UNIVERSITY OF Southampton
School of Ocean and Earth Science

# Challenges for Marine Geophysics

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14 April 2014

# Plate evolution

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- How do plates form and evolve?
  - Continental rifts/rifted margins
  - Mid-ocean ridges, ocean basins
  - Subduction zones
- What are the physical and chemical exchanges between the solid Earth and the hydrosphere? How does this exchange affect both systems?
- How does strength of plates vary with age and process?
- How is deformation accommodated in time, space and depth?

# Fluids and melting

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- What is distribution of fluids in the solid Earth?
  - Water
  - Hydrocarbons (including gas hydrates)
- Where does melting occur and how is melt emplaced within the crust?
  - Mid-ocean ridges
  - Volcanic arcs
  - Ocean islands (hotspots?)

# Strategic relevance

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- Hazards
  - Earthquakes
  - Tsunami
  - Volcanoes
- Resources
  - Hydrocarbons, minerals, aggregates
- Environmental change
  - Past and present

# Swath bathymetry

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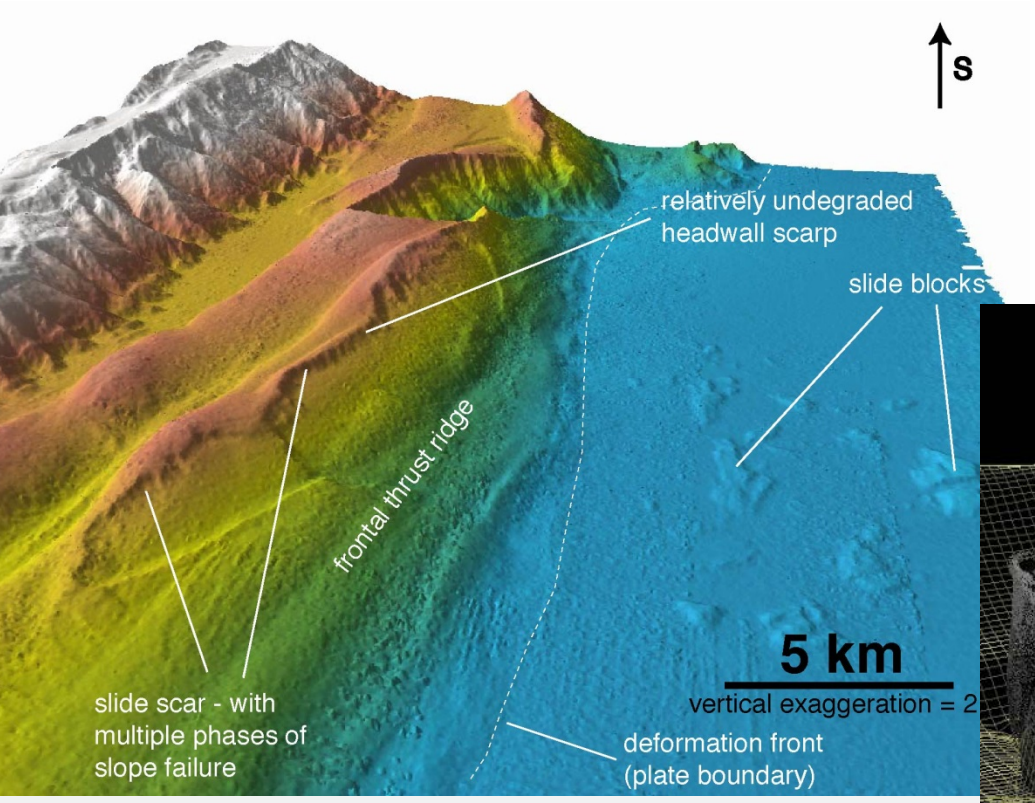
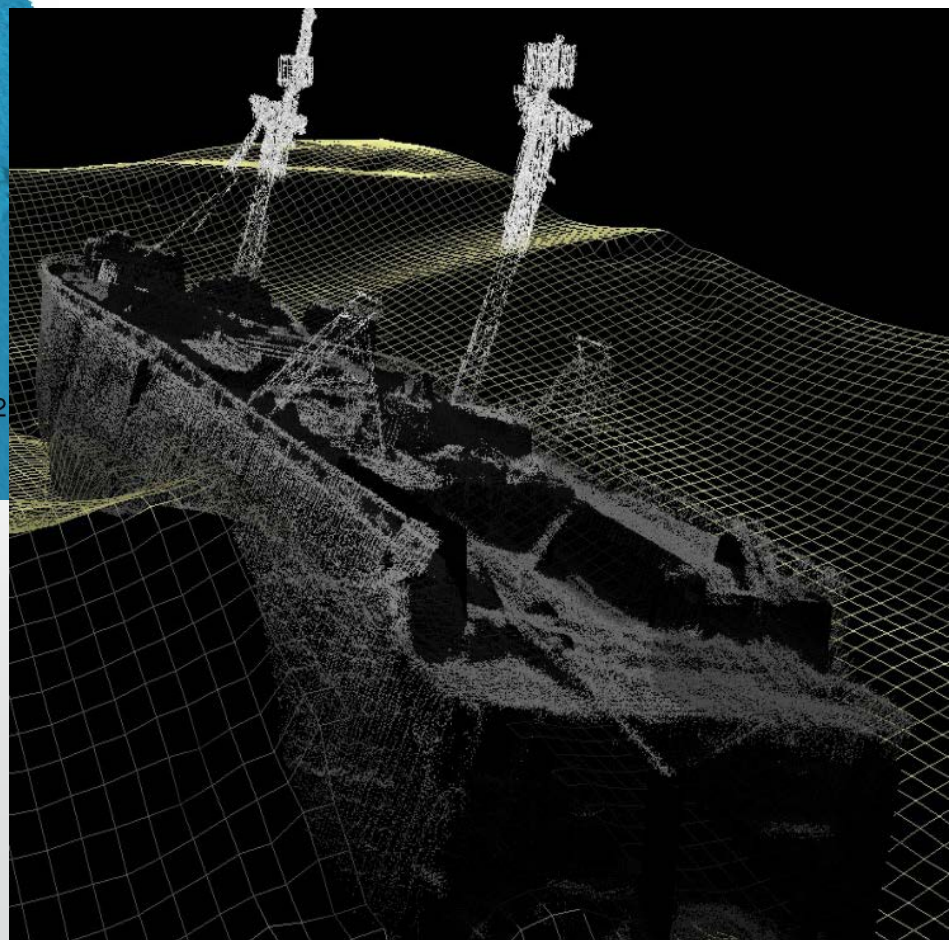



