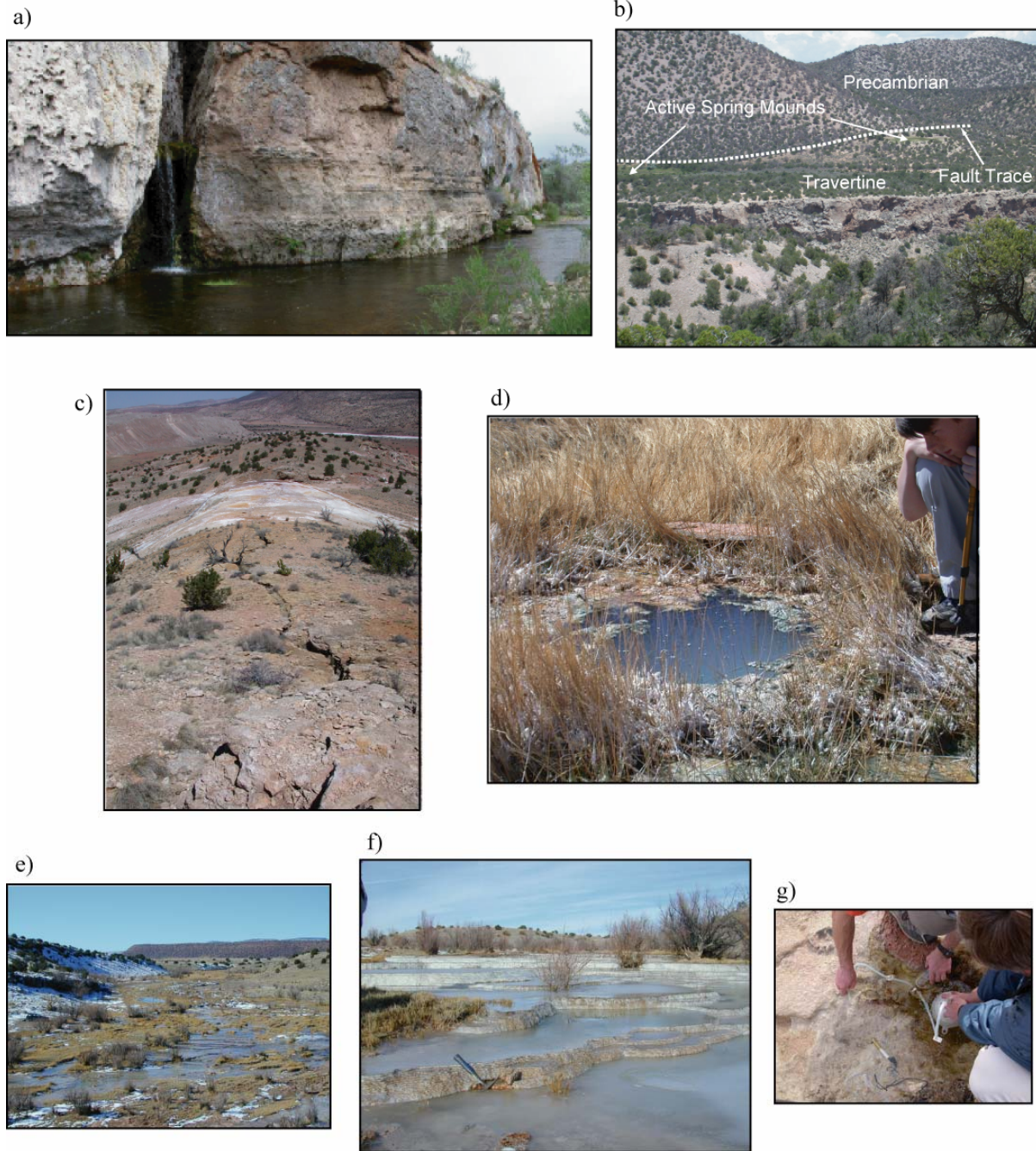


Figure 2. Examples of travertine-depositing springs along the Rio Grande Valley, New Mexico. a-b) La Madera travertine near La Madera, NM showing large fossil travertine platform with active spring mounds issuing along a fault. Spring waters are entering the Rio Ojo Caliente (a), a major tributary to the Rio Chama. c-d) Fossil travertine deposits and active springs of the Tierra Amarilla anticline near San Ysidro, NM. Spring issue along the trace of the anticline (c), are saline and actively degassing (d). e-f) Salado Arroyo travertines west of Belen, NM. Springs issue at the boundary between the Rio Grande rift and Colorado Plateau associated with numerous N-S trending faults. Saline waters are issuing and depositing travertine step-pool dams over several kilometers. g) Gas sampling spring waters at Salado Arroyo.

