Fluid-absent melting of Phase D and the role of hydrous melts in the deep mantle

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The degree of hydration of and the amount of H_2O released from subducting slabs constrains the recycling and circulation of water in the Earth's interior. Water is transported into the Earth's interior via hydrous phases in descending slabs. Numerous high-pressure studies have determined the stabilities and role of several dense hydrous magnesium silicates (DHMS) at mantle conditions and H_2O-saturated conditions, mostly in MSH-model compositions. Among the DHMS, phase D is the one principally hosting water in the lower part of the transition zone (where slabs may travel along the upper/lower mantle boundary) and carrying H_2O from the upper to the lower mantle. The most likely state of a hydrated slab undergoing prograde metamorphism is that of fluid-absent but H_2O-present conditions at which hydrous phases destabilize through fluid-absent melting at their maximum temperature stability. In the present study, we constrain the fluid-absent melting relations of phase D and of phase D + olivine + enstatite in (i) MgO-SiO_2-H_2O system (ii) with Al_2O_3 and (iii) with Al_2O_3 + FeO added in proportions appropriate for the mantle. Stochiometric oxide mixtures of brucite and quartz of phase D composition were used as starting material. Multianvil experiments were carried out at 22-24 GPa and 1000-1800 ºC using 10/3.5 pressure assemblies.

Our data show that phase D decomposes to MgSi-ilmenite + stishovite + melt or MgSi-perovskite + stishovite + melt and indicate that phase D is stable along a slab geotherm to the top of the lower mantle for a range of H_2O contents. Melting temperatures are ~1400 ºC in the MSH system, 150 ºC higher with Al_2O_3 only, but similar to the MSH system with Al_2O_3+FeO. In all 3 systems, the melting temperature is almost constant with pressure. Melt compositions are strongly magnesian with Mg:Si ratio of 1.5-3.2. Furthermore, mass balance calculations of phase D composition experiments (with Al, Fe) suggest that the unquenchable melts contains ~ 23-32 wt% H_2O at the phase D-out, which fits well with EPMA analysis (difference of total to 100%). The data are used to determine the stability of phase D, the proportions of melt formed during melting, the composition of the partial melts and the variation in the melt composition at different pressure temperature conditions. Most interestingly, thermal relaxation to adiabatic temperatures of a slab traveling along the 660 km discontinuity, would lead to fluid-absent melting of phase D, thus producing a H_2O-rich magnesian melt.

THE PLAGIOCLASE AS ARCHIVE OF MAGMA ASCENT DYNAMICS: THE 2001-2006 ERUPTIVE PERIOD AT MOUNT ETNA

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ABSTRACT

Several studies are focused on textural and compositional features of plagioclase as an usefull tool to investigate magma chamber processes, ascent dynamics, and physico-chemical conditions. In particular water content, which plays a fundamental role in volcanic process, strongly affects plagioclase stability and, by conseguence, textural and compositional features. However, such reconstruction are usually biased by too many assumptions; particularly when dealing with past eruptions or remote volcanoes. Only few volcanoes provide an array of instrumental monitoring to constrain timing and modality of eruptive events. In this respect Mount Etna probably represents one of the most controlled volcano in the world and a great wealth of seismological and ground deformations data are available. In this work we present a textural and compositional study of plagioclases from lavas emitted during the 2001-2006 eruptive period on Mount Etna. Textural classification has been done on over 130 thin sections taking into account different portion of the crystals. This allow to recognize different types of core (ehuedral and rounded) and rims (dusty or with melt inclusion alignment) separated by oscillatory zoned overgrowth.

Oxygen fugacity in magmas has been calculated using the method of [1] and results has been used to reequilibrate the melts to mantle equilibrium, adding back the appropriate quantity of fractionated material. Water content of the melt has been estimated using the hygrometer of [2]. These data were used in the MELT model to estimate the plagioclase stability field and to calculate theoretic composition at different water content. Results were integrated with monitoring data acquired during the entire period under study with the aim to reconstruct magma ascent and storage conditions, as well as the mechanism of eruption triggering. Results indicate the 2001-2006 eruptive period involved magmas with quite similar major element composition but different dissolved H_2O. Complex zoning such as dusty areas and alignments of melt inclusions in outer portion of the phenocrysts suggest two different trigger mechanism respectively: i) magma input and mixing with a more basic and volatile-rich magma; ii) fracture migration that induce decompression of shallow magma batches.

[1] France et a., (2010) *A new method to estimate the oxidation state of basaltic series from microprobe analyses* **Journal of Volcanology and Geothermal Research 189**, 340-346.

[2] Lange et al., (2009) *A thermodynamic model for the plagioclase-liquid hygrometer/thermometer* **American Mineralogist 94**, 494-506.