THE MAY 17, 1992 EVENT: TSUNAMI AND COASTAL EFFECTS IN EASTERN MINDANAO, PHILIPPINES

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Abstract

Tsunami invaded the eastern coastlines of Mindanao islands several minutes after the strong ground shaking of the May 17, 1992 quake. Recent field investigations showed that tsunami intensity generally decreases southwards and northwards relative to Bunga and Zaragoza areas. There was an unusually high tsunami wave height (~6m) at Bunga that was most probably due to local site effect. Tsunami waves were generally preceded by the lowering of sea water level while the tsunami arrival times have some variation particularly in Bobon and Panompon. The period of the tsunami wave was quite difficult to determine because of sketchy details and so much variation in terms of the number of waves that attacked the areas investigated.

In terms of regional and local geomorphological effects, the 1992 event caused very minor changes. Tsunami sediments were dumped in very few places. It was noted that the coral reefs located between 100-250m from the shore of eastern Mindanao were the coastal features that most probably attenuate the effects tsunami. Local subsidence was likewise observed west of the affected areas.

Recommended future activities are tsunami simulations and detailed shore morphology mapping to explain anomalous observations like tsunami intensity, unusual tsunami height and subsidence. Furthermore, considering that there were two large events that occurred during that day less than 30 minutes apart, it is was quite interesting that only one strong ground shaking was observed by local inhabitants. Thus, it is highly recommended that a closer look into the seismic data would be undertaken to explain such anomaly.

Introduction

Recent field investigations under the Tsunami Mapping and Hazard Assessment Program (TMHAP) of the Philippine Institute of Volcanology and Seismology (PHIVOLCS) confirmed various notable tsunami effects of the May 17, 1992 earthquake. During that event, tsunami invaded the eastern coastlines of Mindanao islands several minutes after the strong ground shaking. However, the initial location of epicenter by PHIVOLCS at that time indicated that the event occurred inland and associated the event to the Philippine Fault Zone in southeastern Mindanao. Thus, most of the activities undertaken were on recording of aftershocks while the documentation efforts were focused on the damages related to ground shaking and finding the inland ground rupture (Daligdig and Tungol, 1992). However, later determination of epicenter pointed to an event associated with the Philippine Trench (Narag et al, 1992), but the information gathered through the 1992 field mapping activities on tsunami was not enough to assess the extent of floodwaters inundation-related damages. The same can be said in terms of assessment regarding the arrival times and oscillation of waves relative to the main event. This event was reported recently by Lander et al (2003) as an earthquake with minor tsunami. It should likewise be noted that during that day, two large earthquakes occurred only 26 minutes apart from each other with the following parameter, (1) origin time is 09:49:19.11 GMT; located at 7.239ºN, 126.645ºE; 25 km deep and magnitude, Ms 7.1 and (2) origin time is 10:15:31.31 GMT; located at 7.191ºN, 126.762ºN, 33 km deep and magnitude Ms 7.5 (NEIC Preliminary Determination of Epicenter) as shown in Figure 1.

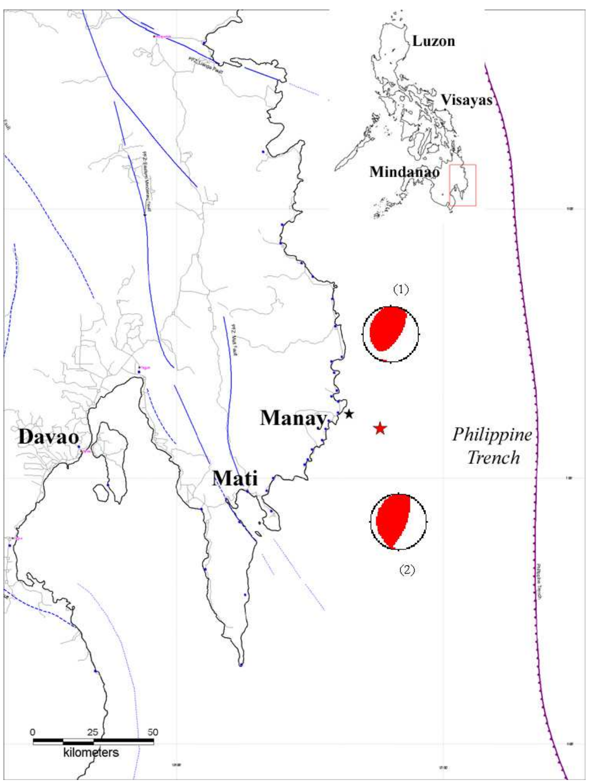

Figure 1: Map showing the location of the study area and the focal mechanisms of the earthquakes that occurred in May 17, 1992. The location of the first and second events are shown in black and red stars, respectively. The beach balls show their corresponding focal mechanisms. Index shows the location of study area relative the Philippine archipelago.

