Smong: How an Oral History Saved Thousands on Indonesia's Simeulue Island during the December 2004 and March 2005 Tsunamis

Brian G. McAdoo,[a] **Lori Dengler,**[b] M.EERI, **Gegar Prasetya,**[c] **and Vasily Titov**[d]

The tsunamis on 26 December 2004 and 28 March 2005 killed only 7 people on Simeulue Island in Indonesia's Aceh province. At Langi, on the north end of Simeulue, which is 40 km south of the December earthquake's epicenter, maximum wave heights exceeded 10 m less than 10 minutes after the shaking ceased. In the more populous south, wave heights averaged 3 m and caused significant structural damage, destroying entire villages. Oral histories recount a massive 1907 tsunami and advise running to the hills after "significant" shaking ($\sim$1 minute). All the interviewed Simeulue survivors knew of this event and of the necessary action. However, Jantang, on the Aceh mainland, suffered far more casualties. Simeulue's oral history provided an extraordinarily powerful mitigation tool that saved countless lives where even a high-tech warning system with a 15-minute response time would have been of no help. [DOI: 10.1193/1.2204966]

INTRODUCTION

Simeulue Island is a forearc (outerarc) high less than 100 km off the shore of Sumatra's conflict-ridden Aceh province (Figure 1). The island was affected by two great earthquakes—the $M_w = 9.3$ 26 December 2004 earthquake and the $M_w = 8.7$ 28 March 2005 earthquake (Stein and Okal 2005, USGS 2005). The epicenter of the 26 December earthquake was just over 100 km from the capital, Sinabang, and 40 km from the northernmost tip of the island. The 28 March earthquake was centered 80 km southeast of Sinabang and caused much more damage. Each event was tsunamigenic. The December tsunami height exceeded 10 m at Langi in the Alafan subdistrict of northern Simeulue, and the March event triggered a tsunami that caused significant damage at Labuhan Bakti on the island's southern tip.

Of the island's population of 78,128, only 7 died on 26 December as a direct result of the tsunami, according to local government officials (UNIMS 2005a). The United Nations Humanitarian Information Center reports 35 deaths due to the December earth-

[a] Vassar College Department of Geology and Geography, 124 Raymond Avenue, Box 735, Poughkeepsie, NY 12604
[b] Department of Geology, Humboldt State University, 1 Harpst Street, Arcata, CA 95521
[c] BPPT, Jakarta, Indonesia
[d] NOAA/PMEL/OERD, 7600 Sand Point Way NE, Building 3, Seattle, WA 98115-0070

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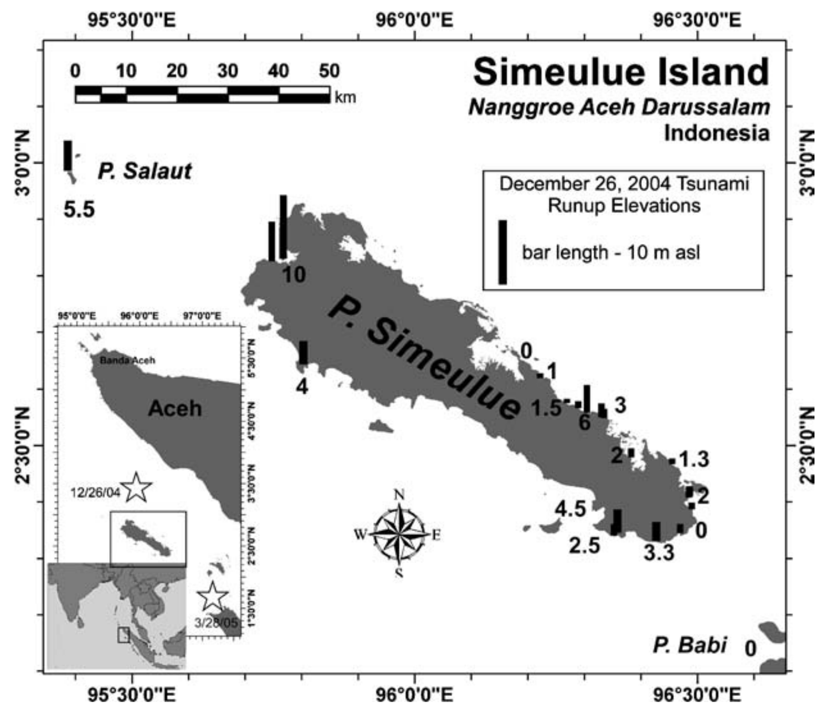

