3.4 Vella Lavella Island

3.4.1 Location and topography

Vella Lavella Island is located 15 km northwest of Ghizo Island and 15 km northeast of Ranongga Island (Fig.3.4.1.1). Fig. 3.4.1.1 shows the bathymetry around Vella Lavella Island. There is a steep slope on the north side of the island, while a gentle slope characterizes the side facing Ranongga and Ghizo islands (Fig.3.4.1.2). The tsunami source area is estimated to spread out to the offshore region of the south coast of this island. The total population of the island is about ten thousand, and three people were killed. One of them was nine-year-old child who was killed because of the shaking of the earthquake.

We carried out the field survey at ten villages on this island and a small island adjacent to the island; Sambora, Vonunu, Varese, Maravari, Niarovai, Lambu-Lambu, Supato, Baga Island, Paramata, Reona, and Iringgila (Fig.3.4.1.2) on April 13th, 18th and 23rd, 2007.

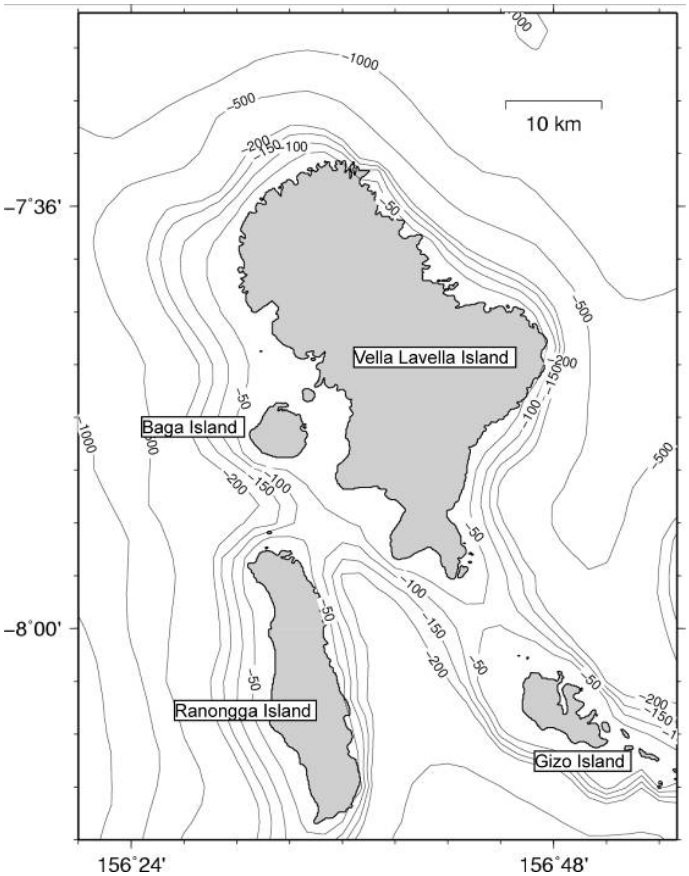

Figure 3.4.1.1 Topography around Vella Lavella Island.

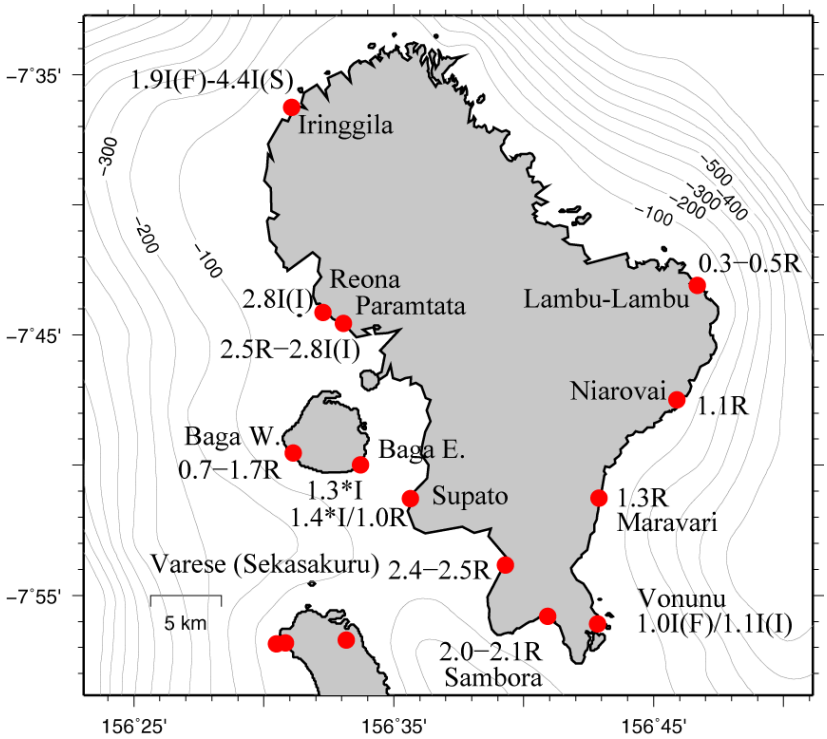

Figure 3.4.1.2 Surveyed sites in Vella Lavella Island (image by Google Earth)

3.4.2 Sambora

Sambora is located on the southern coast of Vella Lavella Island (Fig.3.4.1.2). The population of the village is about 400, and the number of buildings is 109. Nobody was killed by the tsunami, but a nine-year-old child was killed and nine persons were

injured from the shaking of the earthquake. Two buildings were completely destroyed. This village was suffered mainly from the shaking but the tsunami also caused some damage. Because most of the buildings in this village sit on raised platforms lacking diagonal bracing, they are easily damaged by the shaking of the earthquake (Photo.3.4.2.1).

