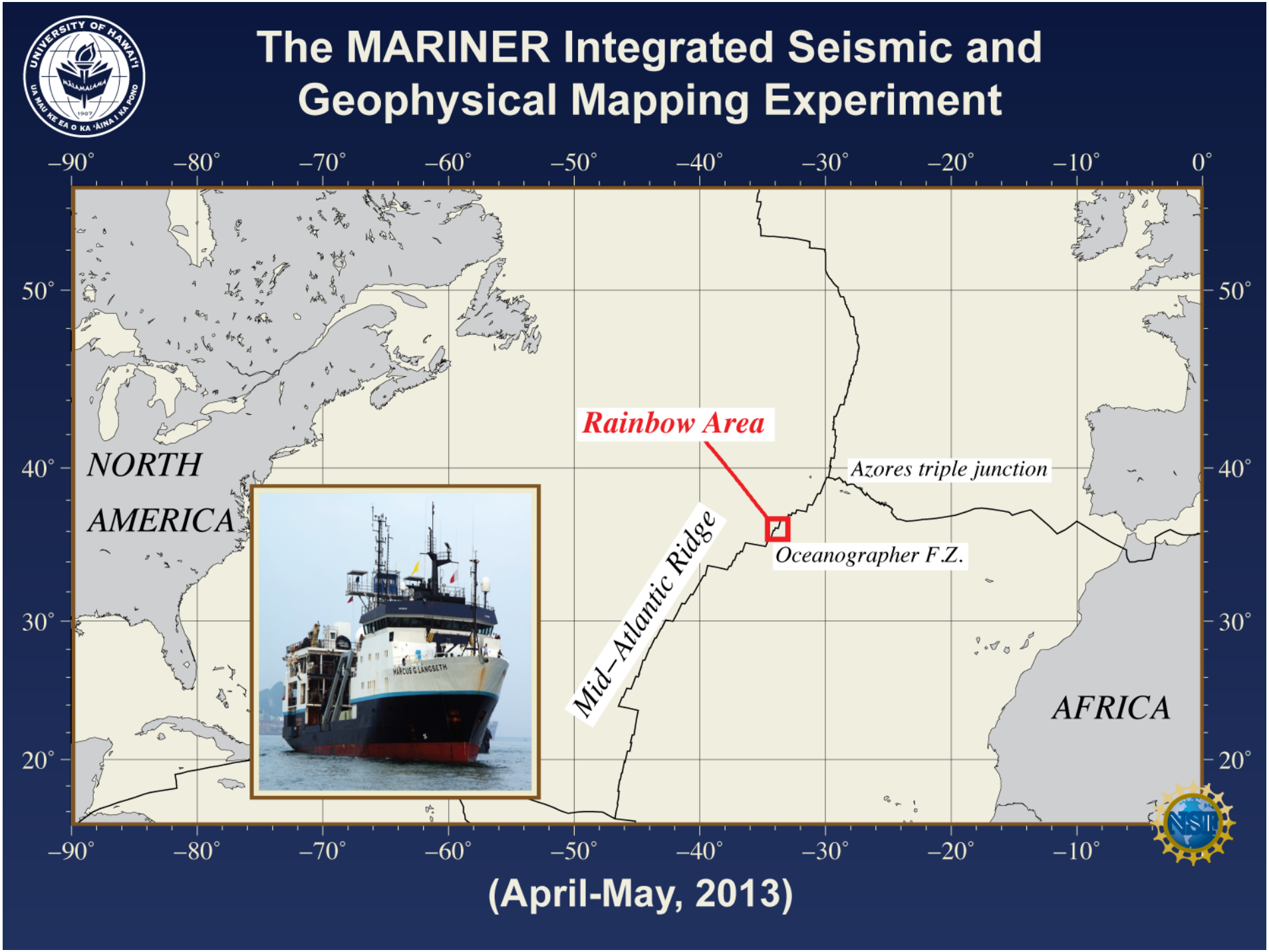
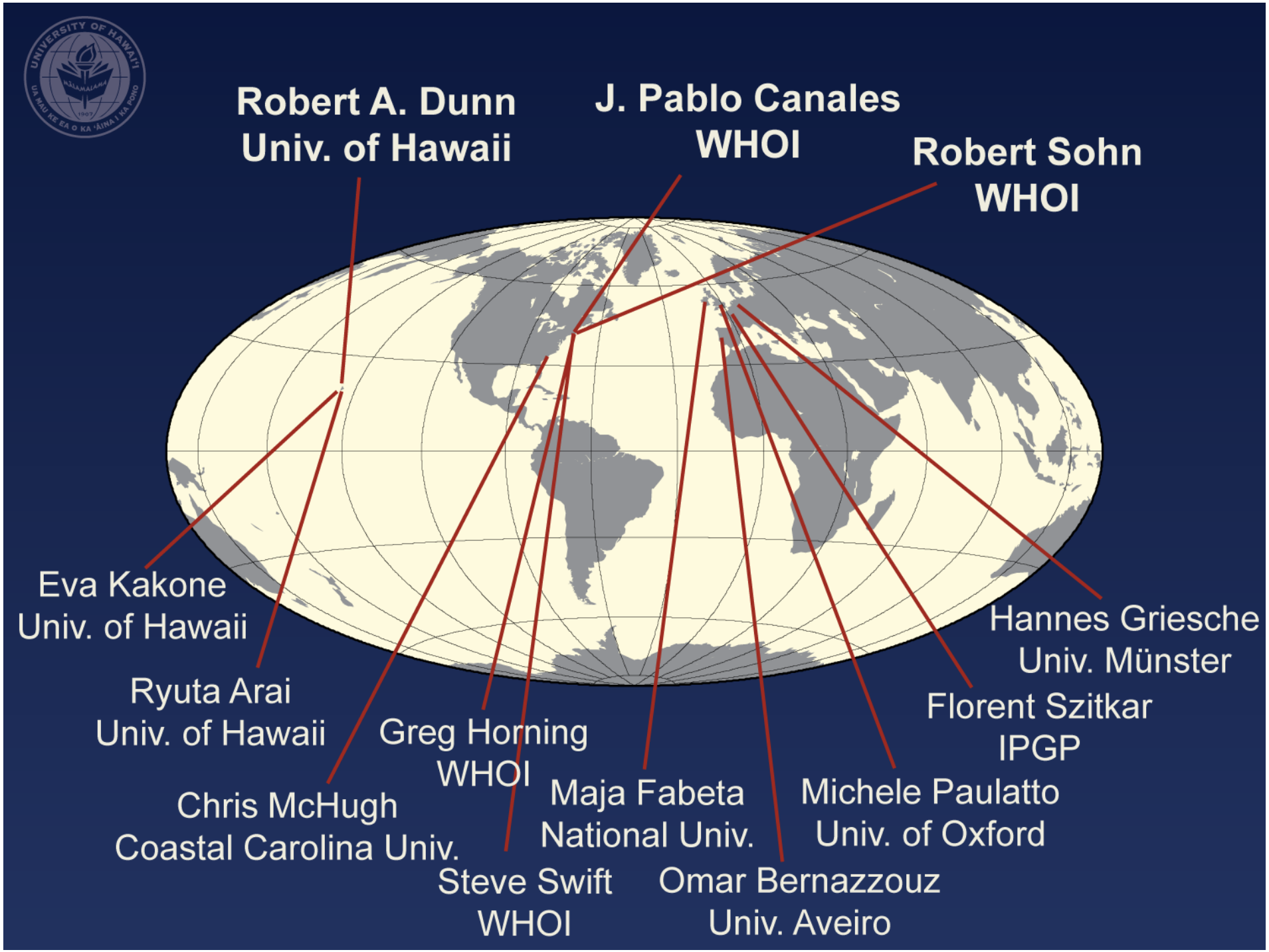
The MARINER Integrated Seismic and Geophysical Mapping Experiment



(April-May, 2013)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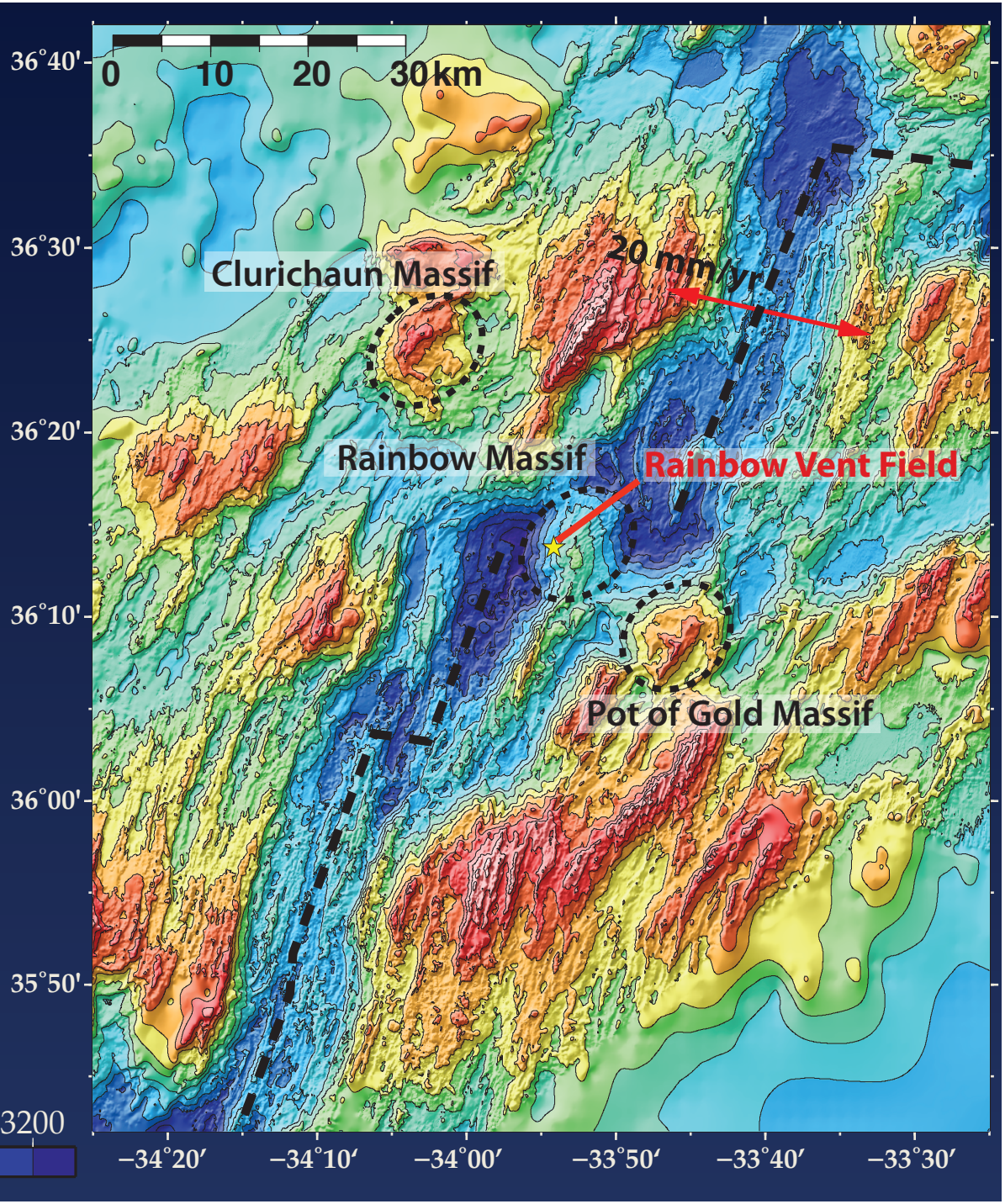
A 15-km-wide ridge offset encompasses the Rainbow massif and ultra-mafic hosted hydrothermal field

