Distributions of elevation-gravity anomaly of subduction zones its mechanical implication

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We classified the global subduction zones based on their gravity and topography distribution to consider the possibility of huge earthquakes.

We used elevation data of Global Bathymetric Chart of Ocean (GEBCO) and Free-air gravity anomaly of World Gravity Map (WGM) by International Gravimetric Bureau (BGI), and volcanic eruption catalogue by National Oceanic and Atmospheric Administration (NOAA).

First, we divided all global subduction zones into shallow and deep ones.

The subduction zones with their trench depth shallower than 6000 m generate M8 or greater earthquakes everywhere. Spatial variation of the gravity anomaly and the elevation around these trenches are so small that further classification based on gravity and topography is difficult. Gravity anomaly is suppressed for the buoyant young lithosphere with shallow trench because Isostasy would be easily established due to its relatively flexible lithosphere.

In contrast, the subduction zone where the trench is deeper than 6000 m does not cause frequent great earthquakes of M8. However, we experienced two M9-class huge earthquakes at off the coast of Tohoku and off Kamchatka Peninsula included in this group. It is impossible to classify the possible source area of huge earthquakes only by the depth of the trench. We divided variation patterns of gravity anomaly around the deeper trenches into four types: 1-a. Steep and monotonic increase from trench toward arc (1 deg or less before reaching the maximum value). 1-b Slow and monotonic increase (larger than 1 deg to reach the maximum value). 2. A small peak with a trough behind it before increase toward arc. 3. Mismatch of trench and gravity minimum: Minimum gravity occurs at arc-side of the trench. Among these four groups, slow and monotonous increase include subduction zones that have ever caused earthquakes of M8 or greater (Japan, Kamchatka, Tonga, northern and middle Chile).

Scatter plot between distances of gravity maximum and volcanic front from trench shows a positive correlation between them. Since the trench distance of volcanic front corresponds to inverse subduction angle, distant gravity peak corresponds to gentle subduction angle of the slab.

Bassett and Wasst (2015) proposed a trench-parallel fore-arc ridges (TPFRs) induced from gravity anomaly and topography. They used deviatoric values of gravity (TPGA=Trench parallel gravity anomaly) and topography (TPTA=Trench parallel topography anomaly) from trench-distance ensemble average for each subduction. They proposed that the down dip limit of inter-plate seismogenic zones corresponds to location of TPRF. This is because stress concentration at the down-dip limit by inter-plate coupling during inter-seismic period cumulate a plastic deformation just above it, which develops TPFRs. They advocate that TPRF is useful as an index for evaluating earthquake potential. Some of the peak gravity locations obtained in this study correspond to that of their TPFRs. This suggests that TPFRs can be seen even in the case of absolute value and there was no big difference as distribution. Furthermore, in our study, the peak of gravity anomalies appears in the fore arc in all of the subduction zones deeper than 6000 m in contrast that Basset and Wasst (2015) do not necessarily show TPFR for all the trench. Although their subtraction of ensemble average should well emphasize along-trench perturbation for relatively uniform angle subduction zone, subduction zone whose slab angle varies laterally may generate apparent variation of TPGA and TPTA preventing to see actual perturbation due to inter-plate coupling.

As a future research, I will investigate the relationship between the peak of gravity anomaly and seismic activity.

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