Marine and Land Active-Source Seismic Imaging of mid-Miocene to Holocene-aged Faulting near Geothermal Prospects at Pyramid Lake, Nevada

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Pyramid Lake Basin Geological Overview

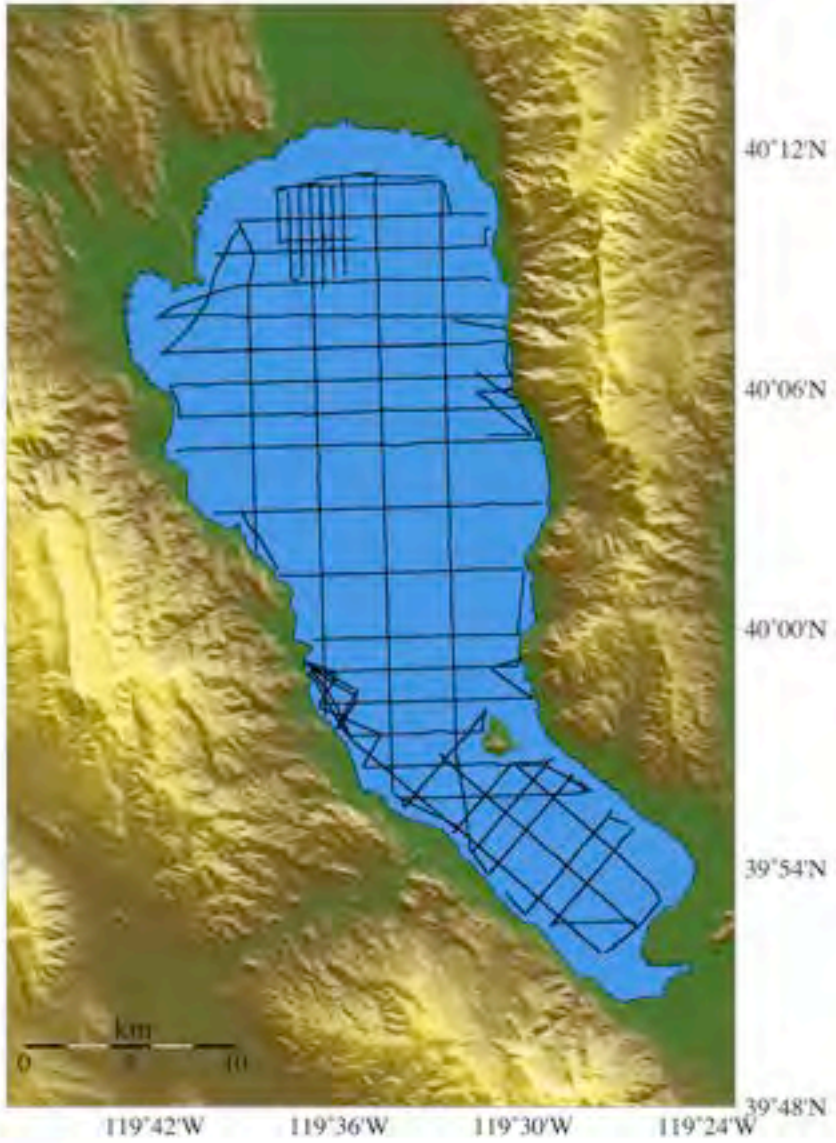
- Northern Walker Lane
- Trantensional environment
- Great Basin
  - Greatest concentration of known geothermal fields
  - GPS geodetic show greater extension rates
  - Extensional regimes and dilational faults

Project Motivations:

- Help the Pyramid Lake Paiute Tribe develop natural geothermal reservoirs
- Gain a greater understanding of the tectonics and earthquake hazards in the Pyramid Lake basin and the northern Walker Lane, through advanced and economical seismic methods

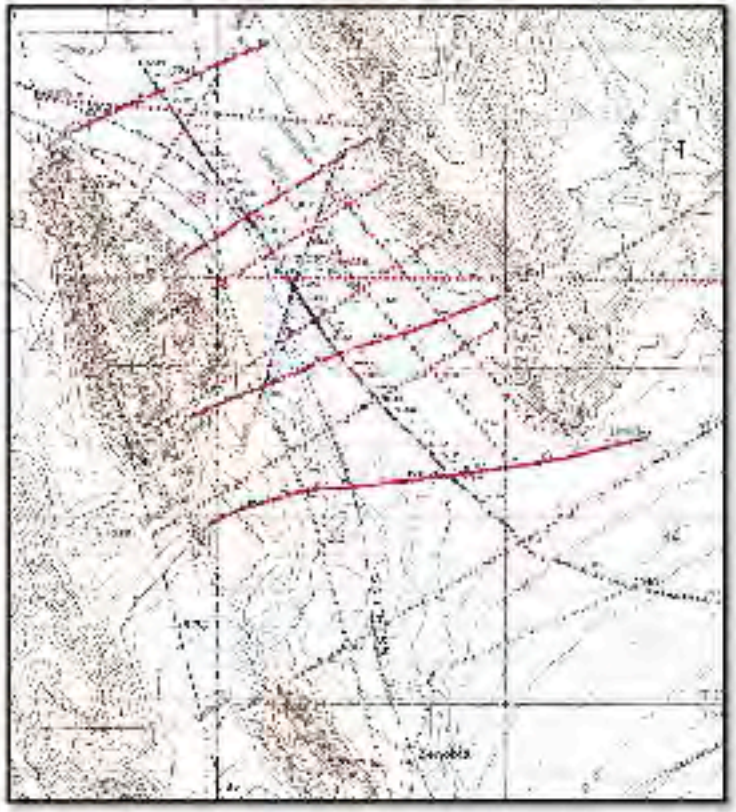
Methods:

