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Discerning Fault vs Liquefaction Features Through Geomorphic and Isotopic Analysis in a Geothermal Setting, Dixie Valley, NV

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BACKGROUND

The Central Nevada Seismic Belt (CNSB) is an area in the western Basin and Range province that records historical events of large-magnitude (M 7.0+) earthquakes, and prehistoric surface ruptures (Bell et al., 2001). The piedmont and range-front features have been mapped throughout Dixie Valley, and Pleasant Valley, relating them to specific past-seismic events, but scarps at the end of the south Tobin Range have undetermined origins. Reclassification of scarps as a secondary ground expression or liquefaction zone was recognized along the area between Stillwater Range and the playa. Therefore, this study will be focusing on two unnamed, subparallel scarps on the northern Dixie Valley with aim of supporting an interpretation of the origin of the scarps—faulting or liquefaction?

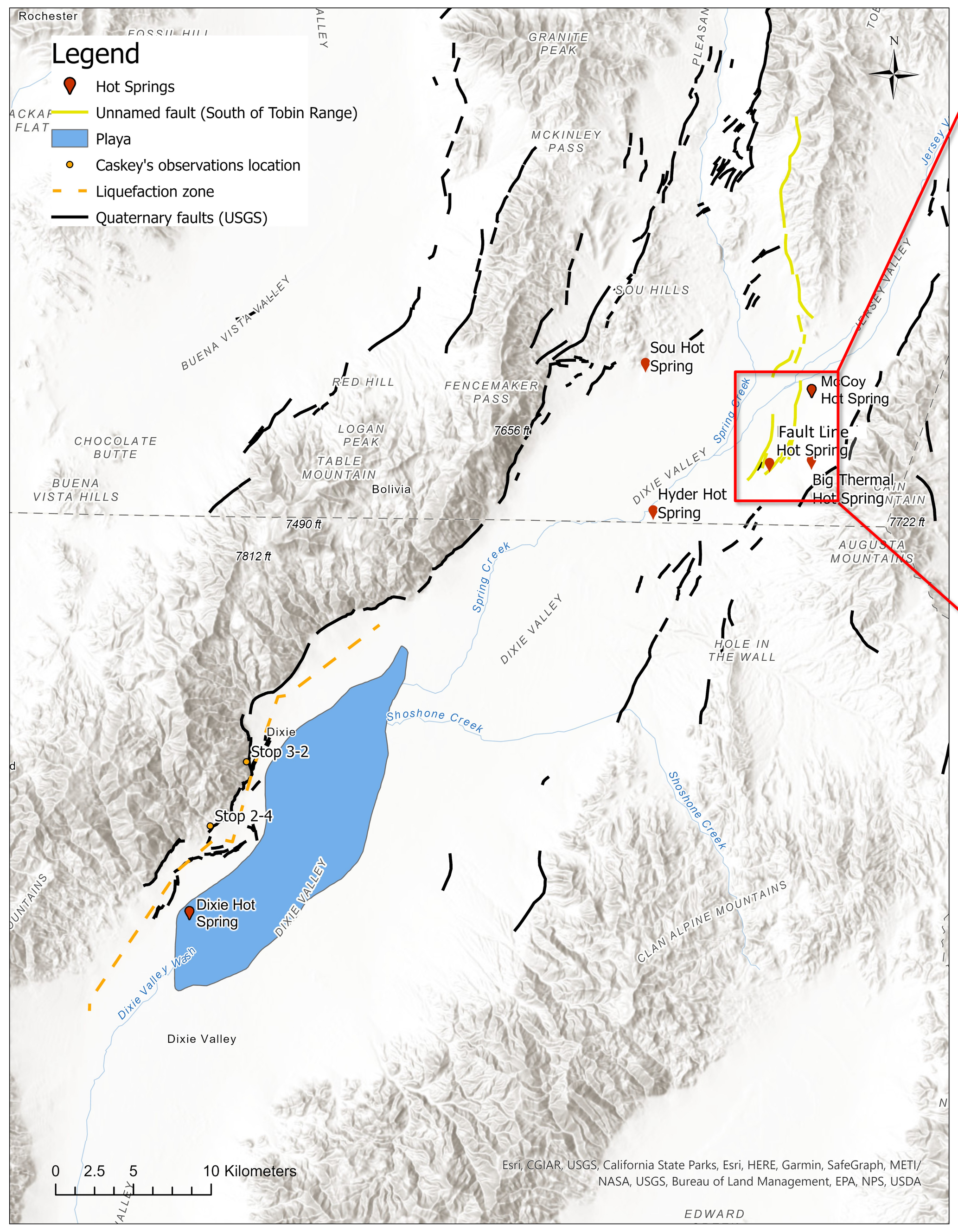


Fig. 1—Northern Dixie Valley, Nevada.
