Preliminary result of Research Cruise of R/V Natsushima around the epicenter of Sumatra-Andaman Earthquake, 26th December 2004 under Urgent study of the Great Sumatra Earthquake and Tsunami Disaster

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Summary

Magnitude 9.3 Sumatran-Andaman Earthquake took place on December 26, 2004. A huge Tsunami that was generated by it hits each country around the Indian Ocean. It has suffered big damage in the victim who exceeds about 300,000 people and the region including Indonesia due to this Tsunami and the earthquake so far. As for this, the research cruise has been made in an international frame that wishes the cause investigation and the revival of this disaster. To examine the bottom of the sea change immediately after the earthquake jointly, urgent research program was made under umbrella between Japan Agency for Earth-Marine Science and Technology (JAMSTEC) and Agency for the Assessment and Application of Technology of the Republic of Indonesia (BPPT) in collaboration with in collaboration with Federal Institute of Geosciences and Resources, Germany and Lamont-Doherty Earth Observatory, Columbia University, USA. The investigation navigation was divided into two legs, and investigated for 41 days in the water off the coast of Indonesia Aceh Province.

This program aims to better understand the mechanism of the earthquake occurrence of the Sumatra earthquake of the magnitude of nine-class and the destruction spread and the hypocenter of neighborhood. Then the research program activity involved 1) bathymetric survey, 2) remote operatively vehicle (ROV) survey of direct observation for the sea bottom change immediately after the earthquake, 3) Ocean Bottom Seismograph array examination in the place presumed to have displaced bottom of the sea most greatly.

Consequently, the bathymetric chart with high accuracy in the sea area presumed to be the first time discovery of shuttered sea bottom and the collapse of the cliff, etc. in the world in the hypocenter neighborhood region due to this earthquake, and the short-term type ocean bottom seismograph was collected, and about 3,000 aftershocks under the observation were obtained right after the earthquake. These data suggest us that the displacement of the crust took place greatly in a shallow part. In conclusion, the study area was particularly displaced as tsunami source area; the Tsunami attacked the north Sumatra including the Banda Aceh.

Objective

This study aims to investigate nature of sea bottom in the rupture zone and to understand the seismogenic mechanism and the mechanism for generating big tsunami. In conjunction with results from the damage investigation, this study aims to understand the scale and cycle of the great earthquake and tsunami from observation of precise distribution of aftershock, survey of high resolution bathymetry and contributes to the disaster prevention in this area.

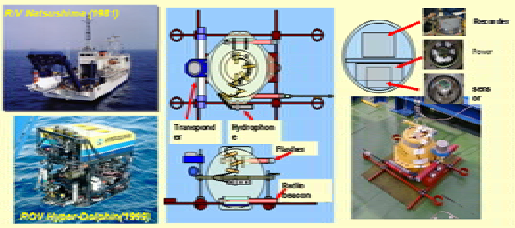


Figure 1: Our facilities including R/V Natsushima, ROV hyper-Dolphin and OBS.

Outline of the survey

JAMSTEC's Research Vessel "Natsushima" and Remotely Operated Vehicle (ROV) "Hyper-Dolphin" will be engaged in this cruise in the inferred larger displacement area off northern Sumatra near the epicenter (see, study area). The survey included swath bathymetry and back-scattering image, making ROV dives to observe directly the shuttered sea bottom by this earthquake, and deployed and recovered 17 short-term Ocean Bottom Seismographs (OBS) and measurement by 2 long-term OBS is going on until end of June, 2005.

Figure 2: Onboard scientific party and the Captain Saito and his crew.

How we conducted the survey

Ship R/V Natsushima schedule:
Leg 1 (Singapore to Penang) from 14th Feb. to 6th March.
Leg 2 (Penang to Bali) from 8th March to 26th March

Operation

Bathymetry: Research area of an approximately 4,000 km² was covered at the trench side boundary and basin side boundaries of the outer-arc high.
Dives: At 6 pinpoint sites (9 days observation), water depth ranges between approx. 3,000 to 2,100 m.
Single channel seismic survey: 950 km long single channel seismic lines were examined.
Ocean bottom seismometer array observation: 17 short-term OBS's were successfully installed and recovered. 2 long-term OBS's (6 months) are still in operation.
Others: A deep-towing subbottom profile survey was done.

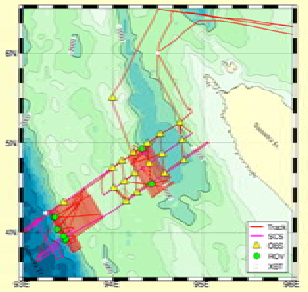


Figure 3: Ship track chart showing the study area. It is located off northern most of off Sumatra, where is 250 km far from the epicenter but it is inferred to be displaced significantly rather than the epicenter by Harvard CMT.

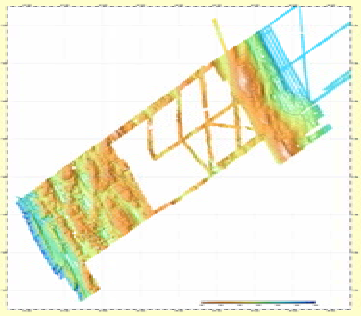


Figure 4: Bathymetric chart. It covers over 4,000 km², in particularly on the trench side and basin side boundaries of the outer-arc high.

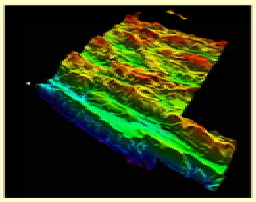


Figure 5: 3D map in the front of trench side boundary of the outer-arc high. Note that the significant escarpment of over 1 km relief was identified on the front of the trench slope.

