

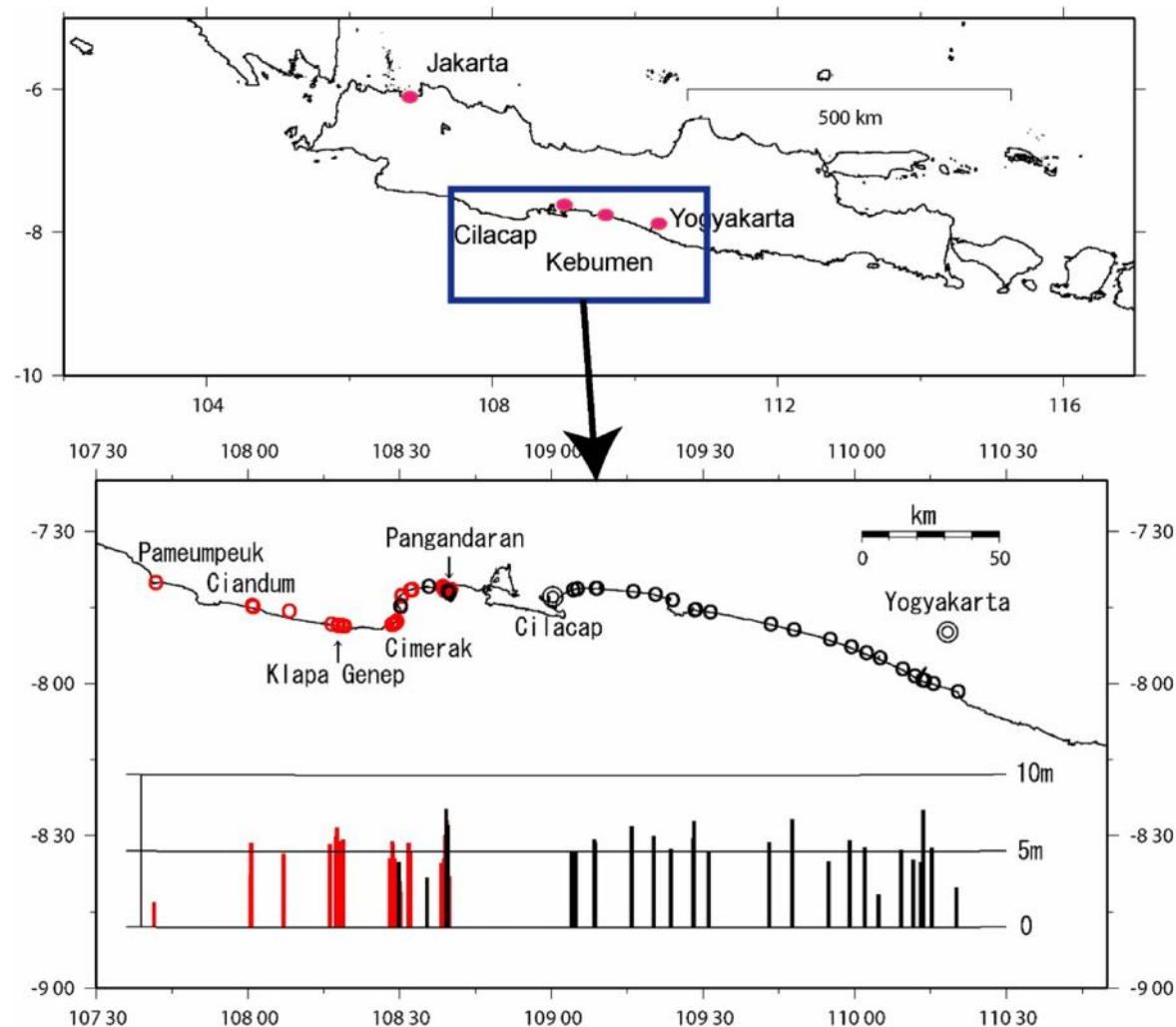
TSUNAMI SURVEY ON PALU BAY 2018

Team:

1. Dr. Sugeng Pribadi (BMKG Jakarta)
2. Indra Gunawan, S.Si, M.Phil (BMKG Jakarta)

3. Jimmy Nugraha, ST, MT (BMKG Puslitbang)
4. Tri Haryono, S.Si (BBMKG Wilayah IV Makasar)
5. Erwan (Stasiun Geofisika Gowa)
6. Candra A. Basri, S.Si (Stasiun Geofisika Palu)
7. Irawan Romadon, S.Si (Stasiun Geofisika Palu)
8. Alhusen Mustarang, S.Tr (Stasiun Geofisika Palu)
9. Heriyanto (Stasiun Geofisika Palu)
10. Tatok Yatimantoro (BMKG Jakarta)

Survey Tsunami experiences in Pangandaran 2006 (Sugeng, Fahrizal, Iwan & Indra, Tsunamiiji dkk)



http://www.eri.u-tokyo.ac.jp/Tsunami/javasurvey/index_e.htm

Members of BMKG Tsunami Survey Team³



Sugeng Pribadi¹, Indra Gunawan¹, Tatok Yatimantoro¹, Jimmi Nugraha¹, Tri Haryono², Candra A. Basri³, Irwan Romadon³, Alhusen Mustarang³, Lukman³, Herriyanto³, Erwan Susanto⁴, Sandi Nur Eko Wijoyo⁵, Jumhan Arif⁶

¹Badan Meteorologi, Klimatologi dan Geofisika, ²Balai Besar Meteorologi Klimatologi dan Geofisika Wilayah IV Makasar – Sulawesi Selatan, ³Stasiun Geofisika Palu – Sulawesi Tengah, ⁴Stasiun Geofisika Gowa – Sulawesi Selatan, ⁵Stasiun Geofisika Manado – Sulawesi Utara, ⁶Stasiun Geofisika Balikpapan – Kalimantan Timur

Instruments:

Laser point

Tripod

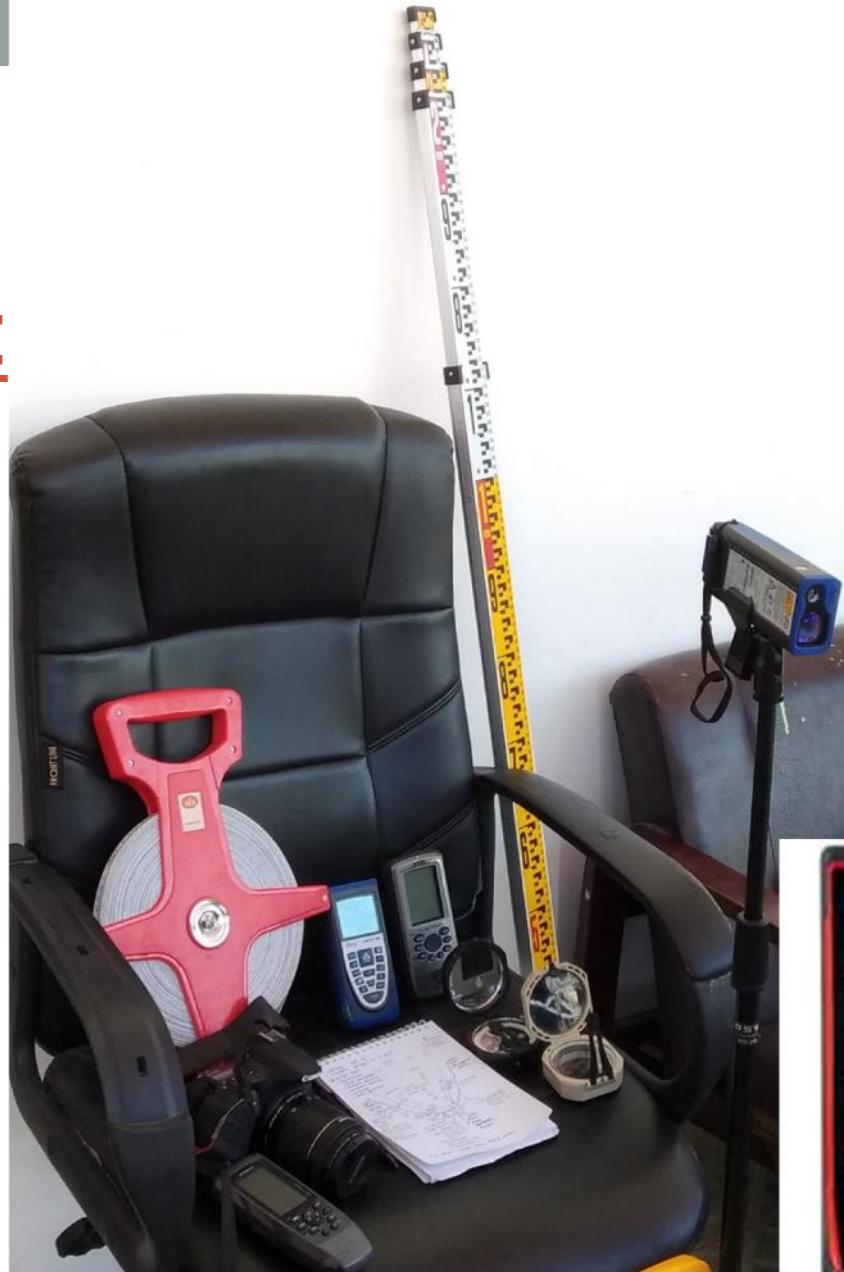
GPS

Compass

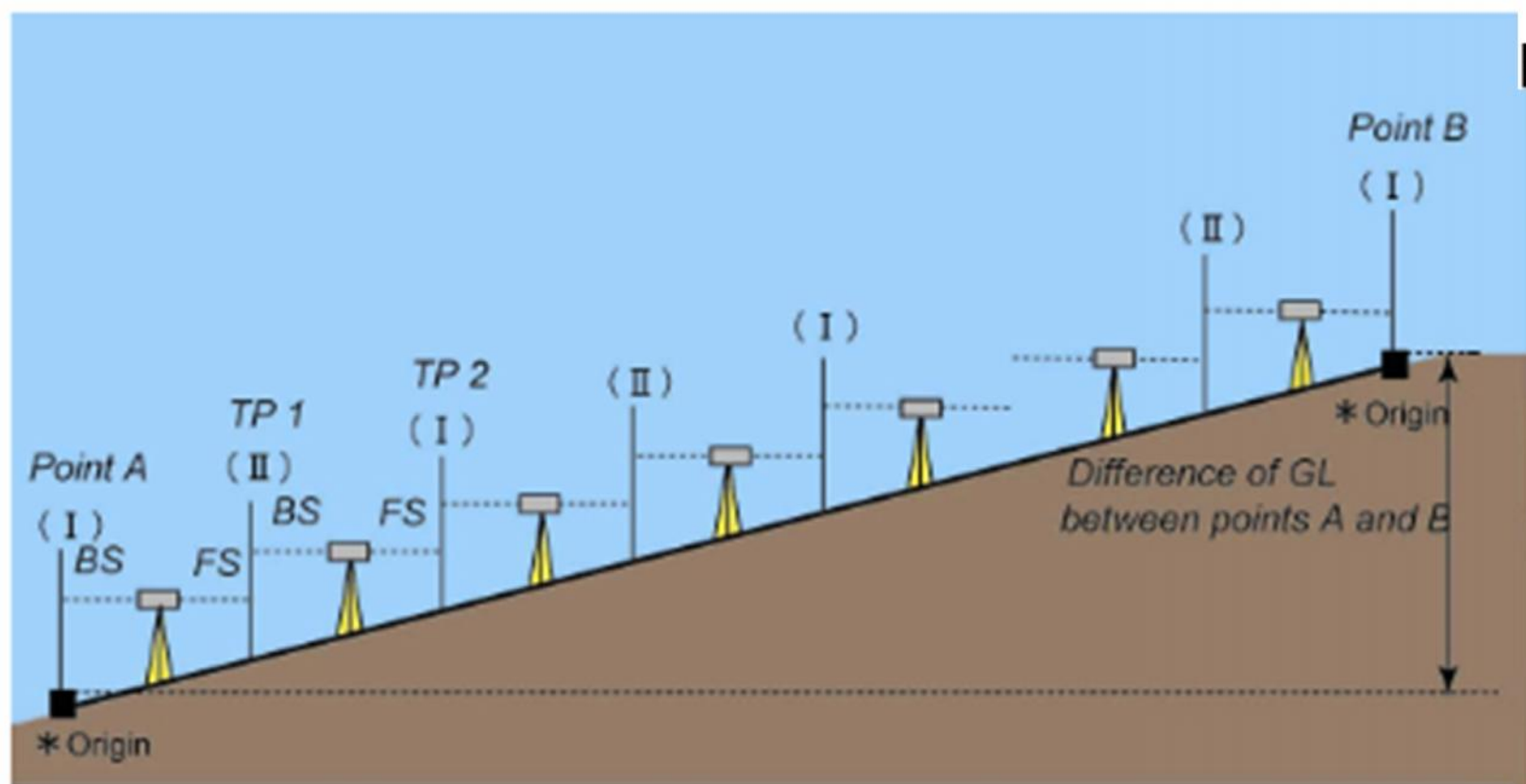
Camera

Height ruler

Roll bar



Principle of level survey



Difference between ground level of point A and that of point B
$$= \sum \text{Back Sight} - \sum \text{Fore Sight}$$

Team minimum = 1 level-man + 1 staff-man (2 persons)

Problem in the field since 3rd day after earthquake (29 September 2018 – 6 October 2018)



**But it is very profitable for science
because we get fresh and complete data**

- Power outage
- Very limited and costly gasoline
- No signal communication
- Road is cut off
- Dust, bad smell corpse and dirt
- Sharp material, nails

