# Marine EM on Land: MT Measurements in Mono Lake

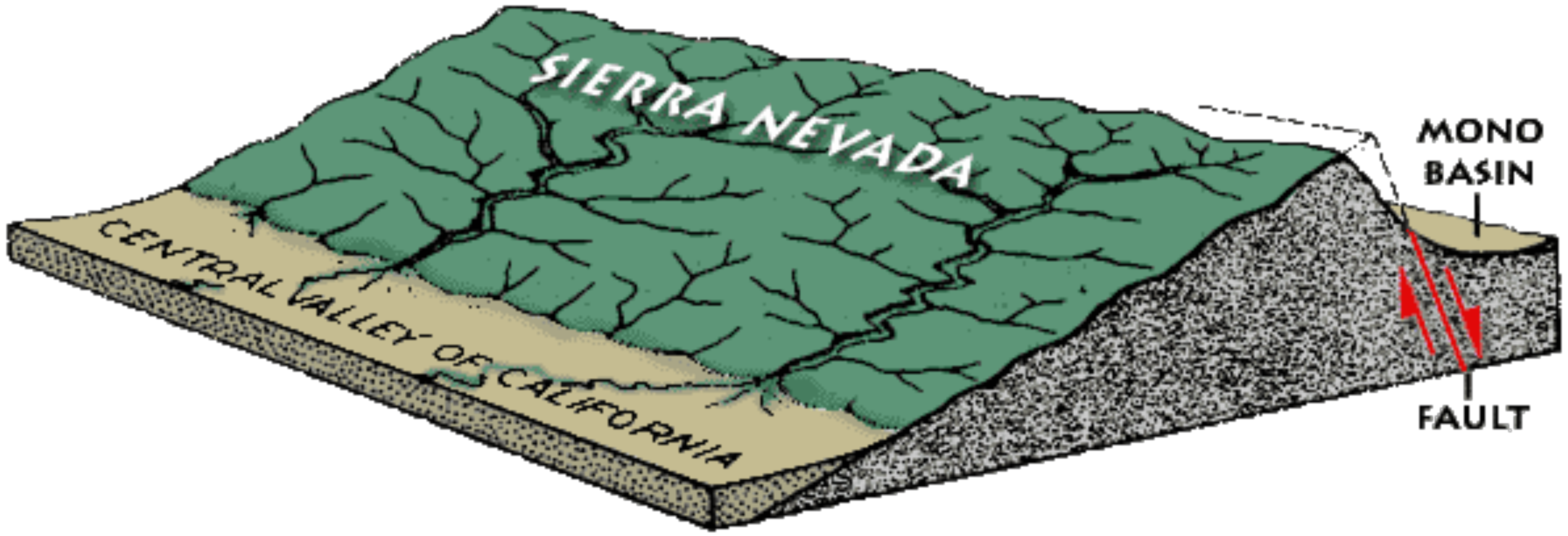
Steven Constable, UCSD/SIO
Jared Peacock, USGS

EMIW 2018


*http://digital-desert.com/geomorphic-provinces/*

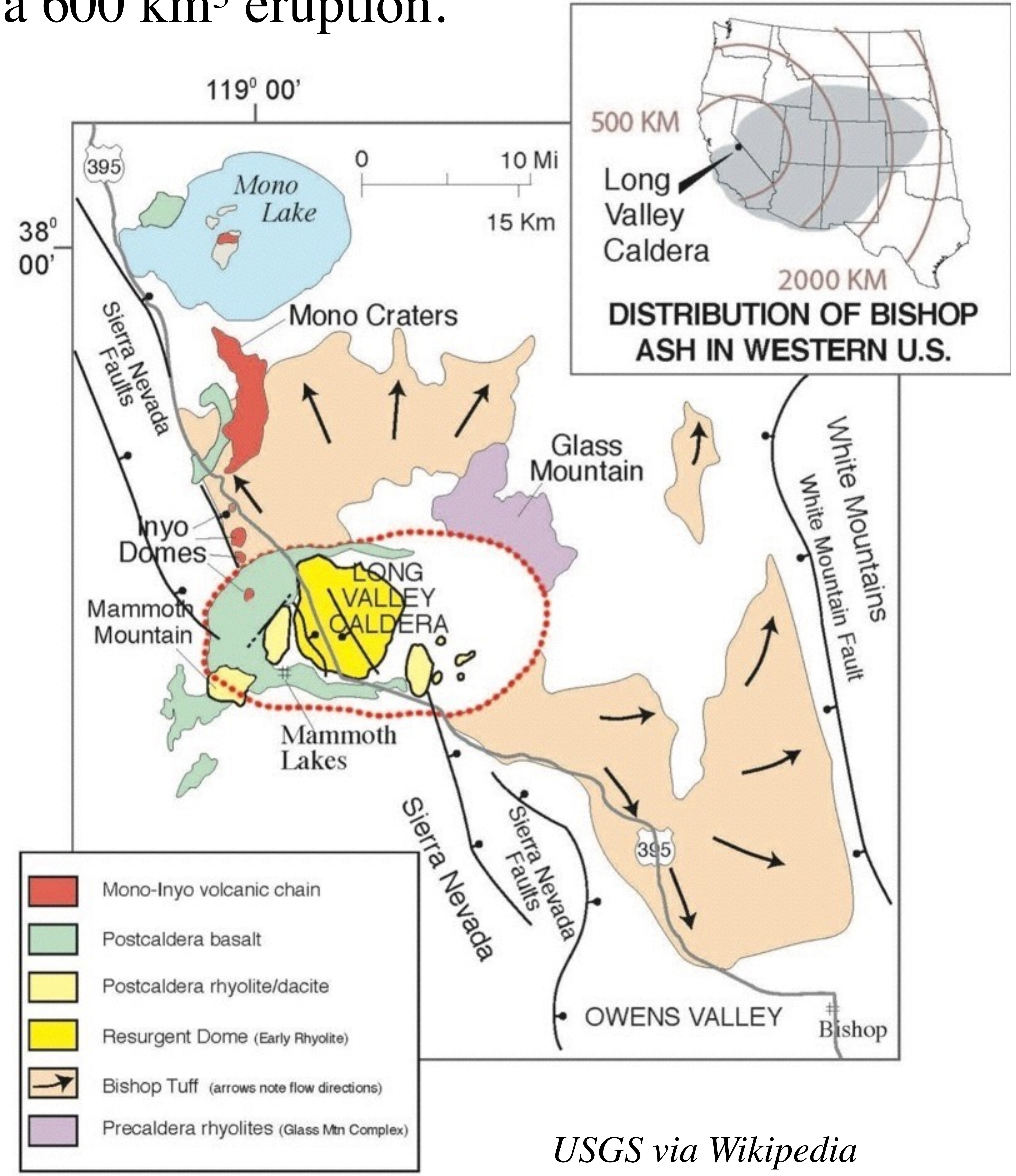
Mono Lake sits in the Mono Basin, where the Basin and Range meets the Sierra Nevada.

The Sierra Nevada is a tilted block bounded on the east by the Basin and Range province.



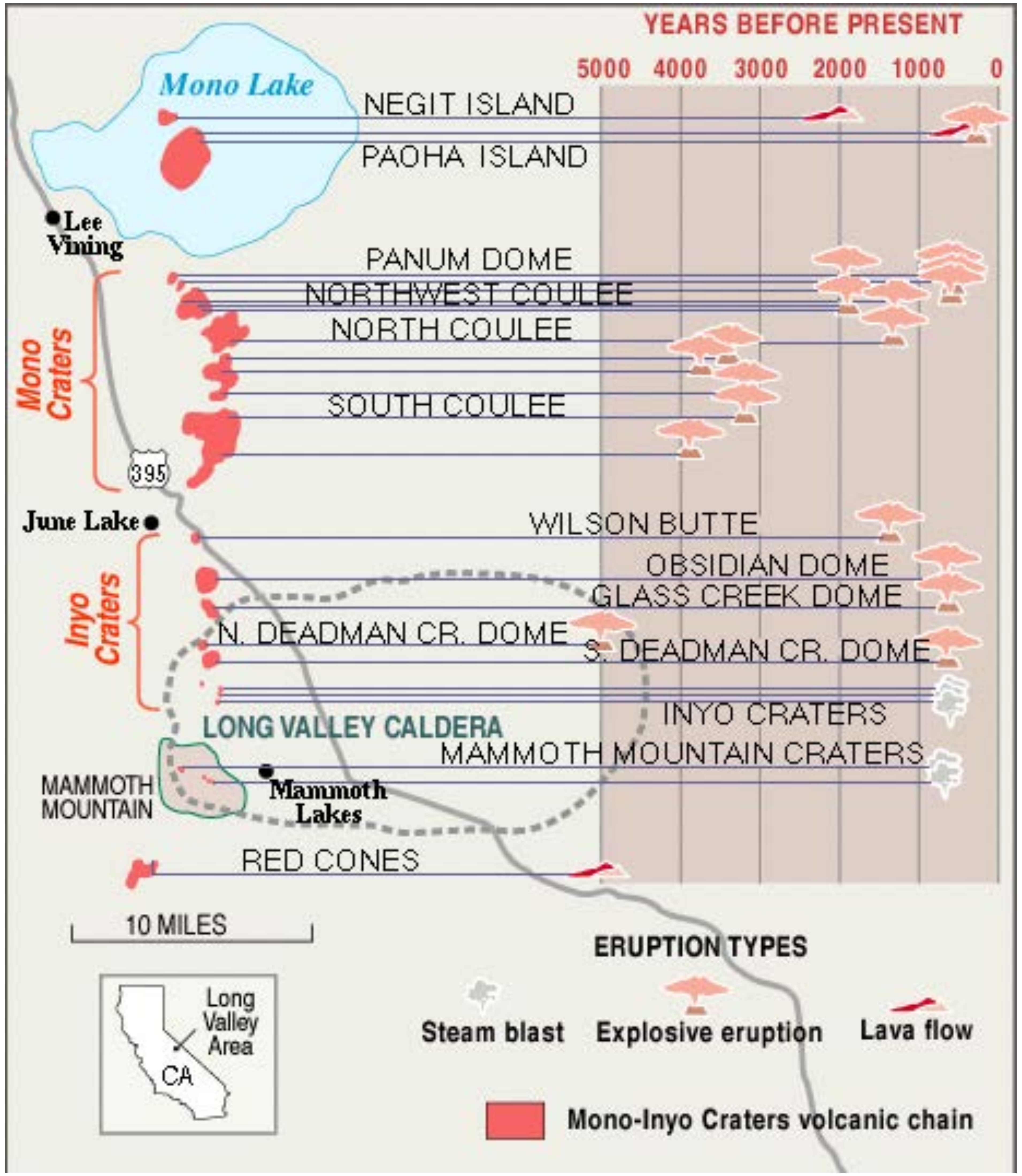

*USGS via Wikipedia*

Long Valley Caldera formed 0.76 Ma with a 600 $km^3$ eruption.