Sumatra subduction zone – survey by HMS Scott



SS Richard Montgomery – combined swath and LIDAR survey by MCA

# Seismic reflection

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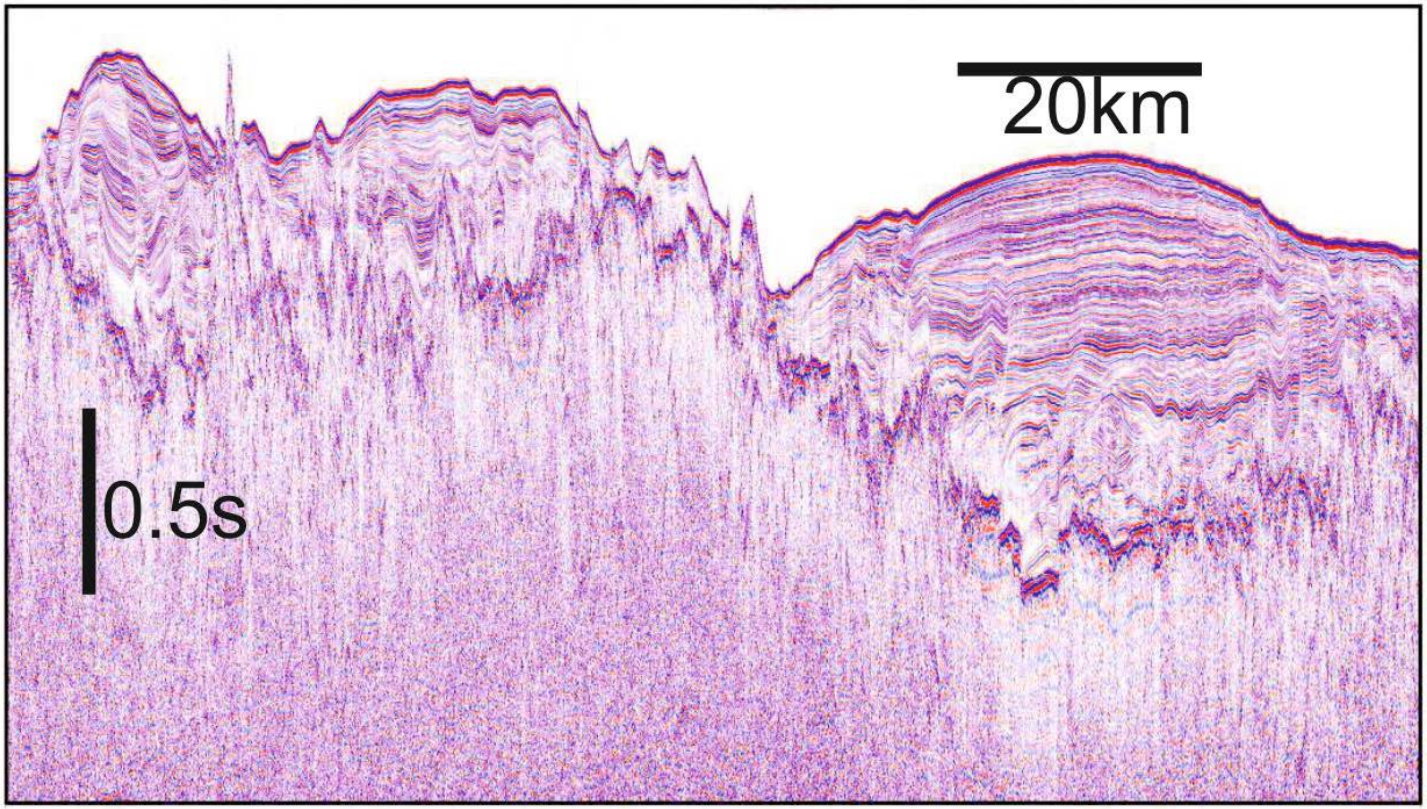
- Range of resolutions/depth of imaging:
  - Top few km (sediments) -> tectonic history, link to hydrosphere processes




