MGL1004 & MGL1206
Shatsky Rise
Shooting the World's Largest Volcano

William Sager
Department of Earth & Atmospheric Sciences
University of Houston

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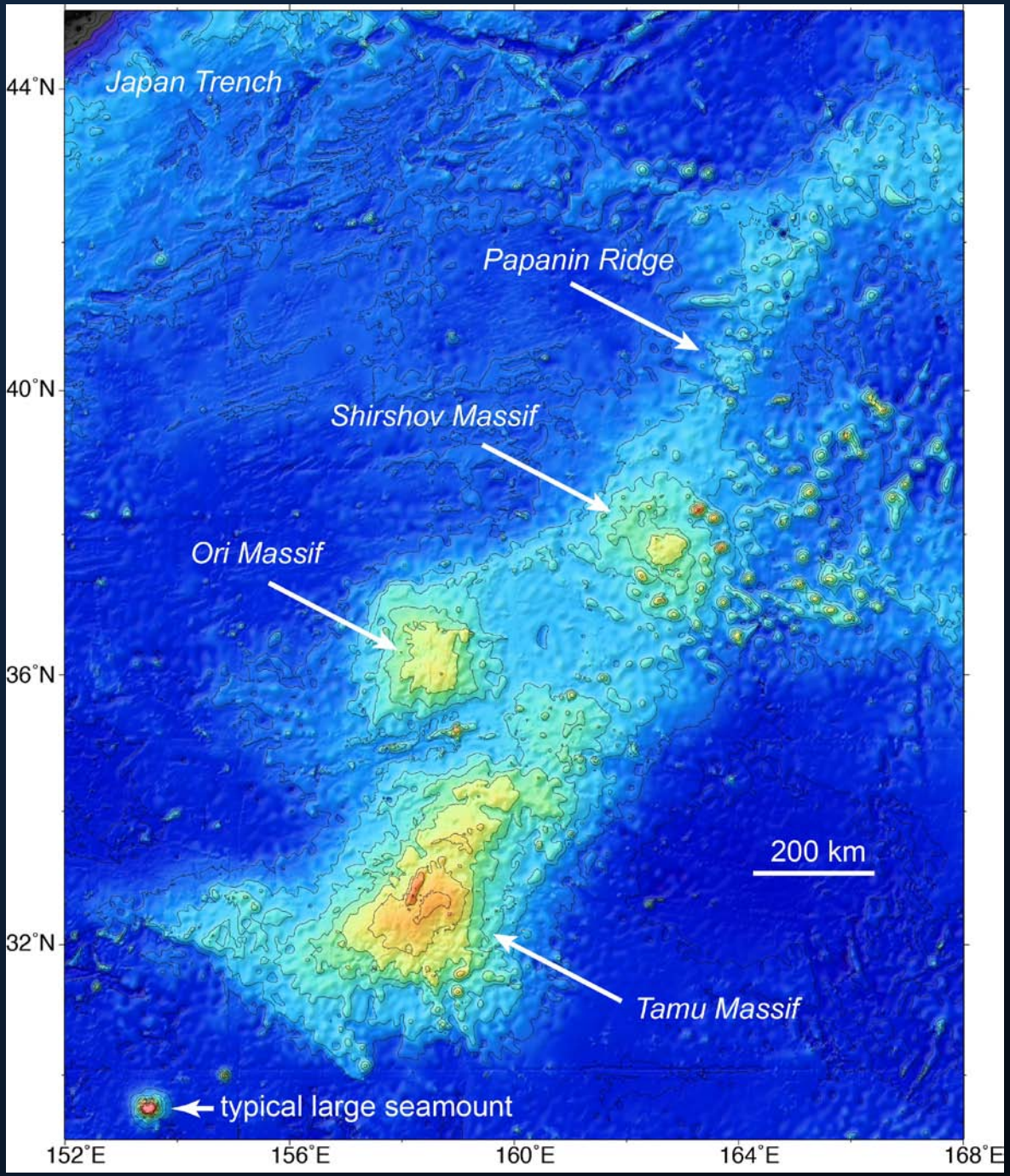
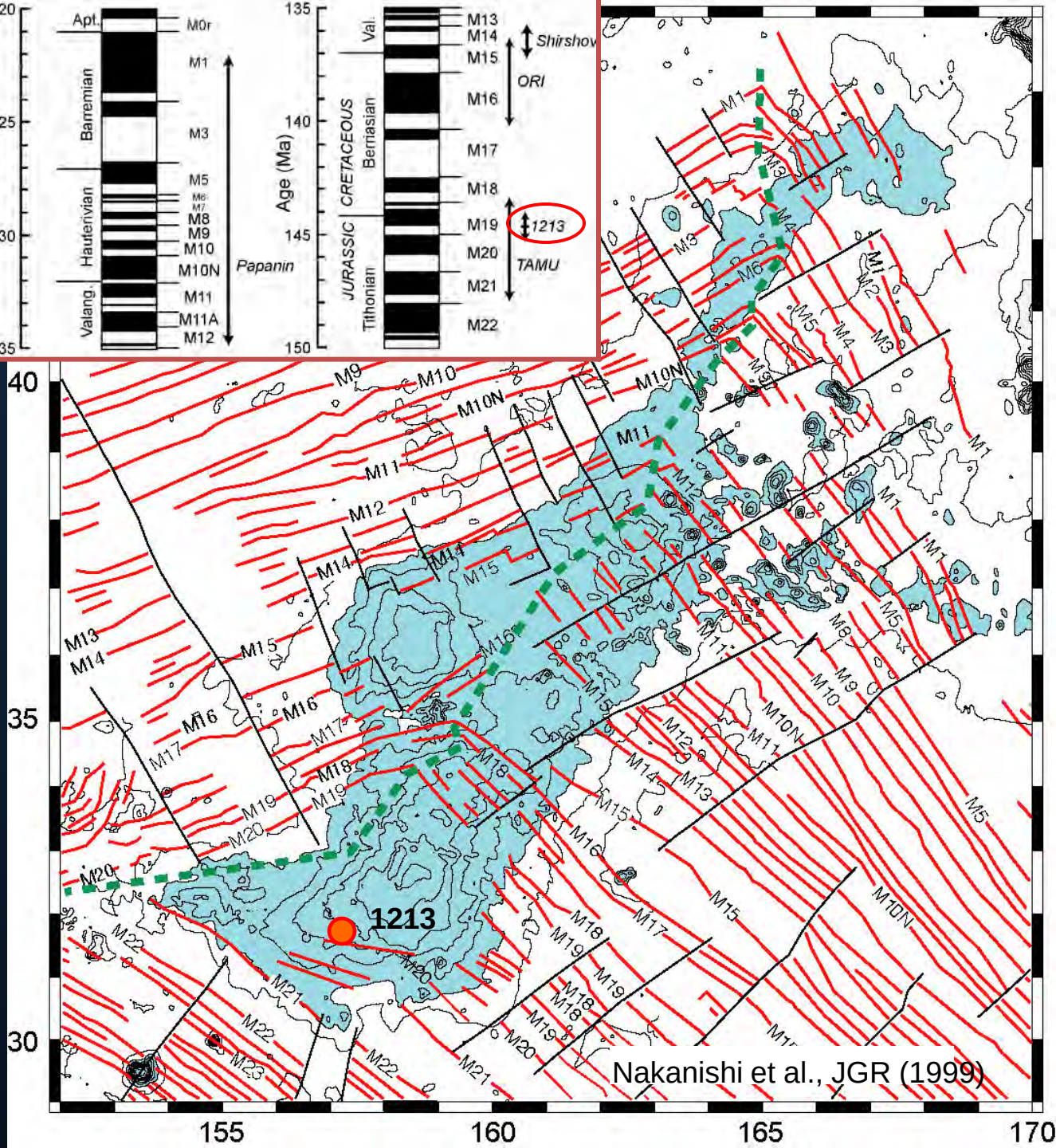


Shatsky Rise Bathymetry

- Three large volcanic mountains (massifs)
- Tamu largest and oldest (first to form)
- Low ridge
- Two basins
- Mysterious seamounts
- In total - similar area to California

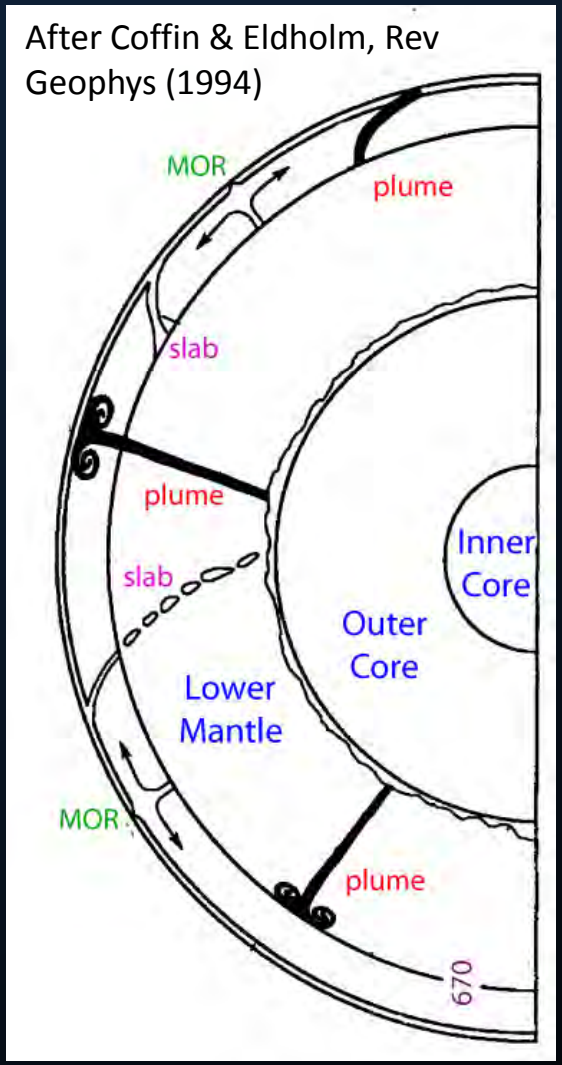
Magnetic Lineations

- Magnetic bights show SR formed at Pacific-Farallon-Izanagi triple junction (dashed)
- SR seems to be same age as lithosphere
- Date from ODP 1213 basalts is 144.6 ±0.8 Ma
- Age progression from SW to NE



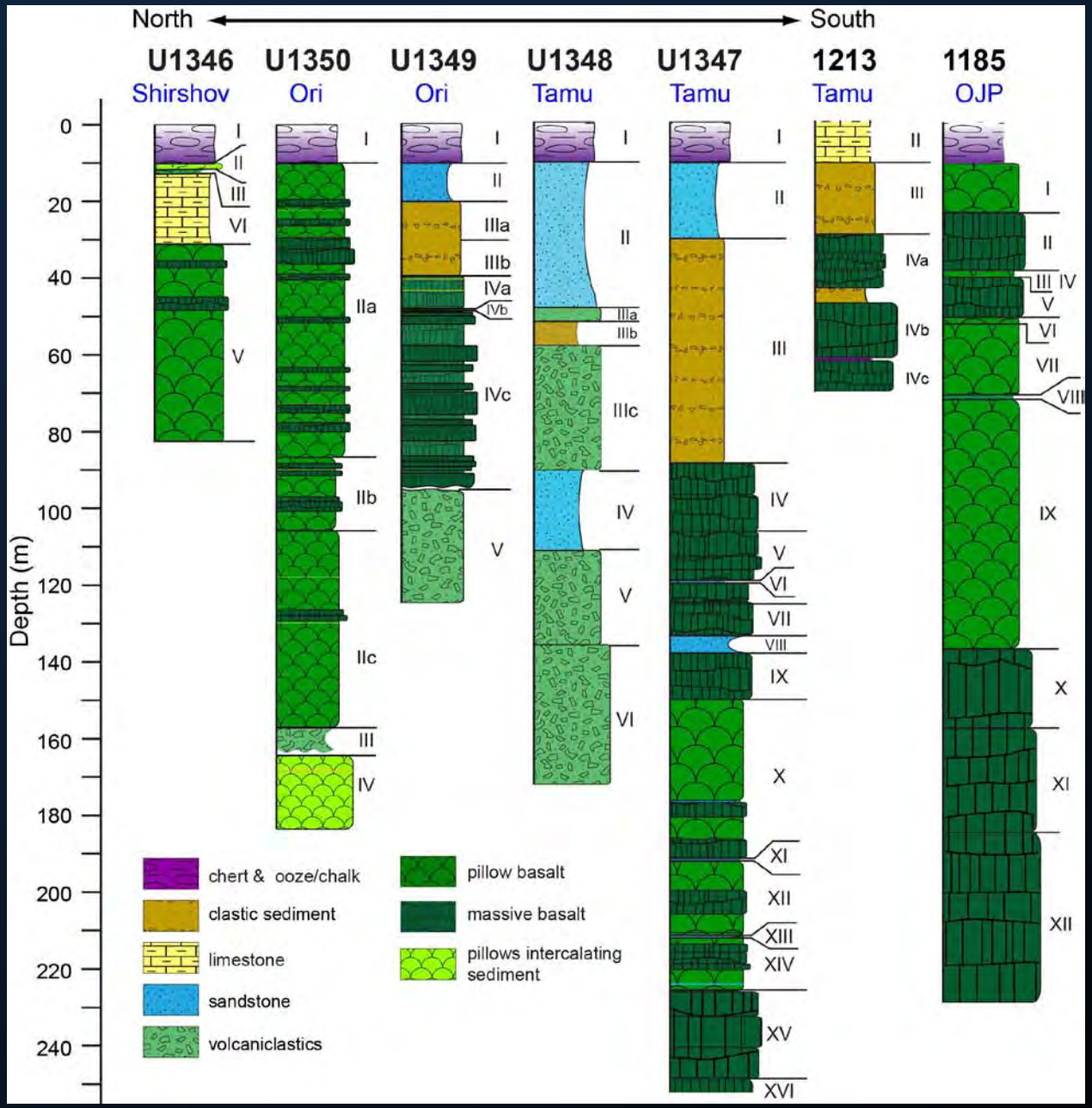
Why Are There Oceanic Plateaus?

