

J-RAPID Report Symposium for Anak Krakatau volcano eruption and Sunda Strait tsunami

# Field Survey of Anak Krakatau on August 2019



#### **Research Collaborated by**

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Institut Teknologi Sumatera (Indonesia)

- Tokyo City University (Japan)
- Niigata University (Japan)

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#### The Aims for The Research

- To investigate mechanism of tsunami generation as a result of volcanic eruption of Anak Krakatau, we conducted field survey around Anak Krakatau in the middle of August 2019. The content of field survey was mainly divided into followings:
- 1) Identification of tsunami height at three Islands surrounding Anak Krakatau
- 2) Measurement of topography of Anak Krakatau by using UAV
- 3) Bathymetric survey around Anak Krakatau
- 4) Questionnaire survey at Sebesi Island

#### Notes of Research Permit

 It should be noted that we obtained research permit from Kementerian Riset dan Teknologi Republik Indonesia in order to legally carry out our researches regarding Anak Krakatau and surrounding three Islands.

 Final research permission was obtained at 15<sup>th</sup> August when the survey members arrived at Jakarta.

# A Voyage of Field Survey



- On 15th Aug 2019, we arrived at Lampung and stayed at hotel located at coast near Sebesi Island.
- On 16th Aug, we departed from Smatra Island. Firstly, we directly went to Anak Krakatau (field surveyed), and then returned to and stayed at Sebesi Island.
- On 17th Aug, we focused on field survey around Anak Krakatau.
- On 18th Aug, from Sebesi Island, we went back to Jakarta.



The field survey was conducted
to measure a possible tsunami
height at three Islands which
we landed on from small boat.

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- Sonar equipped in main and
  small boat, which went around
  Anak Krakatau many times,
  measured oceanic bathymetry.
- UAV took many pictures of Anak Krakatau to construct digital elevation map by using photogrammetry on Photoscan.

#### Pulau Krakatau Kitjil



- A lot of trees on Pulau Krakatau Kitjil were withered and ground was largely eroded, meaning that generated tsunami apparently attacked this Island.
- We measured a height of tsunami from water level after we landed on some area of this Island.



#### Pulau Krakatau Kitjil



- In other parts, a lot of trees on Pulau Krakatau Kitjil were withered and ground was largely eroded as well.
- There is a still controversial, however, tsunami was probably run-upped and overtopped this Island. If so, possible tsunami height was over 80 m.



#### Pulau Krakatau



- Severe erosion was observed at Pulau Krakatau as well. In addition, trees were withered in low ground elevation area.
- Tsunami probably reached a boundary between bare ground and trees planted area. Its height was approximately 50 m.



#### Pulau Krakatau (from side angle)



- From side angle, it can be observed that a lot of gravel were scattered near coastal area, but were concentrated in some part.
- We can recognize a clear boundary between with and without trees.



#### Pulau Sertung



- The severe erosion was observed at Pulau Sertung as well. The trees probably disappeared in the front area meeting Anak Krakatau.
- A possible tsunami height was nearly 40 m, if the tsunami height was equal to the boundary.



#### Pulau Sertung



- The severe erosion could be observed in other area of Pulau Sertung.
- The cliff was also existed in the front area of Pulau Sertung, meeting Anak Krakatau.



### Tsunami Height at Three Islands



- It should be noted that tsunami height was roughly measured.
- The possible tsunami height at Pulau Sertung and Pulau Krakatau ranges from 40 ~ 50 m.
- At Pulau Krakatau Kitjil, where tsunami was expected to be overtopped, a possible tsunami height was nearly 80 m.
- There can be still discussions regarding the tsunami heights.

#### **Bathymetric Survey**



- The pictures show a scene when we attached Garmin's sonar to small boat.
- The bathymetric survey was conducted by using a small boat and the main boat to measure bathymetry and estimate its changes due to eruption of Anak Krakatau.

### **Bathymetric Survey**



- The bathymetric survey was conducted around the Anak Krakatau.
- We went around Anak Krakatau many times in order to obtain dense bathymetric map and to find out the bathymetric changes associated with volcanic eruption.
- The results of bathymetric survey have been now under analysis.

