Seismic structure of NE Japan forearc region and its implications for big interplate earthquakes

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The frequent occurrences of the great thrust earthquakes have caused widespread damages to the coastal areas through strong shaking and tsunamis. Information on the detailed seismic structure of the forearc regions of the subduction zones is scanty because of few seismic stations available there to record the events. We adopted a new approach (Zhao et al., 2002) to investigate the 3-D P and S wave velocity and Poisson's ratio structures under the Pacific Ocean between the Japan Trench and the Pacific coast of Northeast Japan. We used two groups of earthquakes recorded by the 226 seismic stations of Tohoku University and 172 Hi-net seismic stations. One group consists of about 1500 shallow and intermediate-depth earthquakes, which occurred beneath the NE Japan land area (1997-1998) having reliable hypocentral locations. The other is of about 900 earthquakes that occurred in the NE Japan forearc region (1989-2003) whose hypocentral locations were well determined by sP depth phases. We applied the tomography method of Zhao et al. (1992) to about 100,000 P and 50,000 S wave arrival times from the 2400 events. The 1500 events under the land area were relocated in the inversion process, while the hypocentral parameters of the 598 events determined by Umino et al. (1995) and 300 events relocated by this work under the Pacific Ocean were left nonrelocated during the inversion process. The restoring resolution tests validate the resolvability of the Vp, Vs and Poisson's ratio images.

Our preliminary results reveal the strong lateral heterogeneities in Vp, Vs and Poisson's ratio in the forearc region. Different pattern of interplate seismicity and seismogenic coupling between north and southern parts of NE Japan around 38.5N is evident which is characterized by high-Vp, low-Vs and low Poisson's ratio. The zone around 38N may represent the site of locking of slip, which may serve as strong structural asperities. Two prominent structural anomalies are imaged very close to the Japan Trench and the anomalies are streching parallel to the trench axis. One is imaged dominantly with low to average-Vp, high-Vs and low Poisson's ratio between 38N and 40N that corresponds to rupture zone of the 1896 tsunami earthquake (M 8.5). The other is imaged with high to average-Vp, low-Vs and high Poisson's ratio between 40N and 42N which corresponds to rupture zones of the 1968 Tokachi-oki (M 7.9) and the 1994 Sanriku-oki (M 7.6) earthquakes. This observation suggests that nature and extent of seismic coupling is not uniform near the trench axis and that seems to have segregated near 40N. This transition may help to rate hazards for a future large tsunami earthquake. A comparison of the tomographic images along the subducting slab boundary with the distribution of large interplate earthquakes (M 6.0-8.5) shows that about 70% of the big interplate earthquakes are located in the areas of low-Vp, low-Vs and low to average Poisson's ratio while some earthquakes (22%) occurred in the areas of high to average velocity and Poisson's ratio. Few large earthquakes (8%) occurred in the transition zones of high to low velocity and Poisson's ratio structures. This suggests that seismic coupling changes from segment to segment in the plate and subduction interfaces along the Japan Trench due to a dramatic change of structural heterogeneities along the plate boundary. This may have attributed to the change of friction parameters that could lead to a seismic slip following the breakage of asperities with a velocity-weakening property. A distinct interplate seismic gap from the Pacific coast under Sanriku to the Japan Trench (39-40N; 142-143E) is imaged with low-Vp, low-Vs and low to average Poisson's ratio where none of the big interplate earthquakes is located so far. This may be interpreted as a decoupled patch on the slab boundary.