Stanford research finds unusual 'two-faced' rupture caused Japanese destruction

Lisa M. Krieger, Bay Area News Group, 5-25-11

The catastrophe that struck Japan in March was triggered by a sequence of unusual geologic events, according to new research by a team of Stanford University and University of Tokyo scientists.

The fault that generated the Tohoku-Oki earthquake did not fracture in the usual way, they report in the latest issue of the journal Science Express. Instead, it ruptured in a "flip-flop" fashion -- first breaking westward, then eastward.

The first motion violently shook Japan, with magnitude-9 shocks. The second motion -- generating magnitude-6.5 aftershocks -- deformed the seafloor with such force that a huge tsunami was triggered.

Damage from the March 11 earthquake was extensive in part simply because it was so large, according to Stanford geophysicist Greg Beroza.

But the two-faced rupture made the devastation greater than it might have been otherwise, he said.

"Now that this "... has been observed in the Tohoku-Oki earthquake, what we need to figure out is whether similar earthquakes -- and large tsunamis -- could happen in other subduction zones around the world," Beroza said.

The project was a collaborative effort. Stanford's Beroza and graduate student Annemarie Baltay measured the energy released by the quake, while University of Tokyo's Satoshi Ide modeled the slippage of the fault.

There is a denser network of seismometers in Japan than in any other place in the world, Beroza said. These sensors provided the team with much more detailed data than is normally available after an earthquake, enabling them to discern the different phases of the March 11 temblor with much greater resolution than usual.

The earthquake occurred in a known subduction zone, where one great tectonic plate is being forced down under another tectonic plate and into the Earth's interior along an active fault.

But no one predicted its ferocity. The earthquake was the largest ever recorded in Japan, and tied for fourth largest in the world since 1900. The 30-foot tsunami washed over sea walls and swept inland for miles. The death toll is expected to be more than 20,000.

The deeper part of the quake's fault plane, which sloped downward to the west, was bound by dense, hard rock on each side. This rock transmitted the seismic waves very efficiently, maximizing the shaking.

The shallower part of the fault surface, which sloped upward to the east and surfaced at the Japan Trench -- where the overlying plate is warped downward by the motion of the descending plate -- had massive slip.

This punched the ocean water upward with great ferocity. To make matters worse, the rupture occurred in deep ocean, so a large volume of water was displaced.

"It exploded into tremendously large slip," Beroza said. "It displaced the seafloor dramatically.

"This amplification of slip near the surface was predicted in computer simulations of earthquake rupture, but this is the first time we have clearly seen it occur in a real earthquake."