- Oceanic Plateau formation does not fit well with plate tectonics – separate mantle convection
- Plume head hypothesis is widely accepted
  - Giant blob of hot matter from deep mantle
  - Predicts massive volcanic eruption
- Trouble is - there is as yet no incontrovertible evidence for a plume head eruption
- Some scientists question the number or existence of mantle plumes
- Other research suggests that plumes may be more complex - perhaps thermo-chemical



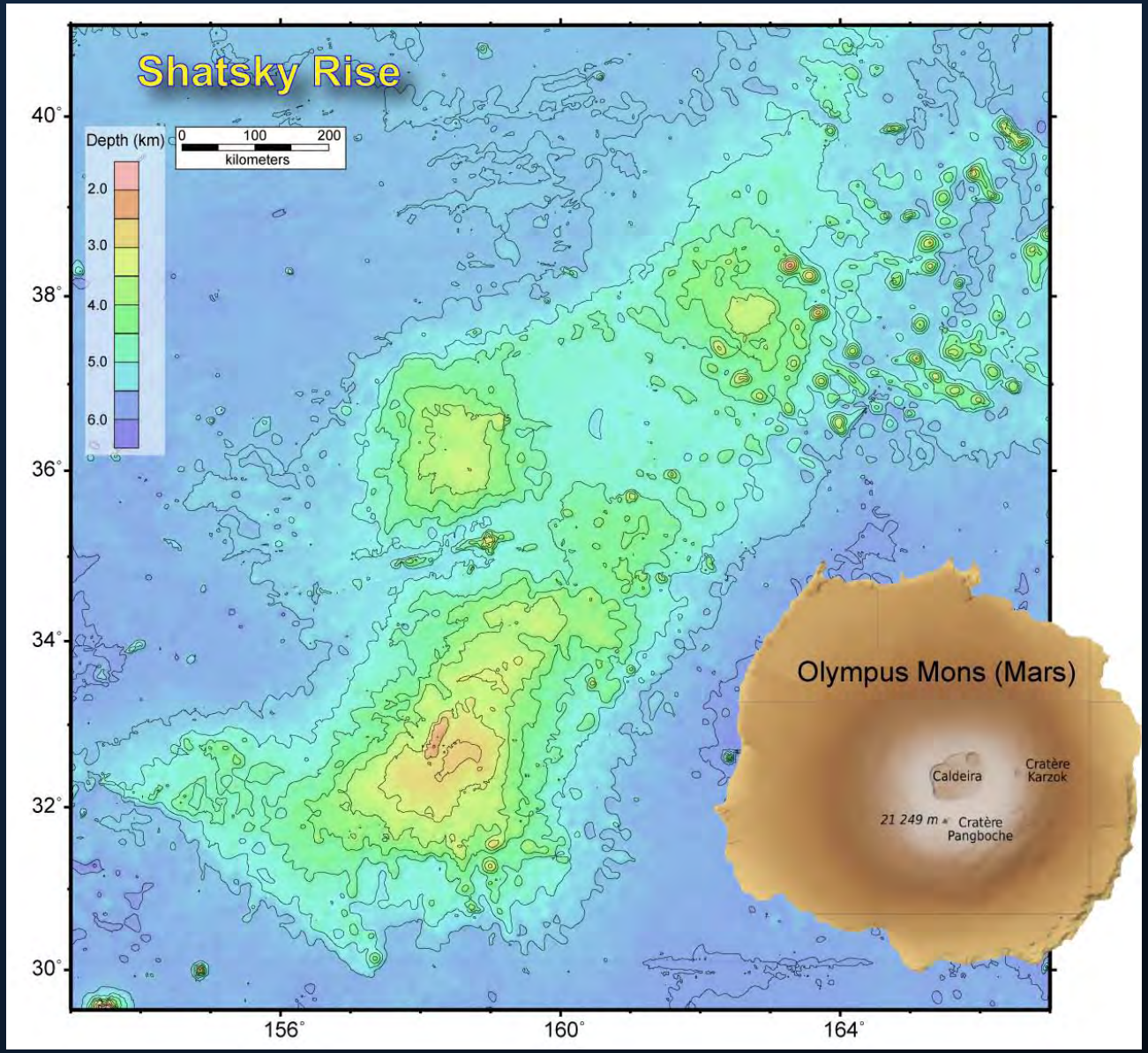
Shatsky Rise lava flows

- Massive flows indicate massive eruptions – high effusion rate
- Tamu has most massive flows
- Pillow lavas show “normal” low effusion rate eruptions
- Progression to lesser effusion with time



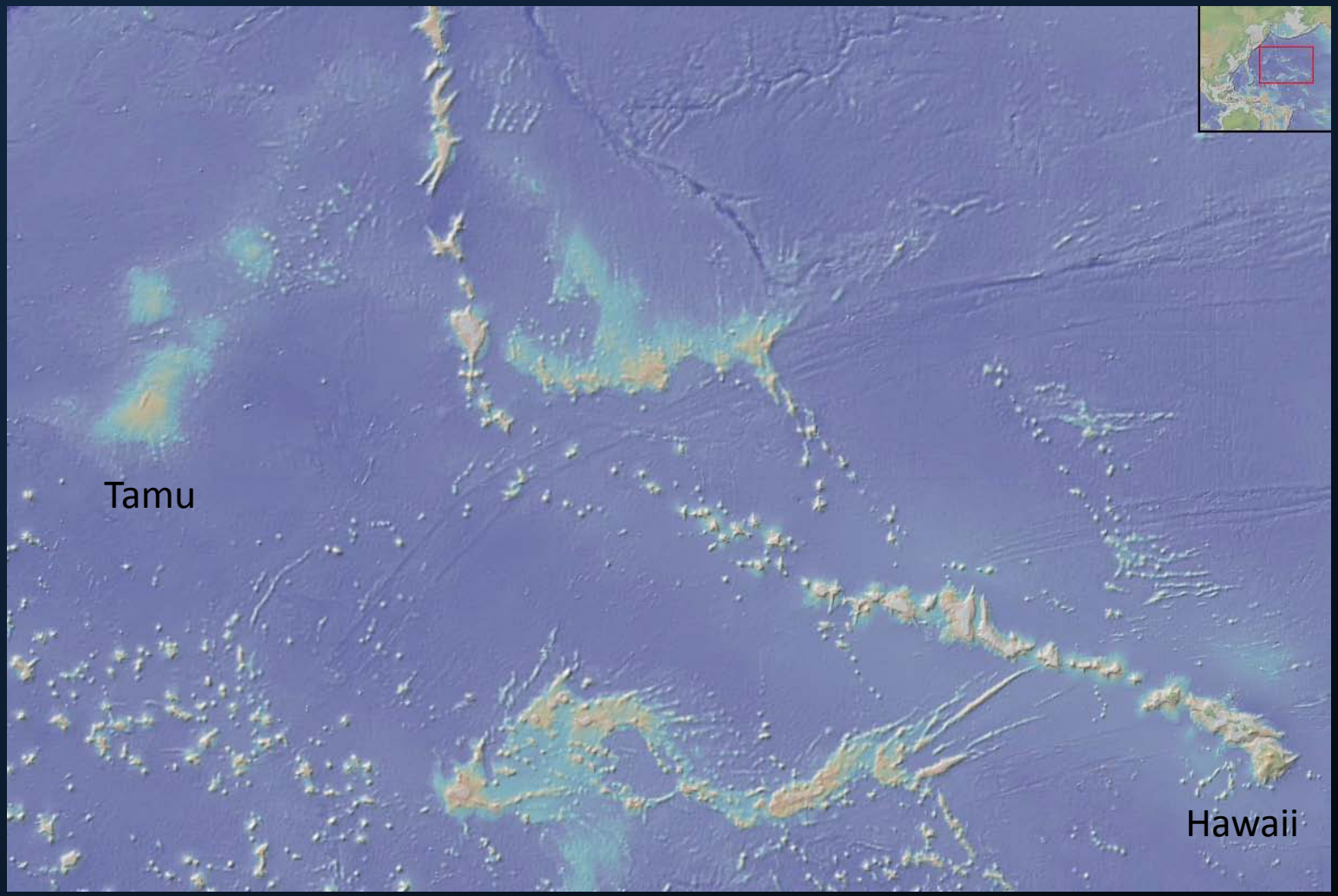
(Sager et al., 2010)

Tamu Massif is Really Big



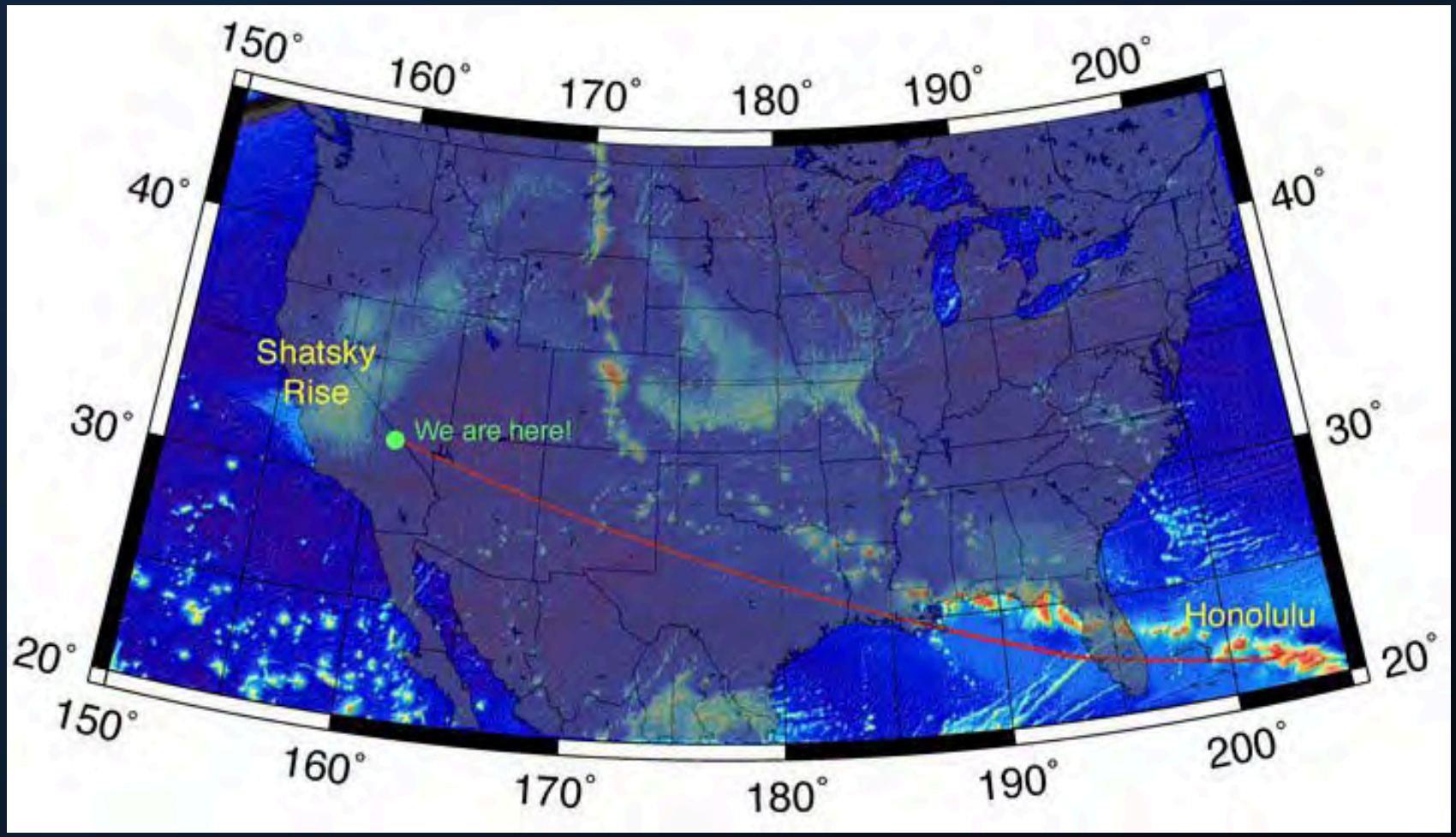
- Same area as New Mexico
- Nearly same area as Olympus Mons (Mars) – the largest volcano in the solar system
- Tamu looks like one big volcano, but without interior structure we can't be sure
- Maybe it is like Hawaii – consists of 5 coalesced volcanoes – including Mauna Loa, largest active – 2% area of TM

Tamu vs. Mauna Loa



- Mauna Loa is the biggest active volcano
- It is one of 5 volcanoes that make up the Big Island

It's a Long Long Way



The transit from Honolulu to Shatsky Rise took 9.5 days – and the same all the way back