Parnell Turner et al, 2012

# Seismic reflection

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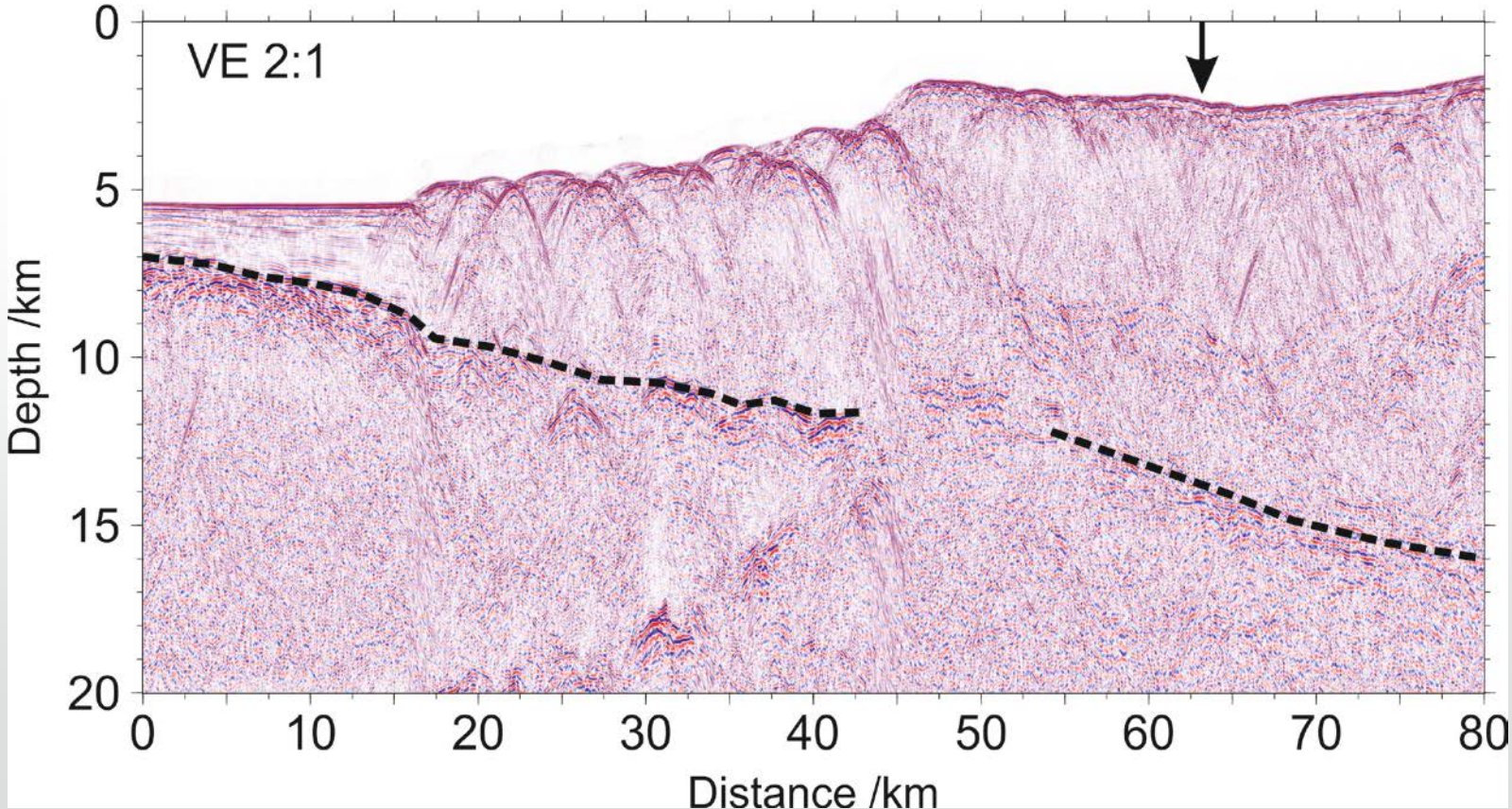
- Range of resolutions/depth of imaging:
  - 10s of km (whole crust/upper mantle) -> main plate tectonic processes, faults, geometry of crust



