

Runaway slip to the trench due to rupture of highly pressurized megathrust, Tsunamigenesis of the 2011 Tohoku earthquake

KIMURA, Gaku^{1*}, HINA, Shoko¹, HAMADA, Yohei¹, KAMEDA, Jun¹, TSUJI, Takeshi², KINOSHITA, Masataka³, YAMAGUCHI, Asuka¹

¹Earth and Planetary Science, The University of Tokyo, ²Graduate School of Engineering, Kyoto University, ³IFREE, JAMSTEC

The gigantic 2011, March 11 Mw 9 Tohoku earthquake is examined from the viewpoint of the pre-seismic forearc structure, the seismic reflection properties of megathrust around the usual up-dip limit of the seismogenic zone, the thermal state of a shallow subduction zone, and the dehydration of underthrust sediments. At the Japan Trench the Pacific Plate is subducting westward beneath the northeast Japan at a dip angle of 4.6. The middle and lower slopes dip eastward at angles of ~2.5 and ~8.0, respectively. The forearc prism beneath the middle and lower slopes is inferred to be in extensionally and compressively critical states, respectively, based on the presence of clear internal deformation features and on the occurrence of aftershock earthquakes. The rapid uplift of the forearc that caused the 2011 Tohoku tsunami may have been associated with this internal deformation of the prism. The critical state of the prism indicates that the effective basal friction of the plate boundary megathrust is <0.03 for the middle prism and >0.08 for the lower prism. The megathrust, especially under the middle slope, is characterized by a prominent reflector with negative polarity; i.e., a landward-increasing wave amplitude. This observation suggests that the megathrust hosts highly pressurized fluids. Underthrust sediments in this part of the Japan Trench are dominated by pelagic and siliceous vitric diatomaceous silt with clay. The dehydration kinetics of opal-A to quartz, the clay transformation of smectite to illite, and the thermal structure of the Japan Trench suggest that maximum dehydration of the sediments would take place at 50-60 km horizontally from the deformation front, where the temperature along the megathrust is 100-120. The zone of maximum dehydration coincides with the prominent seismic reflector that has negative polarity. We hypothesize a possible free slip along this portion of the megathrust during the 2011 Tohoku earthquake, caused by anomalously high fluid pressure resulting from fluid accumulation over centuries.