This paper illustrates some interesting findings of the TMHAP's field mapping activity related to the 1992 earthquake in the provinces of Davao Oriental and Surigao del Sur. This study likewise mentions some tasks to be undertaken in the future based on the analysis of the tsunami event and field observations to the 1992 earthquake.

Methodology

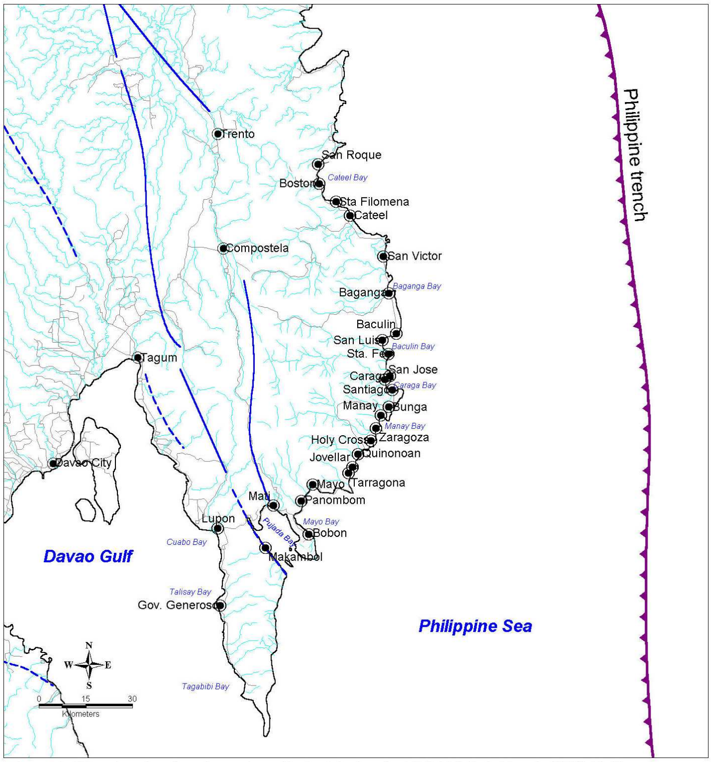

Figure 2: Map showing Davao del Sur and adjacent provinces. Also shown are the places visited during the investigation

Most of the data and information were gathered from field inspection of shoreline morphology as well as from eyewitnesses and survivors through interviews. True wave heights of tsunami were measured and/or estimated from the accounts of the interviewees (i.e. relative to their body or height of watermarks) and landmarks such as trees, rocks, coral reefs, dikes, riverbanks and other natural features found in the area. Existing records from barangays and municipalities were gathered whenever possible for verification purposes, particularly in terms of damages related to tsunami inundation.

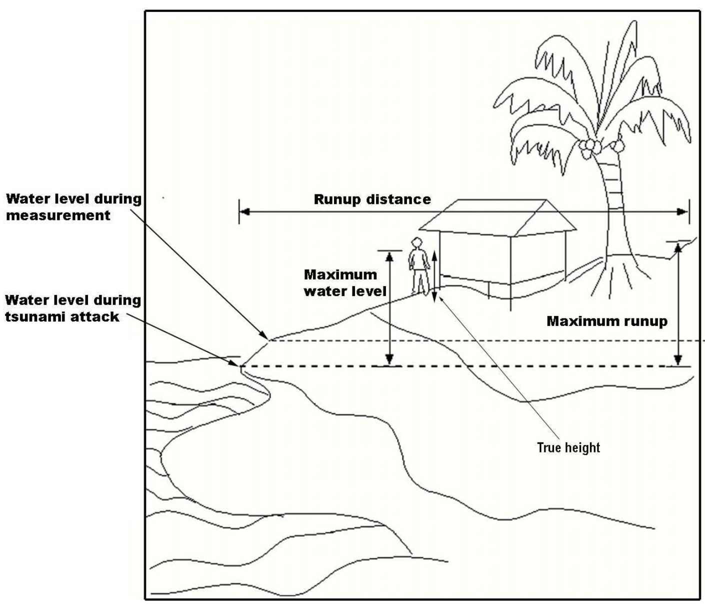

Figure 3: Schematic diagram showing the "true height" of tsunami.