Map is showing Quaternary fault from USGS, reclassified zone of liquefaction, and study extent (red box).

We hypothesize,

(1) If these are liquefaction-related scarps, we would observe evidence of lateral spreading, and subsidence accompanied by low-temperature discharge

(2) If these are fault scarps, we would observe a transect in topography that allow access to deeper high-temperature fluids

METHODS

- Field reconnaissance—mapping, drilling, sampling
- Remote sensing—scarp morphology, elevation profile, spatial distribution of geomorphic features, presence of geomorphic features of interest
- Stable isotope analysis—$\delta^{18}O$ and $\delta^{13}C$ compositions in travertine (hot spring deposits)
- Structural interpretation—cross-section of subsurface geology

Fig. 2—Travertine sample from Big Thermal Core Hole (location refer to Fig. 4). Organic remains indicate the ambient temperature of the source water.

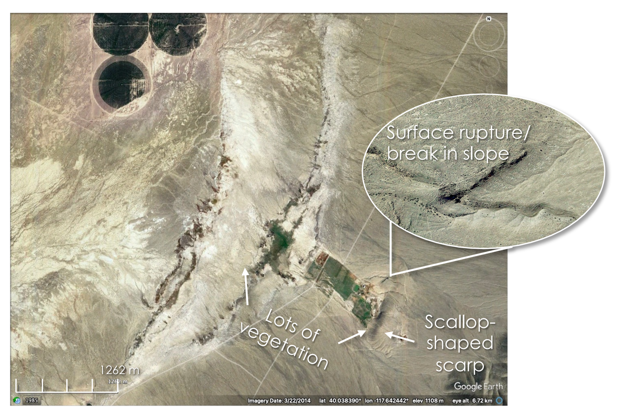


Fig. 3—Satellite imagery of the study area (Google Earth). Signs of liquefaction are present at Big Thermal.

