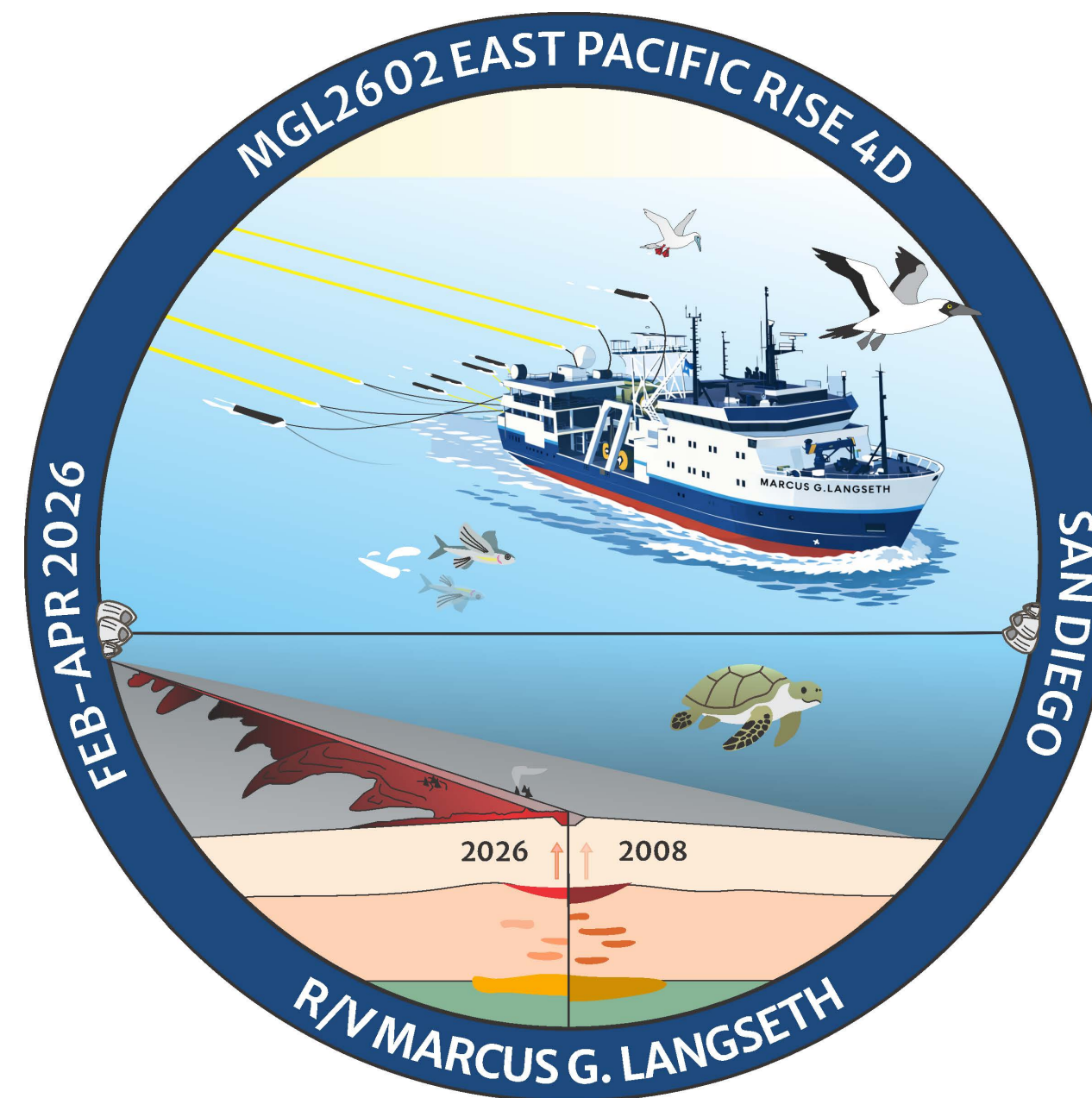


# MGL2602 Cruise Report

## A 4-D Seismic Experiment on the East Pacific Rise

February 22–April 4, 2026  
San Diego, Calif. to San Diego, Calif.



Chief Scientist: Ross Parnell-Turner, Scripps Institution of Oceanography  
Co-Chief Scientist: J. Pablo Canales, Woods Hole Oceanographic Institution  
Co-Chief Scientist: Milena Marjanović, CNRS-IPGP

# MGL2602 Cruise Report

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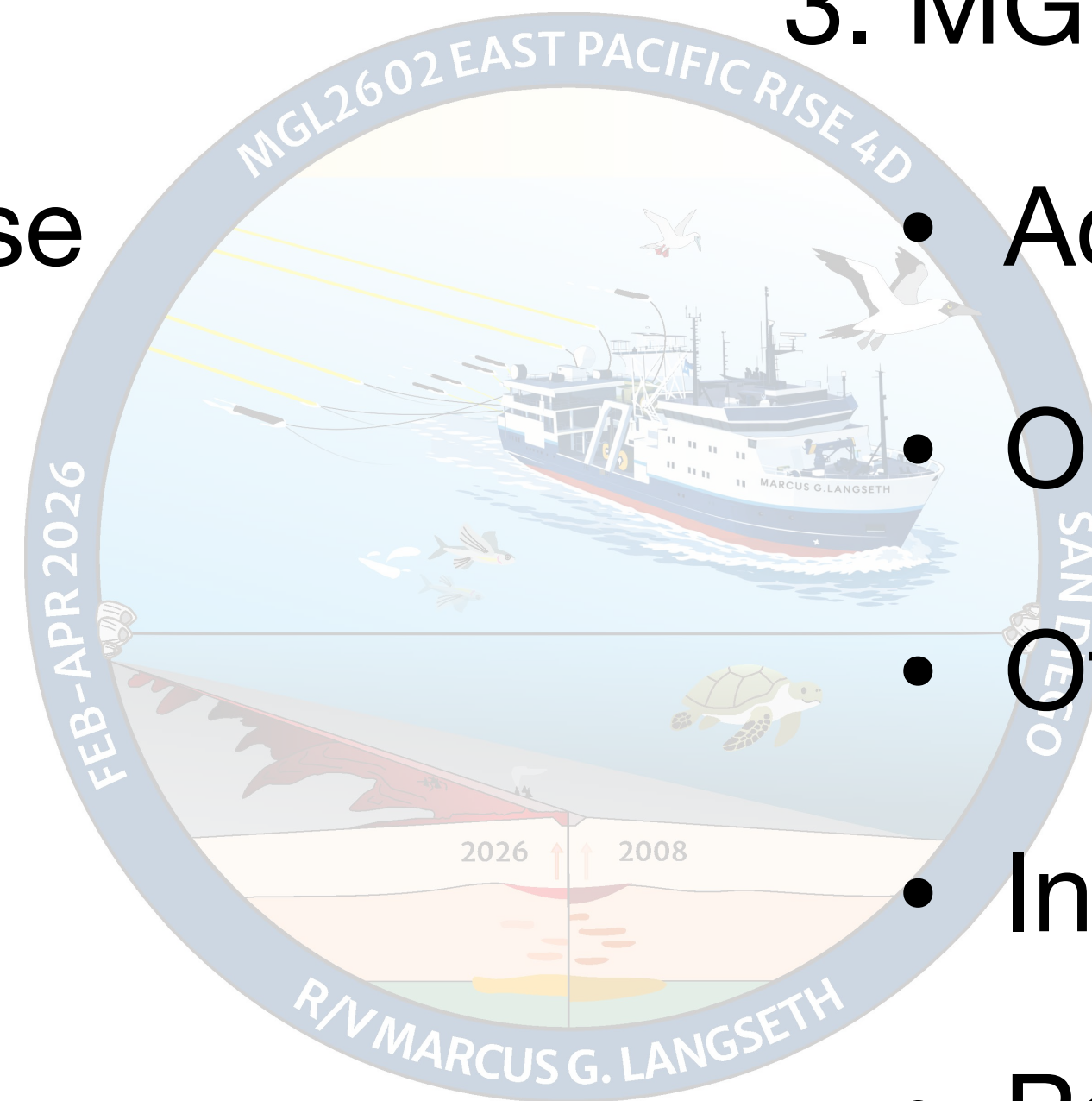
### 1. East Pacific Rise 9°50'N

- 2008 MGL0812 3-D Cruise
- Main Findings

### 2. Motivation for a 4-D (Time Lapse) Study

### 3. MGL2602 3-D Cruise

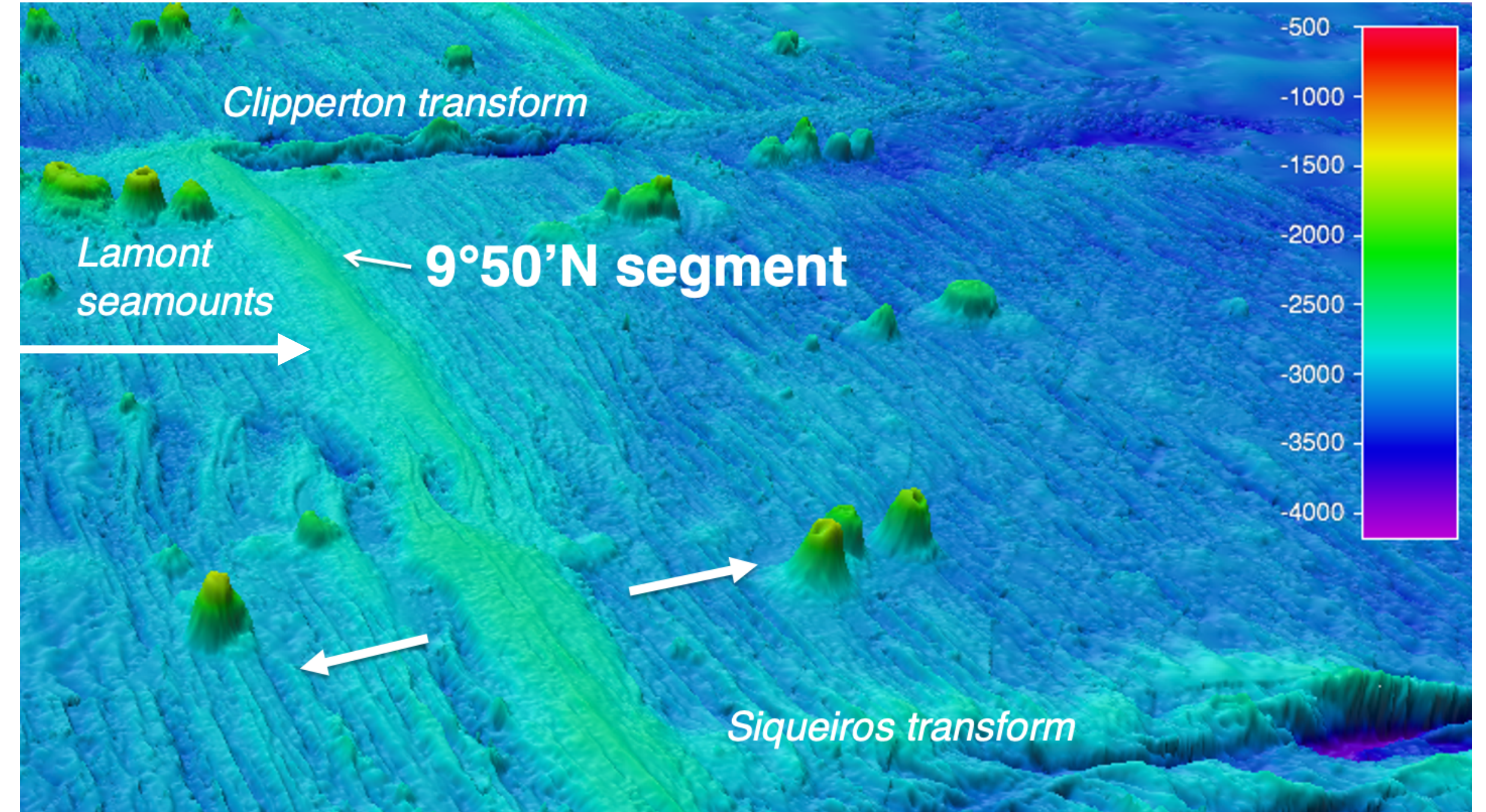
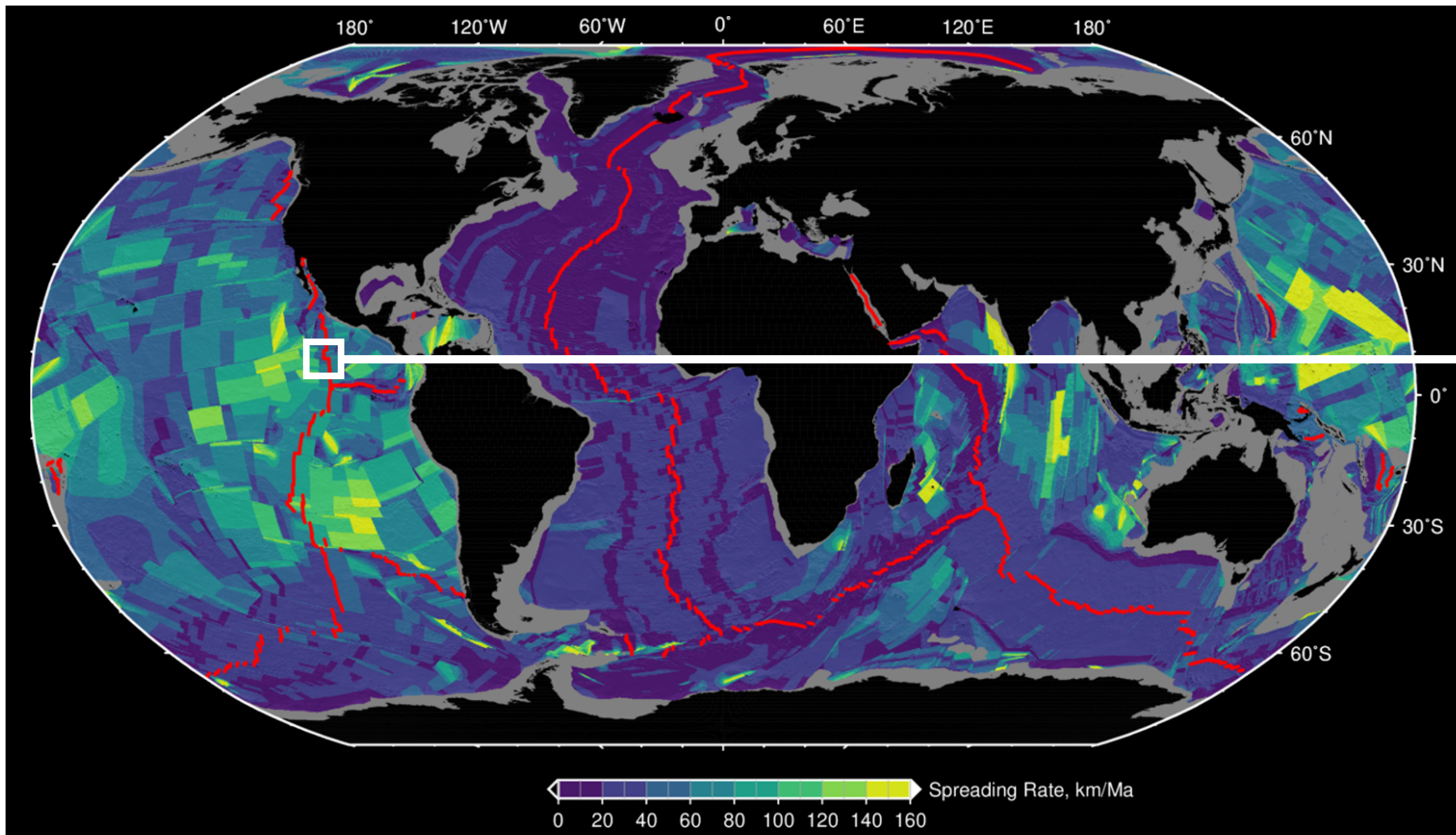
- Acquisition
- Onboard Data QC
- Other Operations
- Initial Observations
- Post-Cruise 4-D Data Processing



Chief Scientist: Ross Parnell-Turner, Scripps Institution of Oceanography  
Co-Chief Scientist: J. Pablo Canales, Woods Hole Oceanographic Institution  
Co-Chief Scientist: Milena Marjanović, CNRS-IPGP

# East Pacific Rise 9°50'N Segment

Integrated Study Site of the NSF RIDGE-2000 Program



Decades of multidisciplinary research investigating hydrothermal, geological, geophysical, biological and oceanographic processes at a fast-spreading mid-ocean ridge

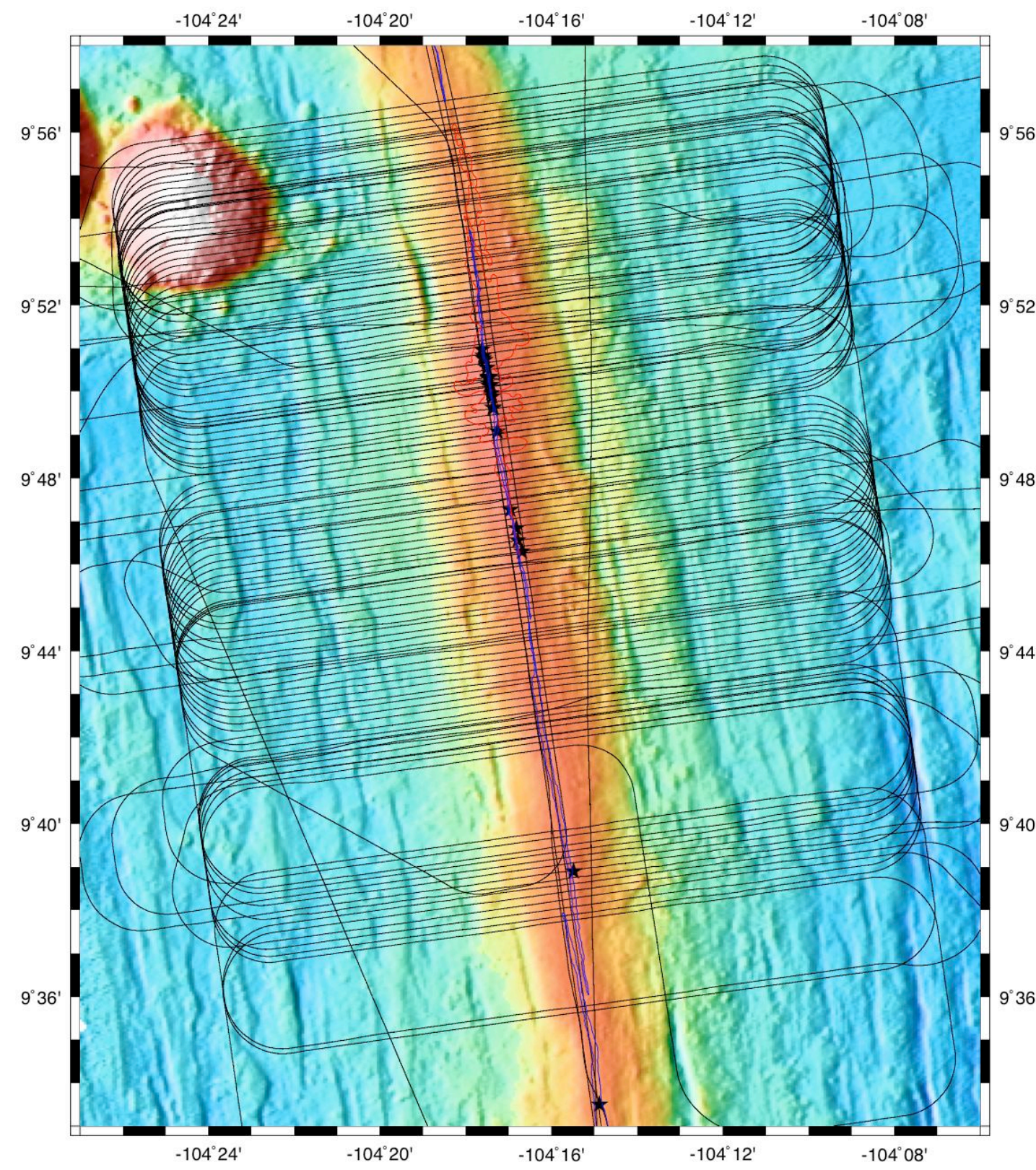
# East Pacific Rise 9°50'N Segment

## Integrated Study Site of the NSF RIDGE-2000 Program

MGL0812 Cruise Report

A 3D MCS investigation of the magmatic-hydrothermal system at the East Pacific Rise 9° 50'N.