Figure 1. Locations and runup elevations from the 26 December tsunami on Simeulue Island. On the north part of the island closest to the epicenter, the wave height exceeded 10 m and destroyed the village of Langi. On the south part of the island where the wave heights approached 4 m, up to 70% of the structures were destroyed. Despite the destructiveness of the wave, casualties were limited due to the quick response of the people (data after Yalciner et al. 2005).

quake and tsunami, 22 of which were in the Simeulue Timur district, which hosts the island's capital and most populous town, Sinabang (UNIMS 2005b). Structural damage to buildings was not severe after the earthquake (Figure 2a), and the tsunami did not inundate Sinabang. Therefore, we assume that most of the deaths in Simeulue Timur were from the earthquake. The earthquake damage in Sinabang was far more extensive after the 28 March event. Evidence of significant structural damage to buildings and liquefaction at the harbor facility suggests much stronger shaking (Figure 2b), and several square blocks of the downtown harbor region were destroyed by a subsequent fire. The death toll after the 28 March earthquake exceeded 100; none of these fatalities were attributed to the tsunami, because many people were still living in refugee camps.

The conflict-ridden Aceh province is Indonesia's most devoutly Muslim region. Simeulue Island is a district in Aceh and is similarly Muslim, but it has avoided many of the troubles. An oversimplified summary of the nature of the conflict in Aceh is as follows. The Free Aceh Movement (GAM) wants autonomy from the Indonesian central government because of long-standing Islamic nationalist tendencies and the desire to have more

(a) (b) (c)

Figure 2. Structural damage on Simeulue after the 26 December and 28 March earthquakes. (a) Clearly visible (albeit minimal) structural damage sustained in a new market building in the capital of Sinabang after the December event. (b) The same building after the March event; the third floor has been sheared off. (c) Evidence of liquefaction at the Sinabang harbor after the March event.

control over the profits emerging from oil production in the region. Simeulue is isolated—it is far from the source of wealth (the oil)—and has therefore avoided much of the conflict. When conflict engulfs a region, one of the principal tenets of Islam suffers, namely, the *ijma* (the consensus of the *ummah*, or community). It is possible that the strength of the *ijma* may have had a role in helping to avoid the disaster on Simeulue Island.

This paper examines how Simeulue avoided disaster during the two tsunamis and how potential future hazards might be mitigated in regions that are very close to the sources of massive tsunamis and may not (yet) have access to high-technology tsunami warning systems. During three separate field trips to Simeulue, we measured wave height and inundation, estimated the power of the wave, studied the physiography of the island, and talked with survivors about how they knew what to do and when to do it. We also conducted similar studies on the Aceh mainland to find out how it differed. We found that local knowledge, in concert with a thoughtful education plan and appropriate geography, can go a long way toward mitigating the hazards in areas that are closest to the tsunami source.

PACIFIC TSUNAMI WARNING CENTER

The United Nations Education, Science and Cultural Organization (UNESCO) Pacific Tsunami Warning Center (PTWC) has been in operation for the last 55 years in the center of the Pacific Ocean's "ring of fire," where tsunamis are most frequent. Scientists at the PTWC receive earthquake information and then make a rapid assessment of the potential tsunami danger for the Pacific Rim. After the assessment, the PWTC emails messages to a distribution list that anyone with an email account can sign up for. Since the December earthquake, the PTWC has been issuing emails for events in the Indian Ocean as well as the Pacific.

Working with the PTWC, the National Oceanographic and Atmospheric Administration (NOAA) Pacific Marine Environmental Lab (PMEL) has a real-time tsunami monitoring system called the Deep-Ocean Assessment and Reporting of Tsunamis, or DART (Titov et al. 2005). Six "tsunameters" are deployed in the north Pacific because of its history of producing tsunamis that have damaged regions in the basin. These instruments, which are on buoys, detect tsunami waves that are only centimeters high and are moving at close to 800 km per hour. Real-time data are transmitted from the buoys via satellite to computers on the mainland, where the data can be analyzed within minutes for tsunami risk in the entire Pacific Ocean basin.

