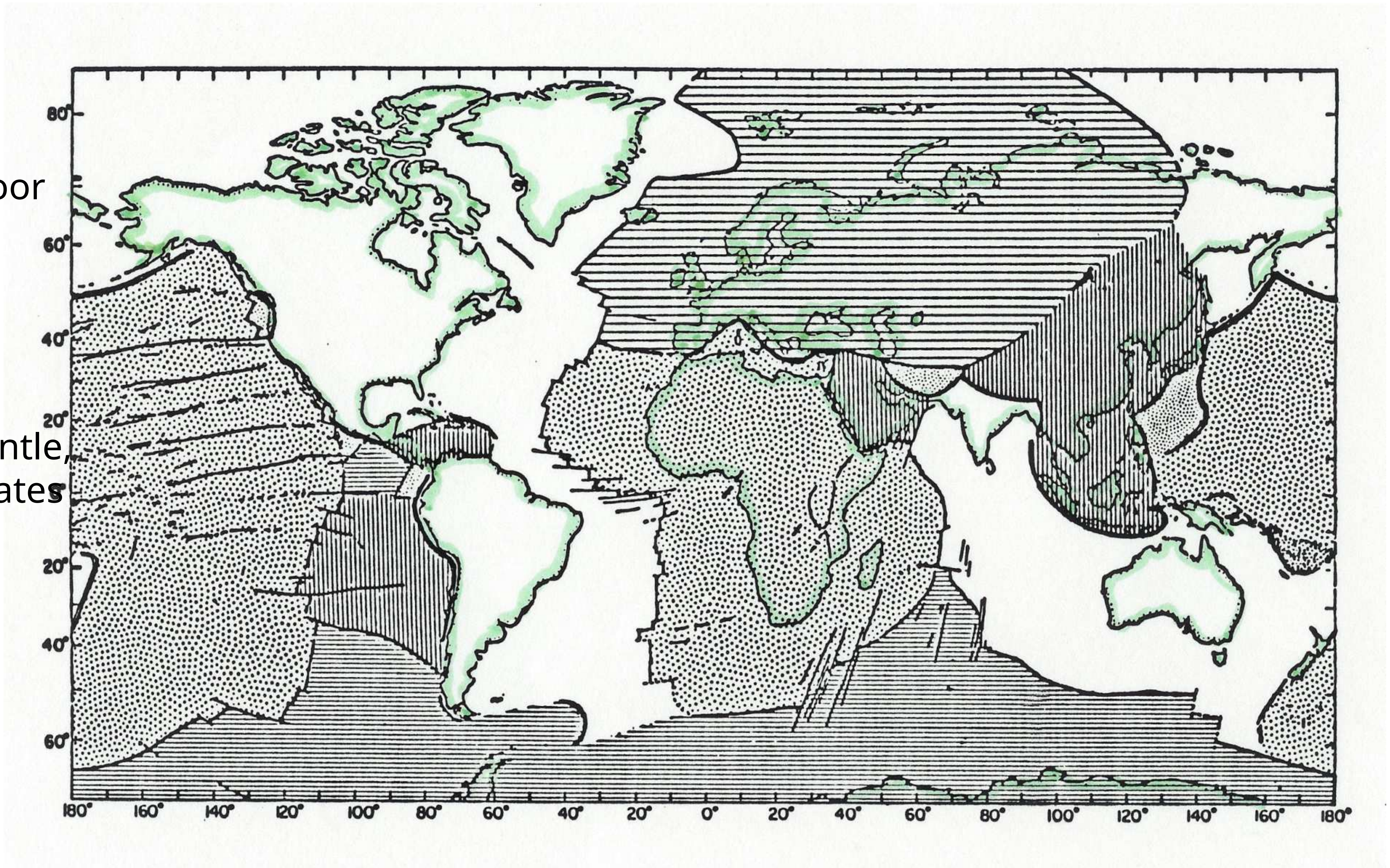
The FAMOUS Decade: 1974-1984

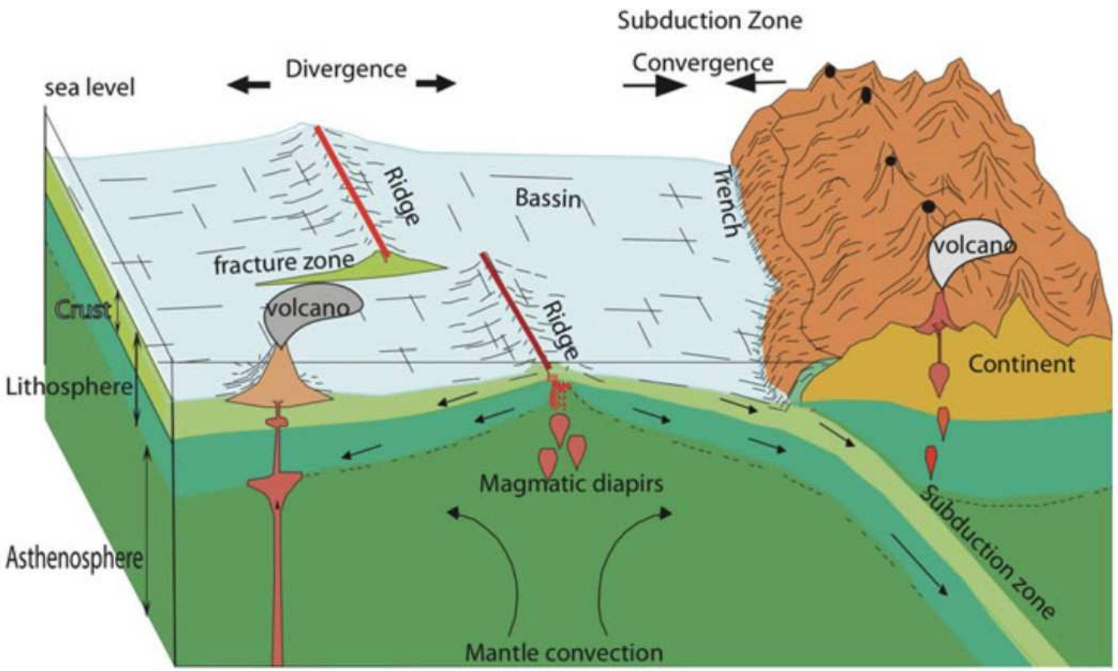
Jason P. Morgan, ICM-CSIC, Barcelona, ES

Mid-Ocean Ridges:
Creation of New Seafloor and Tectonic Plates

Subduction Zones:
Seafloor sinks into mantle, removal of Tectonic Plates



W. J. Morgan (1967/68) – First Map of Earth’s Tectonic Plates



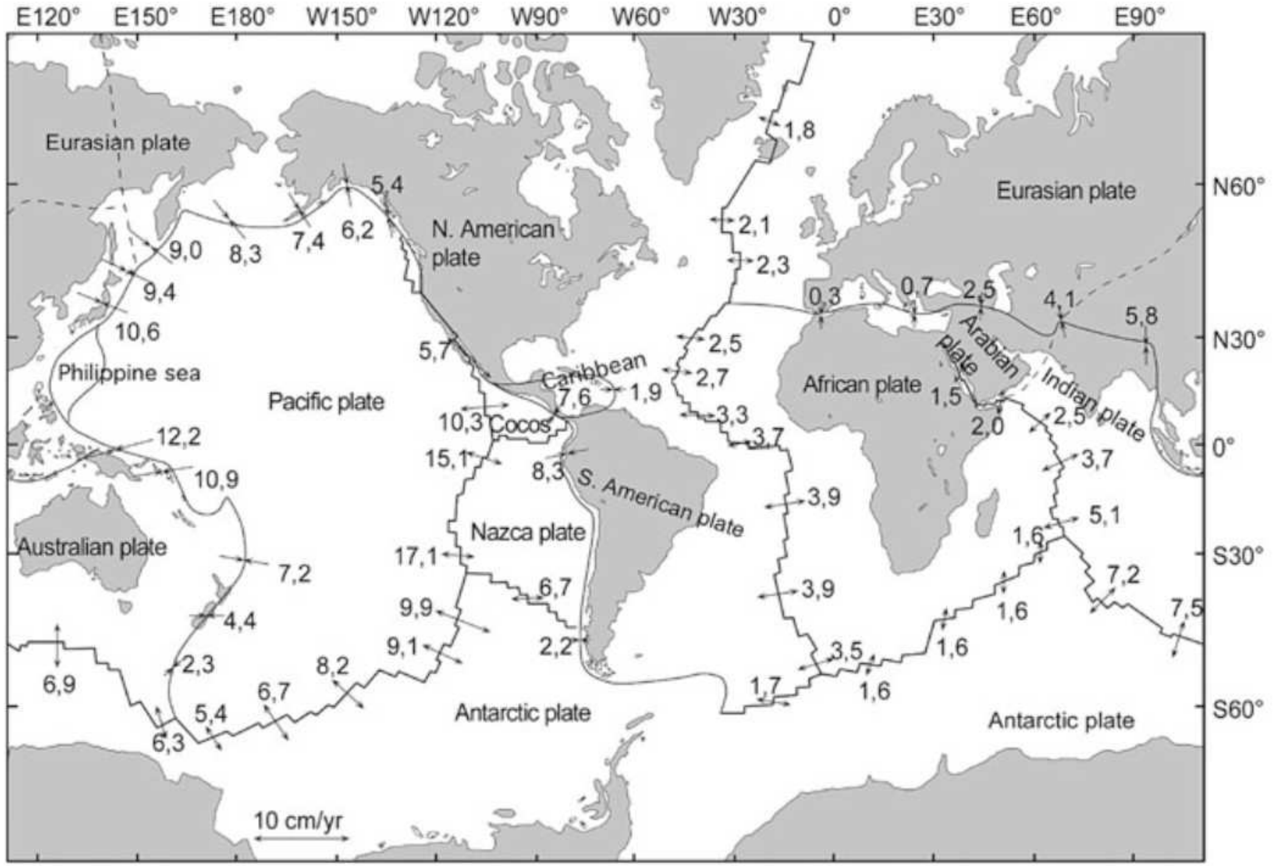
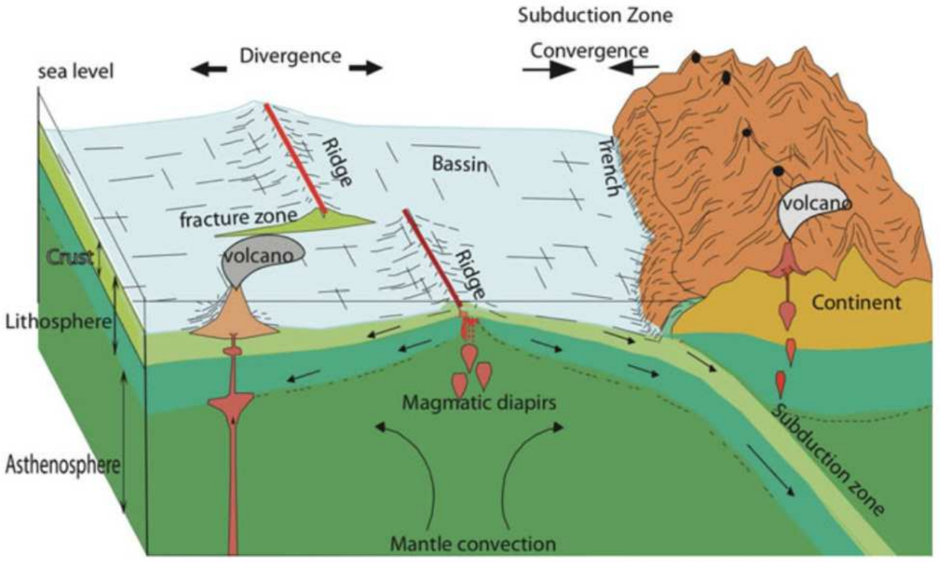


