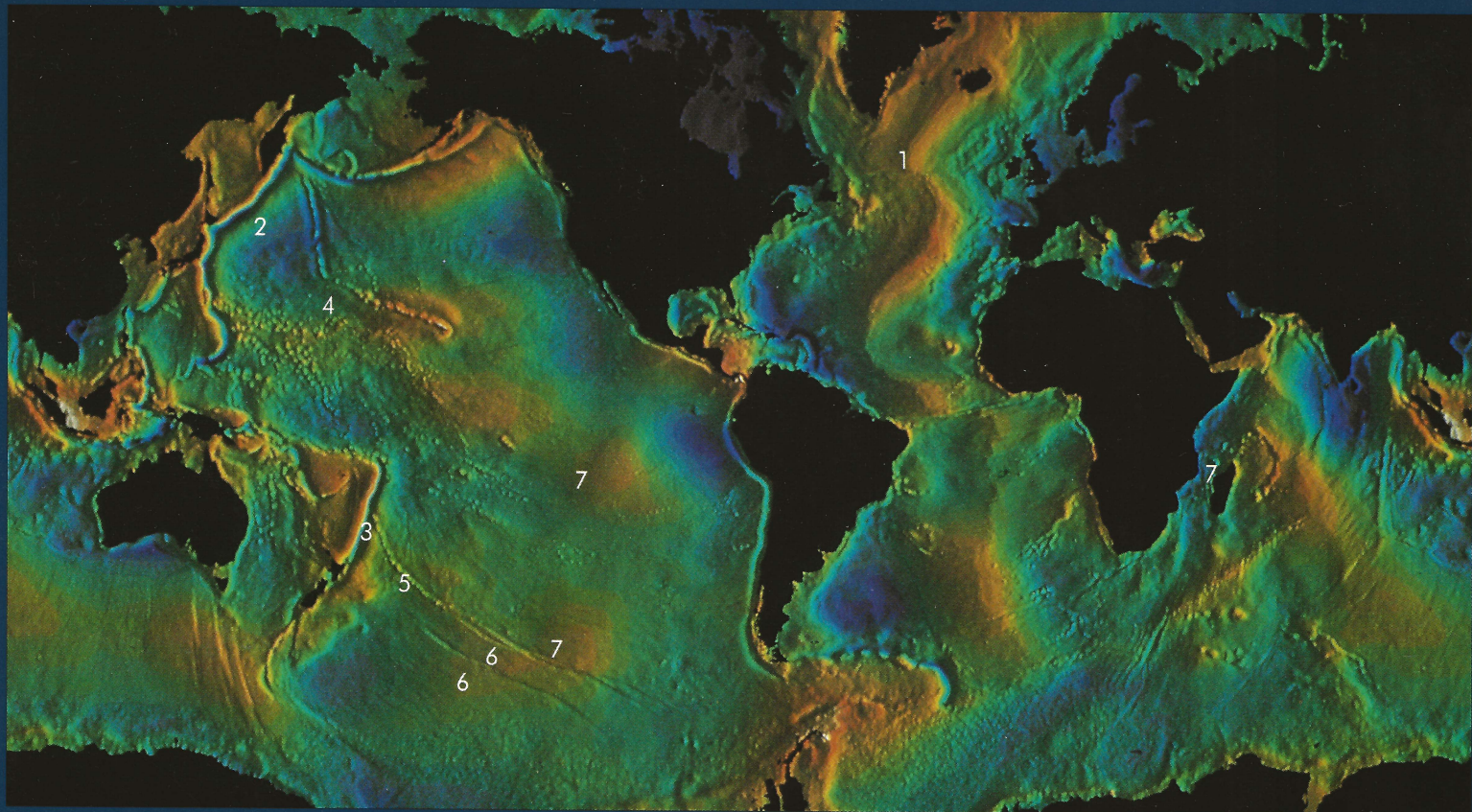
