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Solute-rich Supercritical Fluids Released from Deeply Subducted Hydrous Mantle

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Fluids in subducting slabs are implicated in a number of petrologic and plate tectonic processes. Despite their pivotal role in these settings, great uncertainties still concern their nature and compositions, and this largely depends on the lack of natural rock materials available for analysis. Current modelling suggests that either hydrous silicate melts, or aqueous solutions are evolved during subduction. Moreover, recent experiments (Bureau and Keppler, 1999) indicate that increasing mineral solubility in water at high pressure generates solute-rich supercritical solutions behaving as melt-like agents for mantle metasomatism. Other uncertainties regard the compositions of subduction fluids. Agents fertilising the mantle above subducting plates appear enriched in large ion lithophile elements and light rare earths with respect to high field strength elements. These fluids experienced complex flow pathways into the mantle, and it is unclear whether the slab or the mantle wedge dominate in controlling their ultimate compositions (Hawkesworth et al., 1993; Brenan et al., 1995). In this scenario, subduction of hydrated oceanic mantle is an important variable. In these rocks breakdown of antigorite to olivine, orthopyroxene and water delivers 10-13 wt% bulk H_2O at depths to 200 km (Scambelluri et al., 1995; Ulmer and Trommsdorff, 1995), and is the event producing the largest amount of subduction fluids, whose main features and compositions are yet unexplored. In nature the high-pressure (eclogitic) transition from antigorite serpentinite to enstatite-olivine rock has been observed at Cerro del Almirez, SE Spain. In this area, the antigorite serpentinites represent an early stage of subduction crystallisation in the presence of stable antigorite and still preserve water-rich, liquid + vapour inclusions in olivine. The olivine-orthopyroxene rocks represent subduction recrystallisation at higher grade (beyond antigorite stability) and display spinifex-like textures, indicating fluid-assisted mineral growth at minimum 1.5 Gpa and 640-720 ºC (Trommsdorff et al., 1998). Here we report a study of primary liquid + mineral inclusions within spinifex-like olivine, which represent remnants of the fluid phase evolved during antigorite breakdown. The spinifex olivine contains liquid + mineral inclusions occurring either as core clusters of primary inclusions, or as pseudo-secondary inclusions along microfractures which never cut across the olivine grain boundaries. The fluid inclusion patterns are locally cut by late-stage serpentine microfractures: these features indicate fluid inclusion entrapment within the stability field of olivine + fluid. The liquid + mineral inclusions prevalently display cubic and/or negative crystal shapes, the infilling oxide-silicate-liquid phases very often display constant volume ratios, grossly consisting of 30% oxide, 50% silicates, 20% liquid. By means of Raman analyses an inclusion assemblage of magnetite, olivine, chlorite and water has been identified. Scanning electron microscopy of these inclusions allowed identification of apatite as additional daughter phase. IR spectra of spinifex olivine close to these fluid inclusions indicate very low concentrations (often below detection) of structurally-bound hydrogen. This indicates that hydrogen and fluid loss from the inclusions may have not been dramatic: the high volume proportion of mineral phases in the inclusions reasonably represents a primary feature. The liquid + mineral inclusions thus trapped a silicate-rich supercritical fluid produced from de-serpentinization of subducted hydrous oceanic mantle. The trace element composition of this fluid was determined by means of laser ablation ICP-MS analyses of representative fluid inclusions. In terms of trace elements, they are enriched in Sr, Ba Pb, Cs (from 10 to more than 100 chondrite) and depleted in Y and Ti (less that 1 chondrite). We propose that fluids evolved at antigorite breakdown in hydrous oceanic mantle correspond to silicate-rich supercritical solutions, with trace element enrichment in LILE and depletion in HFSE. Such a slab fluid can transfer to the overlying mantle the metasomatic imprint observed in many subduction settings.

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