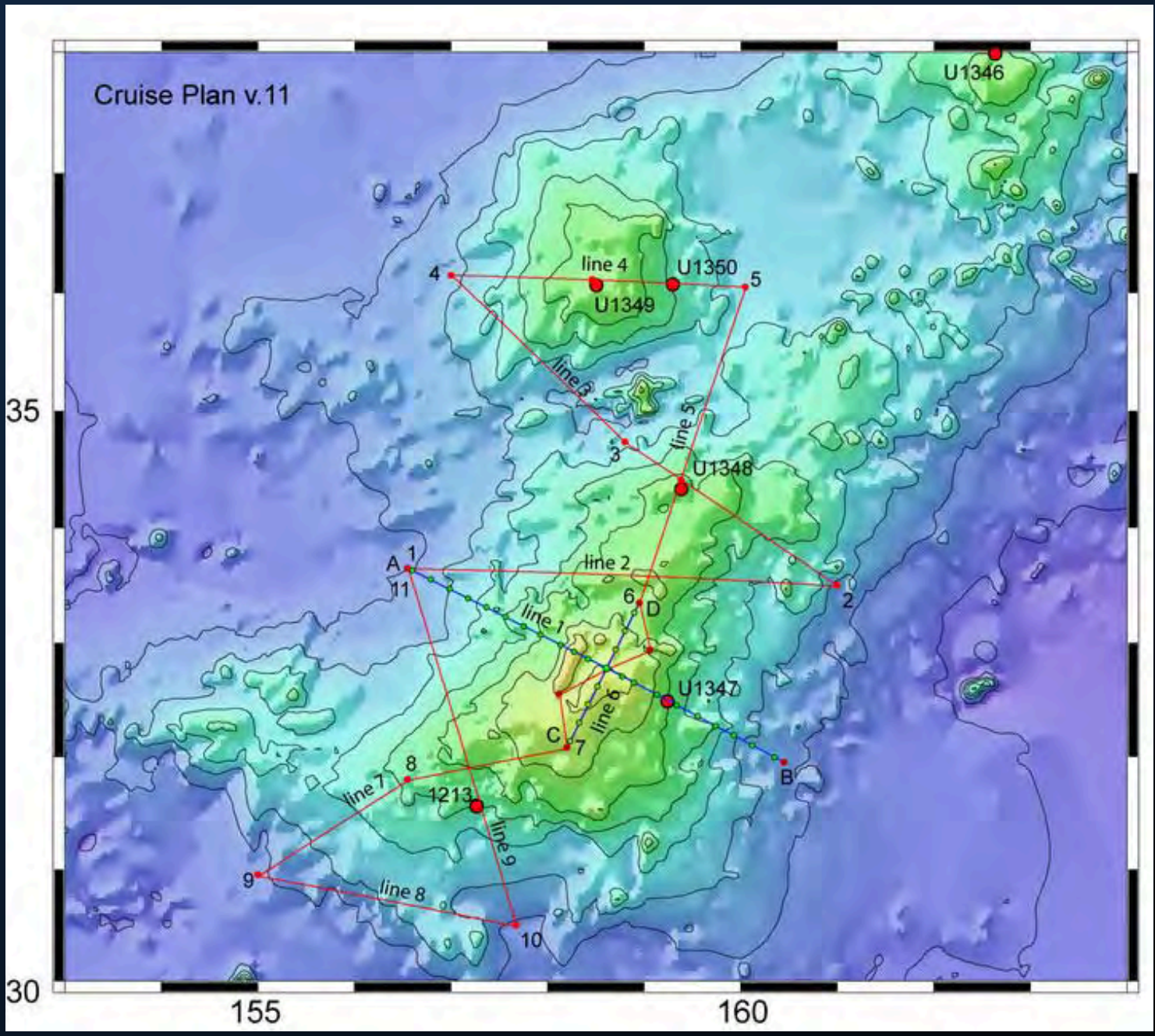
Original cruise design called for 8 days transit - new plan called for 20 days of transit

MGL1004 - The Unluckiest Cruise Ever?

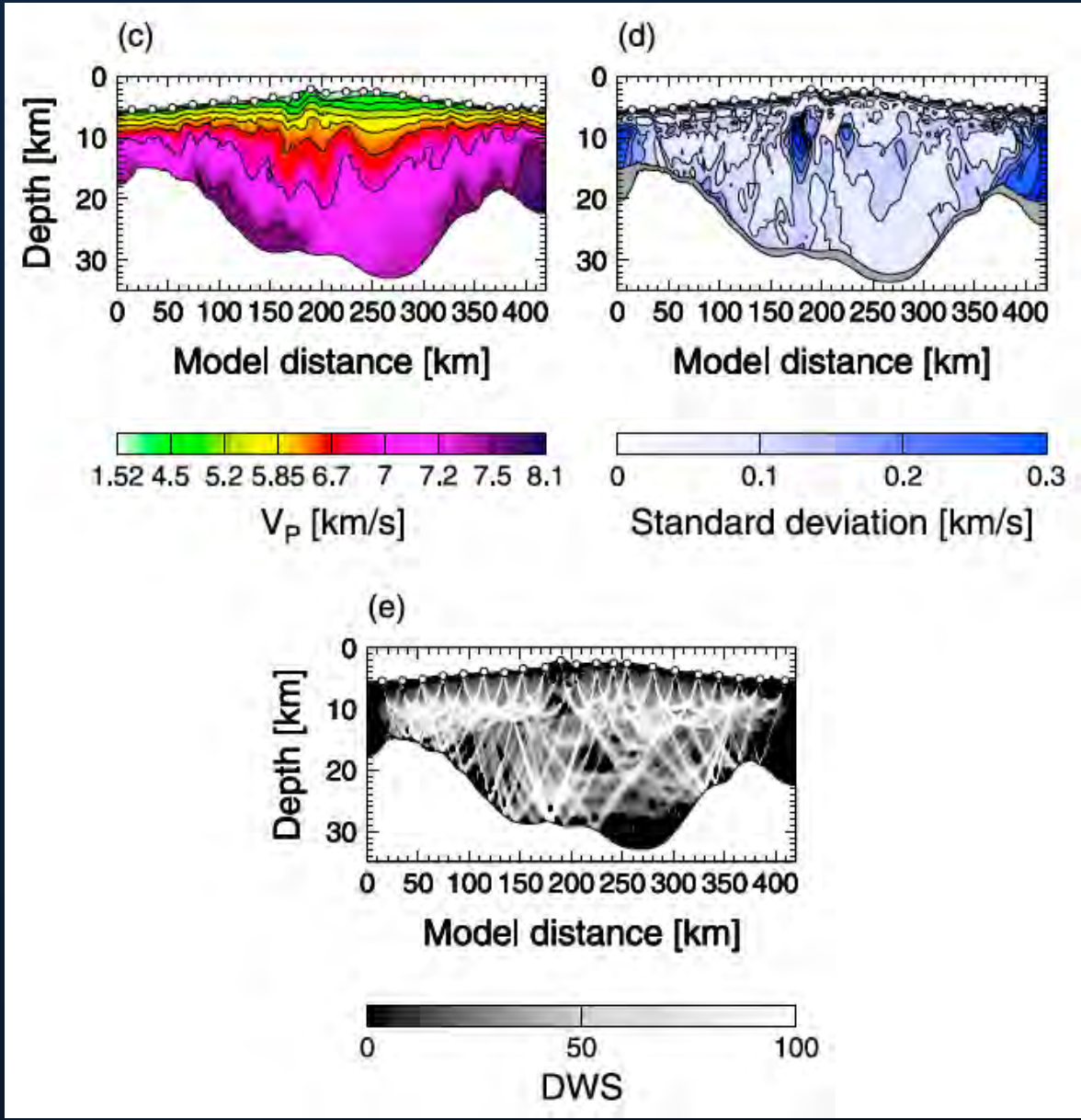
- Cruise delayed 6 weeks in shipyard
- Cruise delayed 2 weeks owing to engine control problems
- Cruise assigned 20 days transit because other cruises postponed
- P.I. John Diebold passes away, July 1, 2010
- Cruise delayed 2 days waiting for IHA
- Cruise delayed 10 hours because of late technician
- MMO John Nicolas passes away, July 30, 2010; triggers 8.5 day medical evacuation
- Second medical evacuation declared August 16, 2010; triggers 7.5 day trip to Japan
- September 20, 2010 Hawaiian kahuna blesses ship to banish evil spirits

Survey Plan

- Two refraction lines
- 3 MCS lines across axis
- 1 MCS line along axis

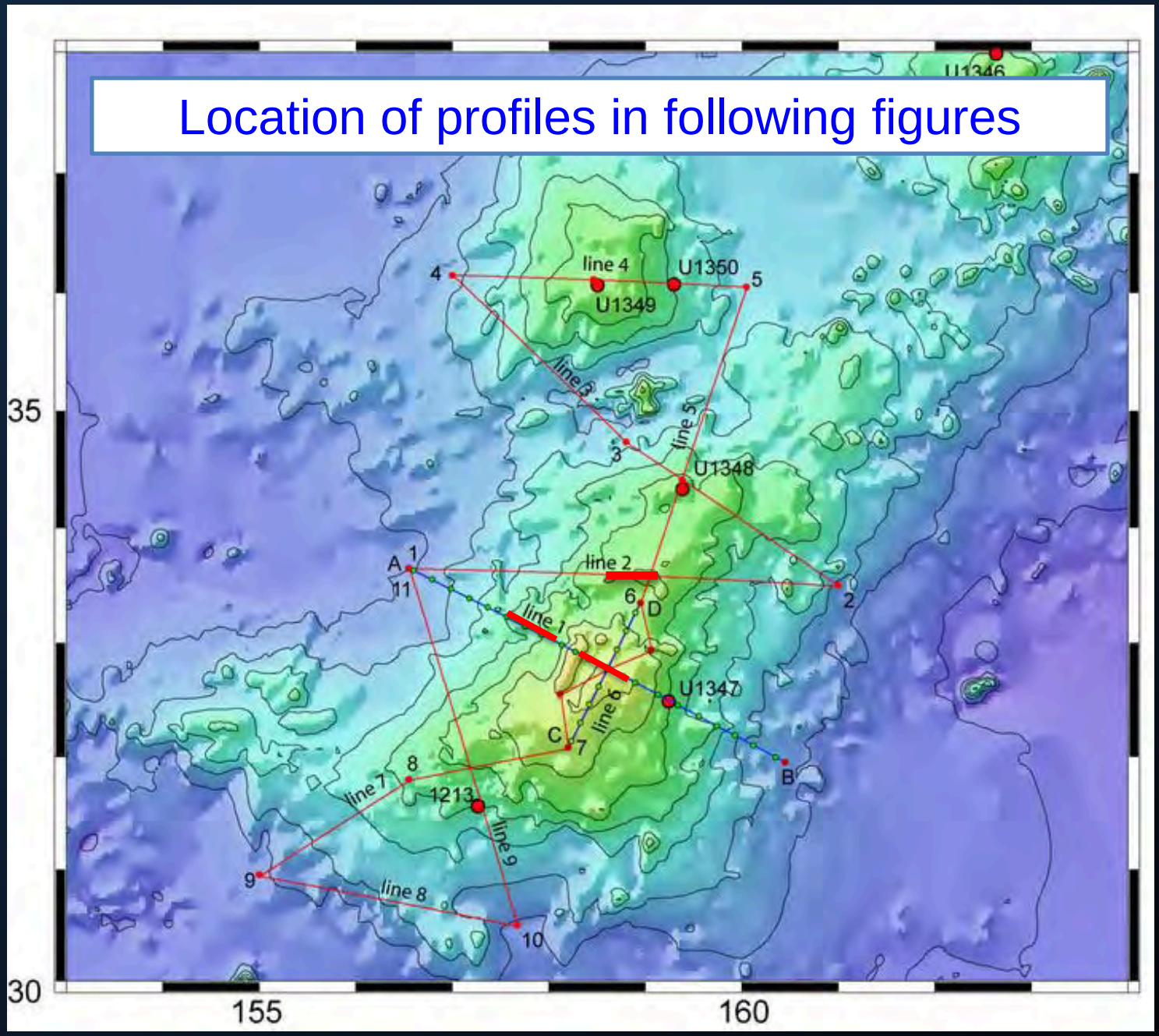


OBS Data Show Tamu Massif ~30 km Thick

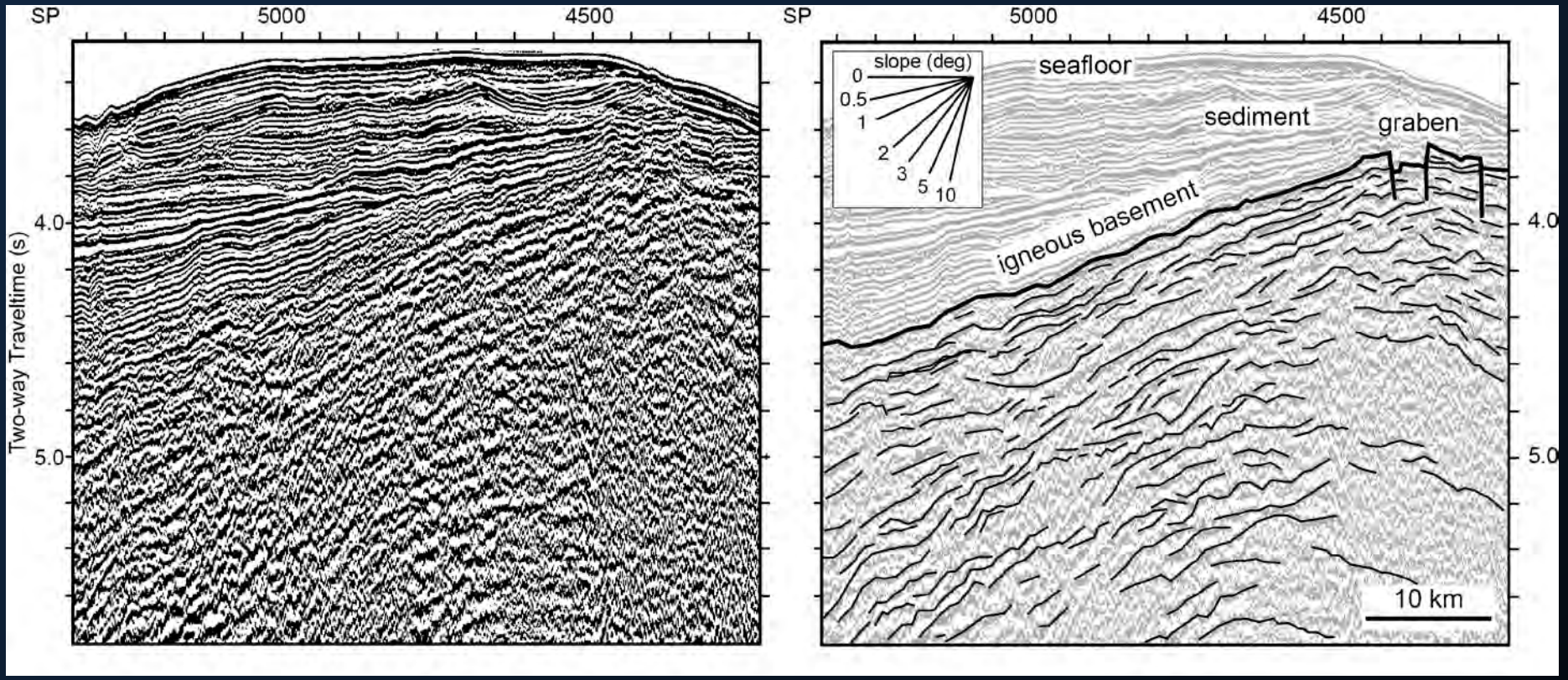


- Thickest crust under center of plateau
- Consistent with Airy compensation
- Shows that Tamu Massif is like an iceberg – most of bulk is mantle root
- Published in 2012 (Korenaga & Sager, JGR)