During interviews, information was extracted from the interviewees both through a patterned set of questions and through their own spontaneous accounts from the time they felt the strong ground shaking until the tsunami waves receded to its normal level. Interview was conducted at least every 10 to 20 kilometers for a uniform sampling point between municipalities and communities along the coast (Figure 2). Each tsunami intensity measurement for all the areas visited is based on the Tsunami Intensity Scale (Ambrasey, 1962).

Data

The data and results from interviews are illustrated in the succeeding maps. Each site where the inspection, interview and measurements were undertaken is shown in Figure 2.

Aside from the accounts of interviewees, other geo-morphological features in the vicinity were likewise noted. Heights and/or water level mentioned throughout the report refer to wave "true height" as shown in Figure 3. Further details for each site are found in the 2002 report by Besana et al (*unpublished report*).

Analysis and Discussions

Out of twenty-four (24) towns and communities that were visited, nineteen (19) sites were directly affected by the tsunami that was generated during the May 17, 1992 event. These sites were located mainly along the coastal areas of Davao del Sur and Surigao del Sur. True heights were measured in all locations together with the arrival times and period of tsunami waves (Table 1). Other observable features like subsidence, uplift, erosion etc. were likewise noted.

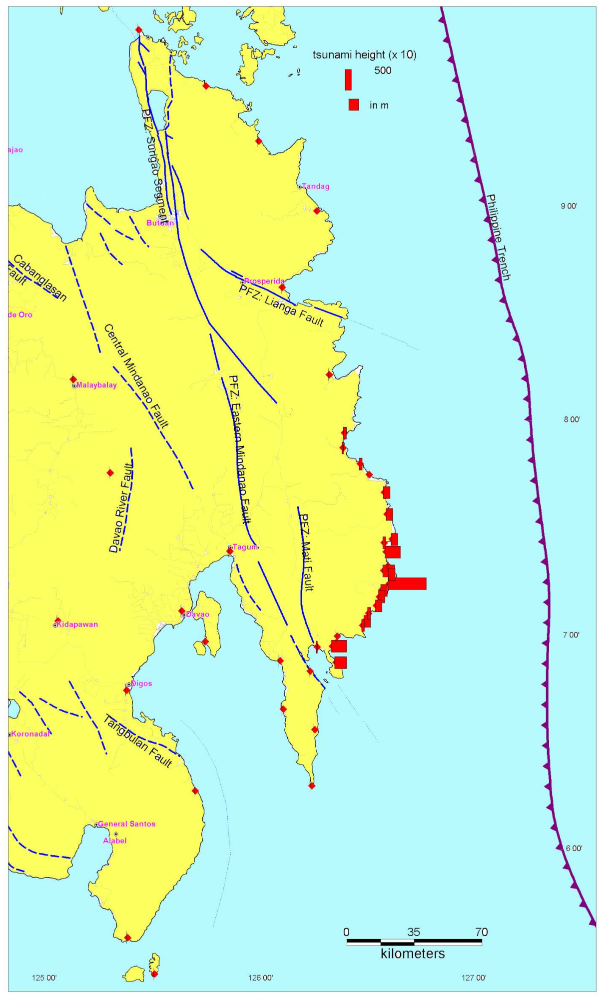

Figure 4: Measured tsunami height along the eastern cost of Davao Oriental and Surigao del Sur.

Considering the true heights of tsunami, the highest wave that was measured is located at Bunga (~6m), a northern barangay of Manay municipality. It has a very big difference in height relative to the measured waves at Santiago and Zaragoza by about 400%, thus, causing the worst effect in terms of damages due to wave inundation. This is quite unusual considering that the height of the wave that inundated Barangays Santiago and Zaragoza were both 1 meter (Figure 4).

Figure 5: Photo (looking ESE) showing the cove in Bunga, Manay.

During the field visit, it was seen that as the waves approach the shores of Bunga at about 100m from the shore, the wave height is about 20cm to about 50cm. But as it enters the concave-shaped coastline (Figure 5), the wave increase its size to almost double or triple as it breaks on the shore. Such increase in wave height is an indication of the presence of features that enhance the unusual wave height. The cause of the unusual height of the tsunami in this area is most probably due to one or combination of these features: the direction of the wave as it approaches the shore, submarine topography and the concave-shaped of the shore fronting Barangay Bunga.