Puddle everywhere

Food is very limited

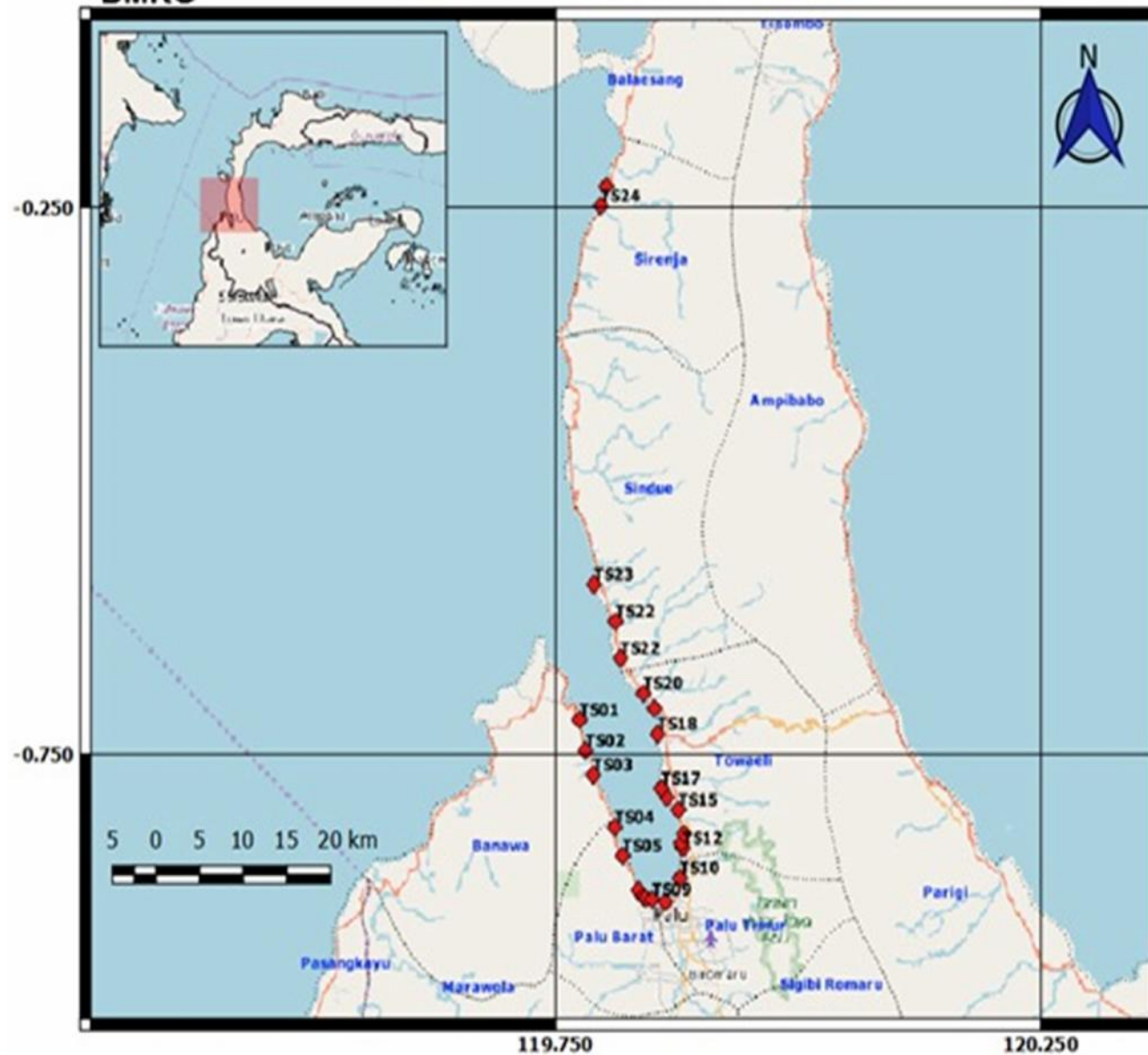
- Paralyzed, dead city

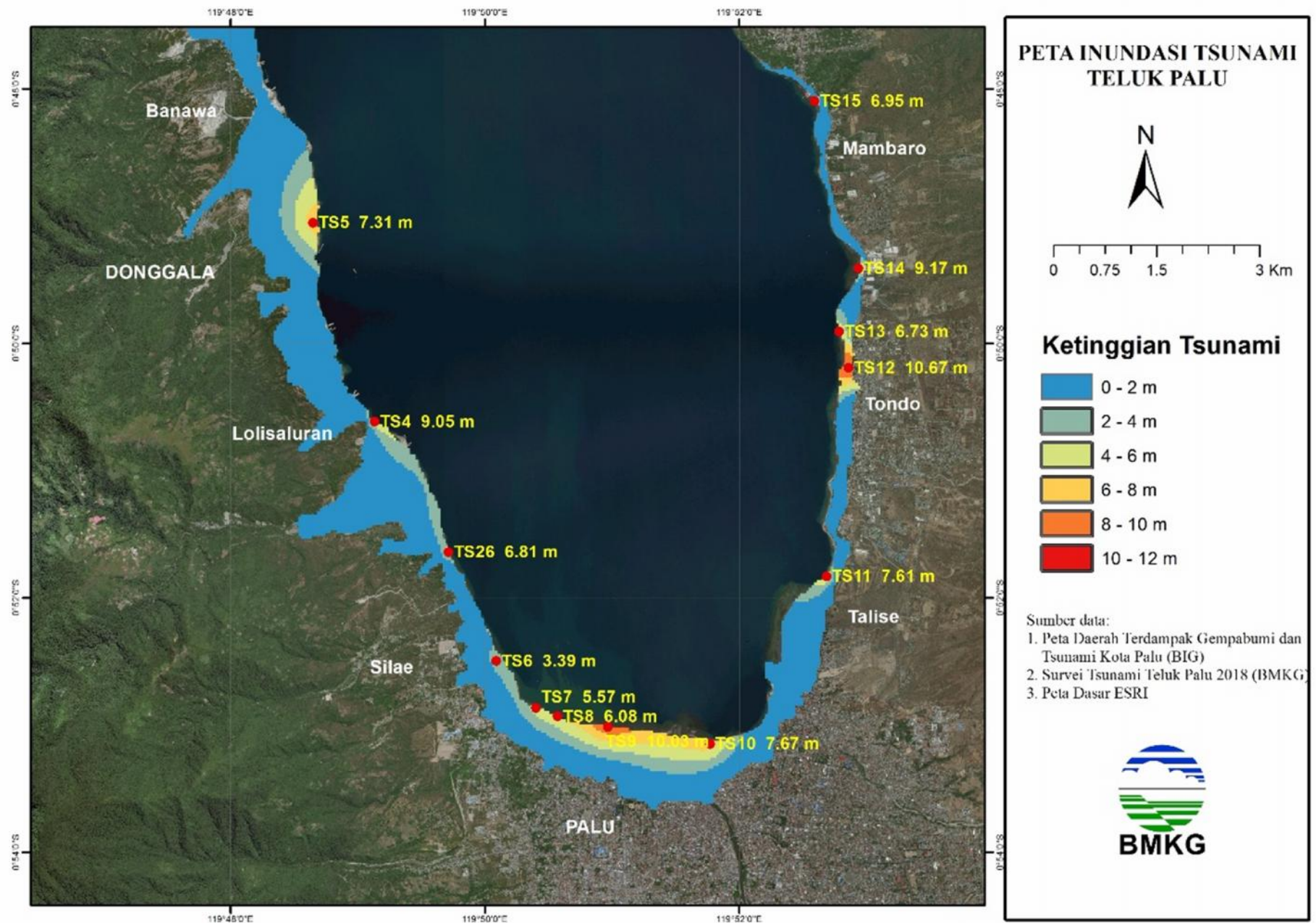
No	Lokasi	Lon	Lat	Tsunami (m)	Inun(m)	Tide cor msl
TS1	Panggang	119,774556	-0,718956	5,1	106,7	4.18
TS2	Lolilondo	119,780534	-0,747154	4,0	97,7	3.15
TS3	Lolipesua	119,788484	-0,769695	7,3	75,6	6.76
TS4	Lolisaluran	119,818903	-0,843634	9,6	101,0	9.05
TS5	Watusampu	119,810797	-0,817553	7,1	74,0	7.31
TS6	Silae	119,834851	-0,874983	3,8	101,8	3.39
TS7	Shophouses	119,840053	-0,881112	5,6	320	5.57
TS8	Grandmall Palu	119,842891	-0,882230	5,6	320	6.08
TS9	Mercure	119,849500	-0,883610	9,2	468,8	10.03
TS10	TVRI	119,862850	-0,885830	7.45	428,9	7.67
TS11	Fisherman vill	119,878140	-0,863900	7,1	75,0	7.61
TS12	Tondo	119,881030	-0,836580	11,3	165,0	10.67
TS13	Citraland	119,879800	-0,831800	7,0	197,0	6.73
TS14	Warehaouse	119,882350	-0,823540	8,3	378,9	9.17
TS15	Handycraft vill	119,876590	-0,801600	6,7	247,1	6.95
TS16	Medic academy	119,864500	-0,790020	6,6	42,0	6.2
TS17	Resort	119,858940	-0,781830	5,8	145,3	5.06
TS18	PLTU	119,855050	-0,732040	8,7	168,8	9.29
TS19	Pantoloan	119,851840	-0,708460	11,1	216,0	10.2
TS20	Port Wani	119,840330	-0,695010	7,1	158,4	7.23
TS21	Labuan	119,816600	-0,662510	4,4	29,3	3.88
TS22	Fish mart Lero	119,811520	-0,629120	5,96	132,7	5.15
TS23	Sand Marana	119,789340	-0,595290	3,9	41,2	2.95
TS24	Tondo Lendi	119,796204	-0,249244	2,3	133,8	1.9
TS25	Mapaga	119,802160	-0,231051	2,2	136,7	2.45
TS26	Tipa	119,828502	-0,860717	6,7	105,0	6.81





PETA LOKASI SURVEY TSUNAMI DONGGALA-PALU 2018





Tondo village, Tsunami height 11,3 m (10,6 m after tide MSL correction)



