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Temperature-dependent frictional strength of dolerite in a nitrogen atmosphere

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Since mid-1990's, high-speed (up to several m/s; equal to coseismal slip rate) friction experiments on variable rocks have revealed that frictional strength significantly decreases with increasing slip rate ≥ 10 cm/s. However, frictional strength possibly decreases due to increased temperatures because the past high-speed friction experiments have not controlled temperatures increased by frictional heating. In fact, friction experiments on dolerite at a normal stress of 1 MPa, a slip rate of 1 cm/s, controlled temperatures up to 1000 ℃ and in air showed that the decrease in frictional strength at fast slip rates is possibly due to increased temperatures (Noda et al., 2011, JGR). These experiments also showed that the temperature-dependent frictional strength of dolerite has a negative correlation with the amount of amorphous wear material as well as a positive correlation with the amount of iron oxides formed by oxidation of iron-bearing minerals. However, oxidation of iron-bearing minerals as observed in the experiments is unrealistic in fault zones at depths due to the paucity of oxygen there.

We therefore have conducted similar friction experiments on dolerite as Noda et al. (2011) in a nitrogen atmosphere with an oxygen concentration of 0.1 %, and investigated the dependence of steady-state frictional strength on temperature and its relation to the amount of amorphous wear material and the ratio of wear material cover on the slip surface. The steady-state friction coefficient was ˜0.52 at room temperature, while it was ˜0.7 being roughly constant at 100-500 ℃ and ˜0.76 at 600 ℃. The amount of amorphous material ranged within 60 $\pm$6 wt% from room temperature to 500 ℃ and ˜38 wt% at 600 ℃. The ratio of wear material cover on the slip surface was ˜0.78 at room temperature, while it was ˜0.9 being roughly constant at 100-600 ℃ . The steady-state friction coefficient of dolerite in a nitrogen atmosphere is significantly lower than that in air (˜0.77) at room temperature, while it is larger than the latter (0.61 $\pm$0.03) at temperatures from 100-600 ℃. It shows a negative correlation with the amount of amorphous material as observed in air at 100-600 ℃, while it also shows a positive correlation with the ratio of wear material cover at room temperature to 500 ℃. However, the former and latter correlations become unclear at room temperature to 100 ℃ and at 500-600 ℃, respectively.

The frictional strength of dolerite at room temperature significantly lower in a nitrogen atmosphere than in air is likely due to the lack of moisture-adsorbed strengthening. However, the reason for higher frictional strength in a nitrogen atmosphere than in air at 100-600 ℃ is unknown at present. It is also unknown at present what are responsible for the correlations among temperature-dependent frictional strength, the amount of amorphous material and the ratio of wear material cover. These are the subjects of our future study.

Keywords: Dolerite, Nitrogen atmosphere, Rotary shear experiment, Temperature dependency, Amount of amorphous wear material, Ratio of wear material cover