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Geological process of the slow earthquakes

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We present an attempt to unveil the geological aspects of slow earthquakes and the related plate boundary processes and to establish a model for slow earthquake formation. As we have investigated material along subduction channel from on-land outcrops and ocean drilling cores, a series of progressive deformation down to the down-dip limit of the seismogenic zone was revealed. Studied tectonic melanges in the Shimanto Belt, Japan are regarded as fossils of plate boundary fault zone in subduction zone. Detailed geological survey and structural analyses enabled us to separate superimposed deformation events during subduction. Material involved in the plate boundary deformation is mainly an alternation of sand and mud. As they have different competency and are suffered by simple shear stress field, sandstones break apart in flowing mudstones. We distinguished several stages of these deformations in sandstones and recognized progress in the intensity of deformation with increment of underthrusting. It is also known that the studied Mugi melange bears pseudotachylyte in its upper bounding fault. Our conclusion illustrates that the subduction channel around the depth of the seismogenic zone forms a thick plate boundary fault zone, where there is a clear segregation in deformation style: a fast and episodic slip at the upper boundary fault and a slow and continuous deformation within the zone. The former fast deformation corresponds to the plate boundary earthquakes and the latter to the slow earthquakes. We further examined numerically whether this plate boundary fault rock is capable of releasing seismic moment enough to fit the observed slow earthquakes. The shallow very low frequent earthquakes (VLFs) are chosen to be modeled and our estimation satisfies the natural data. These results make a strong impact on the study of seismic energy balance because we show a possibility to give an absolute value of them from geological approach, which could not have been achieved with seismology.

Keywords: Slow earthquake, Shimanto Belt, Nankai Trough, plate boundary earthquake, tectonic melange