PROBE Expedition 1: Exploration of the Puerto Rico Trench
The Deepest Part of the Atlantic Ocean

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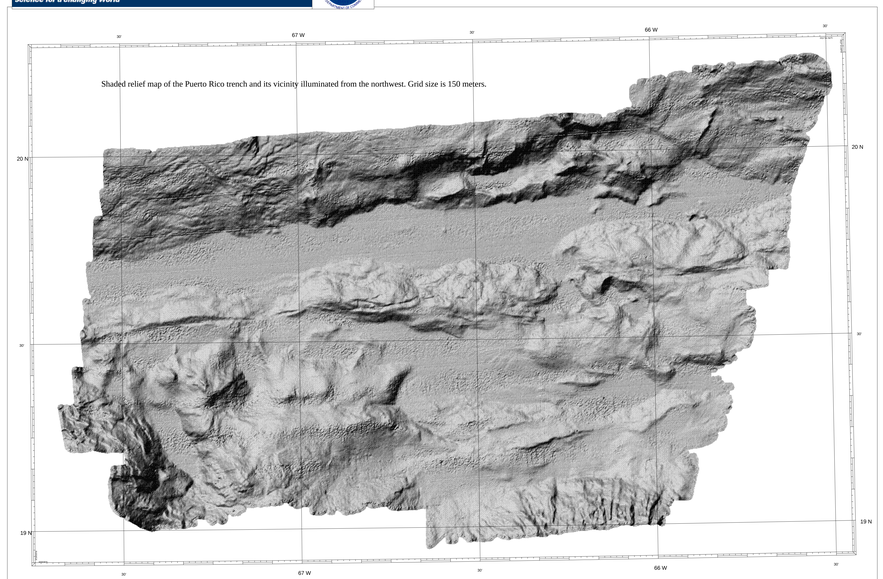
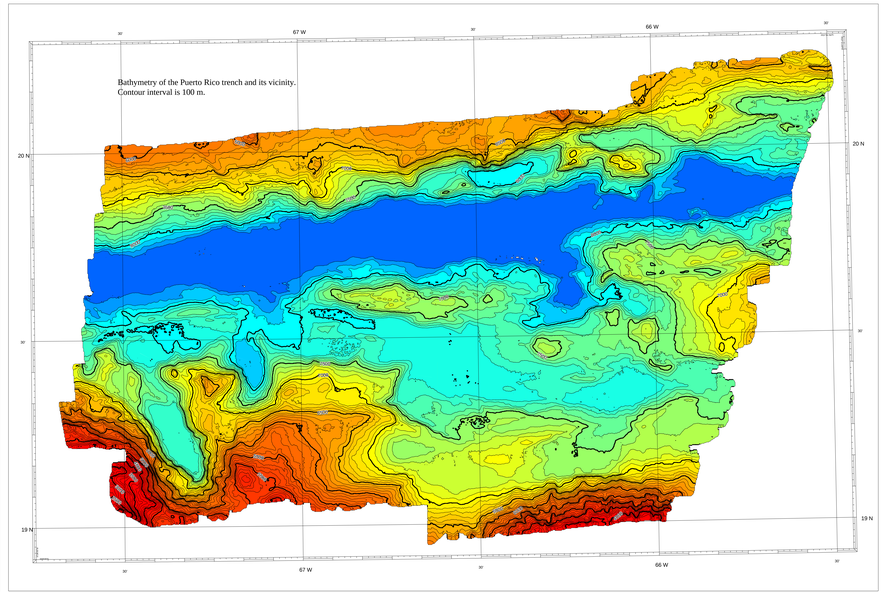
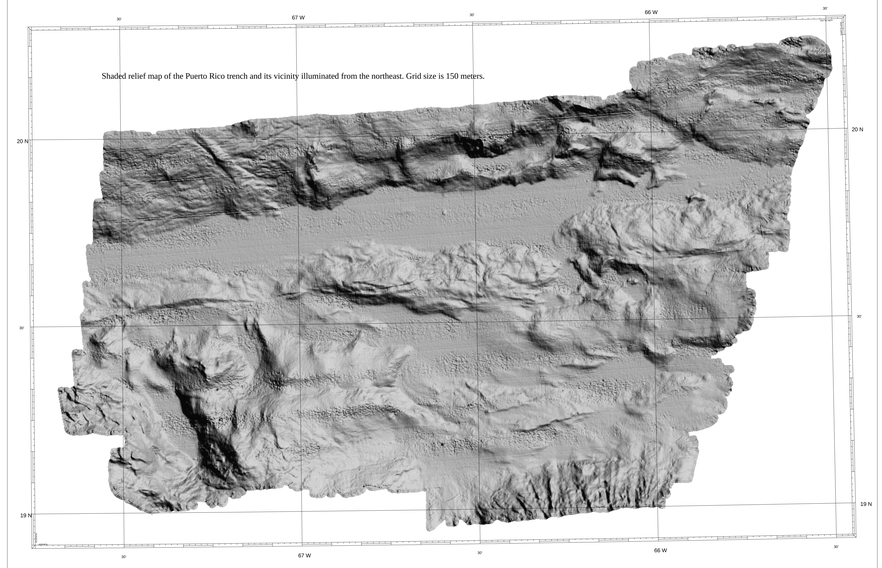