*USGS via Wikipedia*

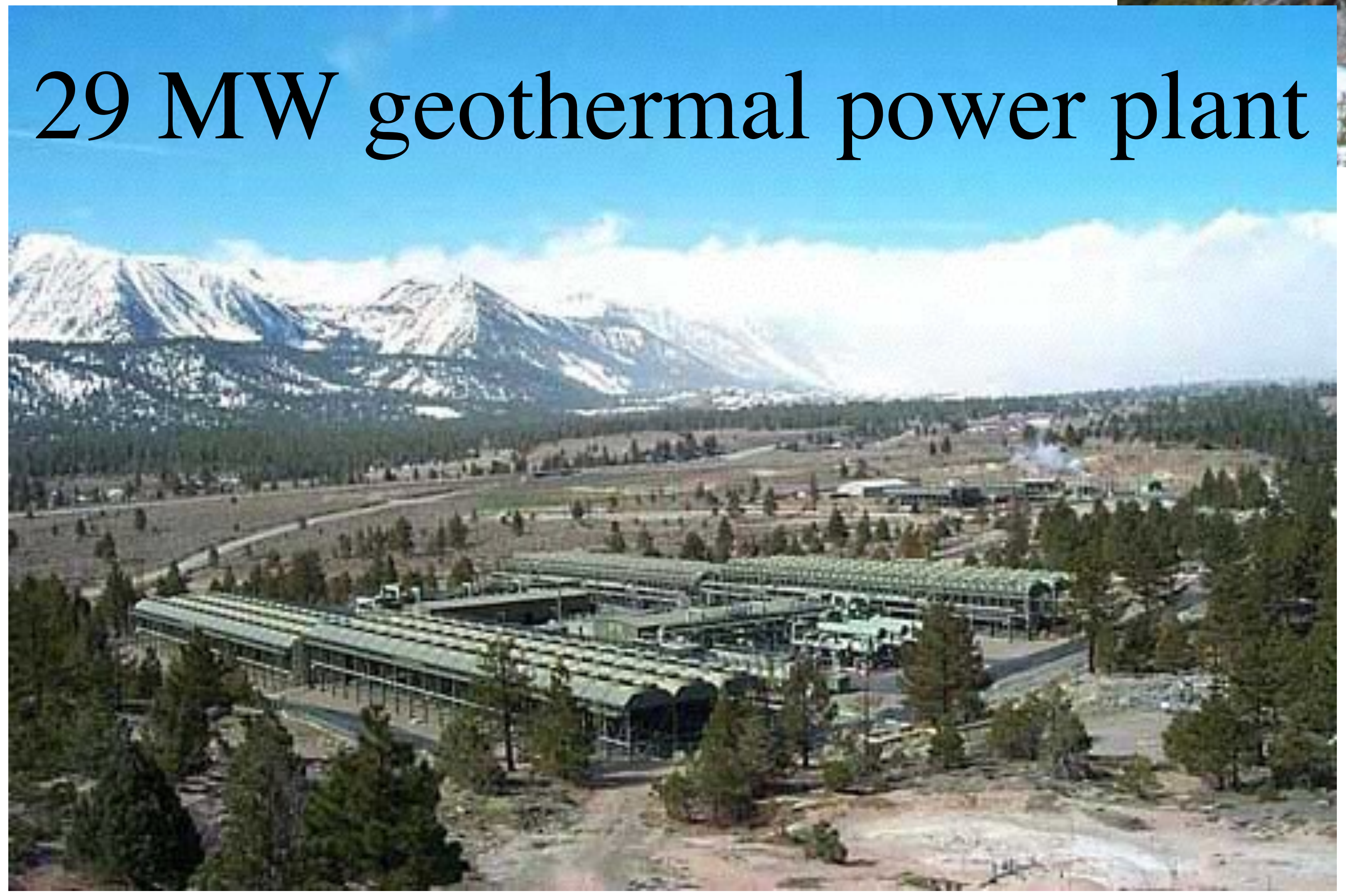
Inyo-Mono craters are recent volcanic features. Paoha Island formed about 300 years ago.




*USGS via Wikipedia*

There is much evidence of recent volcanism in the area.

In 1990, $CO_2$ emissions near Horseshoe Lake killed a significant number of trees.



29 MW geothermal power plant

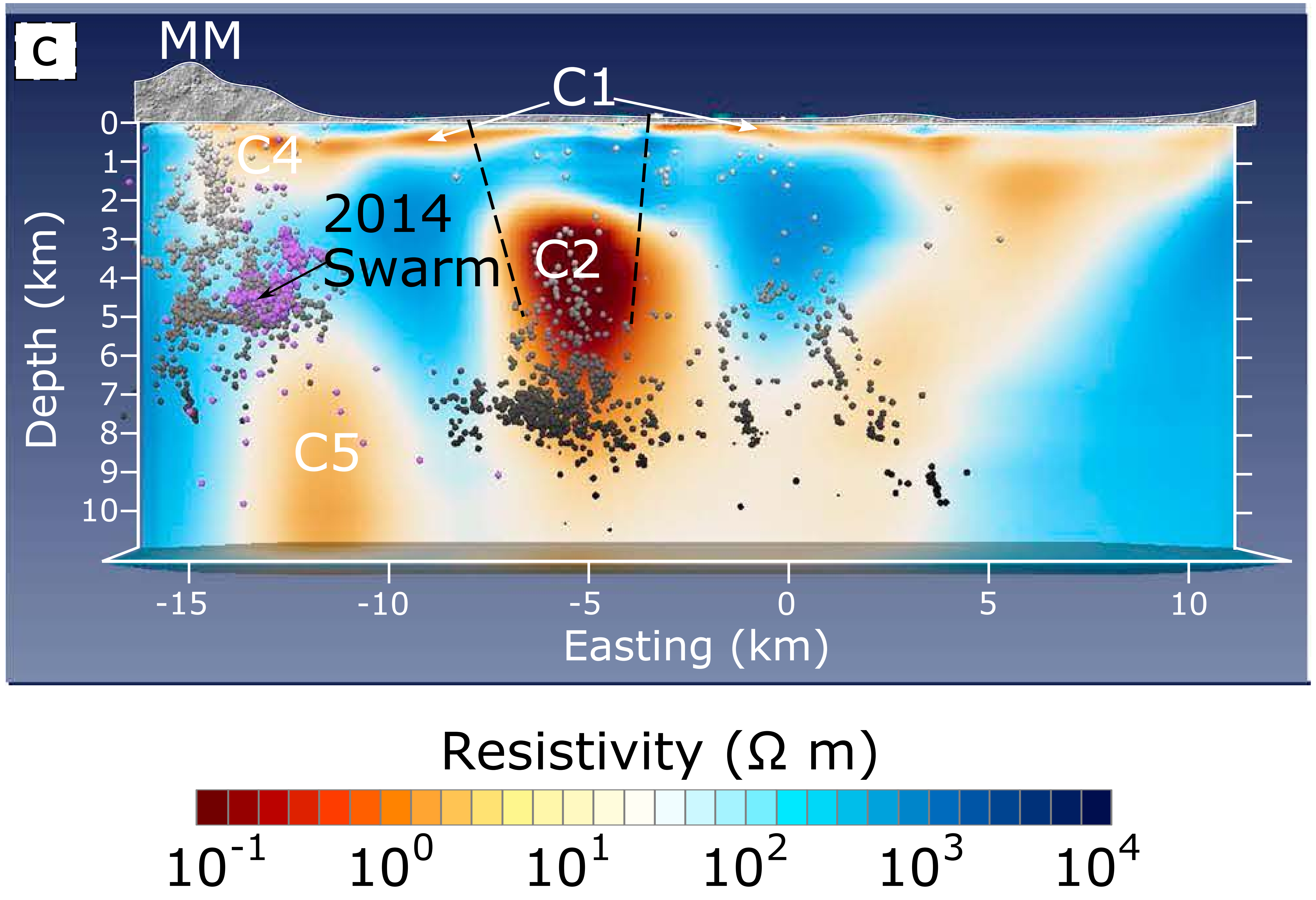
*MammothPacific.com*

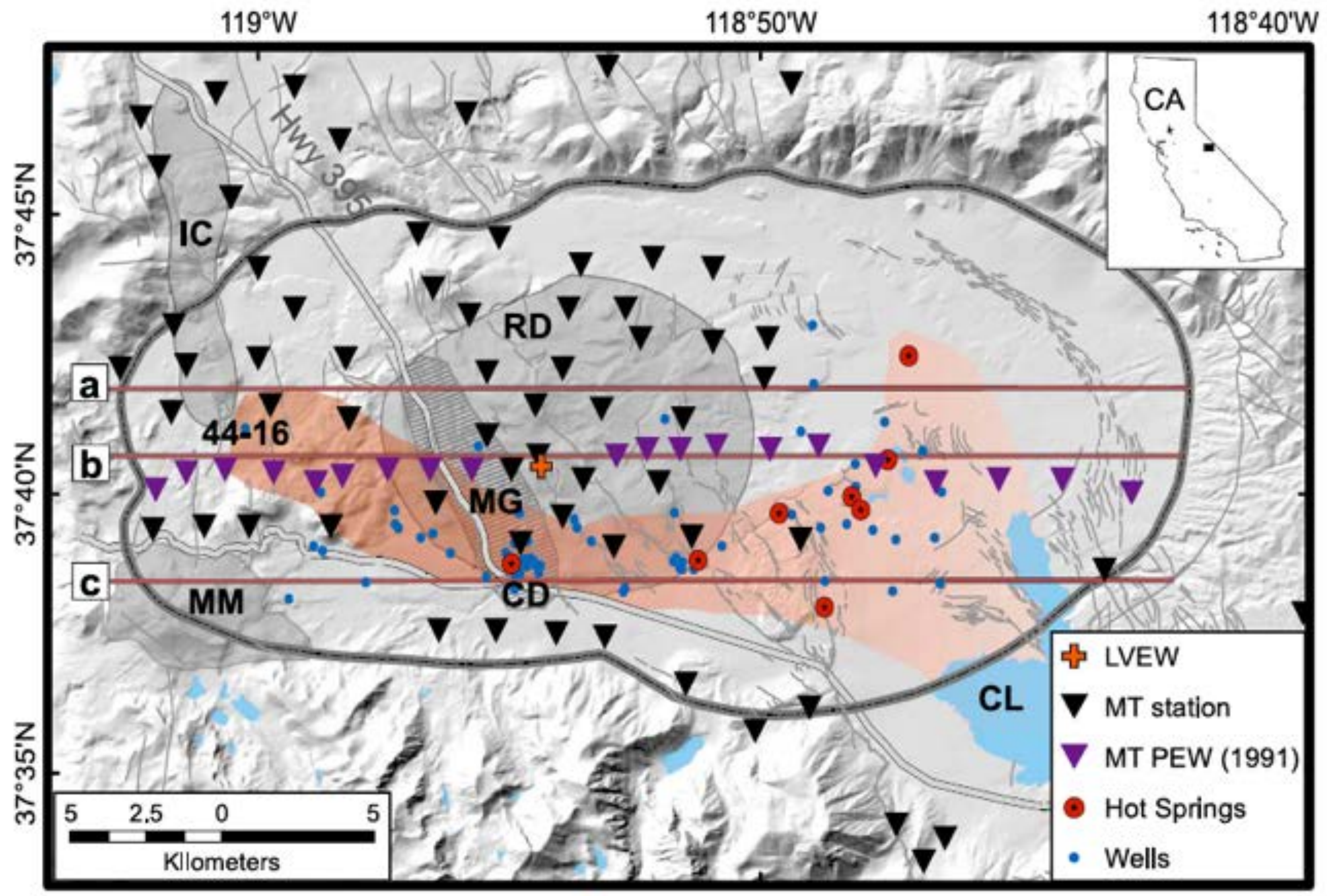
*Tripadvisor*

hot springs abound

USGS has been studying the magmatic and hydrothermal systems using (land) MT.

