2. Solomon earthquake and tsunami

2.1 The 2007 Solomon earthquake and tectonic setting of the earthquake

On April 1, 2007, a great earthquake (Mw 8.1) occurred off the Solomon Islands along the Solomon Subduction Zone. The earthquake generated a large tsunami that killed more than 40 people in Gizo and Simbo Islands near the epicenter. The one-day aftershock distribution showed that the source region was located in the subduction zone where the Woodlark ridge system subducts beneath the Pacific plate (Fig. 2.1 and 2.2). Because of the subduction of the ridge, no trench exists near the plate boundary. Instead, two islands, Simbo and Ranongga, exist unusually close to the plate boundary (Fig. 2.2).

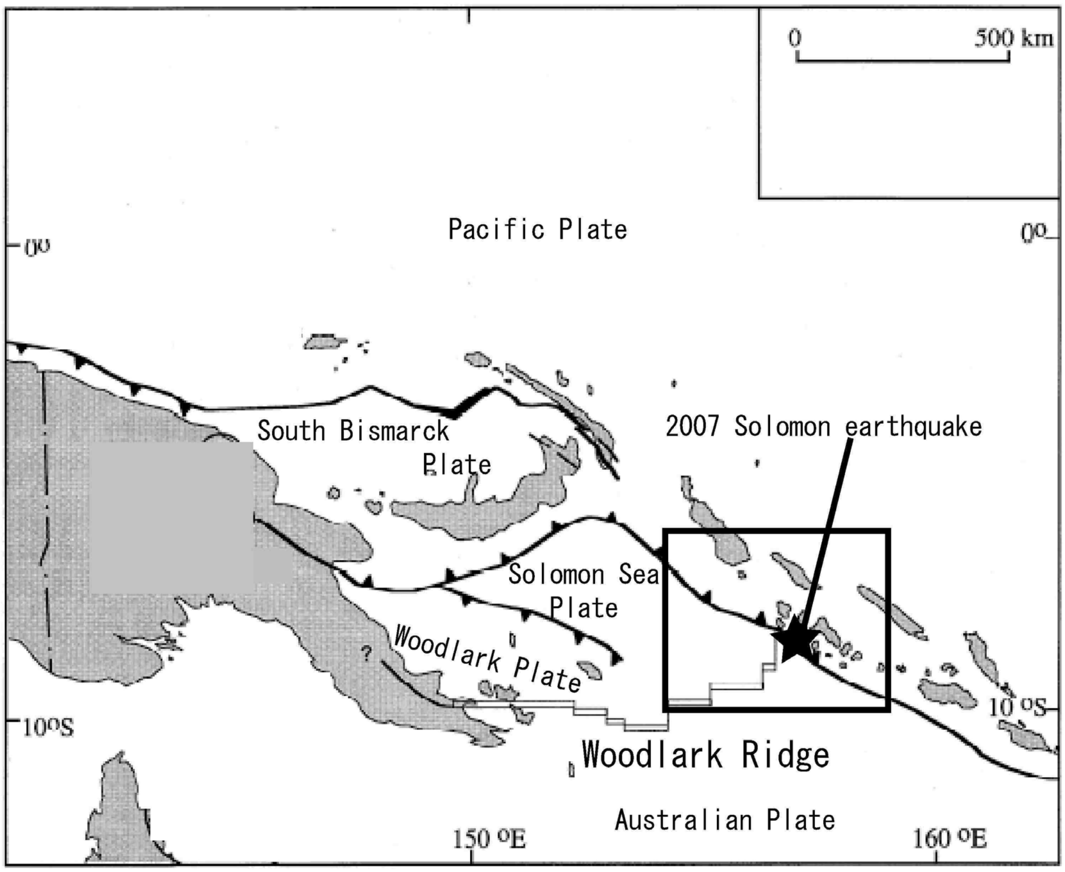

Fig. 2.1 Plate boundaries around the source region of the earthquakes. (from Tregoning et al., 1998) A star shows the epicenter of the 2007 Solomon earthquake. A rectangular shows the area of Fig. 2.2.