2008: Cruise MGL0812  
First US Academic 3D Seismic Survey



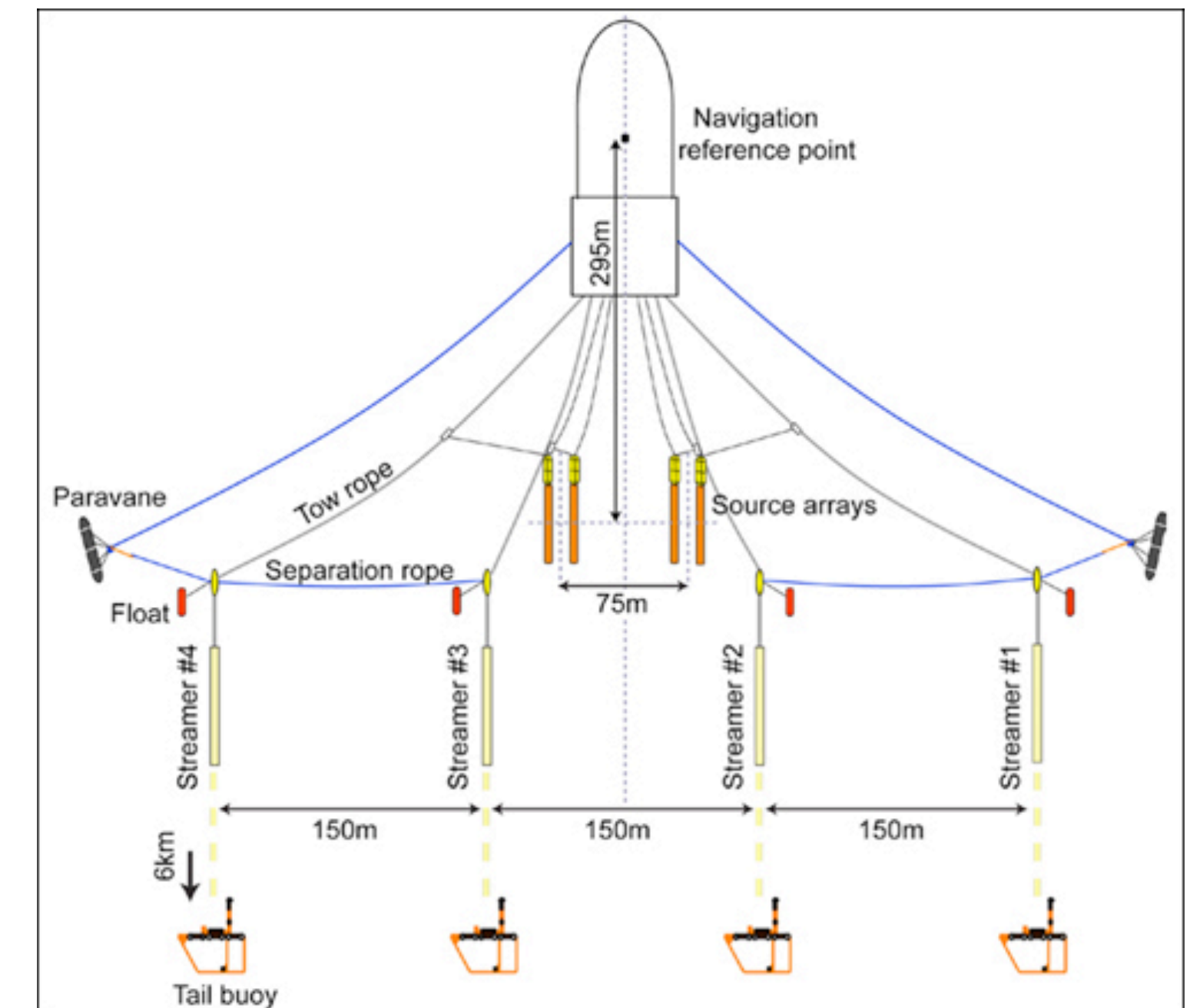
**Receivers:** 4 x 6 km streamers  
(468 receivers each)

**Receiver spacing:** 12.5 m

**Source Array:** 2 x 3,300 cu.in.

**Source interval:** 37.5 m (flip-flop)

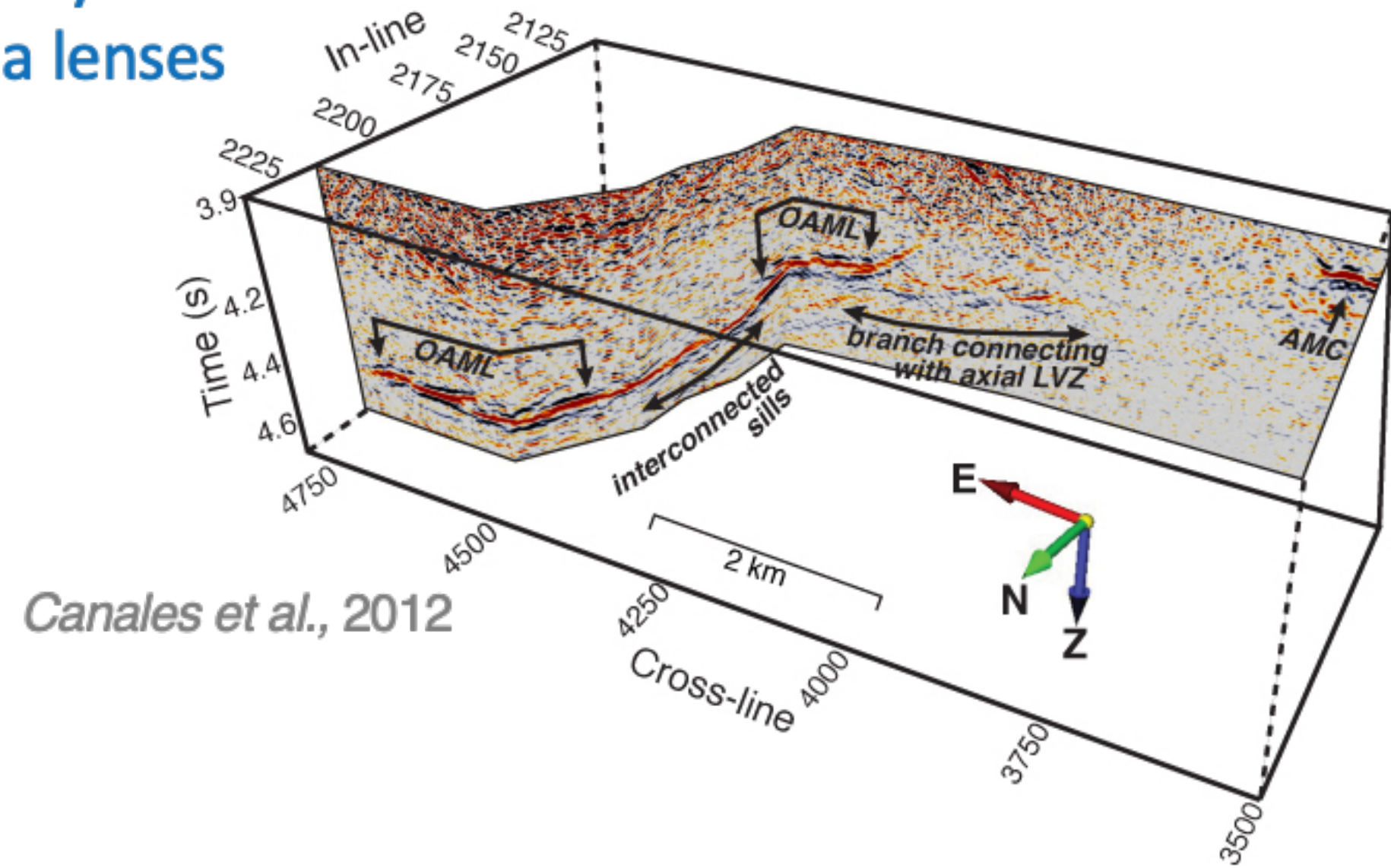
**Surface covered:** 30 x 40 km<sup>2</sup>



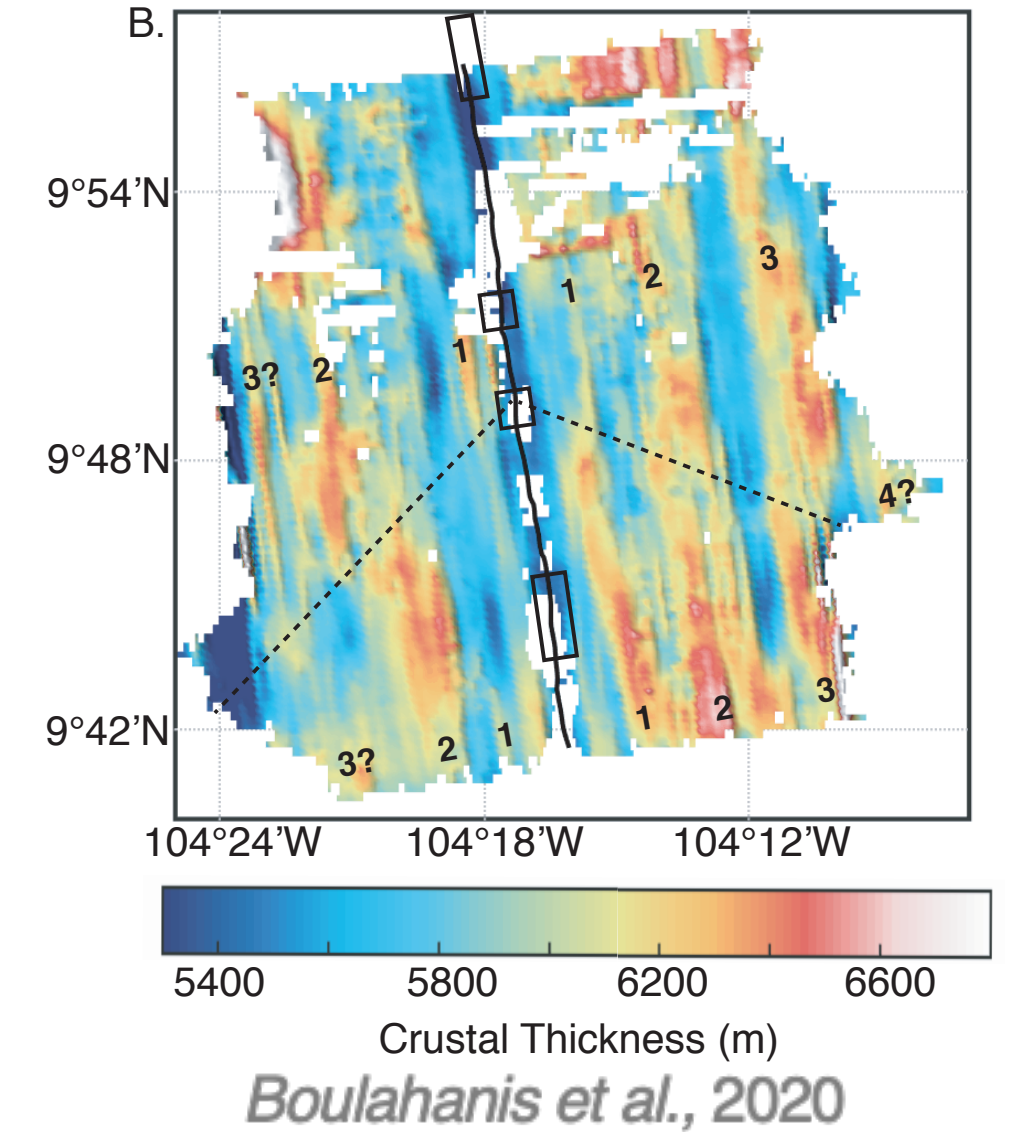
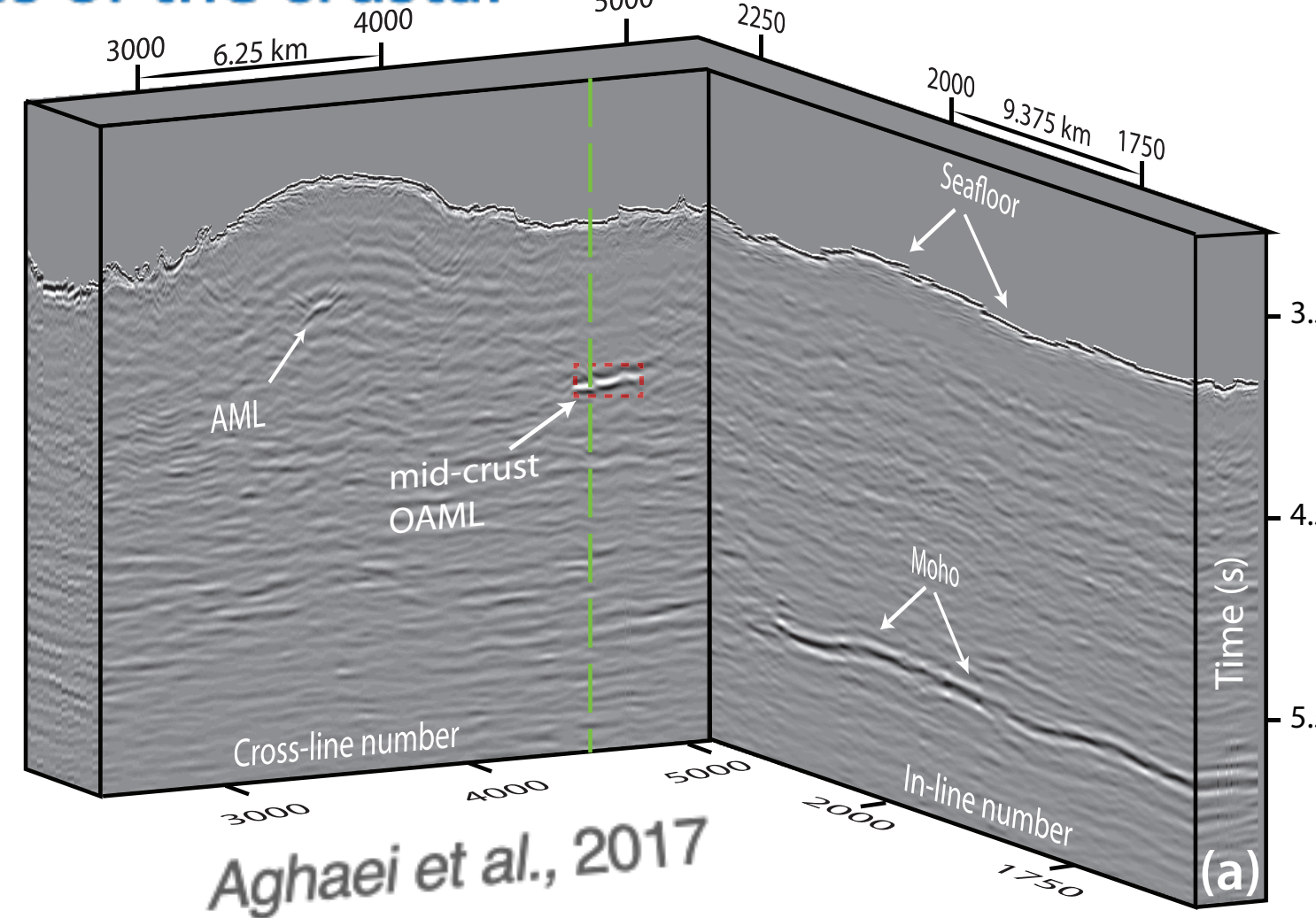
Chief Scientists: John C. Mutter & Suzanne M Carbotte (LDEO),  
Juan Pablo Canales (WHOI), Mladen Nedimovic (Dalhousie University)

