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Friction and roughness of a melting rock surface

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Under extreme conditions like those encountered during earthquake slip, frictional melt is likely to occur. It has been observed on fossil faults that the melt is mostly extruded toward local extensional jogs or lateral tension cracks. A similar condition is reproduced in laboratory experiments with a rotary shear apparatus. When this happens, a thin and irregular melt layer is formed whereby the normal load is still in part supported by contact asperities under an incipient yield condition (as in dry friction models), but also, in the interstices between asperities, by the pressure of the viscous fluid wetting the interface. In addition, roughness of the surface is dynamically reshaped by the melting process of an inhomogeneous material (polymineral rock). In particular, we argue that the roughness decreases with temperature gradient and the melting rate. Taking into account the above conditions, we obtain an expression for the average melt layer thickness and viscous pressure that may be used in estimates of friction in the presence of melt. We argue that the ratio of melt thickness to roughness depends on sliding velocity; such a ratio may be used as a gauge of slip-rate during fossil earthquakes on faults bearing pseudotachylite (solidified melt). Finally, we derive an improved analytical solution for friction in the presence of melt including the effect of roughness evolution.