Palu Grand Mall Tsunami height 6 m



Tsunami puddles around the Green Mosque behind shopping centre



Hotel Mercure, Inundation distance 468 m Tsunami height 10.3 m

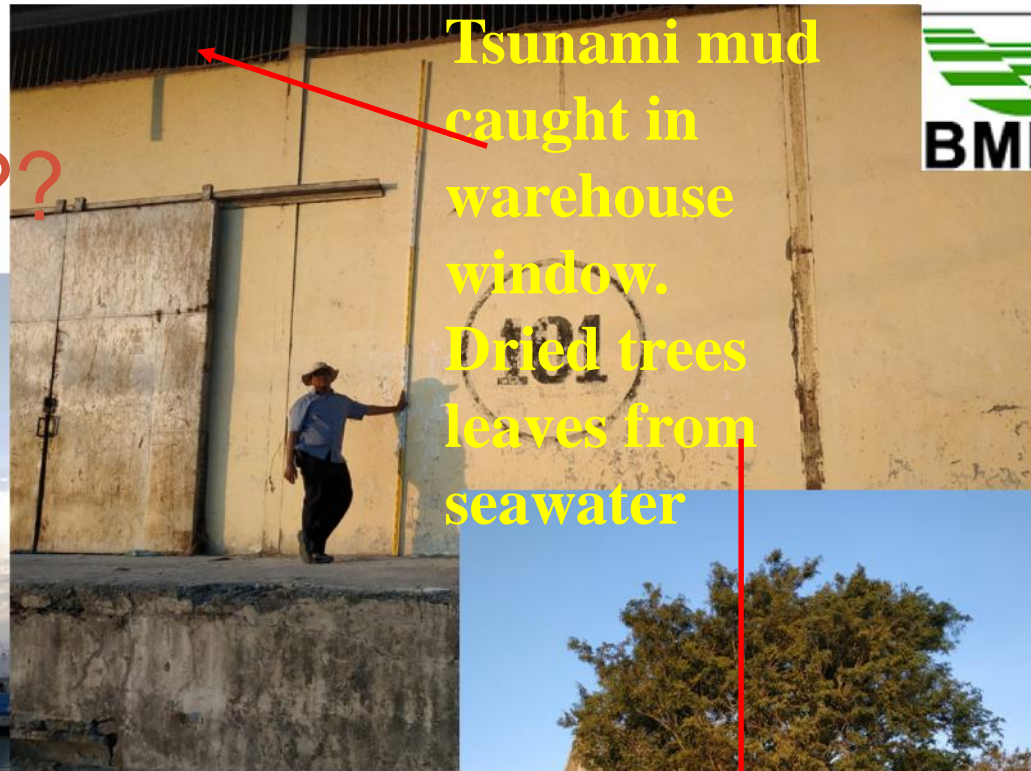
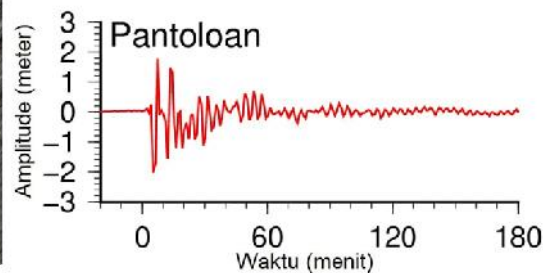
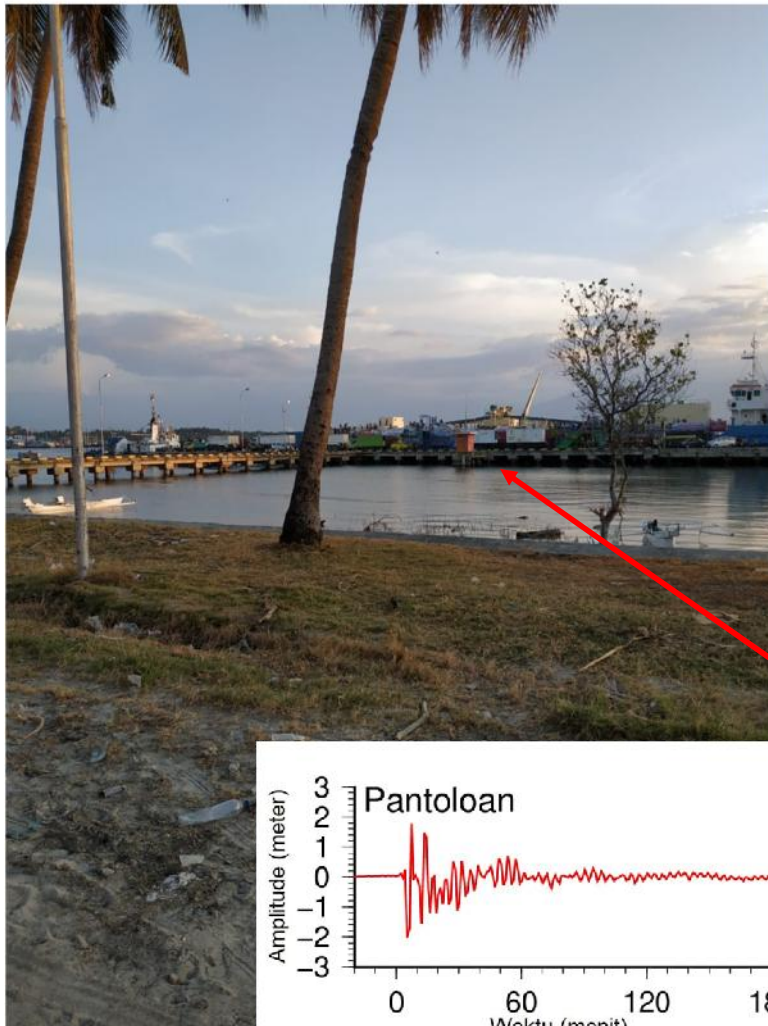


Hotel guests
watched the
Tsunami reach the
second floor
Free viewing
facilities at the hotel
caused Tsunami
wave reach far
mainland

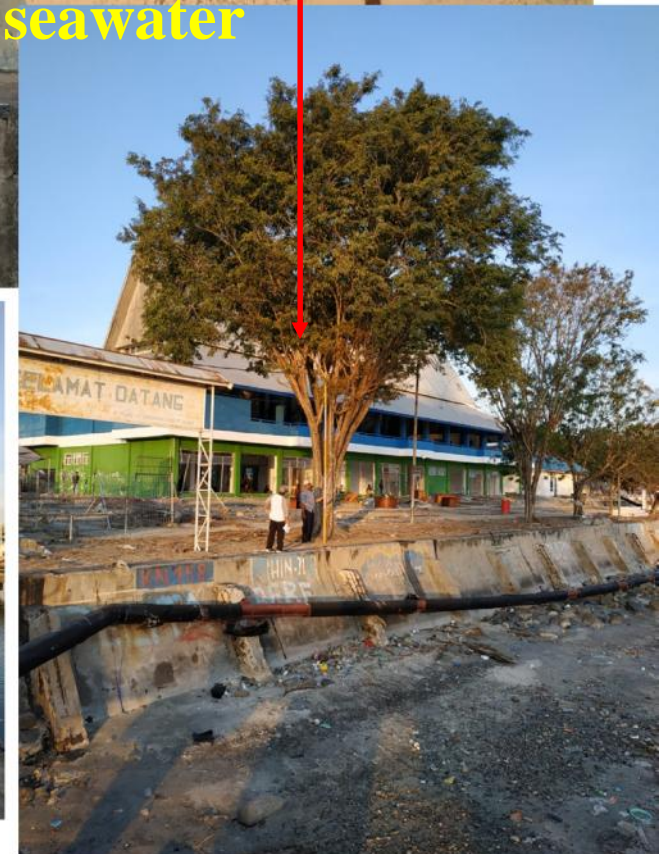
Warehouse Pantoloan port, container scattered
Tsunami height 11,1 m (10,2 m after tide MSL corr)
inundation distance 216 m



Pantoloan 10,2 m
Tidegauge 1.9 m ??



