IS ARCHIMEDES THE KEY TO ECLOGITE EXHUMATION? THE ECLOGITE ZONE IN THE TAUERN WINDOW, REVISITED

KÜHN, A. [1], RING, U. [1] & GLODNY, J. [2]

[1]Universität Mainz, Institut für Geowissenschaften, Becherweg 21, D-55099 Mainz, Germany
[2]GeoForschungsZentrum Potsdam, Telegrafenberg C2, D-14473 Potsdam, Germany
e-mail: kuehna@uni-mainz.de

Eclogites occur in internal parts of many mountain belts and processes responsible for their return to the Earth's surface are widely discussed. Despite obvious and pronounced density differences between eclogites and their enclosing matrix, buoyancy is often invoked as an important driving mechanism for eclogite exhumation from great depths (CHEMENDA et al., 1995, ERNST, 1999). Commonly eclogites occur as blocks and lenses within a matrix of either metasedimentary rocks or hydrated serpentinites that are thought to have experienced the same P-T evolution. In both cases eclogites are more rigid and possess much higher densities as their surroundings. As such, their movement relative to its enclosing, less dense medium is subject to Archimedes' principle, mathematically described by Stokes' Law. This invokes parameters like size and shape of the bodies, density differences and the rheology of the matrix. As a consequence only small eclogite blocks can be exhumed in a weak matrix of hydrated metasedimentary rocks (effective viscosity of ~10^{17} Pas) within a reasonable time-frame. The more viscous the matrix is, the slower eclogite exhumation and the larger exhumed eclogite blocks can be.

To test the validity of these assumptions we re-examined the well-known Eclogite Zone (EZ) in the Tauern Window. Eclogites make up ~25 % of the EZ and occur as blocks or lenses of varying size (10 to some 100 of meters in diameter) within a matrix of metasedimentary rocks. The eclogites have densities of 3.4 - 3.5 g / cm^3, while the densities of the surrounding metasediments are ~2.8 g / cm^3 Peak eclogite facies P-T conditions were 650 °C and ~23 - 25 kbar, corresponding to burial depths of ~80 km. New geochronological data imply a very rapid exhumation rate for the EZ of > 40 mm / a (KÜHN et al., this volume) during the Oligocene. In the EZ the metasediments form a network of shear zones, each between 50 and 100 m thick, enclosing the eclogite blocks. Assuming a minimum shear velocity of 40 mm / a the resulting strain rates vary between $6 \cdot 10^{12}$ s^{-1} and $2 \cdot 10^{12}$ s^{-1} From this follows that the effective viscosities during deformation were rather low ranging between 10^{18} Pas and $2.5 \cdot 10^{18}$ Pas.

Our data support the buoyant exhumation model of the Tauern eclogites by ENGLAND & HOLLAND (1979) who showed that small eclogite blocks embedded in a low-viscosity matrix may be exhumed by buoyant forces if the exhumation rate is > 40 mm / a. However, our calculations applying Stokes' Law show that eclogite blocks are only buoyantly exhumed in a metasedimentary matrix when they are relatively small (< 100-200 m in diameter), otherwise viscous forces are too small to overcome the pronounced negative buoyancy of the eclogite bodies.

References

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