In terms of earthquake intensity, Barangay Santiago, which is the northern barangay of Manay, recorded the highest earthquake intensity. However, based on tsunami time arrival, the earliest wave reached Zaragoza, Manay. Zaragoza is located about 20km south of the town proper. The tsunami arrived in this area within a minute after the strong ground shaking. Relative to Zaragoza, the tsunami waves arrived in the northern and southern coastal areas within 2-10minutes after the intense ground shaking (Figure 6). Wave time arrivals in the southern area, however, have some variations much earlier particularly in Bobon and Panompon. Generally, the tsunami was preceeded by lowering of sea water level from about 50-250m exposing corals and other submarine features. Unusually, Lupon residents noticed the unusual flood-like waves about 90 minutes after the quake. Furthermore, this coastal area remained flooded at about a meter higher than the usual. Thus, the residents had to relocate their houses about 50 meters inland (Figure 7).

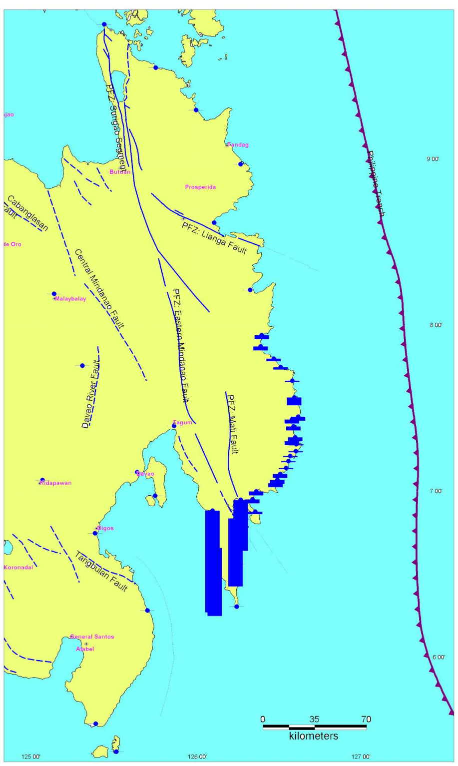

Figure 6: Map showing how many minutes had lapsed between the ground shaking and the tsunami wave inundation along the eastern coast of Davao Oriental and Surigao del Sur during the 1992 quake.

Figure 7: The shoreline in Lupon. Site A and B indicate the former shoreline and some remains of the houses before the 1992 quake, respectively.

Most observations showed that the wave related to the tsunami oscillated for several minutes or sometimes longer in some areas. Notably, the first wave was usually the biggest among the waves. The period of the tsunami wave was quite difficult to determine because of much variation in terms of the number of waves that attacked the areas investigated.

Regarding the effect or ability of tsunami to modify both regional and local geomorphology, the 1992 event caused very minor changes. Tsunami sediments were dumped in very few places. Most of these deposits were eroded or washed away by the waves of the same tsunami event or the succeeding big waves of typhoons and the usual high tides. The only place where the deposit is still available for future and further studies are in Barangay Central at Baganga, Barangay Sta. Fe at Caraga, Barangay Zaragoza at Manay and Barangay Bobon at Mati. Among these areas, the sediment left by the tsunami waves ranges from several centimeters up to about half a meter at Baganga area. The sediments are mostly composed of sand, pebbles and boulders of the same composition of the boulders currently found along the shore. Generally, tsunami inundation varied from several centimeters and reached as far as 200 meters inland wherein Bunga and Baganga suffered the worst where many houses and boats were totally destroyed and/or washed away into the open sea.

On the other hand, there was no area affected by erosion due to the passage of tsunami waves during the 1992 event. Although the TMHAP field team had no time to investigate any tsunami samples, it can be surmised from the eyewitnesses' descriptions that the sediment were eroded locally by the waves. It can be deduced as well that the amount of sediment dumped by the tsunami wave is not significant enough to cause any noticeable local lowering of water level or increase in land elevation relative to the previous mean sea level. However, the observed subsidence at Lupon can be indicative of a subsidence since the areas affected by the rise of water level is quite extensive after the earthquake.

Among the coastal features observed, the coral reef located between 100-200m from the shore is the most significant. Residents noted that the tsunami wave of the 1992 earthquake broke as it encountered the reefs and decreased in height before it reached the shorelines of southwestern Mindanao. Without the coral reefs, the 1992 tsunami wave could have reached the shorelines with a much higher and in more destructive height.

Lastly, it was noted that based from the interviews, only one strong ground shaking was observed by the residents. Considering the magnitude and location of the two events at that time, we can somehow infer that the most probable event that was felt and caused the tsunami was the quake (1). Quake (2), being located further east and much deeper could have occurred without much shaking felt in the eastern part of Mindanao. Although Lander et al. (2003) indicated the quake (2) produced the minor tsunami in eastern Mindanao region but as shown in this paper some considerable damage was observed. Furthermore, much have to be done in terms of seismic analysis to confirm the above mentioned probabilities.