- CHIRP data collection
  - Swept frequencies
  - Single hydophone
  - 0.7-3.0 kHz pulse with a 50 ms duration
  - 500 line-kilometers in ten days
  - Upper 80 m below lake floor
  - Submeter vertical resolution

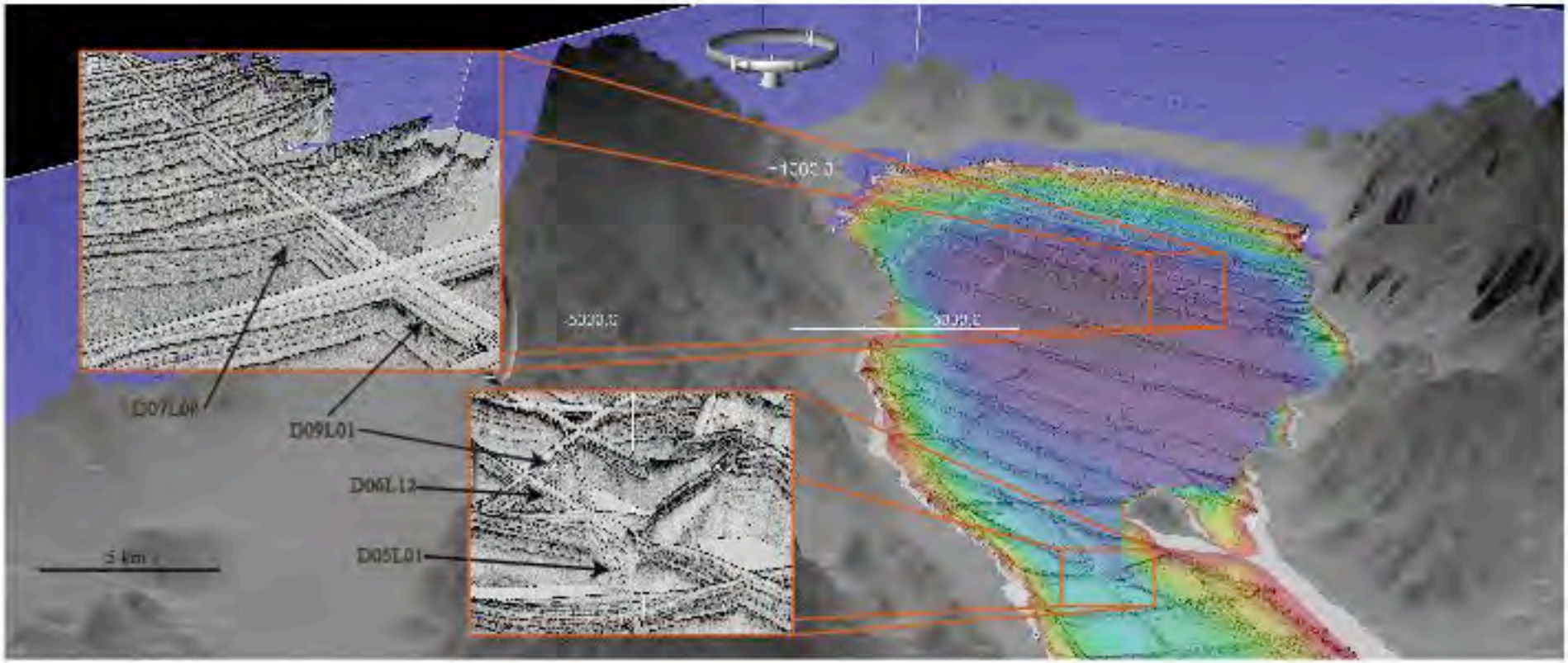


Methods:

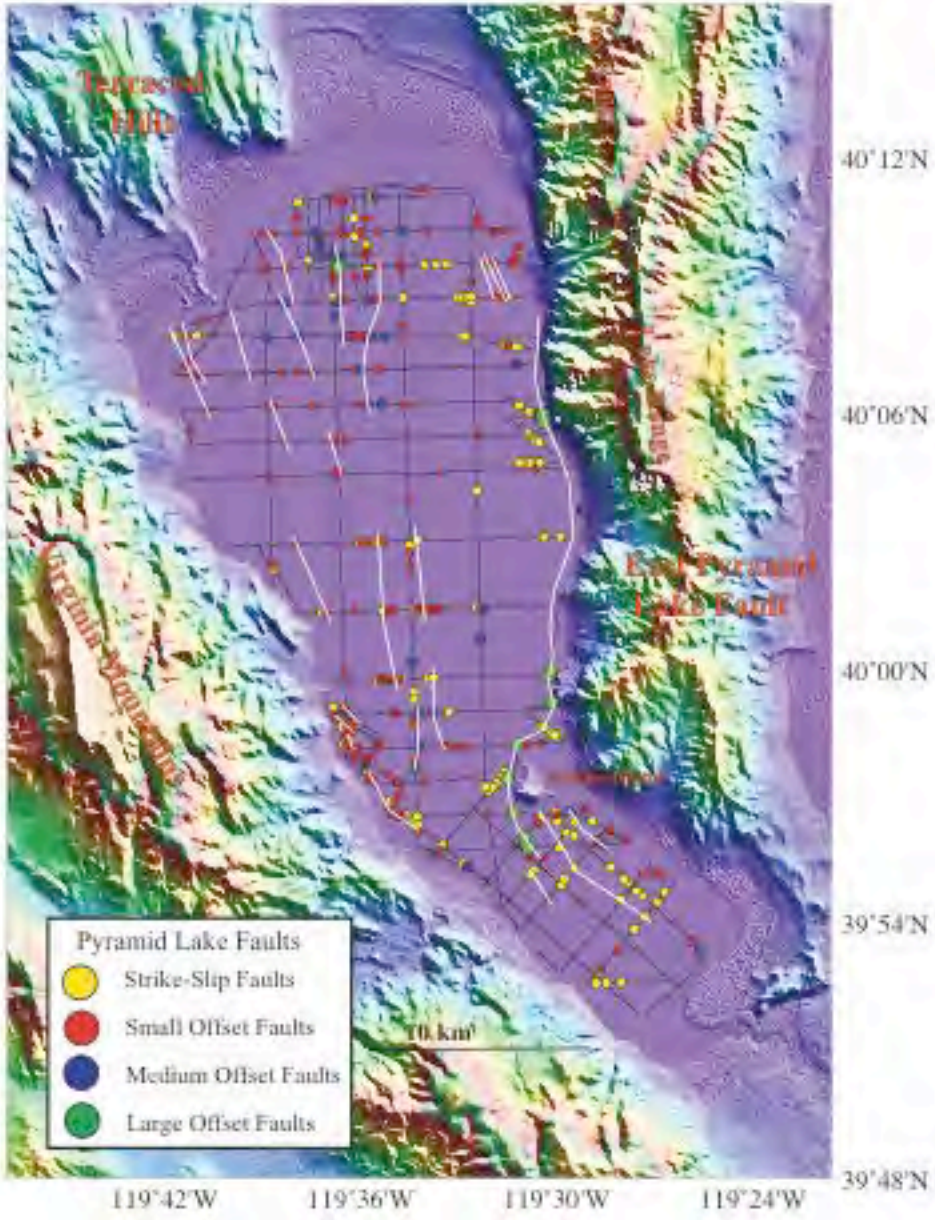
- Land Seismics – Heavy Vibrator Acquisition:
  - 29 line-km collection along 16 profiles
  - Upper 2 km of subsurface
  - 10-25 m vertical resolution
  - 8-second, 10-100 Hz sweep
  - Up to 240 channels live
  - Source-rec. spacing 17-67 m



