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Why is the oceanic crust weak? New results from medium temperature experiments on basalt rocks.

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Basaltic rocks in the upper crust of the oceanic lithosphere are generally considered to be strong rocks that deform in a brittle manner. Previous experiments on Maryland diabase showed that basalts are strong at conditions prevailing in the upper oceanic crust (e.g. Griggs et al., 1960). However, our new experiments on partially glassy basalts show a substantially lower strength of the basalt at temperatures of $500\,^{\circ}\mathrm{C}$. In this presentation, we discuss whether this weakening occurs as a result of 1) mineral reactions in the fine-grained fault rock; or 2) viscous flow of the glass pods present in the partially glassy basalts.

Coaxial deformation experiments were carried out on two partially glassy basalts (Vogelsberg Basalt and Bransrode Basalt) and one diabase (Maryland Diabase) using a Griggs deformation apparatus at T = 300–500 °C, P_c = 500 MPa, $\dot{\epsilon} = 10^{-3.5}\mathrm{s}^{-1}$ to $10^{-6}\mathrm{s}^{-1}$, with and without 0.2 %wt added H_2O. Two types of experiments were performed: 1) Samples were deformed and quenched immediately after fracturing. 2) After fracturing the samples were kept at hydrostatic conditions for 14 days at 300 or $500\,^{\circ}\mathrm{C}$. Digital images with different magnifications were used for the analysis of the microstructures, the presence of mineral reactions, and the grain size distribution.

All three types of basaltic rock deformed at $300\,^{\circ}\mathrm{C}$ is stronger (has a flow stress of ca. 1700 MPa) than granitic rocks deformed under the same conditions (1500 MPa; Keulen et al., 2007). Maryland Diabase deformed at $500\,^{\circ}\mathrm{C}$ (1100 MPa) is approximately 3 times stronger than the partially glassy basalts. In the samples that have been

heat-treated (experiment type 2) and in the partially glassy basalts deformed at T = $500\,^{\circ}\mathrm{C}$ (duration: 40 min) mineral reactions have been observed in the fine-grained gouge (similar to results of Rutter et al., 1985). Pyroxene and plagioclase have reacted in the presence of water to amphibole. At 500 and $300\,^{\circ}\mathrm{C}$ respectively, biotite and chlorite were formed. However, these new phases are not present in large enough volume to have caused a weakening of the fault rock. Instead, at $500\,^{\circ}\mathrm{C}$ the glassy basalt samples deform by distributed viscous flow of the glass pods and passive rotation of the other minerals.

References:

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Keulen et al., 2007, Tectonophysics, 29(8):1282-1300
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