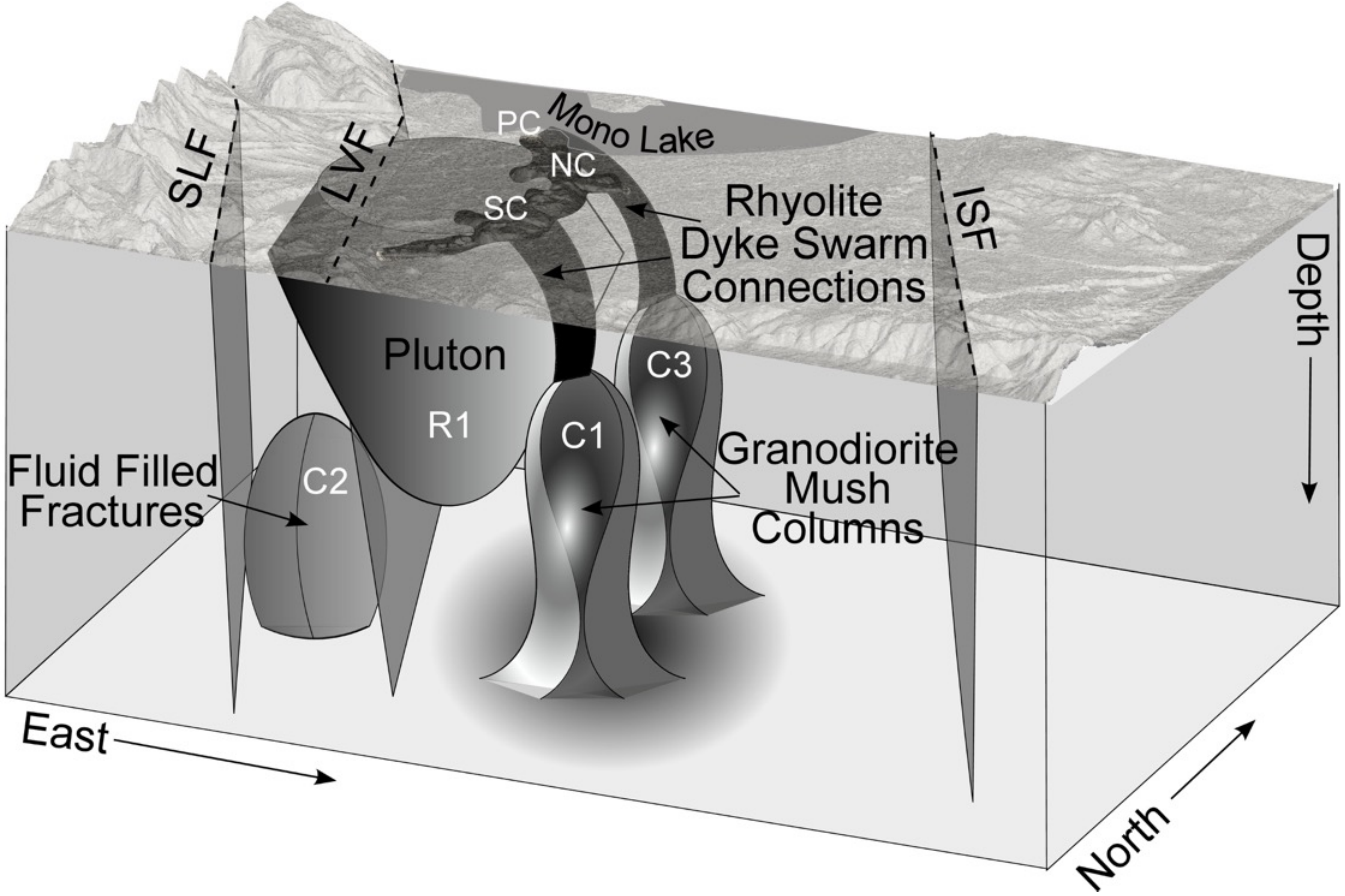
A highly conductive, and shallow, conductor C2 beneath Long Valley Caldera is thought to be a region of hypersaline fluids emanating from a melt region around 7 km deep. C4 is associated with $CO_2$ emissions.

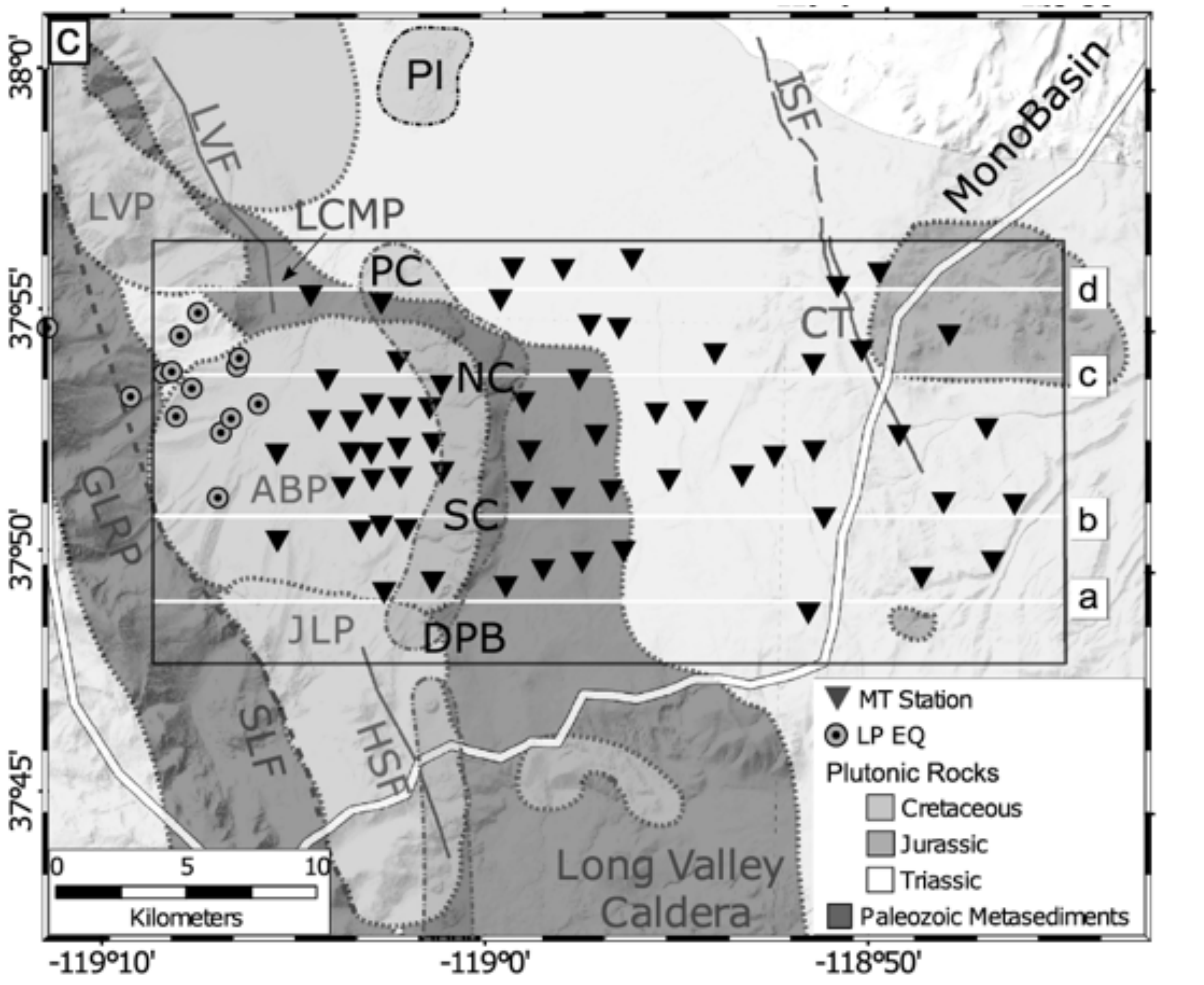



*Peacock et al., 2016, GRL.*

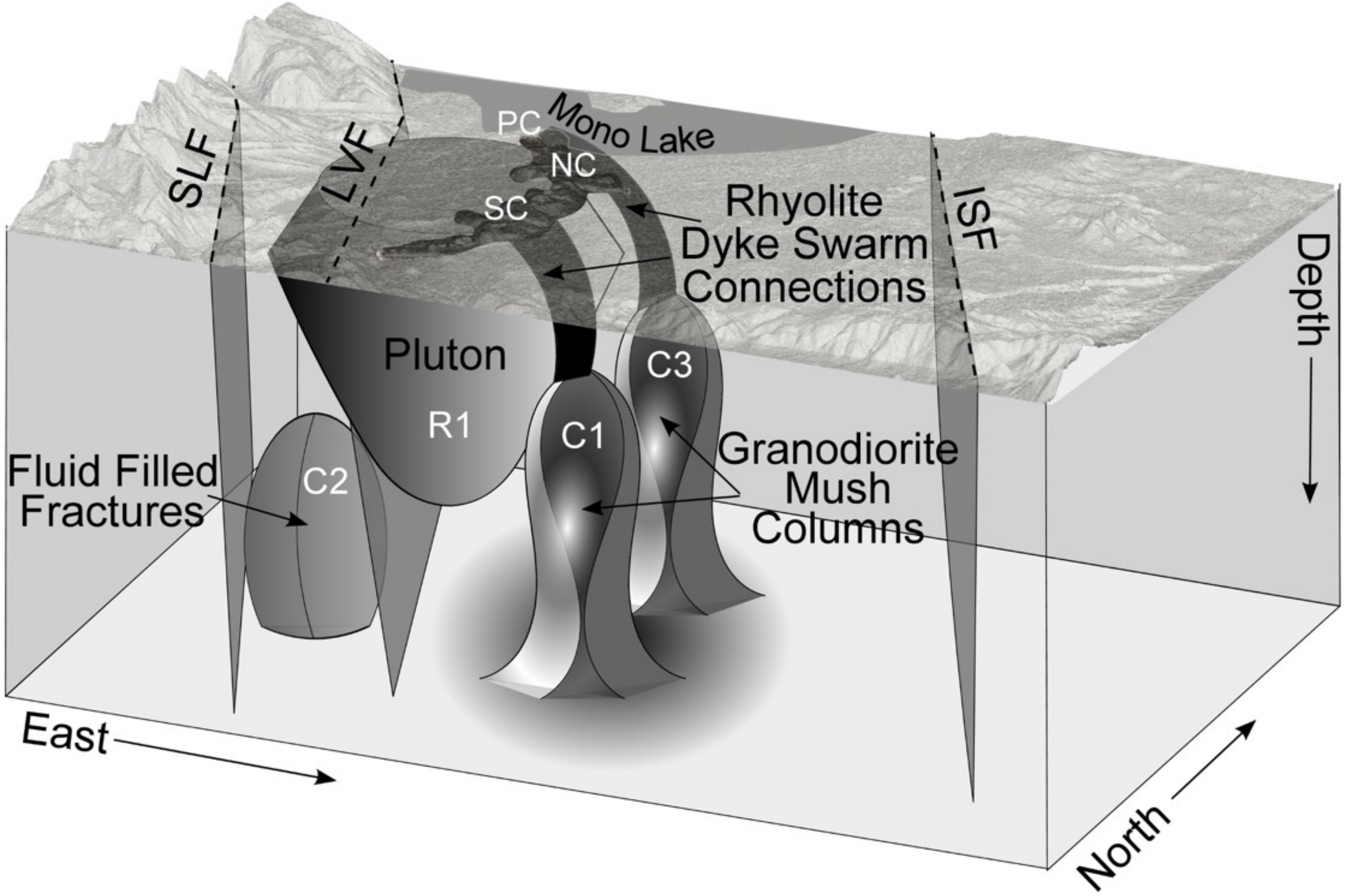
North of Long Valley, interpretation of MT inversions feature crystal-melt columns (C1, C3) feeding Holocene eruptions at Mono Craters (SC, NC, PC). A shallow conductor under Panum Crater is associated with hydrothermal fluids.