CHIRP Results:

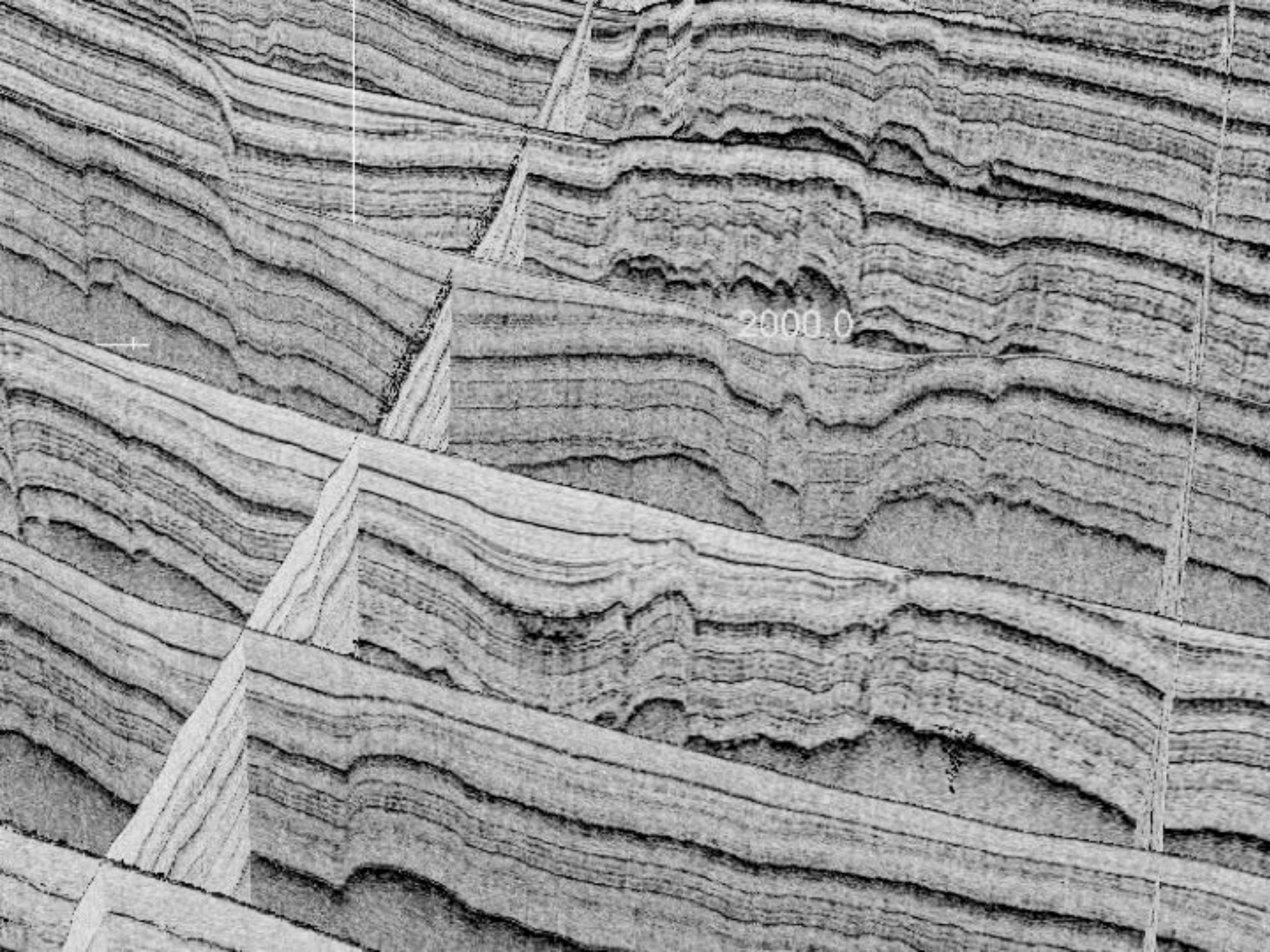


Views from Fledermaus



Preliminary Structural Conclusions

- Certain patterns are already starting to emerge
- Theoretical
  - Pyramid Lake fault
  - East Pyramid Lake fault (Lake Range)
- Imaged
  - East Pyramid Lake
  - Fault Splays
- Structural change
