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Geological and frictional aspects of very-low-frequency earthquakes in an accretionary prism

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Recent observations by on-land seismic networks and broadband ocean-bottom seismometers have identified the occurrence of very-low-frequency earthquakes (VLFE) along thrusts in accretionary prisms and near subduction plate boundaries at slip rates of 0.05-2 mm/s. However, the geological and frictional aspects of VLFE remain poorly understood. Here we show the characteristics of the thrusts in the Eocene Kayo Formation of the Shimanto accretionary complex exhumed from source depths of VLFE and the frictional velocity dependence of the thrusts materials. The host rock of the thrusts is quartz arenite that constitutes sandy turbidites. The thrusts are composed of quartz-rich fault rocks with or without clay foliations. The frictional slip in the thrusts is accommodated by the localized shear along quartz-coated slip surfaces or the distributed shear along clay foliations. Frictional velocity dependence of thrust materials was examined under wet conditions. At slip rates of 0.0028-0.28 mm/s, the powder sample from non-foliated rock show velocity-weakening behavior, while that from foliated fault rock exhibits velocity-strengthening behavior. All samples show velocity-strengthening behavior at slip rates of 0.28-2.8 mm/s. Microstructural analysis reveals that the velocity-weakening samples show a shear localization, while velocity-strengthening sample is marked by clay foliations oblique and parallel to shear zone boundaries. A frictional velocity dependence of the samples from quartz-rich thrust material, showing velocity weakening at 0.0028-0.28 mm/s but velocity-strengthening at 0.28-2.8 mm/s, is favorable for the occurrence of VLFE. The localized shear along quartz-coated slip surfaces in thrust may be the geological evidence of VLFE. However, when clay foliations develop in such thrust, thrust becomes frictionally stable as the samples with clay foliations shows velocity-strengthening behavior at 0.0028-2.8 mm/s. These results suggest that the quartz content and development of clay foliations along thrusts may be factors in controlling the occurrence and spatial distribution of VLFE in accretionary prisms.

Keywords: very-low-frequency earthquakes, accretionary prism, frictional velocity depenedence, fault zone structure