(1) Eyewitnesses' accounts

We obtained two eyewitnesses' accounts in Sambora, Vella Lavella Island.

Witness 1:

Sea water began to withdraw just after the earthquake, and 2 to 3 minutes after it the first wave came. Waves came from the south, and attacked the coastal area three times. The time intervals between one wave and the next were 3 to 4 minutes. The second wave was the largest.

Witness 2:

Some people were shocked at the earthquake and they were panicked. They evacuated to temporary shelters on a hill every night after the earthquake because of their fear of aftershocks. Although no tents were supplied when we visited there on April 18th, they prepared to submit their list of needs to NDC.

(2) Measurement of the tsunami heights

We measured the tsunami heights at two points in Sambora (Fig. 3.4.2.1) judged by a debris line and eyewitnesses' accounts. At Mark 83, which is close to a church, the sea water inundation limit was recognized as the boundary between living and dead vegetation, and moreover we found that the surface of the inundated ground was wet and its color had became darker because of salt (Photo.3.4.2.2). An eyewitness corroborated that the boundary was really the limit of inundation. The height was determined to be 2.1 m above sea level at the tsunami arrival (after correction of the astronomical tide). At Mark 89, we measured the tsunami height to be 2.0 m in the same way.

(3) Benchmark

Though significant upheaval did not occur here, in order to detect postseismic or interseismic deformation, two benchmarks (reference points) were set up as at Lale on Ranongga Island. Their location and tsunami-measured points are shown in Fig. 3.4.2.1. Two benchmarks were near Mark 83. One is located at the top of the base in water supplies shown in Photo 3.4.2.3 (Bench 5: 7°55'50"S, 156°40'56"). The height of the top is measured as 1.800 m above Mean Sea Level. Other is located at the corner of

church in Photo 3.3.2.2 (Bench 6: 7°55'49", 156°40'57"). The height of the top is measured as 2.288 m above Mean Sea Level.

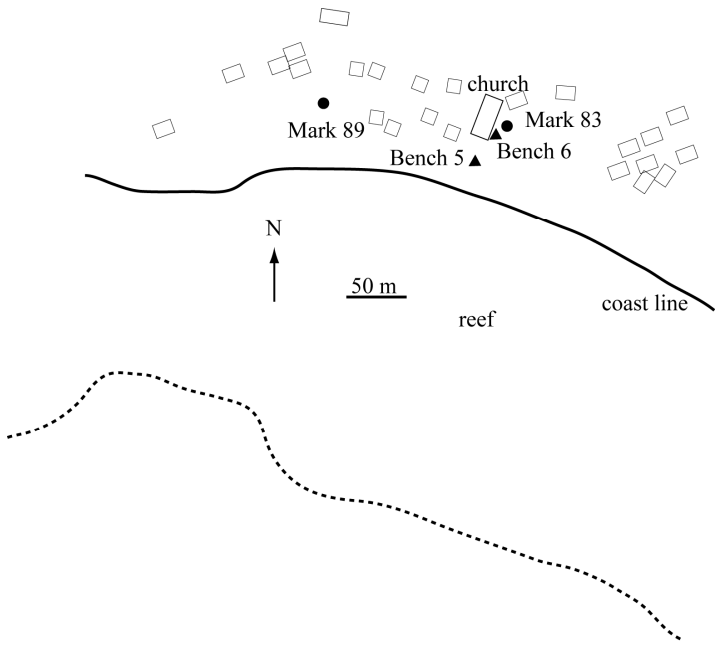

Figure 3.4.2.1 Location map of tsunami survey points and benchmarks at Sambora

Photo 3.4.2.1 Connection between piers and floor in Sambora.

Photo 3.4.2.2 The tsunami runup limit in Sambora. The tsunami came up to the standing person in the photo.

Photo 3.4.2.3 Bench mark of Bench 5 at Sambora

The reference point is at the intersection point between the staff and concrete base.

3.4.3 Vonunu

Vonunu is a village on the eastern coast of the south part of Vella Lavella Island. In front of the coast of Vonunu, reefs have developed offshore and small islands exist, as shown Fig. 3.4.3.1. The offshore reefs and small islands reduced the tsunami striking Vonunu and mitigated tsunami disasters in Vonunu, although the ground level in Vonunu was only about 0.3m above the sea surface.

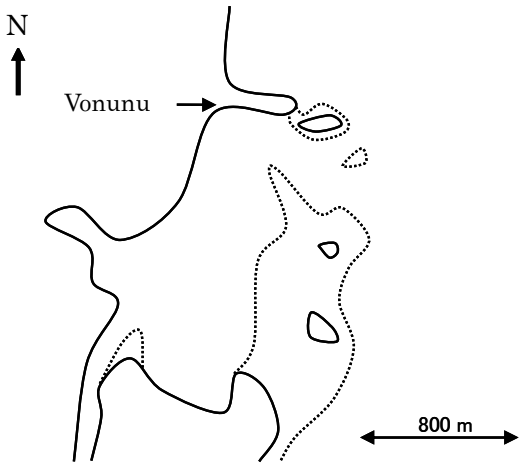

Figure 3.4.3.1 Coastline (solid line) and reef edges (dotted lines) around Vonunu

Tsunami trace heights were measured at two points, Marks 18 (1) and 18 (2), as shown in Fig. 3.4.3.2. Their transects are shown in Figs. 3.4.3.3. Mark 18 (1) was an inundation mark on a seaward-facing wall of a high-floored house with stilts. The inundation height was 1.09 m. Mark 18 (2) was also an inundation mark on an outboard engine of boat in a storage house along the coast, as shown in Photo 3.4.3.1. The inundation height was 1.03 m. Although the storage house was a wooden structure without stilts, it suffered less damage from the tsunami. Less damage of the storage house results from shallow inundation depth of 0.74 m on the ground, which provides less destruction of house as shown in Photo 3.4.3.2. The low tsunami is caused by topographic characteristics in Vonunu.