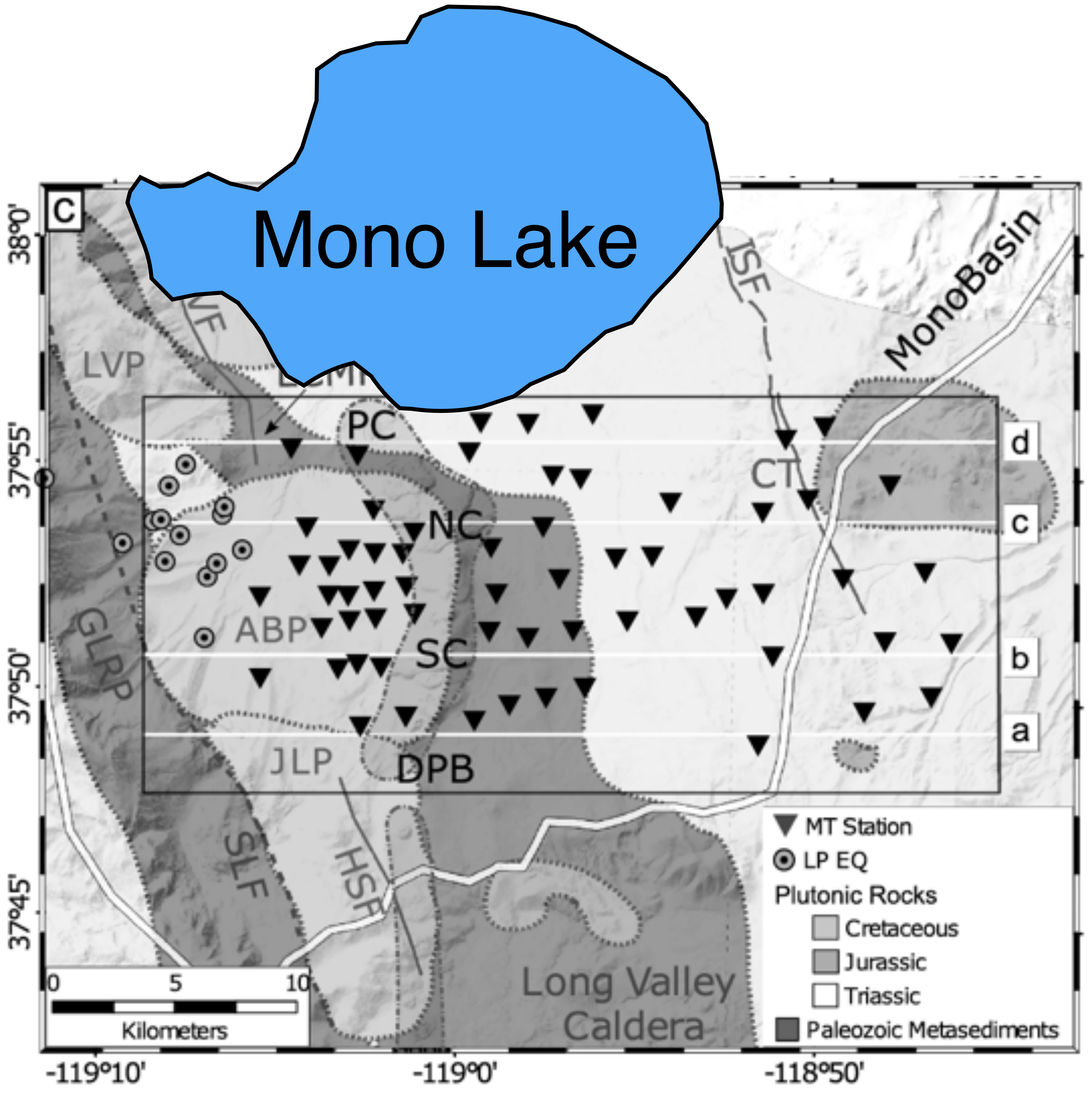



*Peacock et al., 2015, JGR.*

North of Long Valley, interpretation of MT inversions feature crystal-melt columns (C1, C3) feeding Holocene eruptions at Mono Craters (SC, NC, PC). A shallow conductor under Panum Crater is associated with hydrothermal fluids. But the data stop at Mono Lake…

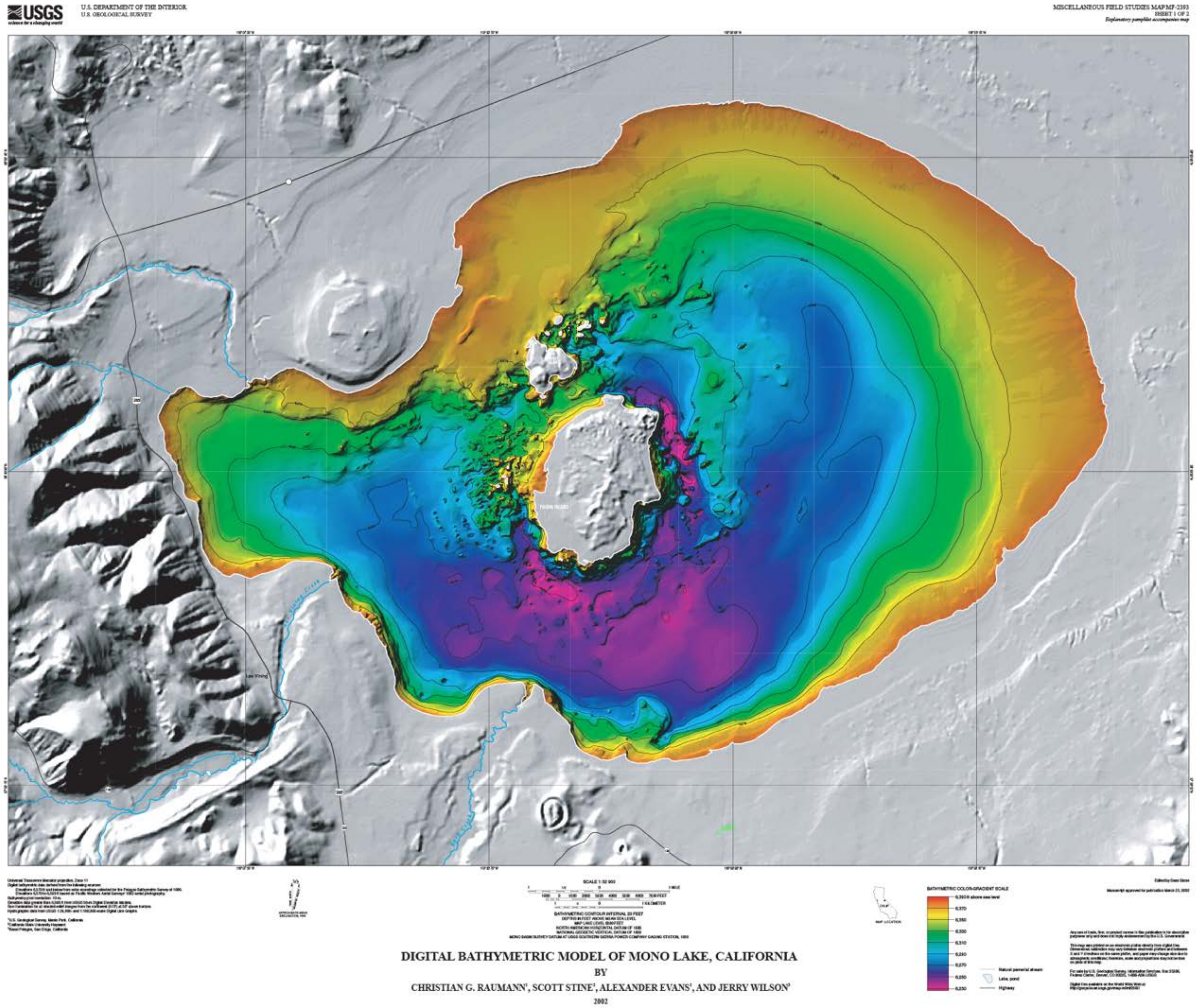



*Peacock et al., 2015, JGR.*

We need to fill the gap.

Mono Lake is 20 x 15 km in size, with salinity about twice that of seawater. The tufa towers are the result of freshwater springs interacting with the saline lake water.