Key questions:

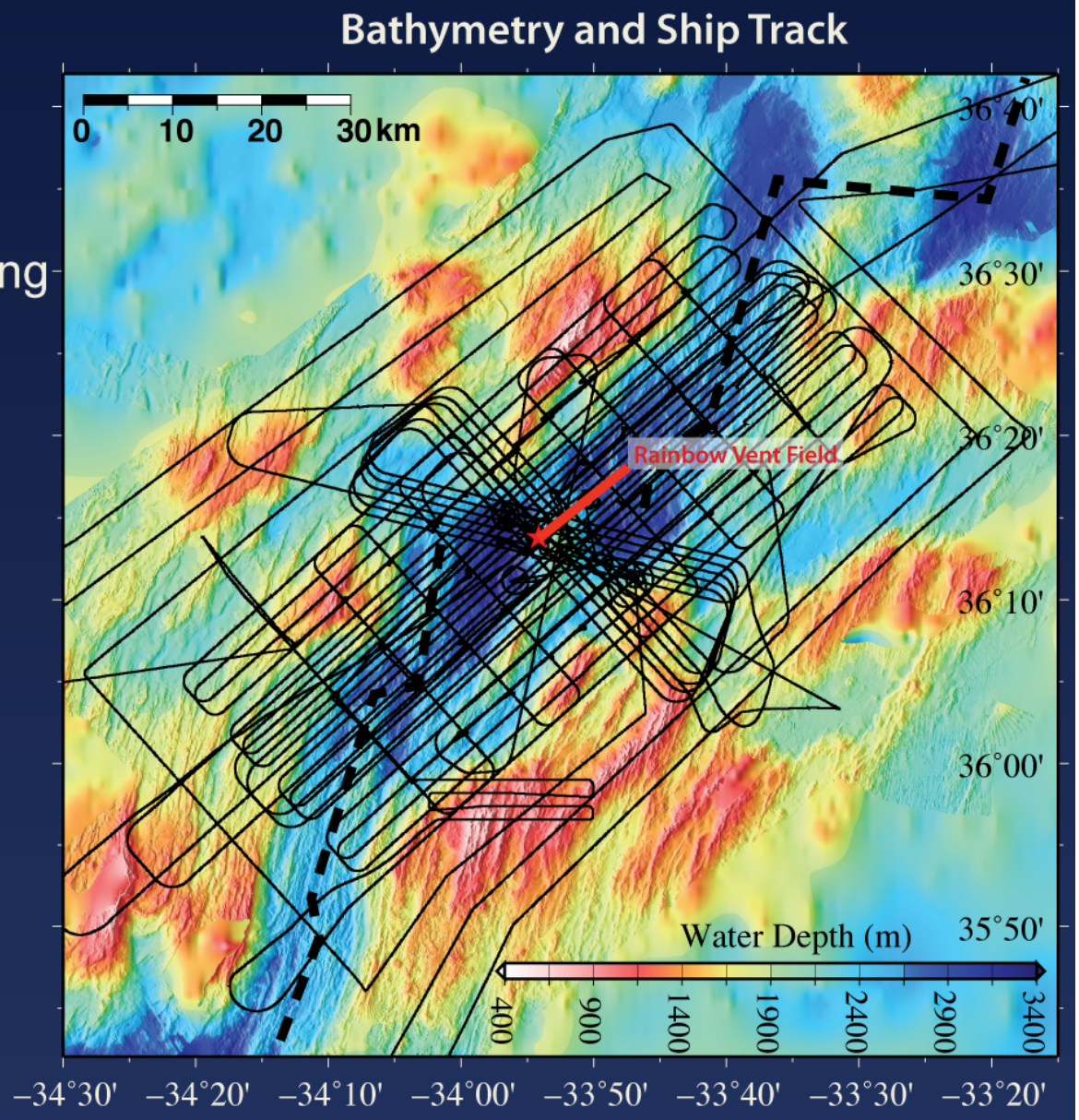
What is the origin of the Rainbow massif? Is it linked to detachment faulting?

What is the source of the heat supply?



A Multi-Disciplinary Approach

- 3-D Seismic Tomography
- 2-D Seismic Reflection Imaging
- Passive Seismic Monitoring
- Bathymetry Mapping
- Seafloor Reflectivity Mapping
- Magnetic Field Mapping
- Gravity Field Mapping



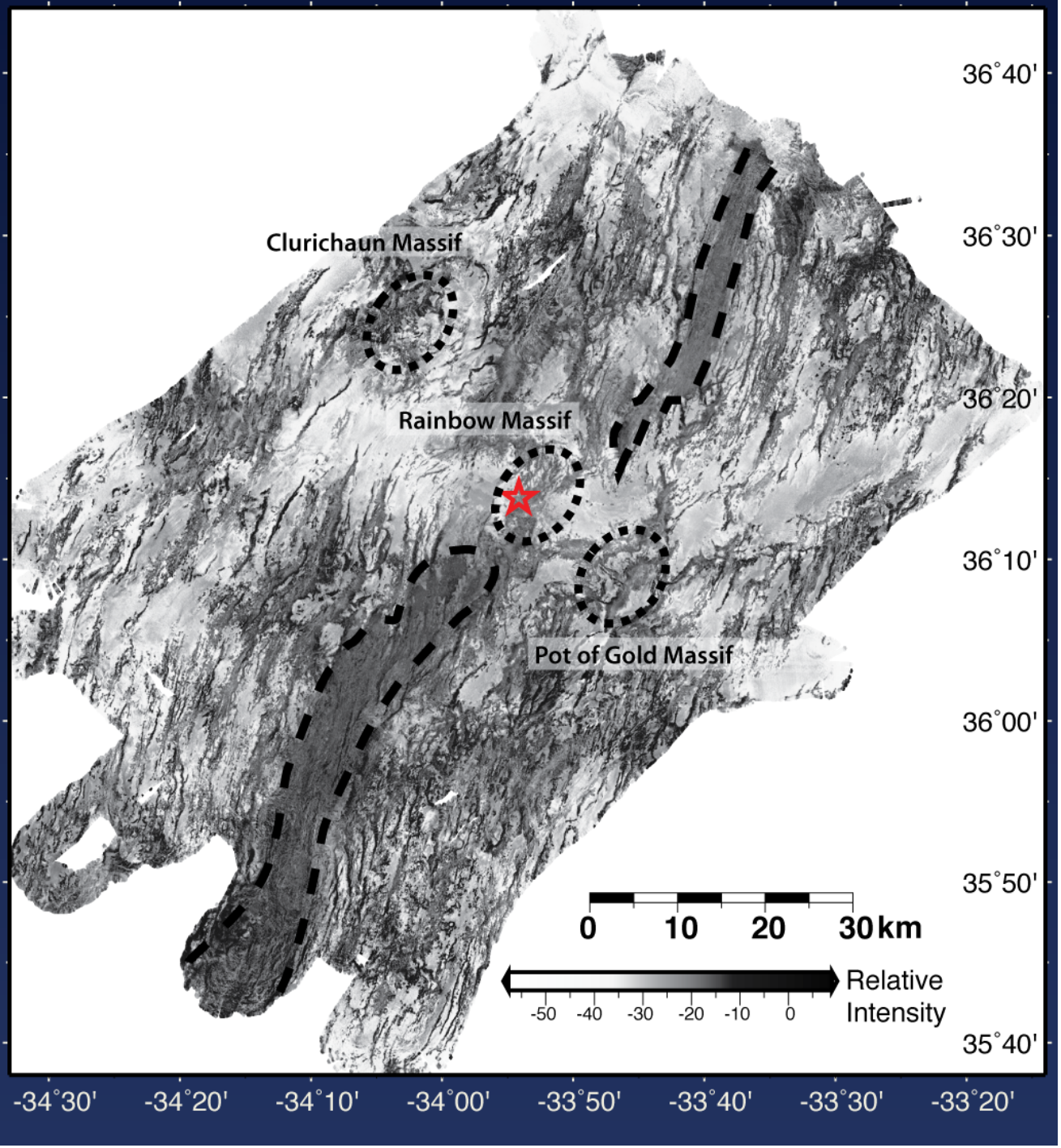
Seafloor Sonar Image

Darker =Higher Reflectivity

Sonar image highlights:

- Neovolcanic zone within the axial valley
- Tectonic terrains
- Sedimented terrains

Massifs have a mottled appearance, perhaps due to compositional variation, heavy alteration, and sedimentation