# Discoveries from the 2008 volume

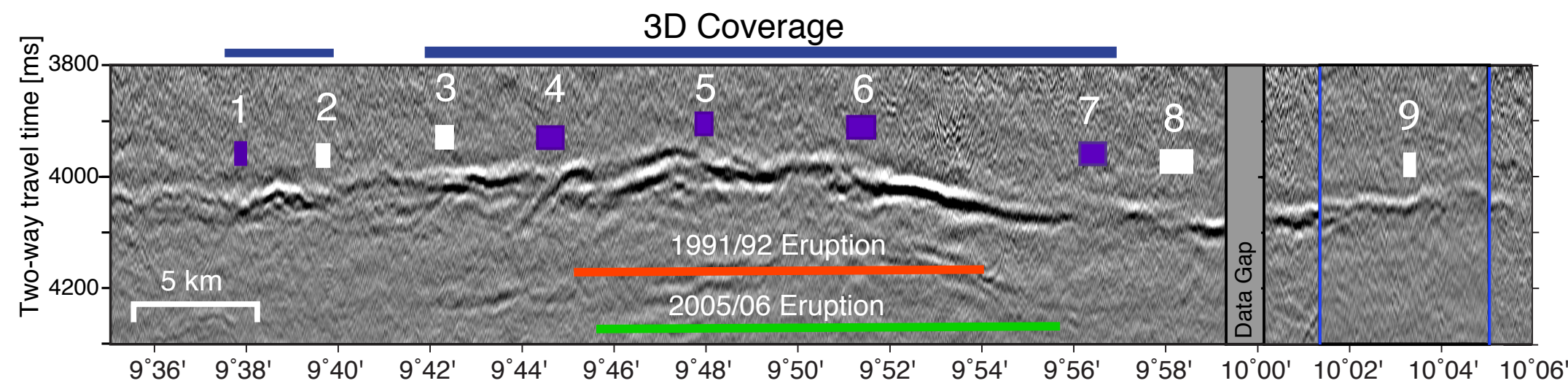
Discovery of off-axis magma lenses



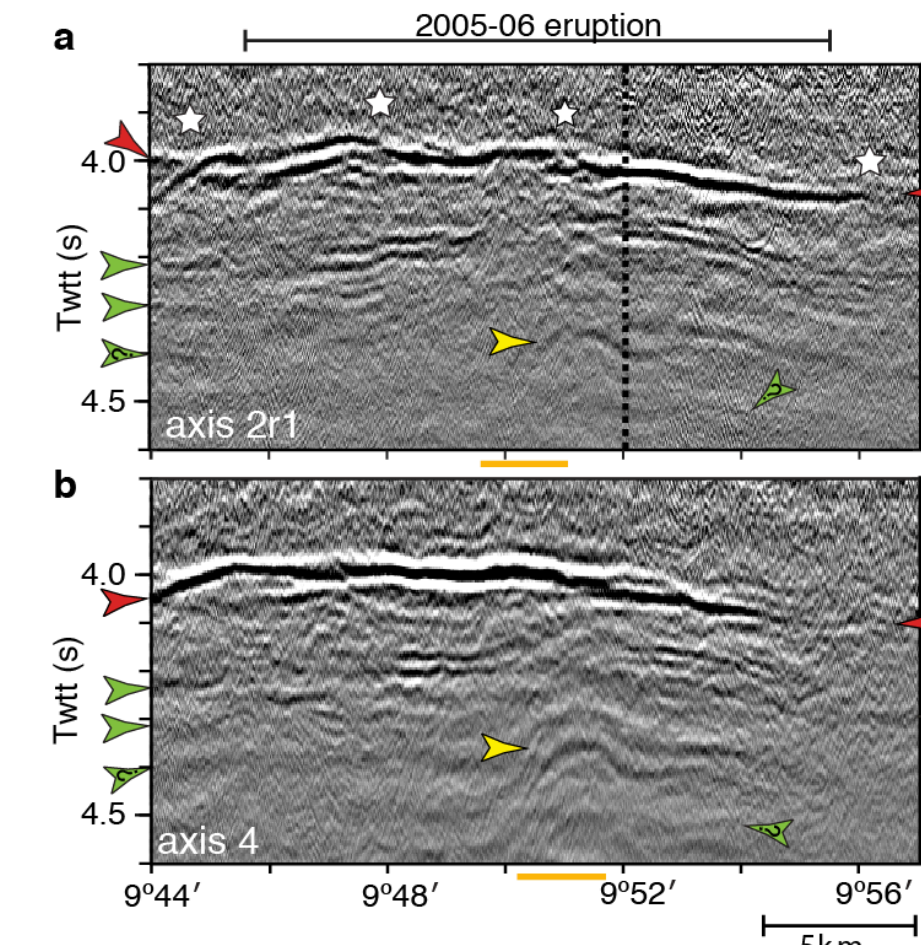
~Estimates of the crustal thickness



- mapped the segmentation of the magma body



- discovered the presence of deeper magma bodies

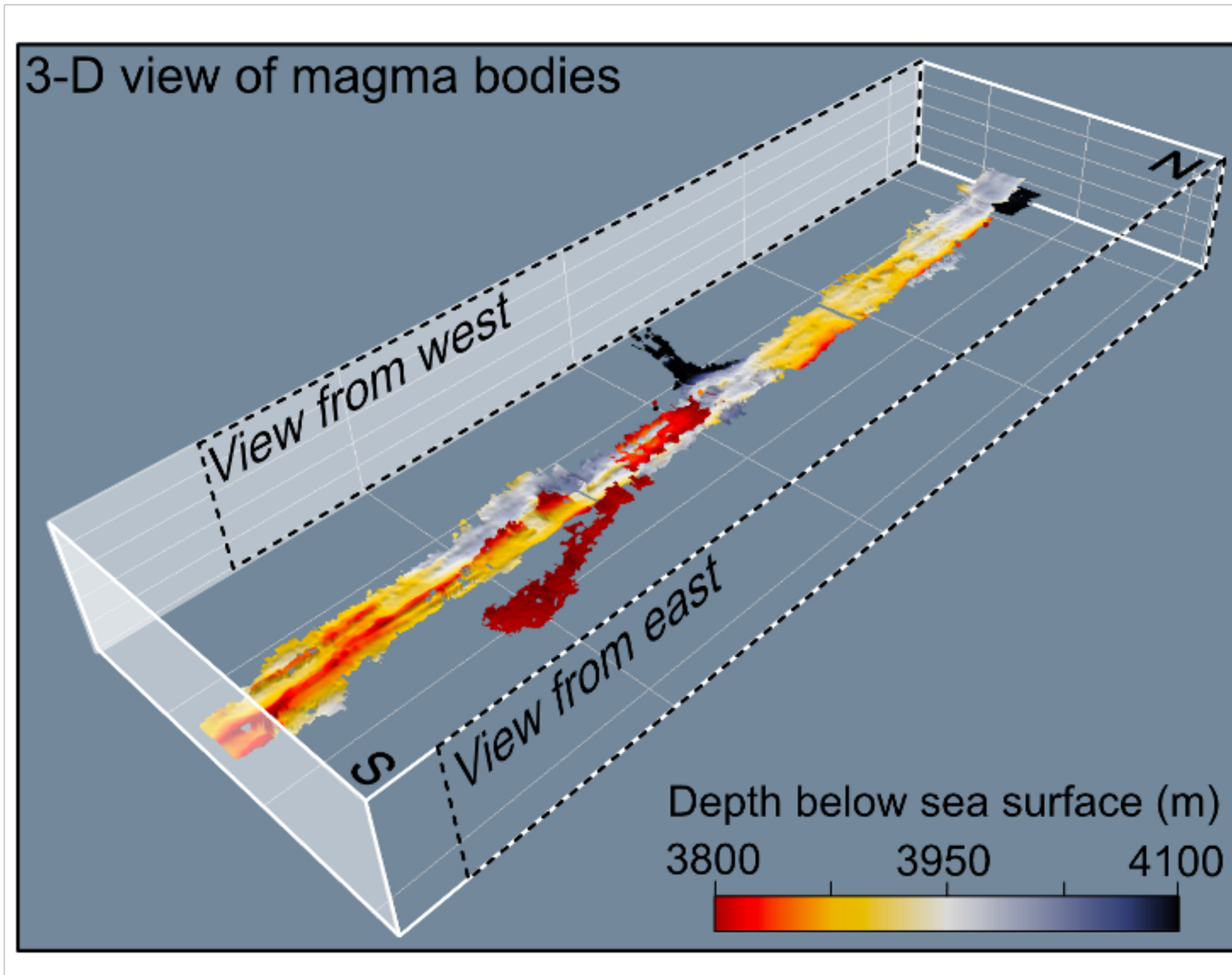


- gap in SAML
- ☆ AML disruption
- ▶ pull-up structure
- ▶ AML
- ▶ SAML
- ▶ inferred SAML

*Marjanović et al., 2014*

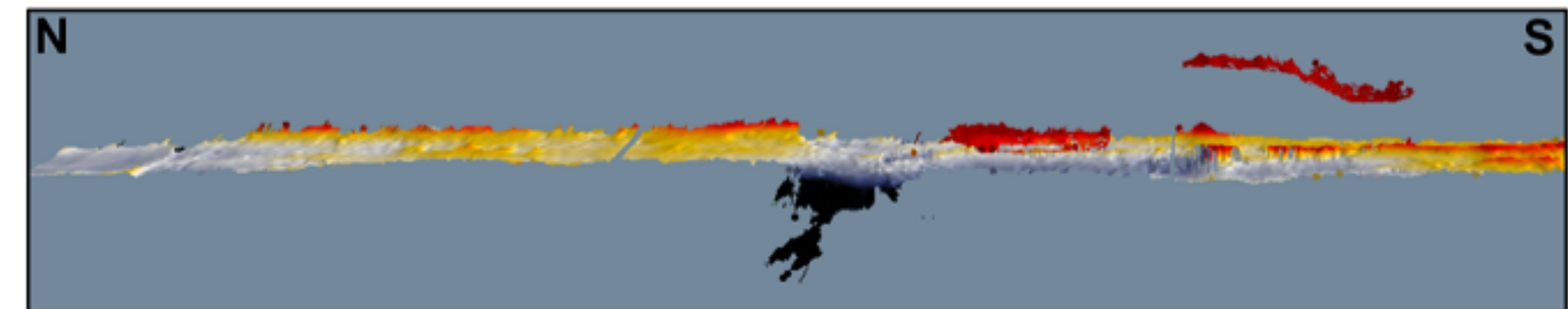
# Imaging top-most level of the magmatic system in 3-D

## Mapped AML horizons in seismic volume

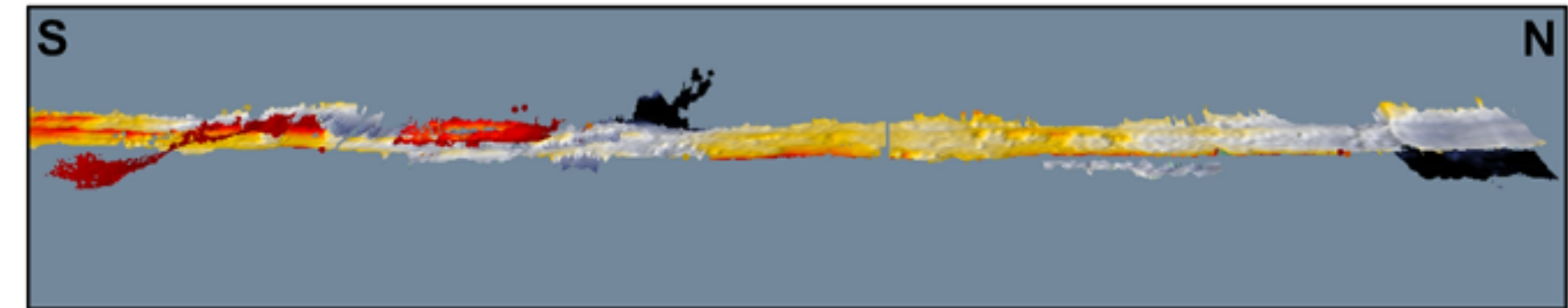


➤ Magma bodies exhibit topography modulated by tectonic and volcanic processes.

View from west



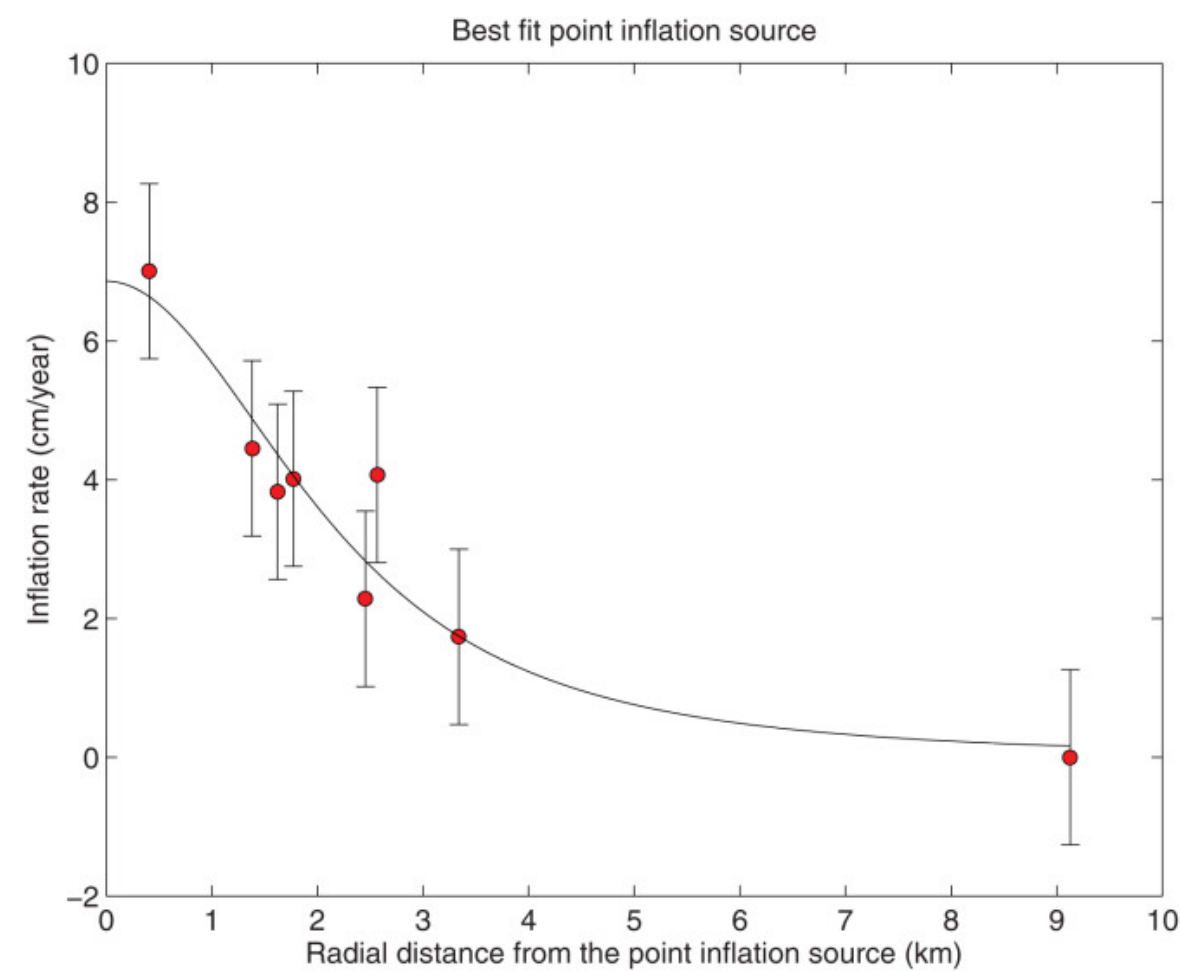
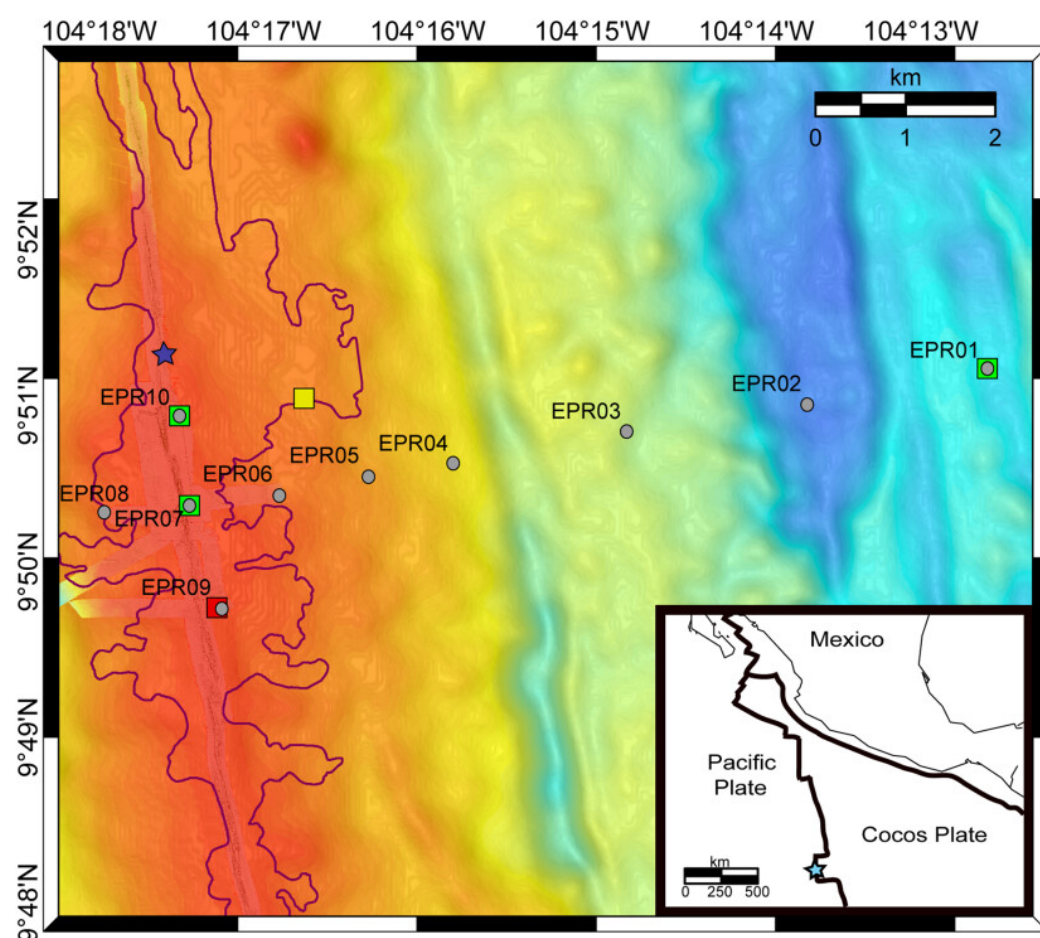
View from east