  - Northwest-striking narrow south end of Pyramid Lake and the north-striking, broader north end
  - Fanning/opening up of the basin to the north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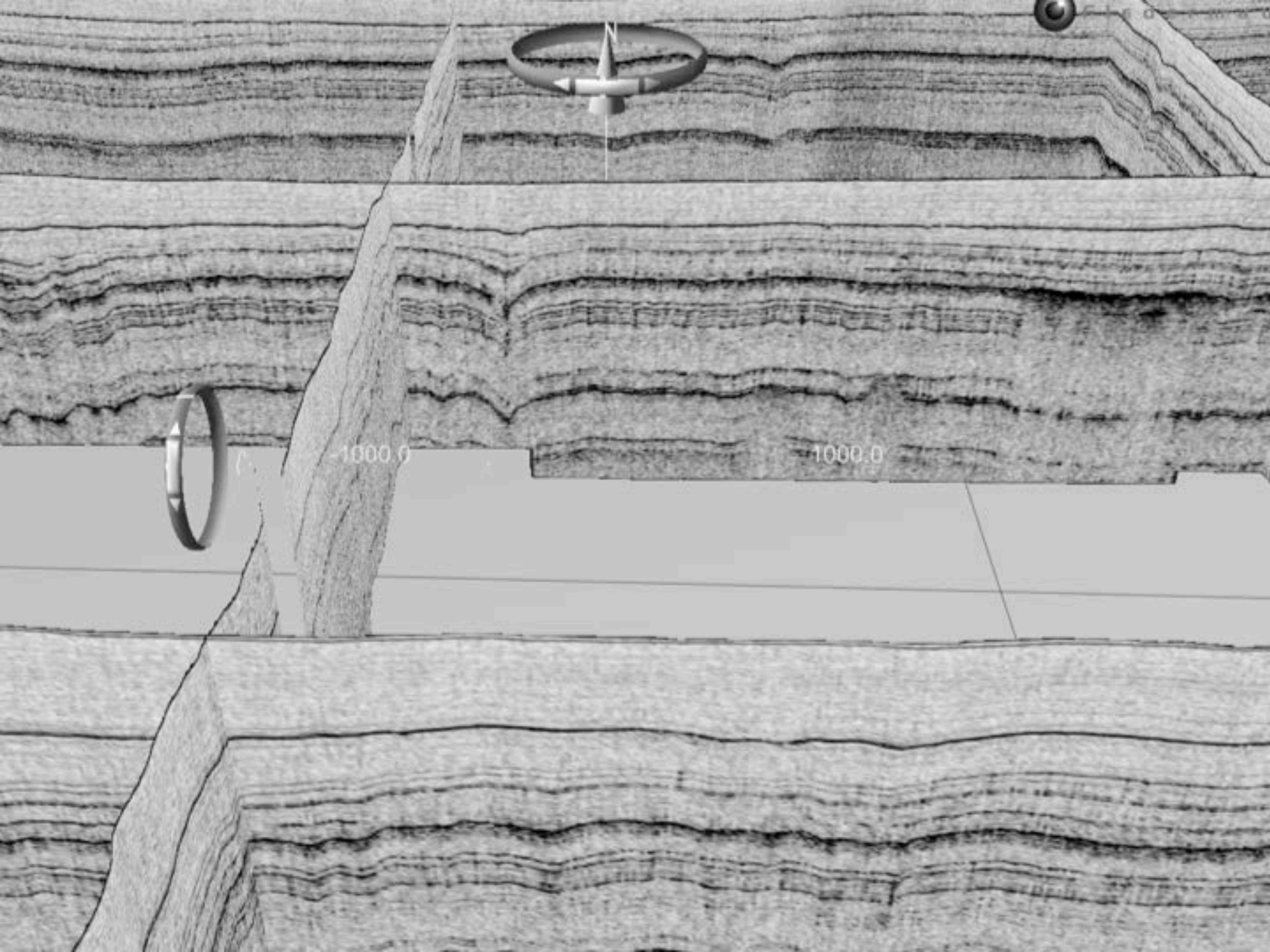
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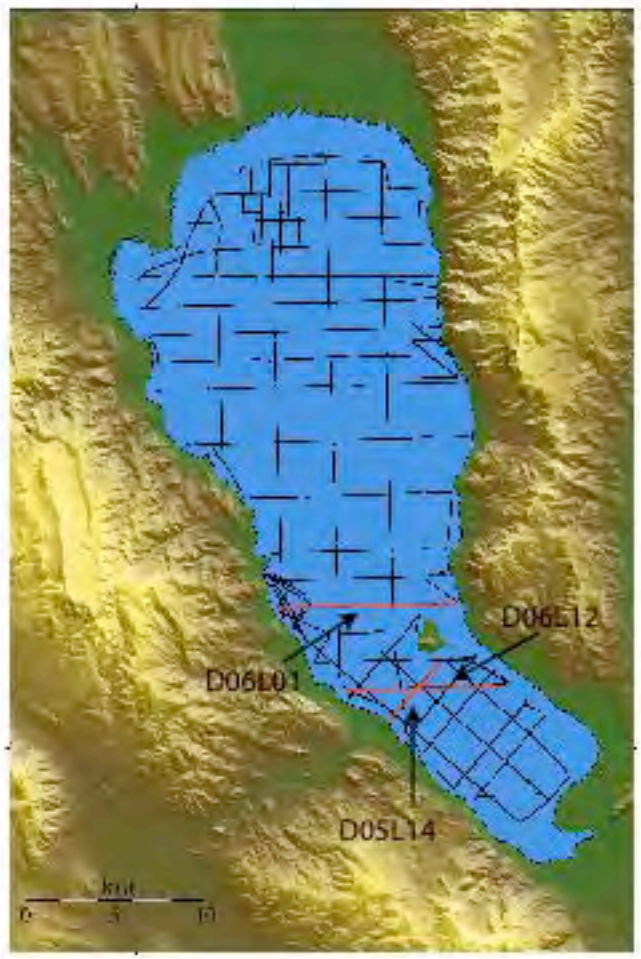
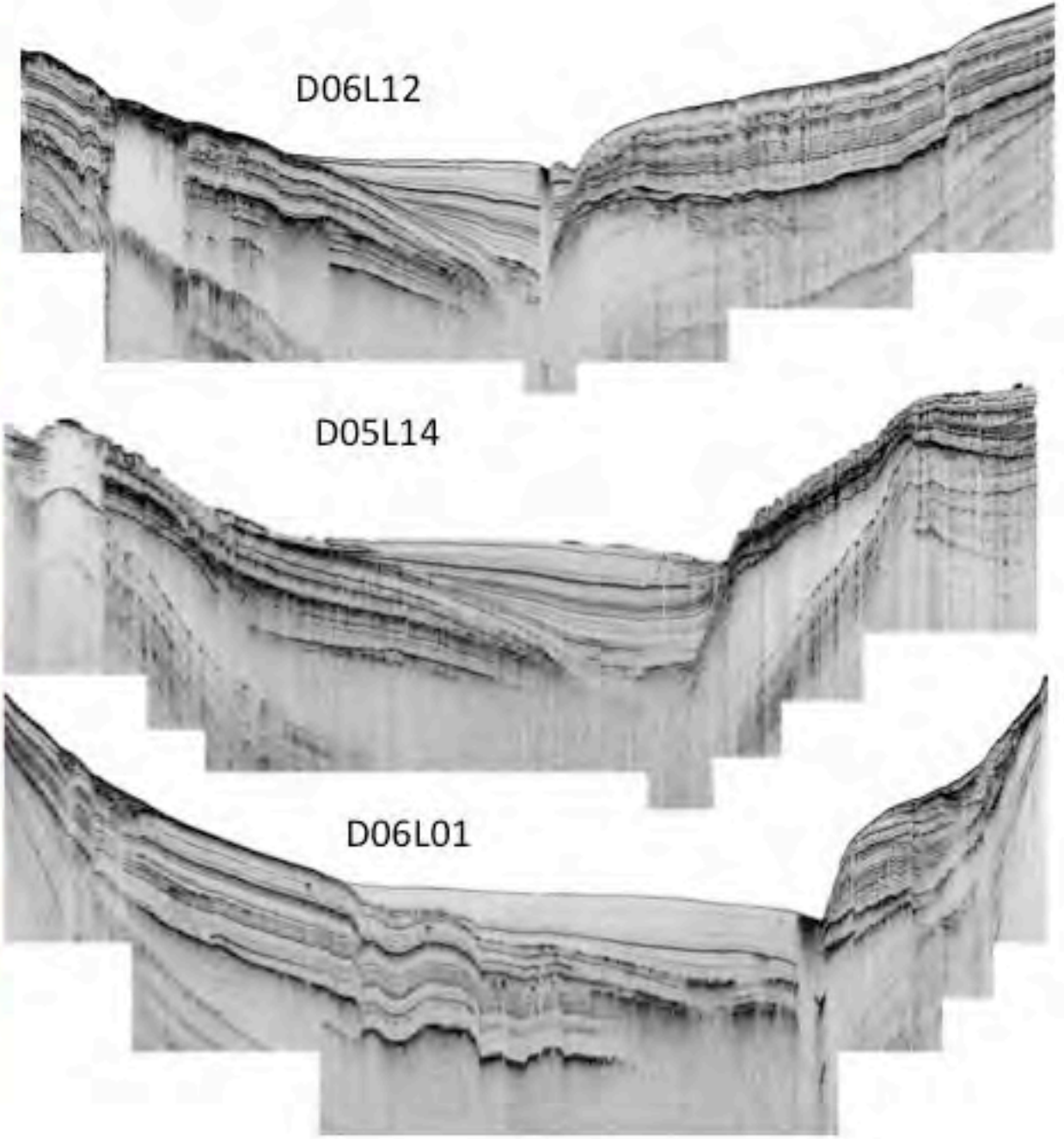
Geothermal Fluid in CHIRP:





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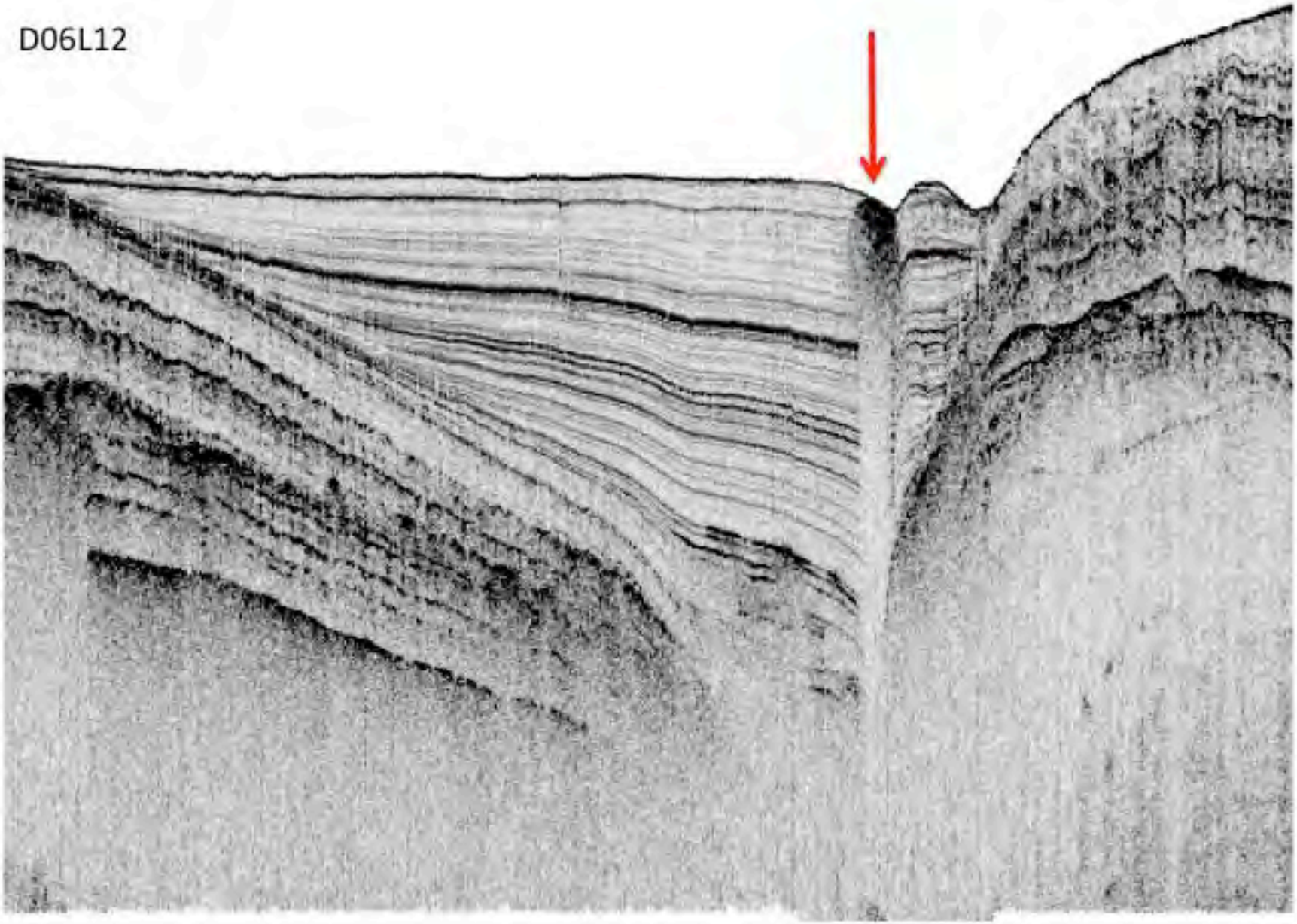