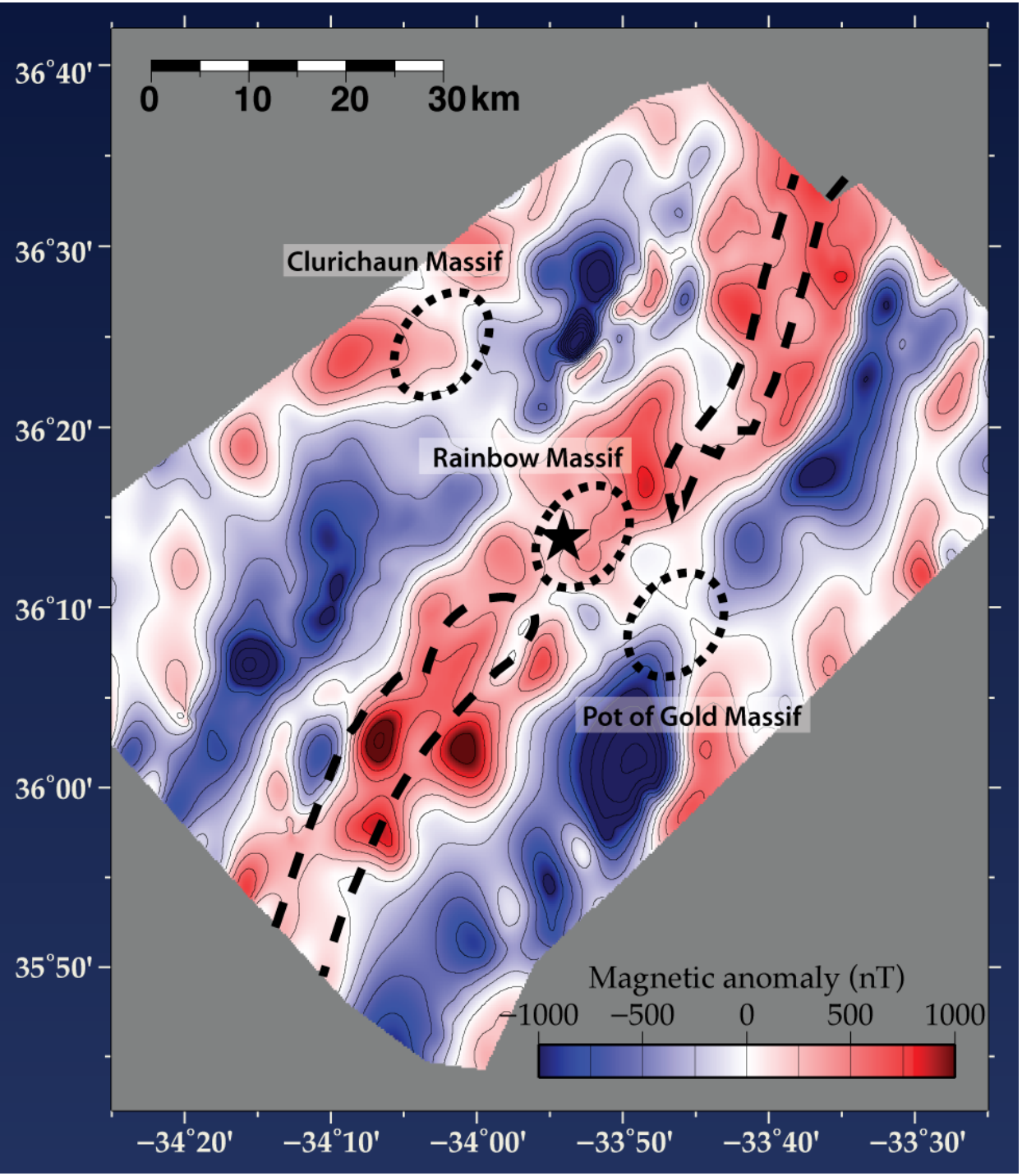


Magnetic Anomalies

A band of normal polarity along the ridge axis is flanked by negative polarity regions.

This pattern is consistent with the Bruhnes-Matuyama reversal (0.78 Ma)

Massifs are generally coincident with relatively lower values

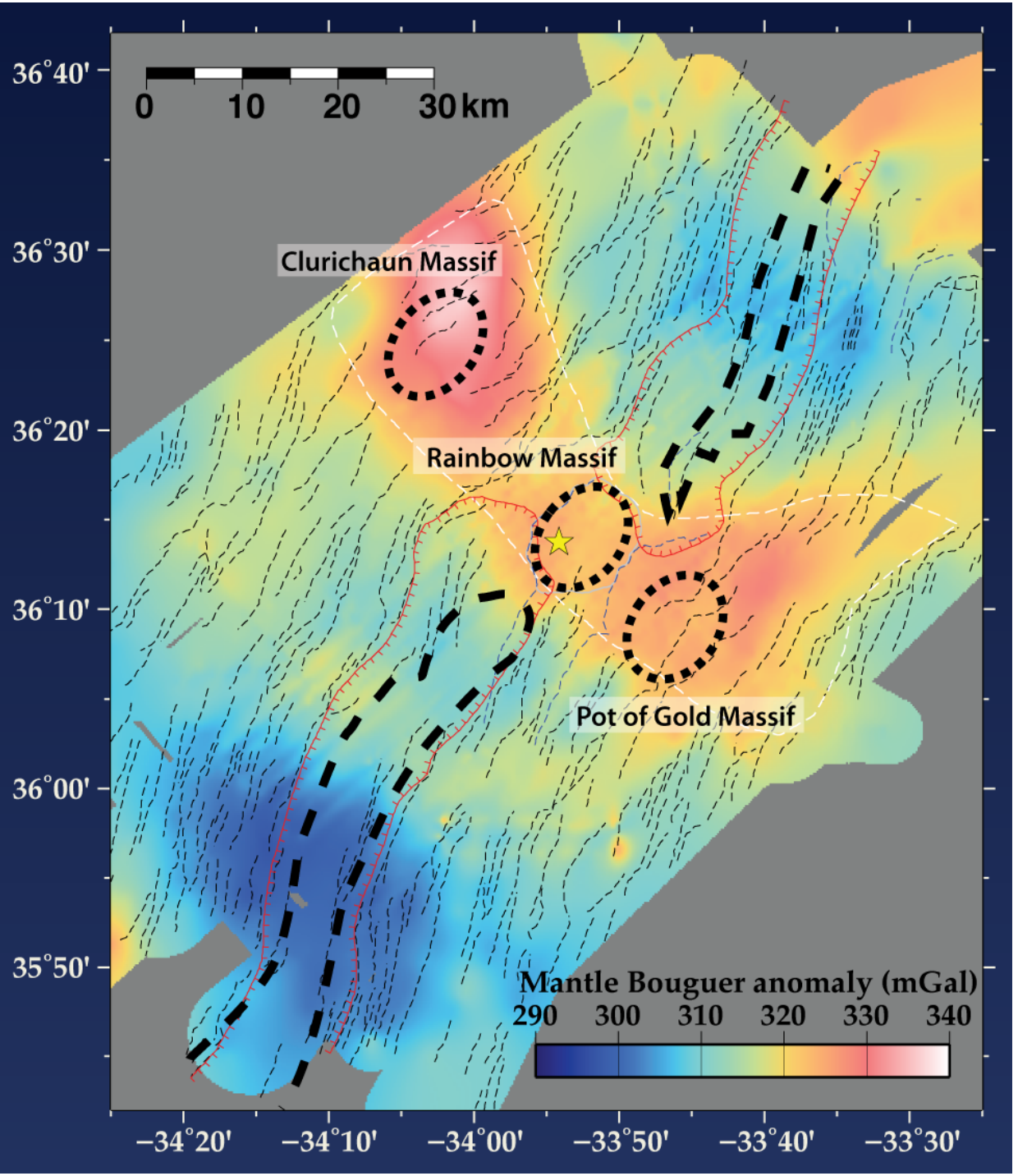


Mantle Bouguer Gravity

A band of high gravity values (reds) is found across the non-transform offset

Lower values (blues) are found near the ridge segment centers

Gravity is consistent with thin crust having been produced at the non-transform offset for at least 1.5 million years



46 OBS -black/red circles

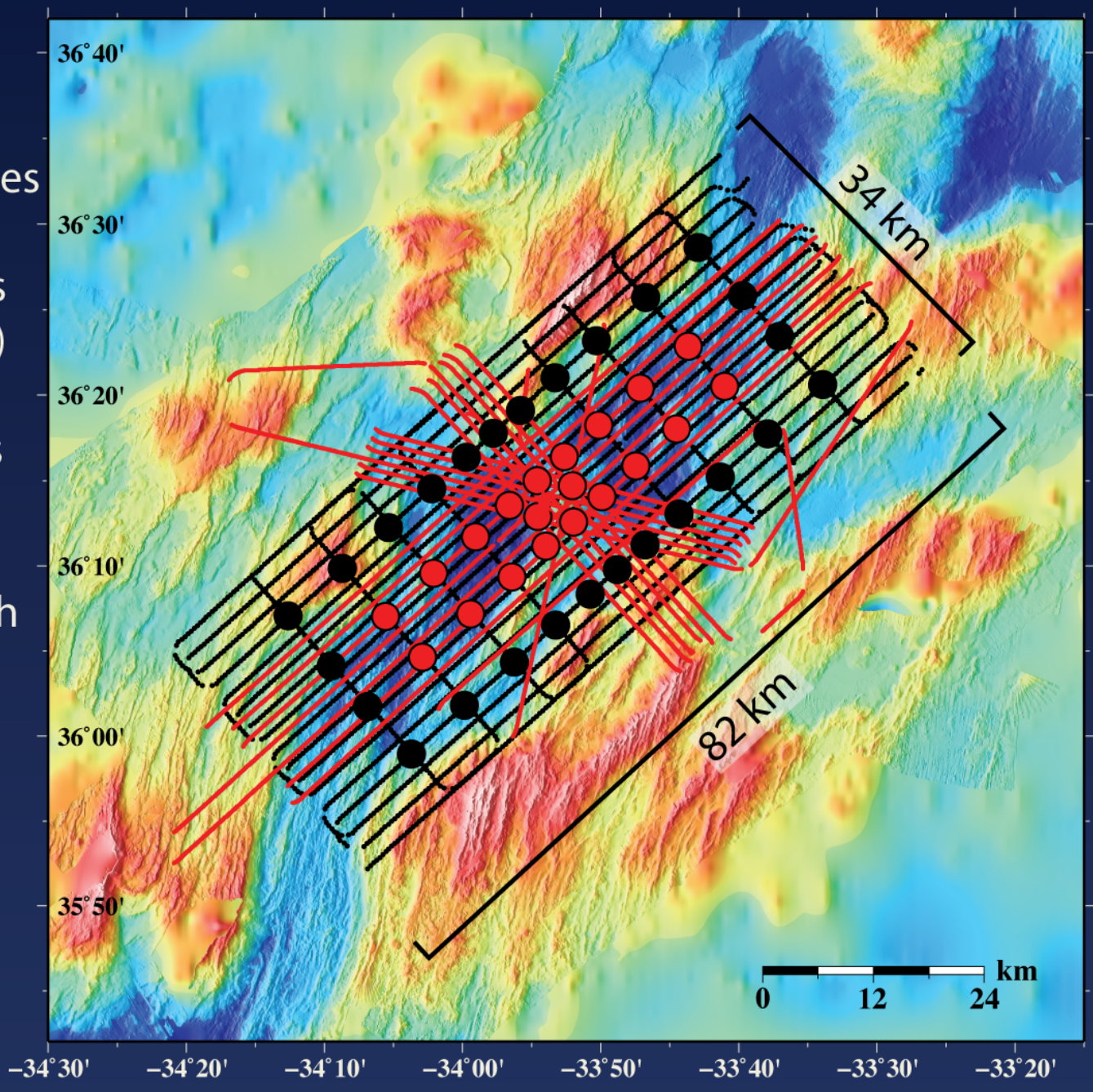
26 refraction shot lines (black - 450 m interval)