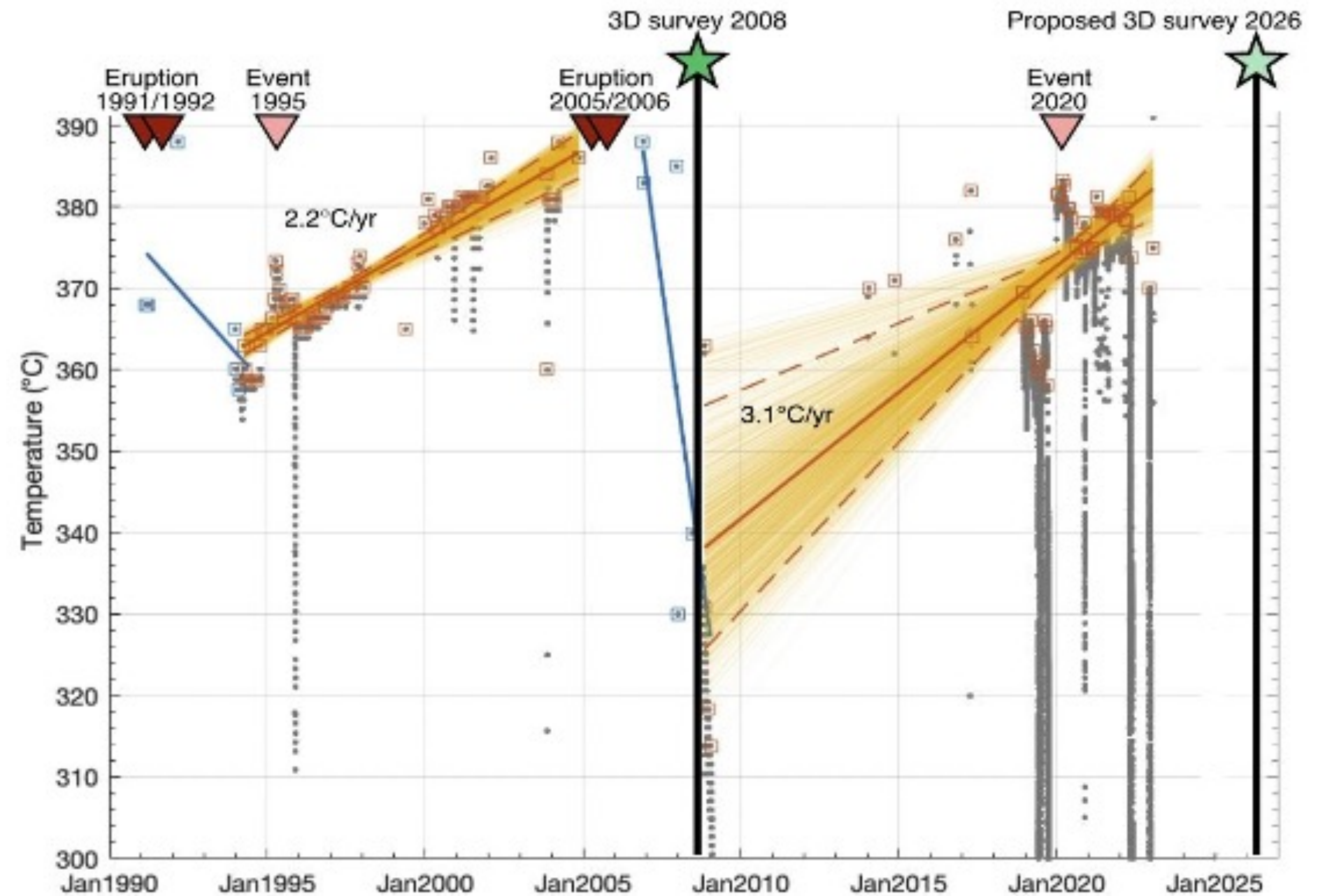
# Motivation for a 4-D (Time Lapse) Study

Early post-2005/06 eruption inflation rates and decadal hydrothermal vent temperature time series predict possible eruption in 2025-2026

period of inflation was very brief, lasting only a few months. Therefore, we believe that since the EPR eruption occurred 3–4 years prior to the observed uplift shown here, this phase of inflation was already past. If the observed inflation rate at the EPR represents a steady linear long-term inflation, we expect the magma chamber to be fully re-inflated and primed for an eruption by 2026, after an approximately 20 year interval. We obtain this result by using  $47 \times 10^6 \text{ m}^3$  as the total volume of magma evacuated from the magma chamber



Nooner et al., 2014



Courtesy of T. Barreyre

An underwater scene showing a robotic arm on the right side, reaching towards a rocky seabed. The rocks are dark and appear to be covered in a thin layer of sediment or algae. The lighting is dim, typical of an underwater environment. The text is overlaid in white on the left side of the image.

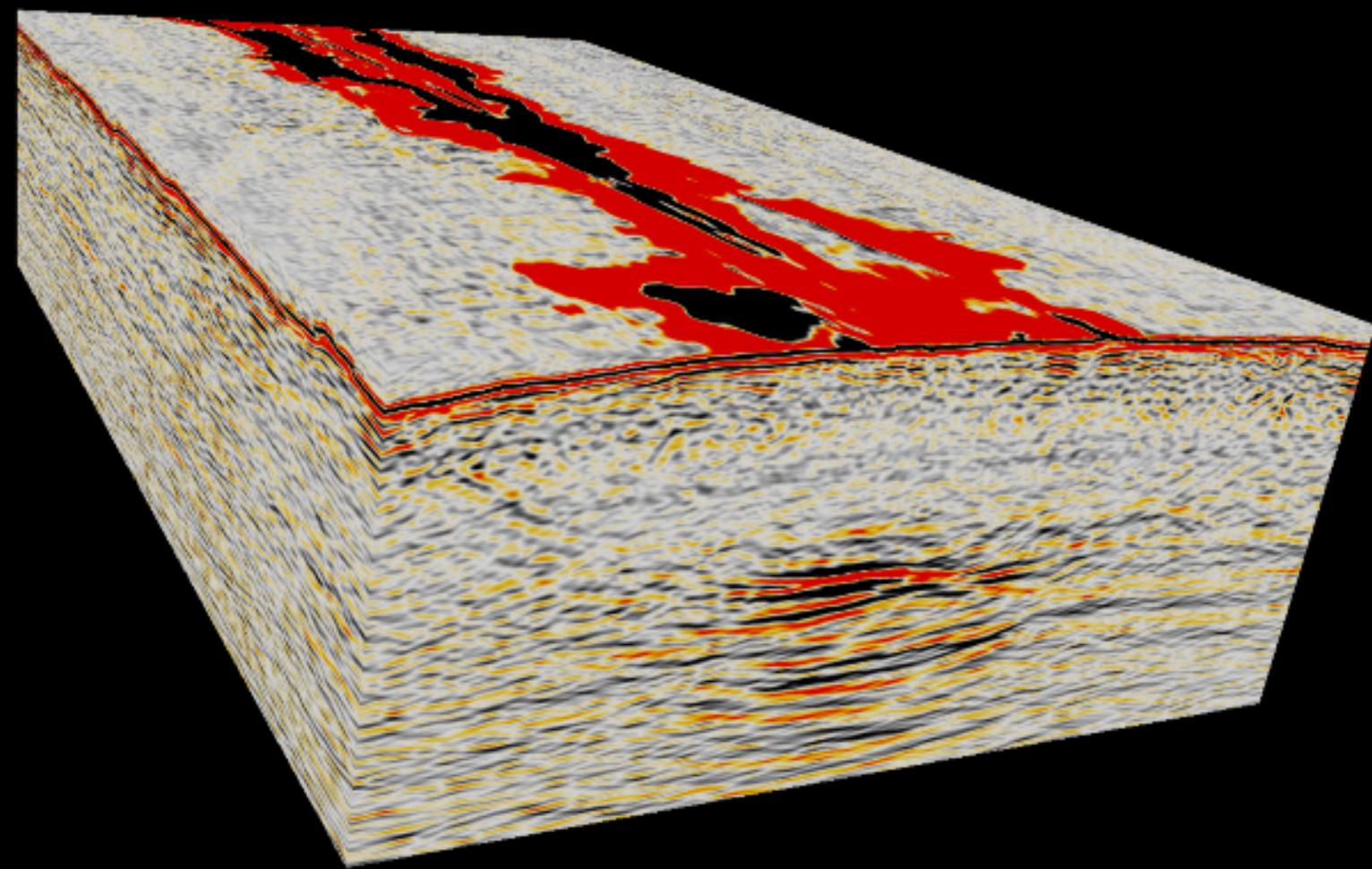
Have the magma lenses  
recharged and emptied?

What has changed since 2008?

**Need to repeat 2008 3d survey**

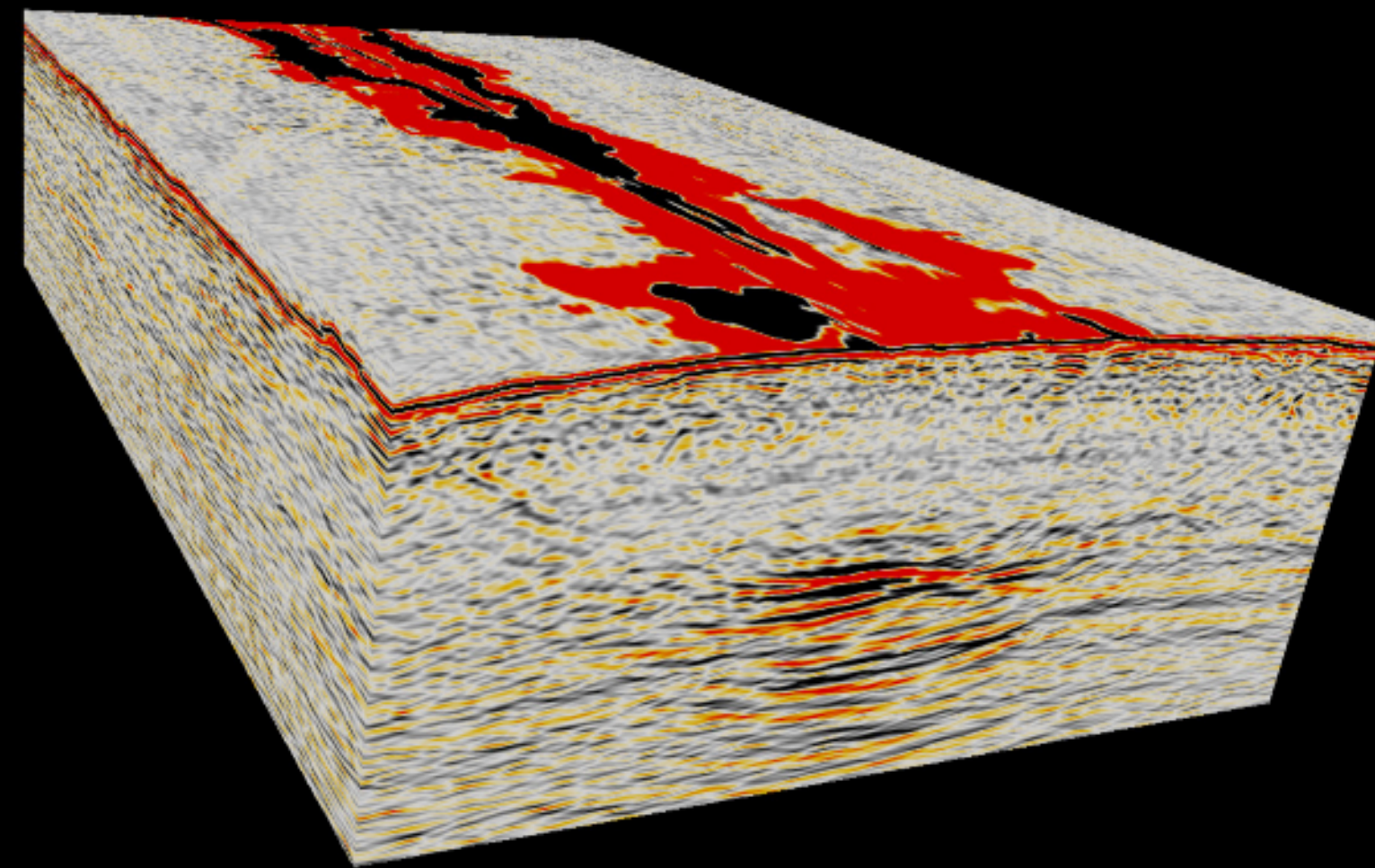
# Time lapse experiment

*baseline survey*



**2008**

*repeat survey*



**2026**

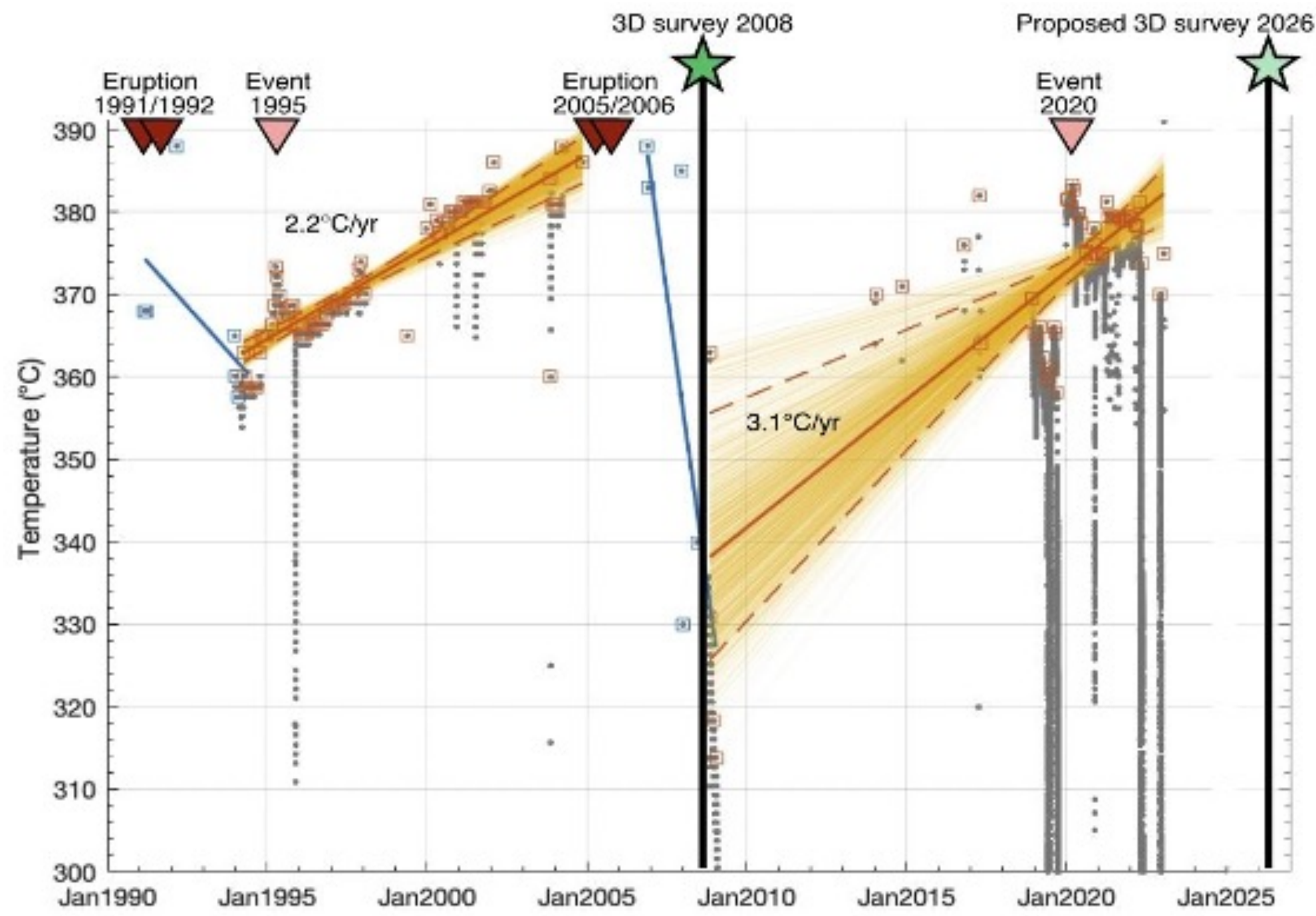
*minus*

**= ?**

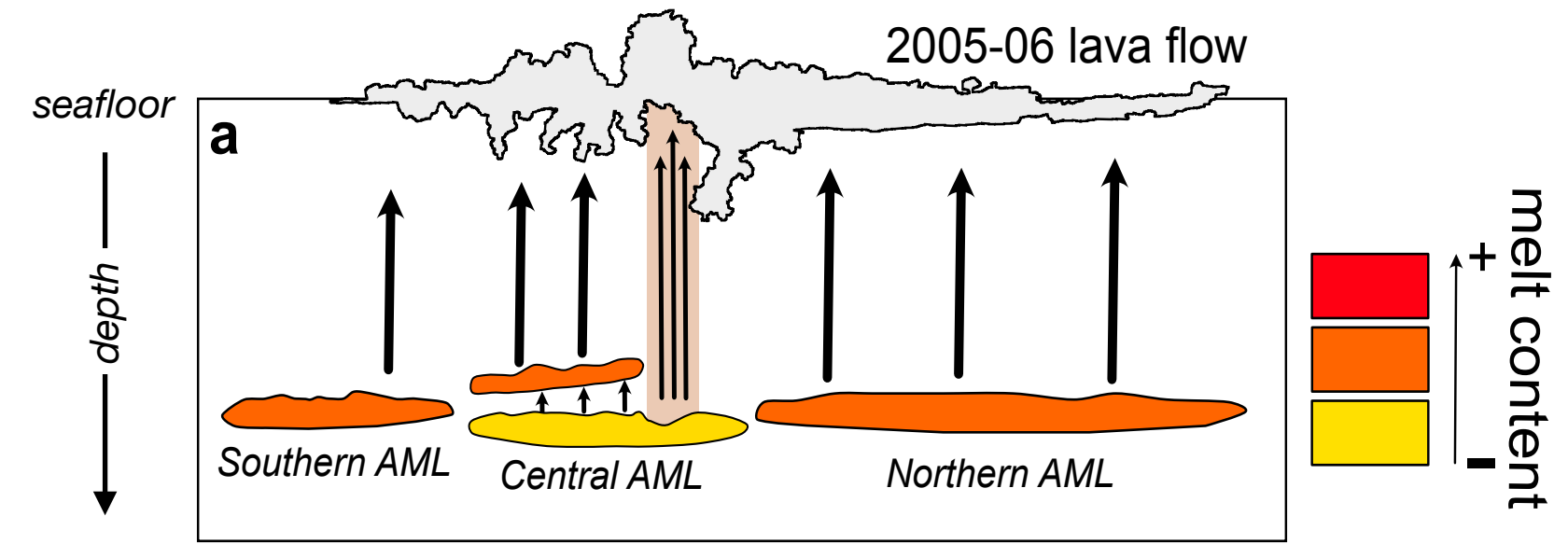
# Motivation for a 4-D (Time Lapse) Study

## Uncertainty in eruption timing:

Repeat survey before or after future eruption?