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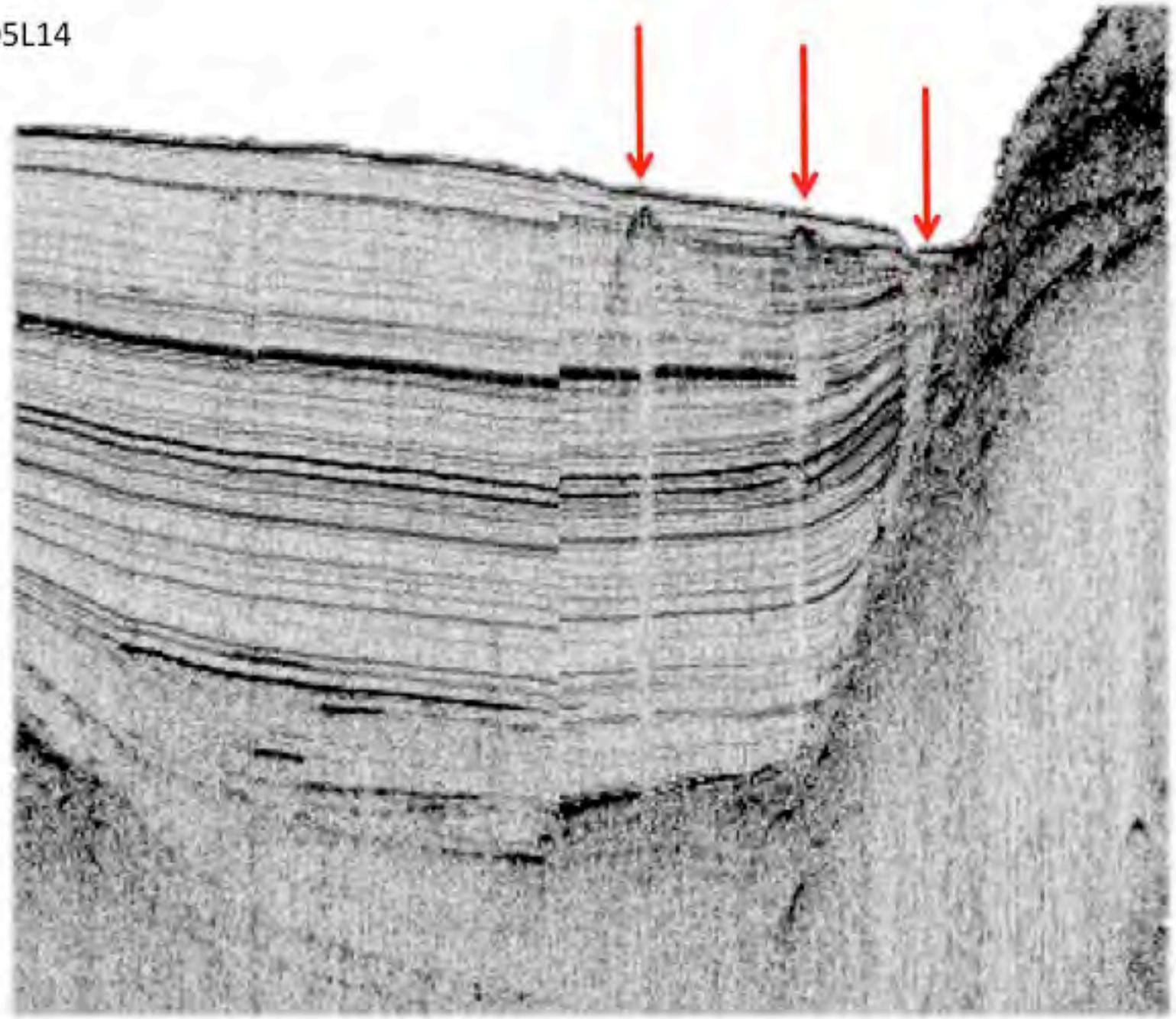