Fig. 2.7 Spreading ridge segments, major faults and subducting zones separate twelve major "rigid" plates. The *arrows* show the direction of tectonic plate motion and the spreading rates (after Hekinian and Binard 2008)

Giant Scientific Question in 1970:
Mid-Ocean Ridges are where Tectonic Plates are Created. But how are plates created?



- How wide is the zone of plate creation?
- Is it mostly volcanic? (basaltic volcanism??)
- If so, why do we find serpentinites (mantle rocks along mid-ocean ridges?
- What do mid-ocean ridge volcanoes look like?
- Do volcanoes cluster near the spreading center? How wide? How active?
- **???? What do mid-ocean ridges actually look like?** (Iceland is one plate where the ridge axis pops above sealevel, but Iceland has hugely anomalous volcanism which is why the ridge axis goes above sealevel.)

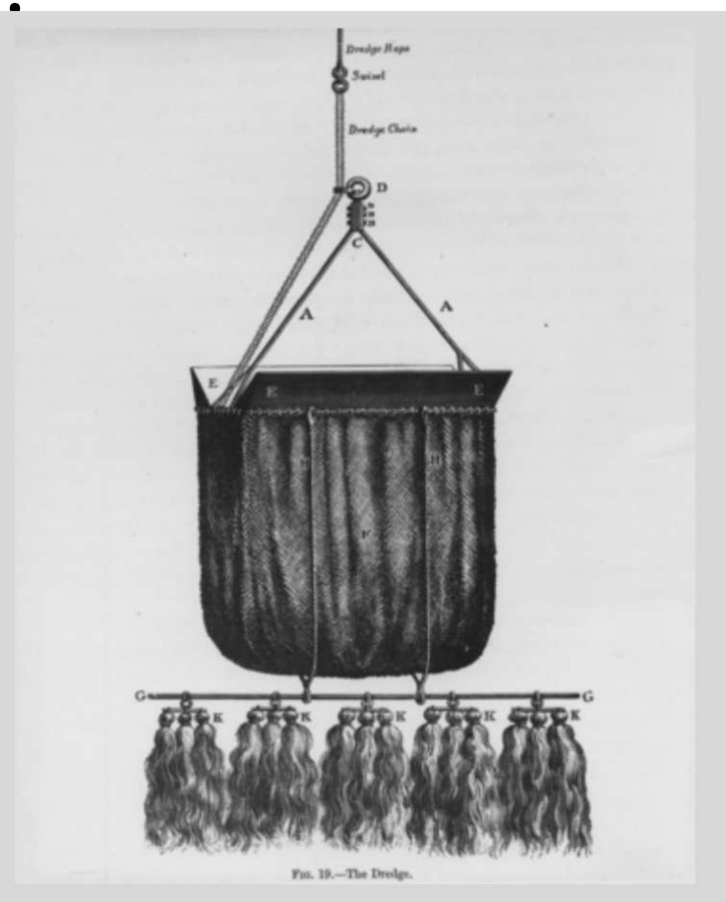
Giant Scientific Question in 1970:
Mid-Ocean Ridges are where Tectonic Plates are Created. But how are plates created?

• We need bathymetric maps of mid-ocean ridges — *what is the shape of the seafloor?*

• We need pictures of the seafloor at mid-ocean ridges. *What does mid-ocean ridge seafloor look like?*

• We need *rocks* from mid-ocean ridges. (*What kinds of basalts are there? What is the variation in these rocks? Are mantle rocks exposed? If so, where?*)

Until now, all rocks from the seafloor have come from dredging – i.e. *dragging a 2x1m wide basket over the seafloor*



Dredge used in 1872-76 *Challenge*
Expedition (like modern dredges!

Spark behind the FAMOUS Expedition: Let's use submersibles and bottom photography to study a spreading center segment and find out!...

• FAMOUS (French-American Mid-Ocean Undersea Survey) initiated in March 1971 at the Oceanexpo meeting in Bordeaux. (Xavier Le Pichon (CNEXO), Claude Riffaud (CNEXO), Commander Gerard de Froberville (French Navy), Bracket Hersey (US NOAA)

• CNEXO had been formed in 1967 to promote French Study of the deep oceans and resist US hegamony in exploitation of potential deep sea riches

– had world-leading submersibles (legacy of development by Jacques Cousteau)

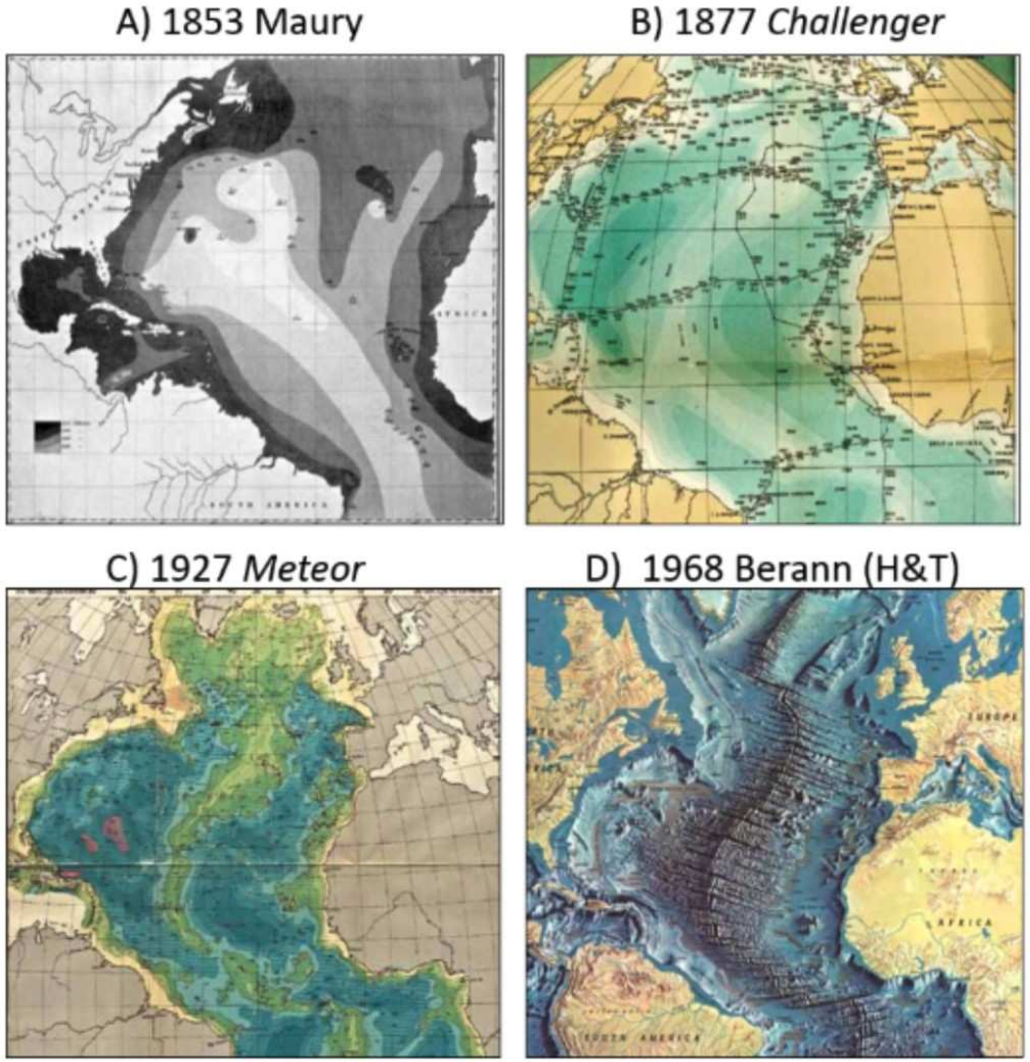
– scientific leader Xavier Le Pichon (34 years old) hired a team of young scientists as researchers