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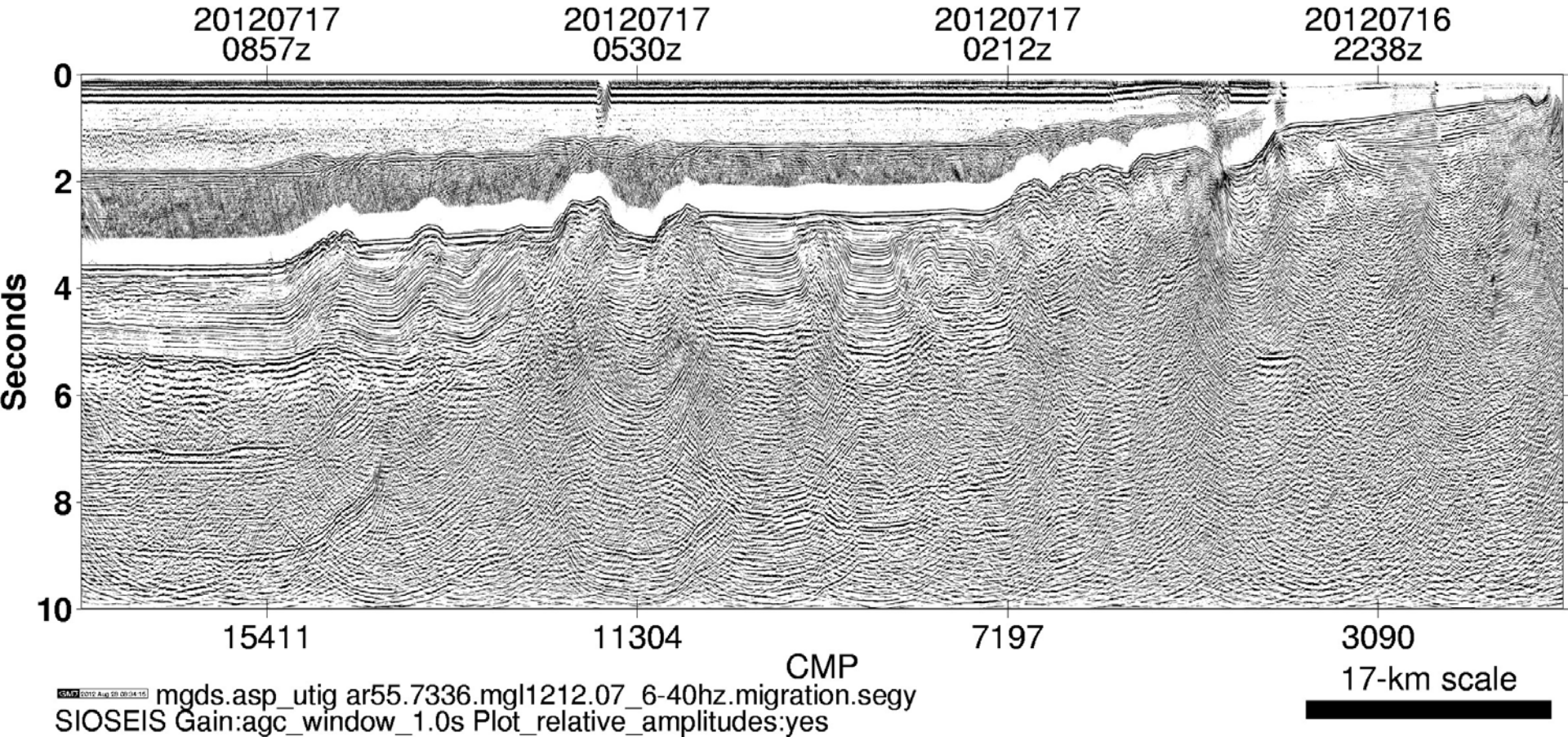
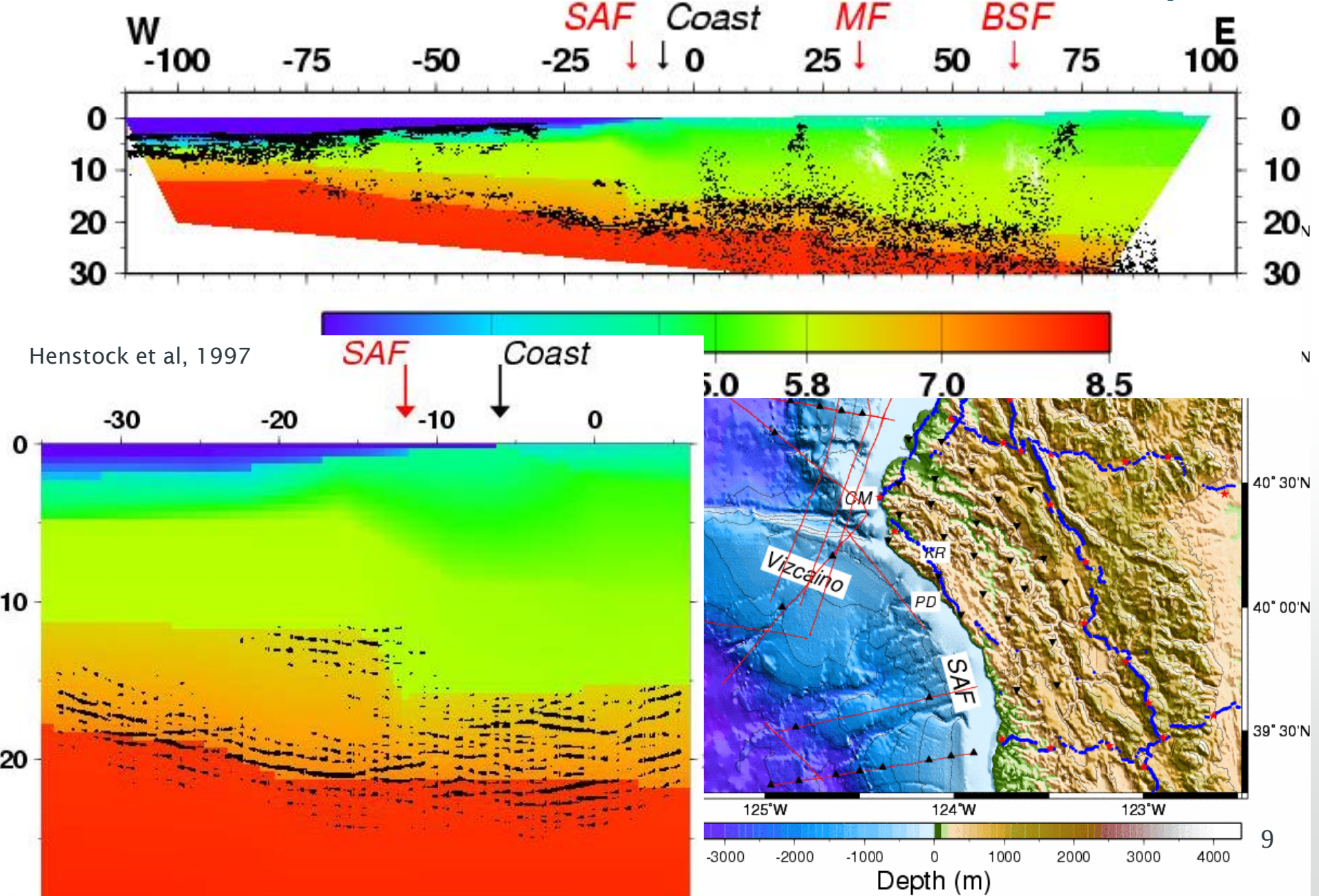