RESULTS

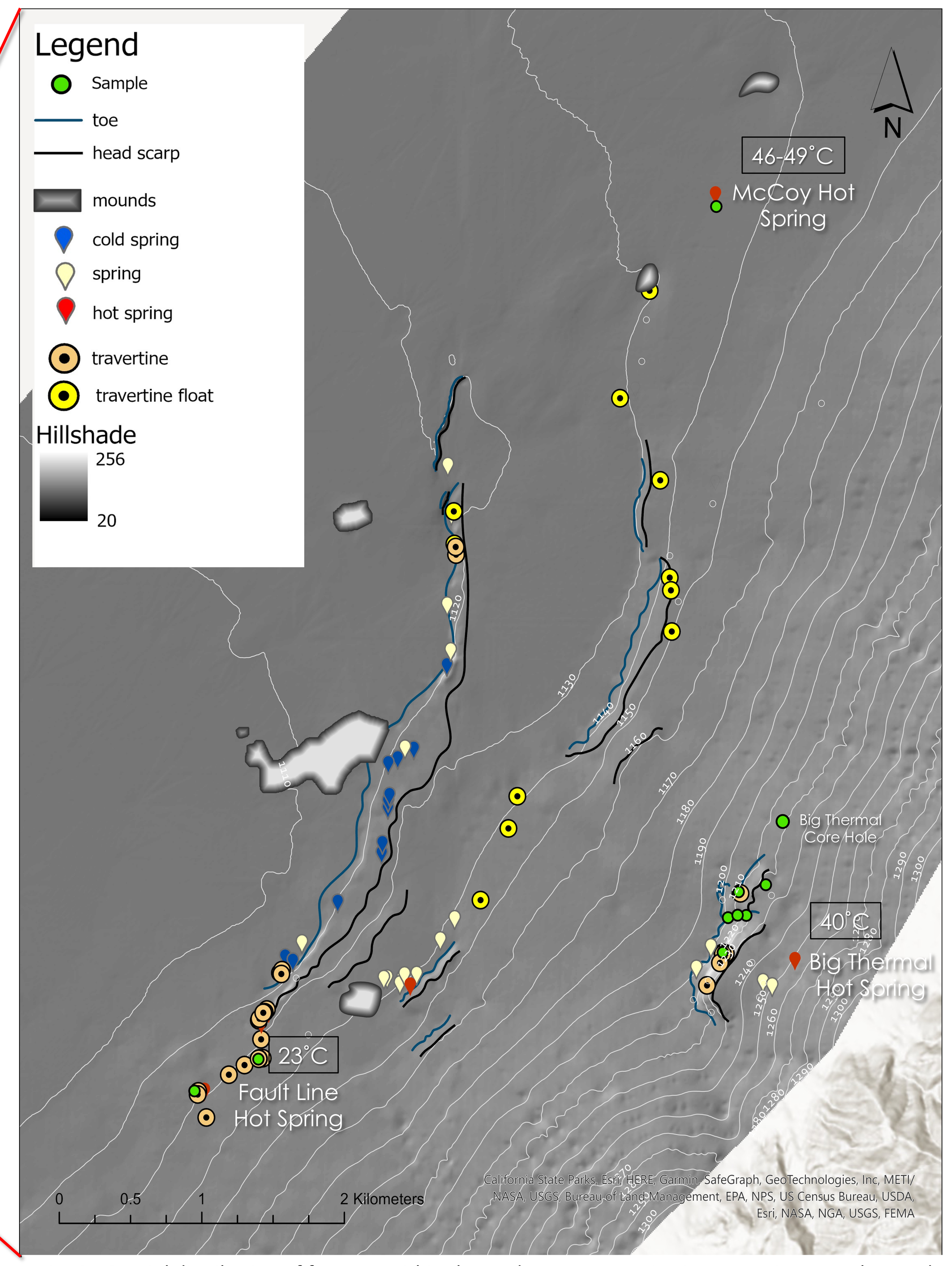


Fig. 4—Spatial distribution of features within the study area extent. In-situ travertines are clustered only around the hot springs. Ambient surface water temperature. No other geomorphic evidence was found to indicate liquefaction except suspected mounds from the hillshade raster.