Location of profiles in following figures



Intra-basement Reflectors



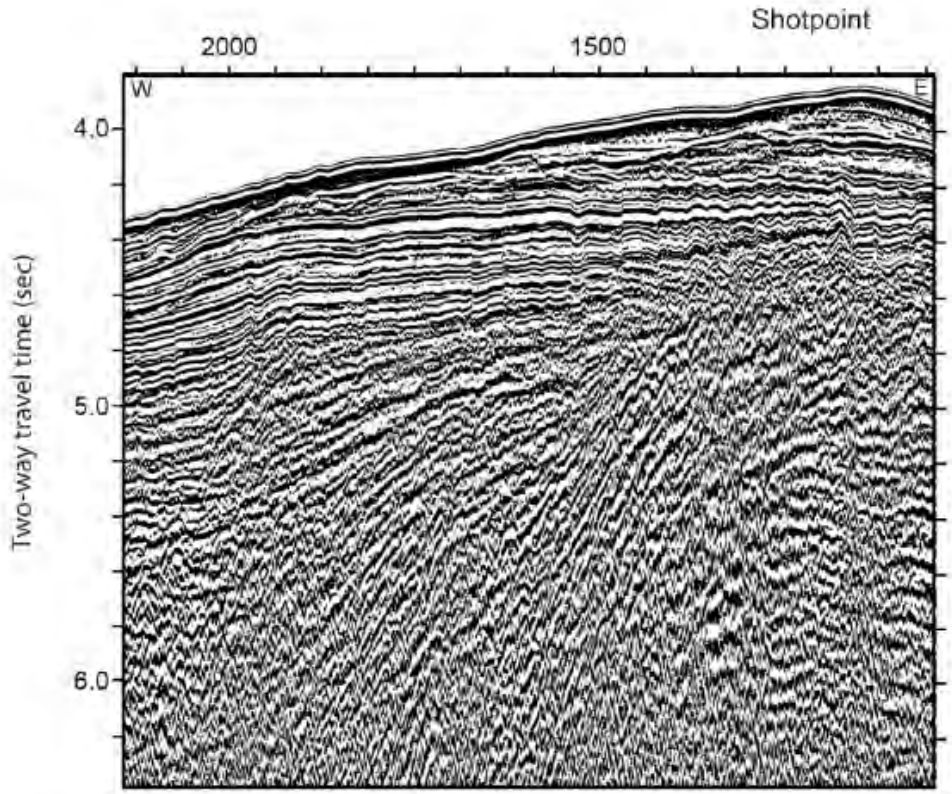
Reflectors are seen within basement

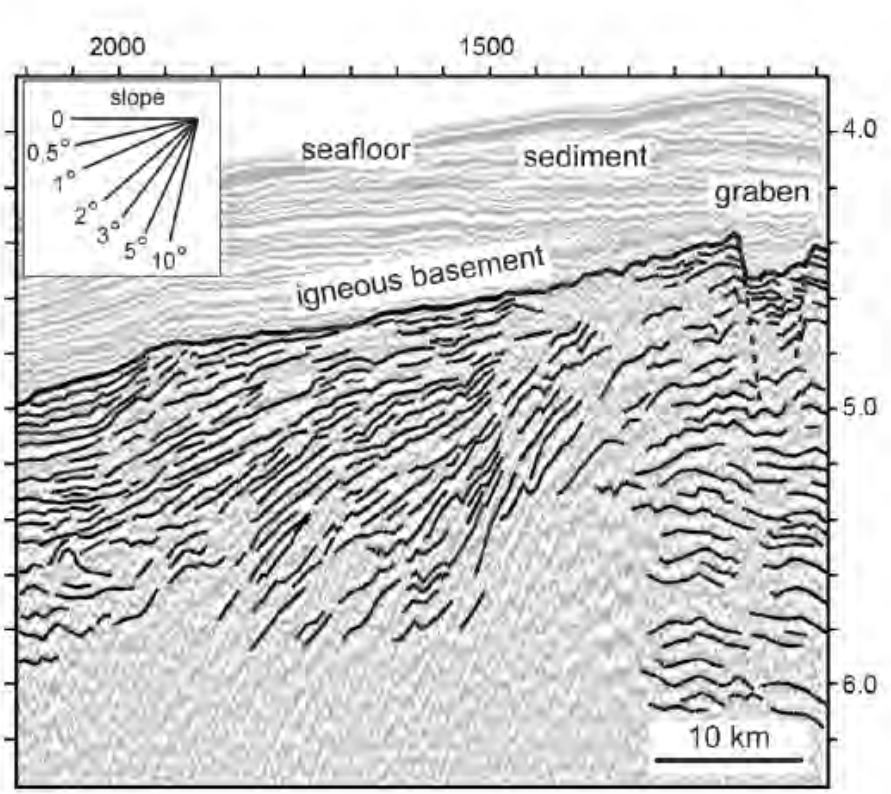
Typically traced 5-20 km, but “piecewise continuous” down flank

Seismic data image these reflectors 0.5-2.5 seconds twtt into basement (1-5 km depth)

Basement surface dip is low ~1°

Intra-basement Reflectors

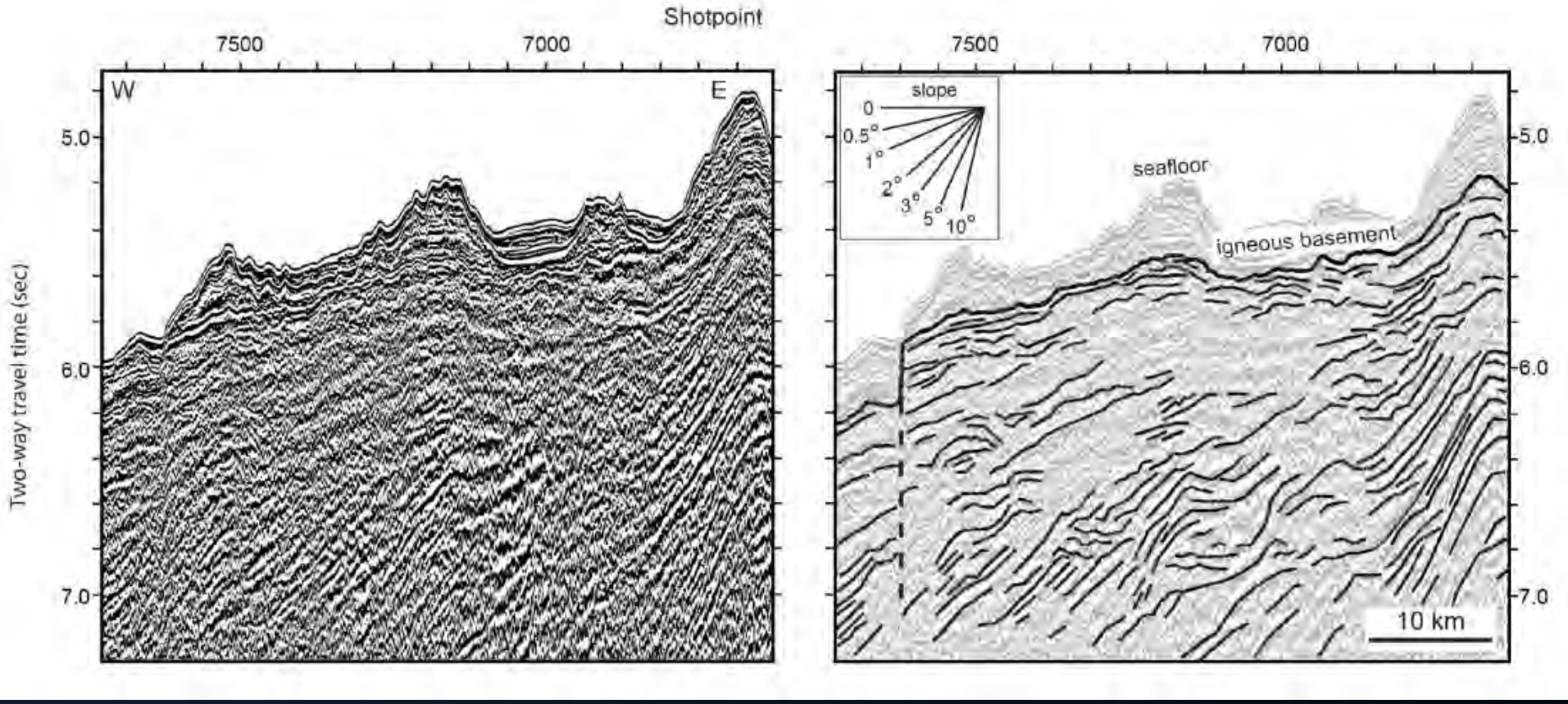




Similar to last profile in character

Also observe “graben” (caldera)