FAMOUS would partner with the US oceanographic community (esp. Woods Hole Ocean. Inst.) to study an accessible segment of the mid-Atlantic Ridge

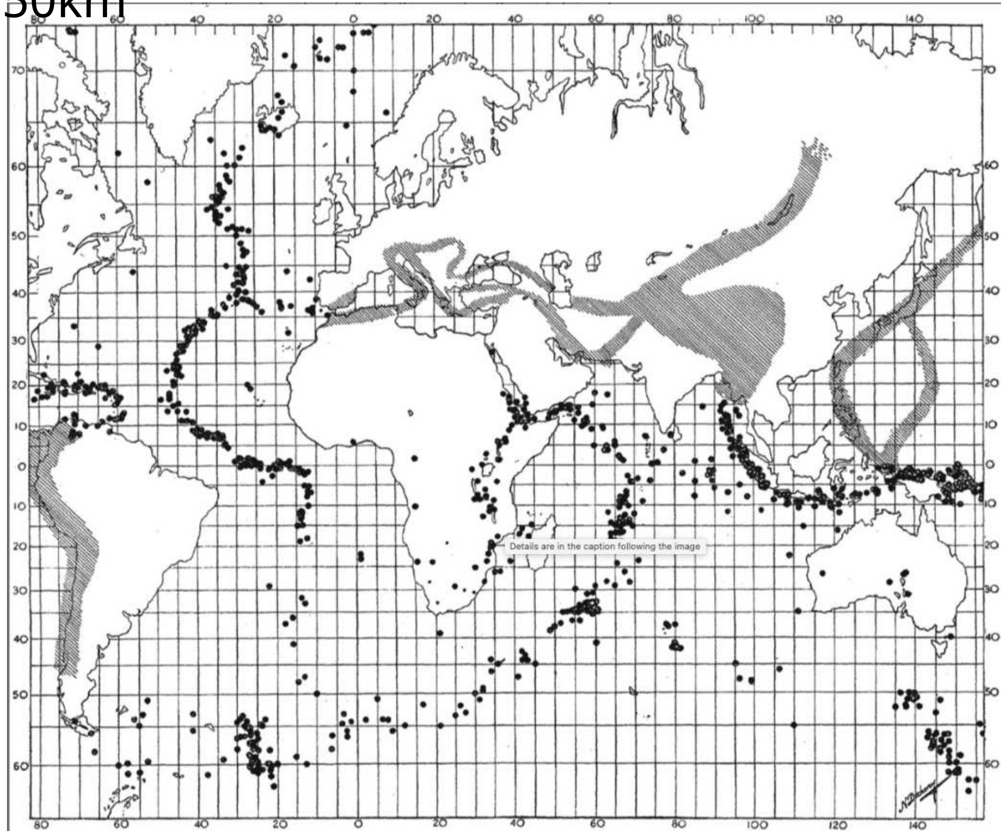
Xavier Le Pichon, (18 June 1937-22 March 2025)

FAMOUS had to do a lot of background work before diving

- Even the location of the ridge axis was not known!
- US Navy collected classified multibeam bathymetry (using GPS for location) to make a classified background map. (*Both GPS and swath-mapping were classified technologies*)
- Until ~1981, in the deep sea, research ships only knew their position to within ±5-10 Nautical miles
- In 1959, compilation of existing ship tracks crossing the Atlantic led to the recognition that the mid-Atlantic Ridge usually had a valley at its center (Bruce Heezen and Marie Tharp)



In 1968,mid-ocean earthquake locations known to ~30-50km



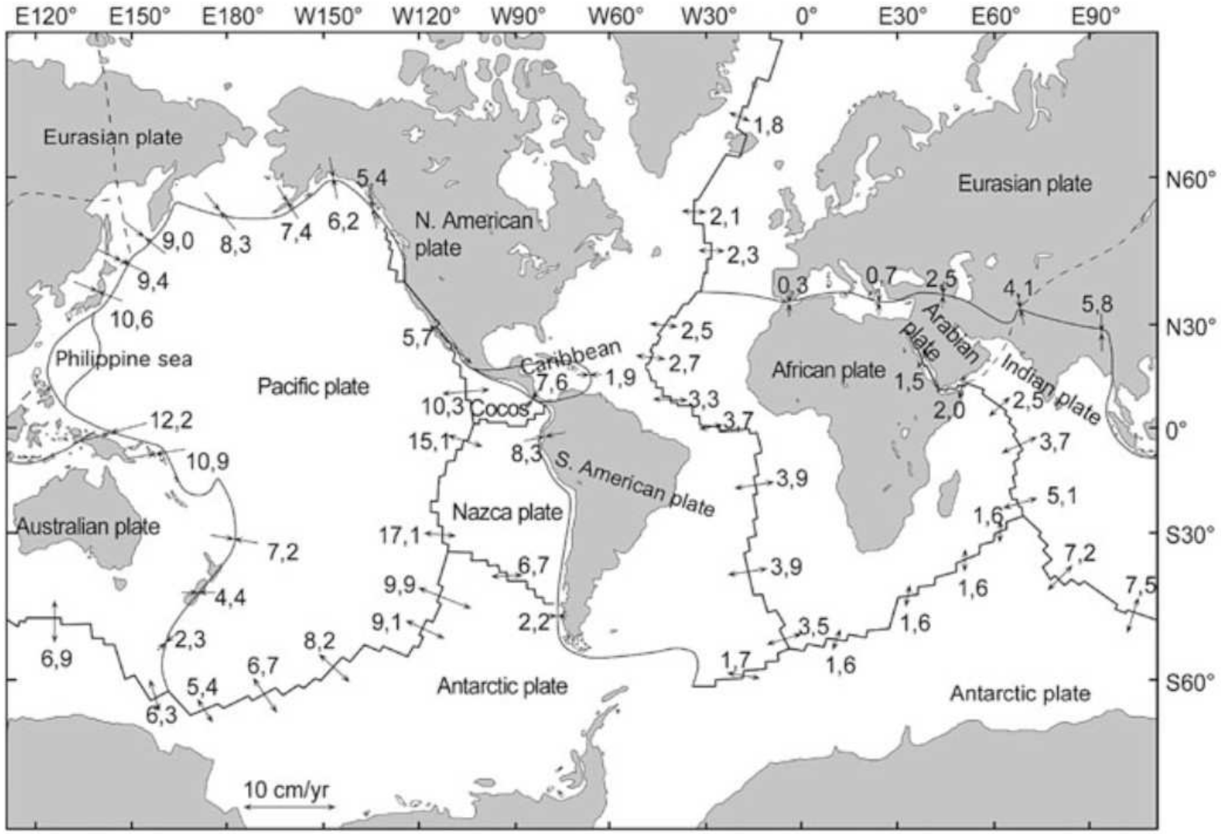
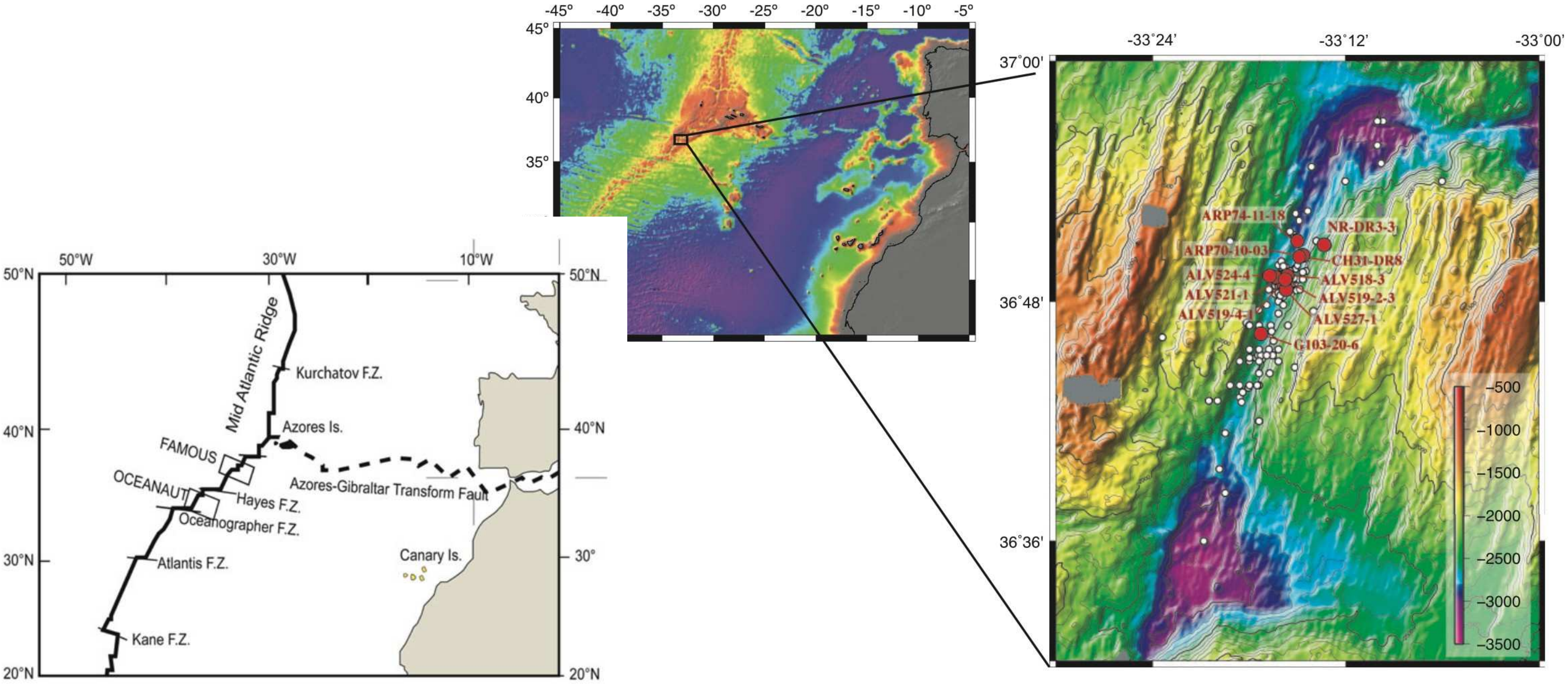
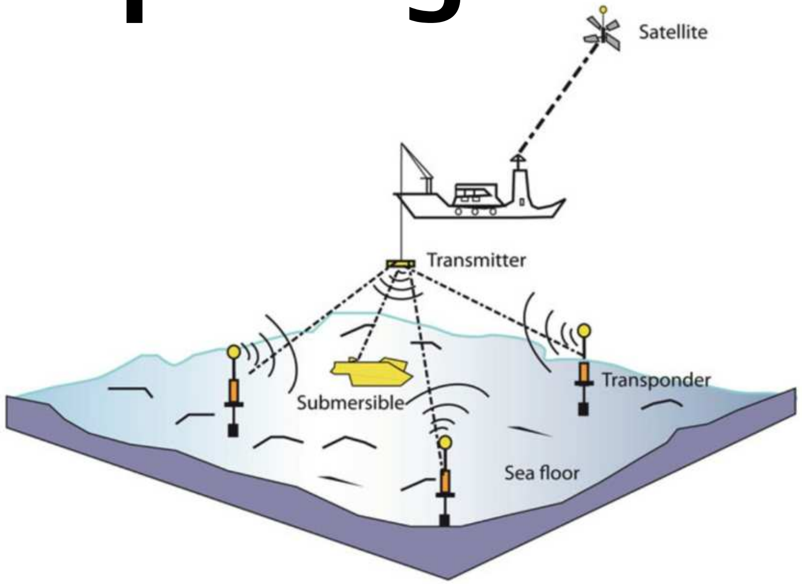


