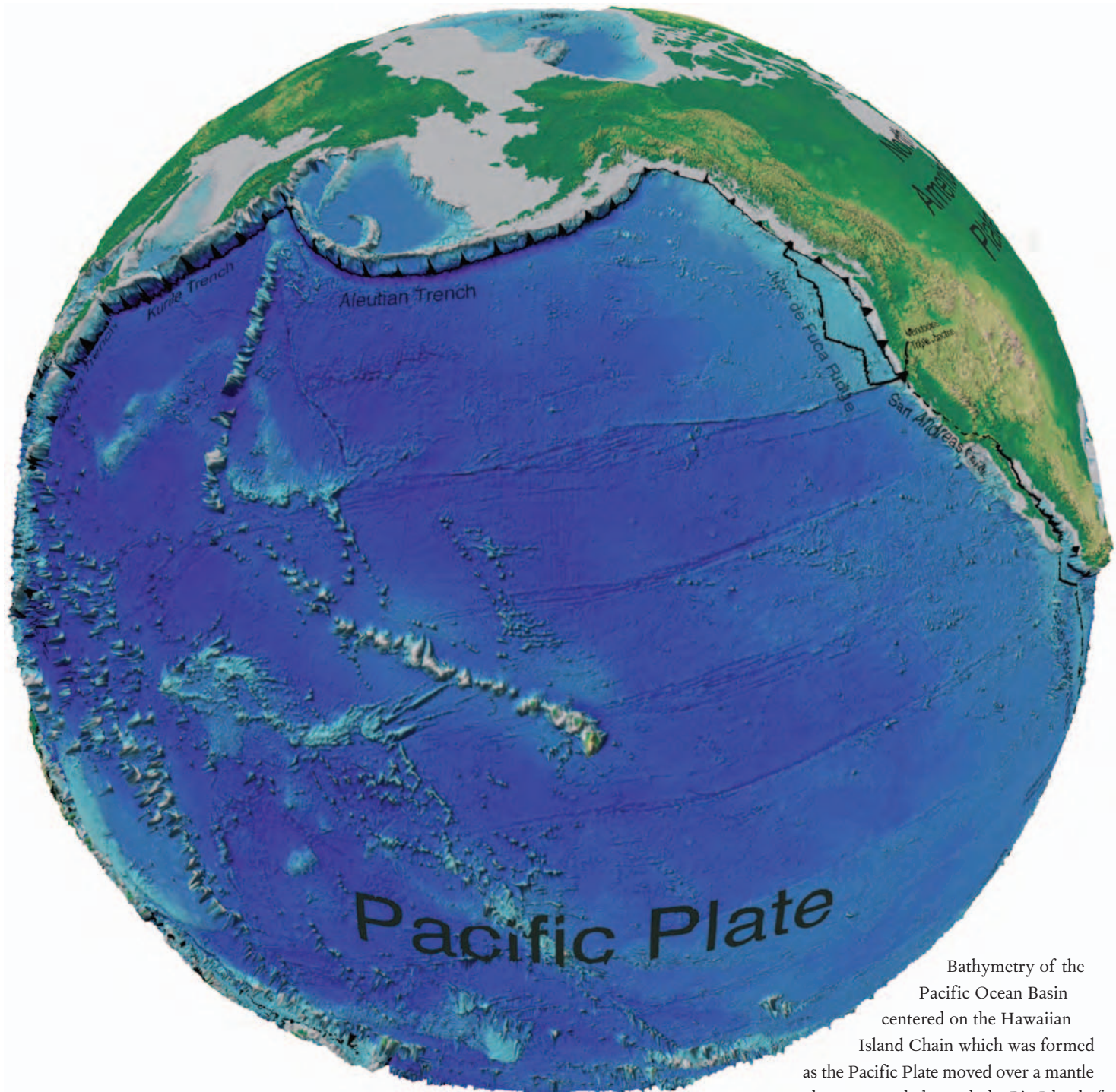


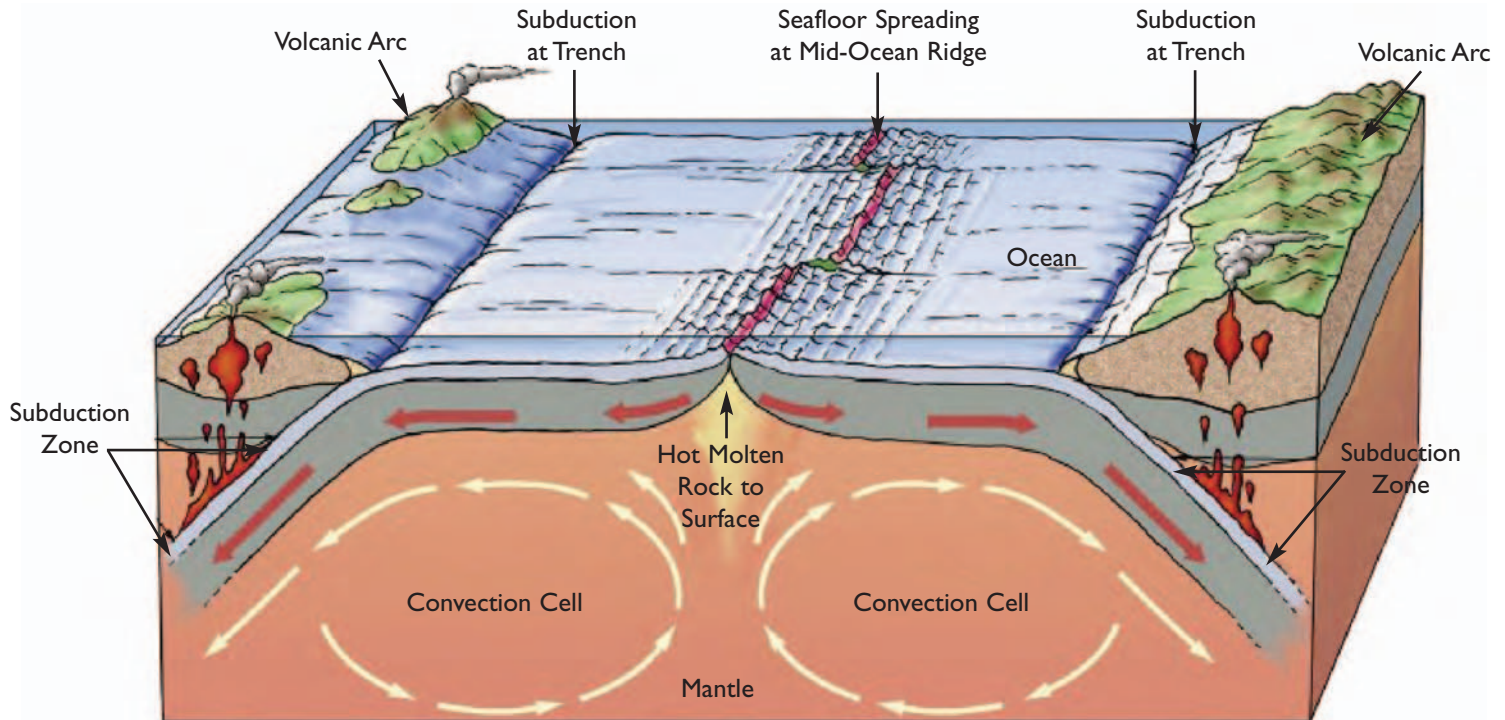
# Ocean Bathymetry and Plate Tectonics

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More than two-thirds of our planet is covered by deep oceans. What would the Earth look like if we could drain the oceans? You would probably ask for a window seat on your next flight to Hawaii. Today we know the topography of Mars 100 times better than the topography of the oceans. Why are the oceans so poorly surveyed? What would you see if

Bathymetry of the Pacific Ocean Basin centered on the Hawaiian Island Chain which was formed as the Pacific Plate moved over a mantle plume currently beneath the Big Island of Hawaii. Hawaii is the tallest feature on our planet rising 9,700 meters (31,800 feet) above the seafloor. (Data derived from sparse ship soundings and dense coverage from the GEOSAT (US Navy 1985) and ERS-1 (ESA 1994) satellite altimeters.)