24 reflection shot lines (red - 37.5 m interval)

Red OBS recorded both types of shots

Source: 36-element, 6,600 cu.in. array; RV Langseth

Streamer: 8 km; 636 channels



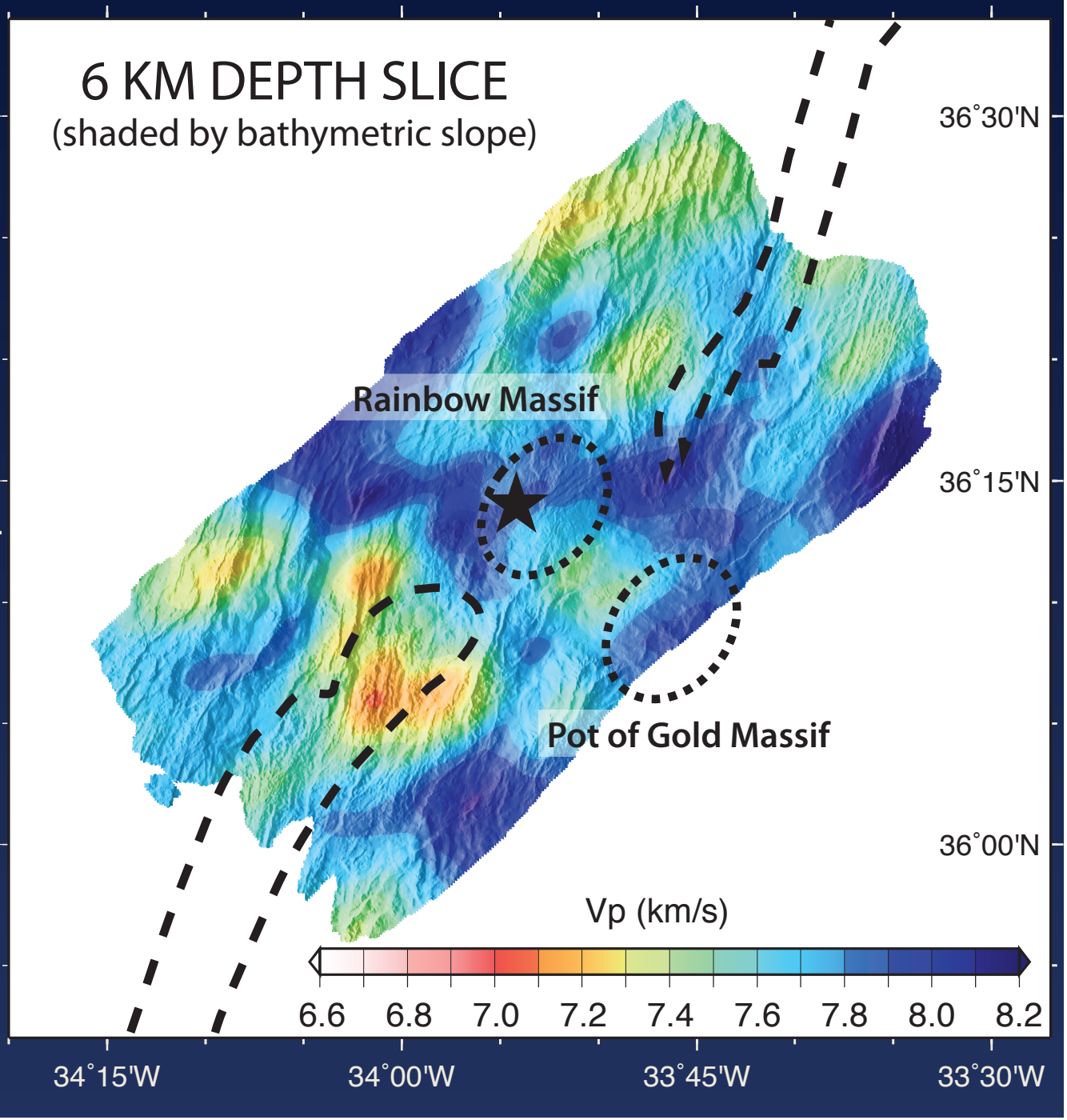
P-wave Image

Mostly mantle Vp values

Lower values may indicate higher temperatures, a combination of mantle and gabbroic material, or altered mantle

