Effects of source heterogeneity and upwelling rate on trace element distribution during mantle melting

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Several lines of evidence suggest that the melt generation and segreatation regions of the mantle are heterogeneous consisting of chemically (enrich vs. depleted) and lithologically (peridotite vs. pyroxenite) distinct domains of variable size and dimension. Partial melting of such heterogeneous mantle source regions give rise to a divers range of basaltic magmas erupted on the sea floor. Although significant progresses have been made in understanding the processes of mantle melting using simple (e.g., batch, fractional, dynamic, and fluxed) melting models, none of the models identified can be readily used to study the effects of source heterogeneity and melt and solid flows on the distribution and evolution of trace elements and isotopes in the melt and residual solid during partial melting in an upwelling mantle column.

In order to better assess the role of source heterogeneity during mantle melting, we have undertaken a theoretical study of trace element and isotop distribution during partial melting in an upwelling mantle column. The 1-D version of the advection-diffusion-melting equation of McKenzie (1984, his Eq. A42) was solved analytically for both uniform and distributed melting rates and under the assumption of constant and uniform partition coefficient, porosity, melt and solid velocities. For simplicity, we negeleted diffusion in the melt. Souce heterogeneities of various forms (e.g., pyroxenite vein) were introduced into the melting column through initial and boundary conditions. Main results of our analyses to date can be summarized as follows. (1) Since melt flows faster than the solid, heterogeneities introduced at the base of the melting column are decoupled during melting and upwelling: while being diluted during melting, the incompatible element signatures of the source travel with effective velocities that largely follow the flow of the melt, whereas heterogenities recorded by compatible elements follow mostly the solid matrix. Hence the overlaying mantle (above the pyroxenite vien, say) is cryptically metasomatized by the percolating melt derived from the pyroxenite. (2) When melting happens only in the lower part of the column (distributed melting), significant extent of metasomatism occurs in the upper mantle column. A lack of chromatographic separation among trace elements in lavas may indicate additional means of melt migration: i.e., flow through porous channels or open fractures. (3) The simple analytical solutions obtained in this study make it possible to invert for mantle source compostions through sytematic studies in the the future.

Examples illustrating the distribution and evolution of selected trace elements and isotopic ratios during partial melting of a pyroxenite-veind lherzolitic mantle will be discussed.

Deciphering the time of igneous activity in the Lavrion ore province, Attica, Greece: Manifestation of Late Miocene and Triassic magmatism

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The Lavrion area, known as a 3000 years old mining district, is part of the Attico-Cycladic Belt (ACB). A detachment fault separates the Lower Mesozoic metamorphic Basal Unit from the overlying Cycladic Blueschist Unit (Skarpelis, 2007). 9.4±0.3 Ma old granitoid dykes and a Late Miocene granodiorite stock intruded the footwall of the detachment in a roughly N-S directed regional extensional stress field. With the aim of assessing the Miocene metallogenic evolution in Lavrion area, in conjunction with the igneous activity in the ACB, we dated by U-Pb of zircon (SHRIMP; GSC Ottawa) slighty deformed, hydrothermally altered porphyritic S-type granitoids occurring as sills along or within the hangingwall, close to the detachment fault. The zircon in cathodoluminescence (CL) displays euhedral long-prismatic crystals consisting either of a single oscillatory zoned, igneous domain or of a round (resorbed) inner core with relatively homogeneous CL and an oscillatory zoned, igneous rim. The resorbed character of the core, in combination with its homogeneous CL, are typical for zircons recrystallized under granulite-facies conditions. The cores and the igneous domains yielded (Tera-Wasserburg) lower intercept $^{206}Pb/^{238}U$ ages of 11.93±0.41 Ma and 8.34±0.20 Ma, respectively (error: 95% c.l.), interpreted as the time of a granulite-facies metamorphism (for the first time reported in ACB) and the time of magmatic crystallization, respectively. Emplacement was facilitated by the detachment fault. The dated S-type rocks of Lavrion, interpreted as partial melts of lower crustal granulites, are ca. 7-1 Ma younger than S-type granitoids in the ACB, also associated with an extensional tectonic regime. Above zircon ages constrain the time interval of active ductile to ductile-brittle deformation of the detachment fault.

Orthogneiss lenses within the metaclastic part of the Basal Unit in Lavrion (Kaesariani schists), previously considered of Tertiary age, yielded a lower intercept $^{206}Pb/^{238}U$ zircon age of 240±4 Ma interpreted as the time of crystallisation of the magmatic protolith. Opposite to earlier ideas about only Tertiary felsic magmatic rocks in Lavrion, our data show that there is an age diversity of the magmatic activity. The resulting age is consistent with the regional pattern of Triassic magmatism in the Hellenides.

Reference

Skarpelis, N., (2007), *N. Jb. Miner. Abh.* **183**, 227-249.