Tsunami mud
caught in
warehouse
window.
Dried trees
leaves from
seawater



The vessel weight of 1500 tons stranded in Wani port, Tsunami 7,2 m

Tsunami waves turned the bow of the ship from the direction of the ocean to the mainland village



Tsunami flow depths: garbage in trees, puddles on walls of building, coral lifted onto land (Location Watusampu, Silae, Mambaro)





Tsunami flow depths: waste in trees, twigs, grass, dead leaves that were exposed to seawater (Location Silae, Mambaro)



Flow-depth 9,6 m in loli Saluran



Tsunami flow depths:
Coconut trees exposed to sea water, run-up as high as hill (Location Lolisaluran)





Flow-depth 6,7 m in Tipo



Tsunami
inundation:
roof & broken
windows,
material waste
(Location Tipo)



Tsunami flow depths: dried leaves, roofs of houses, buildings & crushed excavators, electric poles collapsed (Location Mambaro, Pantoloan, Primkopal)



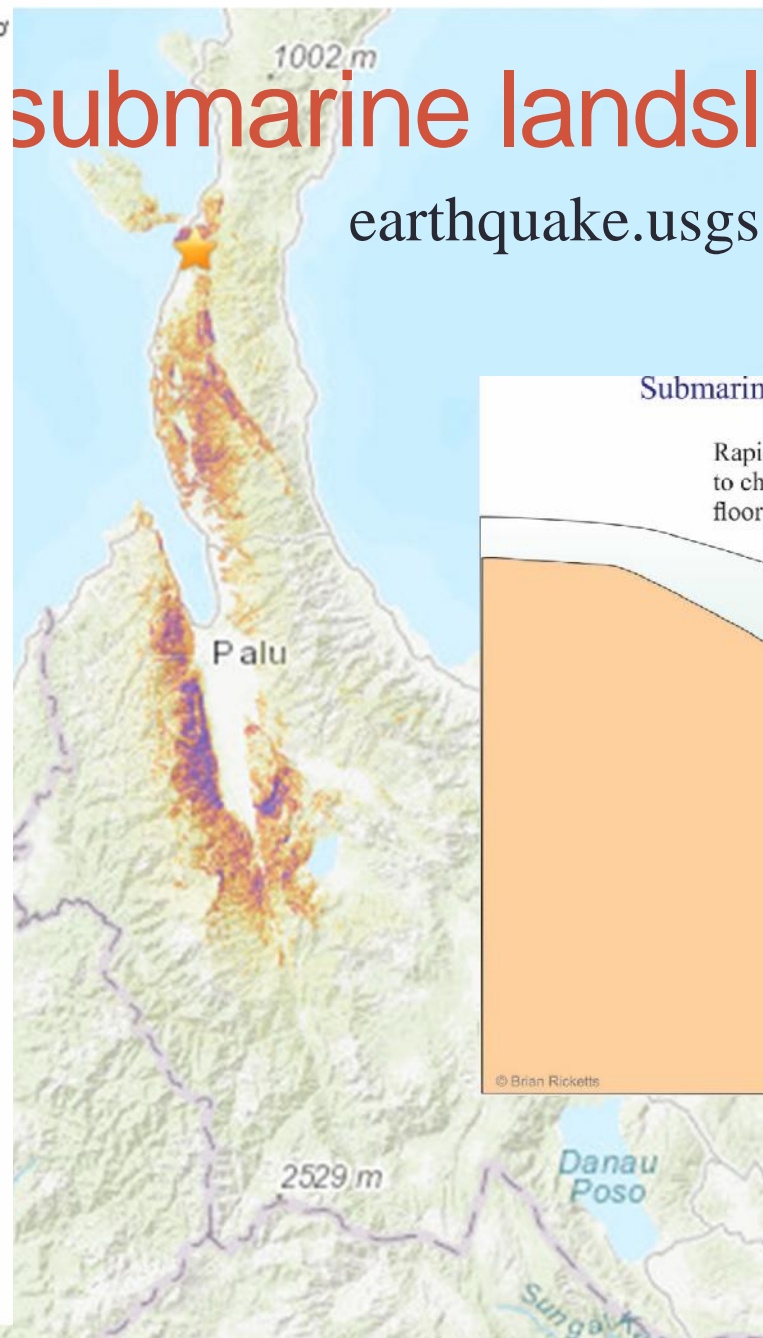
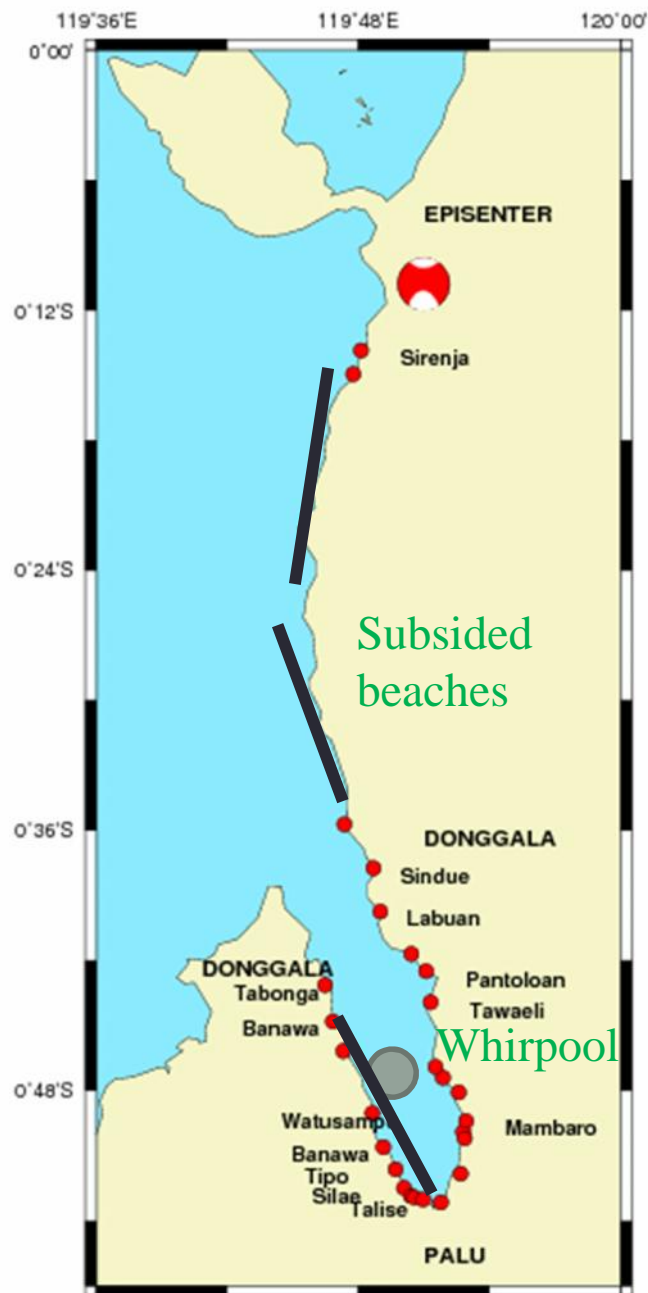
Old house since
1938
experienced
Tsunami twice
1968 & 2018

Indications of seabed landslides:

1. Fish cage farms with a 200 m anchor depth sink to the bottom of the ocean due to sea floor avalanches.
2. There are some beaches that disappeared into the sea at Marana Beach, Enu, Labean, Lolisaluran, Lolipesua and Lolilondo.
3. The formation of a whirlpool is seen on the sea surface based on the testimony of residents in Lolisaluran Beach, Lolipesua and Lolilondo and videos uploaded by Pilot Batik Air.
4. Video taken in the ocean from a sailor of sand mining vessel (PT Delta Abadi) that trapped in the middle of three whirlpools of Loli area.