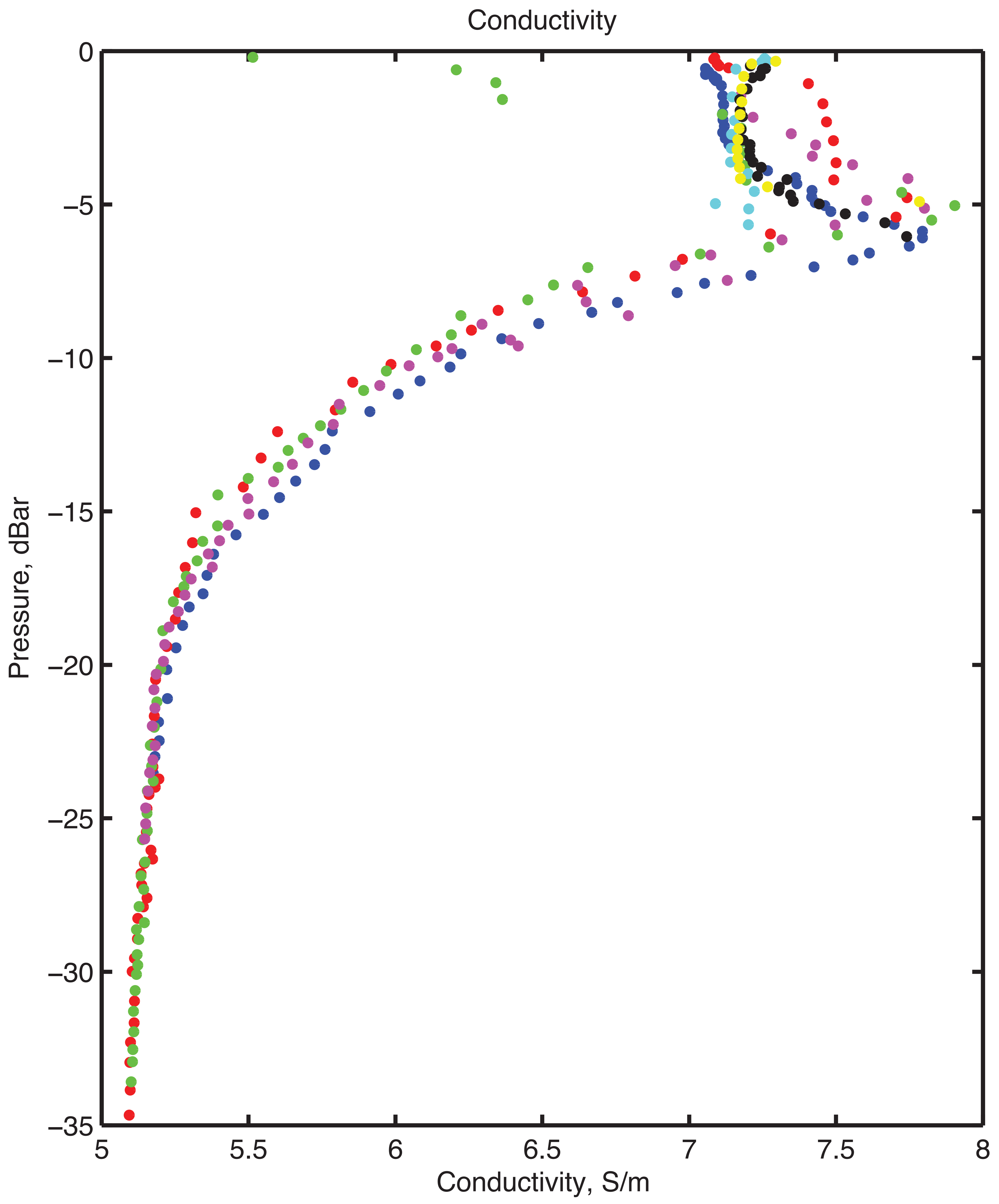


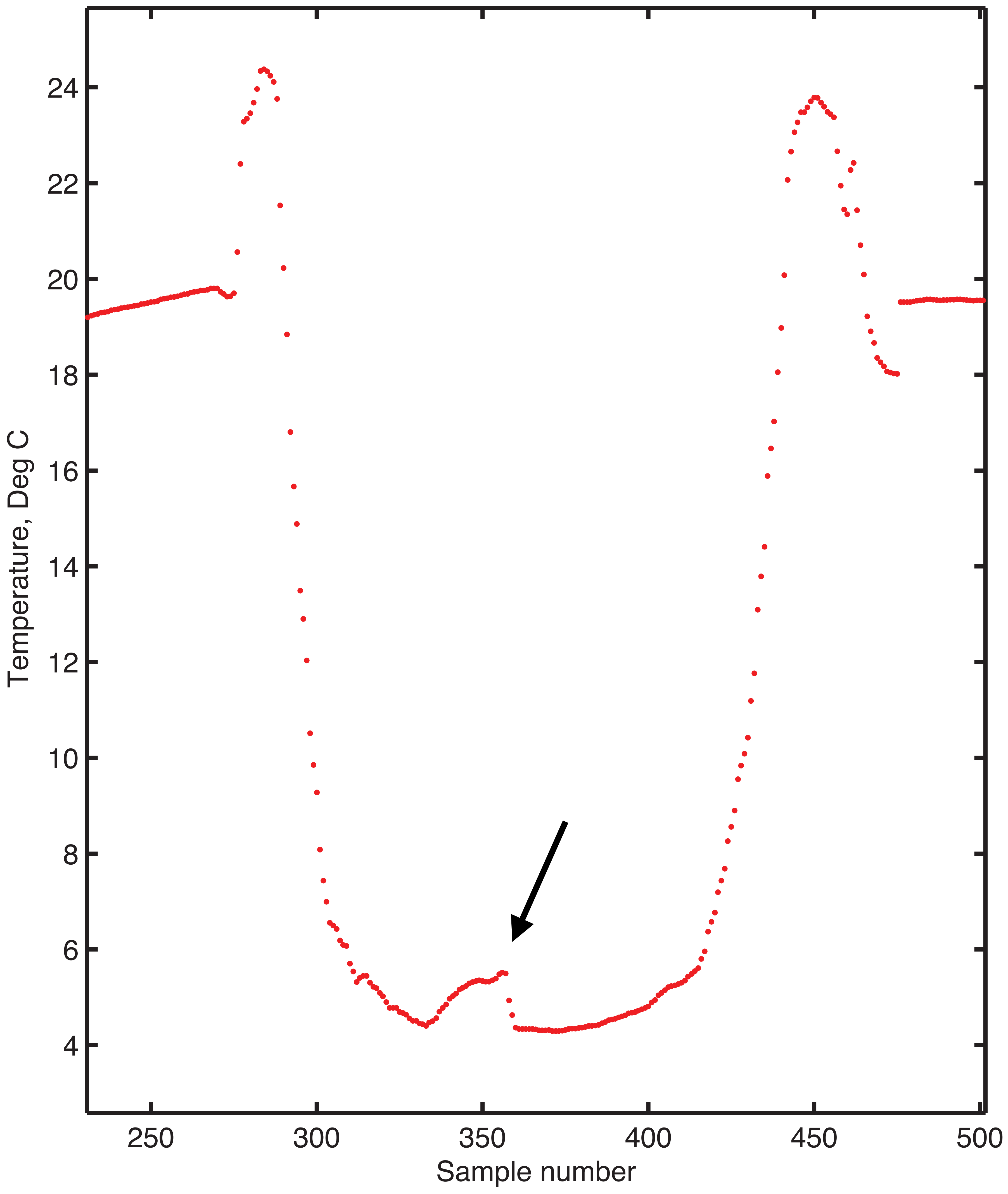

Mono is well mapped, with a maximum depth of 48 m, meaning that moored instruments could be deployed. (Contours are 20’ interval.)

Instruments are basically 7 marine MT receivers with E-dipoles shortened to 3 m, with no flotation or acoustic units.  We decoupled the float from the instrument with diving weights.

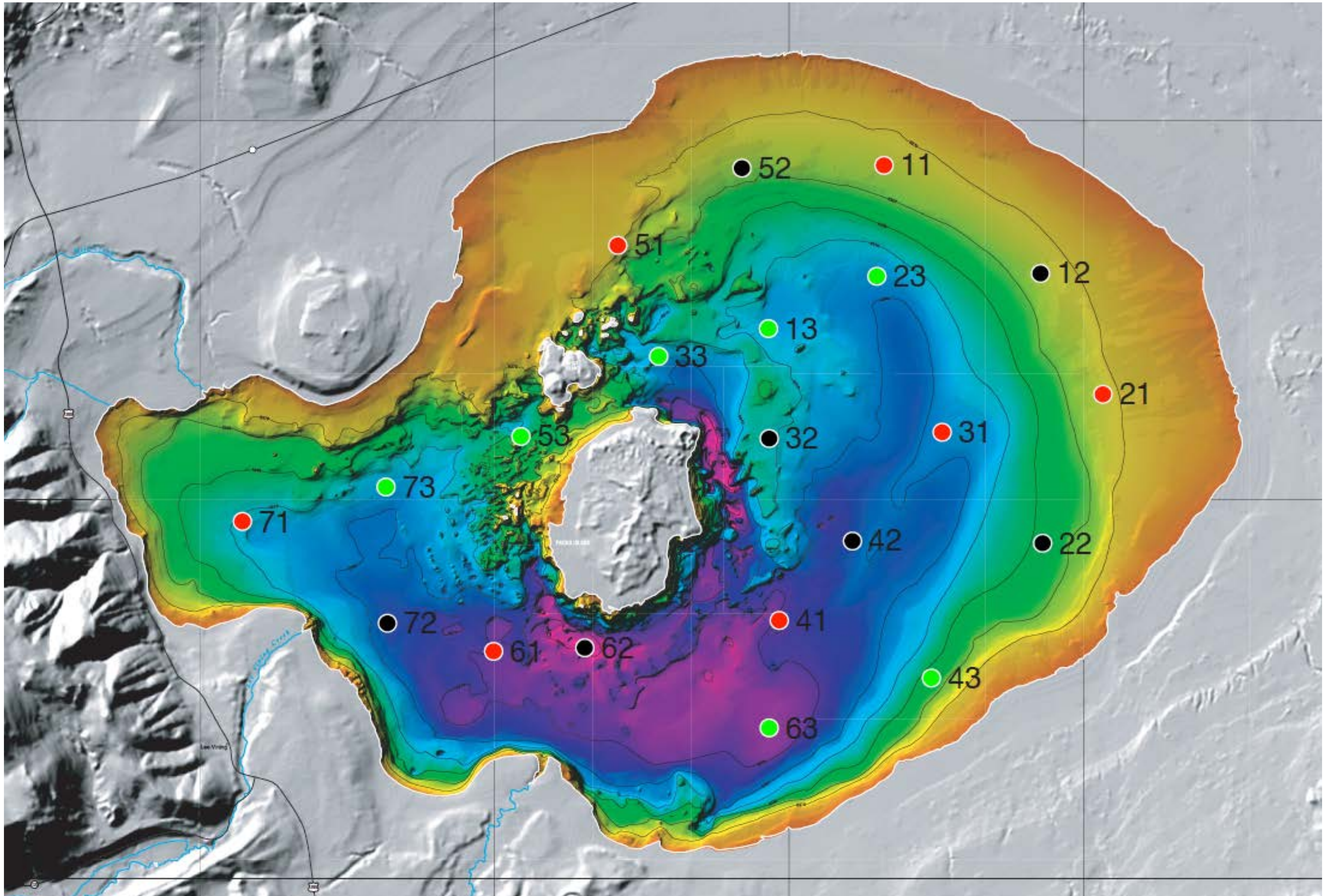
*Photos courtesy Chris Armerding*

Conductivity-Temperature-Depth (CTD) soundings were made at 7 sites around the lake.
Temperature of the bottom mud is higher than the lake water.



