Stress of Sliding Plates Builds Near Chile

Henry Fountain, New York Times, 2-7-11

When a magnitude-8.8 earthquake struck off the coast of Chile last February, geophysicists and seismologists were not surprised. The quake's epicenter was on a roughly 200-mile stretch of a fault where stresses had been building for nearly two centuries, and experts had expected that one day the strain would be relieved in a cataclysmic event.

But as scientists have pored over volumes of data from what may turn out to be the best-studied major earthquake yet, they have concluded that the ground movement during the quake did not relieve the stresses as anticipated. The greatest seismic slip was outside the 200-mile segment, known as the Darwin gap since Charles Darwin happened to witness the last earthquake along it, in 1835.

"The pattern of slip was quite different from what would have been expected," said Stefano Lorito, a geophysicist with the National Institute of Geophysics and Vulcanology in Rome. While there was one area of slip south of the epicenter that was within the Darwin gap, he said, the area of greatest movement was north of the gap in an area where an 8.0 earthquake occurred in 1928.

Dr. Lorito said the findings show that "there is a fraction of the gap that probably did not rupture." In addition, he said, the 2010 quake may have added to the stress in the unruptured area, increasing the odds of another major earthquake, although it would probably not be as large as the one last year.

Dr. Lorito is the lead author of a paper published last month in the journal Nature Geoscience describing the slip patterns, based on analysis of tsunami observations and land deformation data from GPS and satellite-based sensors.

But his study is far from the last word on the Chilean quake. At a recent meeting of the American Geophysical Union about a dozen slip patterns were presented, according to Onno Oncken, a geophysicist with the German Research Center for Geosciences in Potsdam.

Dr. Oncken himself was an author of a study published in Nature in September that showed a different slip pattern. His study analyzed only seismic data — recordings of the shock waves, which do not show how the land deformed — from the event. He said it was not unexpected that the patterns would change when GPS and other deformation data was analyzed.

"It's not surprising anybody at this early stage of data evaluation," Dr. Oncken said. "We are learning more and more on a practically daily basis."

"I expect this is going to be the best-observed large earthquake that we've ever had," he added.

But as for Dr. Lorito's suggestion that the 2010 event may have increased the chances of another earthquake, Dr. Oncken expressed caution, saying there were relatively few data points in the area where a new quake was forecast. "Personally I would not have dared make such a strong statement," he said.

The quake, which killed more than 500 people, occurred in a subduction zone, where one tectonic plate is sliding beneath another. In this case, the Nazca plate is sliding eastward beneath the South American plate at a rate of about three inches a year. The movement causes stresses to build up at the plate boundary. In the 2010 quake those stresses were relieved when the western edge of the South American plate suddenly moved

westward and upward. Because much of the movement was underwater, the quake spawned a tsunami that was responsible for many of the deaths.

Jian Lin, a geophysicist at Woods Hole Oceanographic Institution, is also studying the earthquake, although his analysis is focused more on the buildup of stress before the quake than its release. Dr. Lin said that although the various slip patterns presented so far differ in some ways, researchers generally agree that the slip occurred in two “patches,” one to the north of the epicenter and one to the south. Although the quake started at the epicenter, off the Maule region, much of the rupture occurred elsewhere.

“The southern patch did indeed fill some of the Darwin gap,” he said. “This is where the models differ — some models have more slipping in the southern patch, some have less. But I think with all models, part of the Darwin gap remains.”

While the Chilean quake may end up being a particularly well-studied one, Dr. Lin argued that the discrepancies in the slip patterns among the various research groups demonstrated there was still not enough data. “Much of the quake occurred underwater, and underwater we have no instruments,” he said.

“Now that we know that this part could still rupture, now it’s time to put instruments in the ocean as soon as possible,” Dr. Lin said. “If we don’t do it, we’ll have exactly the same problem the next time.”