Fig. 2.7 Spreading ridge segments, major faults and subducting zones separate twelve major "rigid" plates. The *arrows* show the direction of tectonic plate motion and the spreading rates (after Hekinian and Binard 2008)

A working bathymetric map in the valley was collected before the start of the diving expeditions

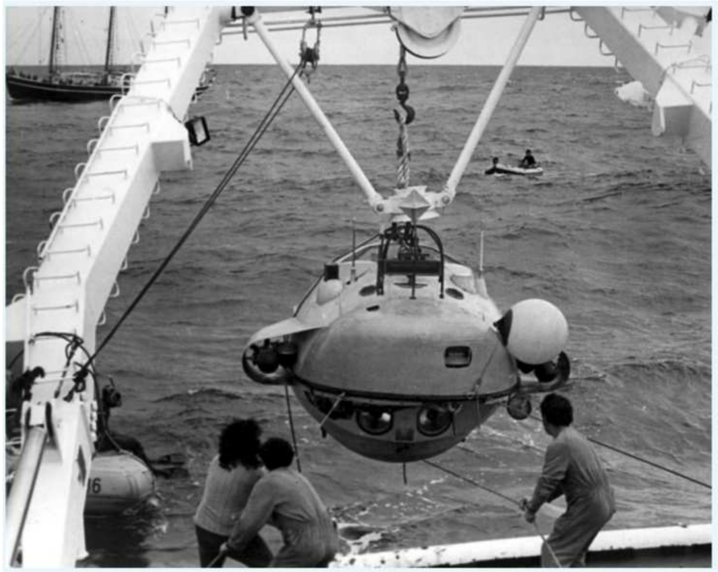


Preparing to dive…



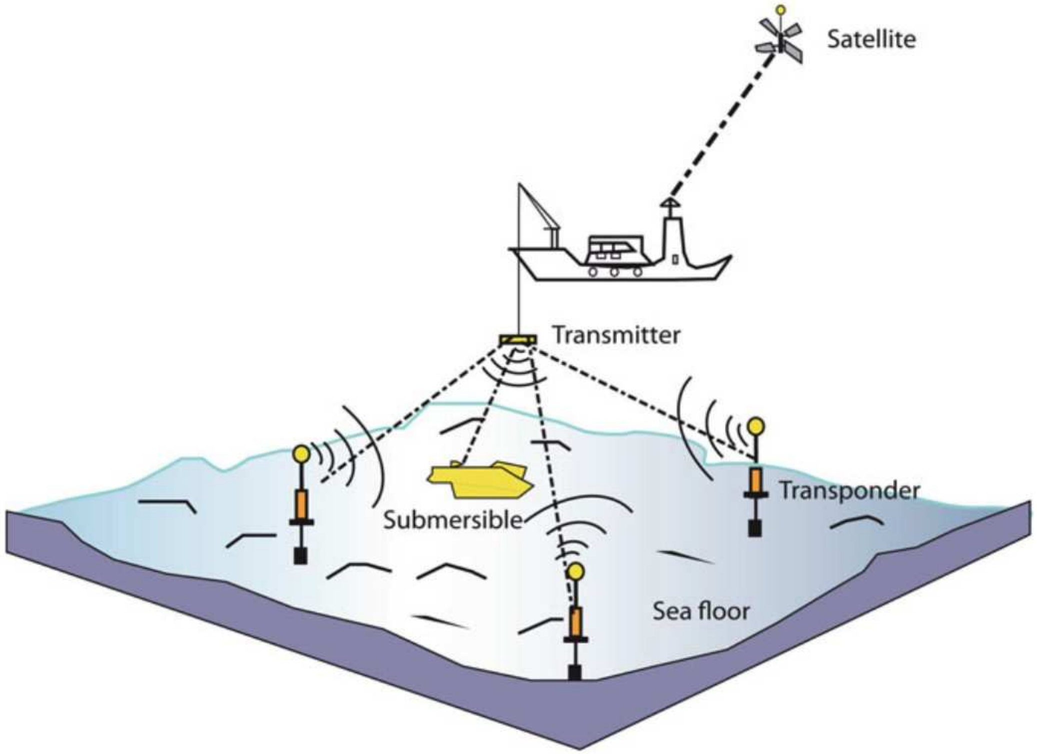
Archimede (bathyscape – too big and expensive for ‘normal research’ but can go *very* deep)

ALVIN at FAMOUS from window of CYANA…

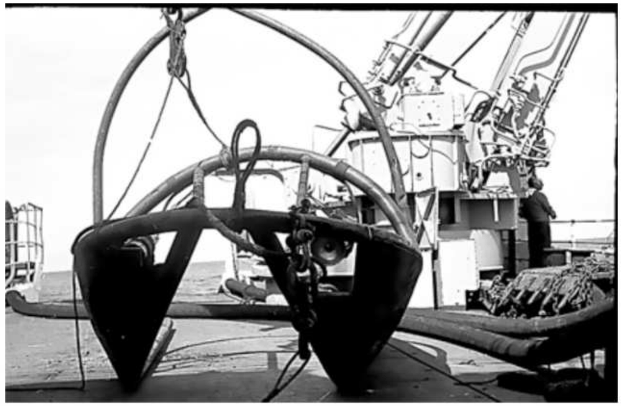


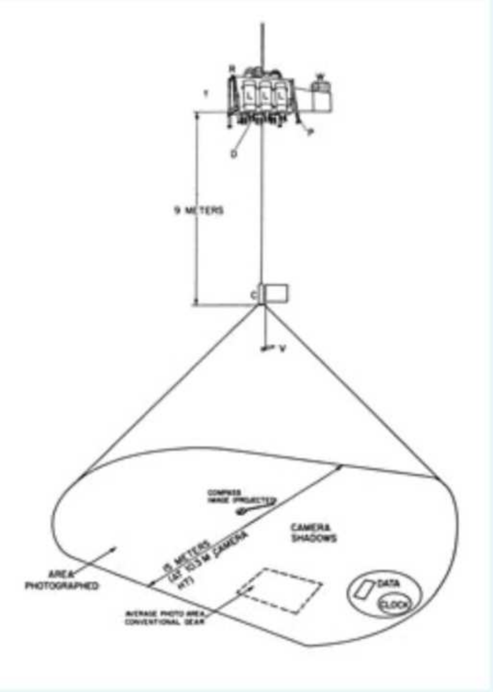
CYANA (diving saucer – 3000m)

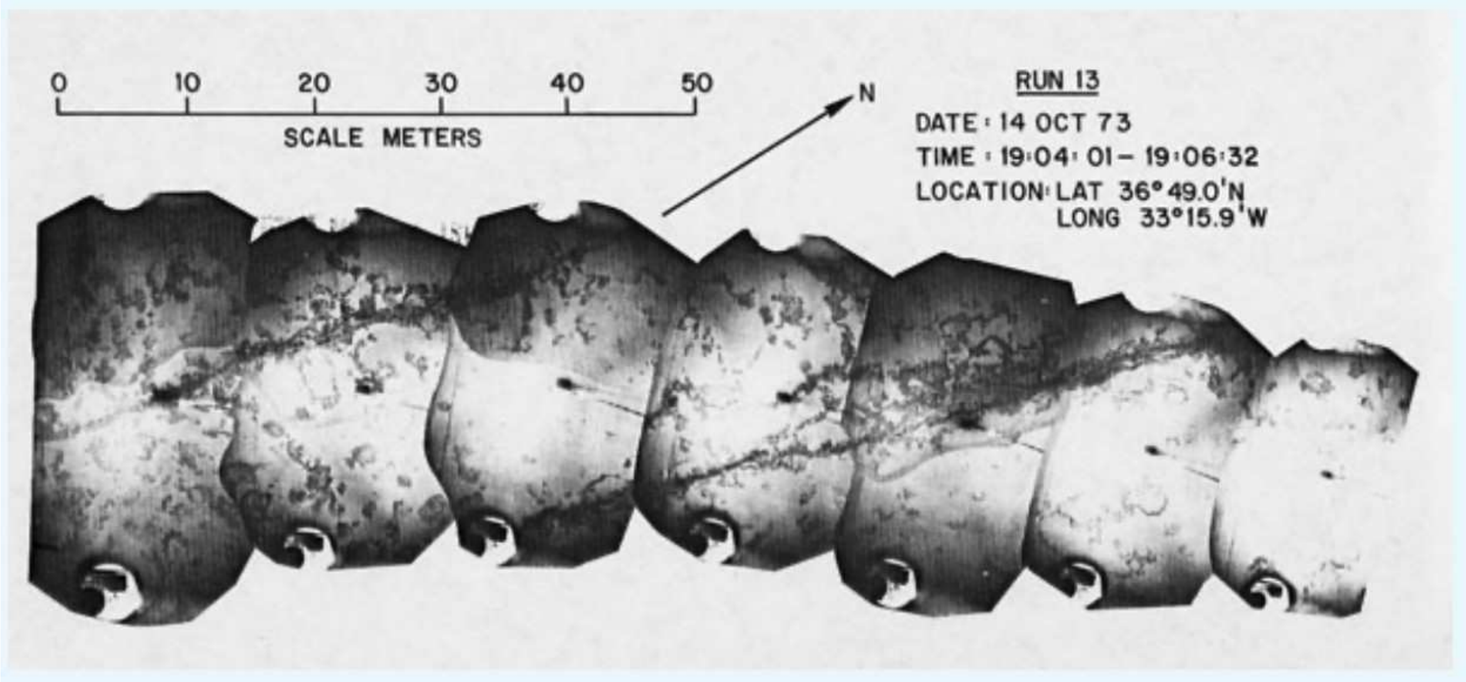
Preparing to dive...