Intra-basement Reflectors



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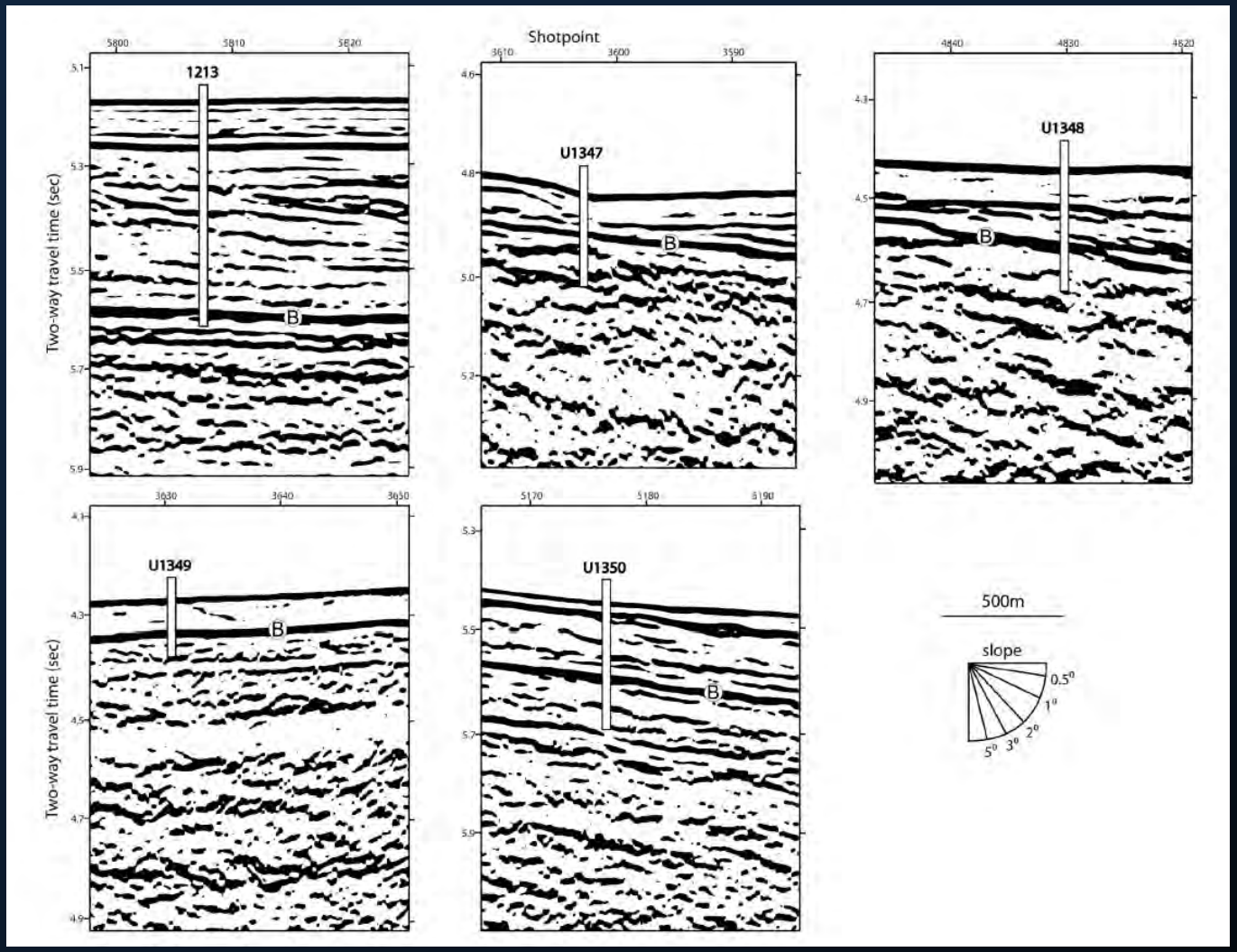
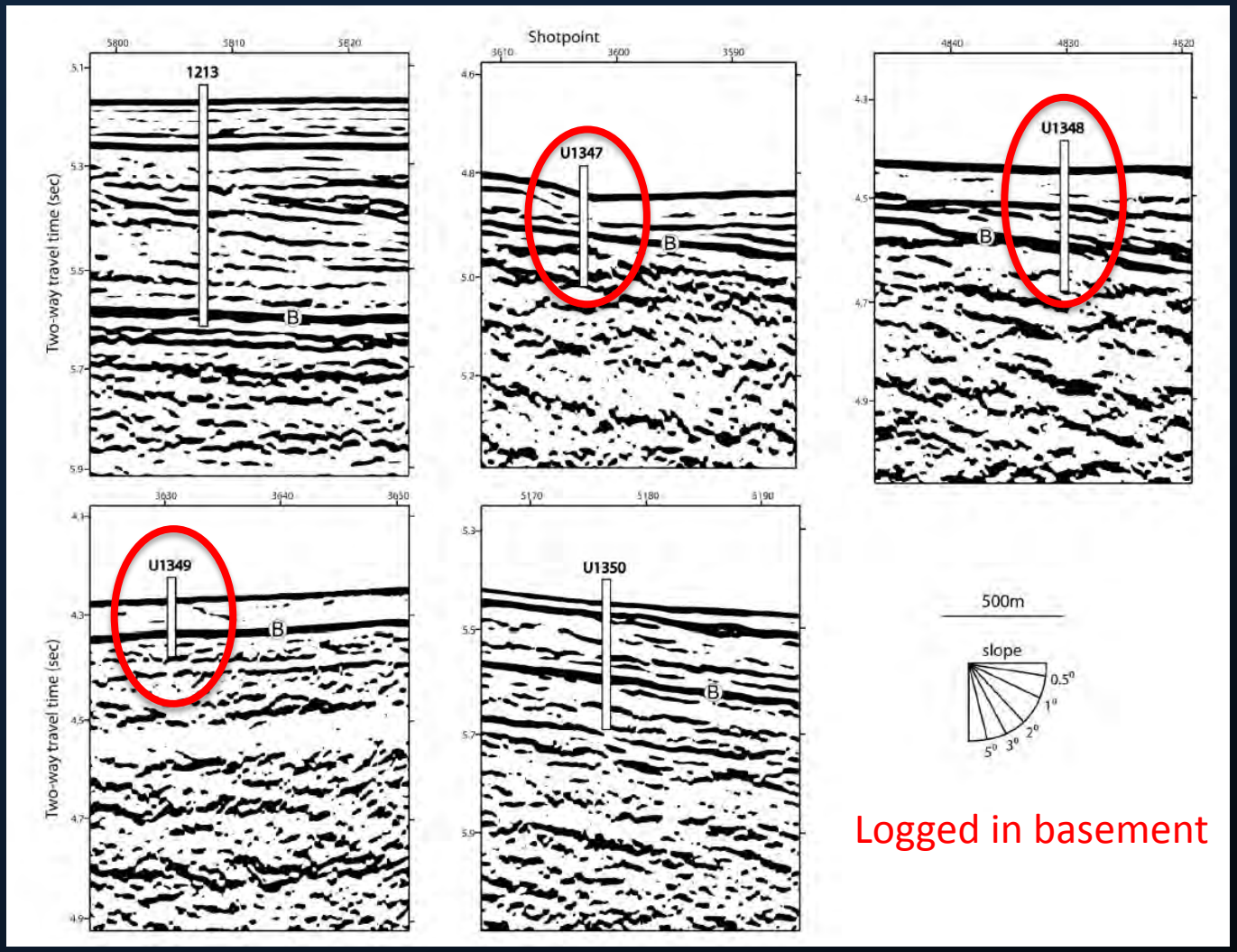
Seismics at Drill Sites



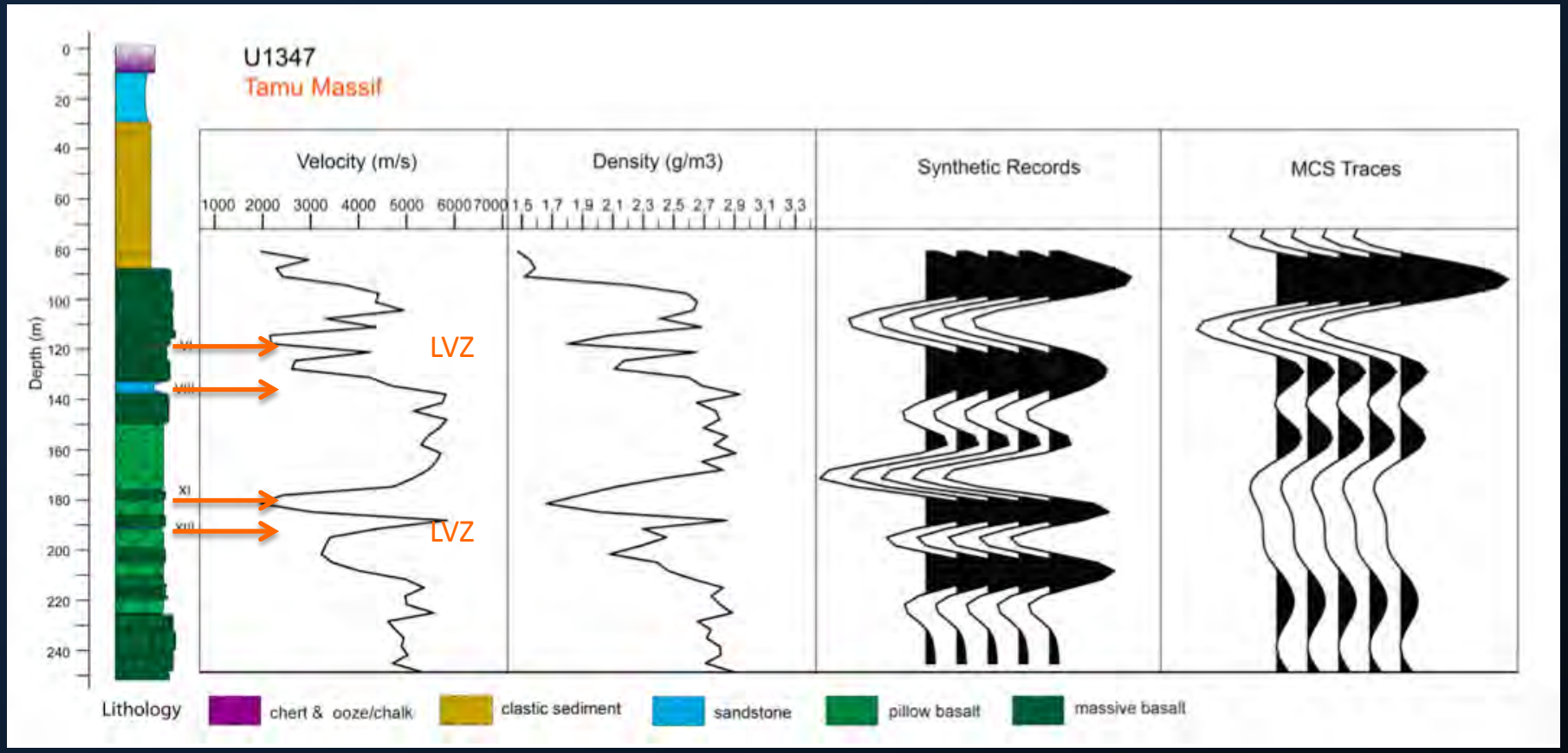
Most drill sites have shallow penetration – so they only cross a few reflectors

Seismics at Drill Sites



Only Site U1347 produced a long section of logged lava flows

Origin of Reflectors

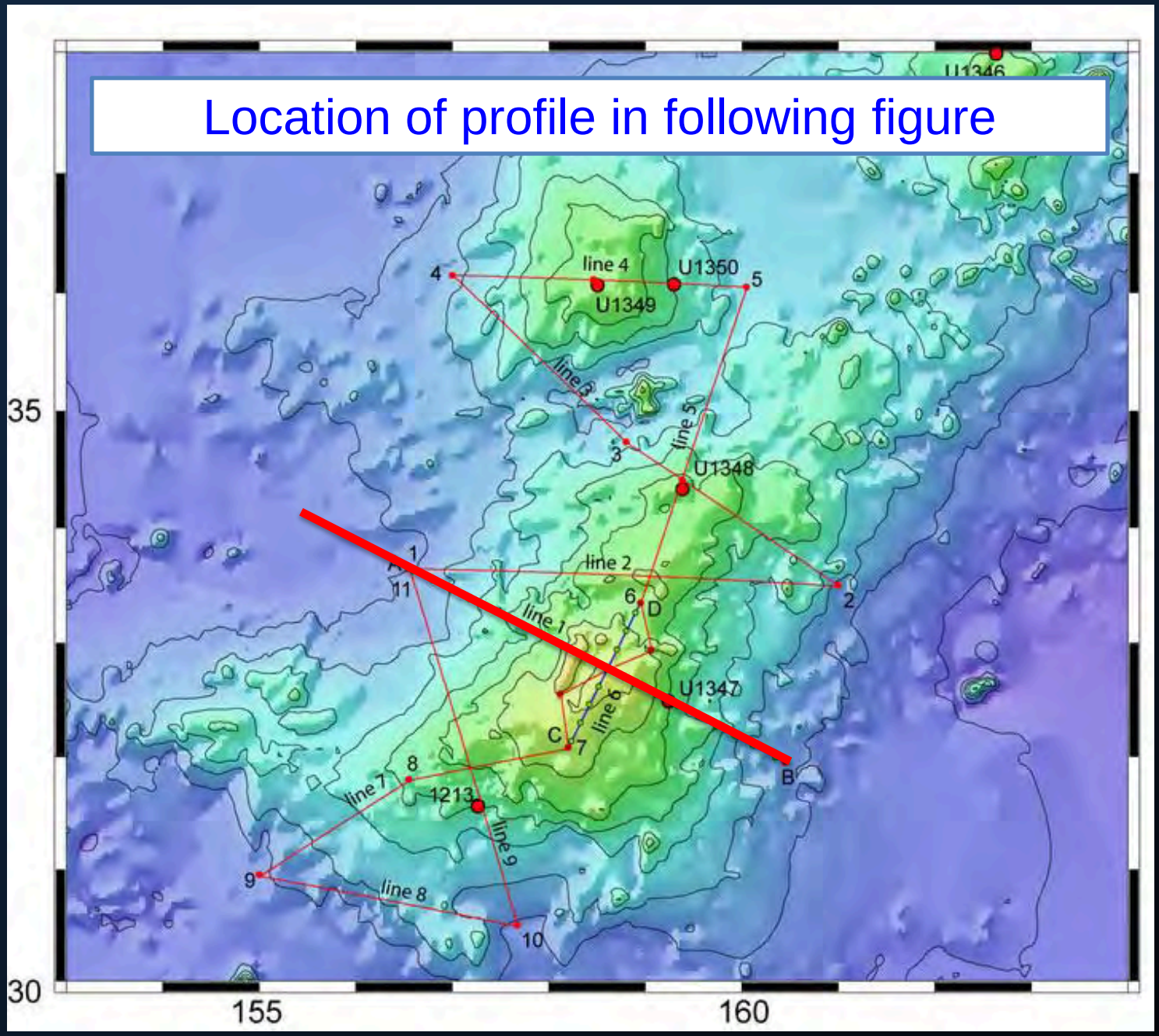


Logging data (sonic velocity & density) from Site U1347

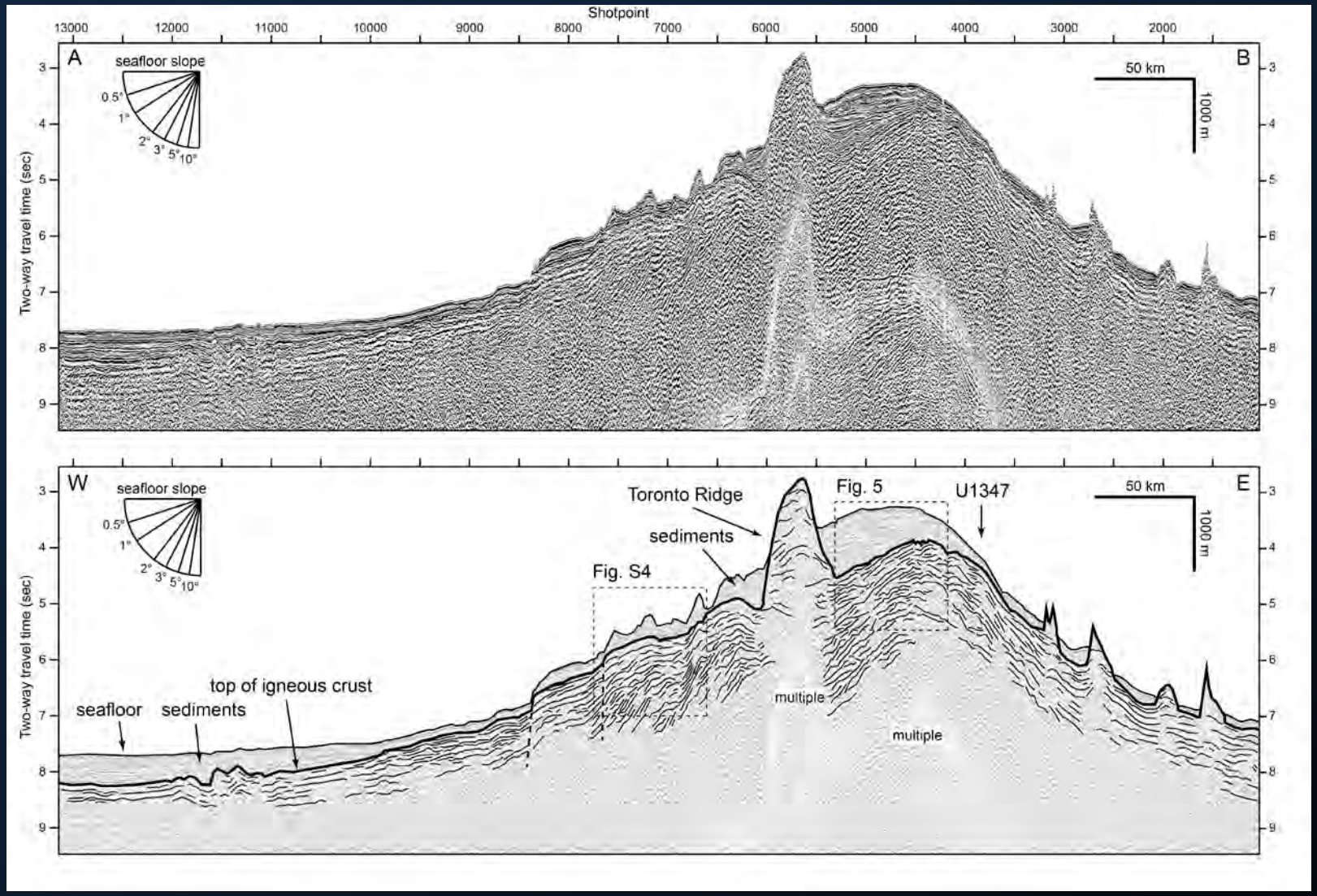
Low Vp zones correspond to thicker (~5 m) sediment layers and zones with large fraction of pillows