# Onshore-offshore



# High-frequency seismology

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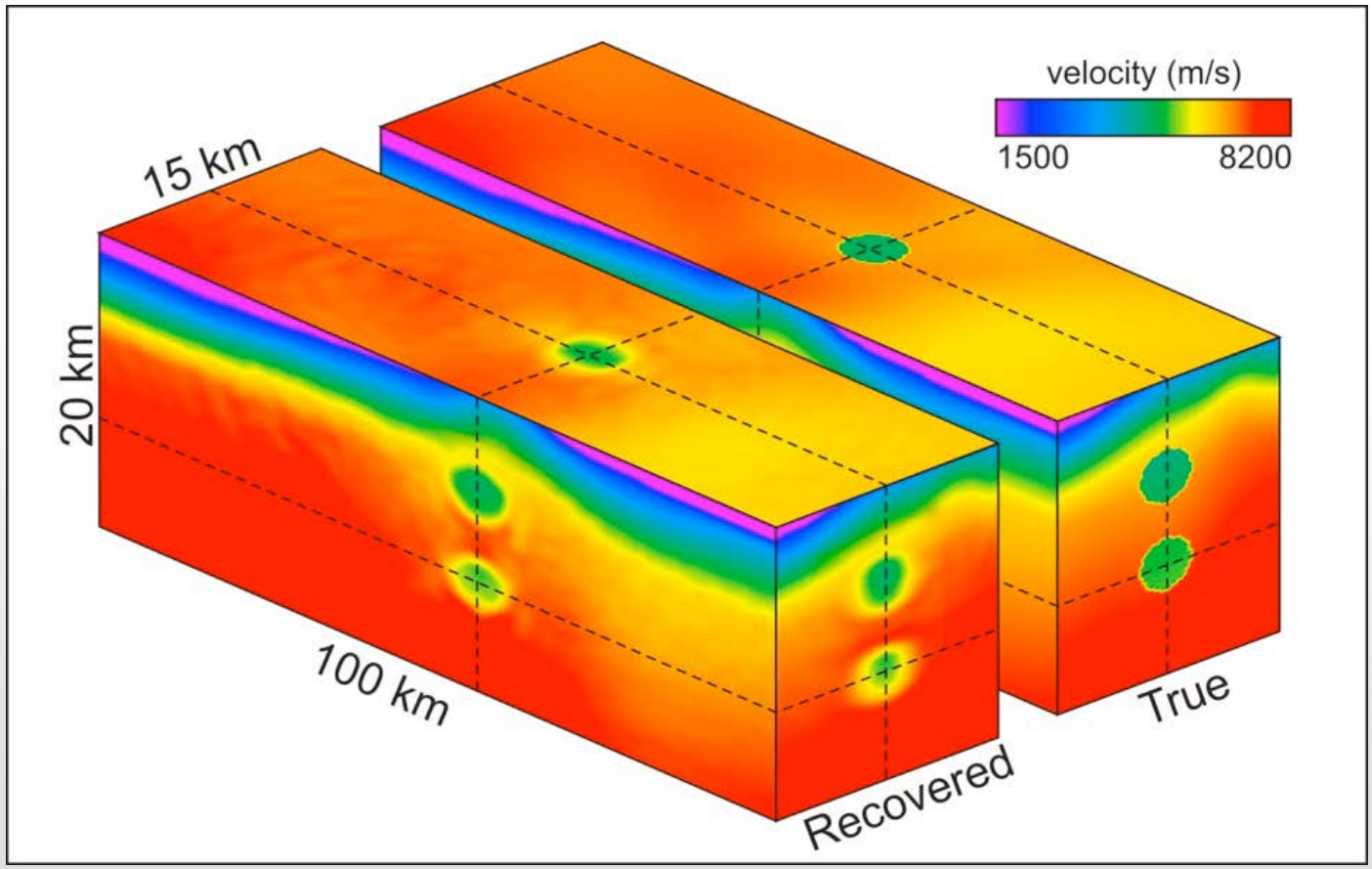
- Seismic refraction – structure of crust and upper mantle
  - Techniques like FWI are now realistic for these problems




Morgan et al., 2013

# High-frequency seismology

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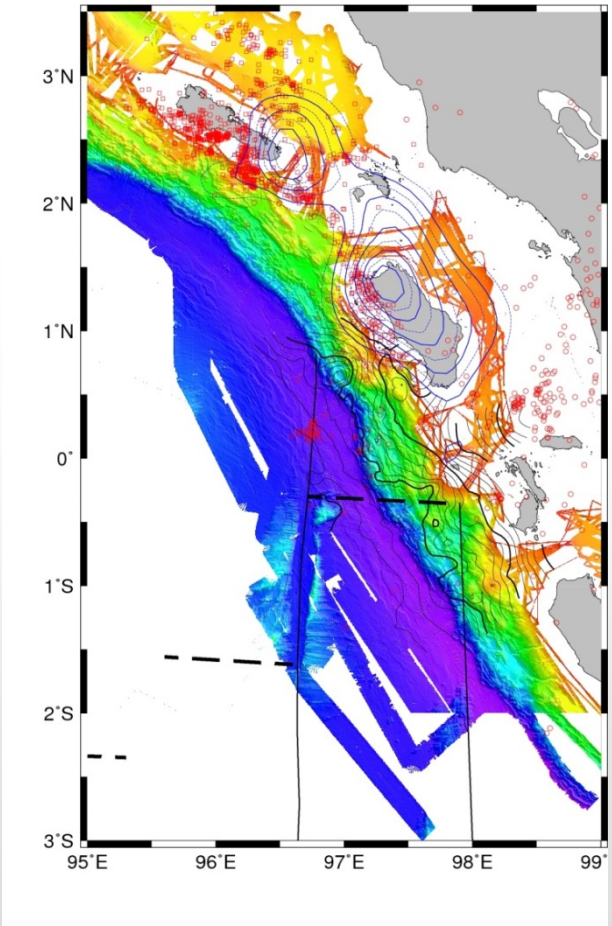
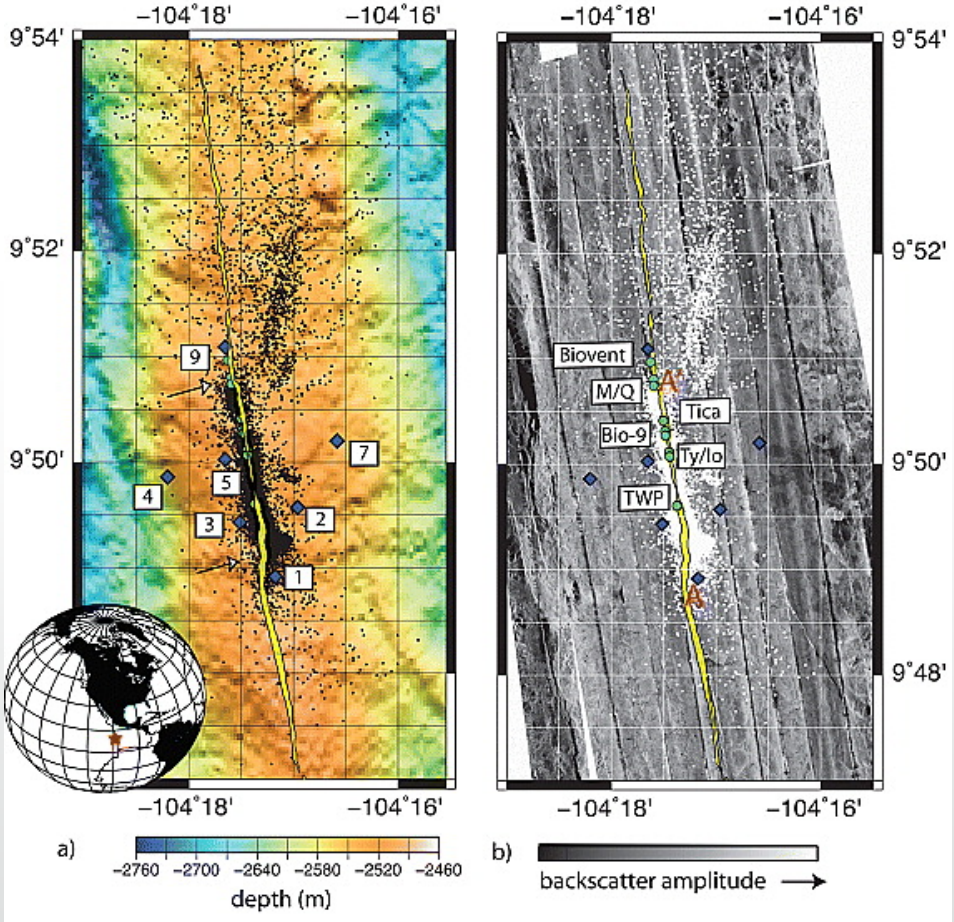
- Local earthquakes – where is strain released seismogenically?