Gravity and reflection results will be used to narrow down the possibilities

No significant thermal/melt anomaly beneath Rainbow



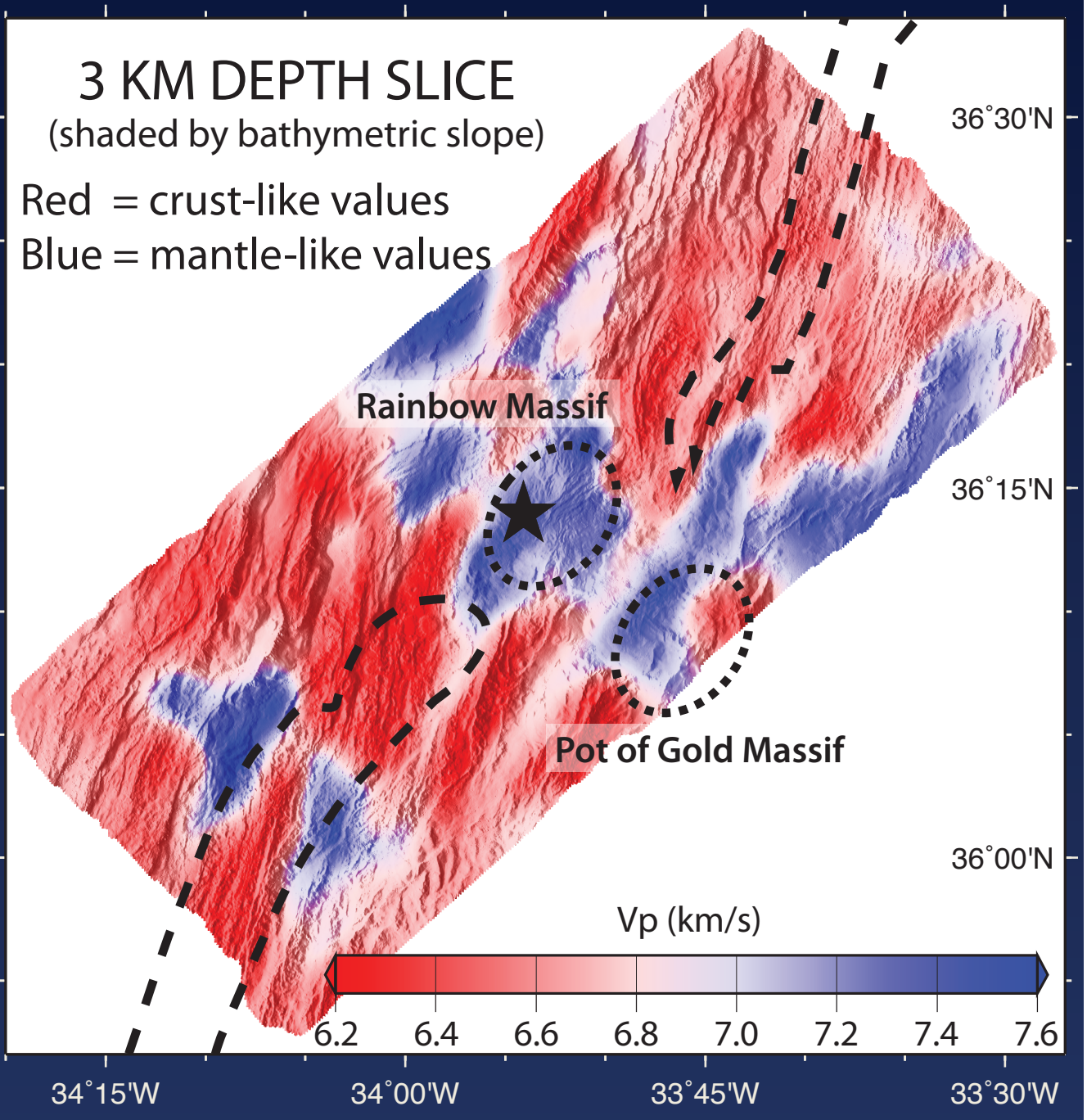
P-wave Image

Image shows variation in Vp about 7 km/s

High velocities follow the trace of the offset and indicate thin crust

Argues against deep mantle alteration under Rainbow massif

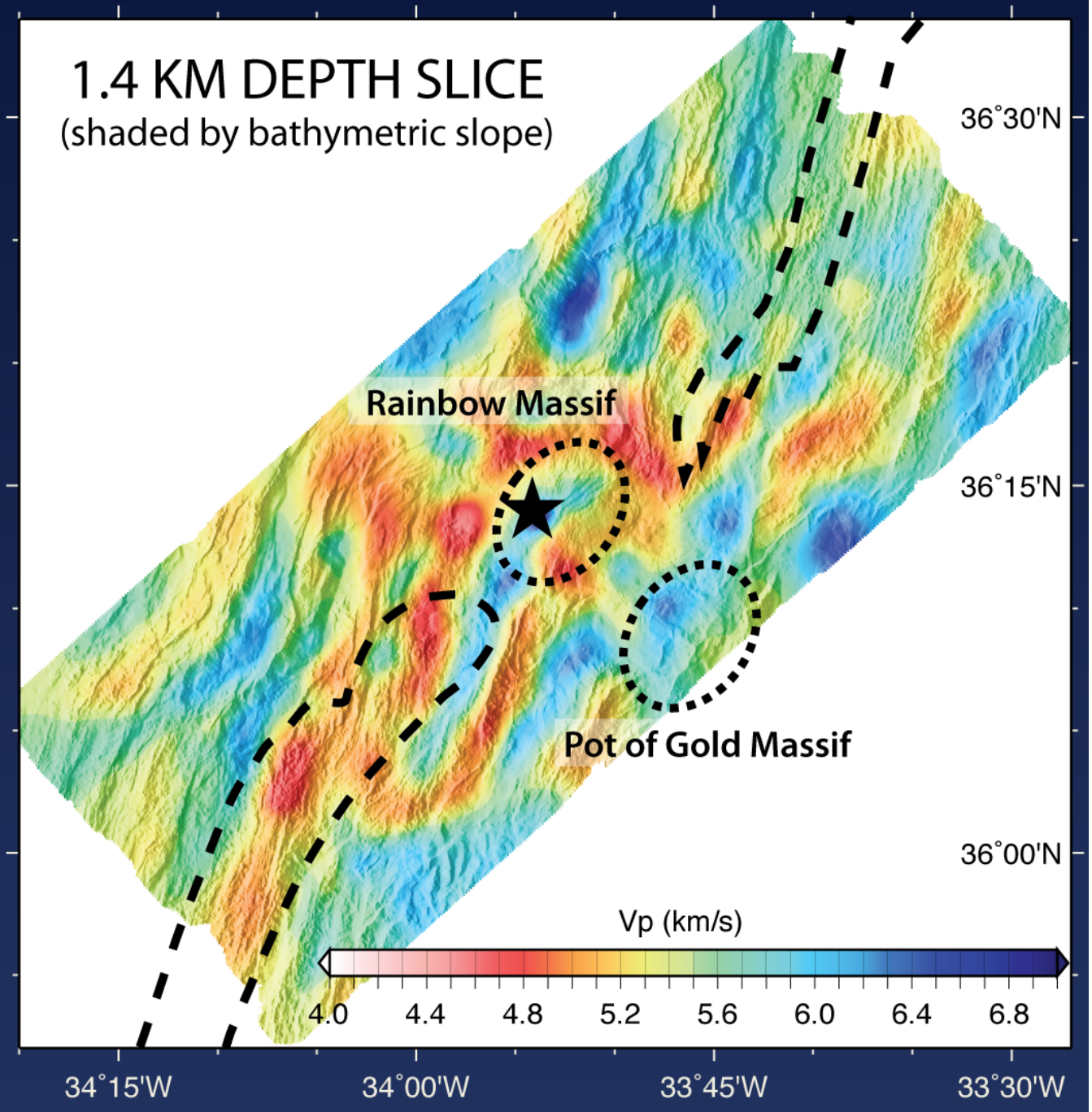
Across the offset, the red and blue colors alternate, perhaps indicating magmatic-tectonic cycles of spreading



P-wave Image

At this depth, Vp most-likely shows porosity variations, but composition and alteration may also play a role

Image has a banded appeance that follows topography, possibly due to cycles of stretching versus magmatic intrusion

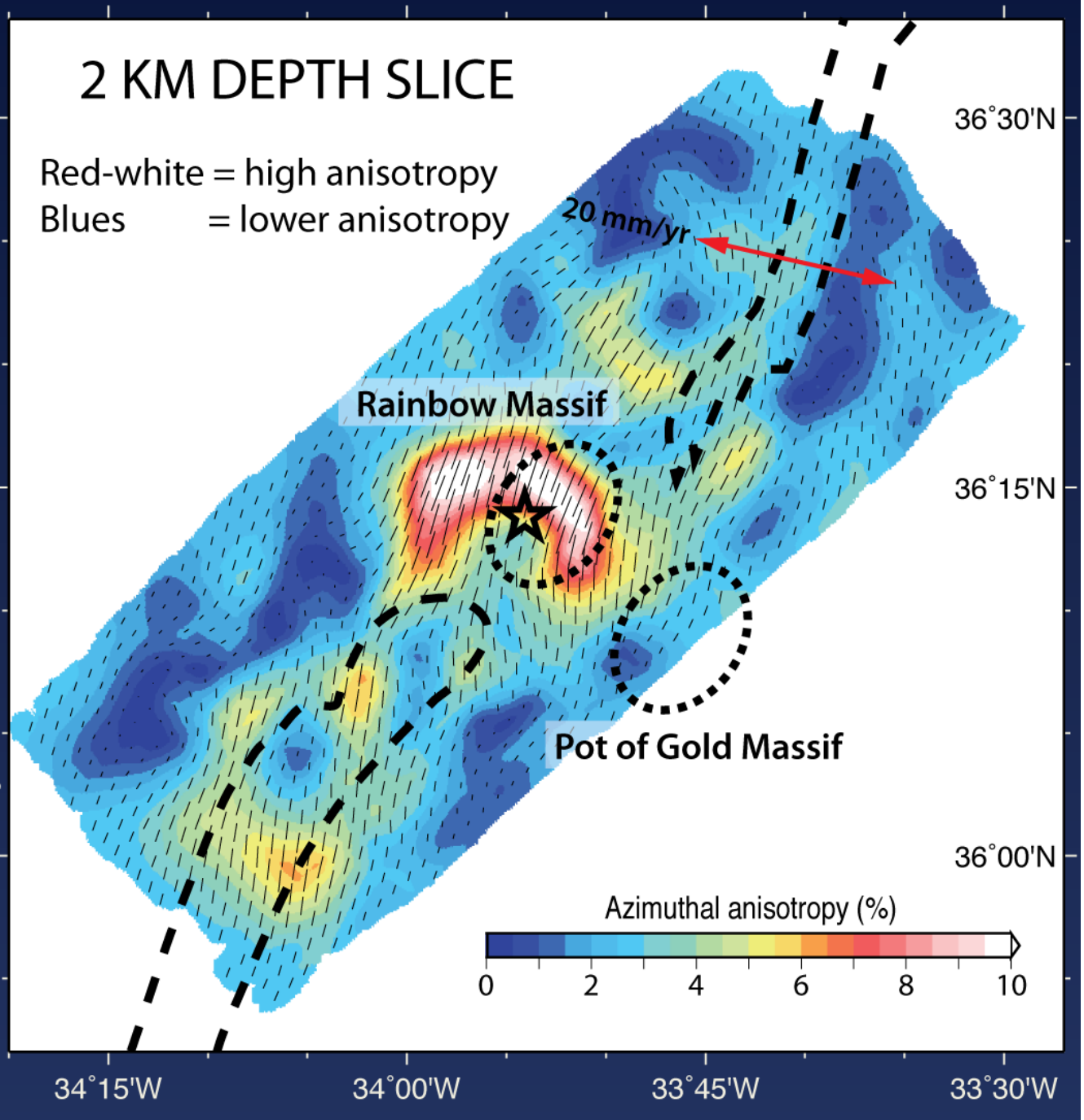


P-wave azimuthal anisotropy

This depth slice cross-cuts a region of high anisotropy that permeates much of the rainbow massif

Anisotropy results from tectonic stretching and the formation of pervasive, aligned cracks

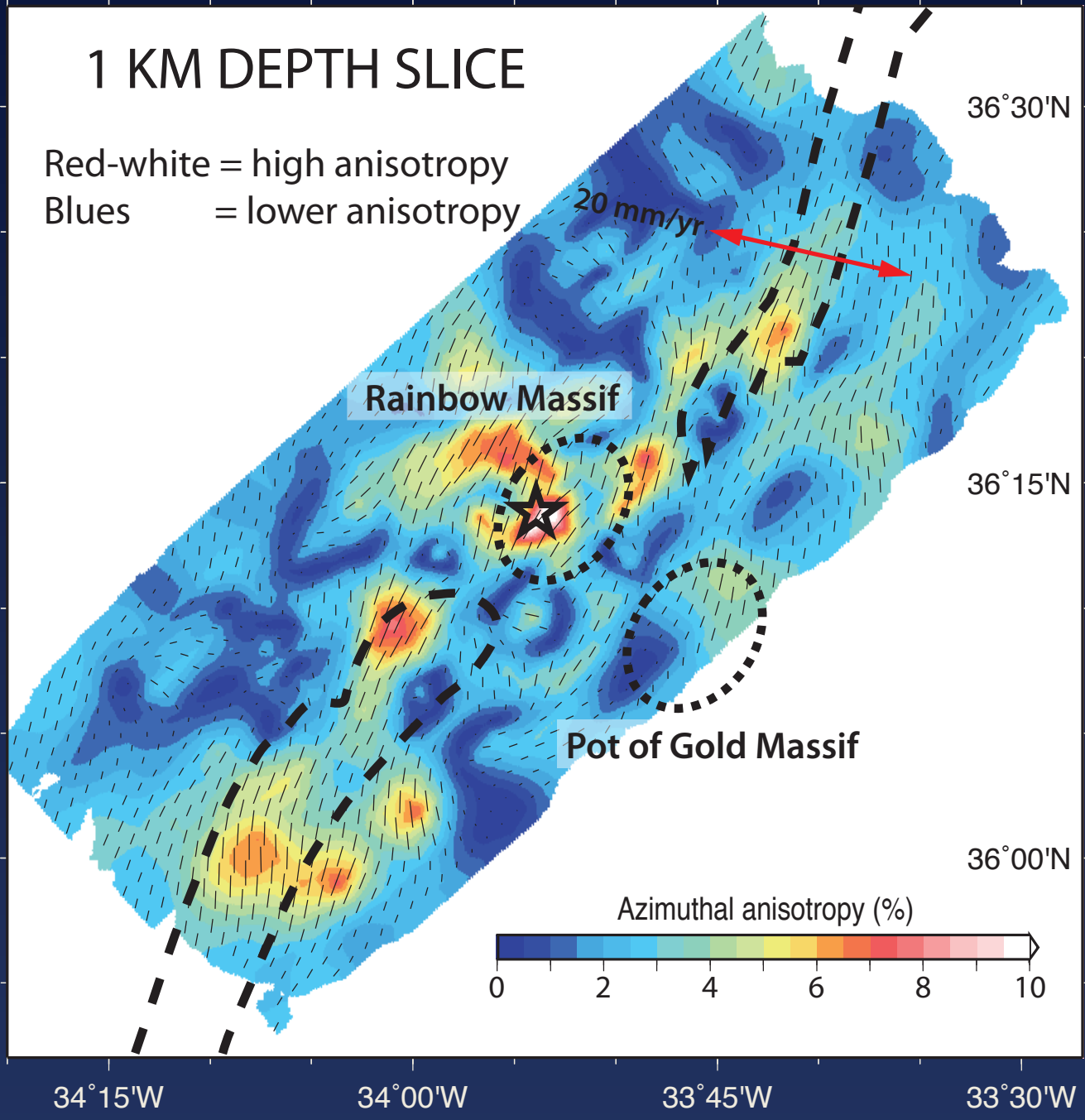
These cracks may help water circulate and extract heat