There was no warning system in place for the Indian Ocean during the 2004 and 2005 events. Had there been a buoy-based warning system in place, it would have done little for the people closest to the epicenter, because the tsunami travel times were as short as 10–20 minutes. It would take at least 10 minutes to analyze the data in a best-case scenario and make a prediction of tsunami likelihood. An integrated warning system would have had the potential to save countless lives in Sri Lanka, the Maldives, and east Africa—where inhabitants did not feel the shaking—because the teletsunami took hours to travel across the ocean.

Despite a history of large tsunamis that have affected Indonesia, the institutional memory of the government agencies failed to recognize the impending hazard and institute coastal evacuation plans. On Simeulue, the collective memory of the people preserved the lessons learned from the devastating tsunami of 1907.

SMONG

The *bupati* (governor) of Simeulue explained why his island had avoided disaster. In 1907, a powerful, but poorly studied, earthquake and tsunami struck Simeulue. At that time, there were no roads—the earthquake struck during the monsoon, and the paths connecting villages were reduced to impassable mud bogs. No one knows how many people were killed in this event, but the legend tells of up to 70% of the population dying, many of whom were found in the tops of coconut trees over 10 m high or in the hills several kilometers inland. Variations of this story were told by every survivor we talked to. The word *smong*, which means "the ocean coming onto the land," remains in the local lexicon today.

Within minutes of the December earthquake, the coastal populace took refuge at nearby high points, and in some cases at prearranged meeting places on the highlands separating the bays. The tsunami wave was highest in the northernmost portion of the island closest to the epicenter, and it subsided to the south (Figure 1). Due to Simeulue's proximity to the epicenter, the residents had an average of 20 minutes to evacuate—enough time to go <2 km to the ridges. In Langi, on the northernmost coast closest to the epicenter ($\sim$40 km), residents had only 8 minutes after the shaking to reach high ground at 30 m above mean sea level. The wave was 10–15 m above mean sea level when it came ashore, leveling the entire village, leaving nothing but concrete foundations (Figure 3). Of the village's population of $\sim$800, no one died.

Near Sineubuk on the southeast coast, residents mustered on a ridge north of town where, according to locals, the community (without government support) had previously built bamboo frames for tsunami evacuation. These frames were on hand so families could simply throw a tarp over them for a temporary living structure (Figure 4). It is not clear whether this location had been maintained as the established meeting place since 1907, or whether the site was used for another purpose. People stayed there for a few days until the major aftershocks subsided and they felt safe enough to return home (after the March event, residents stayed much longer, because the island's uplift gave the impression of a very-long-duration ocean retreat, prompting fears that the water might return as another tsunami).

JANTANG

In marked contrast to Simeulue was Jantang, on the Aceh coast of the Sumatran mainland 225 km from the epicenter. By some reports, Jantang lost well over 50% of its population of $\sim$10,000 on 26 December (Figure 5). According to eyewitnesses, the first of three waves came ashore 20 minutes after the shaking stopped. All wave activity had ceased 30 minutes later. Survivors reported hearing sounds like gunshots or explosions coming from the direction of the ocean. Many people misinterpreted the sounds as being

Figure 3. Village of Langi in January 2005. Damage was extensive, with all homes being completely destroyed, although some trees remain standing and are not visibly damaged. Also note, however, the proximity of higher ground in the rear, at left (photo: V. Kaystrenko).

related to the ongoing conflict between the Indonesian military (Tentara Nasional Indonesia, or TNI) and GAM. Gun skirmishes were frequent in the area prior to the earth-

Figure 4. Makeshift village between Kahat and Sineubuk on southeast Simeulue Island; this village was occupied after the 26 December and the 28 March tsunamis. According to the local residents, the bamboo frames were present before the December event, because of the *smong* legend that arose from a destructive tsunami that struck the island in 1907.

Figure 5. Jantang, Aceh province mainland. A refrigerator 19 m above mean sea level, 0.5 km inland. In the background is what remains of Gleebruk village, which before the tsunami was populated with trees and homes. The wave was clearly very powerful, but even here, rapid response by a knowledgeable populace would have saved countless lives.

quake, and the usual response of local citizens was to stay inside their houses. Of the four survivors we spoke with, none were aware of tsunami hazards and made no association of ground shaking with a potential risk.