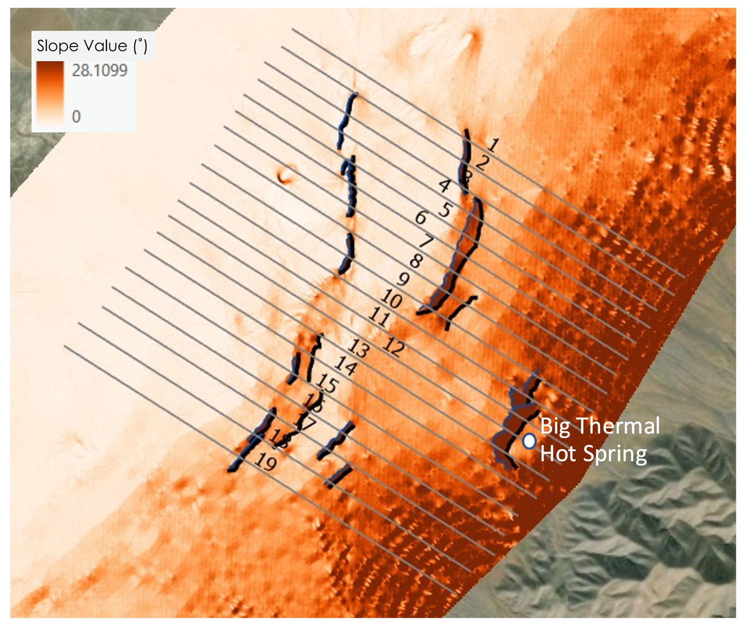


Fig. 5—Scarp morphology reference

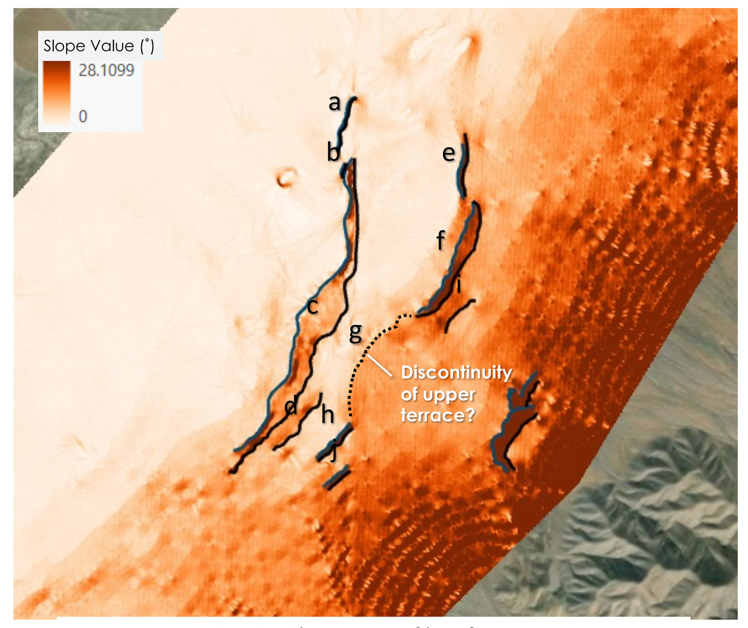


Fig. 6—Elevation profile reference

*Hillshade and slope raster were developed using USGS 10-meter DEM

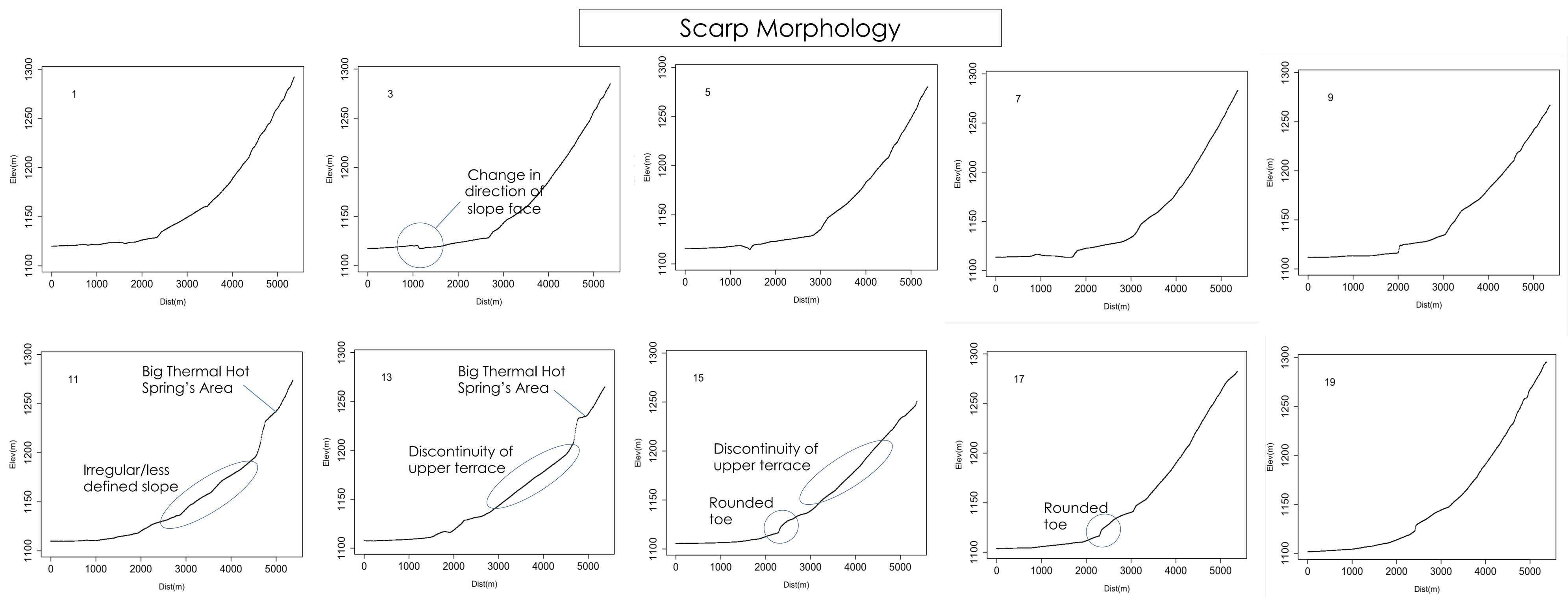