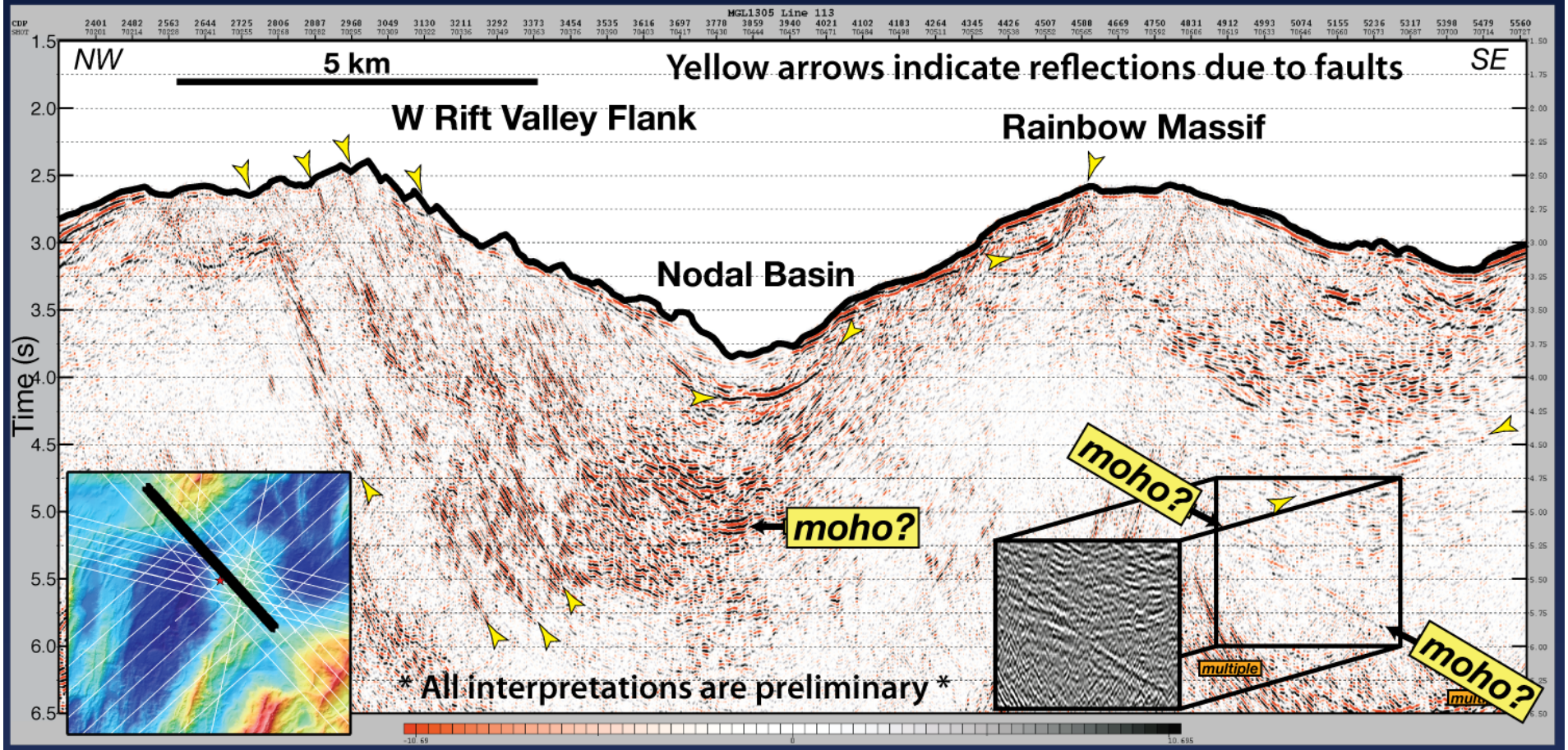
P-wave azimuthal anisotropy

At shallow depths, the highest anisotropy is below the vent sites

Hence, the deeper wider area of intense cracking may act as a recharge zone or mine heat from the mantle, while the shallow cracks may help focus hot fluids directly to the Rainbow vent field