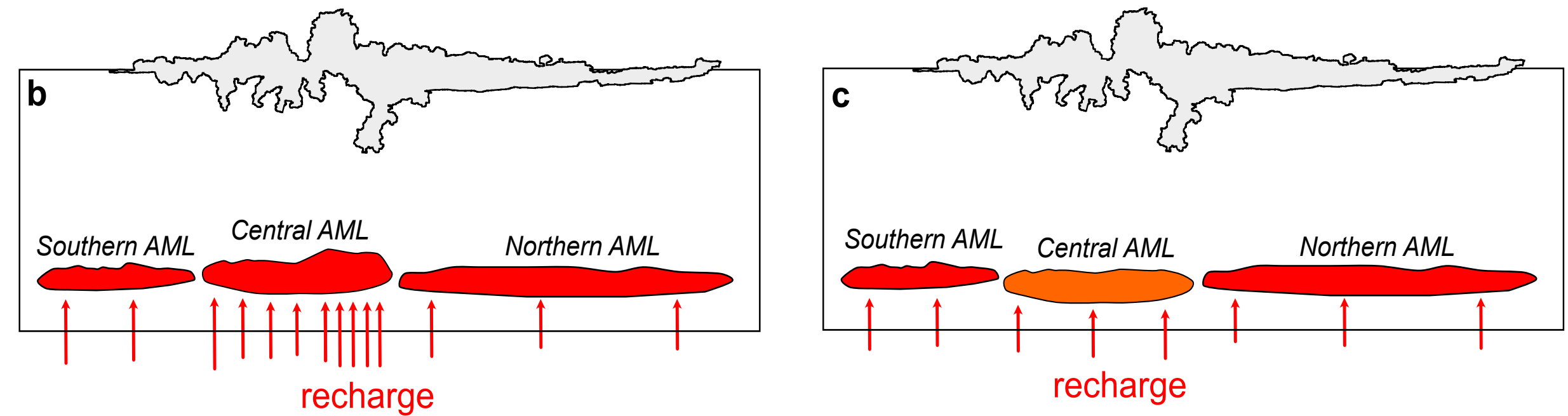


AML state 2008, post 2005-06 eruption (after Xu et al., 2014)



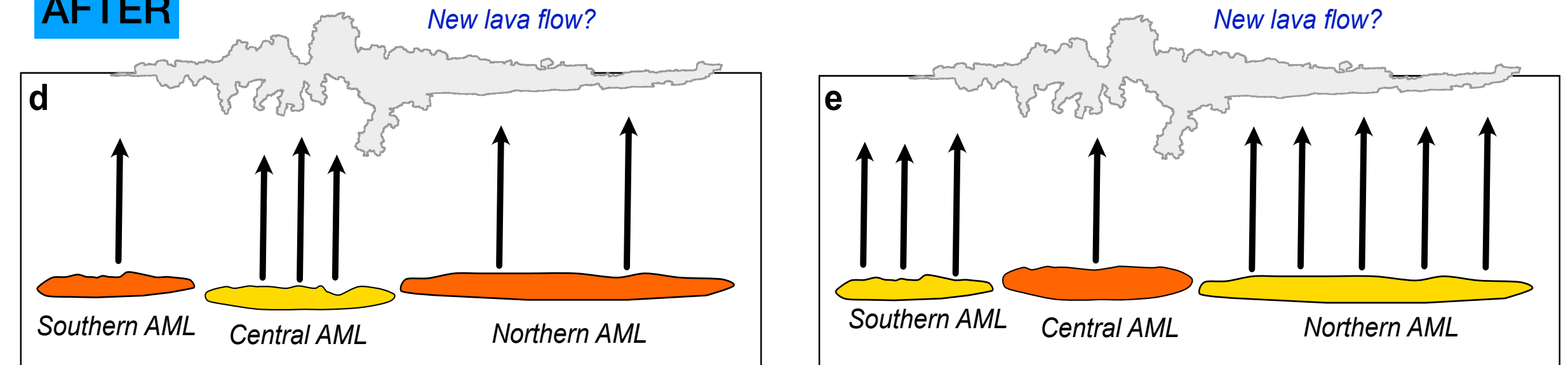
### BEFORE

Scenario 1: Repeat MCS survey before next eruption



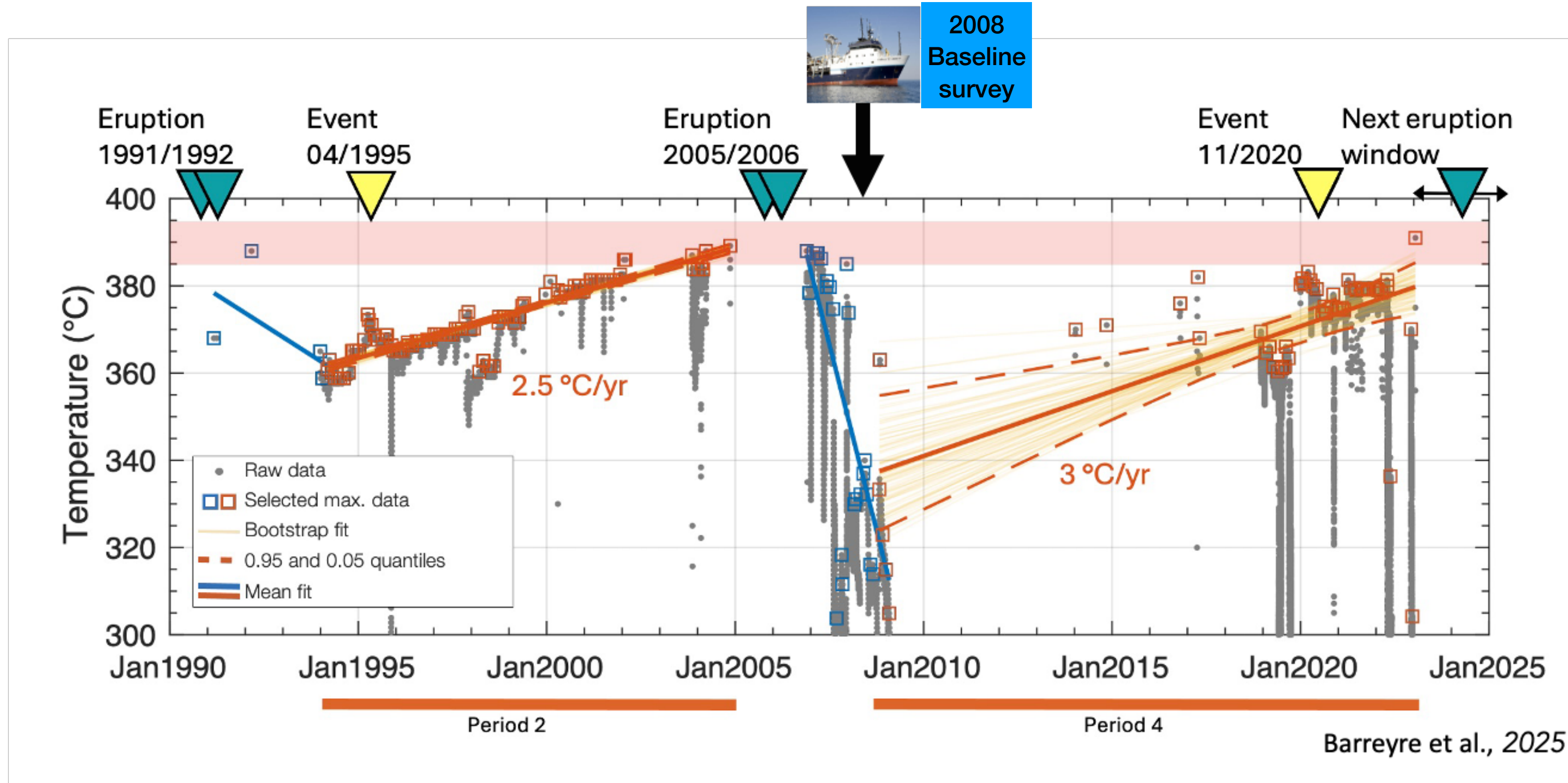
Scenario 2: Repeat MCS survey after next eruption

### AFTER



# April 29, 2025, East Pacific Rise 9°50'N Eruption

## Exit temperature data forecast next eruption



The New York Times

## Volcanic Eruption in Deep Ocean Ridge Is Witnessed by Scientists for First Time

Researchers diving in a submersible in the eastern Pacific realized that the landscape they had studied the day before had been glassed over by fresh lava.



Vibrant signs of deep marine life on the same swath of seafloor before the eruption.  
 Andrew Wozniak/University of Delaware; HOV Alvin Team; NSF; Woods Hole Oceanographic Institution



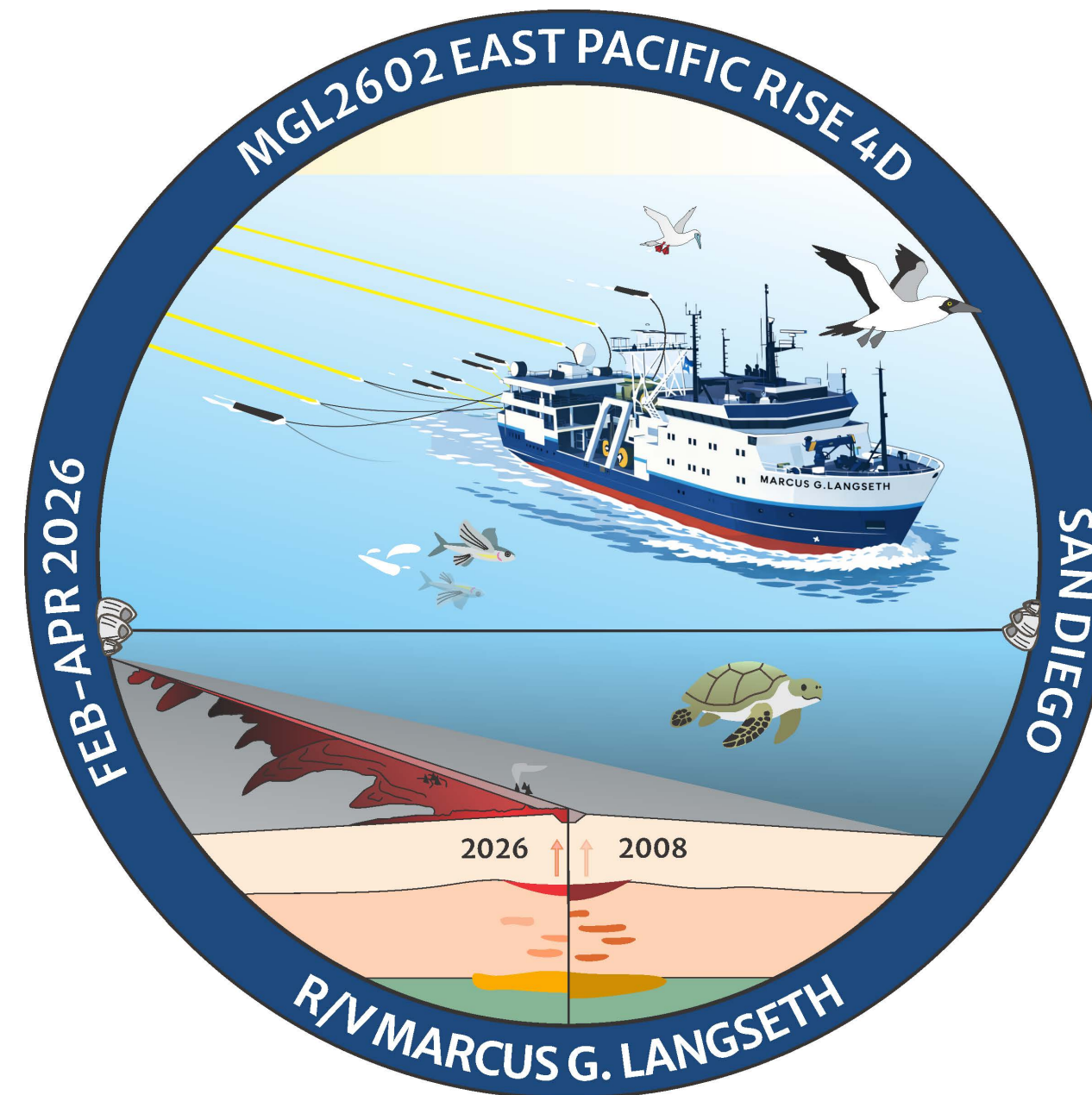
Darkened terrain, punctuated by a single cluster of dead marine worms, was a sign of cooled fresh lava after an undersea volcanic eruption in waters about 1,300 miles west of Costa Rica.  
 Andrew Wozniak/University of Delaware; HOV Alvin Team; NSF; Woods Hole Oceanographic Institution

Shah et al., 2025  
 Wozniak et al., 2026







# MGL2602 Cruise Report

## A 4-D Seismic Experiment on the East Pacific Rise

February 22–April 4, 2026  
San Diego, Calif. to San Diego, Calif.



### MGL2602 by the numbers:

-  22 days of continuous seismic acquisition
-  2,575 km of survey lines collected
-  68,663 acoustic sources triggered
-  Four 6 km-long streamers towed
-  2,256 recording channels
-  10 m seafloor mapping resolution



Chief Scientist: Ross Parnell-Turner, Scripps Institution of Oceanography  
Co-Chief Scientist: J. Pablo Canales, Woods Hole Oceanographic Institution  
Co-Chief Scientist: Milena Marjanović, CNRS-IPGP

# MGL2602 Cruise Report

## A 4-D Seismic Experiment on the East Pacific Rise

### Cruise Objectives

1. Repeat of 2008 survey:
  - Same preplot survey lines
  - Same line direction, source, streamer parameters

2. Recover 3 OBS

#### Post Expedition: Time Lapse Processing (Viridien)

- Elastic full waveform inversion: 2008 and 2026
- 4d difference cube

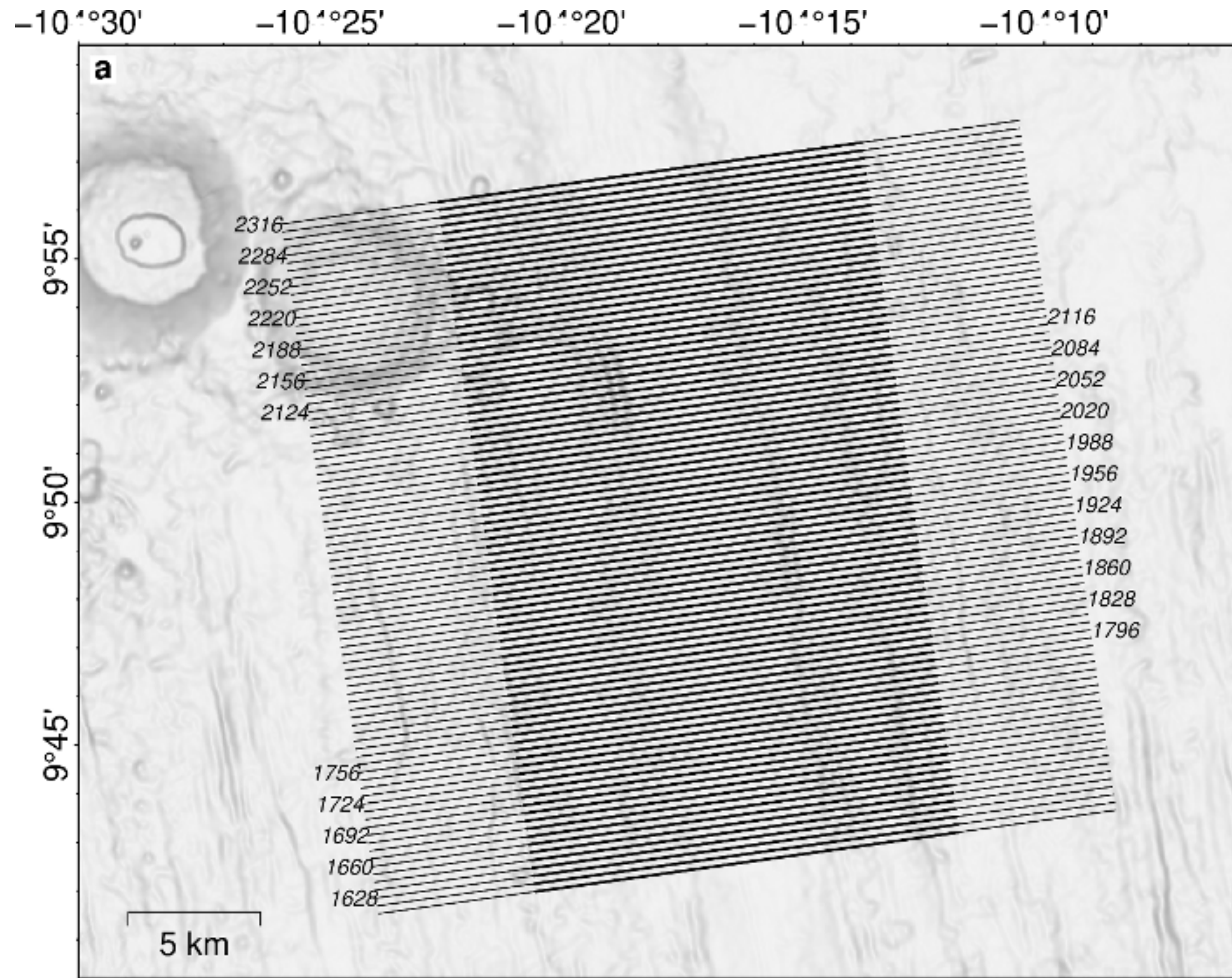
# MGL0812 and MGL2602 Acquisition Parameters