Although the inundation depth was not so deep, small boats were swept inland 70 m from the coastline, as shown in Photo 3.4.3.2.

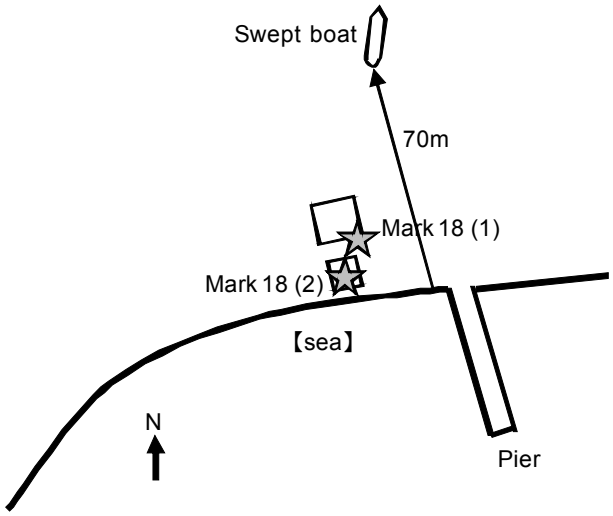

Figure 3.4.3.2 Locations of measured tsunami traces, Marks 18(1) and 18 (2), in Vonunu

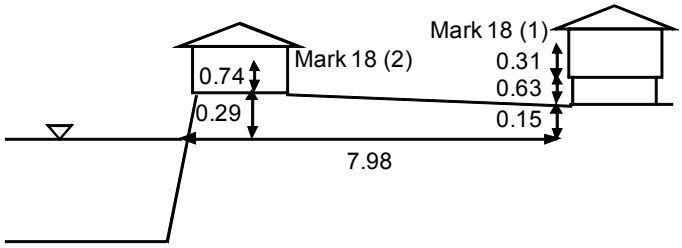

Figure 3.4.3.3 Transect near Marks 18 (1) and 18 (2)

Photo 3.4.3.1 Inundation mark of Mark 18 (2)

Photo 3.4.3.2 Light tsunami damage in Vonunu

3.4.4 Maravari

Maravari is located at the eastern coast of the south part of Vella Lavella Island

(Fig.3.4.1.2). The population of the village was unknown. The second wave was the largest and the wave went upstream ~2 km from the mouth along the river. Only one house on the river was swept away, but no other houses were damaged by the tsunami. More than 80 buildings were completely destroyed by the earthquake.

(1) Eyewitnesses' account

After the earthquake, the sea level withdrew, and two minutes later, the tsunami came from the east-southeast. The waves came three times and the second one was the largest. The intervals between the waves were 1-2 minutes. The wave went upstream ~2 km from the mouth along the river. They lived in temporary shelters on a hill. Tents were supplied, but each tent was for two or three families. Lamps were also needed. Water supply was available.

(2) Measurement of the tsunami height

We measured the tsunami height at only Mark 85 in Maravari judged by the debris. At that point, tsunami ran up to the dead leaves line (Photo 3.4.4.1), which was also corroborated by the inhabitants. The height of 1.3 m was measured.

Photo 3.4.4.1 Tsunami inundation at Mark 85 in Maravari, Vella Lavella Is.

3.4.5 Niarovai

Niarovai is located on the eastern coast of the central part of Vella Lavella Island (Fig.3.4.1.2). The population of the village is 409 and there are 93 (or 63) families. Nobody was killed due to the tsunami or earthquake. Five buildings were destroyed and some buildings were damaged due to the earthquake.

(1) Eyewitnesses' accounts

We obtained two eyewitness accounts in Niarovai, Vella Lavella Island.

Witness 1:

After the earthquake, the sea level withdrew, and about three minutes later, the wave came. The inhabitants escaped to high ground just after watching the tsunami coming. The tsunami came two times with an interval of about three minutes, and the second one was the largest.

Witness 2:

After the earthquake, the sea level withdrew to the edge of reef, and then, the wave came from the front (east). After watching the tsunami coming, the inhabitants escaped to a hill, and they survived. Just after feeling the earthquake, they went out of their house, and three minutes later, the tsunami came. Three minutes after the first wave, the second one came and was the largest. Some houses that had low floors were flooded, but no houses were swept away. All of the inhabitants lived in temporal houses on a hill. No tents were supplied. Drinking water was collected from a dirty stream. Therefore, the cases of diarrhea and malaria increased.

(2) Measurement of the tsunami heights

We measured tsunami heights at two points in Niarovai (Fig.3.4.5.1) judged by the debris. At Mark 86, tsunami ran up to the limit of dead leaves (Photo 3.4.5.1), which was corroborated by the inhabitants. The height of 1.1 m was measured. At Mark 91, we could measure the tsunami height in the same way, and the same height as 1.1 m was measured.