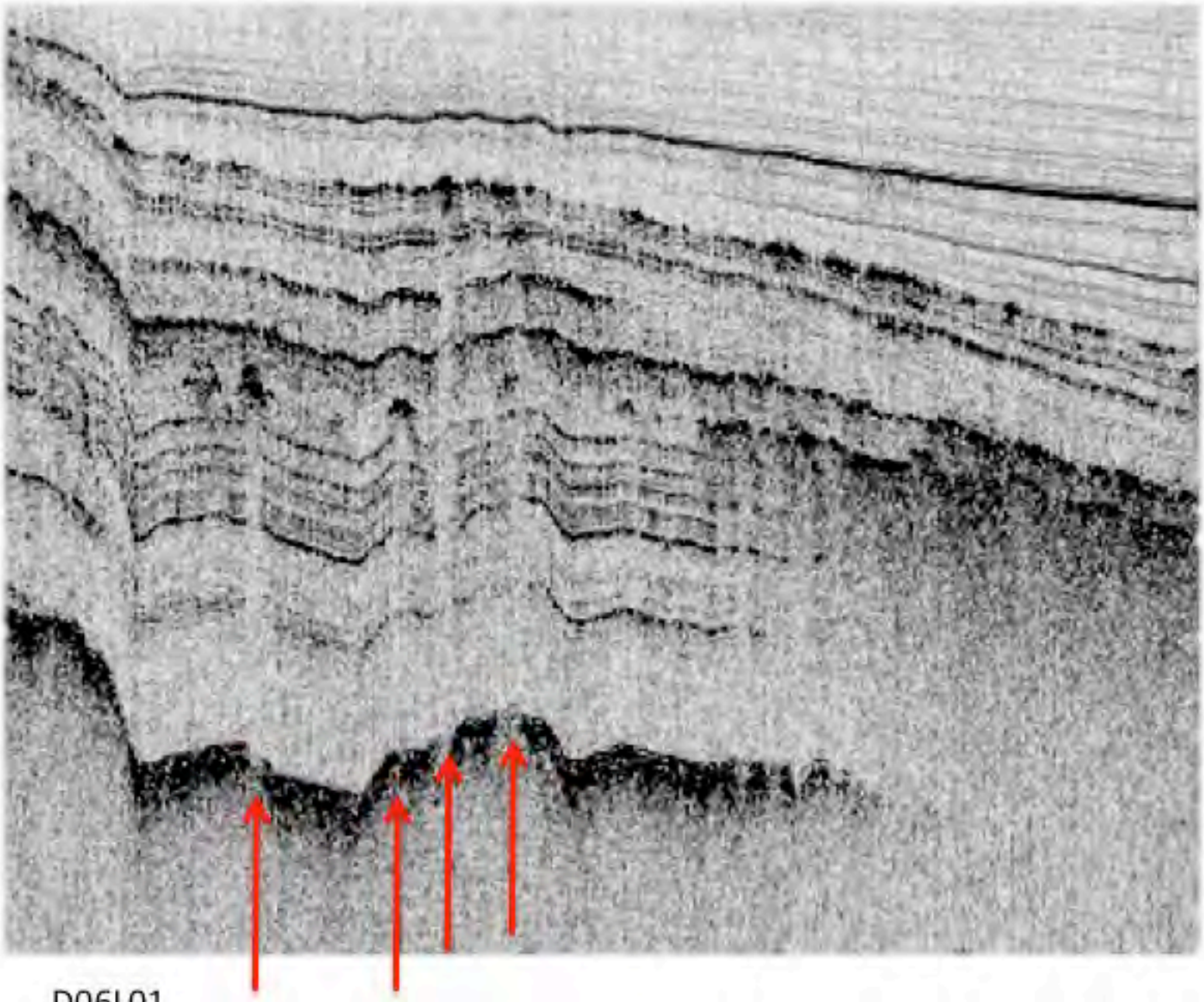
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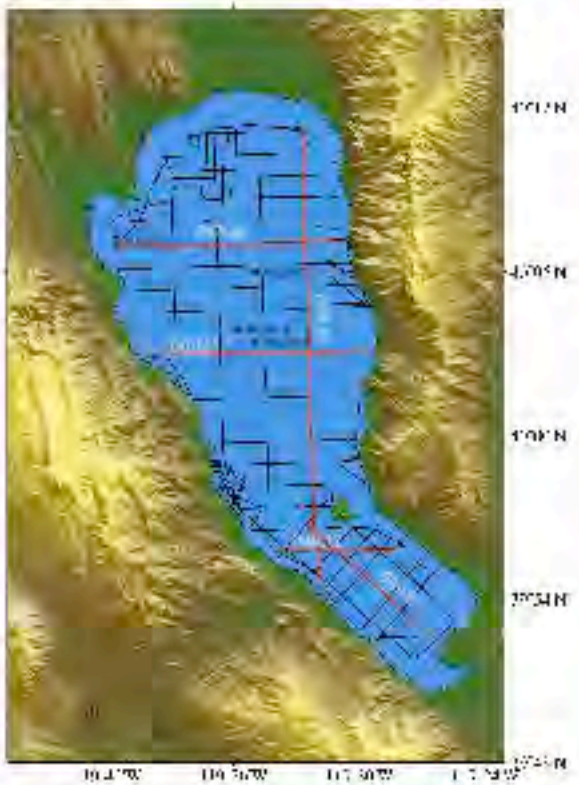
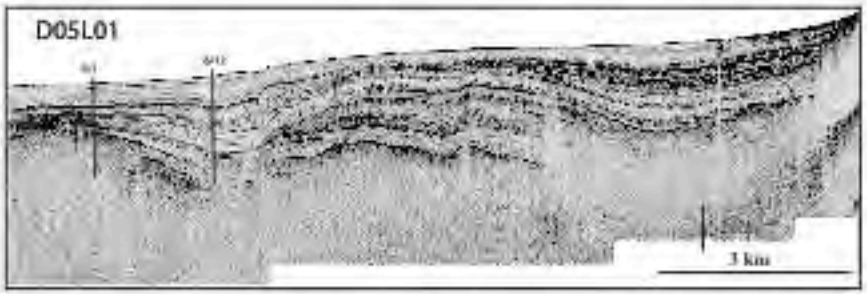
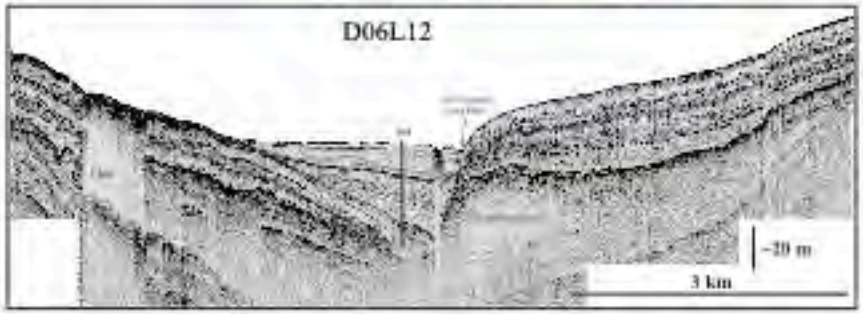
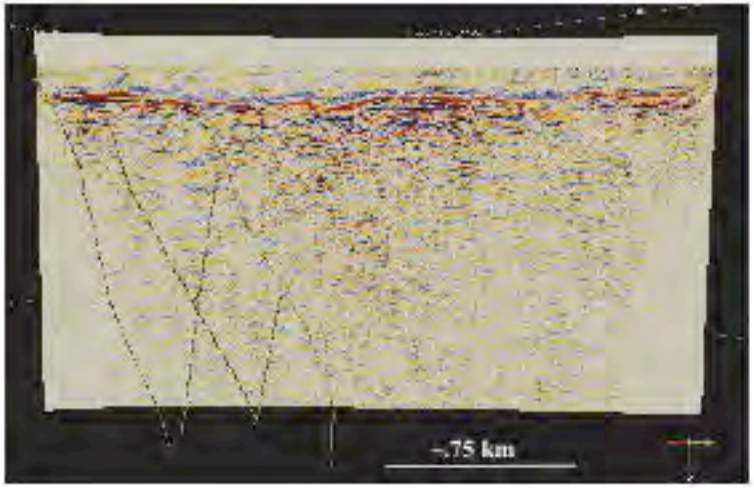
Additional CHIRP Research:





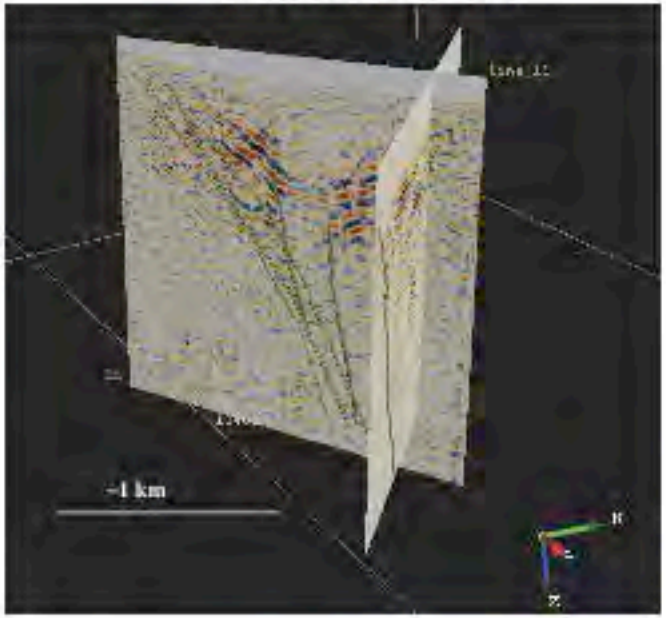


- Cores collected in 2002 by Benson et al.
  - Understand the timing of sediment deposition
  - Calculate major fault slip rate (1.14mm/yr. – 3.02 mm/yr.)
- Tracked CHIRP lines throughout the lake using Fledermaus



Land Seismic Results

- Clear images of normal faults
  - Dextral component
  - Stratigraphic terminations and intersecting fault planes
- Two new 4300 ft wells
  - Confirmed location steeply dipping faults found with seismics
  - Tertiary volcanic stratigraphy, highly reflective basalts below rhyolite domes



Views from OpendTect

Preliminary Conclusions:

- Two distinct phases of faulting
  - Early Walker Lane extension and shear
    - Seen in mid-Miocene volcanics
  - More recent episode of faulting
    - Seen in CHIRP profiles
- Geothermal fluids
  - Moving through late-Pleistocene- to Holocene-aged faults
  - Not mid-Miocene-aged conduits

Pyramid Lake Earthquake Investigation