Effects of frictional melting on seismic slip in a subduction zone: Pseudotachylytes in the Shimanto accretionary complex

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We examined effects of frictional melting on seismic slip in a subduction zone, based on analysis of pseudotachylytes in the Shimanto accretionary complex, southwest Japan. The pseudotachylytes-bearing faults developed during underthrusting or underplating in the upper part of seismogenic zone. Pseudotachylytes occur in a narrow zone of one millimeter-thick that sharply cuts the foliated cataclasite of melange in origin. The pseudotachylyte matrix shows the optical character of glass. Under a backscattered electron image, embayed grains, vesicles, and cracks surrounding grains are present in the homogeneous matrix, indicating frictional melting and subsequent rapid cooling. Compositions of pseudotachylytes determined by an electron microprobe, combined with the characters of unmolten grains, suggest that frictional melting occurred in an illite-rich slip zone with a minimum melting temperature of 1100 degree C. Using both Arrhenian and non-Arrhenian models, viscosities of pseudotachylytes were calculated, based on pseudotachylyte matrix composition, volume fraction and aspect ratio of unmolten grains. The viscosities at 1100 degree C are low: 10^2-10^3 Pa s. Thus the formation of low viscosity pseudotachylyte in an illite-rich slip zone would lead to acceleration of seismic slip. The calculated cooling path of the frictional melt indicates that one millimeter-thick pseudotachylyte layer cools to the temperature of surrounding rock after one second, suggesting very rapid deceleration of seismic slip. The estimated pseudotachylyte layer thickness and temperature rise during frictional melting suggest the earthquake with magnitude 5 to 7 in the ancient subduction zone. Our results may be applicable to other illite-rich subduction thrusts and faults in accretionary prisms.