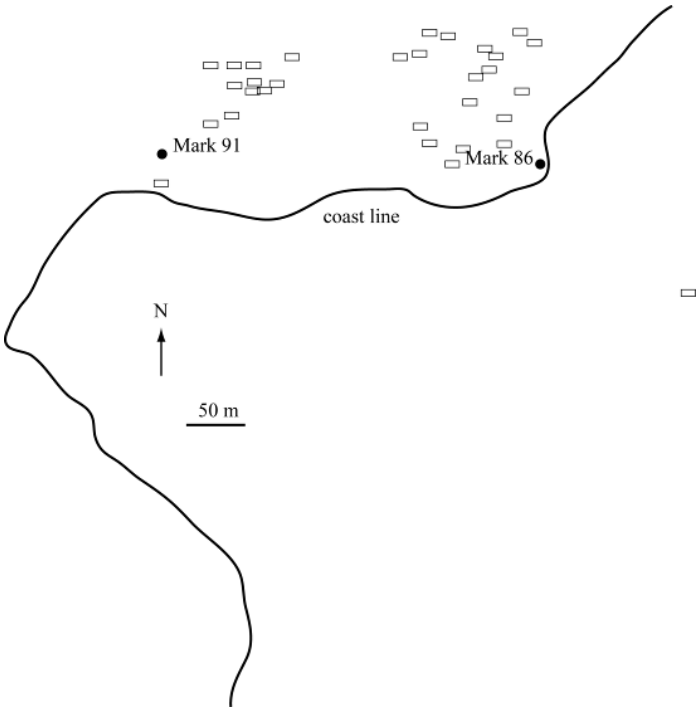

Figure 3.4.5.1 Tsunami survey points at Niarovai, Vella Lavella Island.

Photo 3.4.5.1 Tsunami inundation at Mark 86 in Niarovai, Vella Lavella Is.

3.4.6 Lambu-Lambu

Lambu-Lambu is located on the east coast at the center part of Vella Lavella Island (Fig.3.4.1.2). The population and number of the buildings in Lambu-Lambu is unknown.

Nobody was killed by the tsunami or the earthquake. Some buildings were slightly damaged by the earthquake.

(1) Eyewitnesses' accounts

We obtained two eyewitness accounts in Lambu-Lambu, Vella Lavella Island.

Witness 1:

After the earthquake, the sea level withdrew, and 15-20 minutes later, the wave came. Because the inhabitants knew about the 2004 Sumatra tsunami and that a tsunami might follow an earthquake, they escaped to a hill after sighting the tsunami. The tsunami came three times with intervals of 8-9 min, and the second one was the largest.

Witness 2:

The same comments as Witness 1, but additional comments were as follows. Because of slight damage to their buildings, the inhabitants lived in temporal houses on a hill; while no tents were supplied. Water supply, which was constructed about 20 years ago, became unavailable, and therefore they collected drinking water from the stream. They needed water tanks.

(2) Measurement of the tsunami heights

We measured the tsunami heights at two points in Lambu-Lambu (Fig.3.4.6.1) judged by the debris. At Mark 87, the tsunami ran up to the limit of dead leaves (Photo.3.4.6.1), which was also corroborated by the inhabitants. The height of 0.3 m (after correction of the astronomical tide) was measured. At Mark 92, we measured the tsunami height in the same way, and almost same the height was measured as 0.5 m.

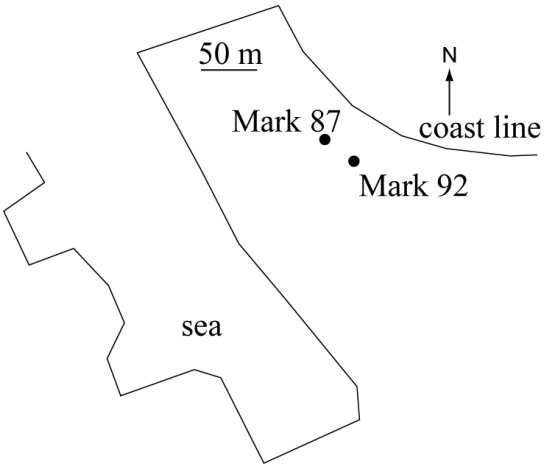

Figure 3.4.6.1 Same as Fig. 3.4.2.1 but in Lambu-Lambu

Photo 3.4.6.1 Tsunami inundation at the Mark 87 in Lambu-Lambu, Vella Lavella Is.

3.4.7 Varese (old name: Sekasukuru)

Varese is located at the south part of Vella Lavella Island and is situated 2 kilometers northwest of Sambora (Fig.3.4.1.2). The population of the village is about 600, and the total number of buildings is 92. No damage occurred from the tsunami, but 13 buildings were completely destroyed and 65 buildings were damaged partially by the shaking of the earthquake.

(1) Eyewitnesses' accounts

We obtained two eyewitnesses' accounts in Varese, Vella Lavella Island.

Witness 1:

Just after the mainshock the sea level began to withdraw, and the first wave came 20 minutes later. Waves came three times, and the second was the largest.

Witness 2:

The intervals between the arrivals of one wave and the next were five minutes. After the inhabitants watched the tsunami coming, they escaped to a hill behind the town. Just after the shaking they went outside and survived. Several buildings were destroyed by the shaking. The inhabitants lived in temporal houses on a hill because of a fear of aftershocks. The temporal houses were not tents but were made of materials obtained from the surrounding forest. No water supply was available, so they carried up water to drink from a stream. They needed the water tanks, tents, paraffin, soap, and mosquito nets. They asked for the necessary goods from the Recovery Center, but their request was not granted. Only a little amount of food was distributed.

(2) Measurement of the tsunami heights

We measured the tsunami heights at two points in Varese (Fig.3.4.7.1) judged by the trace of dead weeds on the ground. At Mark 84, sea water inundated up to the boundary of the area marked by dead weeds where the person stands in the Photo.3.4.7.1, which was also corroborated by the inhabitants. We measured the inundation height at 2.4 m (after compensation for the astronomical tide). At Mark 90, we measured the tsunami height in the same way, and almost same value (2.5 m) was obtained.