Parameter	MGL0812	MGL2602
Acquisition Parameter ID	MGL0812_ACQ01	MGL2602
Acquisition system	Syntron Syntrack 960	Seal 428
Seismic navigation system	C-Nav primary	C-Nav X3
Survey datum	WGS84	WGS84
NRP to C-Nav antenna z (vertical)	-14.5 m	-16.9 m
NRP to C-Nav antenna y (fore/aft)	+4.87 m	0 m
NRP to C-Nav antenna x (stbd/port)	+8.055 m	0 m
NRP to source	295 m	240 m
Antenna to source	299.87 m	240 m
<b>Source to near channel</b>	<b>200 m</b>	<b>154.3 m</b>
Number of channels recorded	1872	2256
Number of cables	4	4
<b>Number of channels per cable</b>	<b>468</b>	<b>564</b>
<b>Channel spacing</b>	<b>Channels 1–468: 12.5 m</b>	<b>Channels 1–192: 6.25 m Channels 193–564: 12.5 m</b>
Cable length	5850 m	5850 m
Cable spacing	150 m	150 m

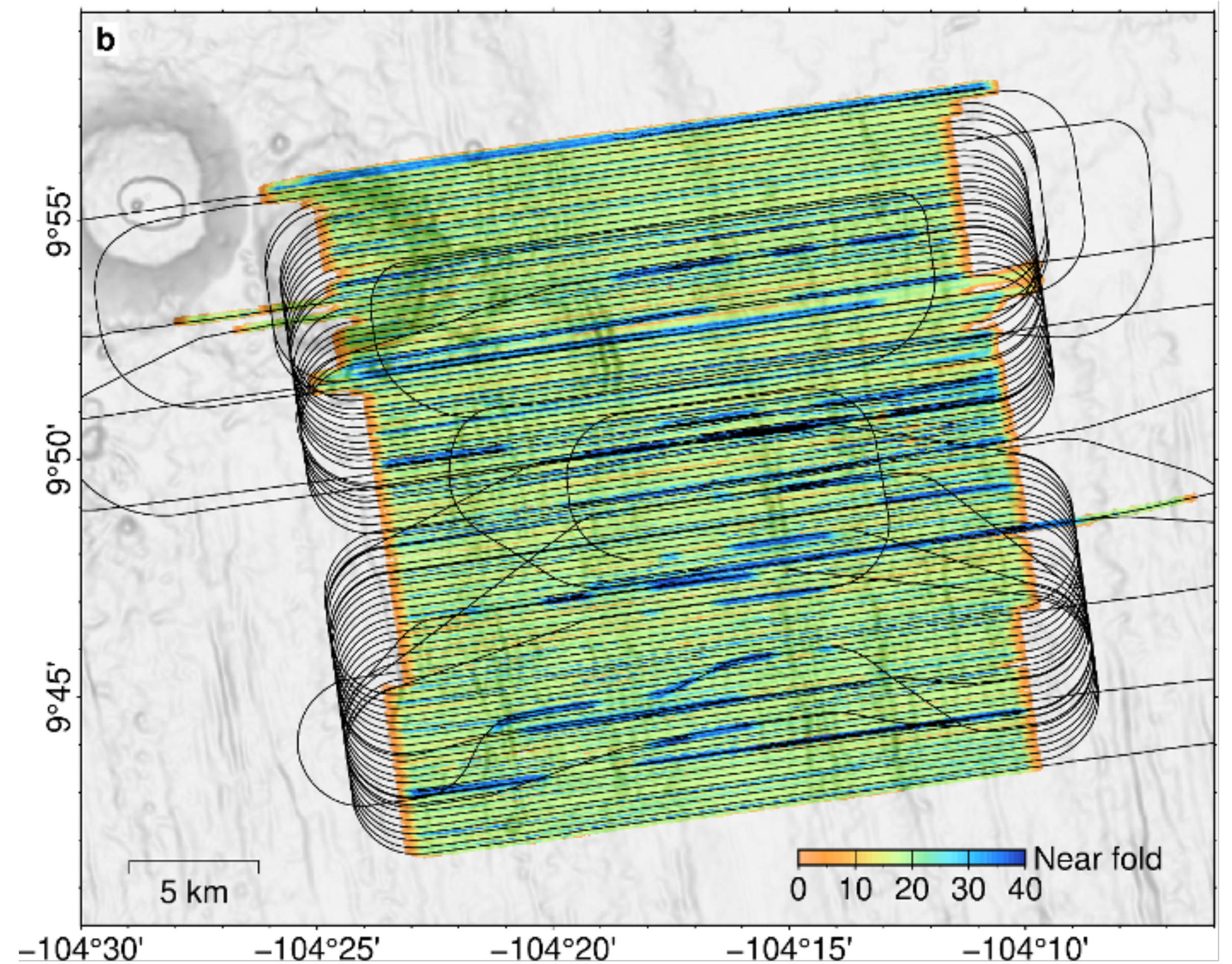
Parameter	MGL0812	MGL2602
<b>Near channel number</b>	<b>468</b>	<b>1</b>
Cable depth	10 m	10 m
Number source arrays	2 (each with two strings)	2 (each with two strings)
Alternate shooting	yes	yes
Source array separation	75 m nominal	75 m nominal
Source volume per array	3300 in cu	3300 in cu
Source pressure	2000 psi nominal	2000 psi nominal
Source type	Bolt	Bolt
Source number	18 (9 guns per string)	18 (9 guns per string)
Source depth	7.5 m	7.5 m
Shot control	distance	distance
Shot interval	37.5 m	37.5 m
Sample interval	2 ms	2 ms
<b>Record length samples</b>	<b>10240 s (5120 samples)</b>	<b>10000 s (5000 samples)</b>
Compass birds	yes	yes
Tail buoy	yes	yes

# MGL2602 Sail Lines

Planned pre-plot lines



Final shiptrack and near-offset fold (target: fold 10)

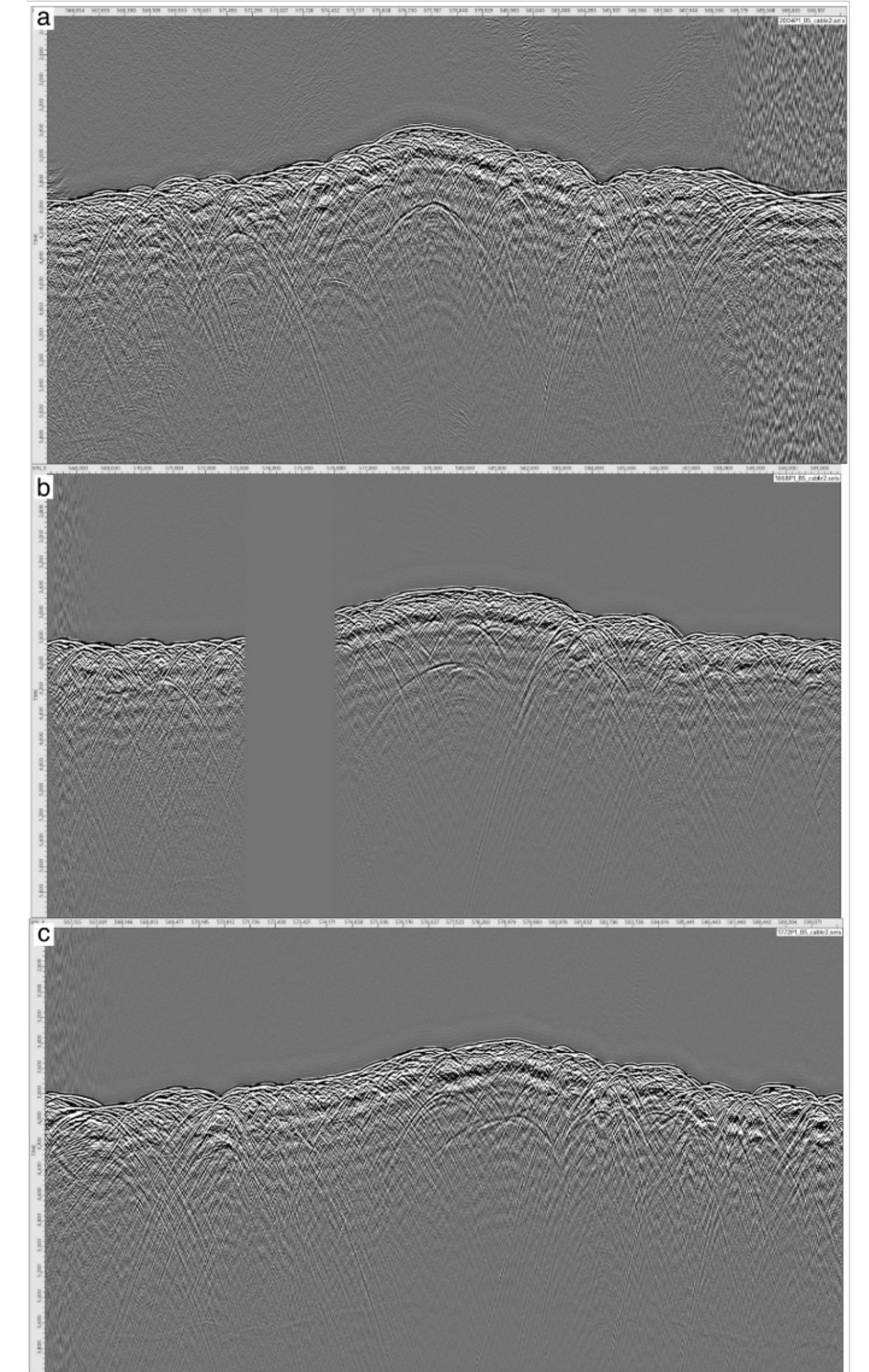
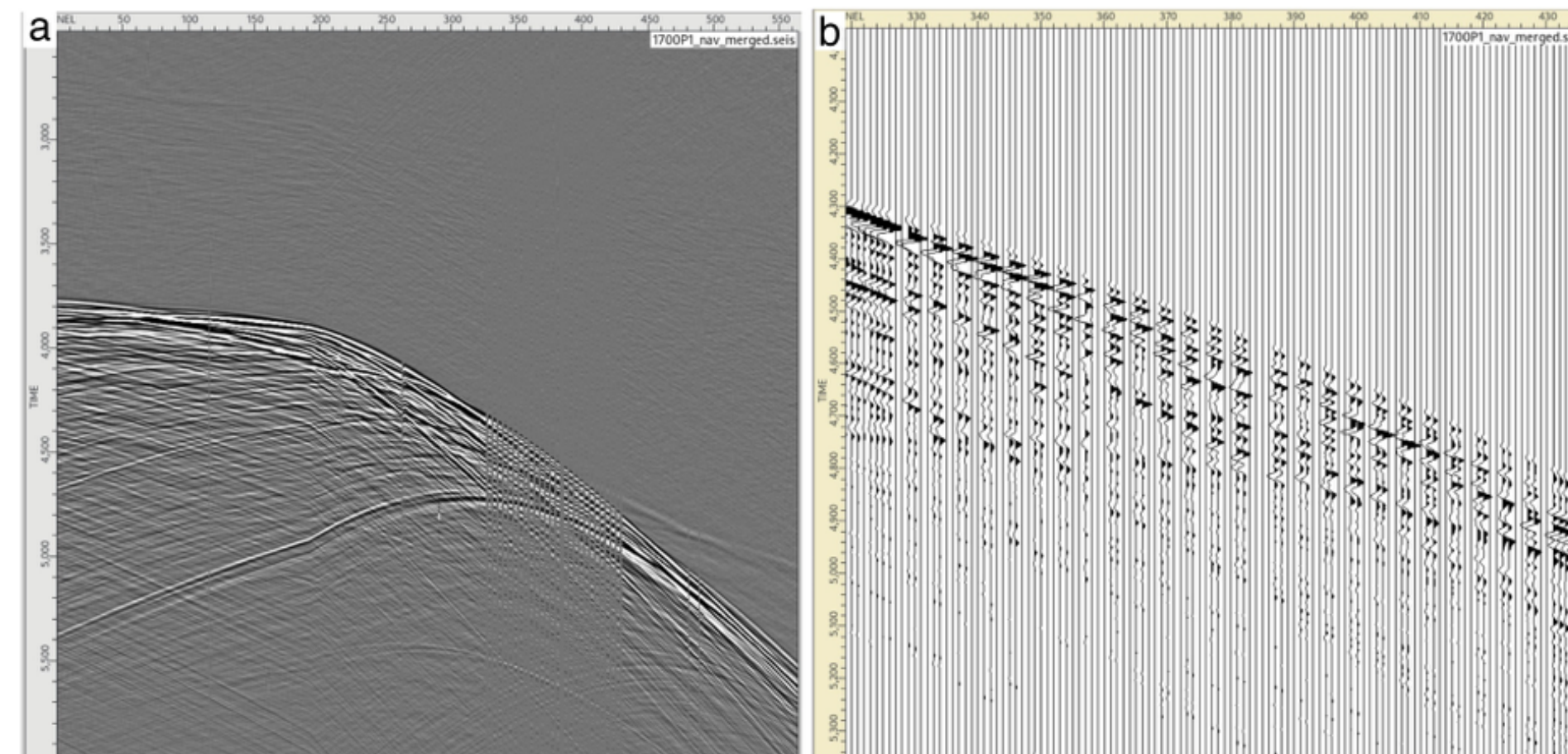
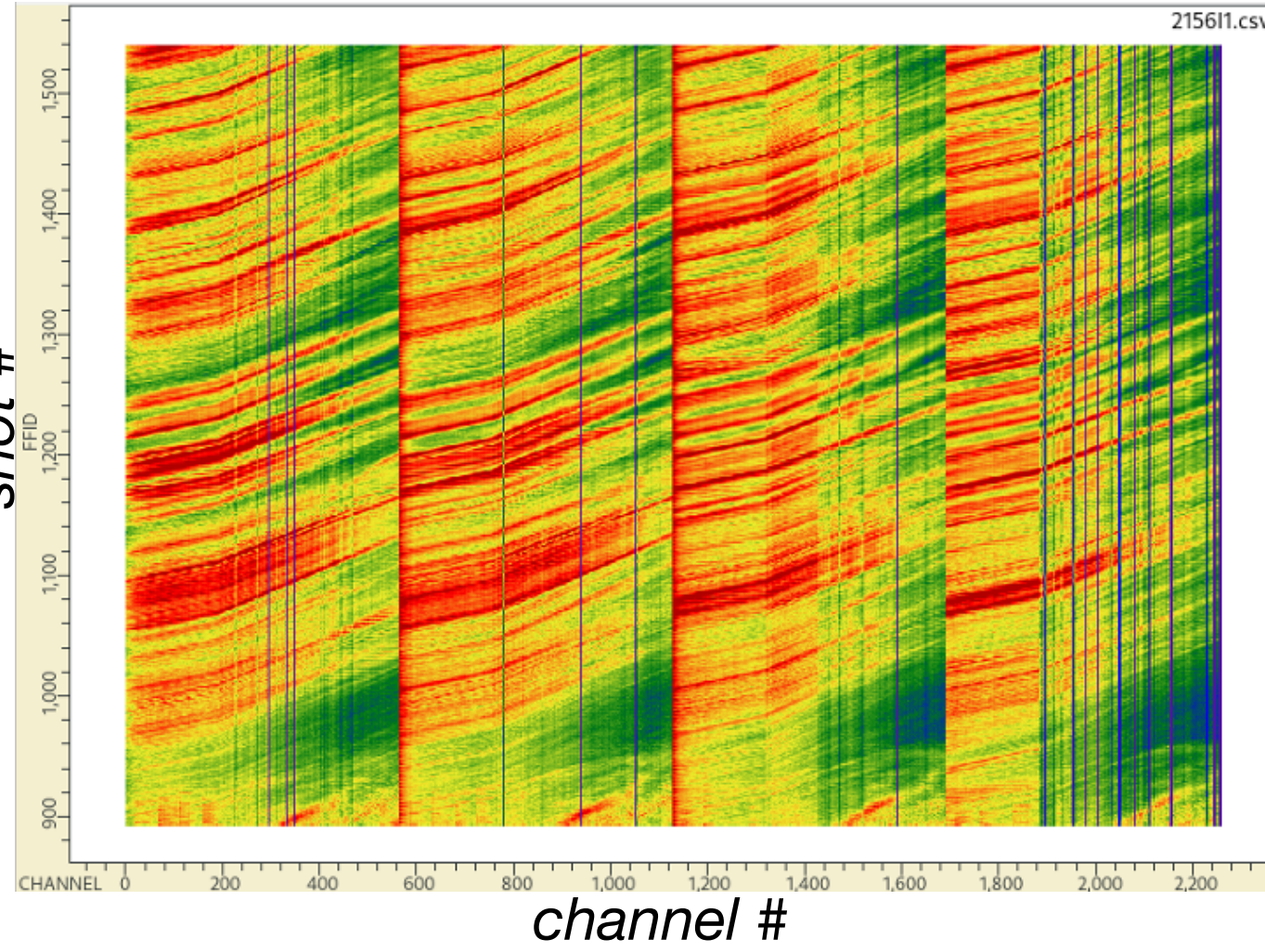