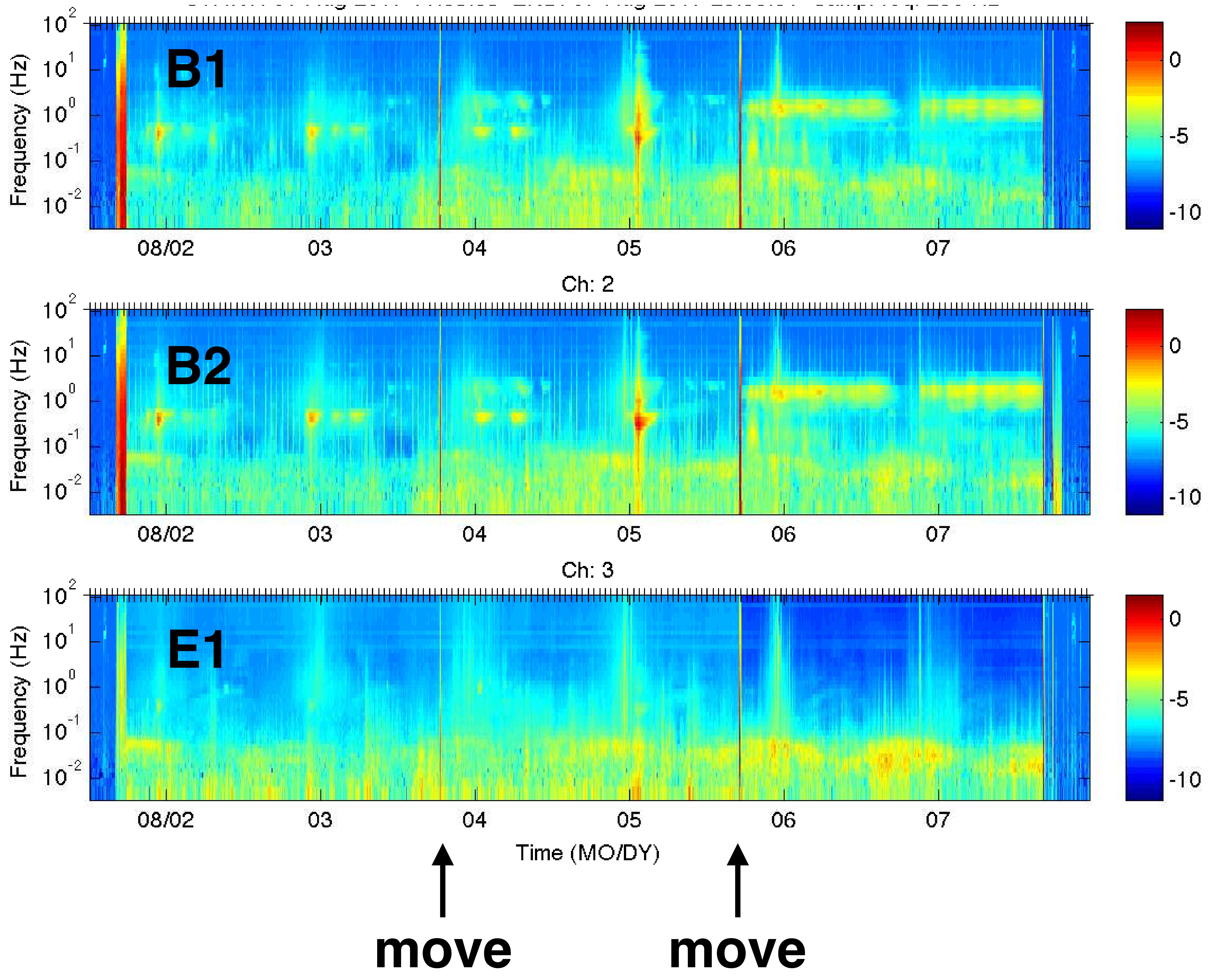



Seven instruments were deployed, left for 2 days, moved twice, and then recovered, for a total of 21 sites and a total of 4 half-days of work spread out over 6 days. Data were processed using Gary Egbert's multi-station code, using land magnetic references.

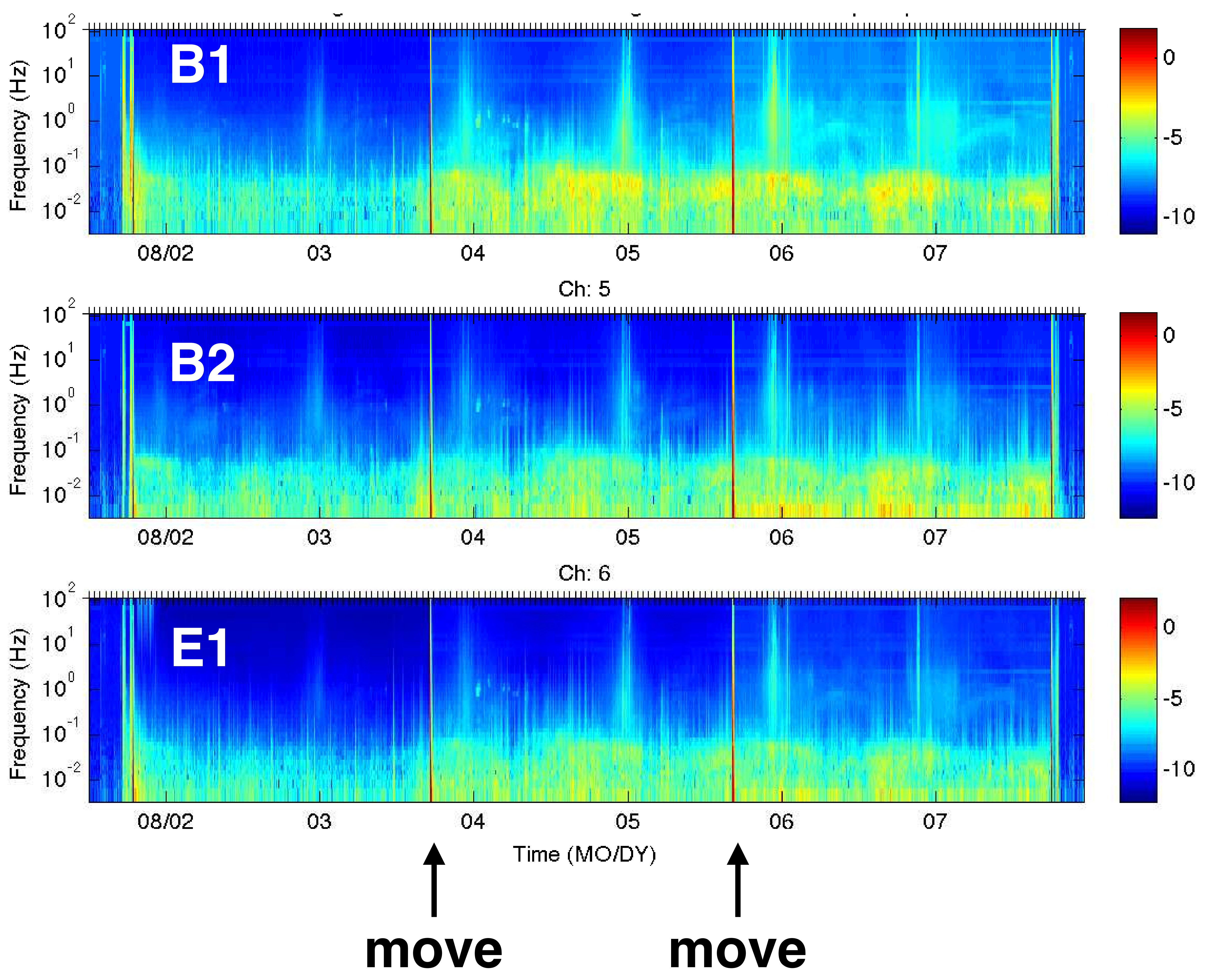


Being seafloor instruments, they have an endurance of several weeks, so we simply let them keep recording during moves. An external compass measured orientation every hour. Late afternoon storms are evident in the spectrograms.