(3) Benchmark

Although significant uplift did not occur here, in order to detect postseismic or interseismic deformation, one benchmark (reference point) was set up as at Lale in Ranongga Island. Its location and that of tsunami-measured points are shown in Fig. 3.4.7.1. It is located at the top of the base in water supplies shown in Photo 3.4.7.2 (Bench 7: 7°55'49"S, 156°39'17"E). The height of the top is measured as 2.156 m above Mean Sea Level.

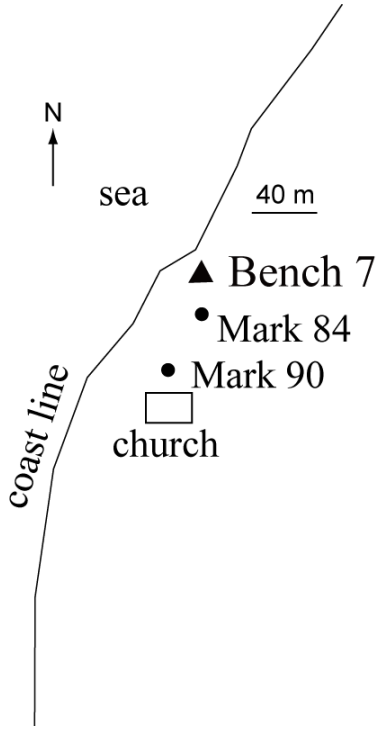

Fig. 3.4.7.1 Location map of tsunami survey points and benchmarks at Varese

Photo 3.4.7.1 Tsunami inundation at Mark 84 in Varese, Vella Lavella Is.

Photo 3.4.7.2 Bench mark of Bench 7 at Varese

The reference point is at the intersection point between the staff and concrete base.

3.4.8 Supato

Supato is a small village near Baga Island, and is 8.2 km distant from Varese. There seemed to be no damage by the tsunami. A resident told us "After the earthquake, a coral reef appeared above the sea surface. The uplift of the ground is perhaps one or two feet". We obtained the information on the position of coastline at low-tide before the earthquake from another resident; the ground uplift was estimated as 0.4 m based on this information.

The inundation limit was determined by eyewitness account (left photo of Photo 3.4.8.1). The height of the location was 1.0 m above sea level at the tsunami event. However, that ground elevation was lower than the dune near the coastline (right photo of Photo 3.4.8.1). Thus, we measured also the height of the dune, 1.4 m. Unfortunately, we could not know the inundation depth on the dune. The actual water elevation was higher than 1.4 m at the dune.

Figure 3.4.8.1 Trace height in Supato

Photo 3.4.8.1 Survey points in Supato (left: inundation limitation, right: top of dune)

3.4.9 Baga Island

Baga Island lies 4 km west of Vella Lavella Island. The diameter of the island is around 6 km. We surveyed two points on this island; however, we could not interview the local people. Because the owner of the farm where we surveyed lived on Vella Lavella, however, we had an interview with a fisherman who was fishing on a coral reef area to the west of Baga Island. He told us "Before the earthquake, the top of the reef

did not appear above the sea surface even at the low-tide", although that appeared above the sea at the interview. As a result he said "The ground uplift might be several tens of centimeters".

On the east coast of the island, we found some debris near the coastline. The tsunami might have inundated beyond this line, however; the limit of inundation was not clear. Thus, we measured the height of debris, 1.3 m. It is possible that the actual height was higher than 1.3 m.

On the west coast of Baga Island, we could not find clear tsunami-traces. The fallen big tree in Photo 3.4.9.2 was not a tsunami trace. However, it was thought that the tsunami could not have exceeded the location of the tree, considering the arrangement of debris and dead vegetation. The height of that place was 1.7 m, thus the runup height was lower than 1.7 m. The runup height of ordinary waves was estimated as 0.7 m, considering the debris on the beach. Thus, the runup height of the tsunami seemed to be higher than 0.7 m and lower than 1.7 m.

Figure 3.4.9.1 Trace heights in Baga Island

Photo 3.4.9.1 Debris at the east coast of Baga Island

Photo 3.4.9.2 Big tree at the west coast of Baga Island (It is thought that this tree is not the trace of tsunami.)

3.4.10 Iringgila

Iringgila is located in the northwest part of Vella Lavella Island. As shown in Fig. 3.4.10.1, a coastal line and reef edges have formed complex bathymetry and geometry. Reefs have developed widely offshore in some areas whereas reefs have developed in the other areas. There is also a river flowing from behind the village to the sea.

In this village, the tsunami caused the death of six among the population of 1439.

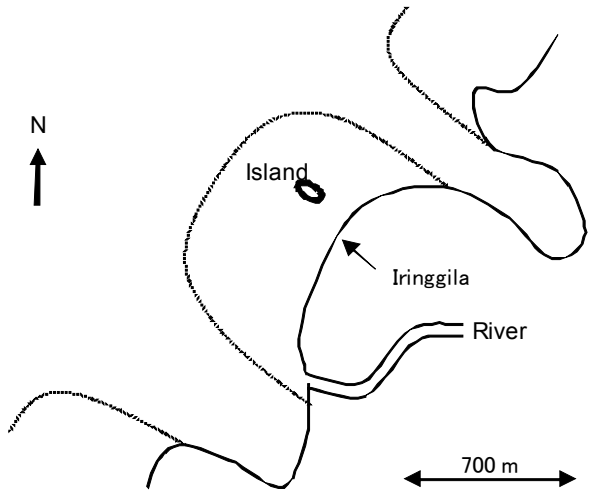

Figure 3.4.10.1 Coastal line (solid line) and reef edges (dotted lines) around Iringgila

Two tsunami traces were measured in Iringgila: Marks 16 and 17, as shown in Fig. 3.4.10.2. Their transects are shown in Figs. 3.4.10.3 and 3.4.10.4. Mark 16 is an inundation mark on a side wall of a high-floored house located behind a small island, as shown in Photo 3.4.10.1. The inundation height was 4.37 m and inundation depth on the ground level was 2.90 m. Mark 17 is also an inundation mark on a facing-to-sea front door of a clinic located in the southwest edge of the village. The inundation height was 1.86 and inundation depth was 0.77 m.