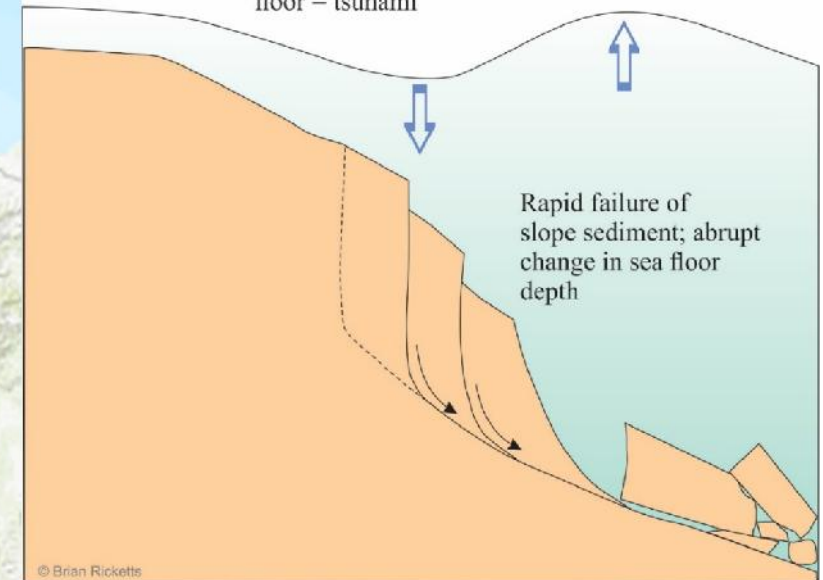
submarine landslide

earthquake.usgs.gov



Submarine landslide-generated tsunami

Rapid response of sea level to changing depth of sea floor = tsunami



© Brian Ricketts

Avalanches on land at Enu district about 15 locations



The beach subsided with a lateral distance of 30 m from the back of the beach



Whirlpools in Lolisaluran, Lolibenua, Lolipesua

West coast of palu bay

Pantai Bagian Barat Teluk Palu

A

B

C

40.714 suka

icoze_ricochet Batik Air ID 6231 scheduled to depart at 17.55, door closed at 17.52 then pushed back. 18.02 after cleared for take off, tower building collapsed. We were just rolling on the runway. I felt something wrong on the runway during take off roll. 18.02 earthquake 7.4-7.7 magnitude on scale rocks Palu. Thank God there is a voice (Holy Spirit i believe) telling me to depart early. I'm rushing the boarding process. Late by 30 second i would not have flown. Thank You Jesus. I took this video just after airborne on 1500ft climbing. Strange wave-Tsunami.

Lihat semua 2006 komentar

Video taken in the ocean from a sailor of sand mining vessel (PT Delta Abadi) that trapped in the middle of three whirlpools of Loli area.





Determination tsunami arrival time from the 2018 Palu survivor interview

- The local time of Palu city, Central Sulawesi is 1 hour faster than Jakarta.
- The people we interviewed did not see the clock exactly. Therefore we use the analogy of the sunset call or azan magrib time to prayer in the Palu area around 17.57 to 17.59 local time in 28 September 2018 (www.muslimpro.com).
- Everyone listens to the azan call because it is sounded through a microphone of every mosques with a range of 3 km. Even before the azan call, mosque officials sang divine praises asking people to pray.
- Various comments from people that the earthquake came before the call or on the call
- Almost agreed that tsunami came after the call and total electricity went out instantly

Interview of 2018 & 1968 Tsunami survivors at



Labean, North East
Donggala (near epicenter)



Lolisaluran



Mapaga, Sirenja



Lolipesua



Panggang village

No	Location	Local time of Sulawesi	Witness/phone/d ate of interview	Information ³⁰
1	Panggang village	Earthquake: 18.00 Tsunami1:18.02 Tsunami2: 18.05	Nurtin, El Laski, 082140969362, 085244415510 (02/10/2018)	Nurtin smelled scorch burning along the beach before the earthquake. He saw the first tsunami flowed as high as calf came from the north. The second tsunami is as high as a waist. El Laski saved himself because he remembered the experience of the 1968 tsunami when he was 20 years old.
2	Lolilondo village	Earthquake: 18.00 Tsunami1:18.02	Fadli, Basyir, Arfan, 082347897656 (02/10/2018)	Basyir saw tsunami 1 came from the south; Tsunami 2 from the north; Tsunami 3 recession. After tsunami finished, Arfan came back to their house closed to beach and saw the sea forming a vortex in the middle.
3	Lolipesua village	Earthquake: 17.55 Tsunami1:18.00 Tsunami2: 18.03	Sarifudin, Taufik, 081242486056, 085395248989 (02/10/2018)	Tsunami 1 from the north, after receding, tsunami 2 was as high as the house and swept the buildings with strong construction include Sarifudin's house.



No	Location	Local time of Sulawesi	Witness/phone/date of interview	Information ³¹
4	Lolisaluran village	Earthquake: 18.00 Tsunami1:18.01 Tsunami2: 18.04	Ahmad, Risky (03/10/2018)	The fish market and housing that stood lateral 30 m from the shoreline, disappeared due to a beach avalanche. After the tsunami finished, coconut trees fall and become flooded. Risky saw a tsunami wave as high as a coconut tree rising to the hill where his nephew lived. The back wash of tsunami dragged his nephews and missing people into the sea. Risky also saw vortex in the middle of sea after tsunami.
5	Watusampu, Primkopal	Earthquake: 18.01 Tsunami1:18.02	Paruli (02/10/2018)	The tsunami was as high as an electric pole. The cape and port subsided.
6	Silae and Lere villages	Earthquake: 18.01 Tsunami1:18.02 Tsunami2: 18.05	Sadimin, Sunandar 08114506804, Erik, Taufik, 0822290100181, Rahmayanti (30/09/2018)	Tsunami 1 comes from the north (Donggala), the height is lower than the fence of his house. 2 tsunamis recede into the sea. Tsunami 3 from the south (Palu City, Talise) is already as high as the fence of the house. Rahmayanti felt tsunami came less than 1 minute after earthquake..





No	Location	Local time of Sulawesi	Witness/phone/date of interview	Information ³²
7	Port Wani	Earthquake: 17.55 Tsunami1:18.00	Sarifudin, Alwiyah, 081245935758, 082394739393 (10/04/2018)	Tsunami 1 came not so high. Tsunami 2 recedes to the sea. Tsunami 3 turned the bow of the ship and lift the ship to the mainland. Sarifudin heard a roar of the tsunami. He saw the tsunami height exceeding the ship and in the form of a black cobra carrying sea mud.
8	Salombone Labuan and Sindue	Earthquake: 17.55 Tsunami1:18.01 Tsunami2: 18.03	Rintal, Zabir (04/10/2018)	Tsunami 1 water rises, sea water recedes 3 times. Tsunami 2 rotates to the sea.
9	Fish market Lero	Earthquake: 17.55	Ilekal Lakajo, 085241362546 (04/10/2018)	Housing and fish markets sank, bathymetry changes, inundation reached to the road.
10	Sand mining Marana and Lunar observation of BMKG	Earthquake: 17.55	M. Dong Hilal, 085394577338 (01/10/2018)	Fish cage farms with a 200 m anchor depth sink to the bottom of the ocean due to sea floor avalanches. Change in bathymetry is very clearly visible along the coastline

No	Location	Local time of Sulawesi	Witness/phone/date of interview	Information ³³
11	Tondo Lende, Sirenja	Earthquake: 17.58 Tsunami1:18.02 Tsunami2: 18.04	Sakti, Arwin, Ahmadi, 085240359635 (01/10/2018)	Many landslides in the Enu area. \ the weather is sunny on the beach, Arwin and Ahmadi the fisherman was tethering his boat suddenly hearing a tsunami sound like water hissing. His experience as a child as a tsunami survivor, so he took action to tell residents to immediately evacuate themselves to the hills away from the beach. At hour 20 local time he returned to the beach, but there was still a lot of stagnant water and the boat was approaching the road.
12	Tanjung Padang, Mapaga, Sirenja	Earthquake: 17.58 Tsunami1:18.01 Tsunami2: 18.03	Dino, 085399643068 (01/10/2018)	The beach is subsiding, the shape of the chasm is very deep.
13	Labean, North East Donggala (near epicenter)	Earthquake: 17.58 Tsunami1:18.01	Jamil, 085399643068 (01/10/2018)	When the Labean tsunami in 1968 he was still 4 years old. Now he has become the village head. On the basis of his experience, he can safe his citizens by evacuating higher ground. The sky was dark . The tsunami made deep ravines on the shore and turned the coastal land into a deep ocean