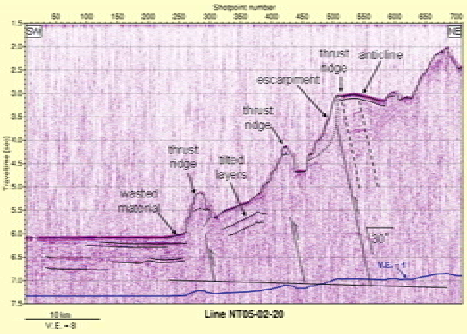


Figure 6: Record of the single channel seismic profile across the Sunda Trench (4,500 m water depth) to the trench side boundary of the outer-arc high (2,100 m water depth). Three thrust ridges were identified in the section. The dive site (see, Figure 7) was carried out the top part of the landward thrust ridge.

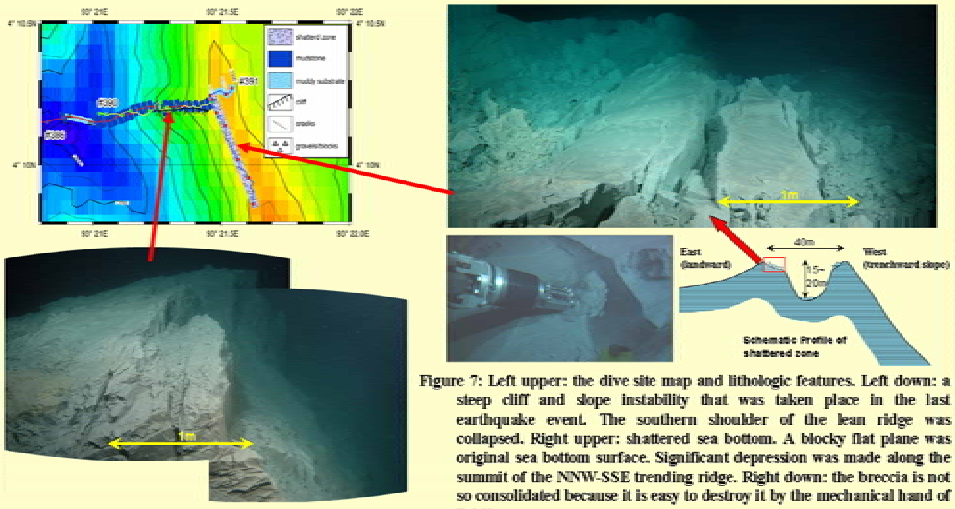
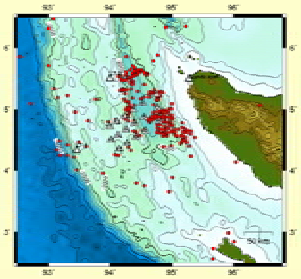


Figure 7: Left upper: the dive site map and lithologic features. Left down: a steep cliff and slope instability that was taken place in the last earthquake event. The southern shoulder of the lean ridge was collapsed. Right upper: shattered sea bottom. A blocky flat plane was original sea bottom surface. Significant depression was made along the summit of the NNW-SSE trending ridge. Right down: the breccia is not so consolidated because it is easy to destroy it by the mechanical hand of ROV.

Results

OBS data shows the deepest limitation of the rupture zone of this earthquake, ranging to 50 km deep. On the other hand, the surface rupture was identified by strong shaking and shattering of the sea bottom just above the landward thrust ridge. They show that the range of the rupture system of the earthquake is large and the shattering of the sea bottom suggests the ground shaking was extremely great. The condition of such an earthquake greatly displaced bottom of the sea, and it caused of the Tsunami.

Preliminary analysis of aftershock from OBS data (2/21 - 2/23, 2 days)



One day record from one of the OBS off Sumatra on Feb. 22, 2005.

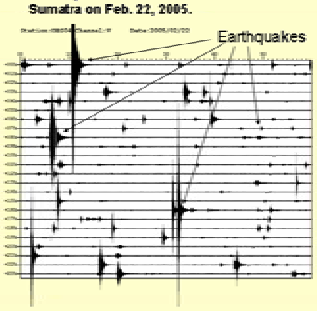


Figure 8: Preliminary results of short-term OBS array survey. Left: epicenter of the aftershock. Right: An example showing the resolution of the OBS record, showing it covers magnitude 0.1 class.

Crustal structure and the mechanism caused of the Tsunami

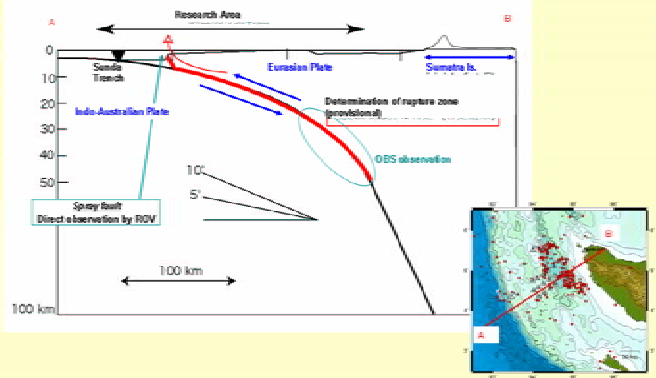


Figure 9: Summary punch picture diagram showing subsurface structure. The deeper horizon of the rupture was estimated by dense distribution of aftershock and the shallower one was splay fault, the escarpment and shuttered sea bottom. The inferred rupture of the last earthquake was located between the both.