The inundation depth at Mark 17 was lower than that of Mark 16, even though the ground level at Mark 17 was lower by 0.38m than the level of Mark 16. If the tsunami heights were the same, the water flowed deeper over the lower area. Therefore, this difference was mainly caused by the tsunami height changing locally—the tsunami striking in the west side of the village was smaller than that of the east side. The change of tsunami height also provided the change in level of damage to houses, that is, houses in the east side of the village were swept and destroyed as shown in Photo 3.4.10.2, even though houses on the west side suffered less destruction.

The local change of tsunami height is probably attibuted to the complicated bathymetry, geometry and topography around Iringgila. Especially, very-shallow water area in front of the village may converge energy of tsunami, resulting in high local tsunami height. The converged tsunami was also watched by residents as described later. Such characteristics can be calculated easily if bathymetric and geometric data are available.

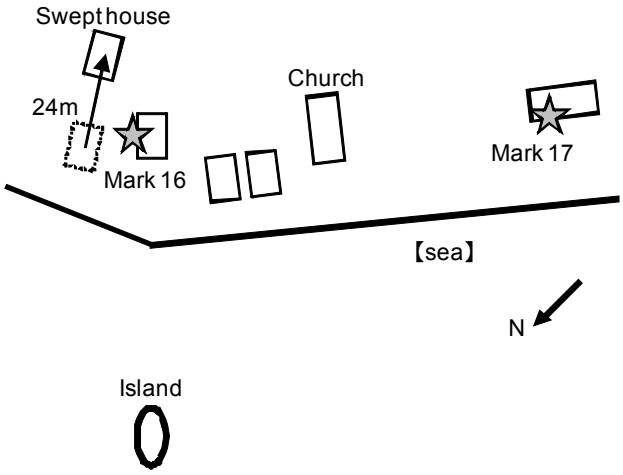

Figure 3.4.10.2 Locations of measured tsunami traces, Marks 16 and 17, in Iringgila

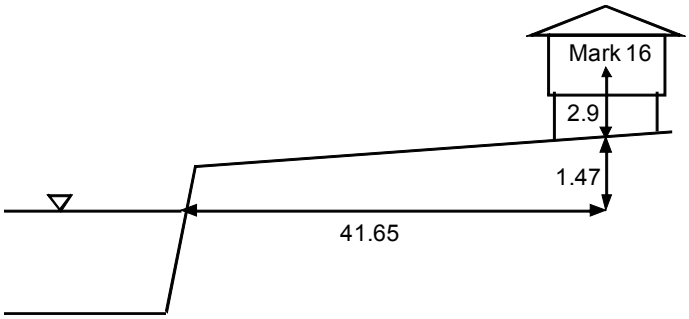

Figure 3.4.10.3 Section view around Mark 16

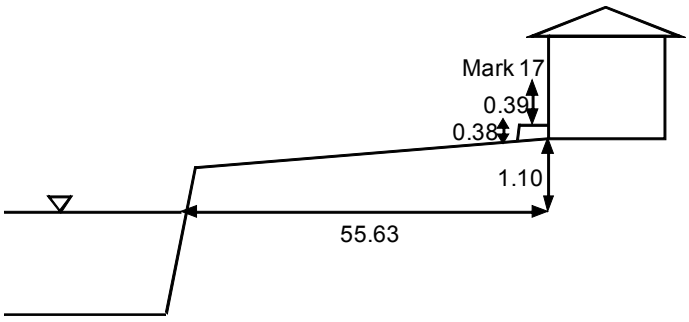

Figure 3.4.10.4 Section view around Mark 17

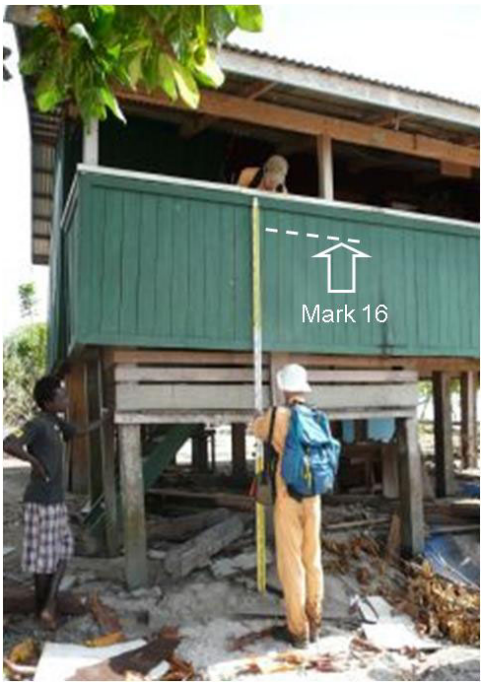

Photo 3.4.10.1 Inundation level of Mark 16

Photo 3.4.10.2 House swept inland by tsunami in the east part of Iringgila

According to resident's witnesses, the characteristics of the tsunami striking the village are as follows:

(1) Three tsunami waves struck the village.

(2) The biggest tsunami was the first.

(3) The first tsunami started as a retreating wave.

(4) At the beginning, the sea receded from around the island in the directions of norteast and southwest, as shown by Arrow (a) in Fig. 3.4.10.5. Then, the fronts

of the first tsunami came from the directions of northeast and southwest and met together around the island, as shown by Arrow (b). After that, the combined tsunami front struck the village, as shown by Arrow (c).