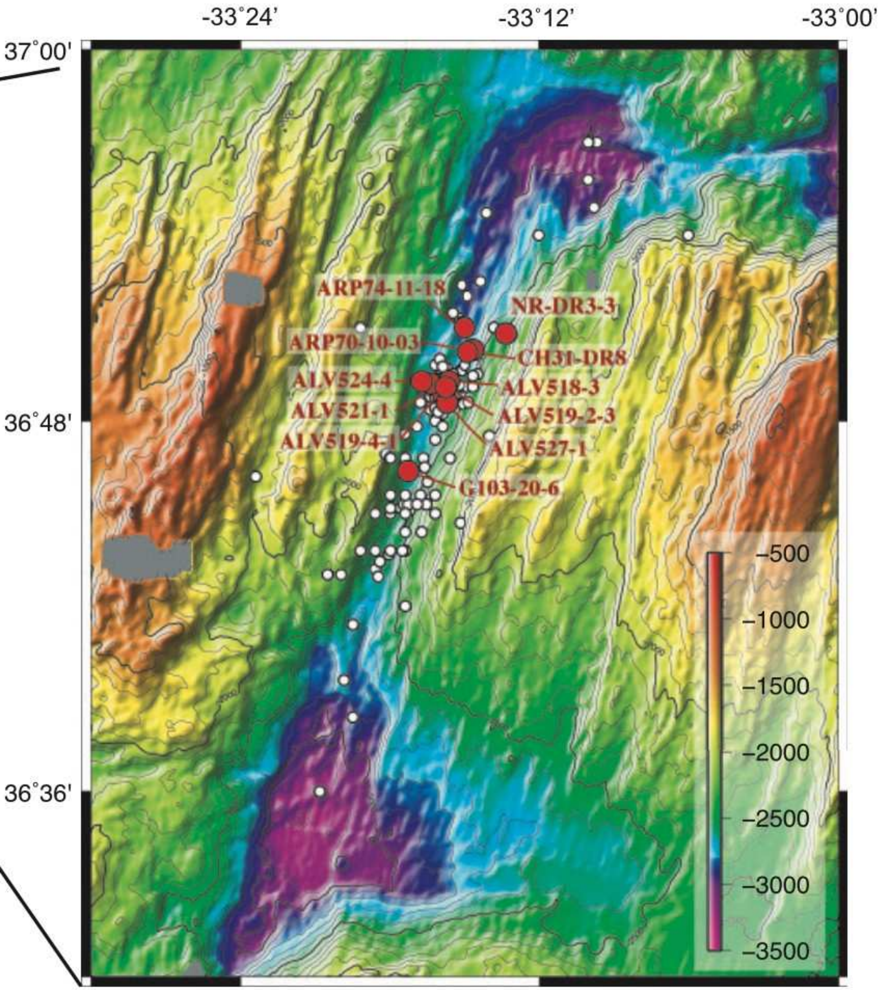
We now have ‘drones’ AUV and deep-towed ROV.



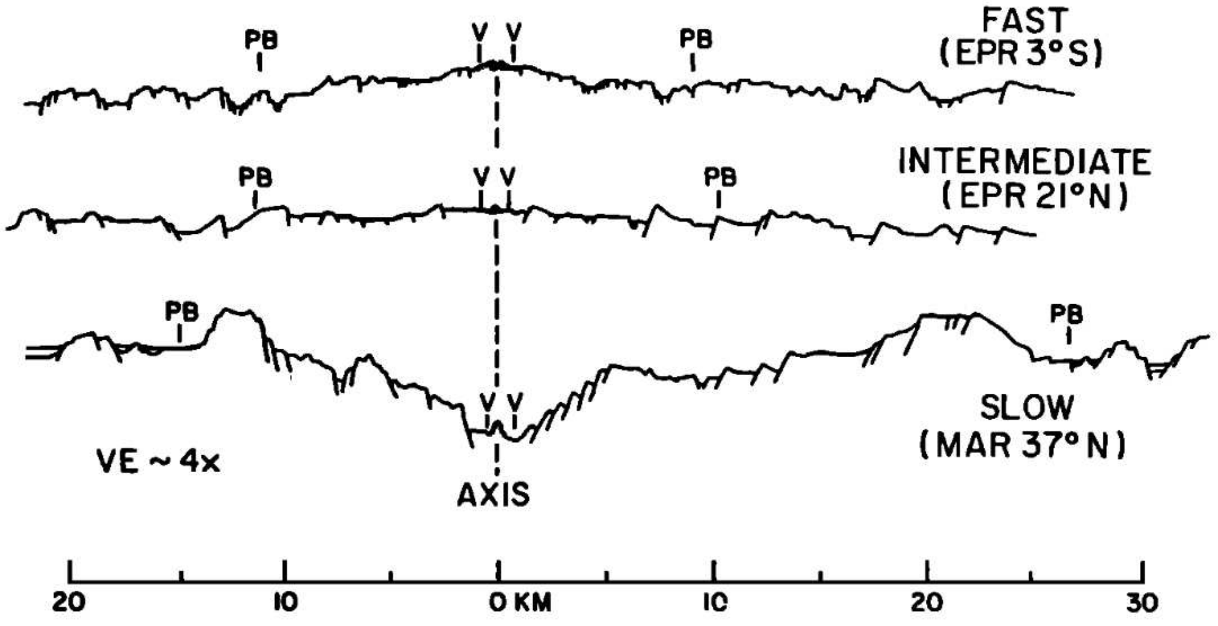




FAMOUS jump-started our knowledge of Mid-Ocean Ridges



- There was indeed a median valley at the Mid-Atlantic Ridge
- Volcanism was wide-spread within the inner median valley
- Volcanism appeared to be fed along-axis from volcanic centers
- There w
amongs



Macdonald (1982)