# MGL2602 Onboard QC

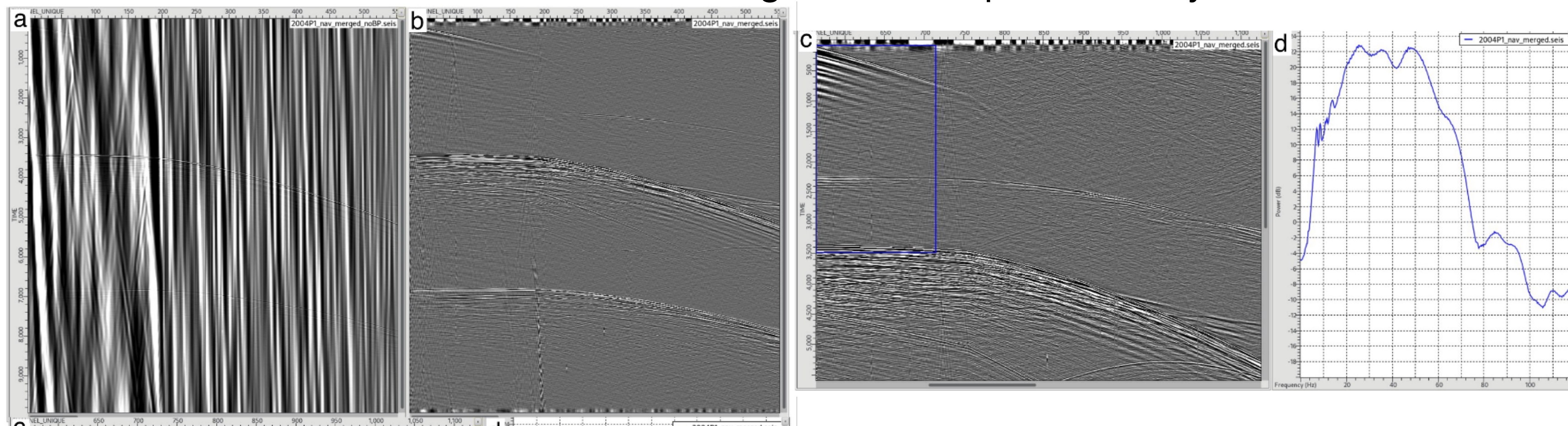
Low-amplitude / dead channels

Brute stacks

streamer 1    2    3    4



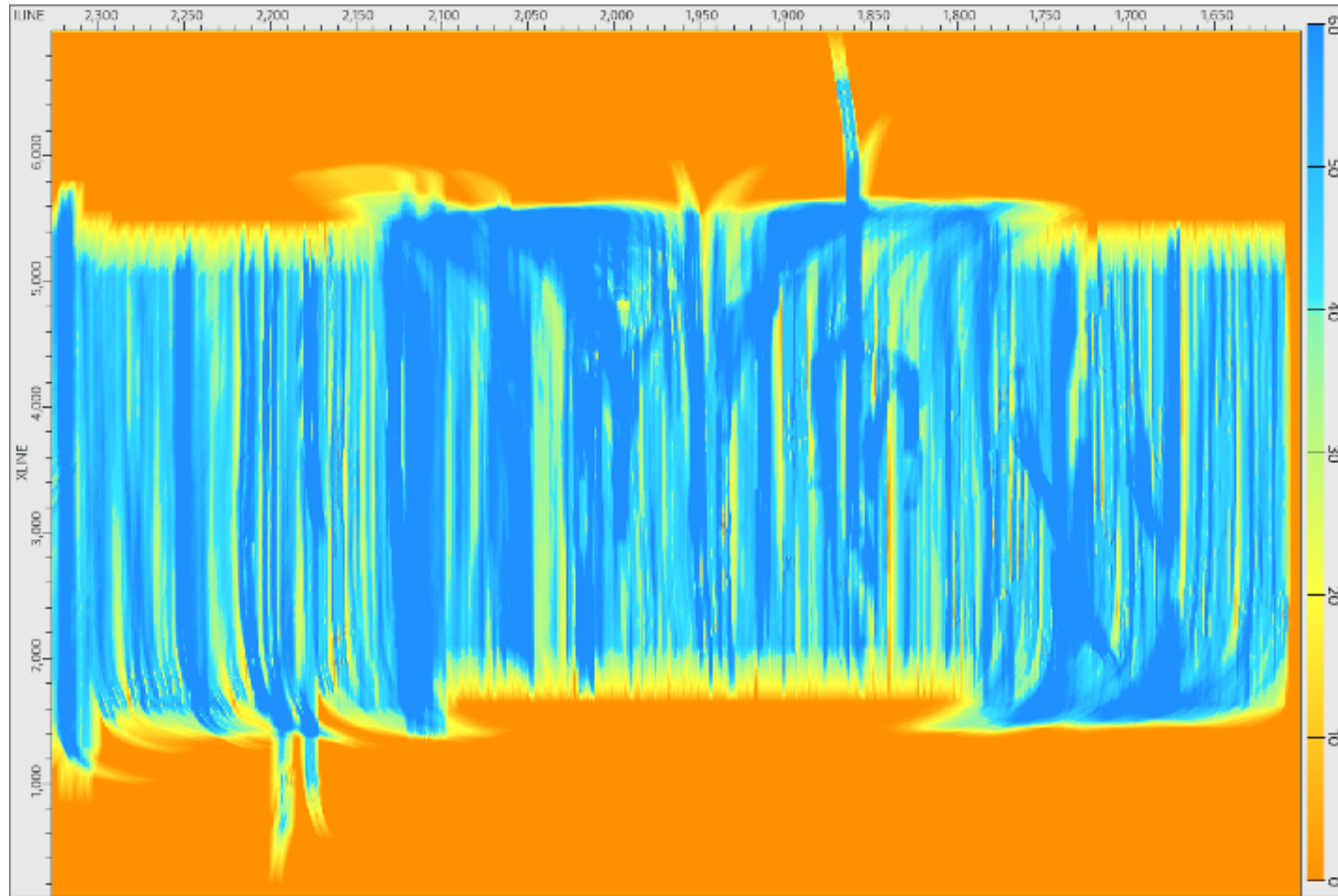
Data QC: filtering tests and spectral analyses



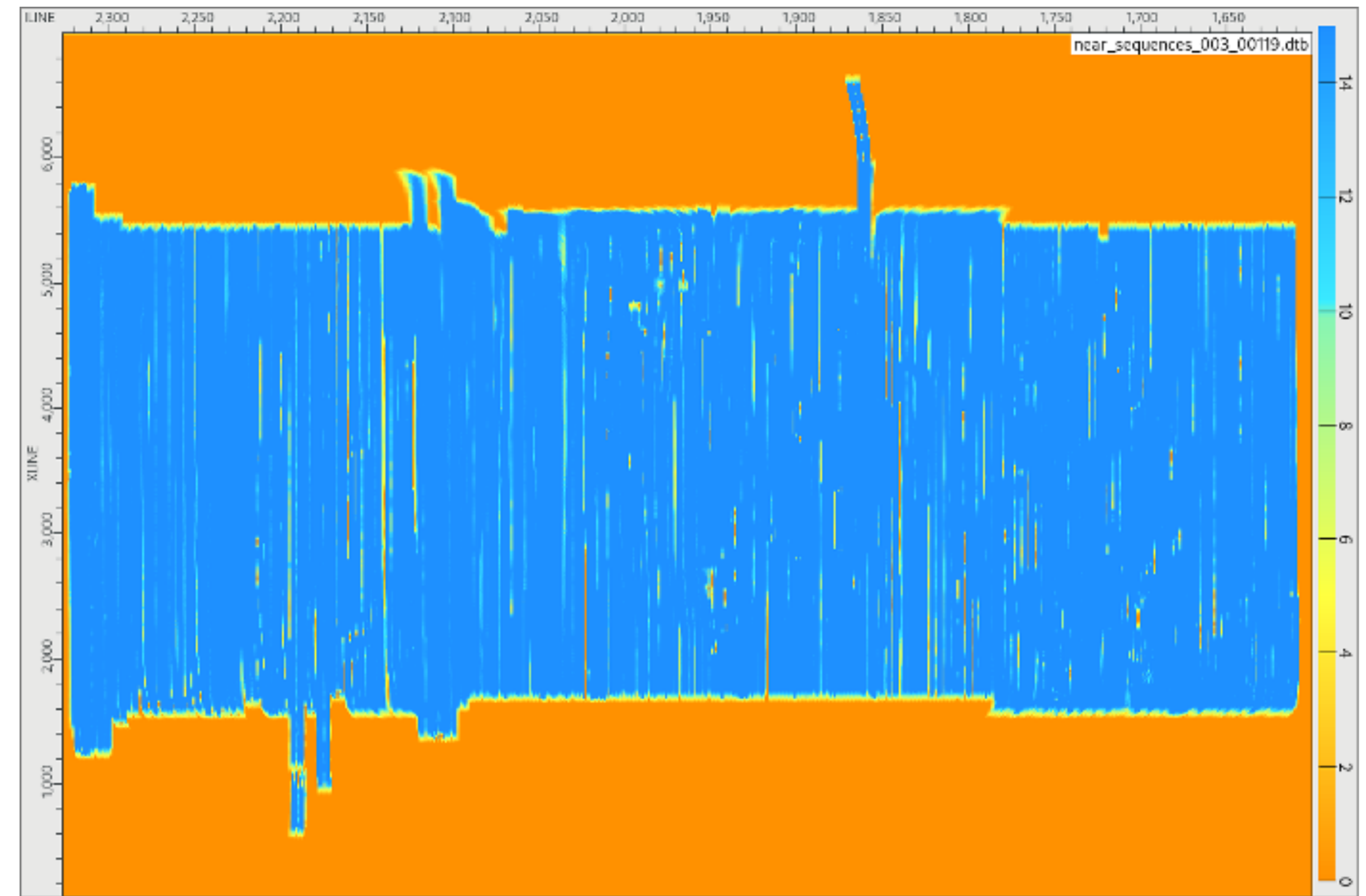
# MGL2602 Final Fold

*Great efforts by Langseth's crew, techs and contractors, OMO, and sci. party resulted in 100% of objectives achieved*

Full Offset Range (0-6005 m). Target fold: 40



Near Offset Range (0-1618 m). Target fold: 10



# MGL2602 Post-Cruise Recommendations

*Great efforts by Langseth's crew, techs and contractors, OMO, and sci. party resulted in 100% of objectives achieved*

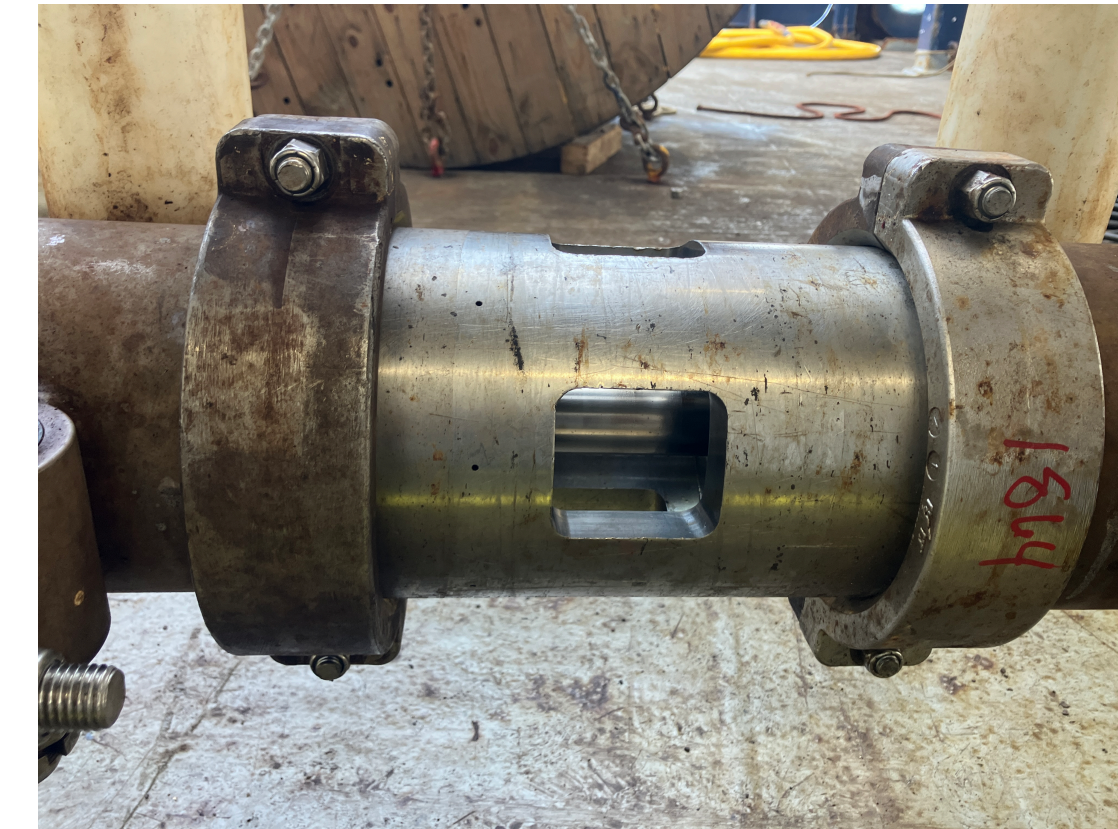
- **Digibird Reliability:**

- Replace older unreliable digibirds with new units.



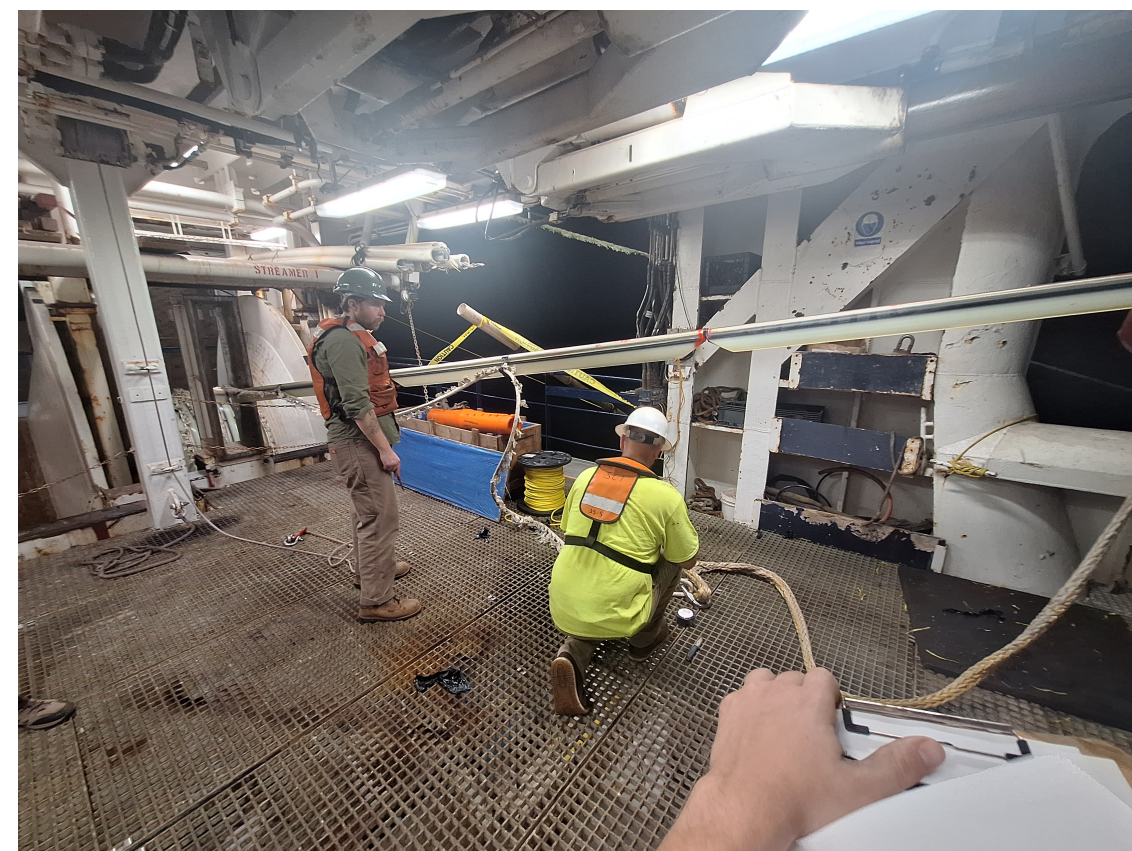
- **Source Array Operational Readiness:**

- After prolonged periods of non-use, airgun sources should undergo full testing at full pressure at sea. Floatation units require further inspection and maintenance prior to use, or re-design.



- **Non-standardized Fairing Designs:**

- Use the same fairing on all streamer lead-in cables.



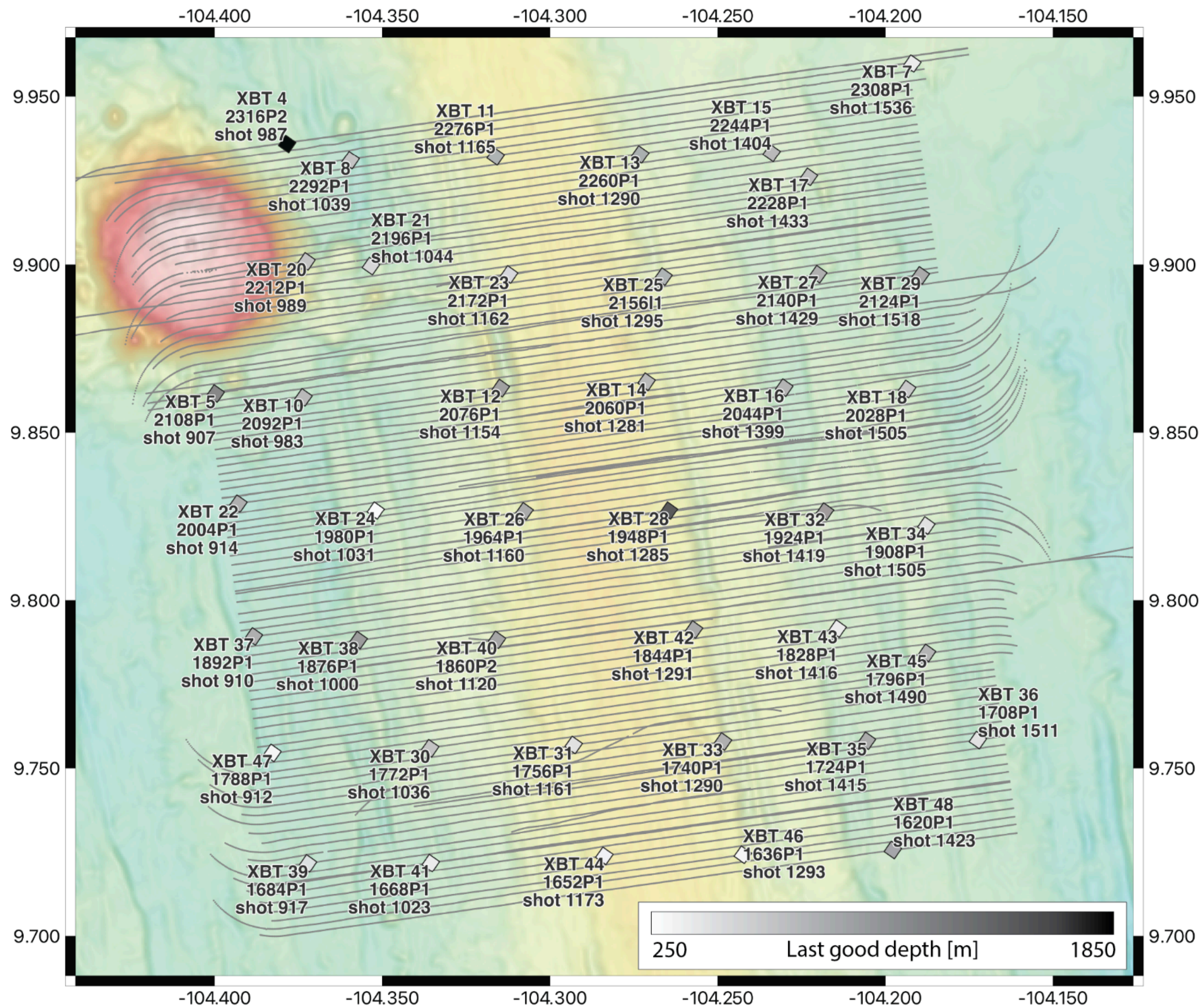
- **Source Array Handling:**

- Consider adding slip rings to source umbilicals, revisit procedures for recovery and deployment to allow handling of individual sub-arrays.