## Sites 11, 12, 13

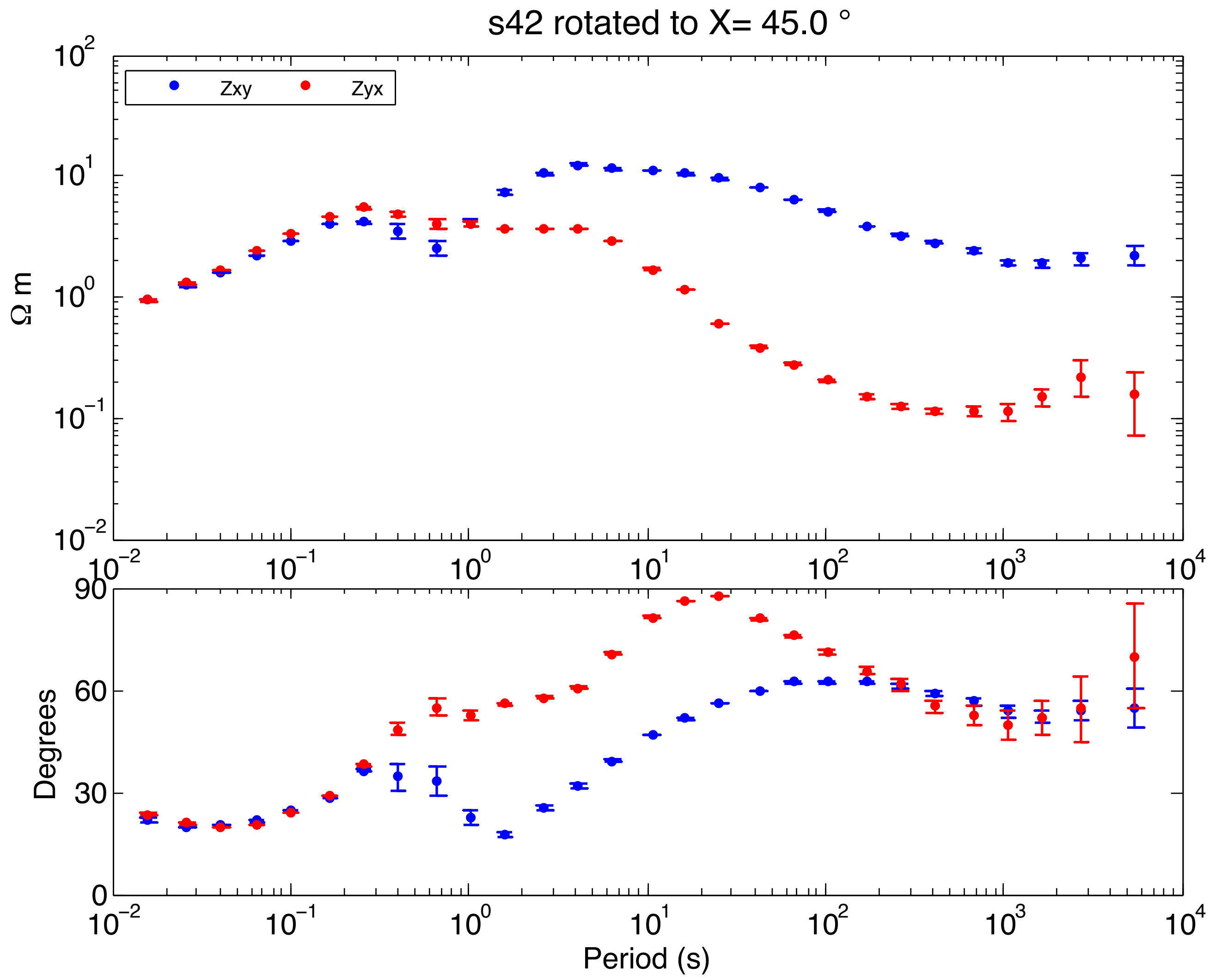


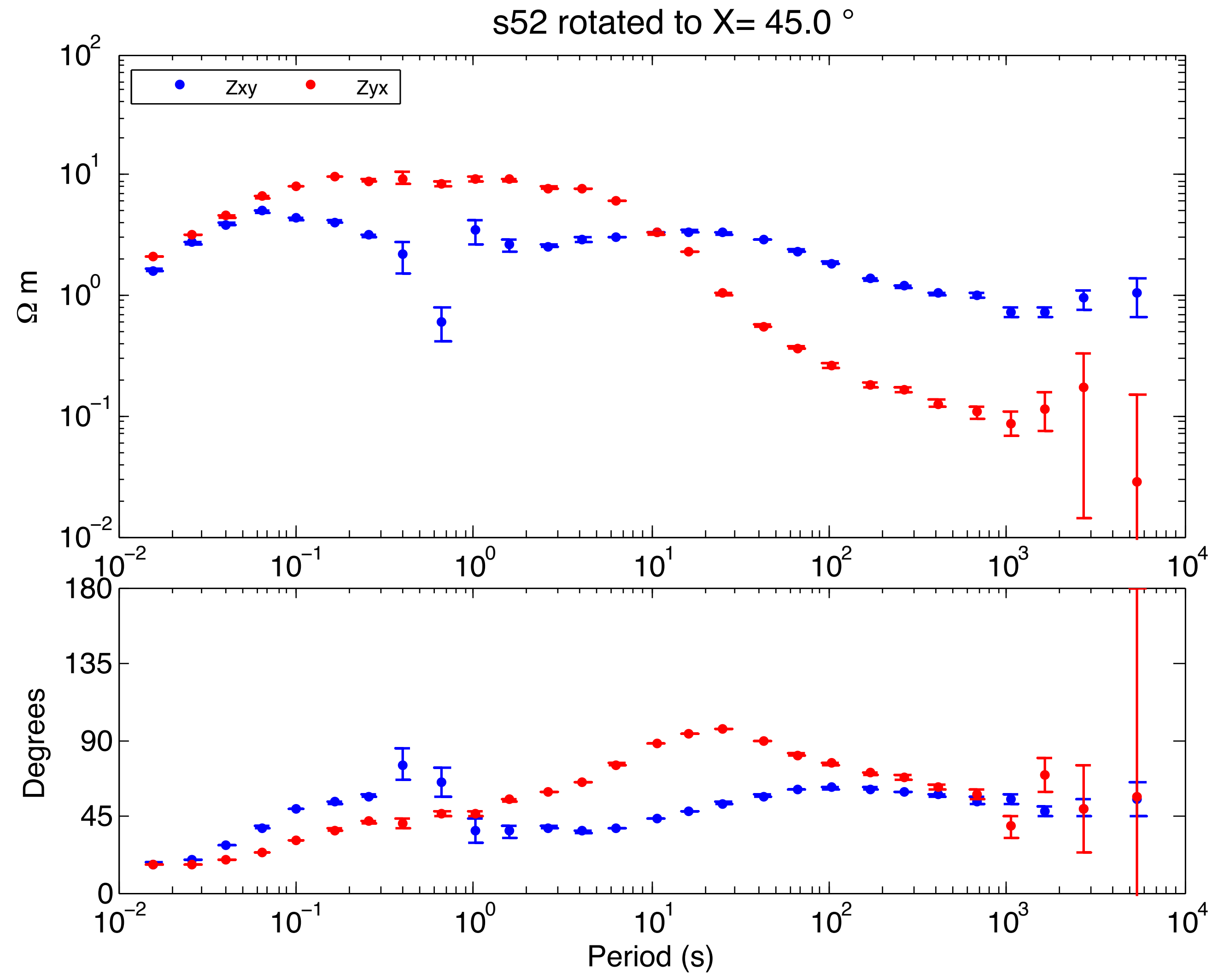

## Sites 41, 42, 43

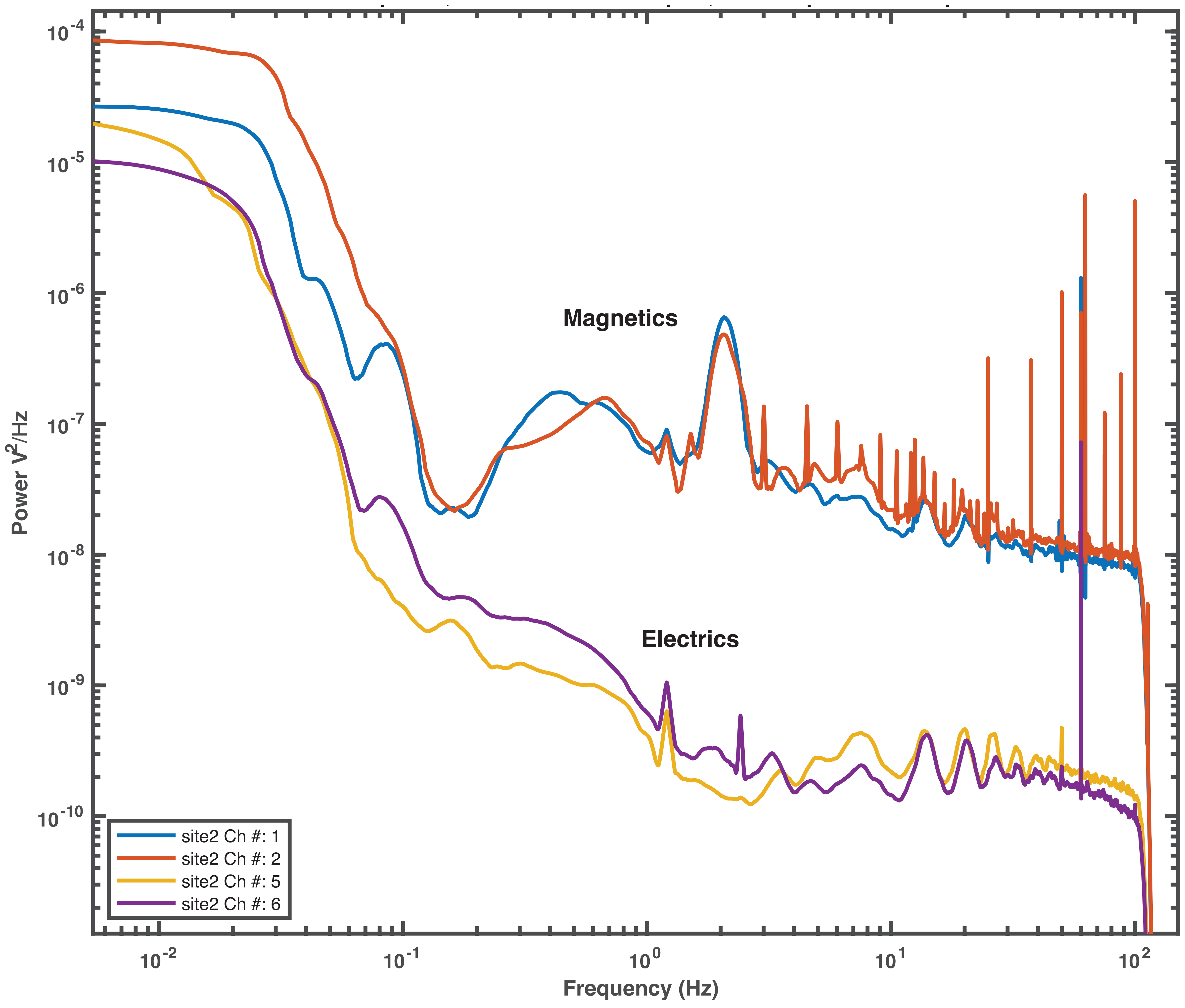


Data quality is good!  Many sites processed out to 1000 seconds.

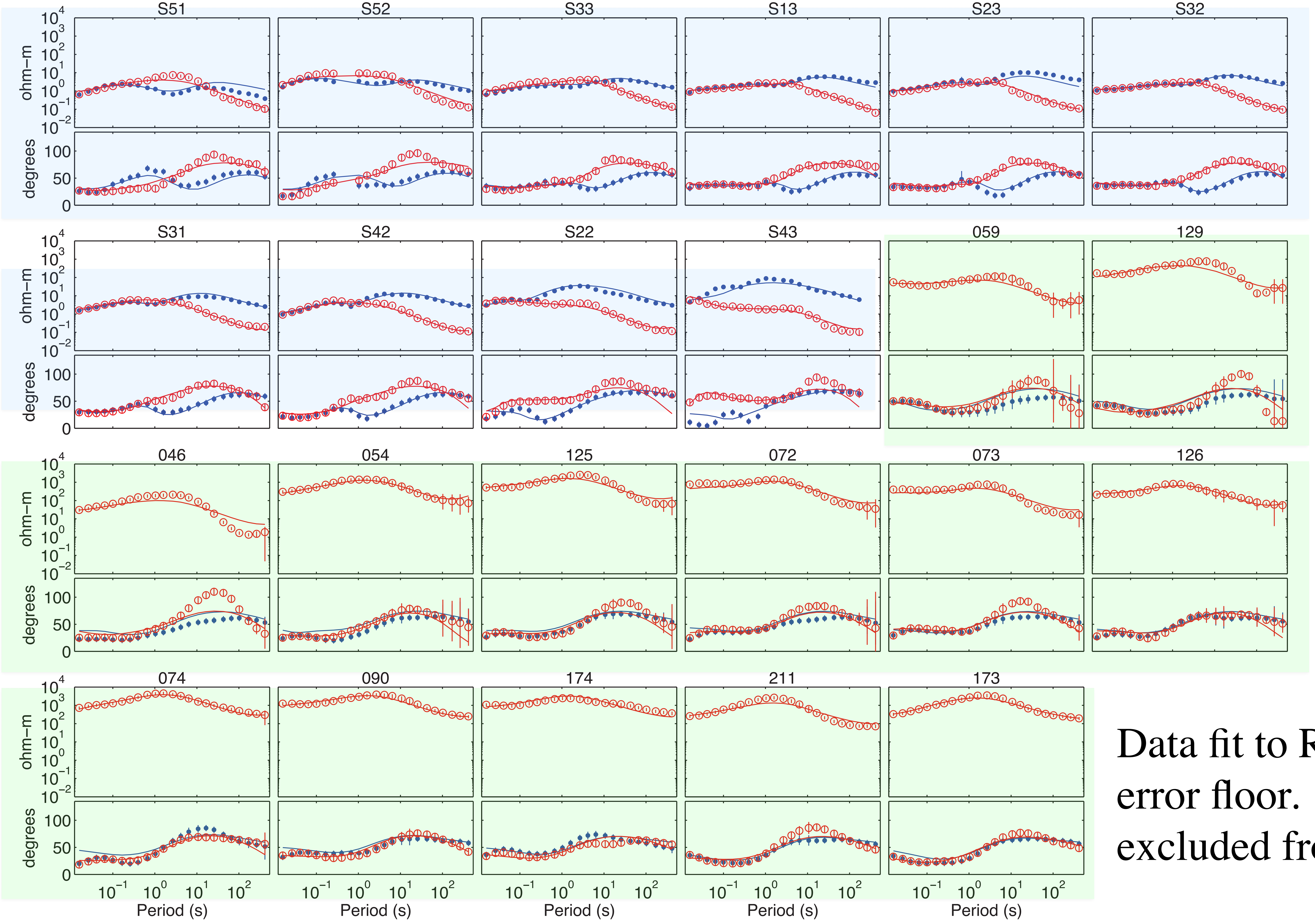
Electric field data are particularly good given only a 3 m dipole.  Schumann resonance is clearly visible.  Some vibration noise in the magnetics around 2 Hz.



Data are borderline 2D.  Strike direction is well defined around 135°.  We selected a group of lake sites, and extended them with land sites from USGS to carry out a preliminary 2D inversion using MARE2DEM.

