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A Geologist in the Field

By Kerry Sieh
June 01, 2005

Caltech geologist Kerry Sieh used to describe the Sumatran subduction zone that sits off the Indonesian island's west coast as a place that is tucked away in a corner of the world that just doesn't have a lot of scientific traffic.

Not anymore. The subduction zone was the location of the December 26, 2004 earthquake that, with the tsunamis it generated, resulted in 300,000 dead or missing Indonesians. And now scientists from around the world are paying it plenty of attention.

The December quake, estimated to have had a magnitude as high as 9.3, originated along the boundary between the Indian/Australian and Eurasian tectonic plates, which arcs 5,500 kilometers (3,400 miles) from Myanmar past Sumatra and on toward Australia. Near Sumatra, the plates meet 5 kilometers (3 miles) beneath the sea at the Sumatran Trench, on the floor of the Indian Ocean. At the trench, the Indian/Australian plate is diving into the earth's interior and being overridden by Southeast Asia. For more than a decade, Sieh has studied this fault zone, studying coral growth that measures the rise and fall of sea level changes, and installing an array of Global Positioning Satellite (GPS) stations that measure the deformation of the earth.

Now until June 10, Sieh and field technician John Galetza and their Caltech associates are back in Sumatra. Along with Danny Natawidjaja of the Indonesian Institute of Science (Sieh's former graduate student and the coleader of the expedition), Natawidjaja's associate Bambang Suwargadi, and other Indonesian colleagues, the team will be taking measurements of the uplift and submergence caused by the earthquakes, and educating locals to the danger roiling under their feet. Here Sieh shares, via e-mail, his personal observations and preliminary scientific findings.

Thursday, May 19, 2005

After nearly a week of running around Jakarta, acquiring various research and travel permits, and in Padang, stocking our boats with equipment, supplies, and food, the crew is assembling tonight in Tello, the capital of the Batu Islands, just a few miles south of the equator. John and I have been traveling up from south Sumatra via helicopter over the past two days while the rest of the crew has been motoring up from Padang over the past day in two boats: the cargo boat that is carrying 33 barrels of fuel for the helicopter and the passenger boat carrying the rest of the gear.

Traveling up the Mentawai Islands by helicopter has allowed us to make minor repairs to the GPS stations on the Pagai Islands and to install two new seismic stations on the islands (at Silabu and Nyangnyang) and two on the mainland (at Air Bangis and Sikuai), without delaying greatly our mission in the earthquake areas. At the island stations we have had the usual enthusiastic receptions from our local friends. We've told them the latest results from the GPS instruments that they have been attending: they moved a centimeter or so south during the Nias-Simeulue earthquake on March 28, 2005.



Courtesy of Kerry Sieh and Catharine Stebbins

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After we bury the seismic sensors a meter into the ground, we ask the local kids if they want to make an earthquake. We get them to jump up and down and count the number of jumps. Then we let them look at the monitor and count the spikes, so they can see that they've made that many earthquakes.

Many, many people in the island villages and towns are still quite afraid that a big earthquake and tsunami might hit them. They know that unlike the Aceh and Nias sections, the Mentawai section of the subduction megathrust has not yet ruptured to produce a giant earthquake. The hills around some villages are dotted with aluminum

sheeting and orange and blue plastic tarps that are the roofs of small pondoks, makeshift structures where the villagers have been either living full time or spending the nights. They know that their villages on or near the coast are in harm's way should there be a big earthquake like those that have hit their neighbors to the north.

Friday, May 20, 2005

Today we flew across the equator to southern Nias and began work along the southeastern coast. The evidence for submergence of the land at Fanedanu village, our first stop a few tens of miles north of Telukdalam, is spectacular. Row after row of coconut palms have been eroded and swept away by the surf since the earthquake. And a lighthouse now sits about 20 meters offshore, with the waves crashing around its concrete pillar foundations. The villagers say that before the earthquake it was about 20 meters inland.

Along most of the coast in front of their village, people say the sea has eroded about 50 meters landward. Much of the village's livelihood came from selling copra from the coconut palms, so they are having trouble now making enough money to keep themselves fed. The tsunami of March 28th flooded the land about 250 meters inland from the current coastline and the December 26th tsunami flooded only about 50 meters short of that. But the village is about 400 meters inland, so it was unflooded. One wonders whether or not the inland location of the village has to do with lessons learned 140 years ago, when the giant 1861 earthquake devastated the island. As far as shaking damage is concerned, only a few homes and part of the concrete-block church collapsed. It is clear that steel reinforcing kept the church from complete collapse and that a bit of steel connecting one wall to another would have kept all the walls up.

This morning in Tello, we hired a pedicab driver who Bambang had used before. He is a young man about 25 years old, I would guess. Over breakfast at Amir's house this morning, Bambang told us this story: About five years ago, the guy was making a living as a driver between his hometown in Myanmar and Thailand. On one trip to Thailand, he went with an expired passport. The Thai police arrested him and sold him to a Thai fishing boat. They enslaved him and six other Myanmar men as fishermen and sailors for two years. He told Bambang that if men got sick on the boat, they were initially given medicine to see if they would get better. If that didn't work, they were thrown overboard, either alive or after being murdered. One day they made port at Tello, and there the six Myanmar men escaped and ran into the hills, emerging only after the Thai boat had left the harbor. Amir and his family took in the guy and have helped him find a way to make a living. Now he owns two passenger pedicabs and one cargo pedicab and has saved about \$100, which he hopes to use to get back home to Myanmar. Just a couple months ago, Bambang delivered a letter from him to his family in Myanmar, in which he told them he was still alive and trying to get back home.