Earthquakes from Tilmann et al, 2010; Lange et al, 2010

Bohnenstiel et al. 2008

# Broadband ocean seismology

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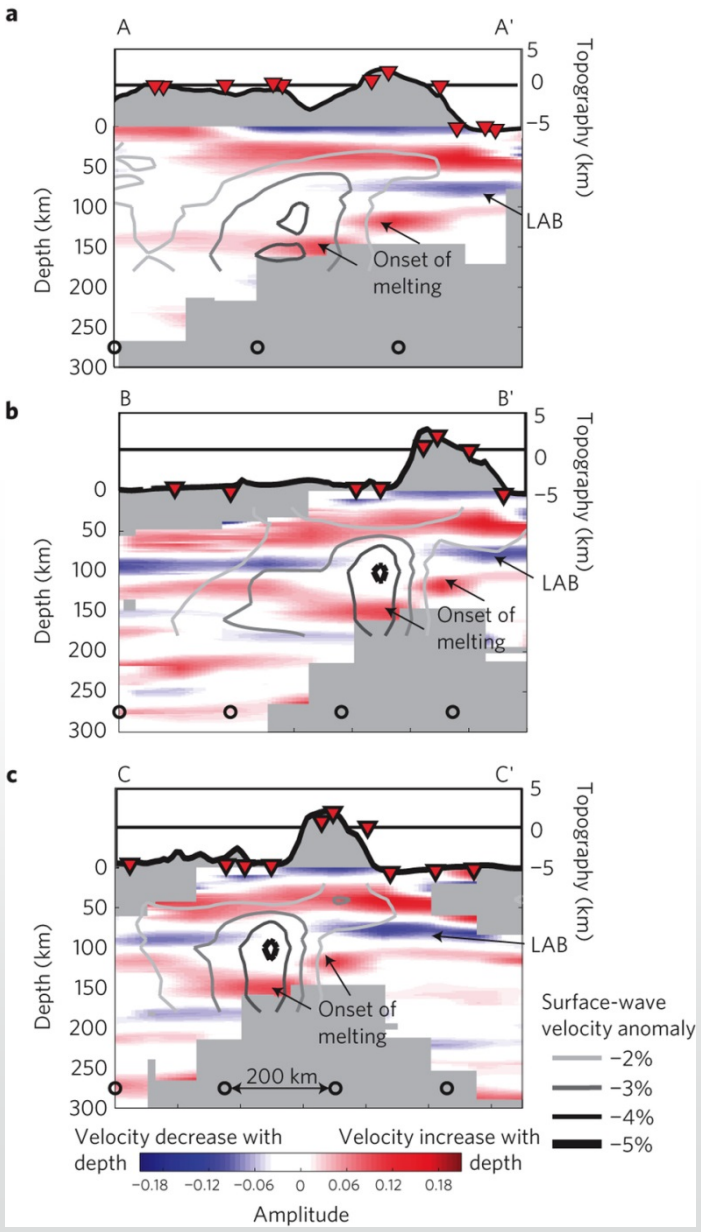
- Ambient noise/other array methods ->structure of crust/upper mantle
- Receiver functions –> deeper interfaces within the Earth
- Whole Earth structure




Rychert et al., 2013

# Shelf seismology

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- "Trawl-proof" system from Cascadia experiment
  - Steel housing
  - Broadband sensor
  - Absolute pressure gauge

