Examination of critical taper theory based on bathymetry data in subduction zones

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The fold-and-thrust belts and submarine accretionary wedges lie along compressive plate boundaries. The critical taper model has been recognized to be the most appropriate theory that describes the first-order mechanics of these structures. Applying the critical taper model in the subduction zones, we can estimate the frictional coefficient of the plate boundary fault with only simple topographical parameters from the cross-section. Thus, this model has been also used in discussions related to earthquakes.
However, in the critical taper model, the following two problems could be pointed out when acquiring the topographic parameters. 1) It is impossible to apply the critical taper model to the area without seismic cross-section. 2) In the depth conversion in the seismic cross-section, the depth of the plate boundary fault largely depends on the velocity model and affects the estimation of the décollement dip angle β. Thus, it is unreliable in terms of accurate comparison. Therefore, when comparing the result with various velocity models, the reliability is low in terms of accurate comparison.
Therefore, in this research, we developed a new method to obtain the topographical parameters only from bathymetry data instead of the seismic cross-section. We verified the validity of the method from the results, with comparing the result from the décollement dip angle β obtained from the seismic cross-sections and the result from the trench seaward slope angle β obtained from the bathymetry. We check the validity of the new method using the Nankai Trough as the target area. In the Nankai Trough, many seismic cross-sections have been acquired for the disaster mitigation of the large earthquake, and the observation based on various methods such as seismic waves or GPS has proceeded. Thus, it should be easy for acquiring the topographical parameters and interpreting the result of the critical taper model.
We found the theoretical blind spot of the critical taper model in the condition of the subduction zone under the sea. When a high pore pressure ratio is assumed for the whole wedge, the effect of β on the result is very small for the effective friction coefficient. Therefore, it is sufficiently possible to discuss the frictional distribution of the plate boundary fault with only the bathymetry data. It is although necessary to pay attention to relatively large error up to about 20%. Since the bathymetry data is spatially densely acquired data, it was possible to calculate the friction distribution of the shallow plate boundary fault along the trench axis in the high density.
As a preliminary interpretation of the results with the bathymetrical critical taper model , this metho is considered to be effective to contribute to earthquake/tsunami disaster mitigation in sea areas where seismic activity segments are not sufficiently studied.

Keywords: subduction zone, critical taper model, Japan Trench, Nankai Trough