High Vp sections at top of massive flow groups

Location of profile in following figure

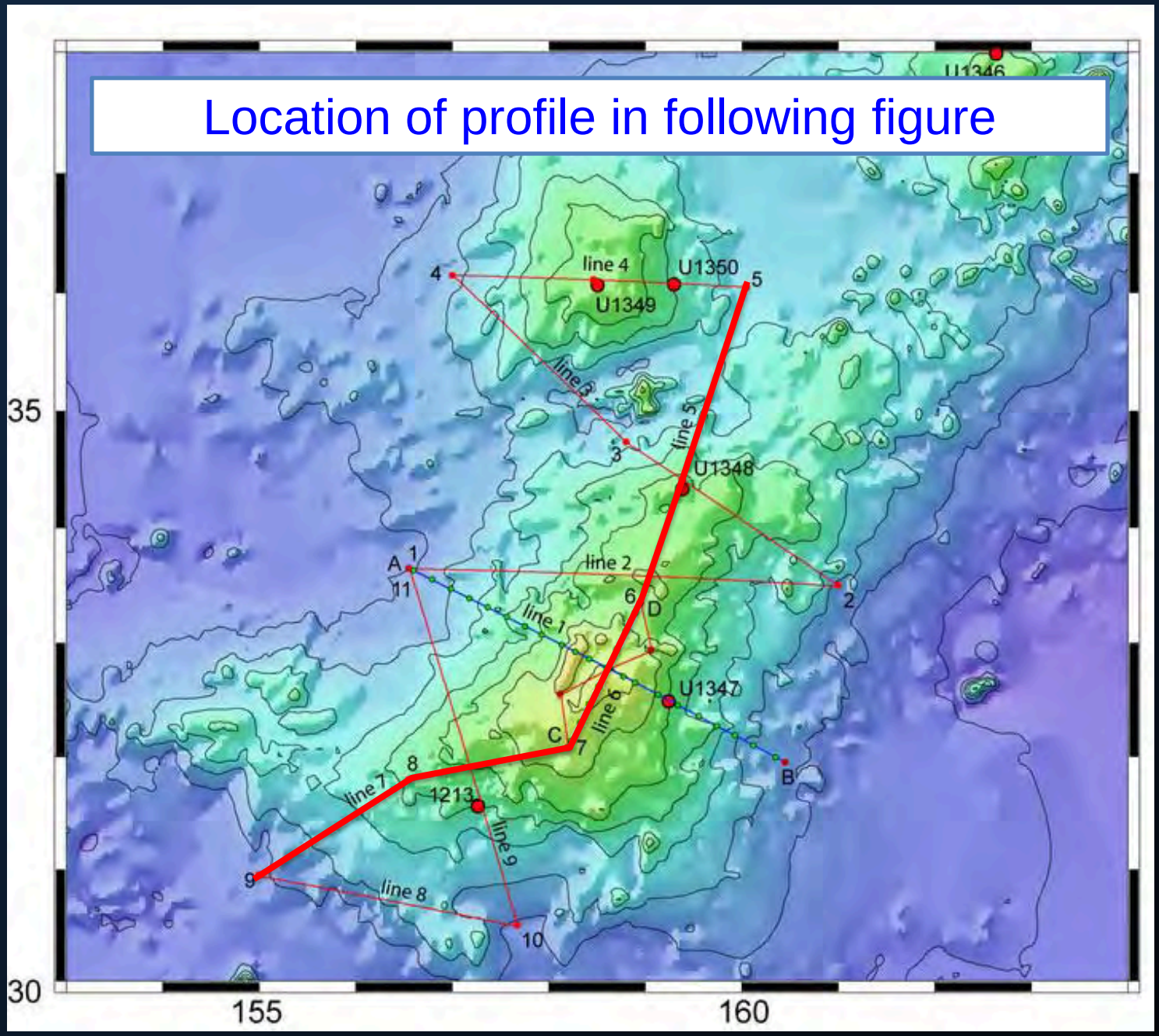


Cross-Axis Profile Shows Broad Single Volcano

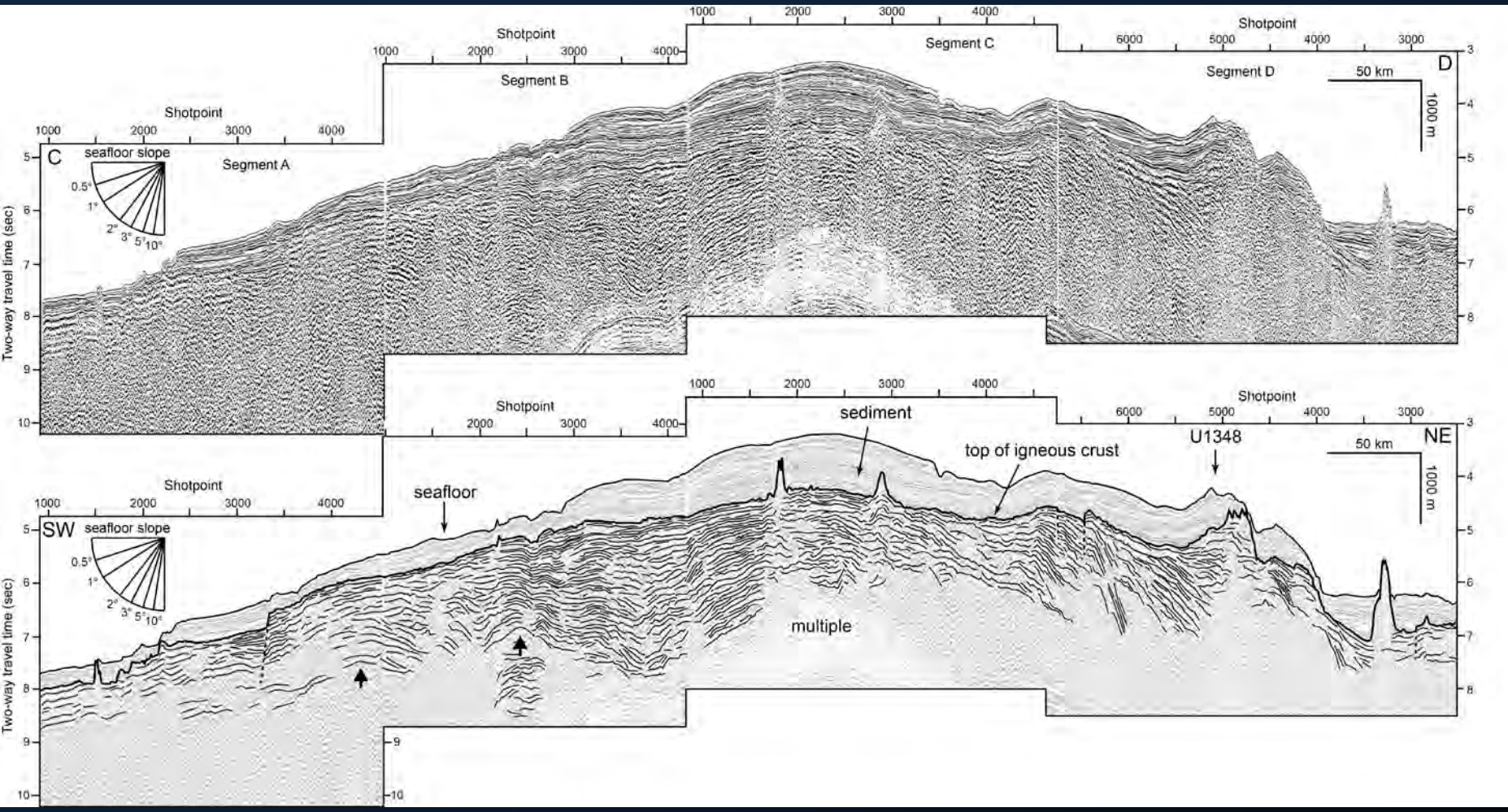


- Intrabasement reflector pattern extends hundreds of km down flanks

Location of profile in following figure



Along Axis Profile Shows Reflectors Dipping Away from Summit



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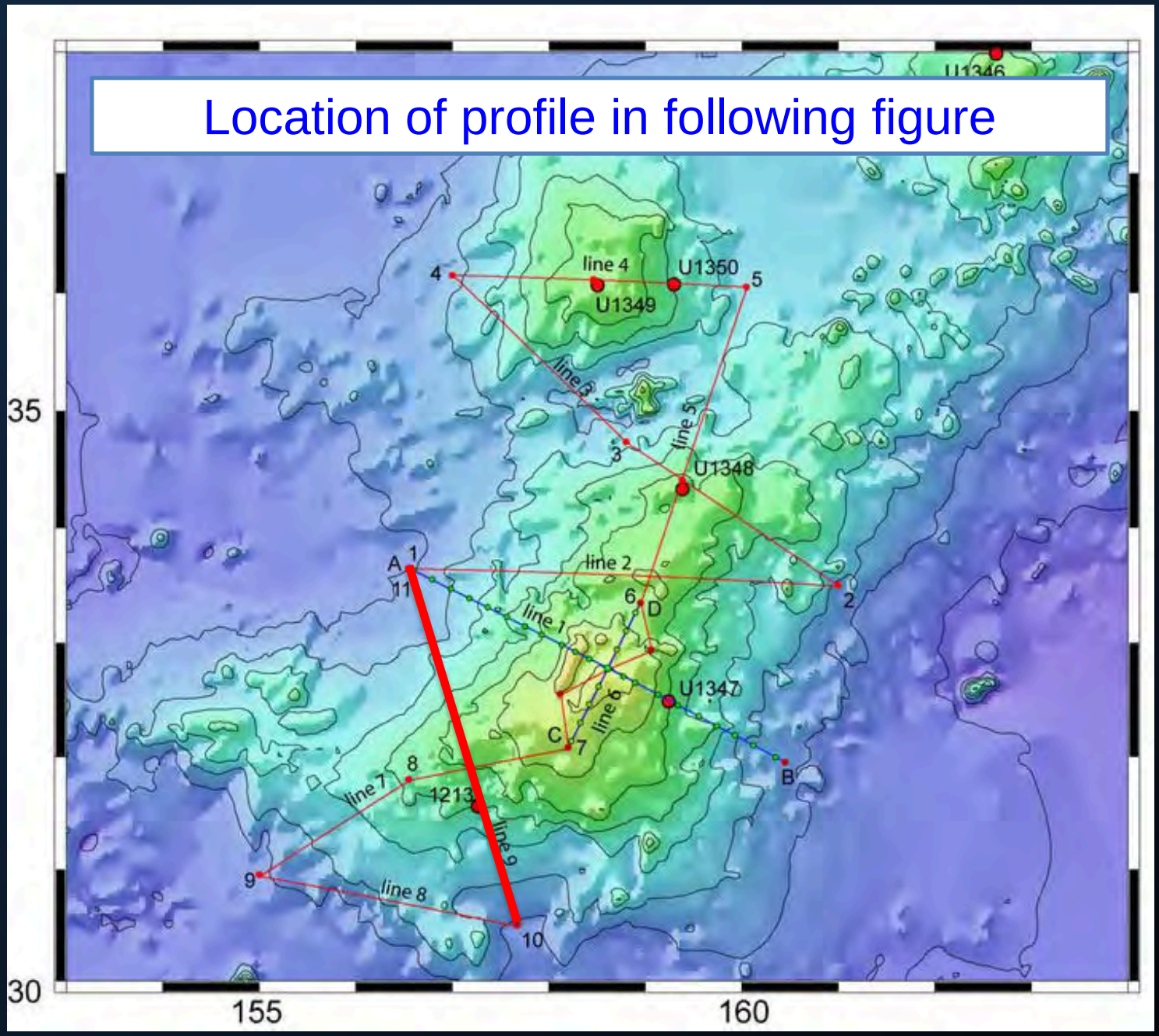
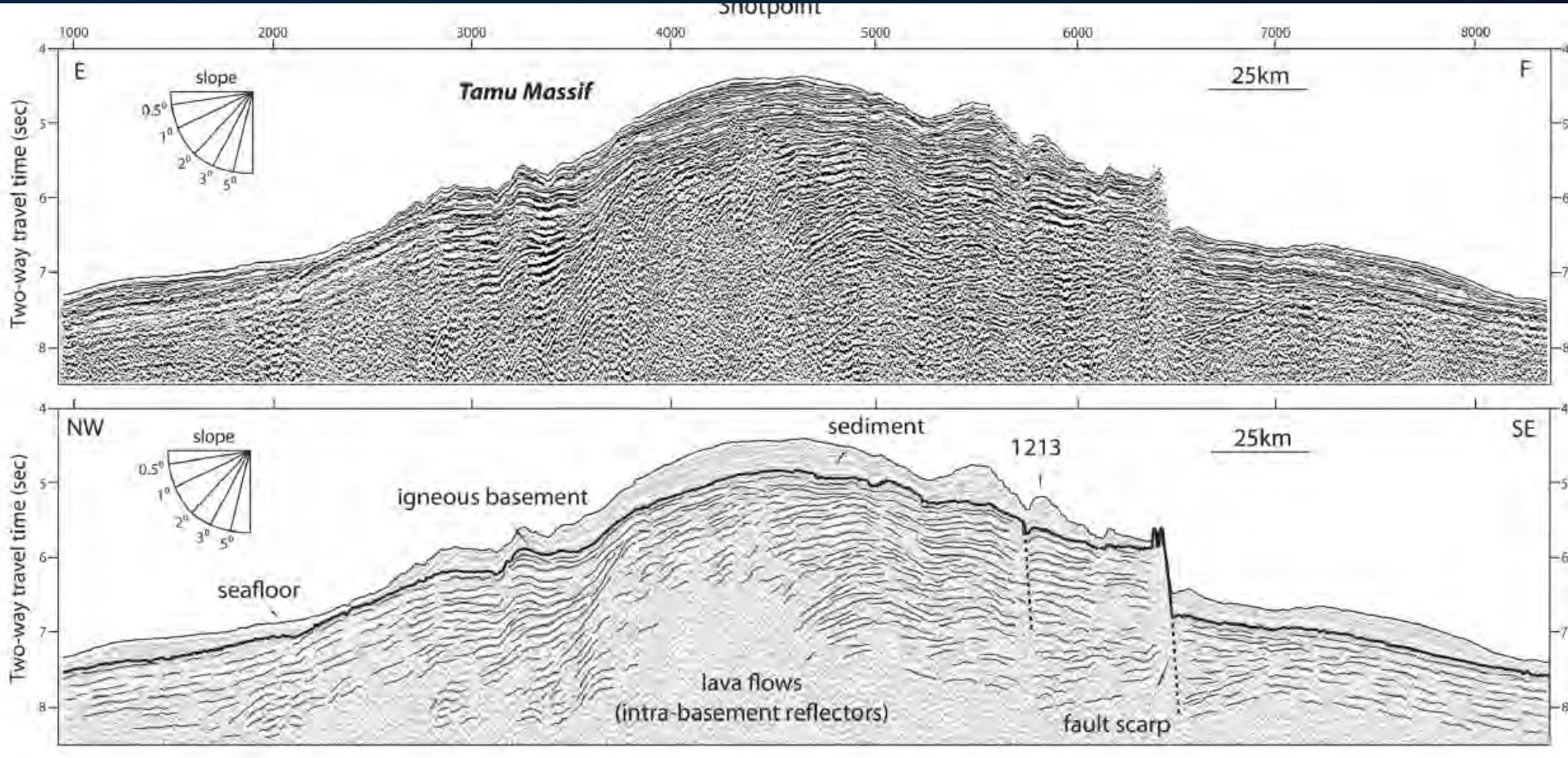
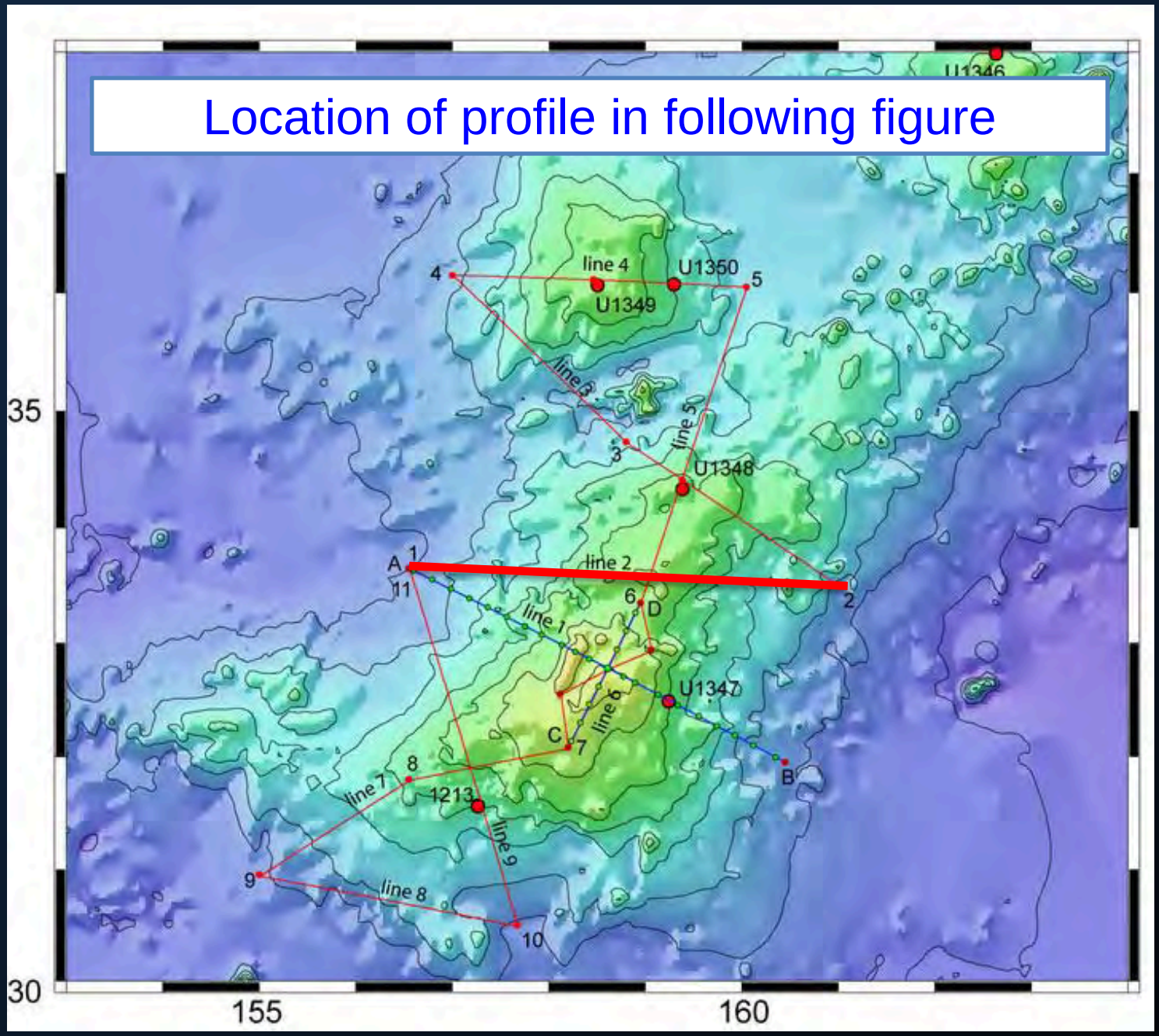