The Second Survey of BMKG Day III (13-10-2018)

Survey to Donggala (TS-01 dan TS-03)

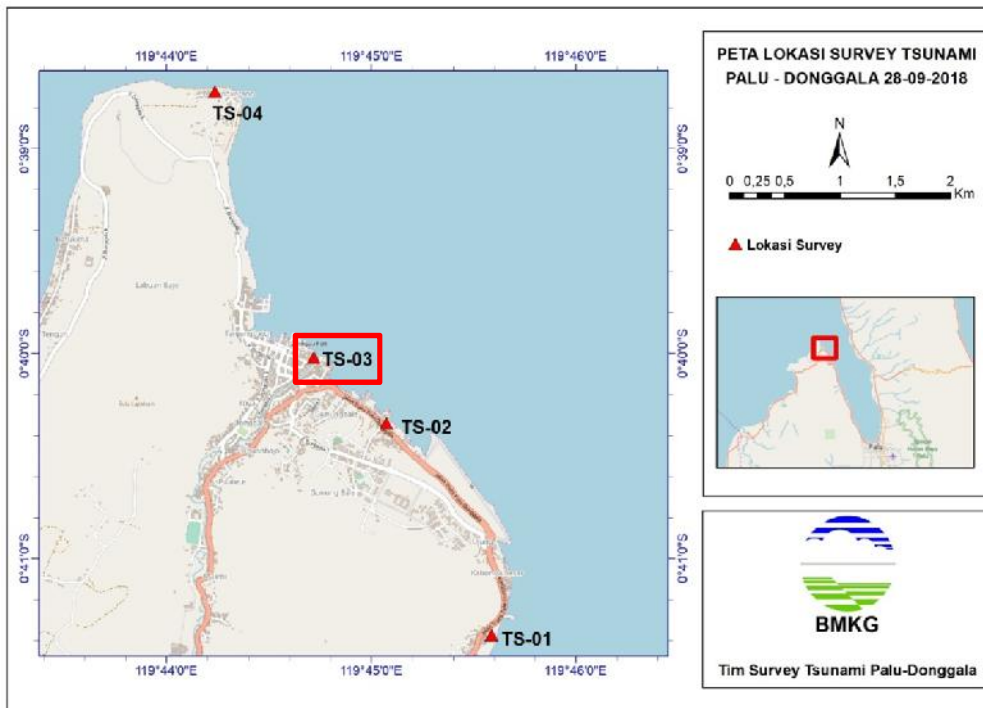
TS-03 Muara (-0.667 and 119.74532)



Landslide cause ± 32 houses
collapse to the sea



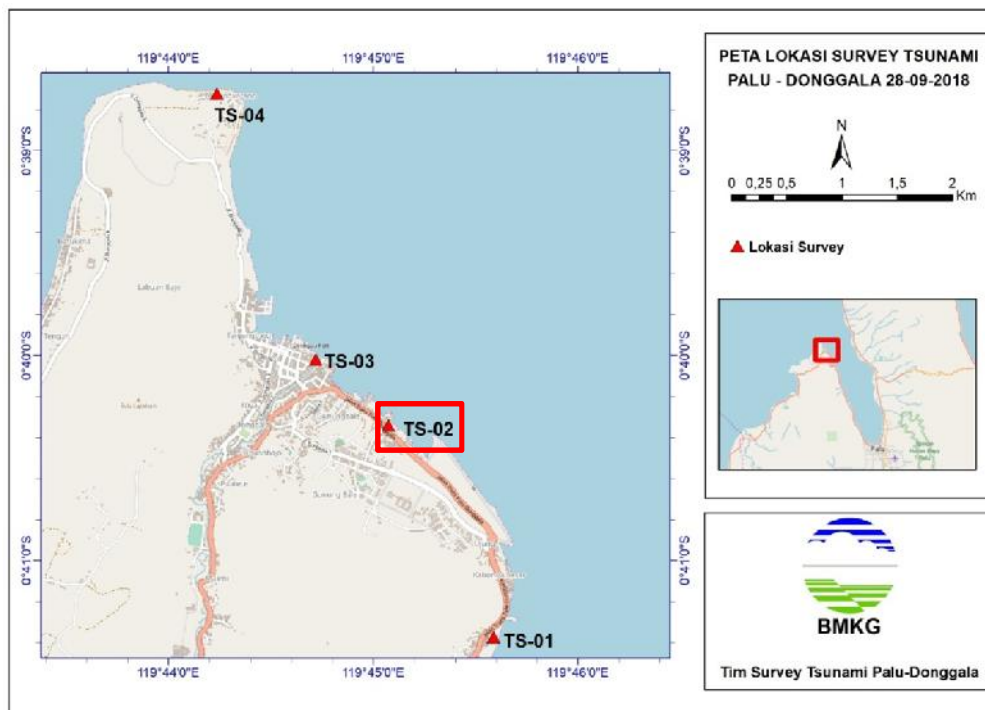
Tsunami ~ 3.015 m



The Second Survey of BMKG

Day IV (14-10-2018)

Survey to Donggala (TS-02 dan TS-04)



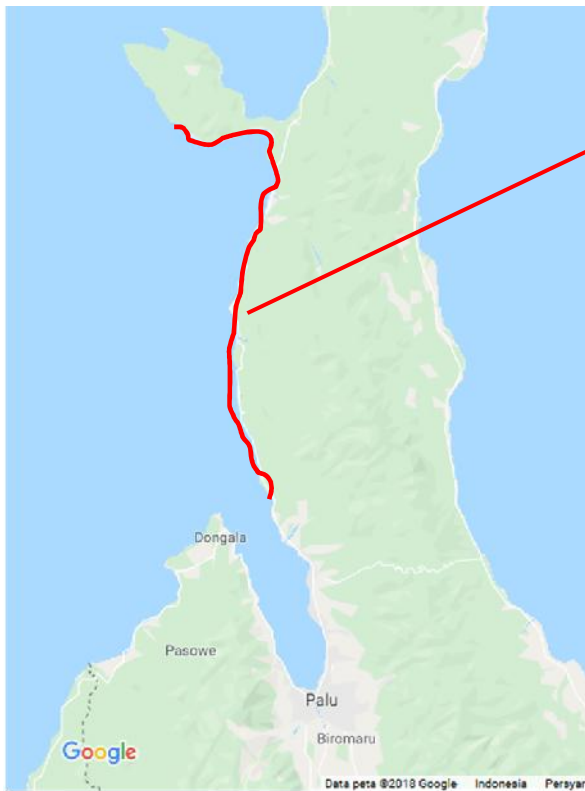
Tsunami ~ 3.33 m

The Second Survey of BMKG

Day V (15-10-2018)

Survey to Donggala

We did not find tsunami trace in this area because we can not reach almost all beach. There are many steep cliffs and landslides on the roads.