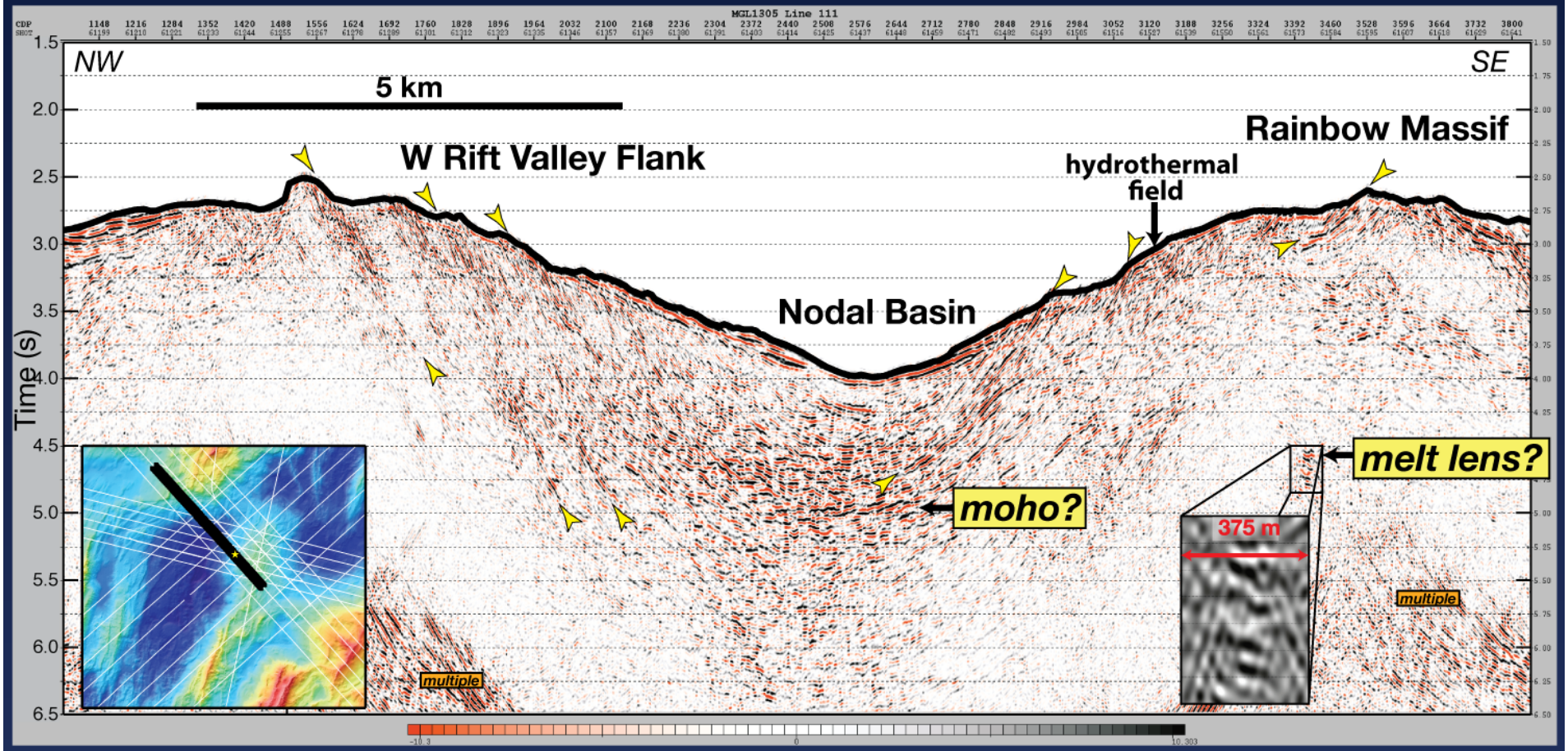


Reflection Section Across Rainbow Massif



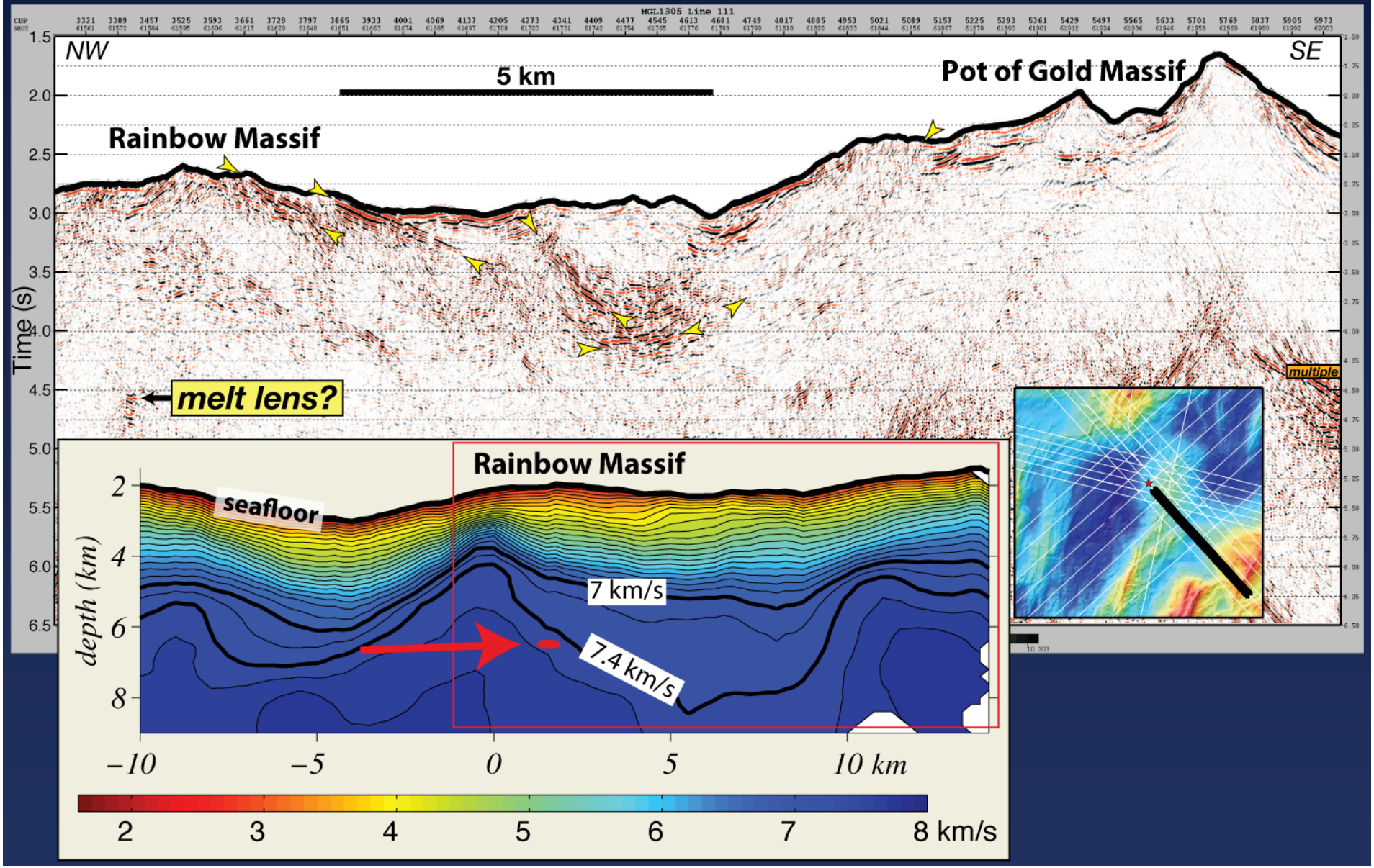
- West flank shows pervasive, steeply-dipping reflectivity extending into the mantle, suggesting bookshelf-style faulting
- This contrasts with the Rainbow & Pot of Gold massifs, where faulting is less extensive, but nonetheless present

Possible Melt Lens Beneath the Rainbow Massif



- Lens width is <375 m
- Such a small feature is not imageable with current tomographic methods

On the basis of the tomographic image, the melt lens would be in the mantle at a depth of ~5 km below seafloor

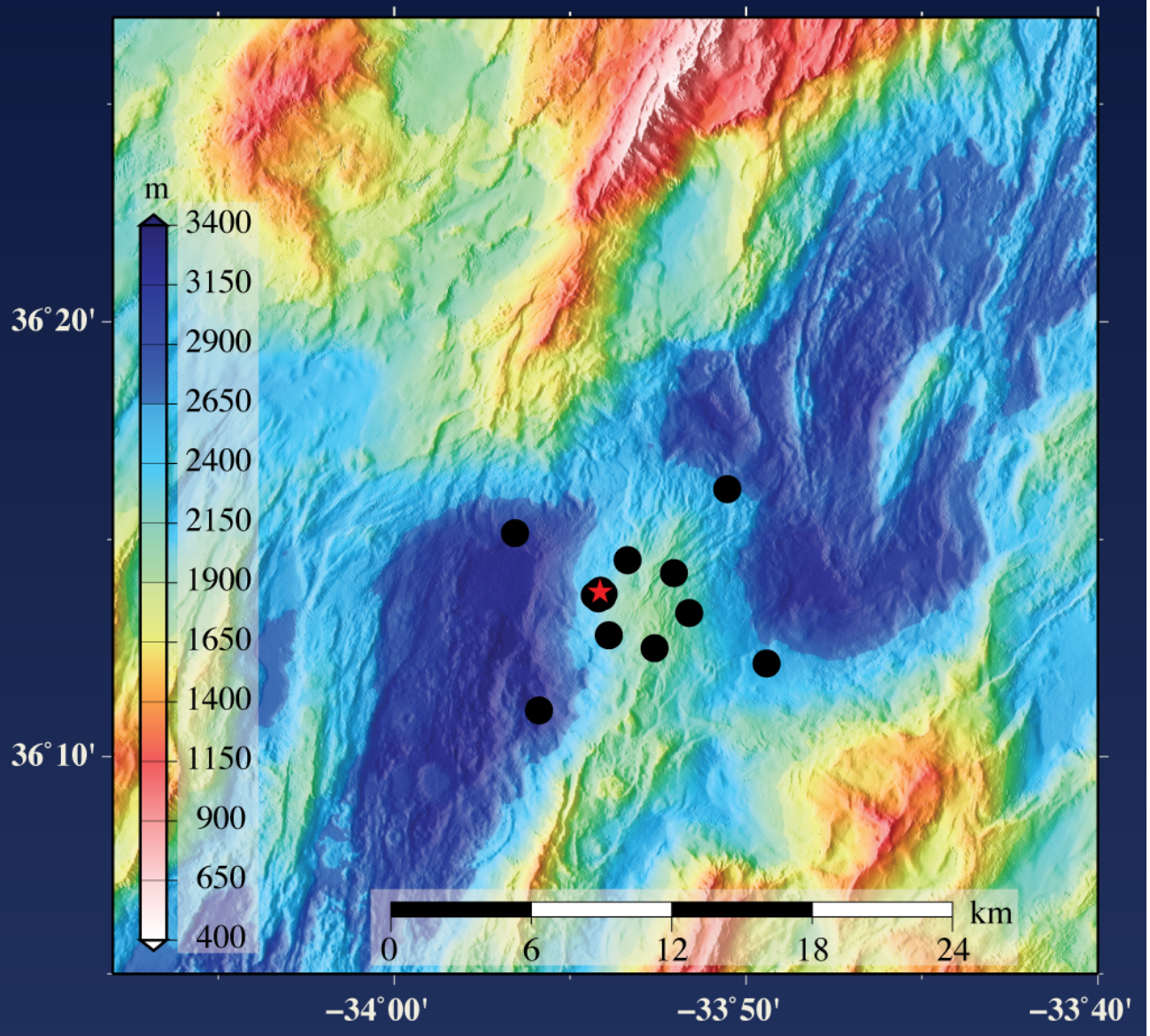


Passive Seismic Monitoring

15 OBS deployed (black dots - with 6 located in a tight cluster about the vent field, red star)

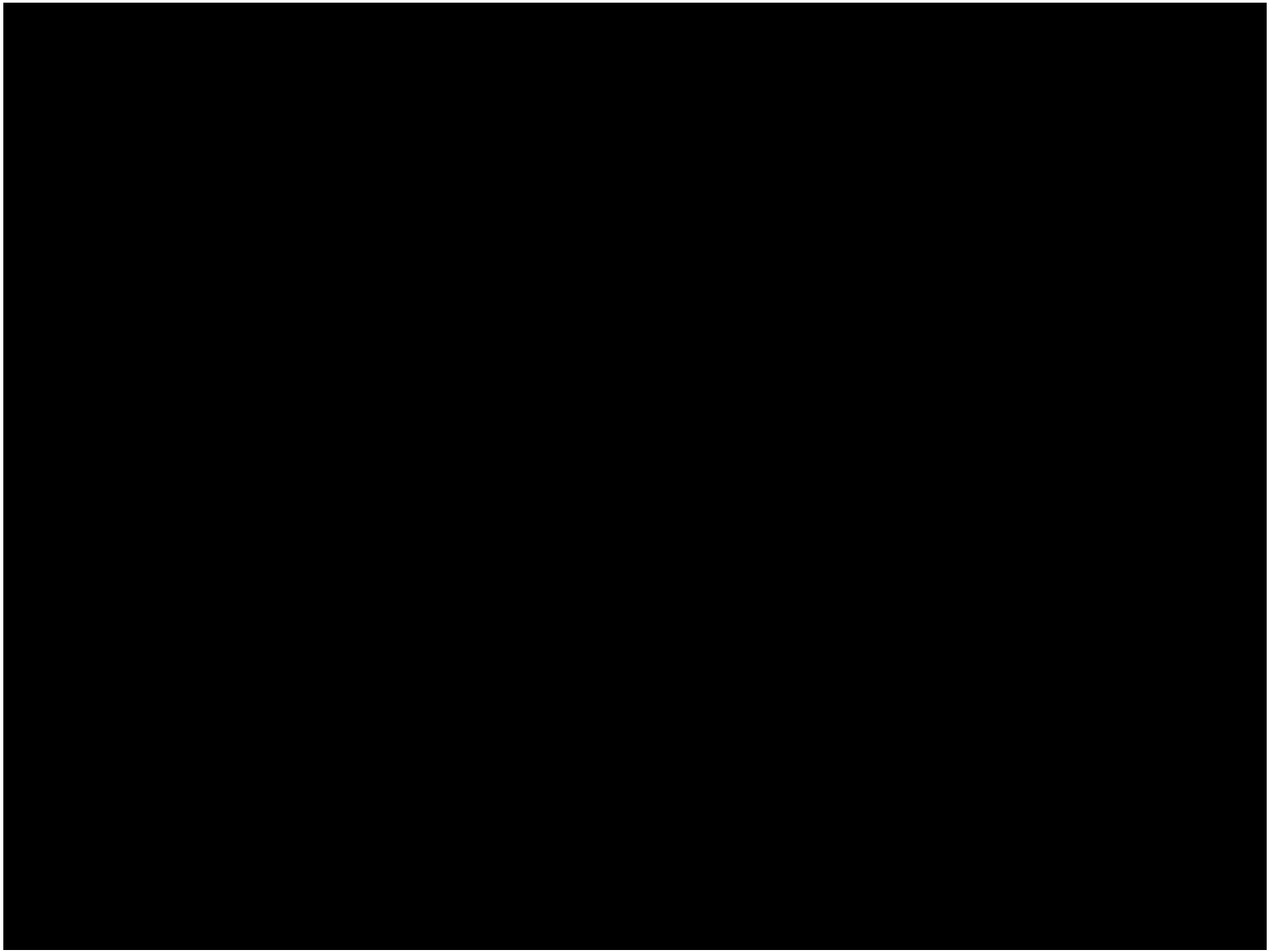
The OBS have been recording since May

Pickup is scheduled for January, 2014



Summary

- MARINER: A highly succesful experiment
- 100% of planned operations completed
- We have a strong start on the data analysis
- Possible heat source for Rainbow vents identified
- Possible recharge and discharge zones for venting identified
- Plenty of work to do