Wednesday, May 25, 2005

The past several days have been a whirlwind of activity, with two field teams going out each day to survey changes to the coastline and the boats motoring to the next port along the coast. So, there has been no time to spare to write. At Lagundri Bay, the famous surfing spot on southern Nias, we measured an uplift of about 70 centimeters, using the old and new levels of green algae on a concrete wall that extends into the sea. A little farther north, we found about the same result.

But by the time we arrived at Sirombu, a little town about half way up the west coast of Nias, we were measuring uplifts of about 2.4 meters. The beach in front of Sirombu is now very broad. And at the harbor, most of the long wharf is out of the water and the end of the wharf is so high above the water that it can't be used. The tsunami in March was small, compared to the one in December, even though the source of the latter was much farther away than the source of the former. The March tsunami reached only to the seawall at the wharf. Thus, it appears that the 2.5-meter uplift basically neutralized the height of the tsunami.

A small island just to the south is now about 10 times its former size and the former shallow reef is now out of the water. A new beach is forming on what used to be the outer edge of the shallow, subtidal reef. The water receded from the reef fast enough that crabs, reef fish, and octopuses had too little time to escape. Their remains were common on the dried sea floor. Or, perhaps the concussion of the earthquake waves stunned them and left them unable to move.

A bit of a miscommunication among ourselves led to half of us spending Saturday night on the porch of a home at Sirombu harbor. The guys on the boat understood that we were supposed to meet in the Hinako Islands, miles offshore from Sirombu. The rest of us thought the agreement was to meet up in Sirombu. We waited for the boats to arrive, with most of our personal gear, dinner, and our bunks but for naught. An hour or so after dusk, a family at the harbor offered us a small meal and company on the porch of their home while we waited. The woman who cooked for us had lost her home in the December 28th tsunami. When it became clear that our boats were not going to arrive, the family offered the use of their well for bathing. The water level has dropped a meter since the earthquake to four meters below the floor of the room. The rope on the bucket is now very long!

We talked until 9 p.m. or so and then they spread woven mats on the porch for us to sleep on. Hordes of mosquitoes made sure that no one slept very well there.

In the Hinako Islands on Sunday, we measured uplift in several places. Steve, who runs the surfing resort on Asu, the northernmost of this cluster of small islands, welcomed us

We have three goals for this month-long journey in the parts of Sumatra affected by the two recent big earthquakes:

First and foremost, we want to continue and to complete measurements of the crustal deformation that occurred during those giant ruptures of the Sunda megathrust. These measurements will be important for understanding how much and where the megathrust moved during both of the earthquakes. We started to do this in mid-January and found that the northern half of Simeulue Island had risen up to 1.5 meters and had tilted toward the Sumatran mainland and toward the southeast.

Now, with the March 28th earthquake, we have about 10 times as much coastline to measure uplift along! And we have places that are submerged as well. The extent of the March 28, 2005 rupture is based on what we have gleaned from eyewitness accounts of uplift and sinking as well as on initial interpretations of seismograms and our GPS data. Let's see how good a job we've done figuring it out before we see it for ourselves!

Second, we want to install a few seismic instruments in the region of the 1797 and 1833 giant earthquakes, because we want to be ready to collect important seismic data if that section should break in the next few months or years. We have six seismometers from Professor Clayton and four accelerometers from professors Heaton and Clayton and Ken Hudnut of the USGS, Pasadena office.

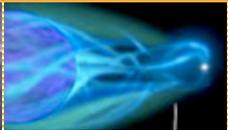
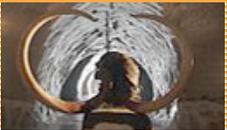
Third, we have some repairs to make to some stations in our GPS network.

-K.S.

when we landed on the beach nearly in front of him. He and his staff were eager to learn what we could tell them about the reasons for the earthquake and tsunami and, more importantly, what might the future bring. He has been living and surfing on Asu for about a quarter century, so he knows the reefs well. He reported that the rocky reefs there were never above water before the March 28th earthquake. Now they are about permanently above. The surfing waves have changed, some for the worse but some for the better.

Sunday night, we anchored off the east coast of Wunga Island, near the northwestern tip of Nias. Twelve years ago, when I had just begun to explore the earthquake story of the islands, the fishing boat we hired took us into the big, beautiful blue lagoon that fills most of the center of this C-shaped island. It was there that I first donned mask and fins to explore the reef with my friend and colleague, Fred Taylor. The back of the C is on the west and the opening is on the east.

An elderly man there had told us that his grandfather taught him that in 1907, a large tsunami had washed across the island from the west, cutting it in two. Twelve years ago, one could in fact see there was a shallow gap in the back of the C, across which waves would wash at high tide. The island is now more than half barren reef, inset with the half dozen or so small green islets that once formed the C-shaped cluster. The bay has shrunk from uplift to a fraction of its former size. We anchored offshore of the opening because it is now too shallow to enter. Uplift here is about 2 meters.

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