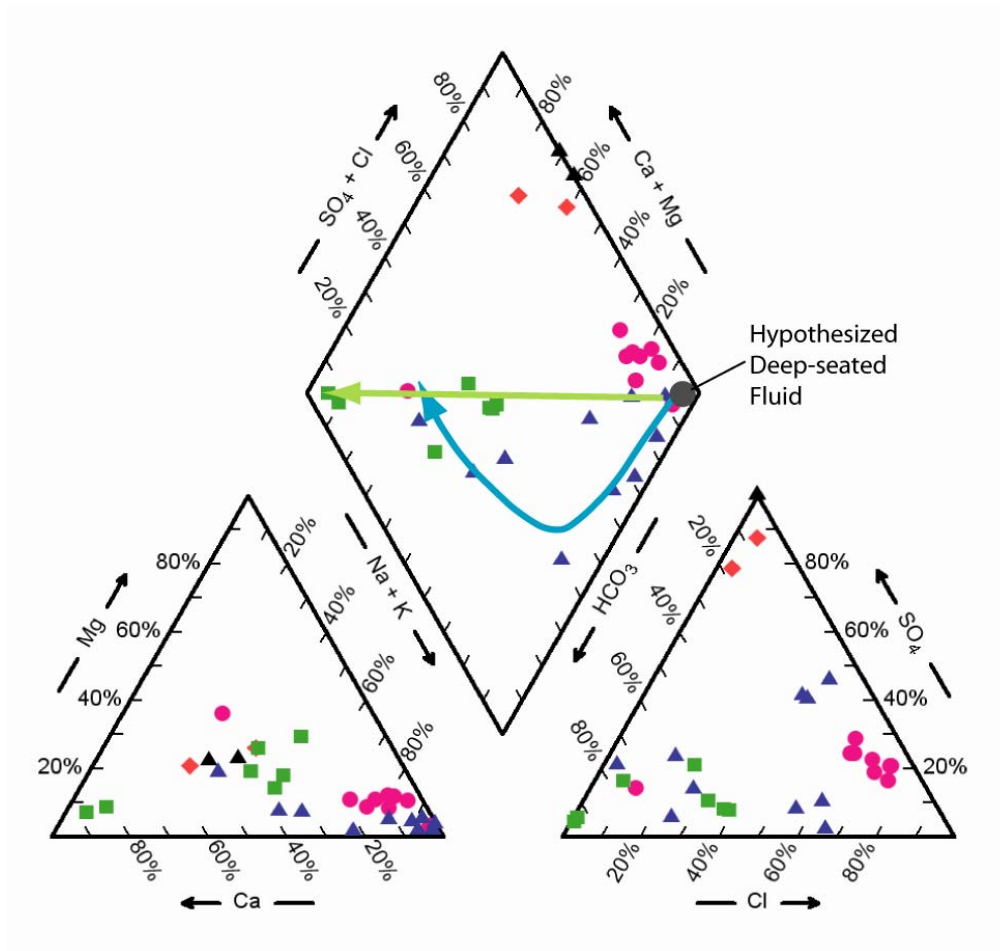


Figure 3. Piper diagram for Table 2 spring geochemical data; different tectonic sub-provinces represented by colors and symbols. Jemez (extra-caldera) = blue deltas; Jemez (intra-caldera) = black deltas; rift = green squares; Jemez lineament = red diamonds; rift – Socorro Magma Body = magenta circles. Potential evolution paths based on water chemistry for the deep seated source are shown for rift springs (green) and extra-caldera springs (blue curve).