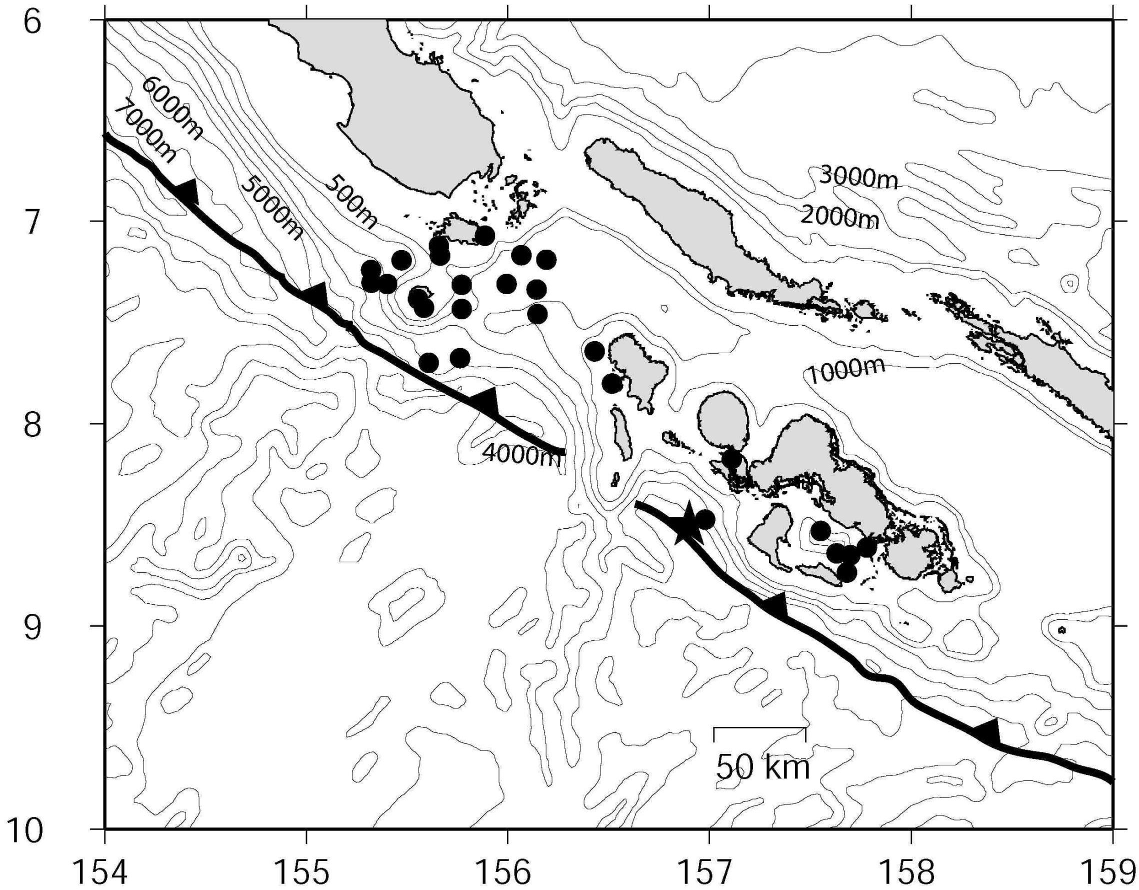

Fig. 2.2 Aftershock distribution of the 2007 Solomon event. A star is the epicenter of the mainshock. Circles are one-day aftershocks.

The focal mechanism of the 2007 earthquake in the Global CMT catalog shows a thrust-type motion (strike=333, dip=37, rake=121). The seismic moment is estimated to be 1.6 x 10^{21} Nm (Mw8.1). The focal mechanism estimated by Yamanaka (2007) also shows thrust motion (strike=310, dip=30, rake=99). Yamanaka estimated the seismic moment to be 1.7 x 10^{21} Nm (Mw8.1). In general, these earthquake mechanisms, occurring in a subduction zone, suggest that the earthquakes were underthrust events occurring along the plate interface in the subduction zone. However, because the 2007 Solomon earthquake occurred where the Woodlark ridge system was subducted, it may not be a typical underthrust earthquake.

In this survey, we attempted to obtain data which can answer a key question: was the 2007 Solomon earthquake a typical underthrust earthquake that ruptured the plate interface?