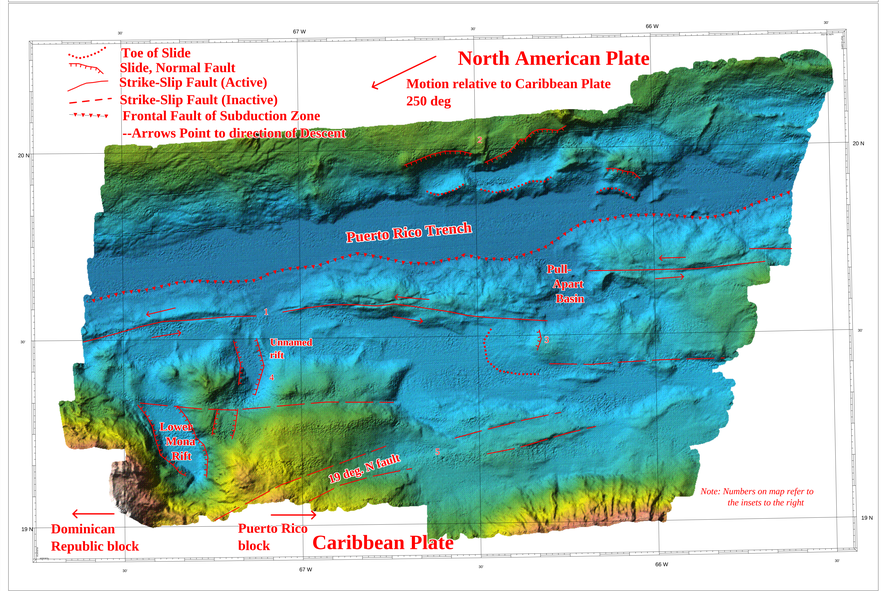
Shaded relief map of the Puerto Rico trench and its vicinity illuminated from the northwest. Grid size is 150 meters.



Bathymetry of the Puerto Rico trench and its vicinity.
Contour interval is 100 m.



Shaded relief map of the Puerto Rico trench and its vicinity illuminated from the northeast. Grid size is 150 meters.

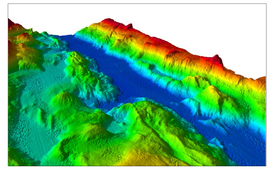


Background

The Puerto Rico trench with water depths exceeding 8400 m, is the deepest place in the Atlantic Ocean. Its depth is comparable to the deep trenches in the Pacific Ocean. Trenches in the Pacific are located in places where one tectonic plate subducts under another one. The Puerto Rico trench, in contrast, is located at a boundary between two plates that slide past each other with only a small component of subduction. The trench is less deep farther east, where the component of subduction is larger.
The deep seafloor is not limited to the trench, but it also extends farther south toward Puerto Rico. The Puerto Rico trench is also associated with the most negative gravity anomaly on earth, -380 mGal, which indicates the presence of an active downward force. Finally, a carbonate platform, which was originally deposited in flat layers near sea level is now tilted northward at a uniform angle. Its northward edge is at a depth of 4500 meters, and its southern edge can be found on land in Puerto Rico at an elevation of a few hundred meters. Many tectonic models have been proposed to explain these unusual observations, and marine exploration efforts of the type reported here are necessary to discriminate between them.

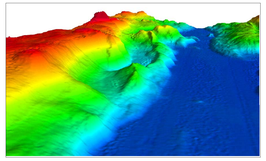
Many earthquakes and tsunamis resulting from these plate tectonic movements have occurred in historical time in the northeastern Caribbean. As population in this region continues to grow, future such events will pose serious hazard to the 4 million U.S. citizens of Puerto Rico and the Virgin Islands. The hazards to these islands are mainly in the form of submarine faults. Our expedition has discovered major new faults and submarine slides, often in areas, where we did not expect to find them based on present tectonic models.

