

IODP for Geohazard mitigation:

Estimation of rupture area and fault models for historical and pre-historical earthquakes by using submarine event deposit detected from ocean drilling survey

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Abstract

Constructing precise fault model of historical and pre-historical subduction zone earthquakes is important for evaluation and mitigation of seismic and tsunami hazards. Because parameters for constraining the model of further past events essentially lack due to limited records, it is necessary to obtain paleoseismological data by offshore piston coring and drilling. Detecting and identifying event deposit such as seismic turbidite, rupture extent can be constrained along the subduction zone.

1. Introduction

Fault model is a foundation to evaluate future seismic phenomena such as strong ground motion, crustal movement, tsunami inundation and so on. To estimate fault models of historical or pre-historical earthquakes, we usually try to know their precise rupture area. Since there are no instrumental observation data for estimating them, it must be identified of the magnitude and distribution of crustal movement and tsunami by analyzing historical records and geomorphological and geological traces. In other words, these evidences are unique indicator, and can provide good parameters to estimate rupture area of such earthquakes. If the rupture area is located on coastal region, it is relatively easy to recognize crustal movement from relative sea level change (abrupt uplift and subsidence) that has been recorded in such as marine terrace. However, most of the rupture area of interplate earthquake along subduction zone is located off coast. In such case, it is difficult to obtain parameters from on-shore field survey.

2. A case of Kanto Region, central Japan

We would like to introduce a case study including this problem in Kanto region, central Japan. The 1703 Genroku Kanto earthquake (M 8.2) occurred along the

convergent plate boundary of Sagami Trough where Philippine Sea plate subducts beneath the North American plate. Historical records and geomorphological evidence revealed that this earthquake was accompanied with vertical crustal movement along the coast from the Sagami Bay to the Boso Peninsula. This fact suggests that a part of the source fault was ruptured beneath the on-shore region. However, tsunami height observed along the eastern coast of the Boso Peninsula cannot be explained by only the slip of source fault beneath the on-shore, but also it needs off-shore fault rupture which probably extended off southeast of the Boso Peninsula.

For the 1703 Geroku Kanto earthquake, some fault models were proposed from coastal vertical movements and/or tsunami heights (e.g. Kasahara et al., 1973; Matsuda et al., 1978; Aida, 1993; Shishikura, 2003). Recent studies from seismic reflection and refraction survey (e.g. Sato et al., 2005; Takeda et al., 2007; Tsumura et al., 2008) made clear that upper depth of the Philippine Sea plate (subducting under the North American plate). To construct the precise fault models of the Genroku earthquake, we compiled these upper depths, and set 49 small sub faults, whose size is 10 km x 10 km, on the upper surface of Philippine Sea plate (Fig. 1). Slip amount is estimated from inversion method of the coastal vertical movements (Shishikura, 2003). As a result, the maximum slip amount of more than 15 m is estimated on the southernmost part of the Boso Peninsula.

The tsunami heights calculated from the fault model composed of small sub faults, however, are underestimated from the observed tsunami along the eastern coast of the Boso Peninsula. To explain the observed tsunami height, we therefore set additional sub faults (sub faults B and C in Figure), which do not have influences of coastal deformations. The calculated tsunami height by using the additional sub faults is consistent with the observed ones. However, such additional sub faults are not confirmed directly. To know the existence of them, or precise rupture area and its moment, off-shore paleoseismological survey is necessary.

3. Evaluation of rupture extent of paleo-earthquake

Turbidite deposit is one of the most useful indicators of seismic rupture: the distribution of a turbidite indicates the area affected by strong seismic motions. A shallow piston-coring survey conducted with the aim of detecting turbidite deposits would enable an estimate of the offshore rupture extent of paleo-earthquake. However, detecting seismic event from gravity flow deposit such as turbidite involves some difficulties. Some noise of storm originated turbidite may disturb to detect seismic event. To remove such noise, survey site has to be selected carefully. For example, isolated

basin which is not connected to submarine channel continued from onshore river is one of better sites for detecting seismic event deposit. Recently, non-gravity flow deposit recording strong ground motion is reported from surface of forearc basin floor along the Nankai Trough (Sakaguchi et al, 2009). It is composed of suspension material, and thus not affected by current erosion. This is another solution for evaluating seismic rupture extent. Multiple piston coring and correlation with each core by chronological methods enable accurate identification of seismic event. Then, to clarify fault activity and rupture process, drilling must be conducted at specific site on asperity of rupture area.

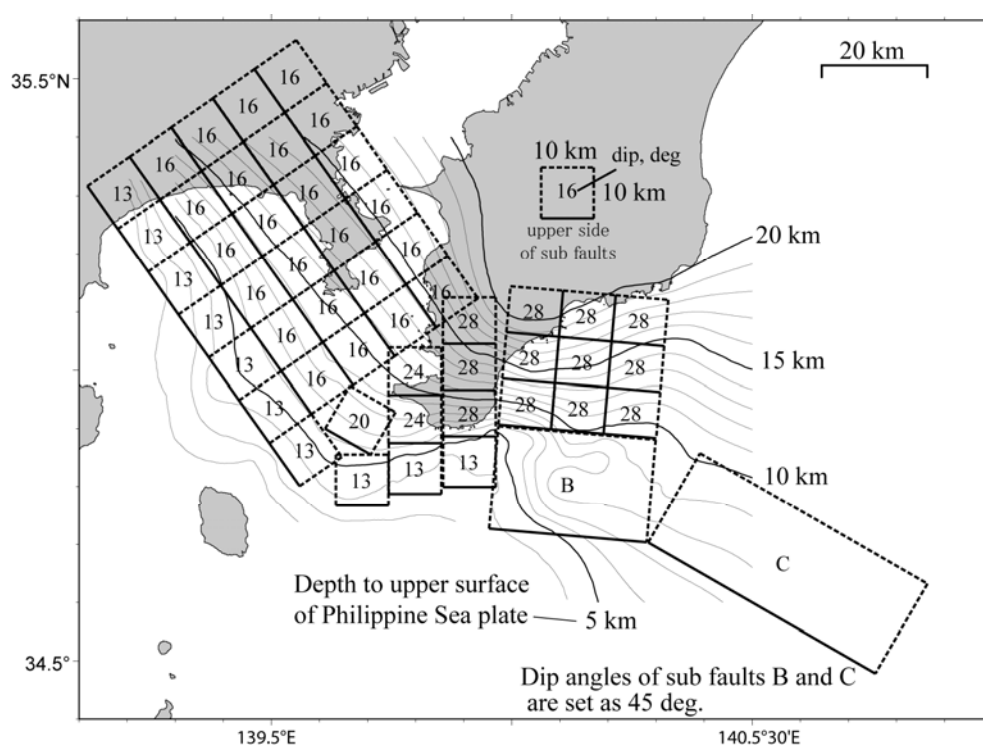


Figure 1. Source fault model of the 1703 Genroku Kanto earthquake, composed of sub faults on the Philippine Sea plate

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