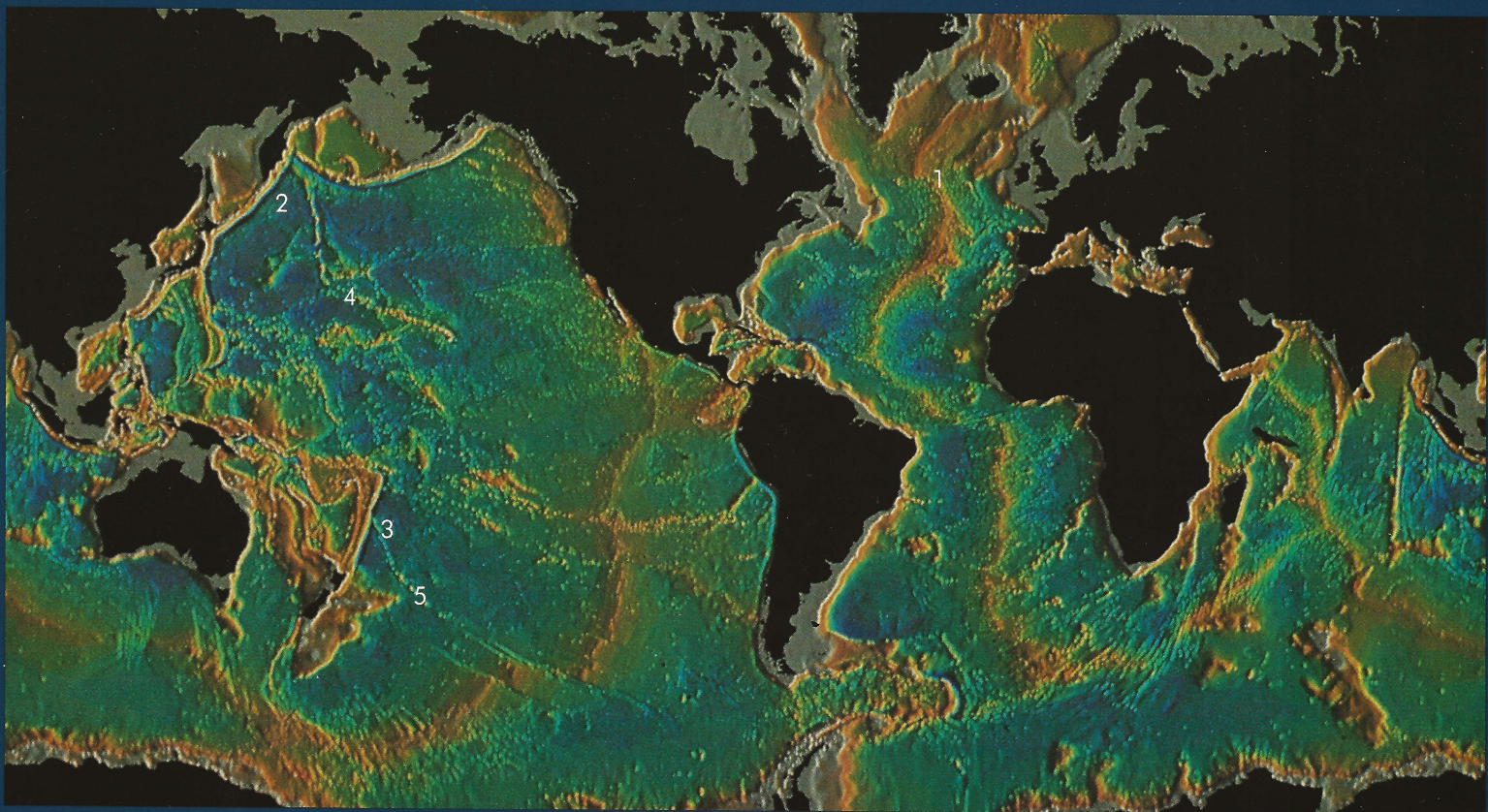