(5) Even though the tsunami striking around the church was smaller, it was broken like a rolling wave on land.

(6) The tsunami climebed the river and overflowed behind the village, as shown by Arrow (d) in Fig. 3.4.10.5.

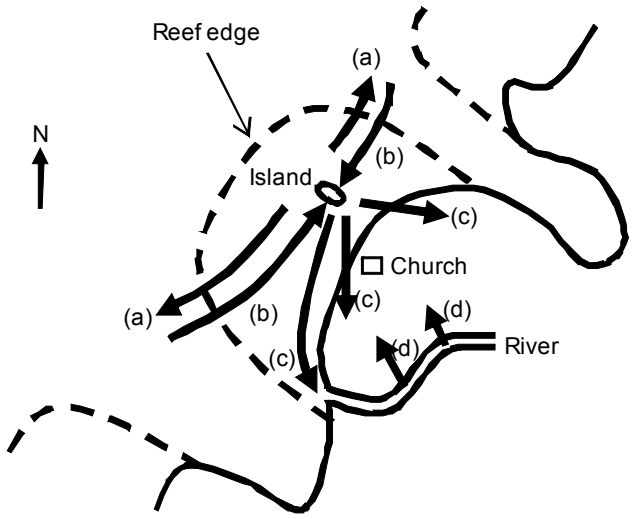

Figure 3.4.10.5 Tsunami striking process by resident's witness

3.4.11 Reona

Reona is located on the western coast in the middle of Vella Lavella Island. Reefs have developed in front of the Reona coast, and a line of reefs parallel to the coastal line have also developed offshore 2.3 km from the coast, as shown in Fig. 3.4.11.1.

Fig. 3.4.11.2 indicates the measurement location in Reona: Mark 15. The transect near Mark 15 is shown in Fig. 3.4.11.3. Mark 15 was an inundation mark on an inside wall of a high-floored house. The inundation height was 2.82 m. The house was not moved by the tsunami but its walls were completely broken.

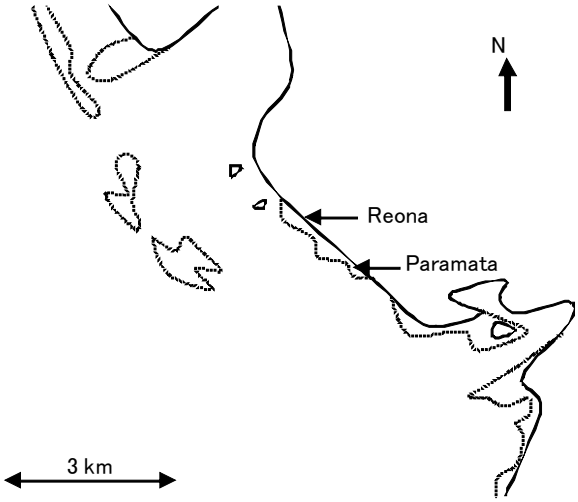

Figure 3.4.11.1 Coastline (solid line) and reef edges (dotted lines) around Reona and Paramata

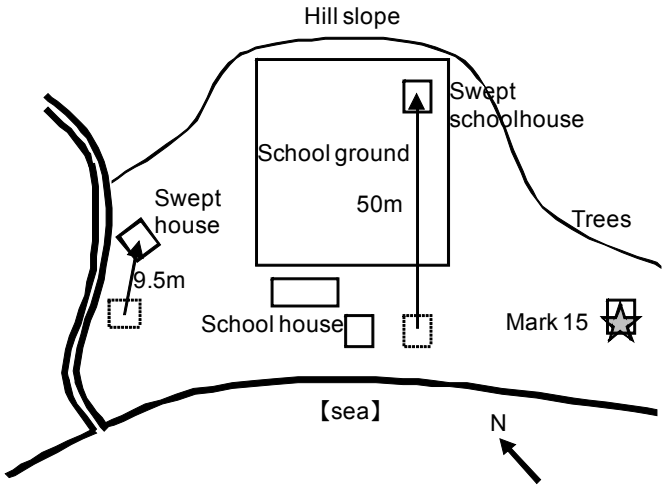

Figure 3.4.11.2 Location of measured tsunami trace, mark 15, in Reona

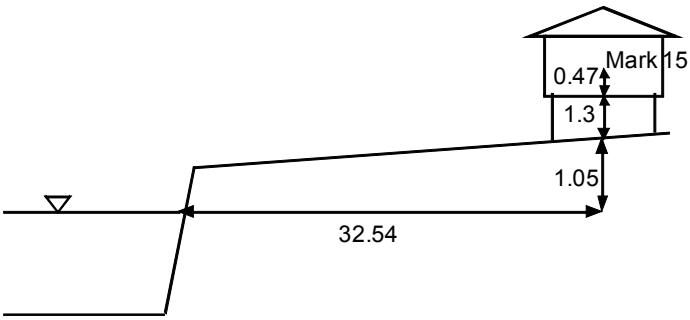

Figure 3.4.11.3 Transect near Mark 15

The tsunami moved several houses. One house in Fig. 3.4.11.2, as shown in Photo 3.4.11.1, was moved 9.5 m from the original position. The schoolhouse was also swept 50 m from its original position.

The tsunami, moreover, eroded the beach as shown in Photo 3.4.11.2, and felled coastal trees. The depth of erosion was 0.5 m.

According to one resident witness, the tsunami struck like a tide and not like a wave. The sea rose up to his neck around the coastal line.

Photo 3.4.11.1 High-floored house in Fig, 3.4.11.2 moved by the tsunami

Photo 3.4.11.2 Eroded beach and fallen trees in Reona

3.4.12 Paramata

Paramata is located on the western coast in the middle of Vella Lavella Island and 1.5 km south of Reona. Paramata quite similar to Reona, that is, reefs have developed in the front of the town.