Cruise Schedule (38 days)

April 11-16	Transit: St. Georges, Bermuda to Study Site. Test acoustic releases.
April 17-18	Deploy 46 OBS.
April 19-23	Airgun deployment. Shoot OBS Refraction lines.
April 24-26	Operations interrupted due to weather. Airgun recovery.
April 27-May1	Airgun deployment. Shooting OBS lines. Airgun recovery.
May 2-3	Recover 26 OBS. Deploy 7 long-term OBS.
May 4-12	8-km-long streamer deployment. Airgun deployment. Shoot MCS lines.
May 13-14	Airgun recovery. Streamer recovery. Recover 20 OBS.
May 15	Deploy 8 more long-term OBSs and acoustic survey the OBS.
May 16-19	Multibeam survey. Transit to Ponta Delgada, Azores.

Cruise Synopsis

For operations, we budgeted 28 days of ship time (not including transits to/from port) and 4 days of contingency time

We completed 100% of the planned operations within the allocated time

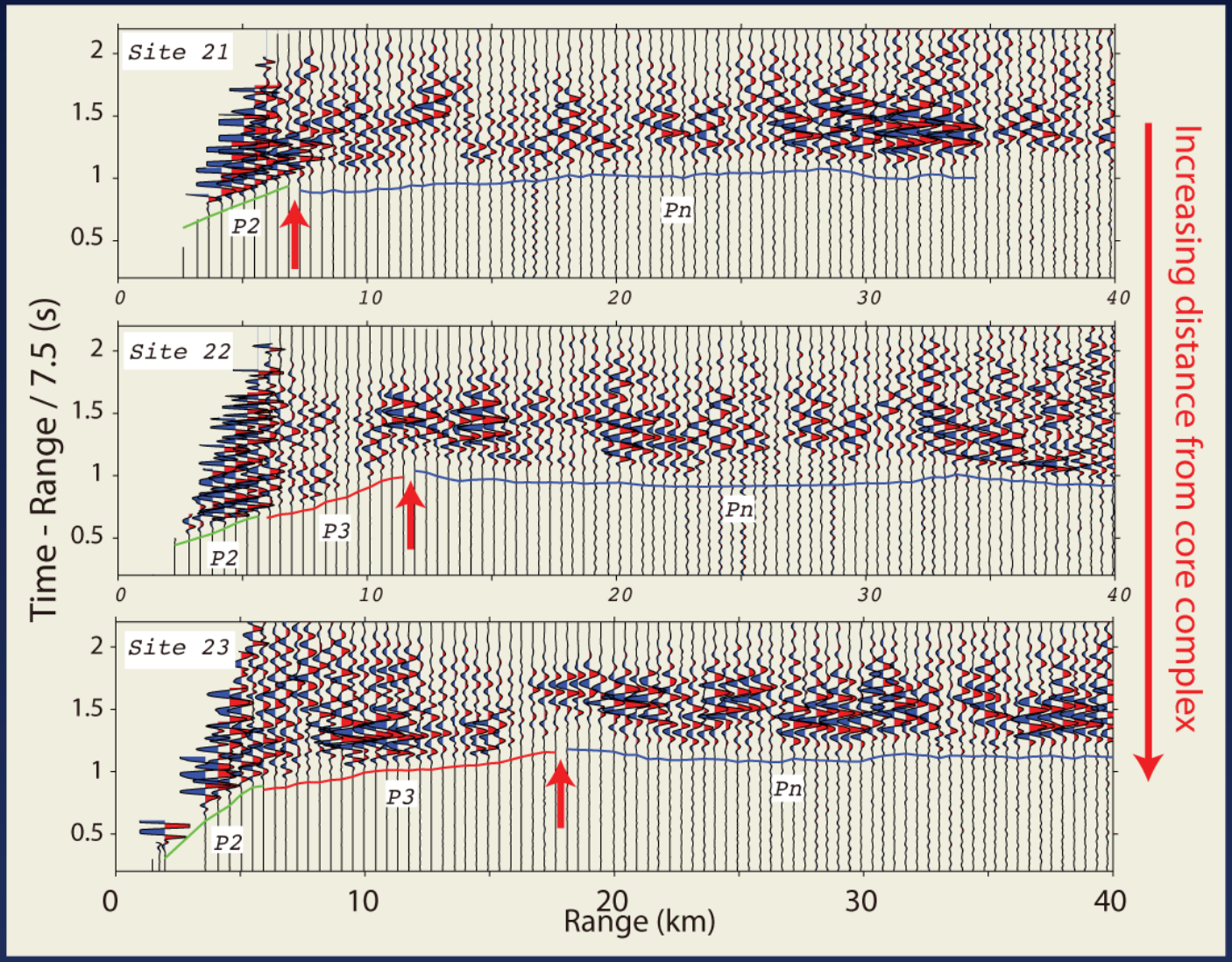
Only ~3% of planned shots for OBS lines were dropped (bad weather)

One OBS did not respond acoustically and did not return to the surface

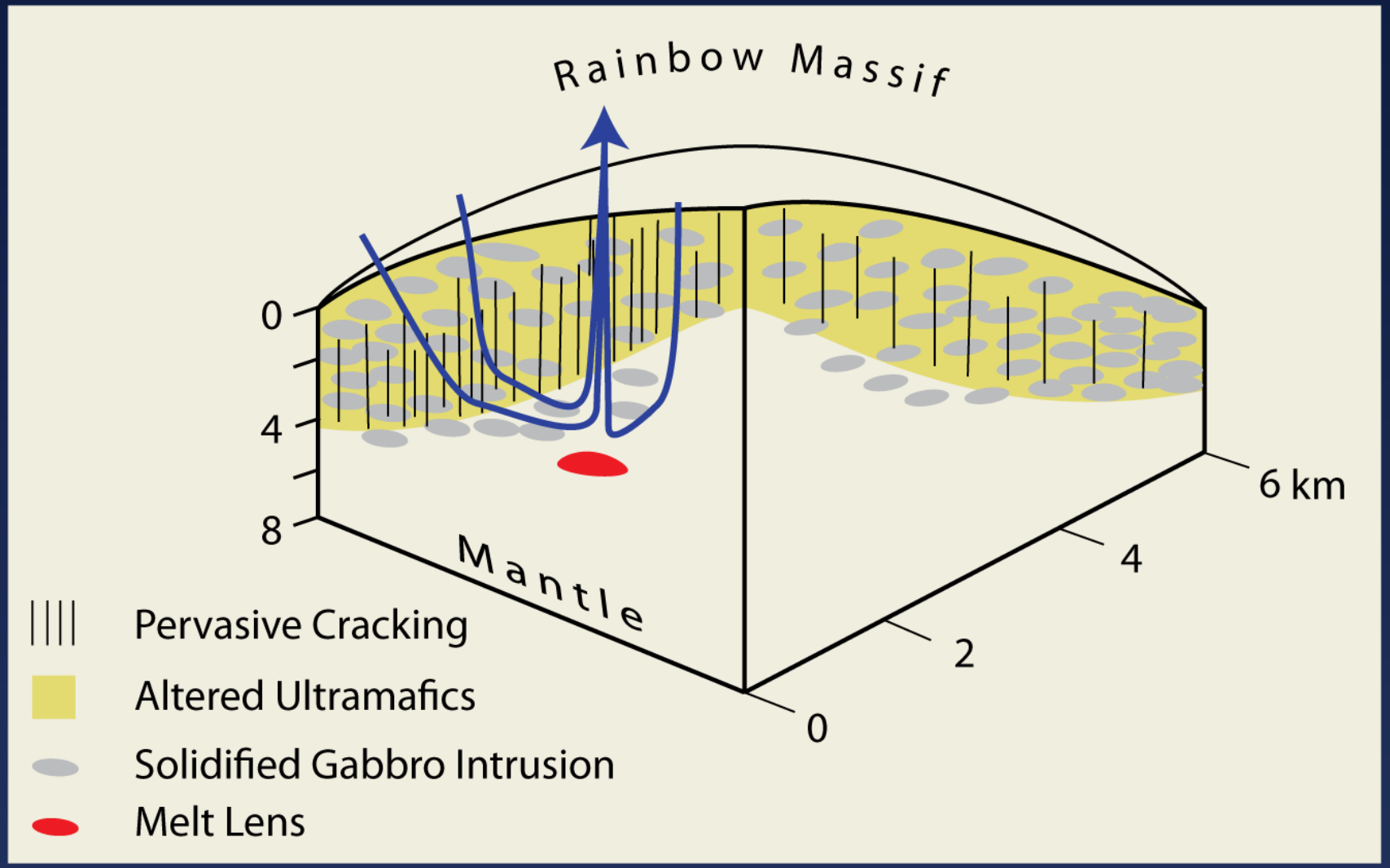
2 OBS had no data

Gravimeter, magnetometer, multibeam systems fully functional

Contingency time was used by delayed departure from port due to ship's rudder issue, being on stand-by due to inclement weather, on equipment maintenance, and OBS recovery delays due to acoustic communication problem



- Little evidence for a Moho reflection
- No lower crustal velocities at the non-transform offset


Rainbow Massif
0
4
8
Mantle
0
2
4
6 km
Pervasive Cracking
Altered Ultramafics
Solidified Gabbro Intrusion
Melt Lens