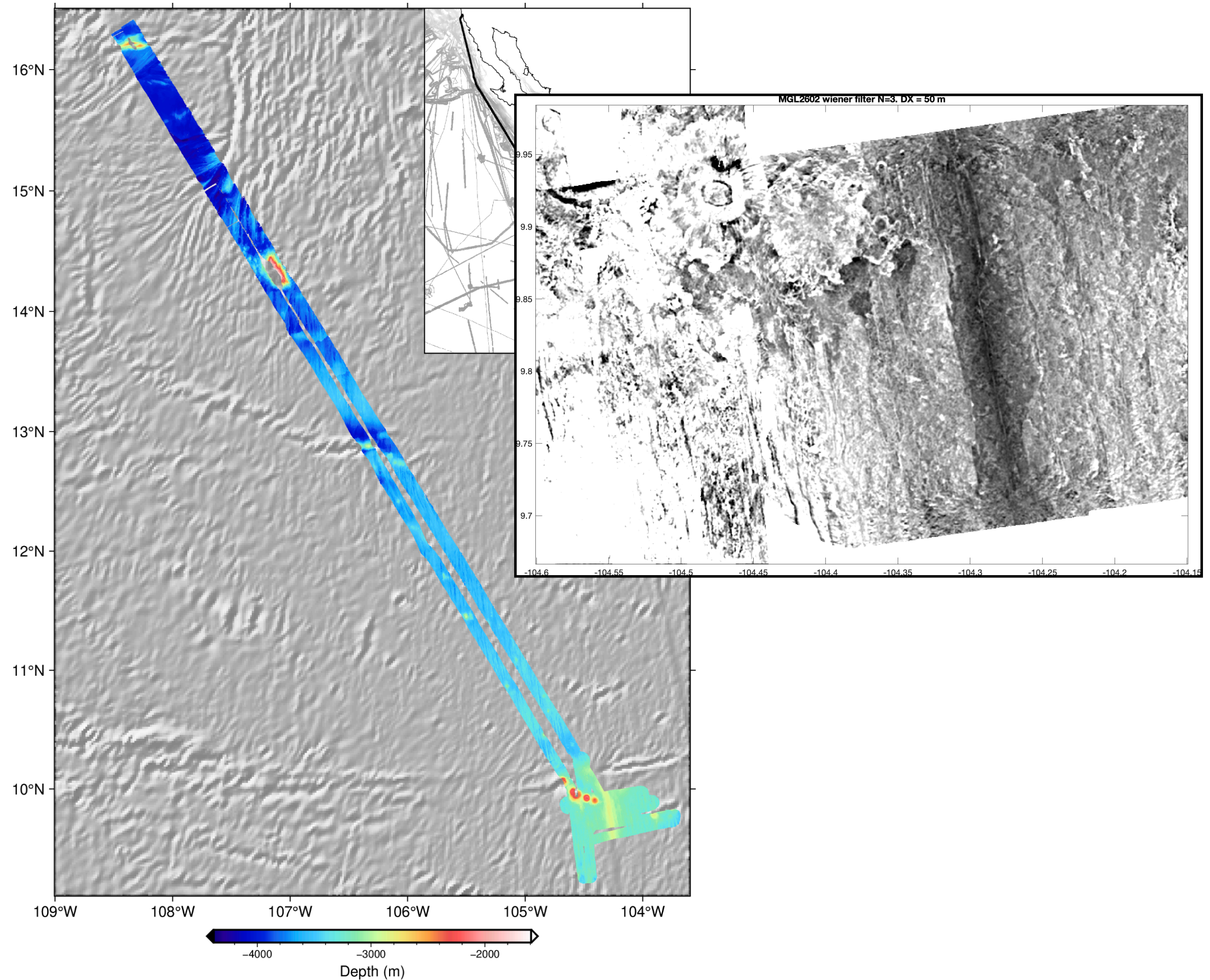


# MGL2602 Other Operations

46 **XBTs**: 4 failed, 42 successful

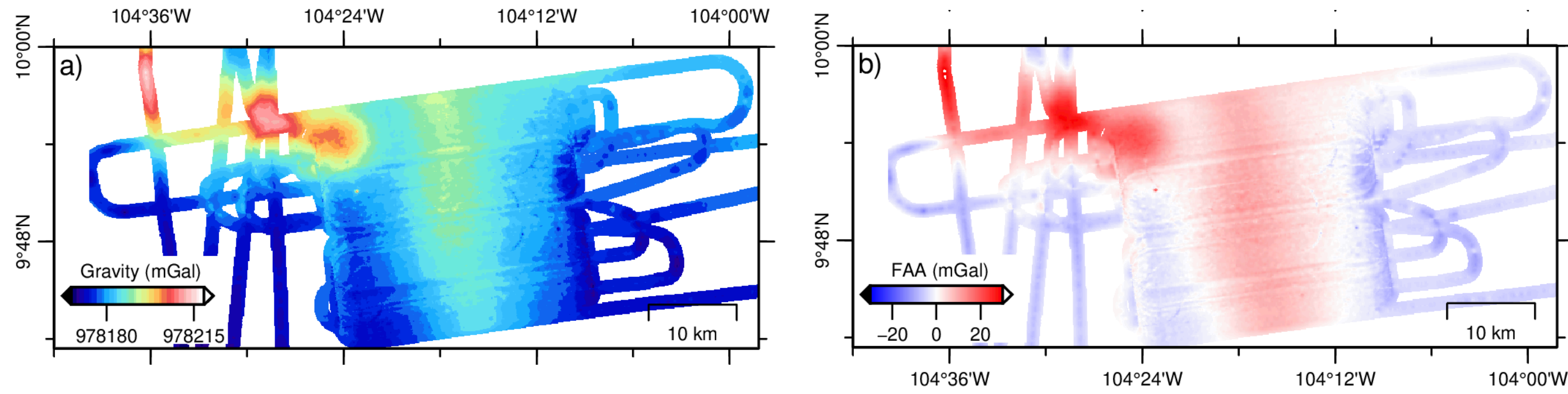


## Multibeam Sonar: Bathymetry, Backscatter & Water Column Mapping



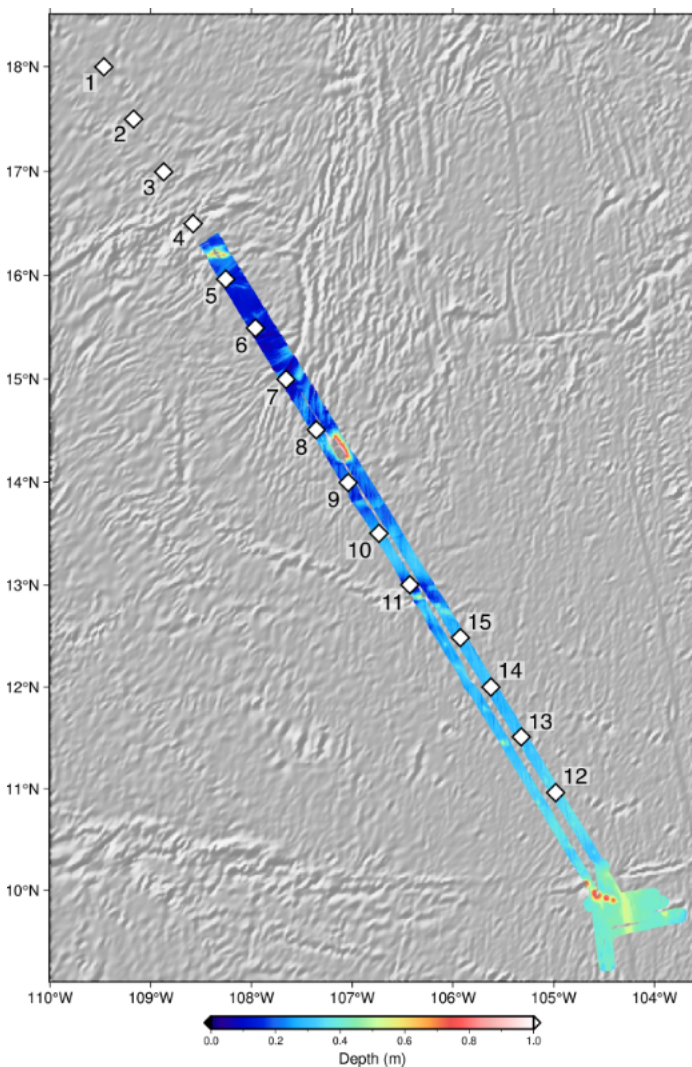
# MGL2602 Other Operations

## Gravity

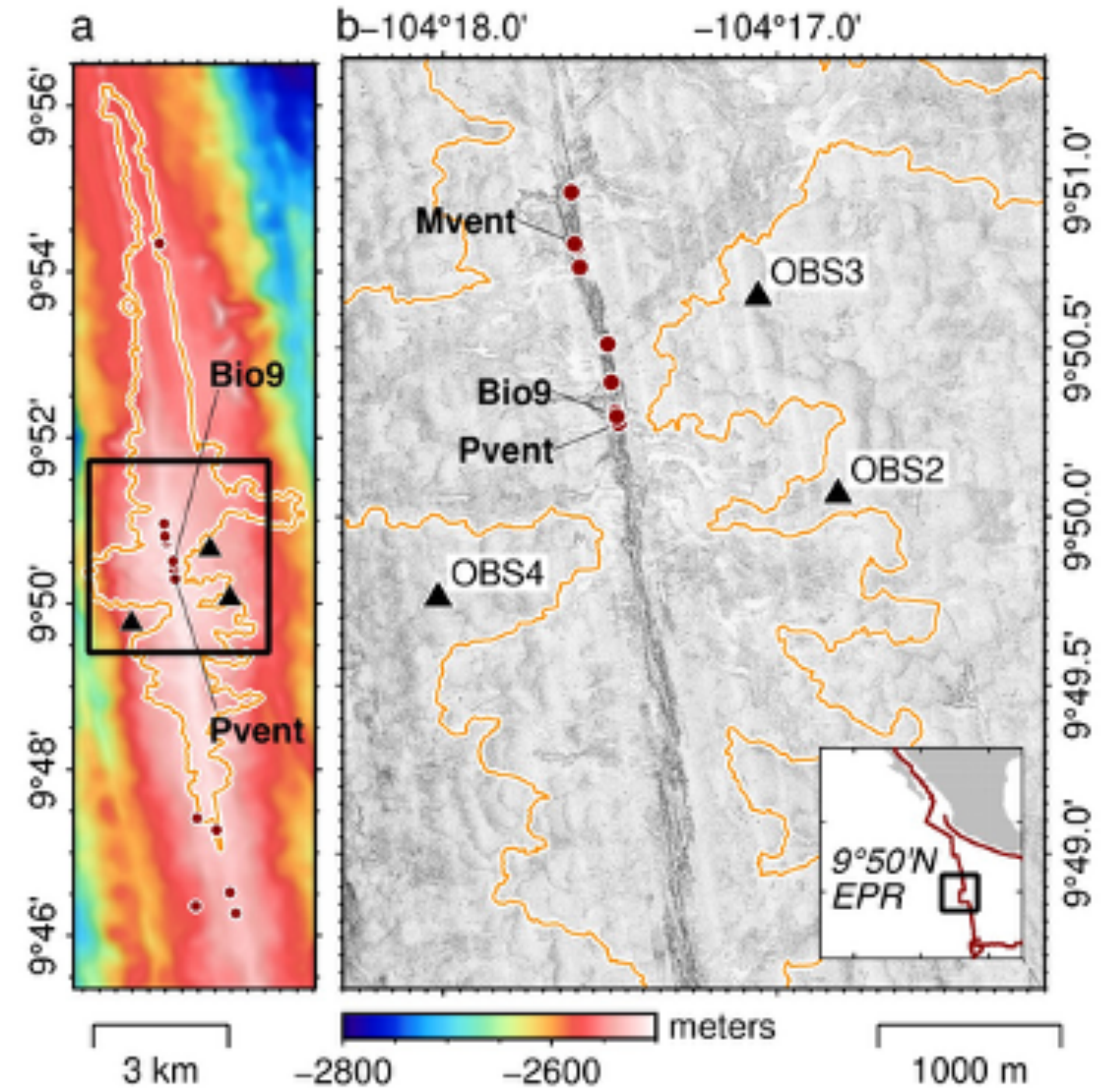


## Drifter deployments

(15, on behalf of SIO Lagrangian Drifter Laboratory)



## OBS Recoveries



# MGL2602 Post-Cruise Data 4-D Processing

Industry (Viridien) & Academic (IPGP, M. Marjanovic) Partnership

## **General Processing Workflow for 2008 & 2026 datasets:**

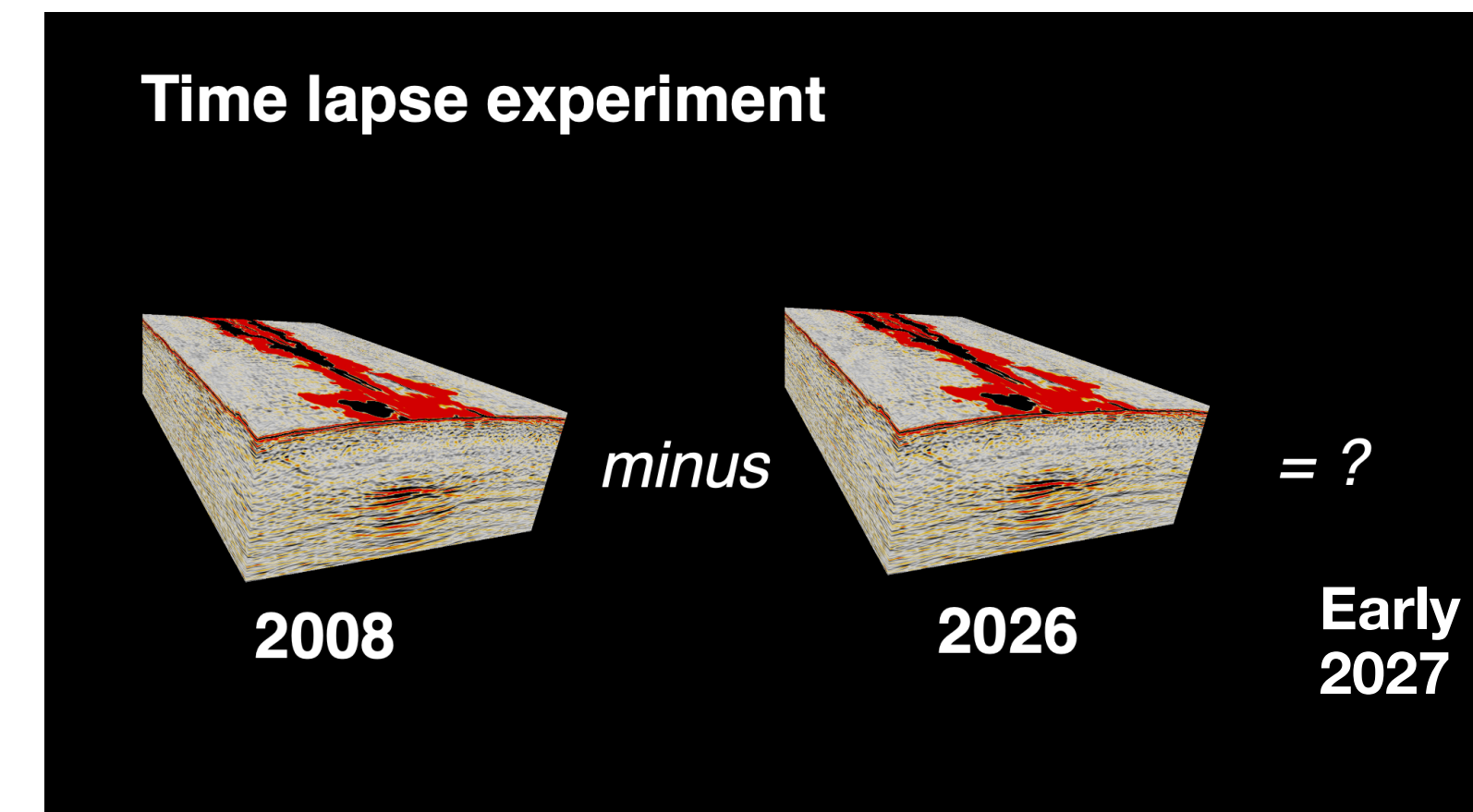
- *Reformatting*
- *Noise attenuation (swell, linear, spikes)*
- *Dynamic corrections*
- *Bubble and ghost removal*
- *Zero-phase filtering*
- *Tidal corrections*
- *Water layer inversion*
- *Amplitude balancing*
- *Multiple removal*
- *3D sailing time de-stripping*
- *Q compensation*
- *3D PSDM*

## **2008 dataset: 3-D Velocity Model Building**

- *CIG preconditioning*
- *Tomography*
- *Shot preconditioning for FWI*
- *3D Acoustic FWI*
- *3D Elastic FWI*
- *Reverse time migration*

## **2006 dataset: 4-D Velocity Model Building**

- *4D Tomography*
- *4D Elastic FWI*
- *Reverse time migration*



# Cruise MGL2602 Participants

## Thank you!



**Acknowledgements: NSF, LDEO OMO, Dr. S. Carbotte (MGL0812)**