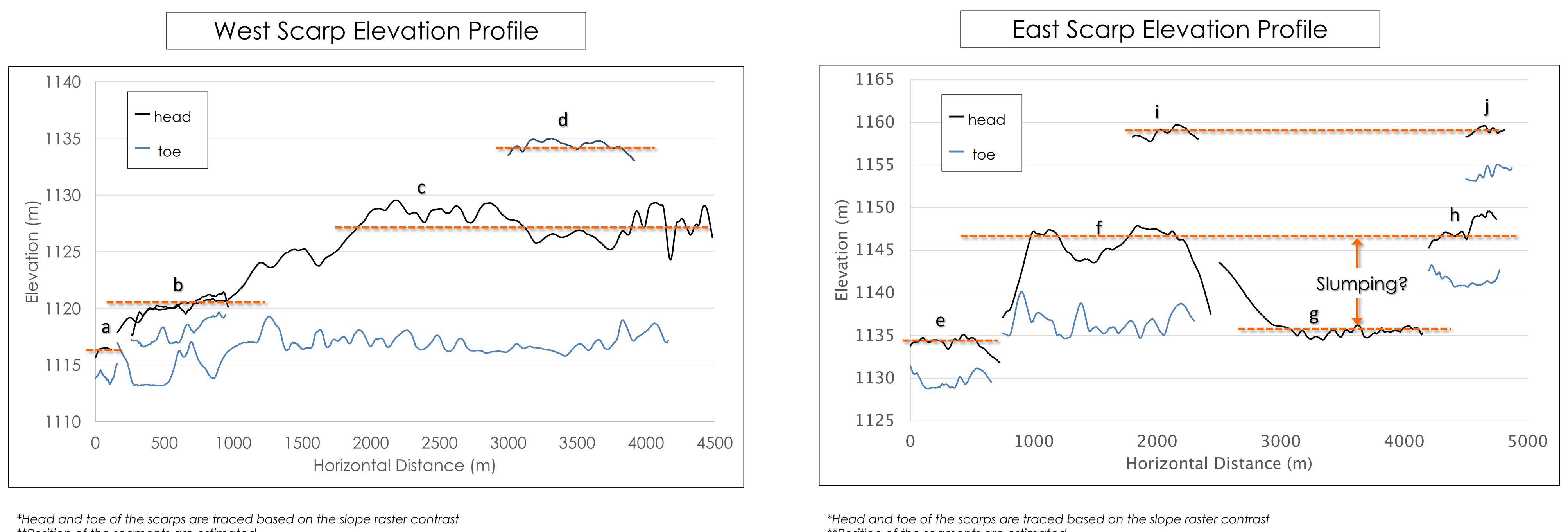


Fig. 7—The scarp morphology are showing abrupt changes in elevation for most of the west scarp, but the east scarp seems to disappear towards the middle (no. 11, 13, 15) (VE=0.05).