Recommendations

Based on the above observations, the following activities are suggested to be undertaken for the eastern coastal areas of Mindanao:

1. Trenching work or ogre sampling from tsunami deposits to get more information about the 1992 tsunami as well as the other possible previous tsunami events.
2. Review other big historical events in the area for future tsunami simulations and correlation with regional geodetic database.
3. Detailed study of morphological features along the eastern coast of Mindanao to identify possible areas that could generate unusually high tsunami waves for disaster mitigation efforts.
4. Closer analysis of seismic record to clearly explain why there was only one strong ground shaking felt and/or to identify which event, quakes (1) and (2), is tsunamigenic.
5. Further investigation of the subsidence near and around Lupon areas to define the extent of affected areas.

Conclusions

Based on field investigations and interviews, people observed the tsunami between 1-10 minutes after the strong ground shaking related to the 1992 event. The water level retreated to about 50-250m several minutes before the tsunami waves arrived. True wave height varies from several centimeters up to 6 meters in some areas. The most common observations showed that the wave related to the tsunami oscillated for several minutes and the first wave was usually the biggest among the waves. The unusual height at Bunga, Manay is probably the result of the combined effects of wave direction, submarine topography and shoreline shape of Bunga. Based on the overall true height of the tsunami, the average height of 1992 Manay tsunami is about a meter high.

Tsunami inundation varied from several centimeters and reached as far as 200 meters inland. There was no unusual uplift and/or subsidence observed in the eastern coast. However, an alleged subsidence was reported in Lupon that needs to be checked for its regional extent. During the above field visits, at least two places were identified for future stratigraphic logging or trenching of tsunami deposit. Existing coral reefs somehow played an important role in attenuating the tsunami heights, thus lessening its destructive effects.

Future activities to elucidate further the 1992 tsunamigenic event are recommended. Trenching of tsunami deposit, review of historical events, and detailed mapping of shoreline morphology would be very helpful. Furthermore, seismic analysis and simulations might explain some anomalous observations.

Acknowledgment

The authors would like to acknowledge the contributions and help of the following who supported our field mapping activities: Key respondents of different municipalities of Davao Oriental and Surigao del Sur; Municipal Mayors and their constituents of Davao Oriental and Surigao del Sur towns; Ms. Melinda Abarca, Provincial DSWD officer of Davao Oriental; Regina Quiambao and Paolo Reniva of PHIVOLCS Main Office; and Mr. Ferdinand Taglucop of PHIVOLCS Davao Seismological Station.

References

Ambrasey, N.N., 1962. Data for the investigation of the seismic sea-waves in the Eastern Medditerranean. Bulletin of Seismological Society of America 52(4): 895-913.

Besana, G. M., M. T. Mirabueno, G. Quiambao, and P. Reniva, Final Report of 1992 Bislig Earthquake: 2002 Documentation of the 1992 Manay Earthquake. Unpublished report, April 2002.

Daligdig, J.A. and Tungol, N.M. 1992. The May 17, 1992 Mindanao Earthquake, PHIVOLCS Annual Report.

Lander, J.F., Whiteside, L.S. and Lockridge, P.A., 2003. Two decades of Global tsunamis 1982-2002, Sceince of Tsunami Hazards, The International Journal of the Tsunami Society, 21(1): 3-88.

Narag, I. C., Lanuza, A. G., Diongzon, N. F., Peñarubia, H. C. and Marte, F. A., 1992 Quick Response Team Report, PHIVOLCS.

Table 1: Observed height of tsunami heights and wave arrival time during the 1992 event in Mindanao, Philippines.

Location	Arrival Time (min)	Height (m)
San Roque	5	0.5
Boston	4	0.2
Sta. Filomena	nd	0.5
Cateel	nd	0.5
San Victor	2	1.0
Baganga	10	1.0
Baculin	5	1.0
San Luis	nd	0.5
Sta. Fe	5	2
Caraga	nd	nd
San Jose	5	1.5
Santiago	2	1.0
Bunga	2	6.0
Manay	2	1.0
Zaragoza	1	1
Holy Cross	2	1
Quinonoan	nd	0.5
Jovellar	5	1
Taragona	nd	0.5
Mayo	nd	Nd
Panompon	4	2.0
Bobon	3	1.5
Mati	60	0.5
Makambol	nd	Nd
Lupon	120	-1.0
Gov. Generoso	nd	nd