FAMOUS jump-started our knowledge of Mid-Ocean Ridges

- Pillow lavas…
- hydrothermal rock

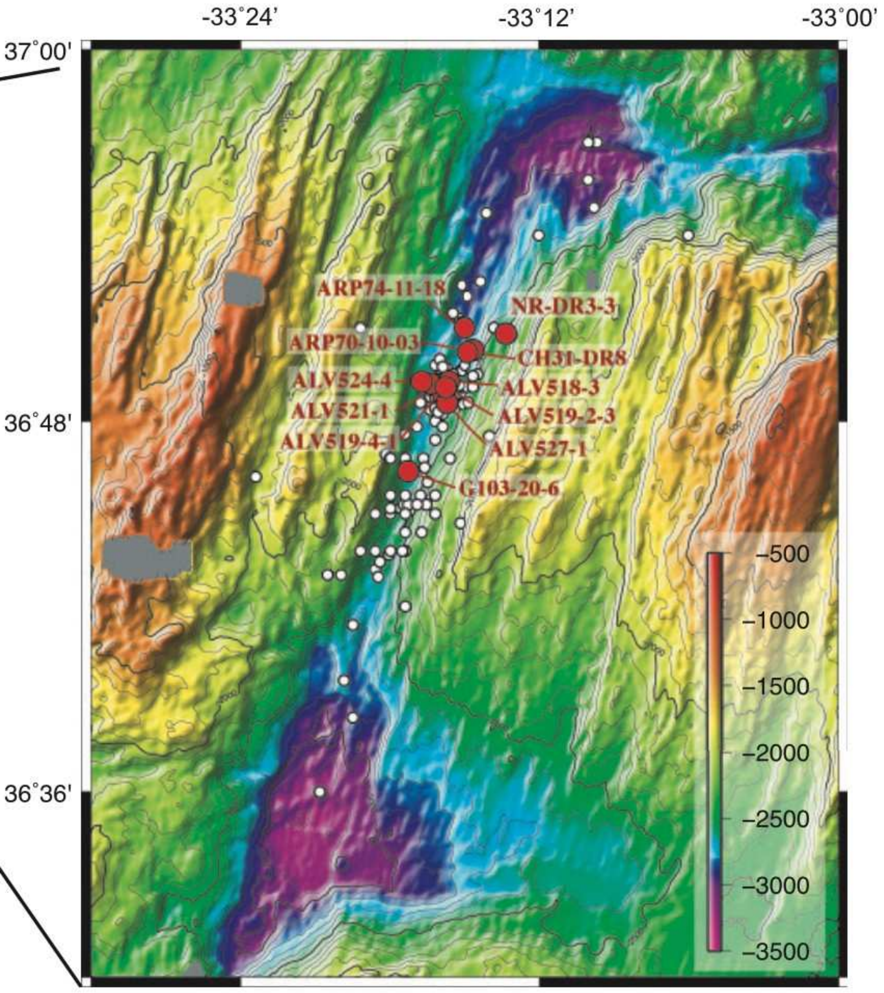
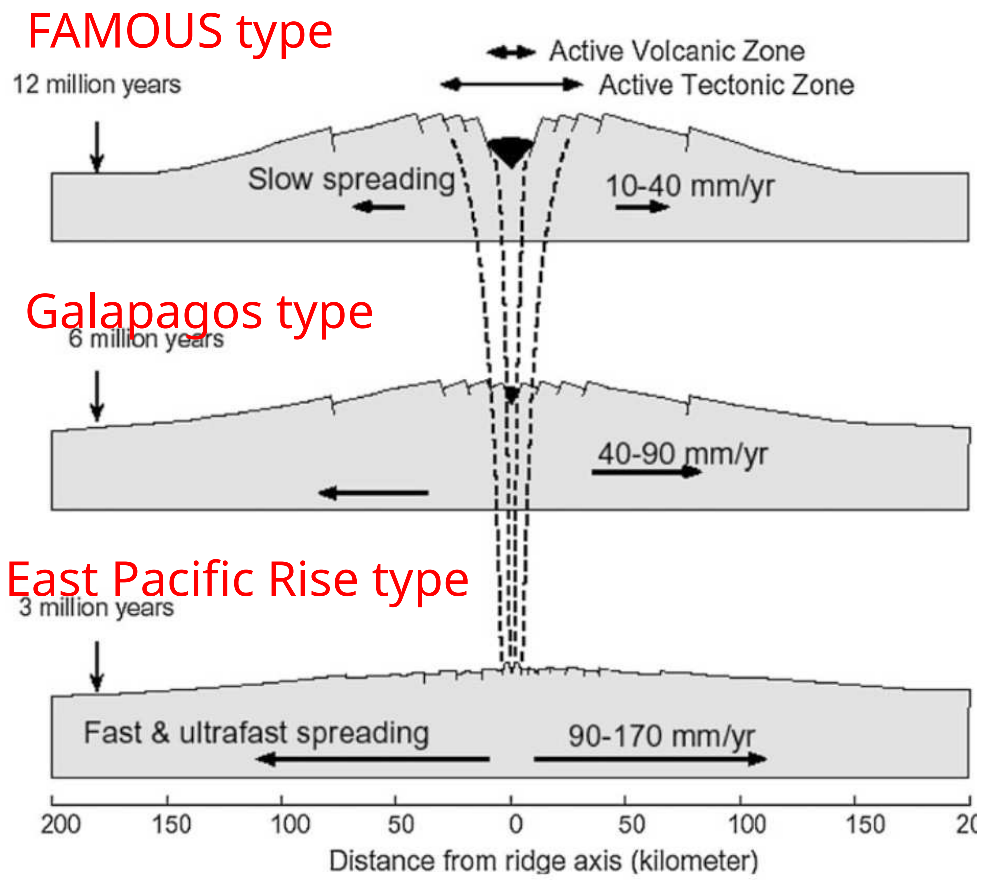


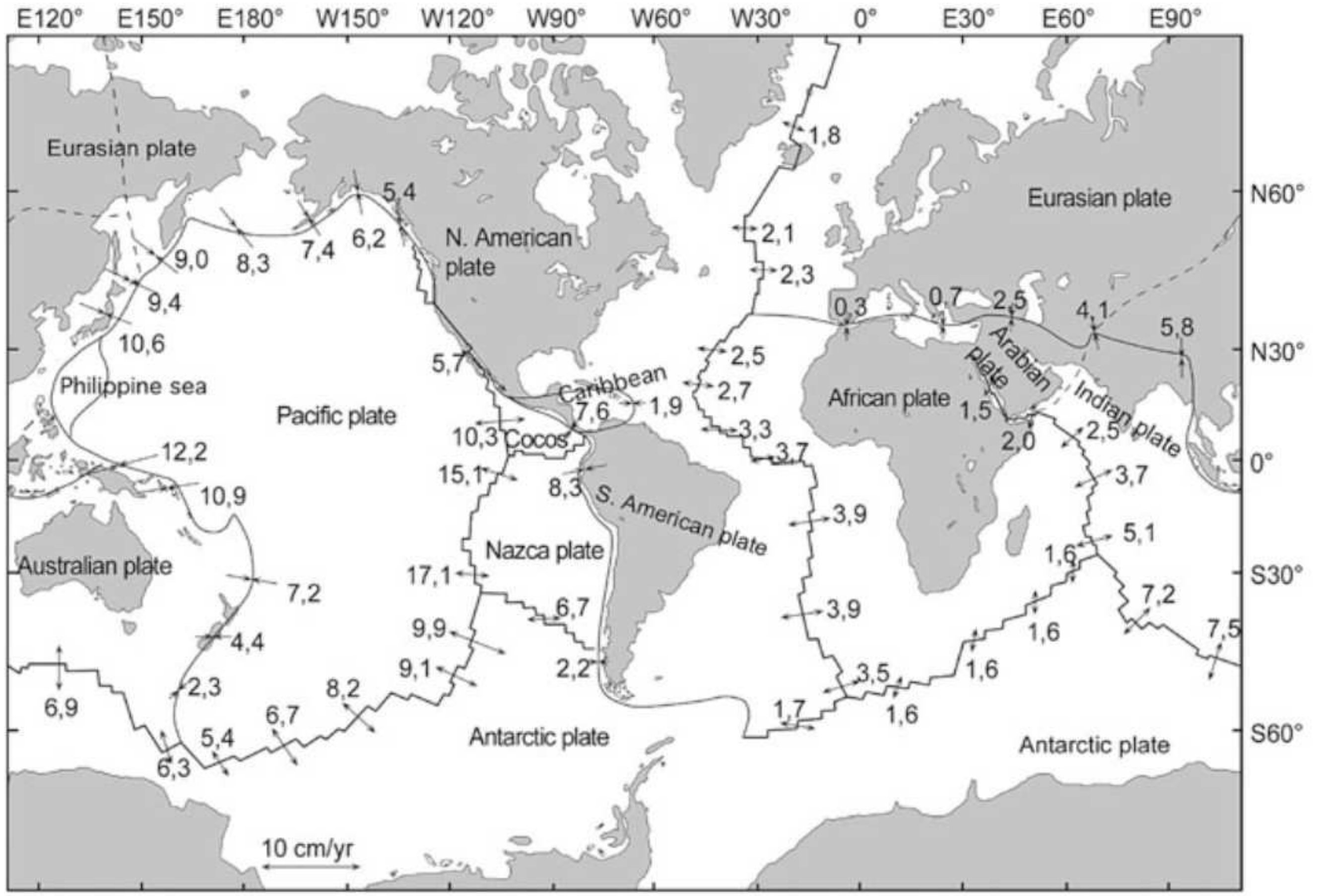
Fig. 7.6 Pillow lava photographed on the eastern flank of Mount Venus during an *Archimède* dive at 2733 m depth on the MAR rift valley at 37°N in the FAMOUS area (Copyright IFREMER, *Project FAMOUS 1973, Archimède dive Ar73-10*)

Fig. 7.7 Iron-silica oxyhydroxide hydrothermal material recovered during a dive (Cy74-76) in transform fault "A" near 37°50′N on the Mid Atlantic Ridge (FAMOUS Project)

The FAMOUS decade 1974-1984

- Explore the surprising variation along the global spreading center system





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The FAMOUS decade 1974-1984

- Explore the surprising variation along the global spreading center system
  - – lava flows, pillow basalts (which we can see erupting underwater in Hawaii)

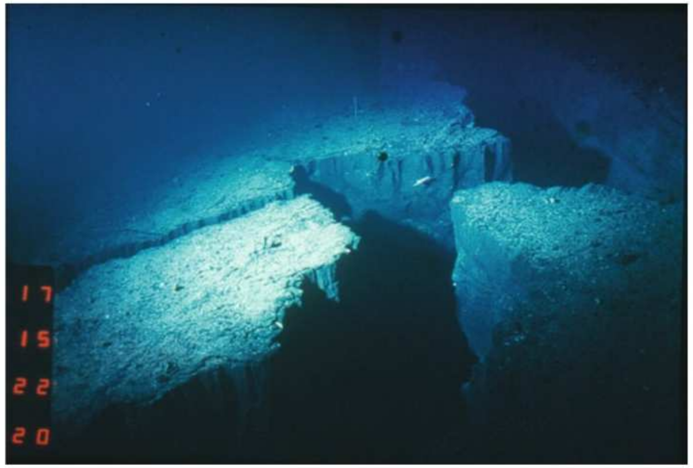


Fig. 5.3 Photograph shows a fissure in the axial graben of the East Pacific Rise segment at 12°50′N, 2606 m depth. The fissure is about 1 m wide and more than 10 m deep. Fissures and fractured crust are pathways for magma extrusion on the sea floor. (Copyright IFREMER, *Cyathem cruise 1982, Cyana dive Cy82-09.*)

Fig. 5.4 Lau Basin showing a columnar dyke complex taken during the *Starmer I* cruise by the submersible Nautile (from Lagabrielle et al. 1994). The dolerite dykes are located in the North Fiji back-arc basin (Lau Basin), at the intersection of a triple-junction between two spreading ridge segments and a fracture zone near 16°40′S–174°W. (Copyright IFREMER, *Starmer I cruise 1989, Nautile dive PL07*)