*Head and toe of the scarps are traced based on the slope raster contrast
**Position of the segments are estimated

*Fig. 8—Elevation profiles of the scarps: relatively flat and shown as the dashed orange lines (VE=0.005). Most of the scarps have head and toe, based on the apparent contrast shown in the slope raster (Fig. 6), but **g** does not. **g** coincides with scarp morphology no. 11, 13, and 15 (Fig. 7)*

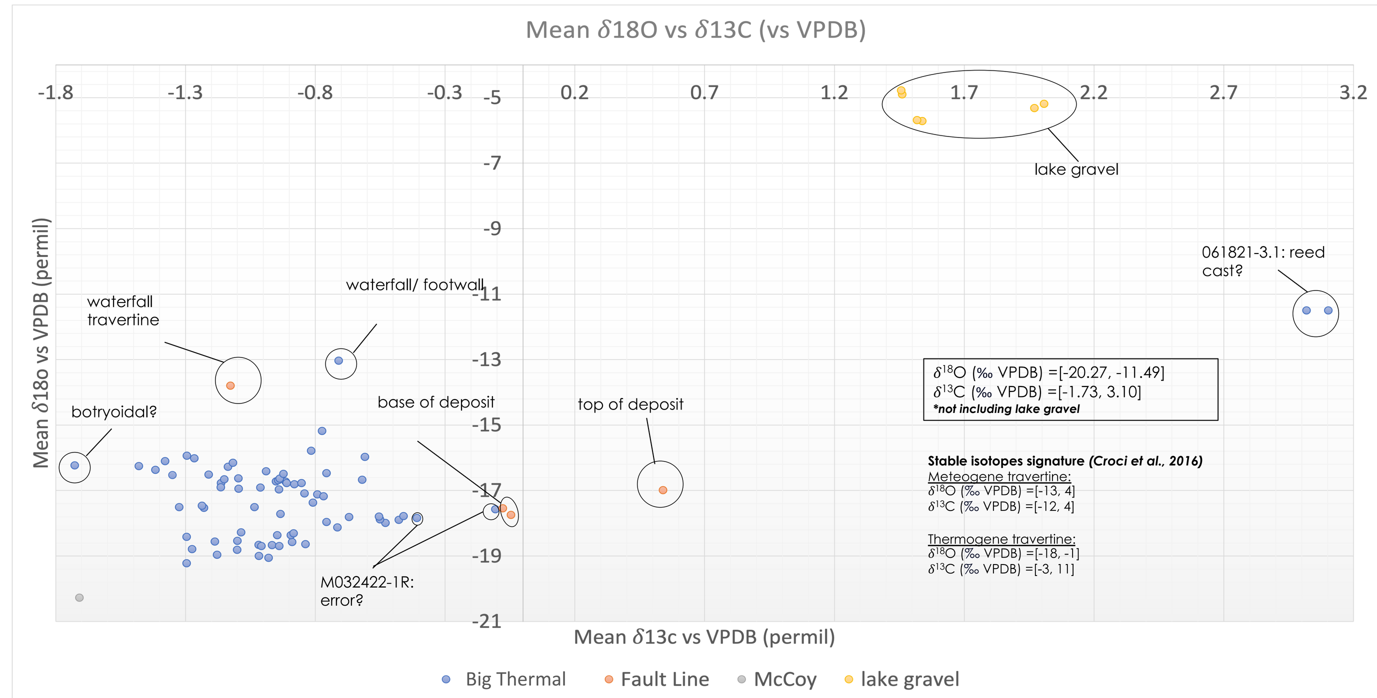


Fig. 9—Scatterplot of $\delta^{18}O$ vs $\delta^{13}C$ (VPDB). Stable isotope compositions of samples are within the thermogene travertine's signature range. Sampling locations are shown in Fig. 4 (Big Thermal Core Hole sample compositions were not analyzed).