LDEO photo

# Electromagnetic methods

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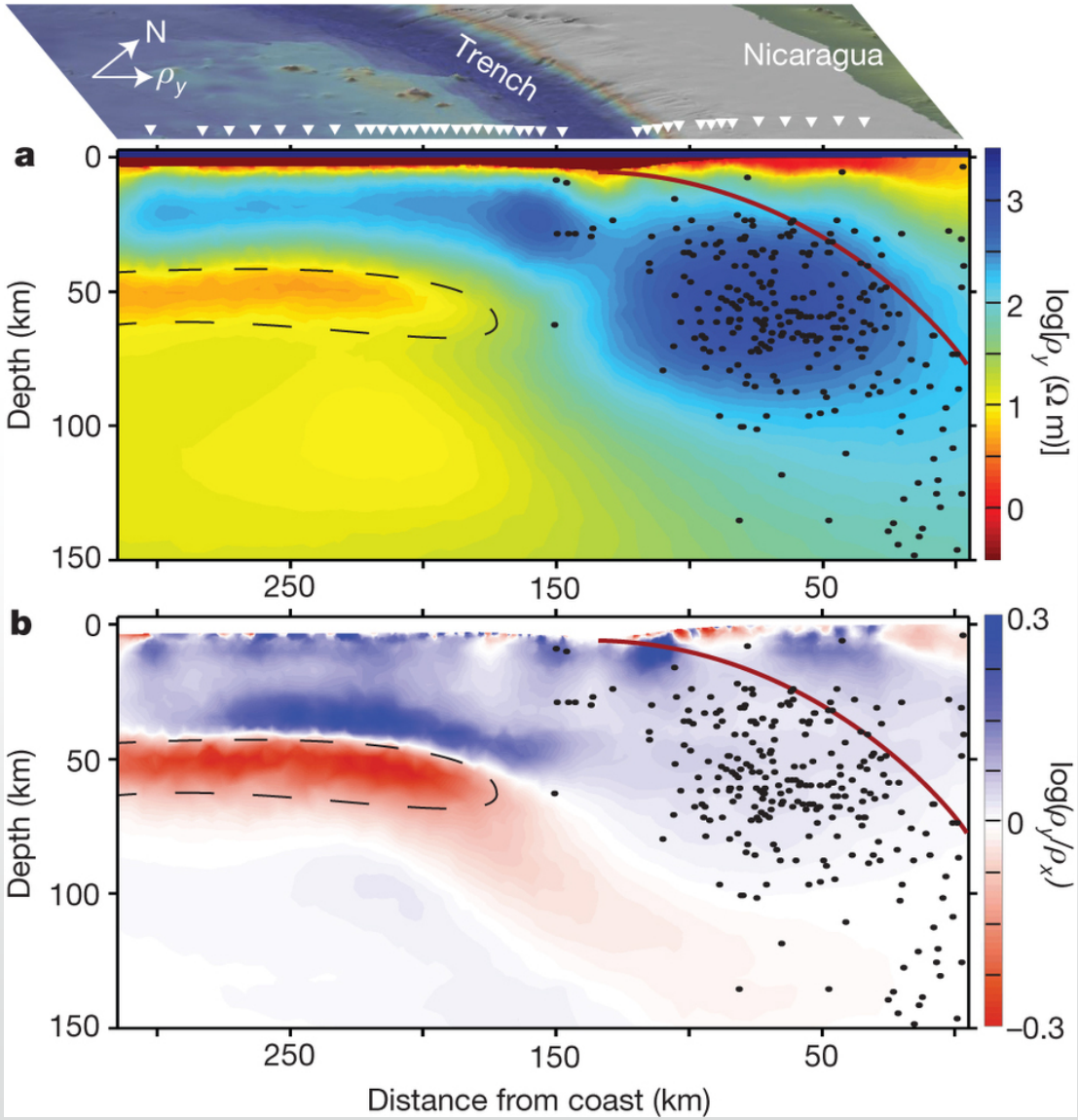
- Conductivity very sensitive to presence of fluids + type of fluids (eg seawater vs hydrocarbons, water vs melt)
  - Subduction zones (fluids in forearc, arc system)




Naif et al, 2013

# Electromagnetic methods

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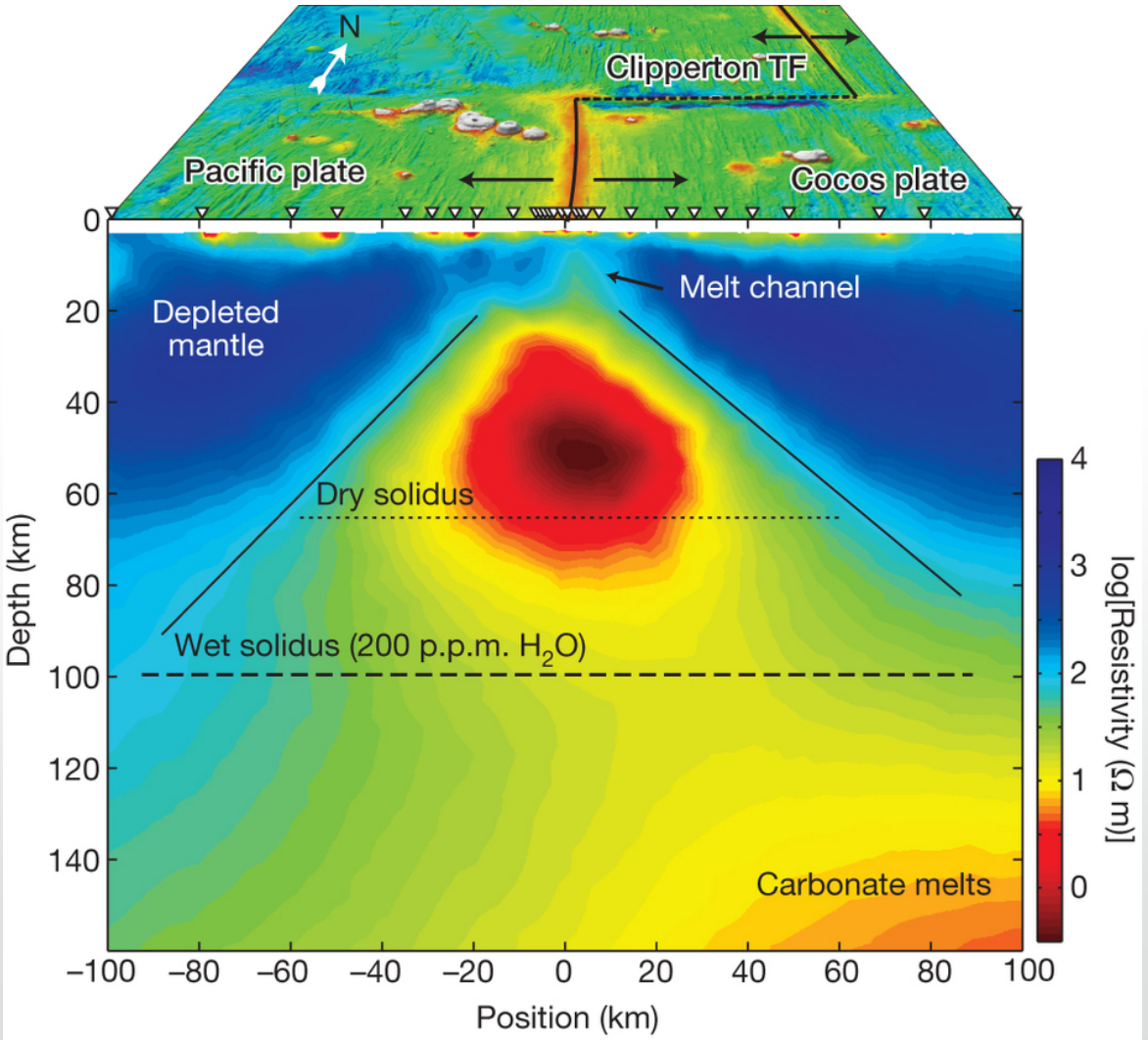
- Conductivity very sensitive to presence of fluids + type of fluids (eg seawater vs hydrocarbons, water vs melt)
  - Ridges (melt production, melt emplacement, hydrothermal systems)
  - Continental margins (hydrates, hydrocarbons)