THE 28 MARCH TSUNAMI

There was a tsunami on Simeulue (and Nias Island, to the south) on 28 March. The news of the tsunami was not as widely reported as the 26 December tsunami, for several reasons. First, it was not an Indian Ocean basin-wide event. Second, its magnitude paled in comparison to the December event. Wave heights on the Sumatran mainland port of Singkil, and at Langundri Bay on the south side of Nias Island, were both greater than the 26 December tsunami at these locations. Labuhan Bakti on south Simeulue was hit hard by both tsunamis but was spared more extensive damage from the second tsunami, because this part of the island was uplifted before the second tsunami arrived. Most of the residents of Labuhan Bakti were living in inland refugee camps at this time, so none were killed by the tsunami.

The maximum uplift from the March event was centered on Nias Island, and evidence of uplift or subsidence was seen on several islands in the epicentral zone. During the December earthquake, Labuhan Bakti subsided by about 50 cm and suffered a destructive 2.5-m tsunami (Yalciner et al. 2005). The same location was uplifted during the March earthquake; even considering that the tsunami flow depth was lower in March, the wave was actually somewhat larger. Because of the extreme uplift from this event, even a tsunami up to 2 m high that came ashore after the uplift would in places go unnoticed.

CONCLUSIONS

There has been much debate over the need for an Indian Ocean tsunami warning system in a region that has had very large, historic tsunamis. Notable among them was the 1883 Krakatoa eruption that produced a global tsunami recorded as far away as the United States and Great Britain (Utsu 2005). The people of Thailand, Sri Lanka, India, the Maldives, and Somalia would not have felt the earthquake, so they would have had no reason to suspect a tsunami, and they would have benefitted immensely from a warning. The people of Simeulue felt the earthquake but had only 10–20 minutes before the first waves arrived—their oral histories and subsequent quick reactions served them far better in this instance.

The need for a combination of high-tech tsunami warning systems, including a full network of satellite-linked "tsunameters" along with local, grassroots education, is painfully clear. When the ground starts shaking and does not stop for over a minute, residents should head to higher ground. They should not wait for an official warning that may or may not come. Teletsunamis can be effectively predicted by using deep-sea observations and computer models; however, the onus falls on national, regional, and local governments to institute evacuation plans. A further burden falls on the people of these regions to protect the assets that assist in mitigating the impact of waves–those natural features whose function it is to buffer wave energy. Local fishermen often see reefs, dunes, and mangroves (and coastal vegetation in general) as hindrances to ocean access. Those are indeed hindrances, but planners and fishermen alike must weigh the alternative (i.e., removing these assets), and the likely adverse long-term consequences of this alternative, against maintaining easy ocean access. Clearly, a balance must be reached, and the decisions must take into account the needs of all parties involved.

The children on Simeulue play a marble game in the Islamic tradition of cooperation within the *ummah*. Two participants and a host of spectators gather at a flat dirt playing field ~2 m long by 1 m wide. The first player scatters a handful of marbles (the quantity is not important, because marbles are a limited resource on this island), but not too far from the second player. The second player chooses a marble. The first player's object is to use a shooter marble to knock that marble beyond a line drawn in the dirt. What makes this game remarkable is that the second player inevitably chooses the marbles that are the easiest to knock beyond the line. When the shooter succeeds, the gathered crowd erupts in celebration. This spirit of cooperation (rather than competition), rooted in Islam and instilled at a very young age, permeates the society. Perhaps this spirit in a geographically isolated and cohesive community helped during the tsunamis.

On the conflict-riddled Aceh mainland, residents mistook the sounds of the incoming tsunami as gunshots fired between TNI and GAM. As gunshots in this area are far more common than tsunamis, perhaps their instinct to stay inside was warranted. When planning potential response scenarios, planners must have acute knowledge of the political, cultural, and physical landscapes of a region. Even if the residents of Jantang had recognized the signs of the impeding tsunami, they might have been wary of taking refuge in the very hills that GAM is known to populate.

There will be another tsunami in this region, perhaps in our lifetime. The Mentawai Islands segment of the subduction zone last ruptured in 1833 and produced a 10-m-high tsunami in Padang, which now has a population twice as large as Banda Aceh and has the similar disposition of being built in a low-lying floodplain. When that event comes, we need to have instruments in place to help mitigate the disaster. These must include a combination of high-tech solutions such as the DART system alongside a decidedly low-tech, grassroots educational approach that passes down lessons learned from our generation to those that follow.

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