2.2 Coseismic crustal deformation by the Solomon earthquake

The coseismic crustal deformation survey was conducted in Gizo, Simbo, Ranongga, Vella Lavella, Kolombangara Parara, New Georgia and Rendova Islands (Fig. 2.3). We saw clearly that the whole island of Ranongga was uplifted by the earthquake because a large area of coral flats around the island, which should be grown below a low tide level, now appears above the high tide level after the earthquake (Fig. 2.4a). On Simbo Island, located just 20km south of Ranongga Island, however, we could not find any evidence for uplift, even at the northernmost part of the island. Instead of uplift, we found evidence for slight subsidence from eyewitness accounts at two villages, Lengana and Riguru. For example, a pier at Lengana was submerged after the earthquake (Fig. 2.4b). Those clearly indicate that a pattern of the vertical coseismic crustal deformation was changed between two Islands, Simbo and Ranongga Islands. In Vella Lavella Island, most of the island was subsided except the southeasternmost tip of the island where we found slight uplift (Fig. 2.3). On Gizo Island, slight subsidence was found along most of the coast. On Parara Island, uplift was found only along the west coast. The vertical deformation along the west coast of Rendova Island is small, less than 1m, with slight uplift along the southen part of the coast and slight subsidence in the most northern part of the coast (Fig. 2.3).

The amount of vertical crustal deformation was roughly estimated from the white lines (Fig. 2.5) showing the mean tide level before the earthquake, the top of dead corals, or eyewitnesses testimony of the pre-earthquake high tide or mean tide level (Appendix 2). Fig. 2.3 shows the observed vertical deformation at the survey points with tide corrections. The details of the observed and corrected vertical deformation are shown in Appendix 2.