Key et al, 2013

# Ocean drilling

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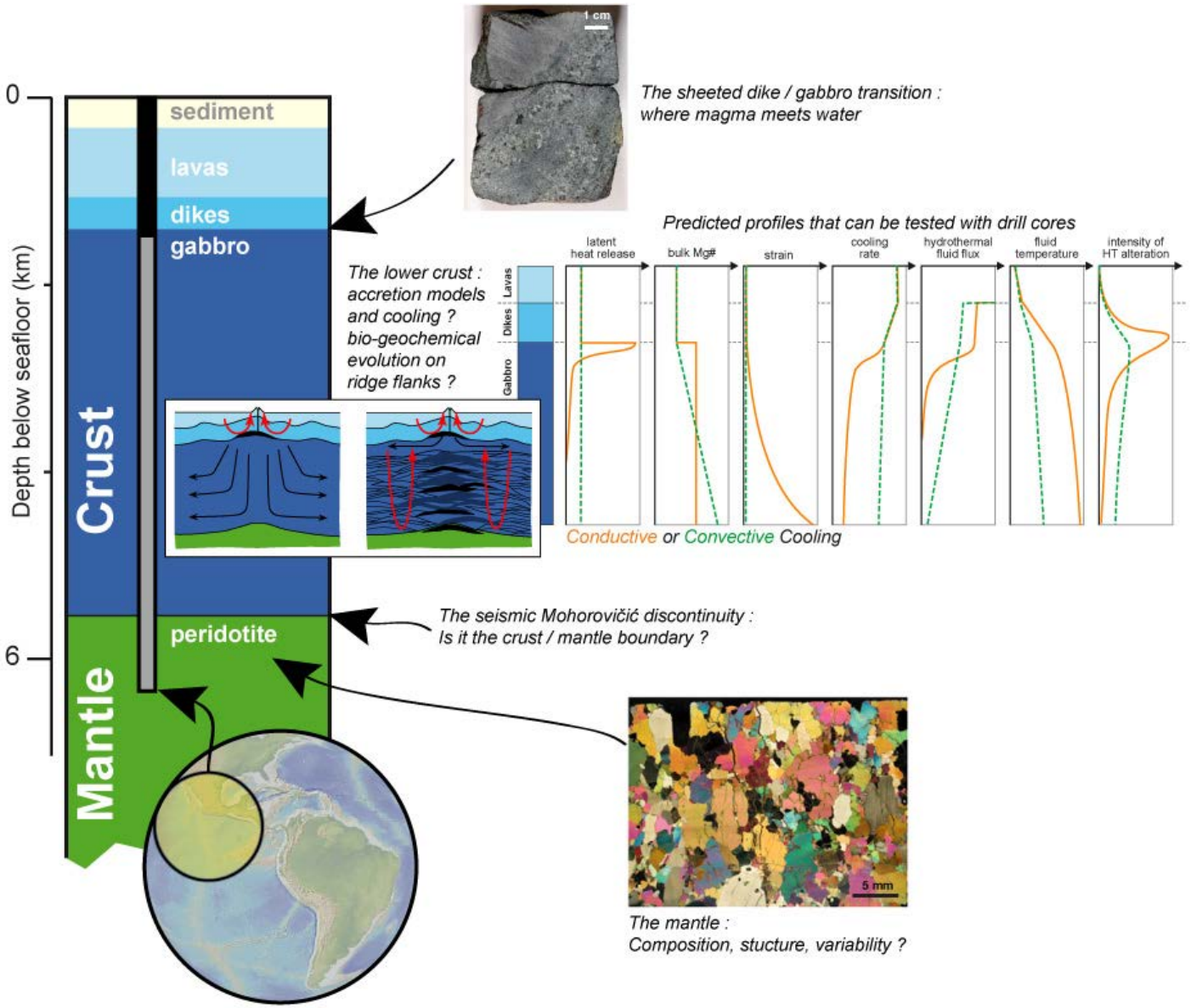
- Ultimate ground truth for marine problems!
- Sampling materials, eg Mohole




Ildefone et al Mohole report

# Ocean drilling

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- Dating of stratigraphy -> timing of tectonic activity
- Measuring (monitoring) in situ properties and time variation (eg Nankai observatories)