#### Anak Krakatau



- Caldera of Anak Krakatau was still active and release gas (there was a smell of sulfur compounds).
- Cloudy sea water (including sediments flowed from Anak Kratatau) was observed near Anak Krakatau. This can be also recognized from Google Earth.



#### Anak Krakatau



- Surface feature of the Anak Krakatau was rough and solid probably as a result of lava flow and collapse of mountain.
- There were a lot of small cliffs and hill which height were roughly below 5-10 m, which could be found when we climbed up Anak Kratatau.



### **UAV Survey**

- UAV survey was conducted to construct digital elevation map (DEM) of Anak Krakatau after eruption.
- DJI phantom 4 pro was flied from the middle of the mount of Anak Krakatau.
- Approximately 50 ~ 60 m flight height above ground was set for drone.
- Manual flight of drone was set.
- Its side and vertical overlap were approximately 30~ 60% and 60 ~ 90 %.

#### Process on photogrammetry



- Flight covers almost all area of Anak Krakatau. The slide view pictures of Anak Krakatau were included in order to construct DEM with high precision.
- Photoscan was used to create the DEM.

### Result of photogrammetry



- Left figure is a result of photogrammetry by using UAV pictures on Photoscan.
  - It can be obviously understood that caldera was created in Anak Krakatau after eruption. It is consistent with other researches and image on Google Earth.

In the front of caldera, flat ground area spreads. The color of this area was yellow probably because of including some sulfur compounds.

According to the DEM, maximum height was nearly 160 m, which can be somewhat agreement with 157 m from indication by the information of LCDV Tous Droits Réservé (2019).

#### **Questionnaire Survey**



- Questionnaire survey was conducted at Sebesi Island where the survey team stayed during the survey period.
- The purpose is to reveal residents' perception of danger and evacuation patterns during the event.
- A total of 34 questions were asked (e.g. the perception of danger regarding the tsunami, evacuation, source of information, preparedness before the disaster, and other personal information.
- Obtained answers from 67 residents.

#### Discussions

- Some other analysis are still under going to correctly understand what happened as a result of eruption of Anak Krakatau. In addition, we understand that a lot of discussions are still needed as well.
- On the other hand, as we judged from a lot of pictures, three islands surrounding Anak Krakatau were severely affected. Consequences included severe erosion of ground surface, trees withered on these islands.
- As a result of eruption, a lot of consequences were seen in Anak Kratatau itself. Examples included the caldera (which can be recognized from satellite imaginary as well). Also, although there are some published papers regarding topography changes of Anak Krakatau (Walter et al. 2019) and tsunami simulation (Grilli et al. 2019), we hope to improve our understanding of consequences of Anak Krakatau eruption based on our field survey.

#### **Current Conclusions**

- Severe consequences were observed at three islands around Anak Krakatau as a result of analyzing field survey. Also, possible tsunami height reached 50 ~ 80 m in these islands.
- As a result of analysis of Anak Krakatau, almost 1/3 volume of mountain disappeared from original volume. This quantitative analysis may contribute to understand generated tsunami which affected the coastal area around Sunda Strait. However, it should be noted that it is being still under analysis and discussions including bathymetric changes around Anak Krakatau.
- We finally appreciate financially support from JST and some office procedures (research permit) from Kementerian Riset dan Teknologi Republik Indonesia. We express gratitude for giving us the opportunity of presentation in this conference.

#### References

Papers:

- Grilli et al. 2019: Modelling of the tsunami from the December 22, 2018 lateral collapse of Anak Krakatau volcano in the Sunda Straits, Indonesia, Scientific Reports volume 9, Article number: 11946.
- Walter et al. 2019: Complex hazard cascade culminating in the Anak Krakatau sector collapse, Nature Communications volume 10, Article number: 4339.

Information:

 LCDV Tous Droits Réservé 2019: OCTOBER 21, 2019. EN. KAMCHATKA : EBEKO , INDONESIA : ANAK KRAKATAU , GUATEMALA : PACAYA , COSTA RICA : TURRIALBA / POAS / RINCON DE LA VIEJA .

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