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Hydrologic characterization of an alpine valley infill through integration of ERT, active seismic and active/passive surface wave interferometry (Unaweep Canyon, US)

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Unaweep Canyon (Western Colorado, US) is an enigmatic alpine landform and hypothesized to represent a partially exhumed paleo valley which was glacially over-deepened in the late Paleozoic. Processing and interpretation of recently acquired 2D seismic reflection and refraction data support the concept of glacial over-deepening and indicate maximum bedrock depths of about 550 meters. Additionally, pronounced reflectors are observed within the sedimentary infill. The seismic data have also been subjected to surface wave analysis revealing a significant increase of the Vp/Vs ratio below a shallow (50 – 150 m depth) intra-sedimentary reflector. A large Vp/Vs ratio can be caused by both saturation and poor consolidation of dry low-porosity materials (e.g. dry sands).

To investigate the potential occurrence of an aquifer associated with this interface, a high-density/long-offset electrical resistivity survey was conducted in fall 2019 along the seismic line. The maximum offset is 915 m at an electrode spacing of 5 meters, aiming at reaching depths of investigations between 150 and 200 meters. Inversion of the ERT data was initially conducted by means of smoothness-constrained algorithms. The imaging results revealed consistent structures with those resolved through seismic methods, at least within the required depth of investigation between 150 – 200 m. Furthermore, improvements in the resolution of the ERT imaging results was investigated after the inclusion of seismic interfaces as structural constraints in the inversion of the data. The comparison of the two approaches permitted to improve the interpretation of the ERT imaging results, which indicate low resistivities in the zone of high Vp/Vs ratios and thus strengthen the aquifer hypothesis. We present an integrated interpretation based on seismic structure, resistivity distribution, Vp and Vs velocities, and a distant well core. In a larger context, the results provide new insights on the subsurface hydrology in this arid part of the continental US as well as on the significance of multi-valued datasets for the interpretation and characterization of aquifers.

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