The formation of low degree hydrous melts in the Earth's upper mantle

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Melting processes in the Earth's interior play a crucial role in the chemical evolution of our planet. The presence of low degree, volatile-bearing melts in the deep mantle is supported by the occurrence of volatile-bearing minerals in xenoliths and by geophysical observations. In order to quantify the proportion of melts formed as a function of mantle water content, we have performed a series of crystallization experiments, following a similar methodology to the sandwich technique, where large pools of hydrous melt composition were equilibrated with a complete mantle peridotite phase assemblage. In particular, we determined the chemical composition of these incipient hydrous melts forming at pressures above 3 GPa. Following this approach, we assessed the water content of the low degree melts by mass balance calculation, based on accurate chemical analyses performed on the large portions of melt. The H_2O concentration of the peridotite mineral phases was determined by NanoSIMS analyses in order to obtain information on the partitioning of water between mantle minerals and low degree hydrous melts.

Based on some estimates of the water content of the mantle, a deep onset for the inception of adiabatic melting can also be implied. However, accurate information regarding the chemistry of low degree H_2O-bearing melts is limited to pressures below 3 GPa. This is a consequence of a number of experimental challenges encountered in performing experiments at high pressure within complex systems, such as quench crystallisation and loss of H_2O and FeO from charges. In addition, the small volume of hydrous melts created by plausible mantle H_2O contents at depth creates challenges even for the analysis of major elements. Sandwich experiments are very useful because they permit large proportions of low degree composition melts to be equilibrated with mantle residual assemblages. Large amounts of melt promote crystal growth and facilitate melt analyses.

Using these results the H_2O contents of mineral and melt phases can be addressed as a function of mantle H_2O content. Our results indicate H_2O concentrations in mineral phases that are significantly greater than previous studies performed at similar pressure, temperature and low degree of melting conditions.

Origin of two different zircon types in metabasite veins from the Izera metagranites, West Sudetes, Poland

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In the northern part of the Izera-Karkonosze Massif, which represents the passive margin of the Saxothuringian terrane, c. 500 Ma granites were intruded by a swarm of the WNW-trending subvertical basic veins and then deformed and metamorphosed. Two types of zircon, types I and II, that differ in colour, size, habit and internal structure were identified in six metabasite veins. Colourless, transparent and euhedral, 300 μm sized, CL-bright zircon of type I display inherited old cores as well as c. 500 Ma oscillatory zoned rims. Their U-Pb ages are almost identical with the previously determined intrusion age of a protolith for the Izera metagranites (U-Pb, zircon, 515-480 Ma). Grains of type I show $\delta^{18}O$ (6.2-9.1‰) values and Ti-zircon temperatures (600-780°C) similar to the data from the Izera gneiss zircons. Their REE patterns exhibit a narrow range. Such coincidence indicates that the zircons of type I are probably inherited xenocrysts incorporated into the basic magma via assimilation of material of local granitic crust. Type II zircons, which yield ages of c. 370 Ma, are brown, turbid, subhedral crystals up to 600 μm size, and dark in CL. Their large (c. 2/3 of the grain size), almost homogeneous and microinclusion-rich inner parts are surrounded by thinner oscillatory zoned rims. They display a wide range of Ti-zircon temperatures (630-800°C), variable REE contents and $\delta^{18}O$ (4.5-8.9‰) values. The origin of these brown zircons is ambiguous. Their homogeneous interiors and oscillatory zoned rims indicate growth in a magmatic melt. Grains showing $\delta^{18}O$ from 5.1-5.5‰ present coherent magmatic-style REE patterns with positive Ce and negative Eu anomalies, also indicative of their magmatic origin. However, dark and inclusion-rich centres of type II grains suggest precipitation from hydrothermal fluids, while low $\delta^{18}O$ (4.5-5.0‰) values, incoherent REE patterns, LREE enrichment and a lack of Ce anomaly in many grains suggest interaction of the metabasites with hydrothermal fluids during crystallization of the brown zircons. The results are consistent with type II zircon of crystallizing from a fluid-saturated residual melt or more likely representing magmatic crystals hydrothermally altered by fluids coming from the surrounding metagranites.

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