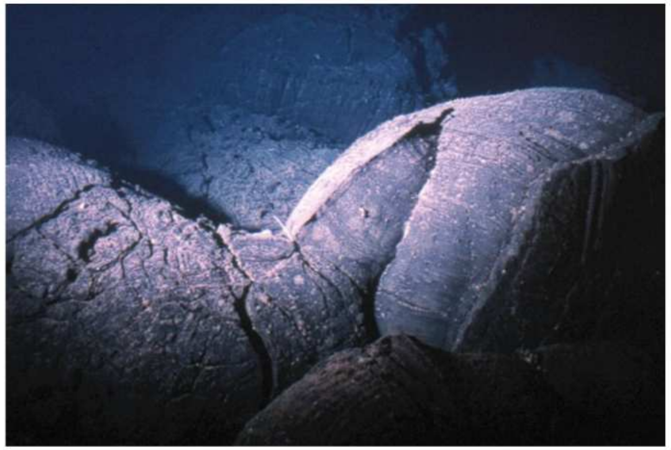
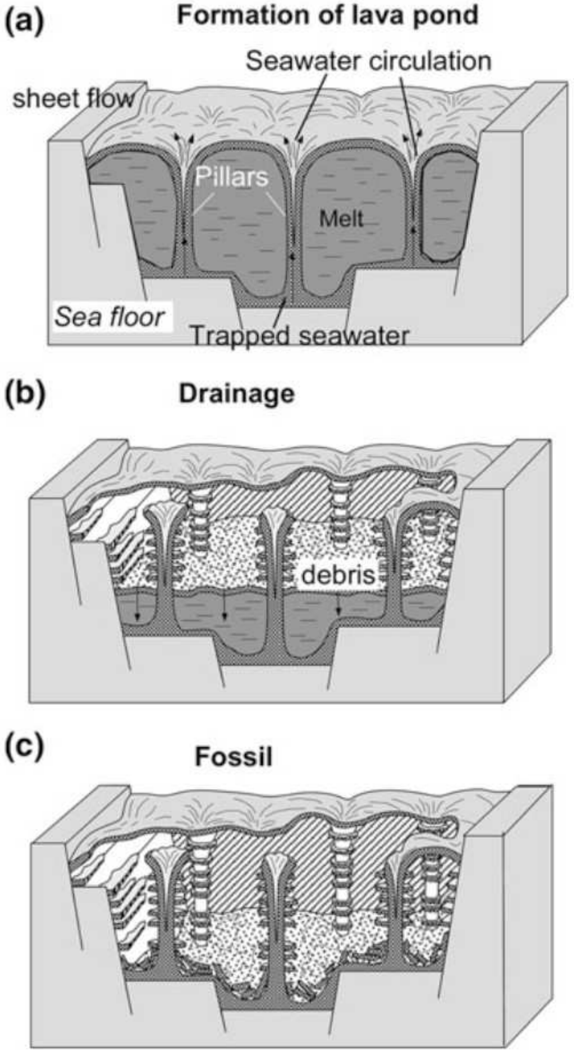


Fig. 5.6 Photograph of a pillow lava from the East Pacific Rise axis at 12°50′N shows the recent extrusion of lava seen at 2628 m depth. (Copyright IFREMER, *Geocyatherm cruise 1982, Cyana dive Cy82-09*)

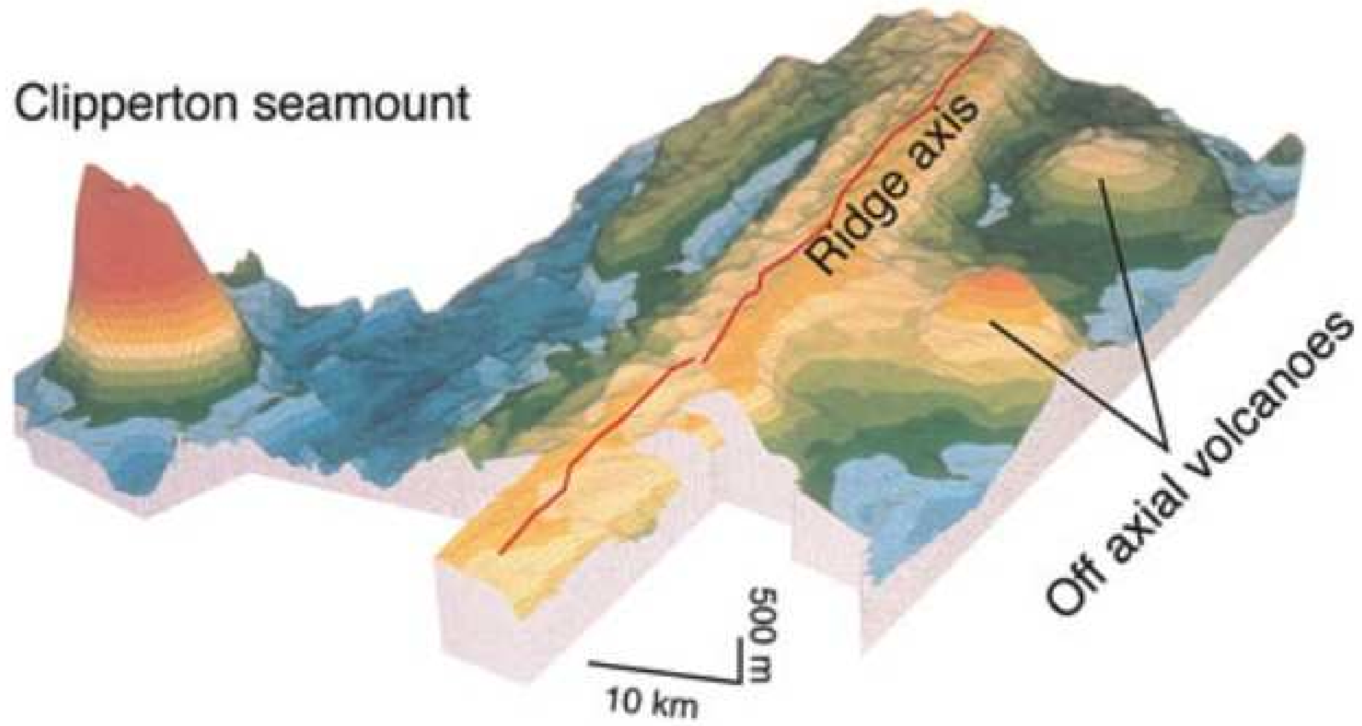
The FAMOUS decade 1974-1984

- Explore the surprising variation along the global spreading center system
  - – lava flows, pillow basalts (which we can see erupting underwater in Hawaii)

Fig. 5.10 Pillar remains of a collapsed lava pond (2,600 m depth) in the axial graben of the EPR at 21°N taken during the Cyamex cruise (Cyamex scientific team 1978). (Copyright IFREMER, *Cyamex cruise 1978, Cyana Dive Cy78-12*)



• Swath mapping and research GPS let scientists more routinely map MORs

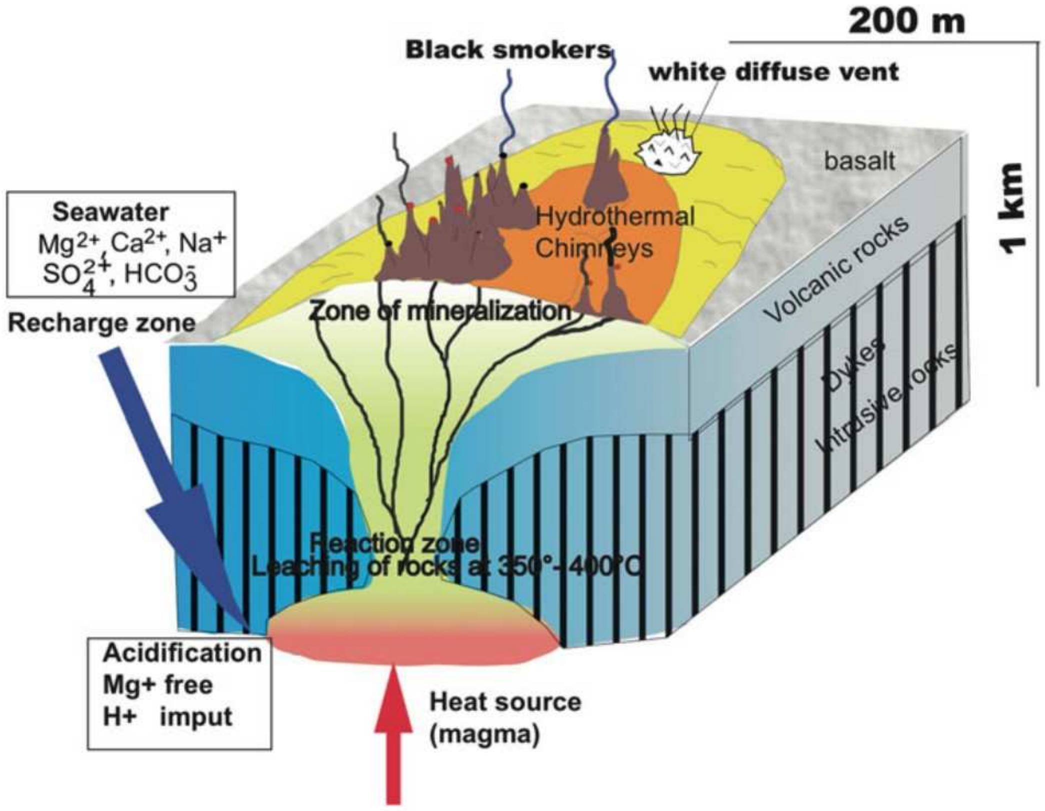


East Pacific Rise
(fast spreading ridge)

Here too France led scientific research, buying a US Seabeam system in 1978 for the Jean Charcot. Once French researchers had multibeam, US scientists successfully lobbied for access to this technology. Now Europe (SIMRAD) is arguably the world-leader in this seafloor

The FAMOUS decade 1974-1984

- Discovery of active hydrothermal vents in 1979 (black smokers, white smokers, seeps)