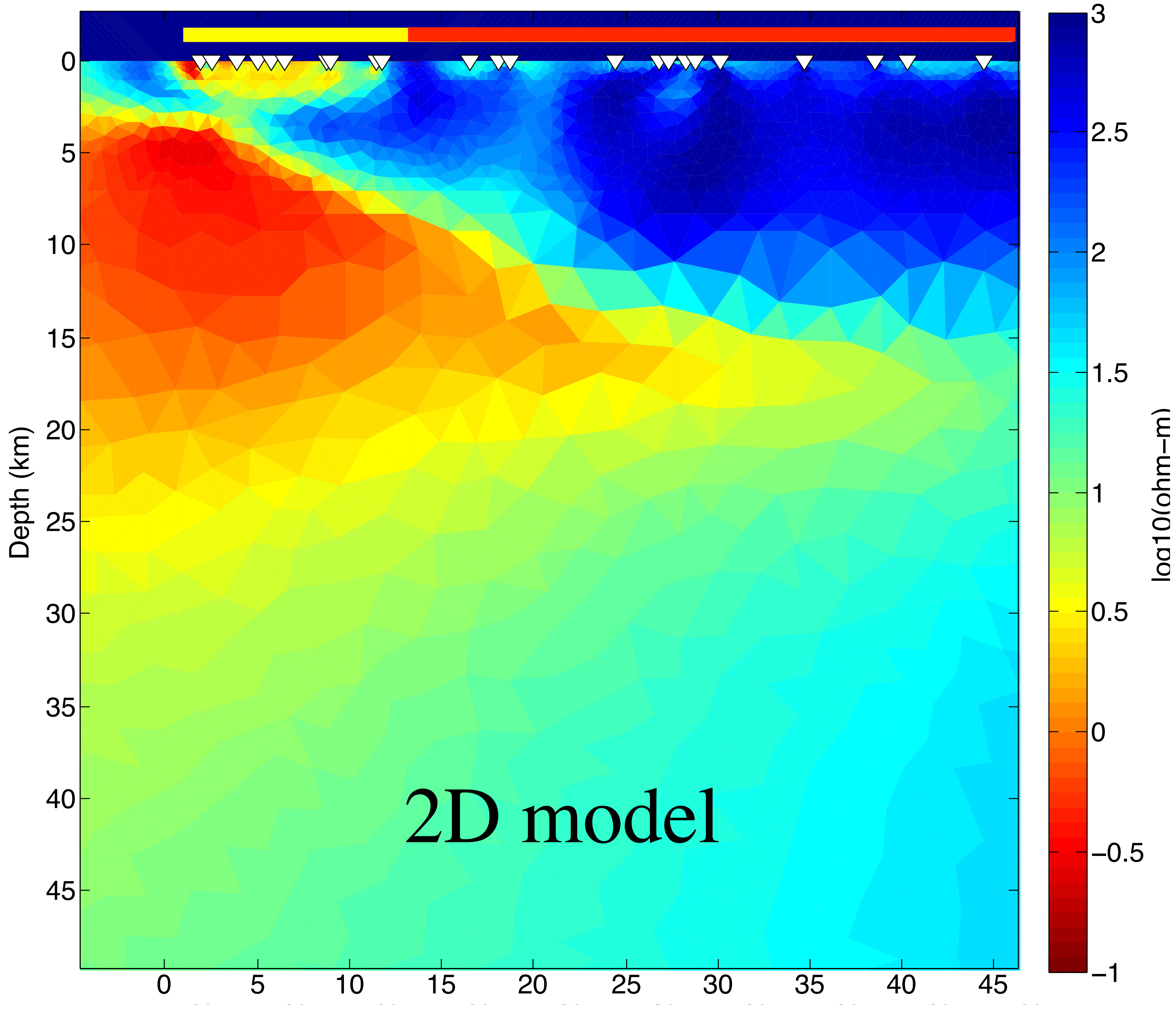


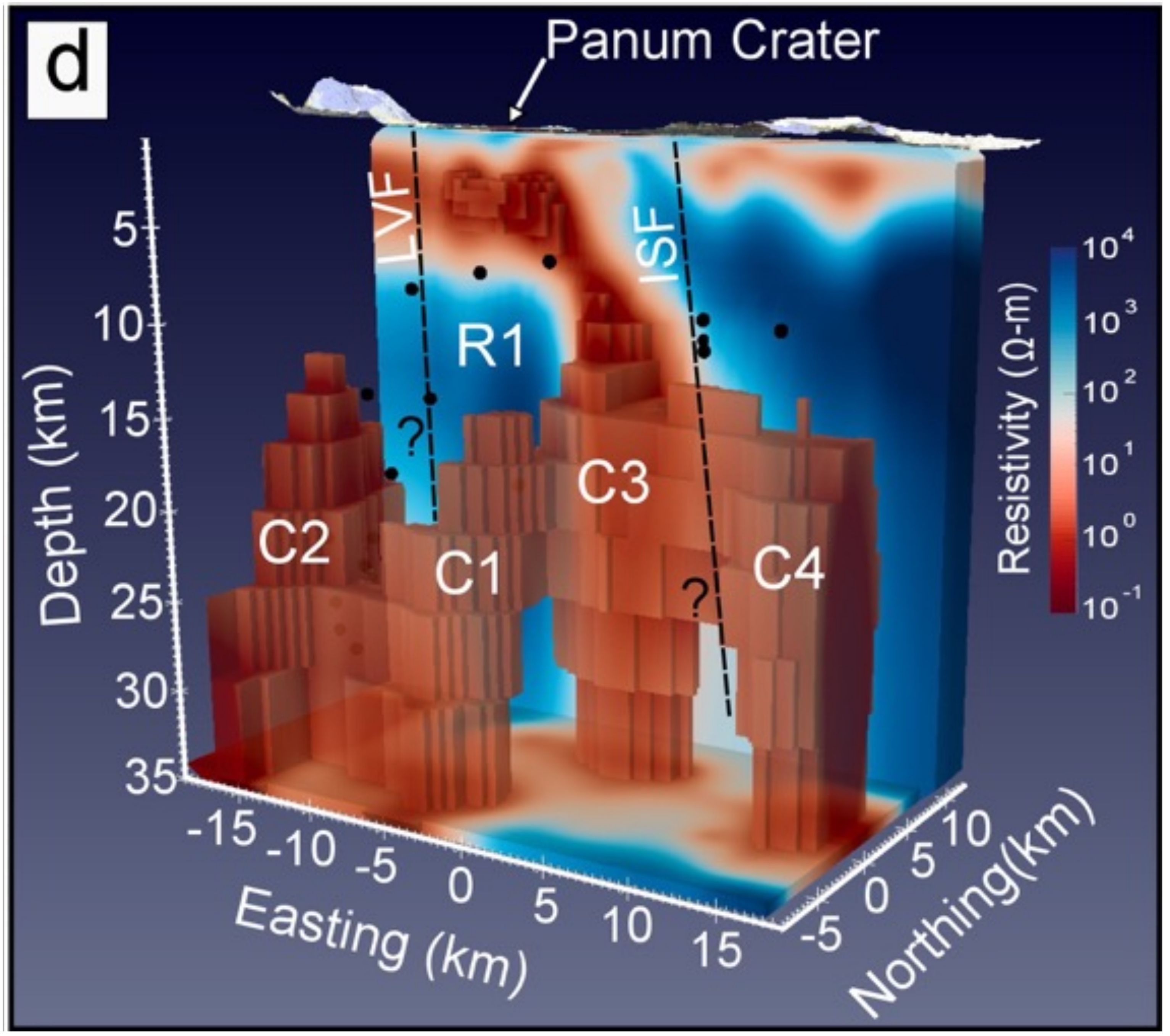

lake sites

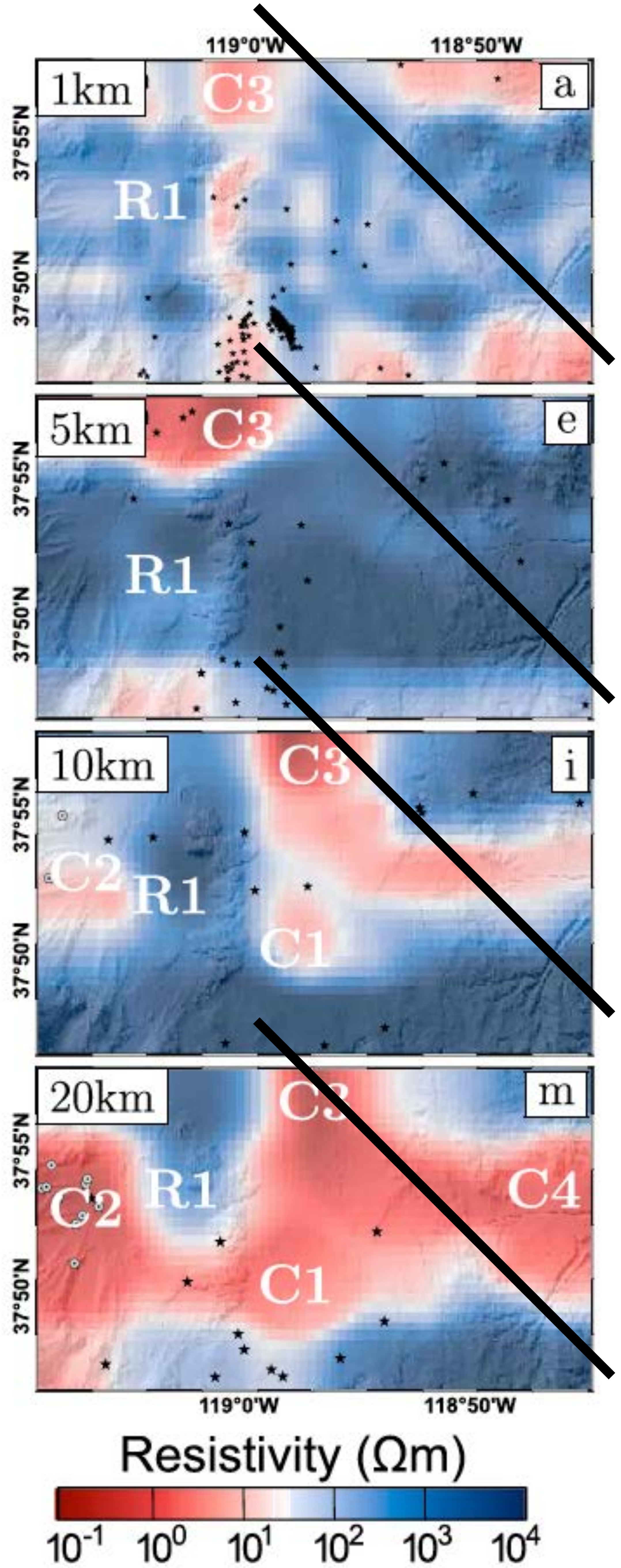
land sites

Data fit to RMS 1.4 with a 20% error floor. TE resistivities were excluded from land sites.


2D model is in reasonable agreement with 3D inversions. It has a highly conductive region, centered on the north side of the lake and dipping towards the southeast. Hydrothermal fluids underlain by magma?




*Peacock et al., 2015, JGR.*

**Conclusions:**

Lake-bottom MT using moored marine instruments is cheap, rapid, and effective.

We have identified a hydrothermal/magmatic system under the north side of Mono Lake.

Clearly, it is worth collecting more land sites north of the lake - planned for October 2018.

It will be interesting to see if the available 3D MT inversion codes can handle lake-bottom data.

**Acknowledgements:** As always, thanks to Gary and Kerry for the processing and inversion codes. Thanks to the USGS interns who helped collect the data, the SIO engineers who build and operate the seafloor equipment, Tom Crowe for running the boat, and the Scripps Seafloor Electromagnetic Methods Consortium for funding.