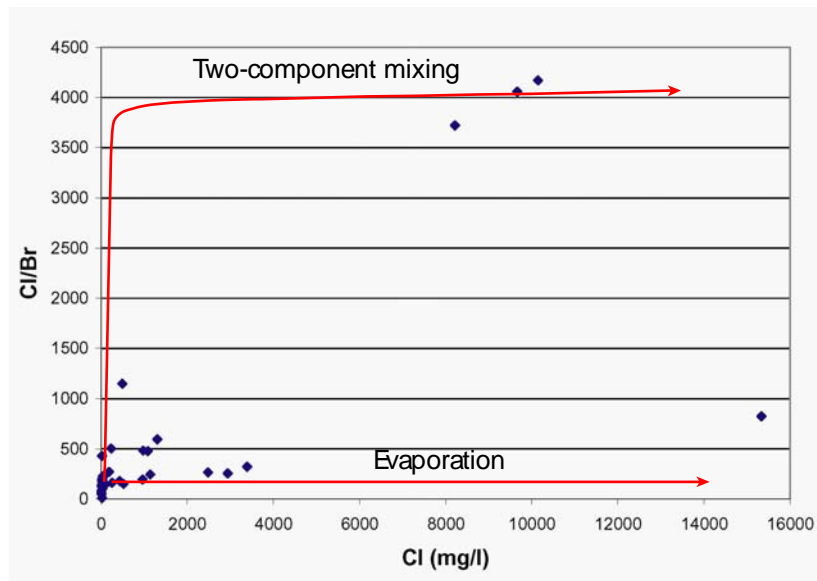


Figure 4. Cl/Br vs. chloride concentration in Rio Grande rift springs. The scatter in data does not support simple evaporation of meteoric recharge water, but suggests a combination of one or more mixing end-members in addition to evaporation. Theoretical trends for evaporation and simple two-component mixing are shown.

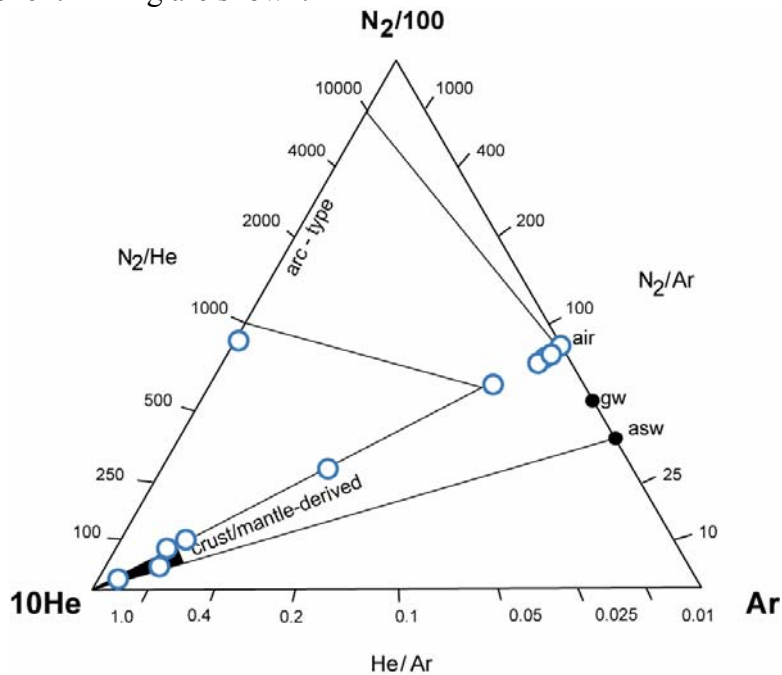


Figure 5. Trace gas chemistry for spring gases showing a trend between air/air-saturated groundwater, and gases derived deep in the crust or from the mantle.

Products

Presentations

Newell, D.L., Crossey, L., Fischer, T., Sharp, Z., Karlstrom, K., and Burke, C., 2004, Tracing the origins of travertine-depositing springs of the Colorado Plateau region, USA: 32nd Int. Geol. Congr. Abs., v. pt. 1, p. 709.

Newell, D.L., Crossey, L.J., Karlstrom, K.E., Fisher, T.P., Kennedy, B.M., Hilton, D.R., 2004. Linking Mantle Tectonism and Groundwater Geochemistry in the Western U.S.: Rocky Mountain EarthScope Workshop, Sevilleta Field Station, N.M.

Newell, D.L., Crossey, L.J., Fischer, T.P., Karlstrom, K.E., and Kennedy, B.M., 2004, Mantle Source for CO₂-Rich Springs in the Southwestern U.S.: Links between Mantle Tomography, Neotectonics and Water Quality: Geological Society of America Abstracts with Programs, v. 36, p. 509.

Proposals

NSF/EAR/EarthScope, 01/01/2005-12/31/2006, Hypothesis for links between mantle tectonism, crustal seismicity, and water quality at the continental scale in the western U.S.: record in travertines and xenowhiffs: PI's: Crossey, L., Karlstrom, K., and Fischer, T. (all at UNM)
\$195,834 total request