The tsunami killed no one in this village but caused damage to houses. However, there were few completely destroyed houses and many houses suffered only partial damage.

Three tsunami traces were measured in Paramata: Marks 12, 13 and 14. Their transects are shown in Figs. 3.4.12.1 to 3.4.12.3. Mark 12 indicated the inundation limit in a forest nearby the village, and was determined by a resident's witness. The ground level at Mark 12 was 2.71 m. Mark 13 was an inundation mark on an inside wall of the warehouse which had less damage. The inundation height was 2.79 m. Mark 14 was also an inundation mark on an inside wall of a kindergarten. The inundation height was 2.74 m. The walls of the kindertgarten had little damage and the floorboards were uplifted, as shown in Photo 3.4.12.1

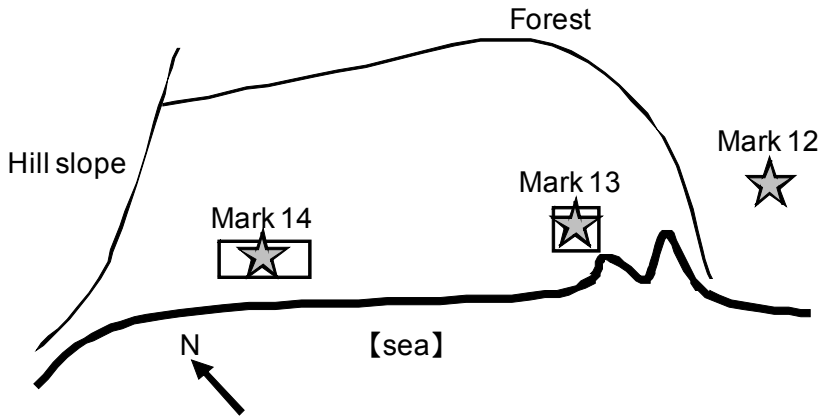

Figure 3.4.12.1 Locations of measured tsunami traces, Marks 12, 13 and 14, in Paramata

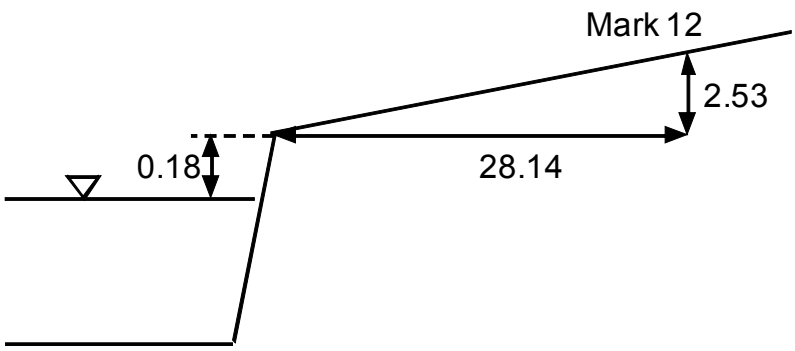

Figure 3.4.12.2 Section view around Mark 12

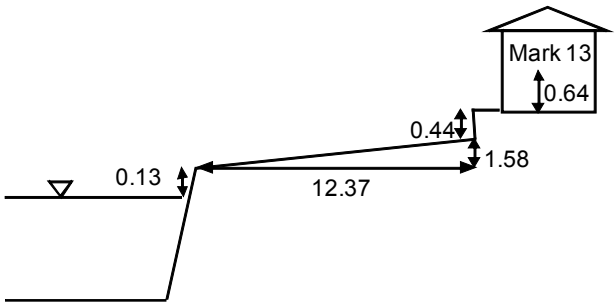

Figure 3.4.12.3 Section view around Mark 13

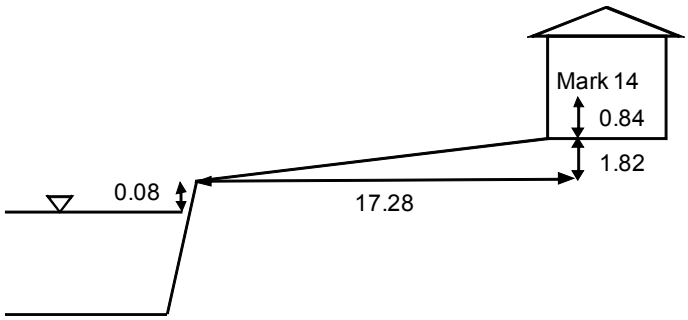

Figure 3.4.12.4 Section view around Mark 14

Photo 3.4.12.1 Damaged kindergarten in Pareamata

Compared to the damage in the neighboring village of Reona, Paramaga suffered relatively less damage, even though the types of houses, stilt length of high-floored houses and distance from the residential area to the coastline in Paramata were similar to those of Reona. One of the reasons why there was difference of damage level was the difference of ground level. The ground level of Reona was 1.1 m and that of Paramata was more than 1.8 m. In low-lying areas the level of damage was higher.

The tsunami eroded the beach in Paramata in the same way as at Reona. Photo 3.4.12.2 shows the beach erosion, whose depth is 0.5 m. In the photo, however, roots of coastal vegetation prevented beach erosion developing inland. It could be one of advantages of coastal vegetation to control tsunami damage.

Photo 3.4.12.2 Beach erosion and roots of vegetation to prevent the erosion developing

According to witnesses, the tsunami striking Paramata was charcterized as follows:

(1) Three tsunami waves struck Paramata.

(2) The first tsunami was biggest.

(3) The first tsunami started as a retreating wave.