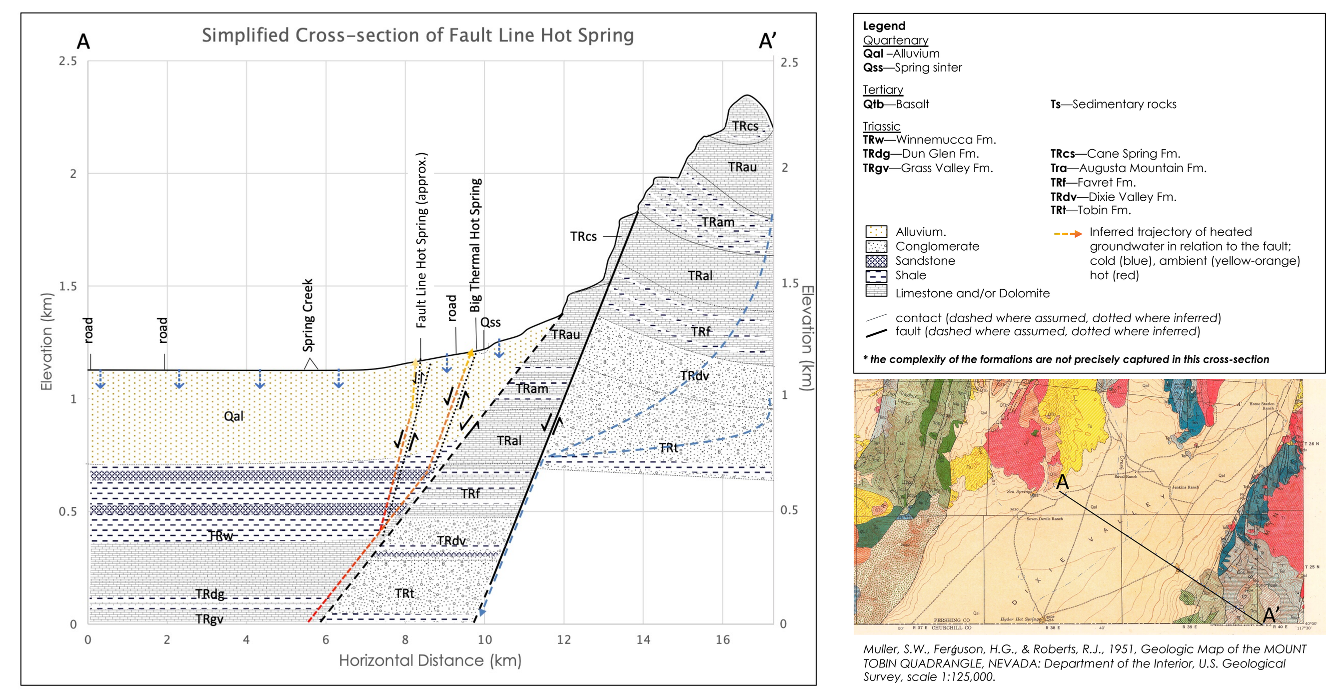


Fig. 10—Cross-section showing an illustrated trajectory of the geothermally recharged groundwater. Reservoir is expected to be within the deeper strata of the Jurassic lopolith and Triassic marine carbonates (not shown, >1km deep). Limestone in this area is expected to have secondary permeability.

CONCLUSIONS

We concluded that the findings support the earthquake-related origin of these scarps. The evidences are showing the sparse distribution of liquefaction-related features within the study area with the scarp morphology indicating independence from topography. The stable isotope composition supports the idea of thermogenic deposition and mixing with meteoric water as it migrates away from the hot springs. Based on these observations, we interpreted the two subparallel scarps to be fault-related and transected the subsurface to reach the km-deep reservoir.

Mapping these features in geothermal settings provides a geological perspective for energy exploitation other than improving our understanding of the differences between the two major ground expressions through geomorphic and isotopic approaches.

Future work: Due to the lack of higher resolution data, and ground truthing, there might be evidence that could better support either hypothesis. We also found that liquefaction events could have happened after the faulting, by which it spreads from the Big Thermal down to the east scarp where slumping is observed in the profile—though it might not be seismically induced.

ACKNOWLEDGEMENTS

We gratefully acknowledge the contribution of everyone who did the fieldwork and collected data necessary for this study, including field assistance from Amanda Jackson, Jennifer Osako, and Jay Mudambi. Stable isotope analyses were conducted at UW IsoLab with help from Andy Schauer and Maciej Sliwinski. This research is funded by NSF Award 2040116 to Owen Callahan, Juliet Crider, and Katharine Huntington. Undergraduate fieldwork was supported by an NSF GeoAllies grant to Owen Callahan.

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