EGU21-10210
https://doi.org/10.5194/egusphere-egu21-10210
EGU General Assembly 2021
© Author(s) 2021. This work is distributed under
the Creative Commons Attribution 4.0 License.

Melting and dynamic pressure: coupling of reactions, heat transfer and deformation

Stefan Markus Schmalholz[1], Evangelos Moulas[2], and Yuri Podladchikov[1]
[1]University of Lausanne, Institut de sciences de la Terre, Lausanne, Switzerland (stefan.schmalholz@unil.ch)
[2]Institut für Geowissenschaften, Johannes Gutenberg-Universität Mainz, D-55128 Mainz

Melting is a major process of plate tectonics, affecting divergent and convergent plate boundaries. Melting of rock is also a typical example of a coupled geological process, in which the associated transformation affects the heat transfer via the latent heat of fusion and the rock deformation via the volume change. However, petrological studies on melting usually focus on chemical aspects, such as differentiation of involved components, thermal studies usually focus only on the impact of latent heat on heat transfer, such as done in the classical Stefan problem of solidification. Similarly, studies focusing on lithosphere and mantle deformation usually only consider the impact on the effective viscosity, such as weakening due to partial melting, or the impact on buoyancy due to density changes. Many studies do, therefore, not consider coupling of melting, heat transfer and rock deformation. Indeed, a common assumption is that rock pressure, or mean stress, remains lithostatic during melting. While this assumption is attractive due to its simplicity, it is against the common knowledge derived from physical experiments and the well-established mechanical theories. Furthermore, theoretical models of melt migration would not work if pressure is everywhere lithostatic, or hydrostatic, because melt migration is driven by local deviations from the static stress state.

Here, we present simple mathematical models based on the fundamental laws of physics and thermodynamics (e.g. conservation of mass, momentum and energy) to study the fundamental coupling of melting, heat transfer and rock deformation, and to quantify dynamic pressure variations due to melting. We show both analytical and numerical solutions for these models. We discuss applications of these solutions to experiments and geological observations and estimate magnitudes of dynamic pressure resulting from melting under natural conditions.