Sea-Surface Topography and Ocean Bathymetry



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Some of the most spectacular geological features on the Earth — mountains several times taller than Mt. Everest and canyons six times deeper than the Grand Canyon — lie hidden from view beneath the surface of the ocean. In the past, oceanographers have relied upon echo sounders to measure the depth of the ocean beneath a ship. This measurement is obtained by determining the time for a sound wave to travel to the bottom and then be reflected back to the ship. Where many ships have passed, the topography of the sea floor (better known as the bathymetry) is well determined, but where few ships have passed, the picture is incomplete. William Haxby at the Lamont-Doherty Geological Observatory has assembled all such ship soundings and, using modern computer imagery techniques, has produced the bathymetric map shown at the bottom.

Both color and shading have been used to indicate variations in the bathymetry. Changes in color occur at 500-m depth intervals, with blues indicating deep areas and yellows indicating shallow. Shading is superimposed on this color map to simulate illumination of the sea floor from the east, thus highlighting features with a north/south orientation. The dominant features in this map are: the mid-ocean ridges which rise to within 2000 m (6600 ft) of the ocean surface, one such example being the Mid-Atlantic Ridge (1); the deep-ocean trenches, which can be deeper than 10,000 m (33,000 ft) and are most evident in the northern and western Pacific (2, 3); and the chains of islands and seamounts such as the Hawaiian-Emperor system in the North Pacific (4) and the Louisville Ridge system in the South Pacific (5).

In contrast to the lower figure showing bathymetry, the upper figure — also produced by Haxby — is a map of mean sea level. In addition to changes in sea level due to ocean waves, tides, and currents, the sea surface has larger-scale hills, valleys, and bulges associated with variations in gravity from place to place on the surface of the Earth. Over large concentrations of mass such as the mid-ocean ridges, gravity is greater than over deep-ocean trenches. Thus, over a ridge the “pull” of gravity will be stronger and consequently will “pile up” water above it, so much so that the sea surface will rise as much as five meters (16 ft). Over a trench, on the other hand, gravity is less and the sea

surface may be depressed by as much as 60 m (192 ft).

This map of sea level was obtained from the altimeter which flew aboard the three-month Seasat mission in 1978. Just as an echo sounder acoustically measures water depth, the altimeter electromagnetically measures the height of the satellite above the sea surface. Given knowledge of the position of the satellite (obtained by accurate tracking), sea level was measured by Seasat with a five-centimeter (two-inch) precision and a 65-cm (26-in) accuracy.

In the upper figure, color changes occur at 2.5-m (eight-foot) intervals, with blues indicating surface lows and yellows indicating highs. The textural characteristics of the surface are similarly highlighted through illumination from the east. Major features again include the Mid-Atlantic Ridge (1), the deep-ocean trenches of the Pacific (2, 3), and the island-seamount chains (4, 5). Fracture zones (6), narrow linear troughs which sometimes extend for thousands of kilometers across an ocean basin, are particularly well resolved in this sea-level map. These fracture zones result from stresses being applied to the plates which comprise the Earth's crust. Since such scars form in the plates as they gradually move about, an analysis of these fracture zones can be used to reconstruct the motion of the plates in our geologic past.

The most surprising feature of the sea-level map is an unusual pattern of low-amplitude bumps, most noticeable in the Pacific and Indian Oceans (7). These bumps may be the first direct evidence for the location of upwelling plumes of molten rock which circulate within the interior of the Earth. It is generally believed that such circulation patterns represent the driving force of plate tectonics, leading to the formation of features such as the fracture zones noted above.

As a follow-on to Seasat, the TOPEX/POSEIDON mission, a joint endeavor on the part of NASA and the Centre National d'Etudes Spatiales (the French Space Agency), will carry improved altimeter and tracking systems which will be sufficiently accurate to map variations in sea level less than 13 cm (five inches). In addition to improving our knowledge of the solid earth, this accuracy will enable resolution of sea-level variations due to the effects of ocean tides and currents. Thus, for the first time, a global view of ocean circulation will be possible.



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