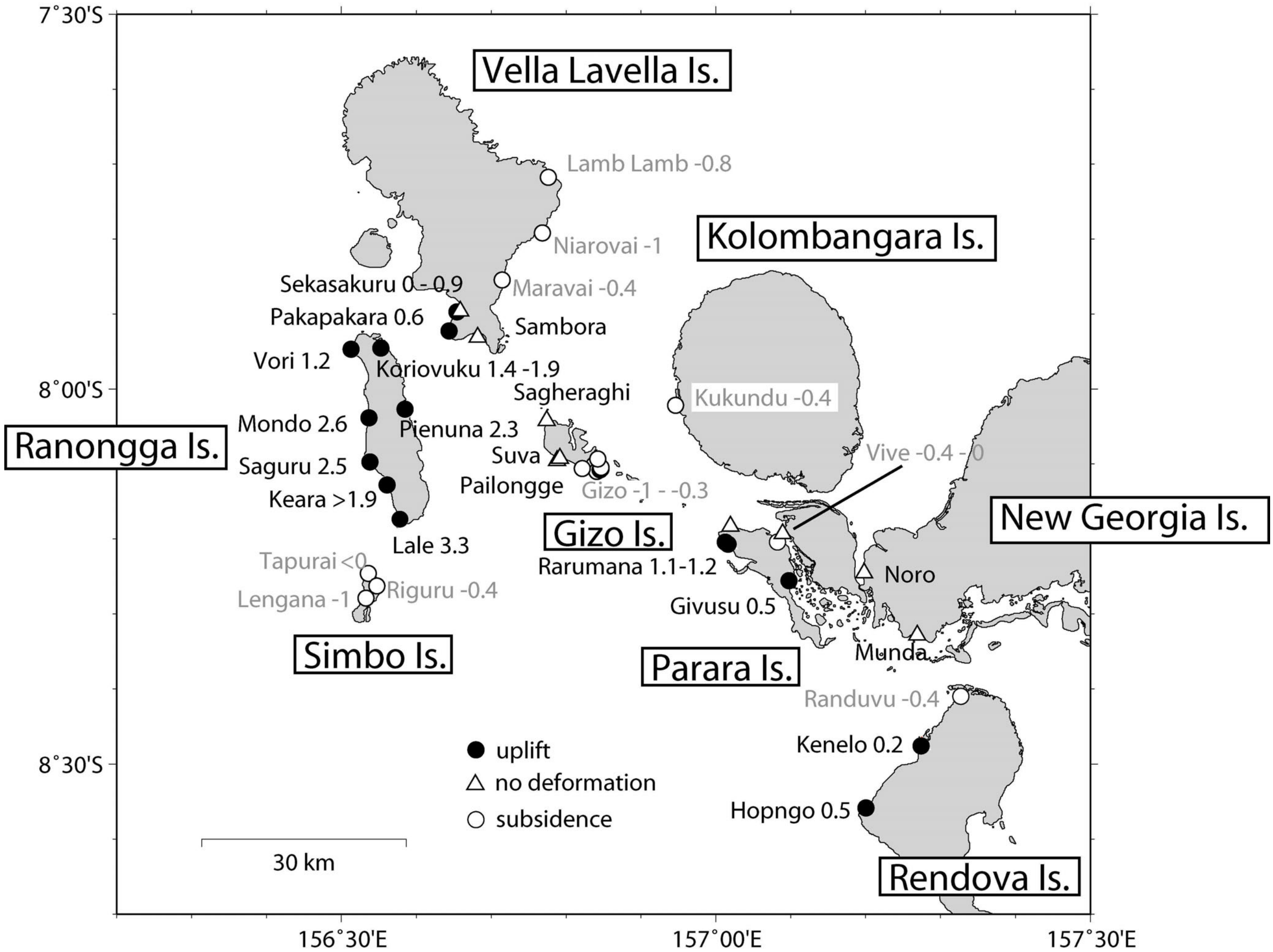

Fig. 2.3 Coseismic vertical deformation by the 2007 Solomon earthquake

(a) Uplifted corals around Ranongga Is. (b) A subsided pier at Lengana Simbo Is.

Fig. 2.4 Photos of crustal deformations.

Fig.2.5 The white line showing the mean tide level before the 2007 Solomon earthquake

2.3 Fault model estimated from coseismic deformation data

A fault model of the 2007 Solomon earthquake was estimated from the survey results of the coseismic vertical deformation (Fig. 2.6). The fault parameters (strike=315 degree, dip=35 degree, width=40km, length=130km, slip=7m) were well constrained except the fault length. The slip amount was estimated to be 7 m which is also well constrained from the coseismic deformation data as shown in Fig. 2.7. The depth of the shallowest edge of the fault is 0km (at the ocean bottom) which is also well constrained. If the depth of the shallowest edge becomes 5 km, the subsidence in Simbo Island cannot be explained at all (Fig. 2.8). The dip angle of the fault is also well constrained. If the dip angle is 15 degrees, which is a typical dip angle of the subducted slab near the trench, the subsidence in Simbo Island cannot be explained either, as shown in Fig.2.9.

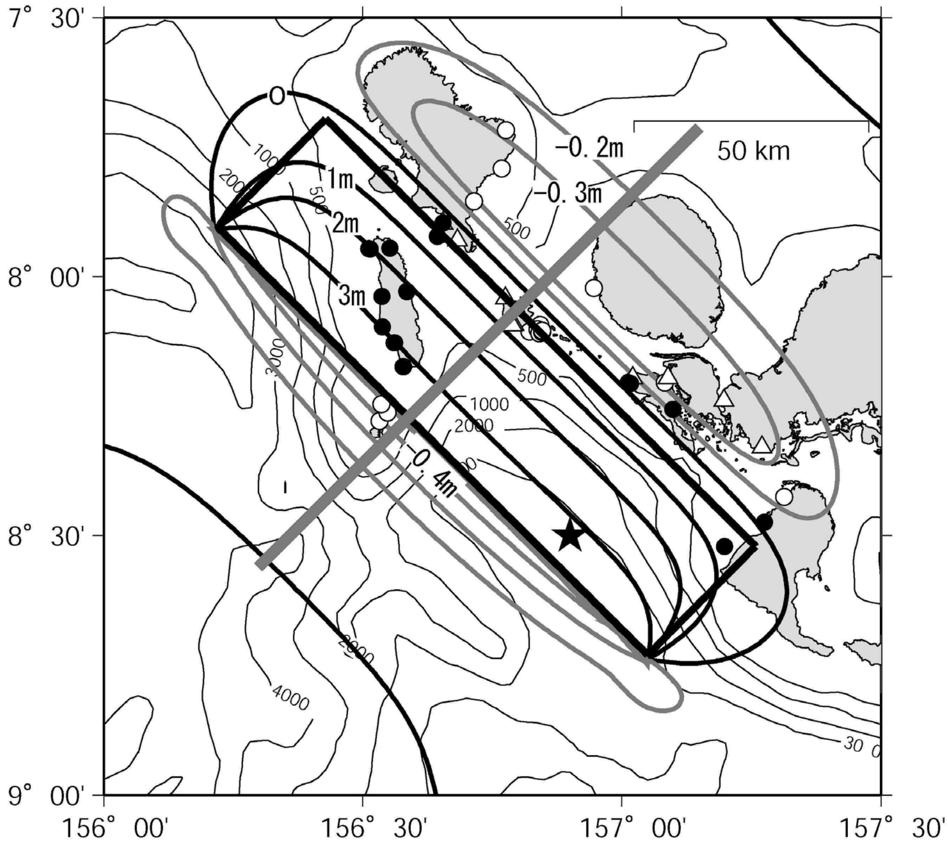

Fig. 2.6 The fault model of the 2007 Solomon earthquake. Solid contours show the uplift (m), with an interval of 1m, and shaded contours show the subsidence (m), with an interval of 0.1 m. An shaded line is the cross-section line for Fig. 2.7. Black dots shows the places where coseismic uplifts were observed. Triangles show the places where no coseismic deformation were observed. Open dots shows the places where coseismic subsidences were observed.