Cross-Axis Profile Shows Reflectors Dipping Outward




Location of profile in following figure
U1346
line 4
U1350
U1349
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5
line 3
line 5
3
U1348
35
A
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line 2
2
11
6
D
line 1
U1347
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C
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1213
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9
line 8
10
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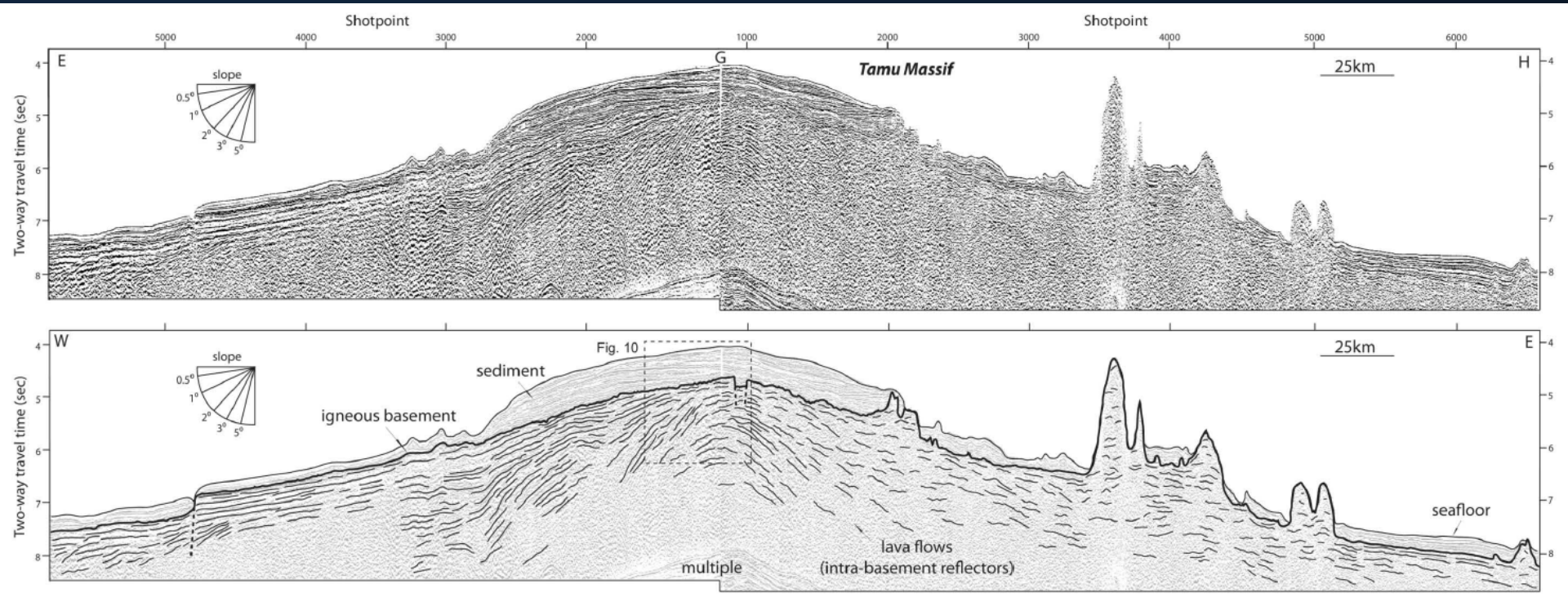
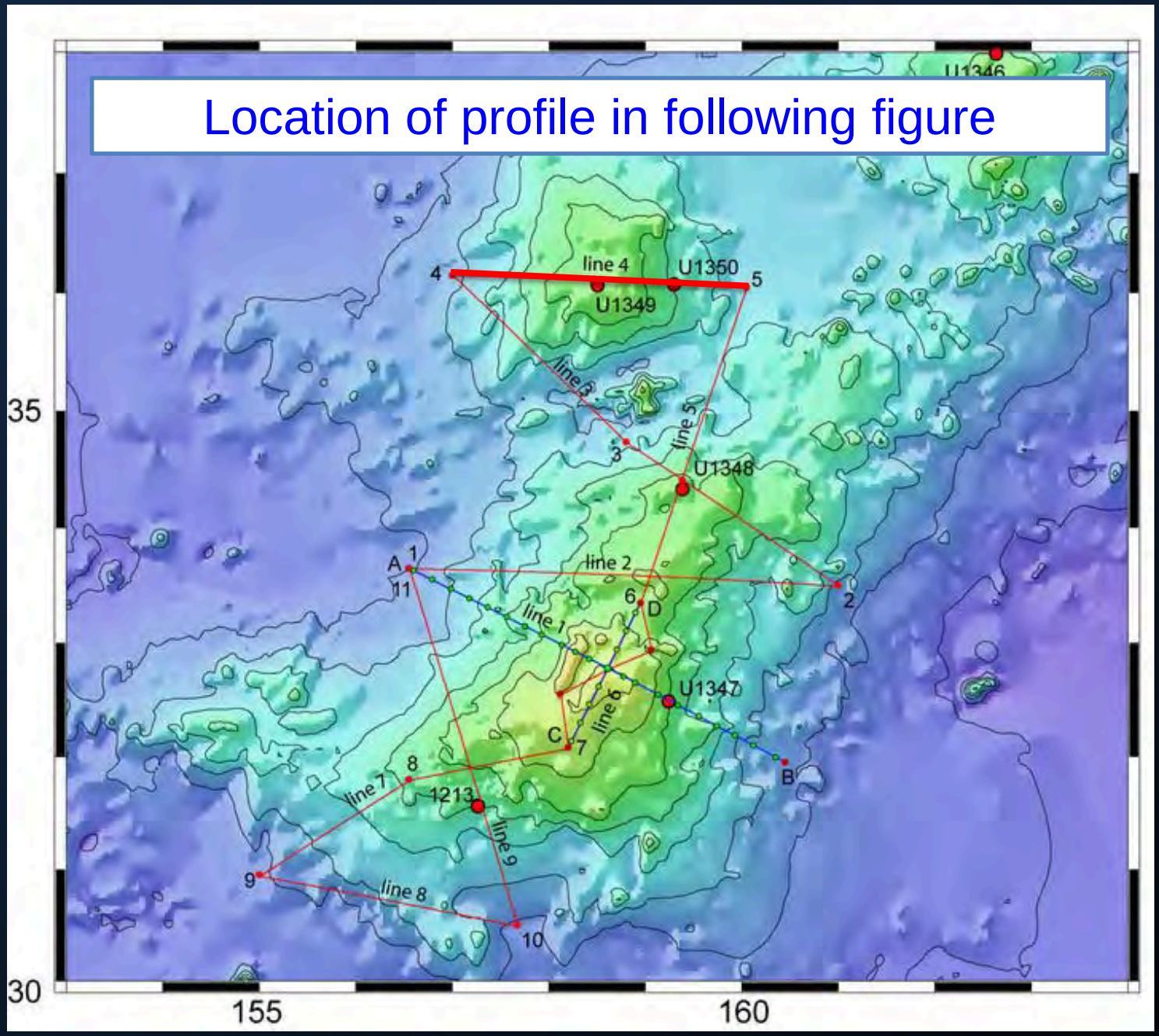
155
160

