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Some comments on rheology of partially molten crustal rocks

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The rheological behavior of partially molten crustal rocks is an important subject for understanding the rheology of the lower crust. It is also important for understanding of the evolution of granitic magmas because deformation is believed to play an important role in transport of acidic, viscous melt from partially molten crustal rocks.

Although it is generally conceived that the strength of rocks should decrease as melting advances, there have been some controversies among researchers about details of the rheological behavior of the partially molten rocks. Some researchers consider that the strength of partially molten rocks does not see a significant decrease until a certain degree of partial melting (melt fraction) is achieved. The presence of such a critical melt fraction for partially molten rocks was first proposed by Arzi (1978) through a theoretical consideration and with some preliminary deformation experiments of partially molten granitic rocks. The critical melt fraction, which was marked by a rapid decrease in rock strength, was termed rheologically critical melt percentage (RCMP). This idea was substantiated by a series of more thorough experiments by van der Molen and Paterson (1979). This concept became very popular in geological literature and has been influential to the geological community.

We re-examined the concept of rheologically critical melt percentage (RCMP) originally proposed by Arzi (1978) for partially molten granitic rocks. It is shown that there was no experimental support to show the presence of RCMP as well as theoretical support. The published experimental data suggests that the effective viscosity of partially molten granitic rocks is reduced rapidly and continuously with increasing melt fraction. We also show that the experimental data may be modeled by means of the upper bound behavior (the Voigt bound) of two-phase material by assuming a melt localization, which implies that there is no partitioning of strain between the solid and the melt.