DRY DEFORMATION OF DIABASE: IMPLICATIONS FOR TECTONICS ON VENUS
S. J. Mackwell, Department of Geosciences, Penn State University
M. E. Zimmerman, D. L. Kohlstedt, D. S. Scherber, Department of Geology and Geophysics, University of Minnesota

Chemical analyses of the rocks on the surface of Venus and observations of the topography of that planet indicate that the Venusian crust is composed predominantly of rock with a basaltic composition. The high surface temperatures of this planet suggest that degassing of magma during eruption and the lack of a return path for water to the planetary interior have probably resulted in anhydrous conditions in the crust and upper mantle of Venus. Thus the tectonics of the crust of Venus is likely to be dominated by the mechanical behavior of coarsely crystalline basalt under anhydrous conditions. On Earth, rocks of the appropriate composition and microstructure can be located in the Triassic sills and dikes in the northeast portion of the United States.

We have performed an experimental study to determine the high-temperature creep behavior of natural diabase rock from near Columbia, North Carolina, and near Frederick, Maryland, under dry deformation conditions to measure the effects of temperature, oxygen fugacity, variation in grain size, and ratio of plagioclase to pyroxene on the creep strength. The Columbia diabase has the coarser grain size (~100 x 600 µm plagioclase, ~200 µm pyroxene) and contains about 70 mol% plagioclase (Ab40An60) and about 25 mol% pyroxene (mostly hypersthene En67Fs33). The Maryland diabase has the finer grain size (~30 x 100 µm plagioclase, ~50 µm pyroxene) and contains about 56 mol% plagioclase (Ab40An60) and about 43 mol% pyroxene (mostly augite Wo35En31Fs34). Samples were predried at 900°C for at least 24 h under controlled oxygen fugacity conditions prior to deformation, in order to remove any water and dehydrate any hydrous minerals that were present in the rock.

The deformation experiments were performed in a gas-medium high-pressure, high-temperature deformation apparatus at confining pressures of 300-400 MPa, temperatures from 900° to 1100°C, and strain rates from 10^{-7} to 10^{-5} s^{-1}, with the samples buffered against either Fe-FeO or Ni-NiO. The dry creep strength of both rocks is significantly greater than that measured under "as-received" or wet conditions [1,2]. In addition, the Maryland diabase is stronger by about a factor of 3 than the Columbia diabase, probably resulting from the lower modal abundance of plagioclase. Previous experimental studies [2,3] have demonstrated that the plagioclase component in the rock is likely to be the weaker phase at temperatures over 800°C, although these experiments were not performed on predried samples. In addition, research on the deformation of clinopyroxenite [4] yield strengths that are higher than those measured for the diabase under similar conditions.

Flow laws were determined for the deformation of the Columbia diabase,
\[ \dot{\varepsilon} = 1050 \sigma^0.9 e^{-509/RT}, \]
when the samples were buffered against Fe-FeO, and
\[ \dot{\varepsilon} = 1150 \sigma^{4.3} e^{-482/RT}, \]
when the sample were buffered against Ni-NiO,
where the stress is in MPa and the activation energy is in kJ/mol.
For the Maryland diabase,
\[ \dot{\varepsilon} = 4.2 \sigma^{5.1} e^{-505/RT}, \]
when the sample were buffered against Fe-FeO.
Both rocks deformed by dislocation creep and are slightly weaker when deformed under more reducing conditions.
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Application of these results to the tectonics of the lithosphere on Venus, assuming a temperature gradient of 25 K/km and a strain rate of $10^{-14}$ s$^{-1}$, predicts a relatively deep brittle-ductile transition (~8 km depth) and a strong lithosphere, dominated by the strength of the rocks in the mid- and upper crust, with no weak lower crustal zone. As the contrast in rheology between these diabase rocks and dry dunite is small at depths greater than 15 km, strong coupling between the crust and mantle seems likely.

![Plot of rock strength versus depth for Earth-type strain rate and thermal gradient conditions, but with a surface temperature appropriate to Venus. CD(this) and MD(this) refer to the measurements on Columbia and Maryland diabase in this study; OI(K) refers to Karato's dunite flow law [5]; MD is from Caristan [2] and FD(ST) is from Shelton and Tullis [1] for unannealed Maryland diabase.](image)

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