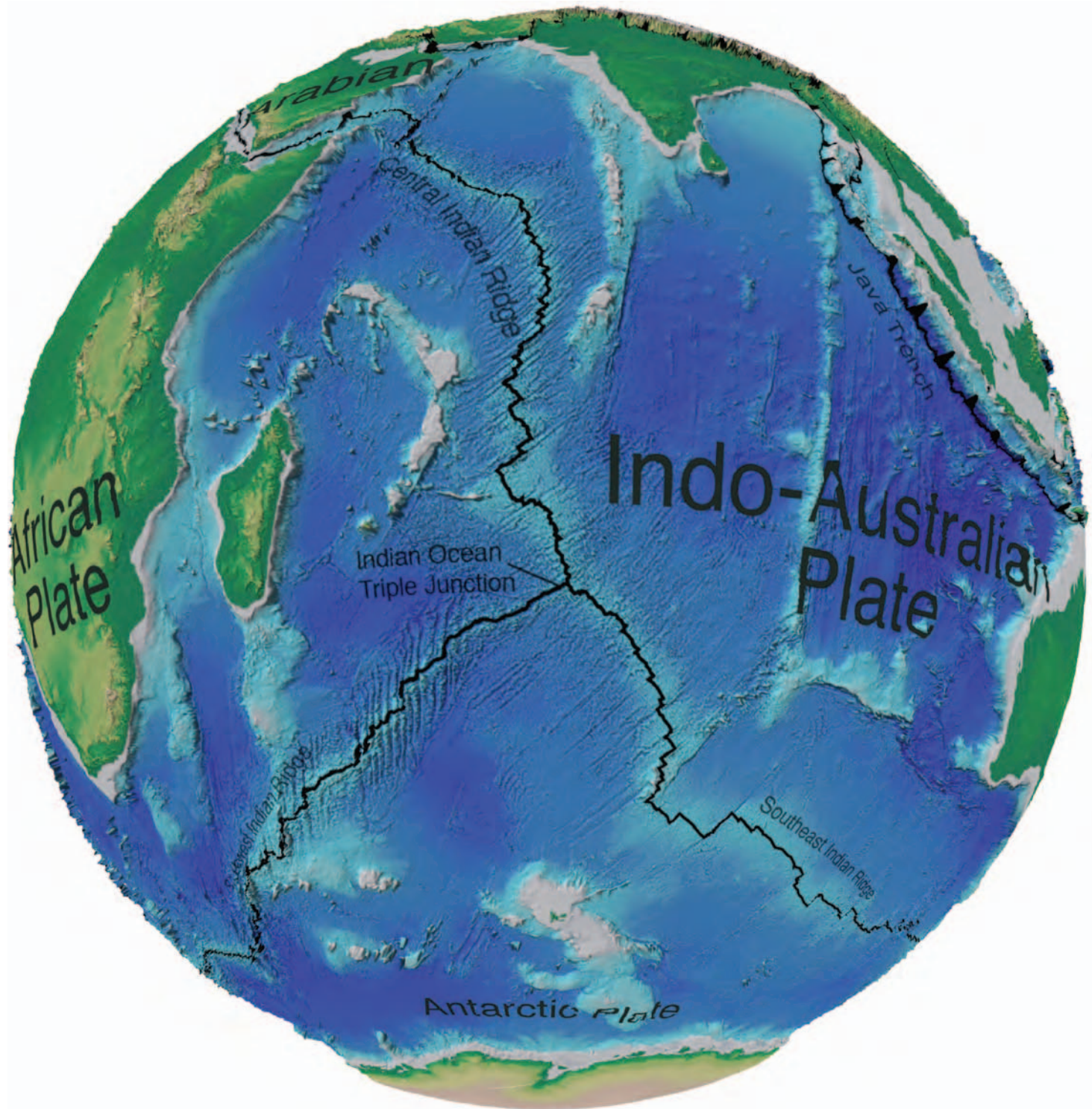
Model of global plate tectonics includes three types of plate boundaries that shape the seafloor bathymetry. Seafloor spreading creates an axial rift and corrugated hills. Spreading ridges are offset by transform faults where some of the most destructive earthquakes occur. Subduction of the cooled plate into the mantle creates the deep ocean trenches and produces major earthquakes and tsunamis. The plates act as giant radiators of heat. They cool, thicken, and gradually subside as they progress from ridge to trench forming the broad-scale patterns of ridges and deep ocean basins.