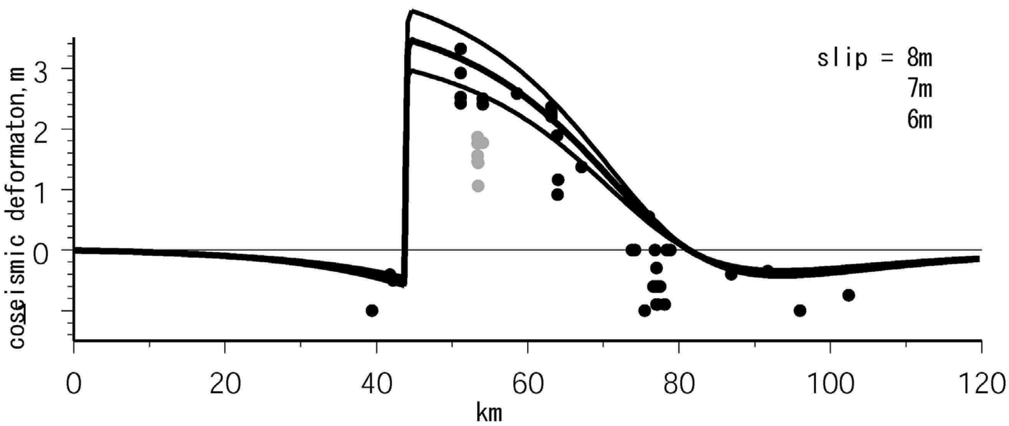

Fig. 2.7. Cross-section of the vertical deformation along the shaded line in Fig. 2.6. Dots show the observed coseismic deformation data. Shaded dots are the coseismic uplifts measured from the top of the coral heads which may be less than the actual uplifts.