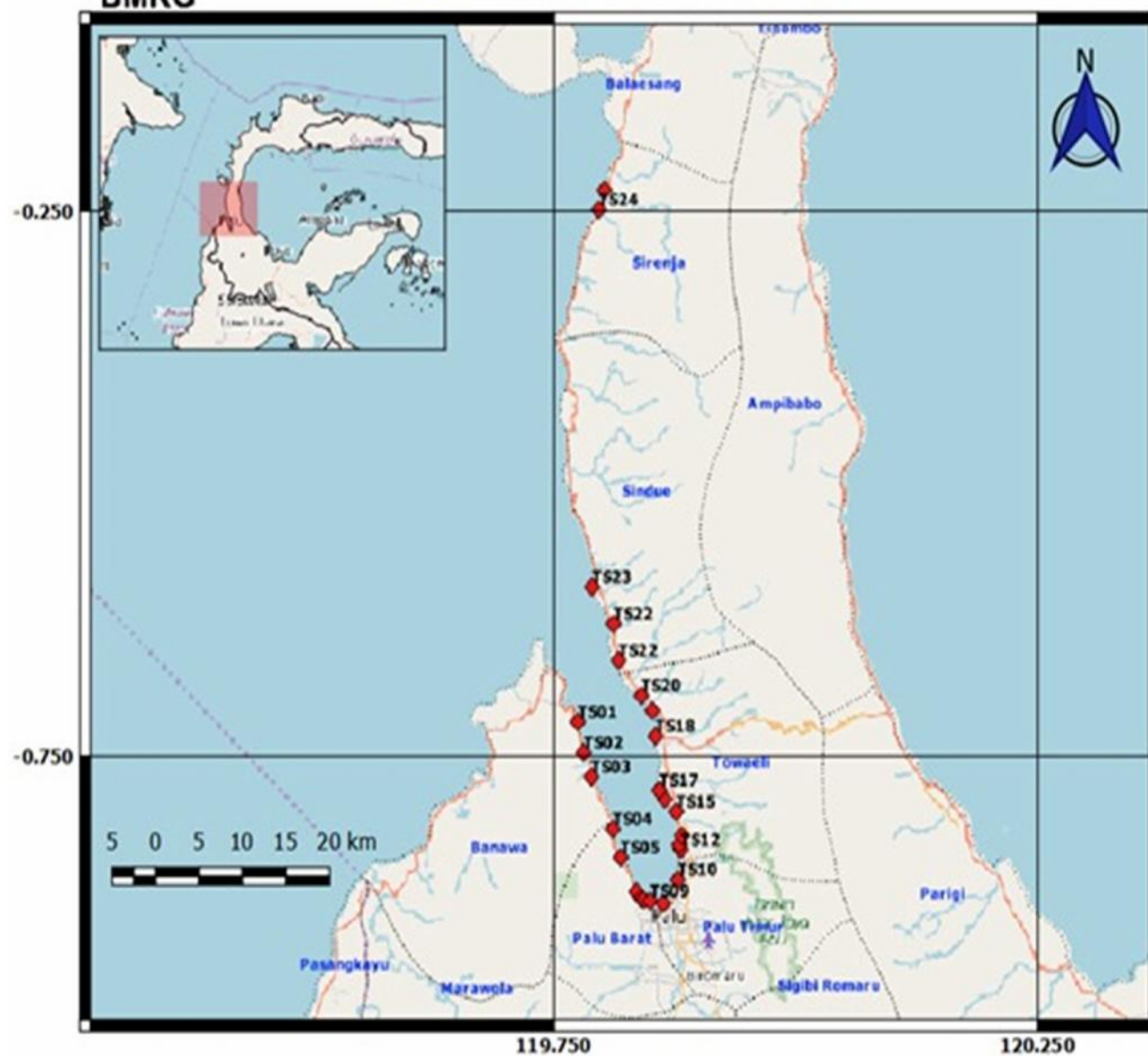


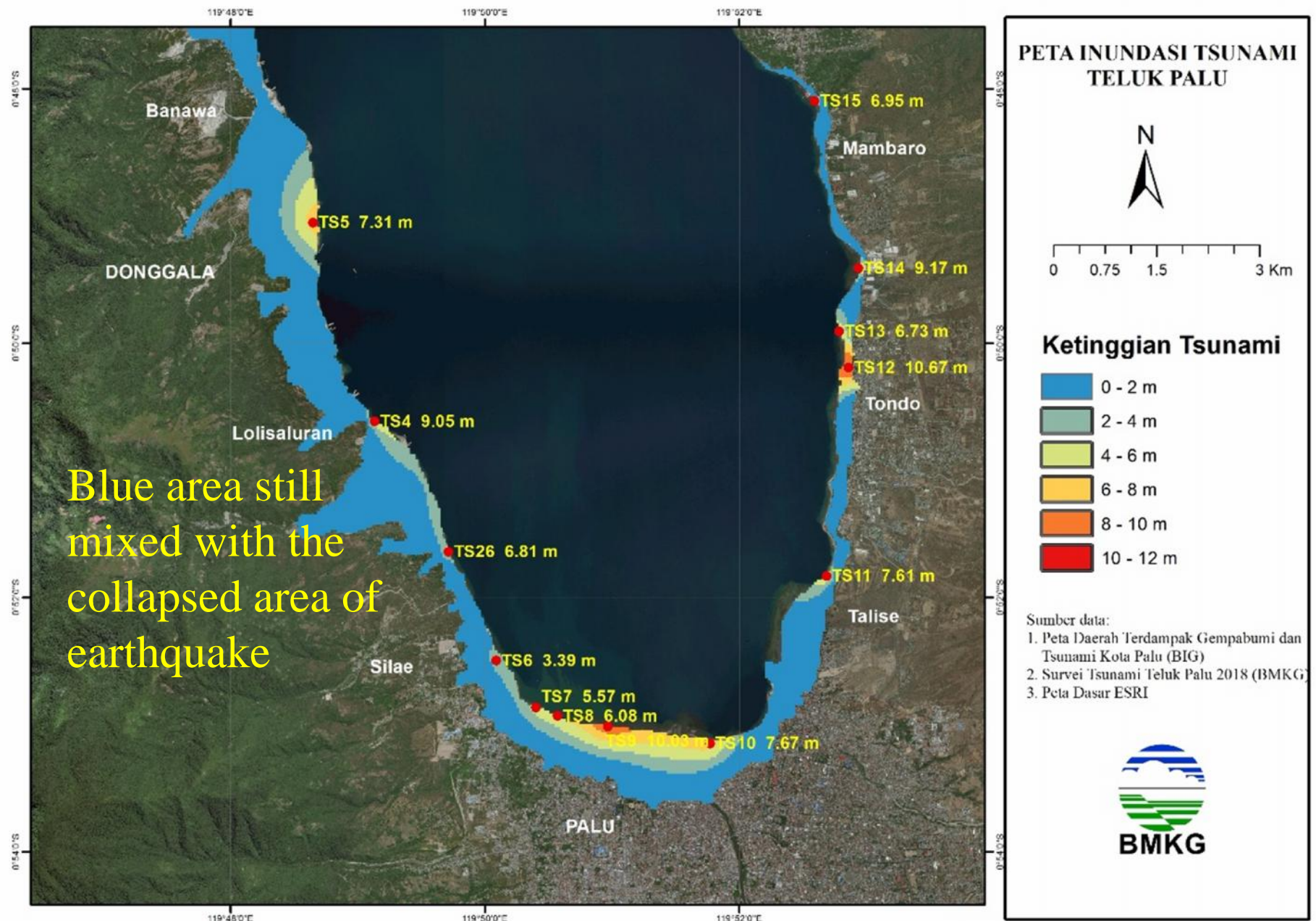
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TS14	Pergudangan	119,882350	-0,823540	8,3	378,9	9.17
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TS16	Poltekes	119,864500	-0,790020	6,6	42,0	6.2
TS17	Resort	119,858940	-0,781830	5,8	145,3	5.06
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TS22	TPI Lero	119,811520	-0,629120	5,96	132,7	5.15
TS23	Pasir Marana	119,789340	-0,595290	3,9	41,2	2.95
TS24	Tondo Lendi	119,796204	-0,249244	2,3	133,8	1.9
TS25	Mapaga	119,802160	-0,231051	2,2	136,7	2.45
TS26	Tipo	119,828593	-0,860717	6,7	105,0	6.81





PETA LOKASI SURVEY TSUNAMI DONGGALA-PALU 2018







SUMMARY

1. Palu Tsunami 28 September 2018 consisted 3 waves that the interval around 1 minutes, 5 minutes and 10 minutes after earthquakes.
2. The tsunami in the narrow Palu Bay caused a maximum tsunami amplification of 10,6 m in Tondo Village, East Palu.
3. The farthest tsunami inundation was at the Mercure Hotel area, Lere, East Palu: 468.8 m from the shoreline.
4. The mechanism of horizontal fractures (sinistral) causes underwater avalanches which generate tsunamis.