we could drain the oceans and how is this related to plate tectonics? How has seafloor mapping technology evolved over the past 40 years?

The bathymetry of the ocean floor reflects plate tectonics processes associated with global-scale mantle convection. There are three types of plate boundaries each producing a characteristic type of seafloor bathymetry. The ridge axes represent a singular point in the system where the upwelling magma meets cold seawater. Hydrothermal cooling of magma chambers at the ridge axes recycles the entire volume of the ocean in just a few million years and delivers nutrients for transient biological communities on the seafloor. Scientists believe that life originated in these hydrothermal environments and that hydrothermal circulation is critical for maintaining life on the Earth.

Since one cannot directly map the topography of the ocean basins from space, most seafloor mapping is a tedious process that has been carried out over a 40-year period by research vessels equipped echo sounders. So far only a few percent of the oceans have been surveyed at the 200-meter resolution. It has been estimated that 125-200 ship-years of survey time will be needed to map the deep oceans and this would cost a few billion dollars. Mapping the shallow seas would take much more time and funding. Fortunately, such a major mapping program is largely unnecessary because the ocean surface has broad bumps and dips which mimic the topography of the ocean floor. The extra gravitational attraction of features on the seafloor produces minor variations in the pull of gravity that produce tiny variations in ocean surface height. These bumps and dips can be mapped using a very accurate radar altimeter mounted on a satellite.

The ability to infer seafloor bathymetry from Space was first demonstrated in 1978 using Seasat altimeter data but the spatial coverage was incomplete because of the short three-month lifetime of the satellite. Most ocean altimeters have repeat ground tracks with



track spacings of hundreds of kilometers so they cannot be used to infer bathymetry. Adequate altimeter coverage became available in 1995 when the United States Navy declassified radar altimeter data from one of their mapping missions flown in 1985. With today's technology, a new altimeter mission could achieve a five-fold improvement in global ocean floor bathymetry.

The bathymetry of the Indian Ocean reveals the triple junction between the African Plate, the Indo-Australian Plate, and the Antarctic Plate. Fracture zones record the direction of spreading at these three plate boundaries. The large-scale bathymetry is dominated by cooling and subsidence of the plates as they slide away from the ridge axes. (Data derived from sparse ship soundings and dense coverage from the GEOSAT (US Navy 1985) and ERS-1 (ESA 1994) satellite altimeters.)

Modern tools for mapping the deep ocean floor. (top) A shipboard multibeam echo sounder uses sound waves to map 10-20 km wide swaths at  $\sim 200$  horizontal resolution. (bottom) An Earth-orbiting radar cannot see the ocean bottom, but it can measure ocean surface height variations induced by ocean floor topography. While the resolution of the echo sounder technique is far superior to the resolution of the satellite altimeter technique, complete mapping of the deep oceans using ships would take 200 ship-years at a cost of billions of dollars. Indeed, the shipboard and altimeter methods are highly complementary. When interesting features are discovered in satellite gravity, these can be surveyed in fine detail by ships.