New Discoveries



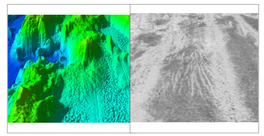
1. Active Faults.

View to the east of a newly discovered active east-west fault system. The fault is on the Caribbean plate close to the trench. Vertical exaggeration is 5:1. The fault is at least 200 km long and traverses the entire mapped area. The fault must have bee recently active as can be seen from the fresh scarps that cut through hills. A pull-apart basin, 8350 meters deep developed where the fault system steps over to the northeast (See interpretation map). The fault likely accommodates the east-west relative motion between the plates, whereas the dipping frontal fault in the trench accommodates the orthogonal dip slip component of the motion between the plates. Partitioning of the oblique convergence between the plates to orthogonal dip slip and a parallel (or strike-) slip motion is typical of most subduction zones and serves to reduce the amount of force required to slide the plates along their inclined interface. It is, therefore highly unusual to find the strike-slip fault system so close to the trench, which might indicate that the friction between the North American and Caribbean plate is very low. This, in turn may suggest that the subduction zone is not capable of generating large dip-slip earthquakes.



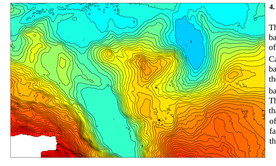
2. Landslides

View to the west of two landslides on the North American plate. Vertical exaggeration is 5:1. The slide in the front, which is 15 km wide is characterized by a "ski-jump" profile. The slide in the back is 25 km across. The bottom of the "ski jump" is flat and is highly non-reflective suggesting that it filled with soft pelagic sediments. Because the slide in the back had time to be filled with sediments, it is likely older than the frontal slide. Landslides have been previously mapped on the southern slope of the Puerto Rico trench on the Caribbean plate as a result of the tilt and collapse of the carbonate platform. However, this is the first time that landslides were discovered on the descending North American plate north of the trench. The presence of slides on this plate suggests that not only did the Caribbean plate collapse, but so did the North American plate near the trench, suggesting that a single process may be responsible for the collapse of the entire plate boundary.



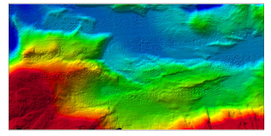
3. A Mysterious Landslide

View to the east of the topography (left) and a backscatter image (right) of an unusual landslide. This landslide produced a debris field about 10 km long with diverging streaks of high reflectivity (white). We do not know what produced these streaks. This landslide is also unusual in that it is located at 7800 meter water depth and its source appears to be a small hill. The left parts of the hill and of the landslide are missing and appear to have been cut off by the newly discovered strike slip fault (see no. 1 above) and by the 8350 meter deep pull-apart basin that it produced. Had the basin been there before the slide, the debris would have filled the basin instead of flowing to the east. The fault may have also moved the main part of the hill that served as a source for this slide.



4. Mona Rift

The Mona rift system shown in this map is very different from previous interpretations based on crude maps of the area. The rift system accommodates a small amount of extension between the Dominican Republic and Puerto Rico, which are both on the Caribbean plate. The extension formed extremely deep and narrow (7-8 km wide) basins with a flat floor. It was previously thought that a single basin on the left side of the map extended all the way to the trench. We discovered, however, that this basin is only 23 km long and another basin to the northeast is part of the rift system. This yet unnamed basin is 8200 meters deep. There are other parallel normal faults that are not associated with the deep basin and may accommodate part of the of the extension. Equally surprising is the fact that the newly-discovered strike slip fault near the trench continues westward across the rift system, whereas previously the rift system was thought to be a barrier to east-west strike-slip faults.



5. Older Faults

Shaded relief showing possible strike-slip fault system farther south of the trench. At least one of these faults, named the 19 degree North fault was suggested to accommodate the east-west motion between the North American and the Caribbean plates. Its location at the base of the slope and close to Puerto Rico was a cause of concern as a source for ground shaking and a trigger for tsunami causing slides. However, this fault, if it exists, and other possible ones appear to be inactive based on the the bathymetry and back scatter image although they appear to cause some of the topographic lineaments, and perhaps control the northern and southern extents of the Mona rift basins.

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This expedition was funded by NOAA Office of Ocean Exploration.
The scientific crew included Dr. Uri ten Brink (Chief Scientist, USGS- Woods Hole Field Office), LT Shepard Smith, NOAA (University of New Hampshire), Charles Worley (USGS-Woods Hole), and Tom Stepka (NOAA/OMAO).