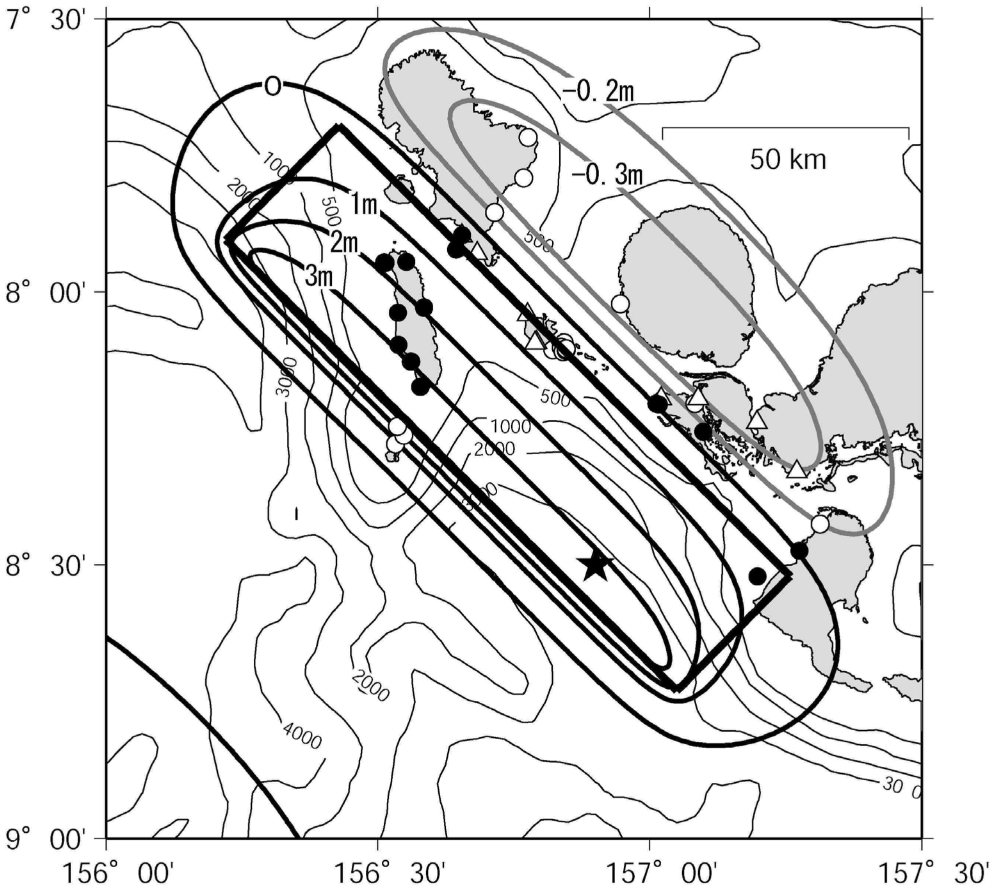

Fig. 2.8. The vertical deformation pattern using a fault model with a depth of the shallowest edge of the fault model of 5 km. The rests of the faults parameters are same as the estimated fault model.

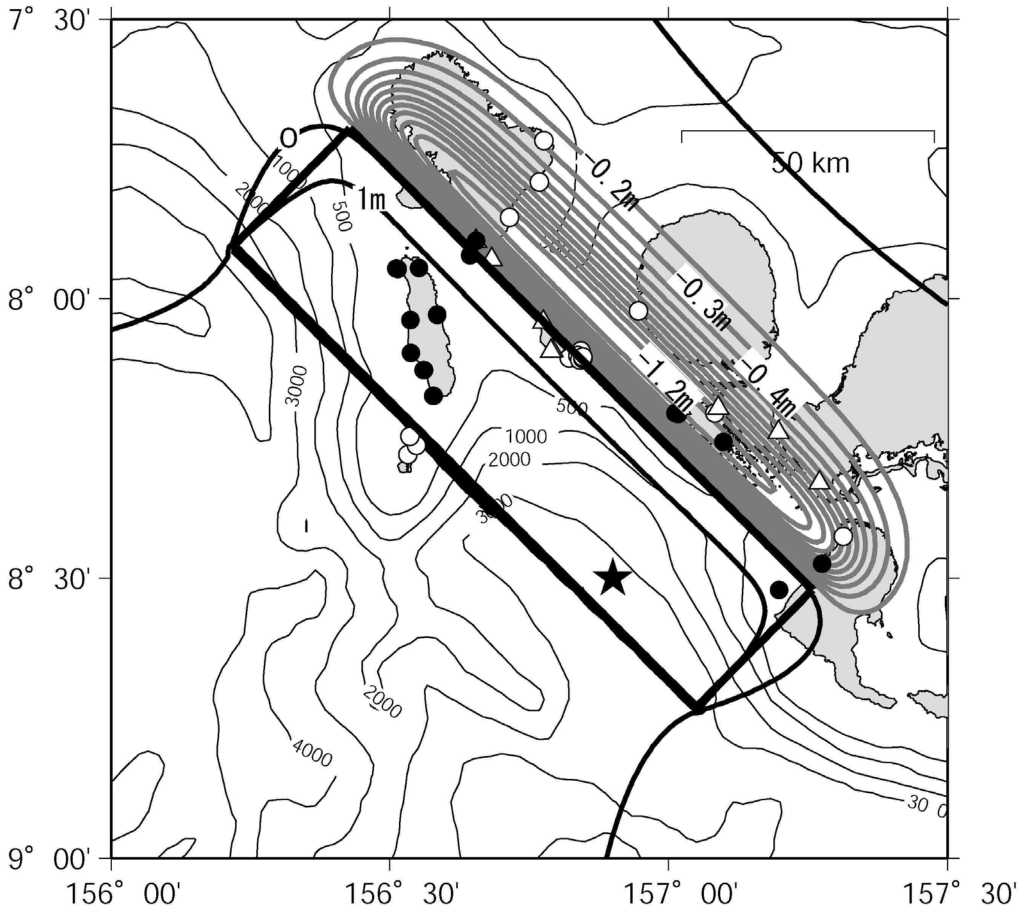

Fig. 2.9 The vertical deformation pattern using a fault model with a dip angle of 15 degree. The rests of the faults parameters are same as the estimated fault model.

The fault parameters (strike=315 degree, dip=35 degree, slip=7m) we estimated in this study are consistent with those parameters estimated from the seismological studies, Yamanaka (2007) and the Global CMT catalog (2007).

This indicates that the earthquake was not a typical interplate earthquake which ruptured the plate interface, but rather an earthquake that occurred on a splay of the main fault. The dip angle of the fault is too high for a typical underthrust event near the trench. This may be due to the subduction of the Woodlark ridge system.