Cross-Axis Profile Shows Reflectors Dipping Outward

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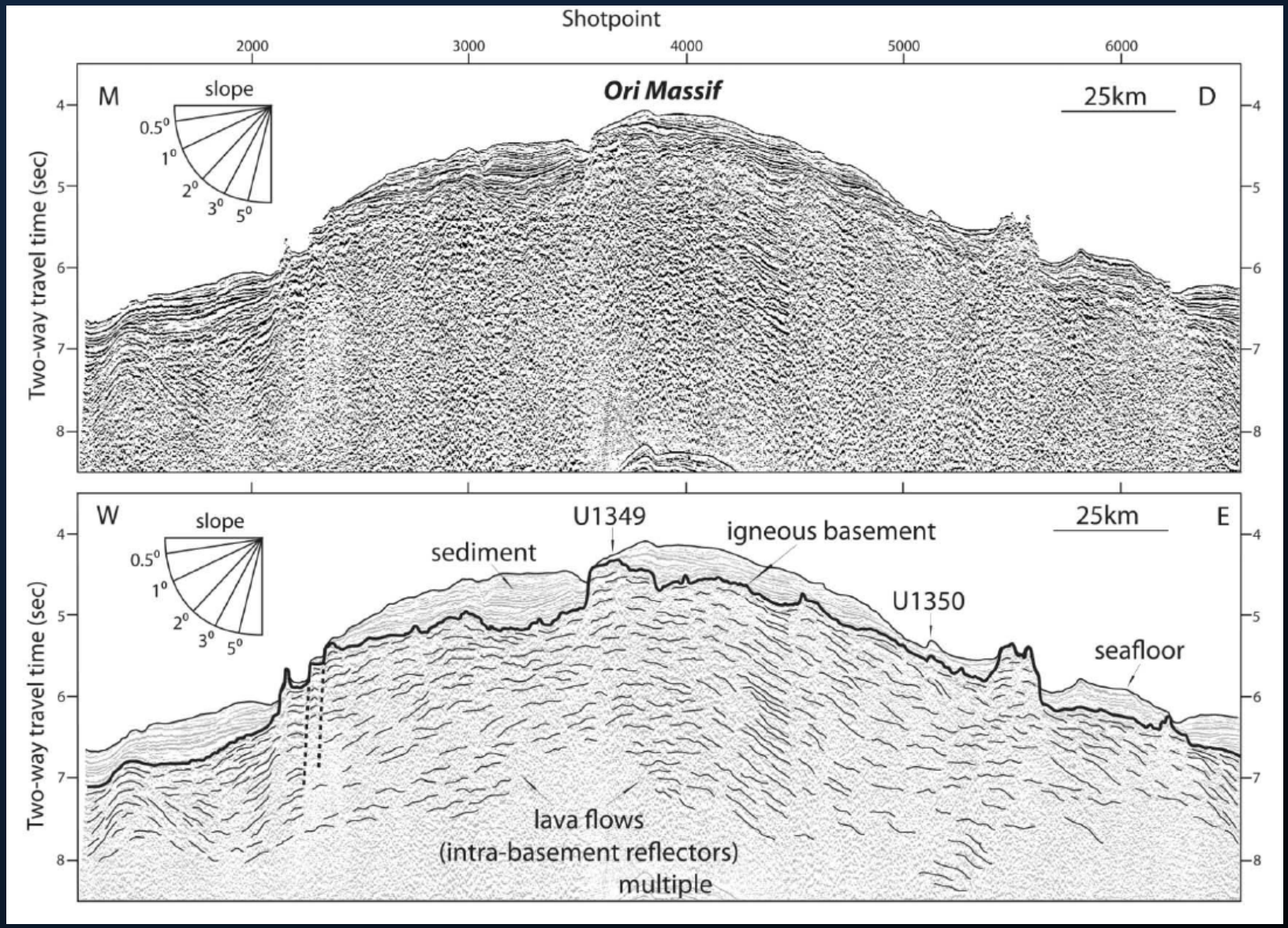
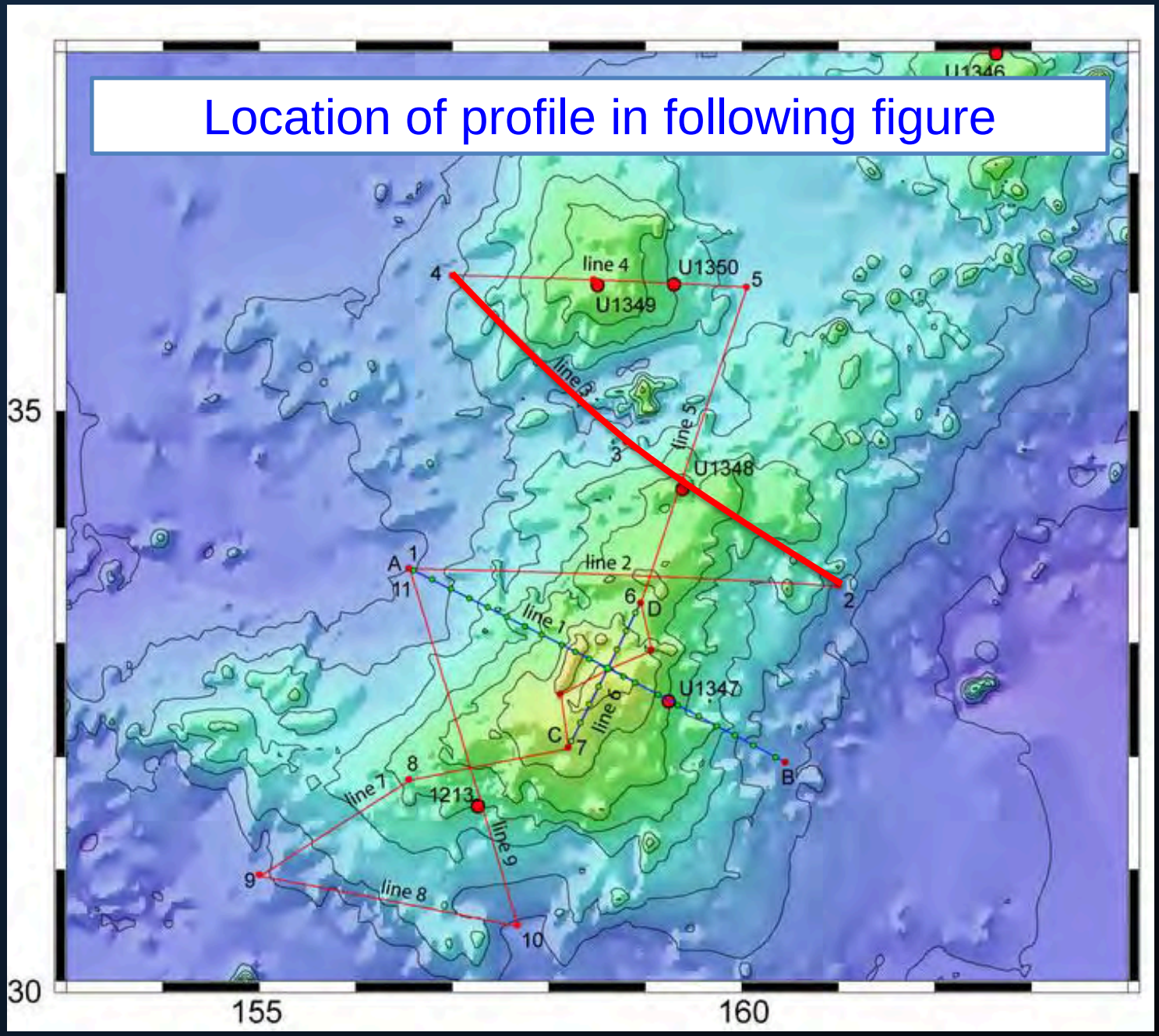
Ori Massif Profile Shows Similar Structure




Location of profile in following figure
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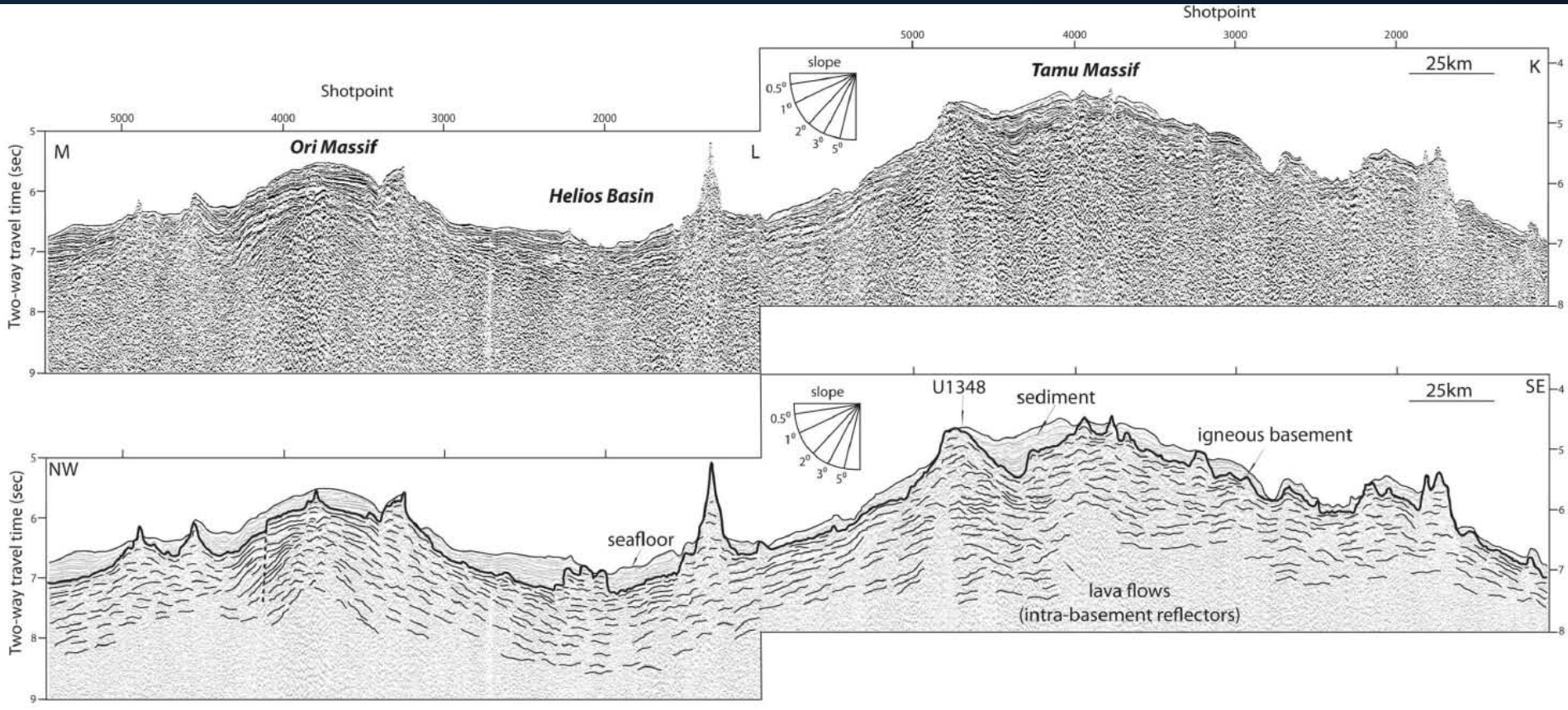
Ori Massif – Helios Basin – Tamu Massif



Helios Basin looks like a rift basin from the bathymetry and magnetics – but no obvious faulting seen in seismic data

Why is “the World’s Biggest Volcano” Important?

- Tamu Massif is vastly larger than the “common” seamount – it is a different class of volcano
  - Morphology is different – it has shield shape but very low slopes (<1 vs >5 for common seamount)
  - Indicates lava flows that travel long distances and do not form high slopes
  - High effusion rate – low viscosity
- Why is Tamu Massif a single volcano?
  - Large emplacement at single locus
  - Plate drifted rapidly between volcanic pulses (Tamu, Ori, Shirshov)
- What does Tamu mean?
  - Plateau formation relies on large extraction of magma from mantle at one spot
  - Massive flows similar to CFB provinces & Ontong Java Plateau – suggests common link
  - Single volcano can be much larger than previously thought – as large as the largest known in the solar system
- Outreach: Through good luck, this research result provided excellent publicity for TAMU, UH, IODP, NSF

MGL Facility

- Despite troubles coming out of drydock, MGL performed well in data acquisition
- Due in large part to dedicated technician team
- Data provided unparalleled detail and penetration into large volcanic edifice – could not have been done with any other platform
- Need for academic processing capability
- Cruise showed the downside of delays and long transits
- Cruise troubles showed the difficulties presented by medical issues
- Cruise was lengthy (60 days) and tested the resolve of all on board – MGL is not a comfortable environment
- I felt sorriest for the poor sailors who had to try to pain over the rust


Questions?