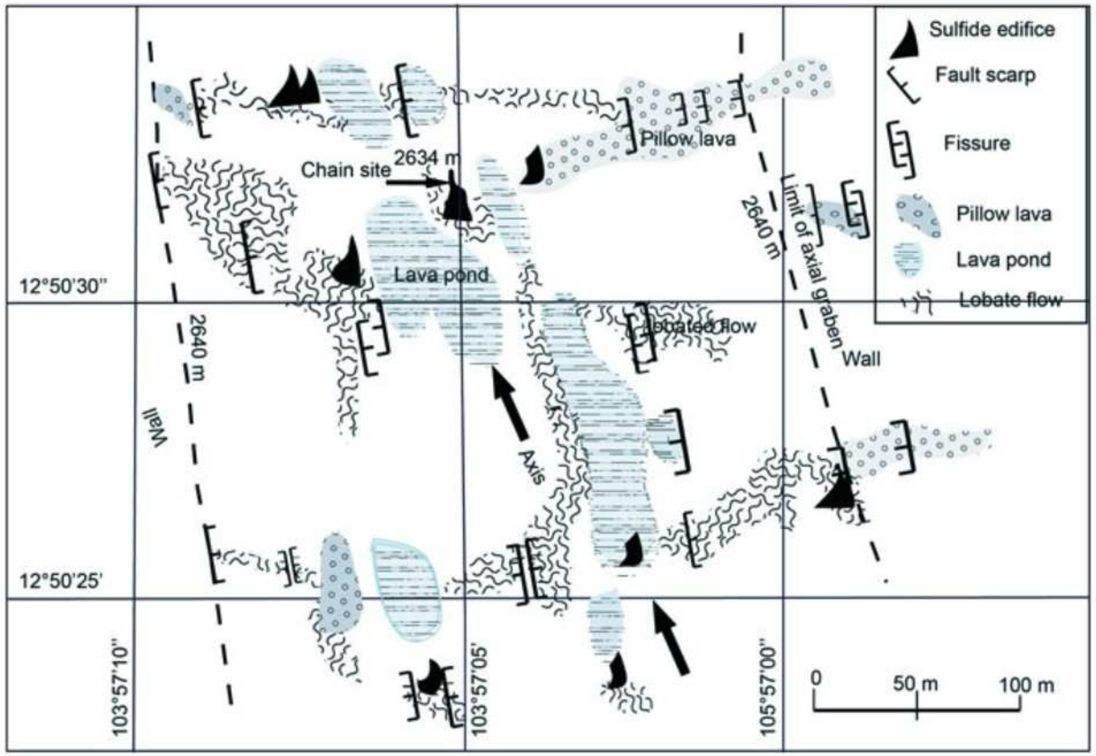


Fig. 7.20 Geological map made during six dives that criss-crossed the axial graben from wall to wall (EPR at 12°50′ N at 2550–2650 m depth) (See also Fig. 7.15, ridge axis area). The lava morphology is indicated: *grey* with *open circles* = pillow lava formation, *grey* with *hashed lines* = lava pond depression, *squiggle lines* = lobated sheet flows. The active hydrothermal edifices are shown by black *irregular triangles*

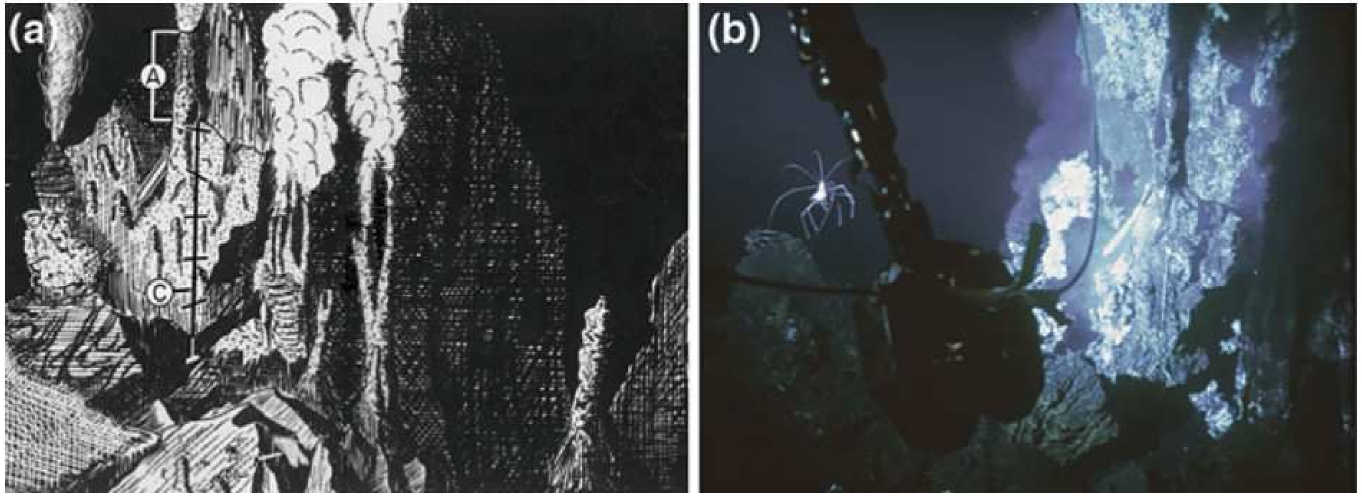
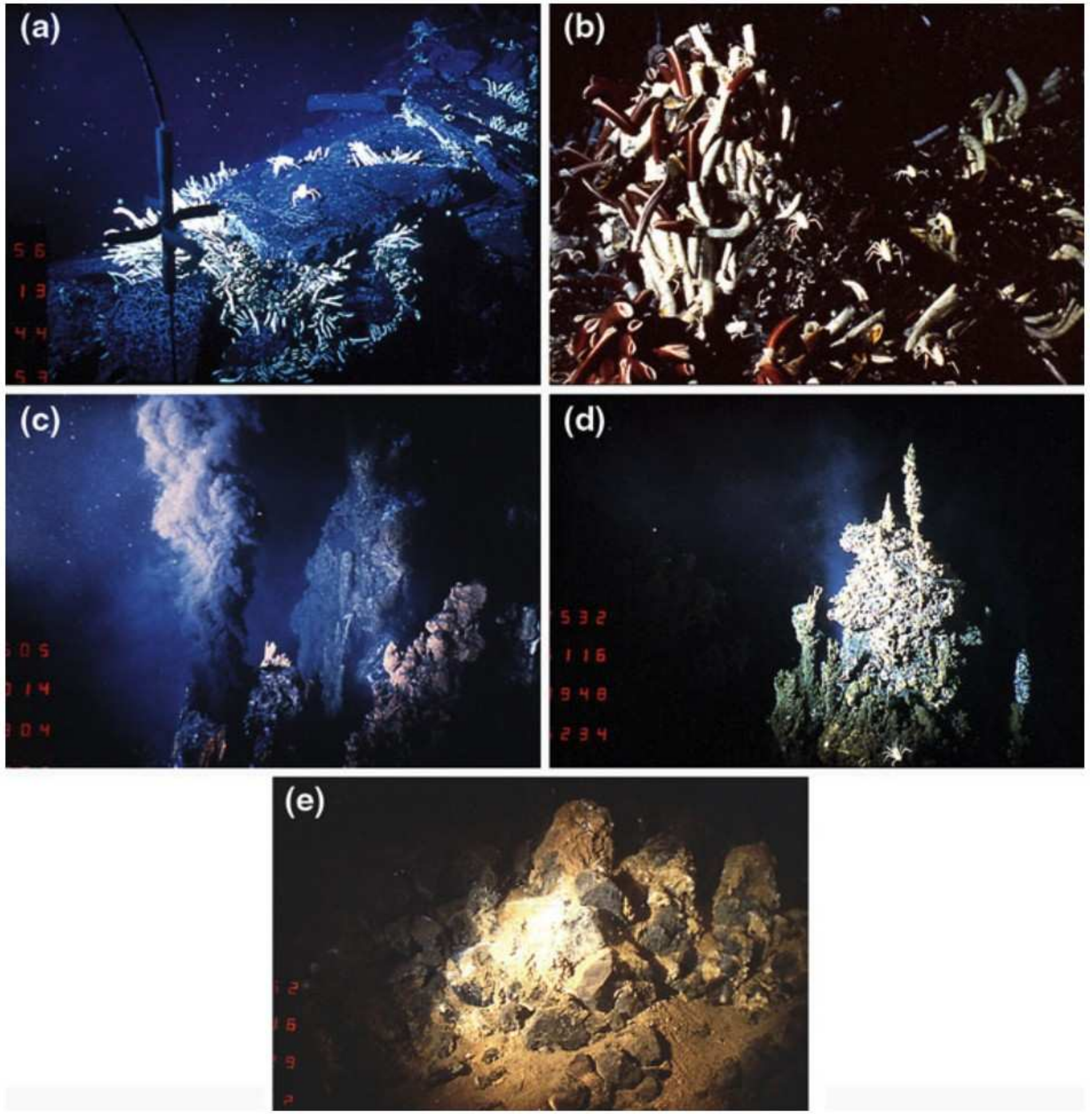


Fig. 7.21 **a** Sketch of the graduated chain device made to measure the growth of a hydrothermal chimney on the sea floor. **b** On February 19, 1982, a graduated chain device was laid on top of a "black smoker" chimney to visualize the growth rate of a hydrothermal chimney on the axis of the EPR near 12°50′N at 2634 m depth. Five days later the graduate chain was sealed by the growth of a chimney. (Photo courtesy *IFREMER Geocyatherm cruise, Cyana dive Cy82-25)*

Return (5-day) measurements revealed that Black Smokers could grow at speeds of cm/day…

The FAMOUS decade 1974-1984

- Discovery of chemosynthetic life at hydrothermal vents



After 1984, the basic textbook picture was largely formed.
Of course, more knowledge has led to many more questions…