ESRF	**Experiment title:** The fate and behaviour of volatiles during subduction of oceanic crustal material towards greater mantle depths	**Experiment number**: ES-240
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Report:

Fluxes of volatiles between the Earth's interior and exosphere remain highly controversial, despite being critical for the development of the atmosphere, the establishment of climatic cycles, for geochemical differentiation of the Earth through the profound influence of volatiles on mantle melting, and for life on Earth[1-3]. The chief means to replenish the Earth's interior with volatiles over geological time is subduction (the transport of near-surface material into the deep interior) and the amounts of volatiles resorbed into the mantle will vary with the pressure, temperature and oxygen fugacity (fO_2) at the location where this resorption occurs, as well as on the bulk composition of subducted material[1-5] (Fig. 1). The latter includes former oceanic crust, which transforms to a rock called eclogite at depths greater than about 30 km, and this eclogite will contain H_2O. This study aims, to determine various oxidation states of oceanic crustal material (that is eclogite) during subduction, and their impact on the mobility of H_2O during subduction by using multi anvil apparatuses as well as synchrotron Fourier-transform infrared (FTIR) and Micro-X-ray absorption near edge structure (XANES) at the Fe K-edge at ID21, ESRF.

Outcomes will allow constraints to be placed on the conditions at which oxidised eclogite+H_2O will transform to reduced diamond-bearing eclogite+fluid during subduction. It will indicate the extent to which eclogite +H_2O will melt during subduction and later upwelling, and how this affects the stability of diamond in residual eclogite that has lost a melt fraction.

Preliminary results: We use average oceanic basalt (GA1, representative of recycled oceanic crust[6]) with H_2O up to 7 wt.%), doped with Ir which acts as a redox sensor[4,5]. We conducted experiments using GA1 at different pressures (6-10 GPa; i.e. up to ~330 km Earth's mantle depth), temperatures (850-1500°C) and bulk %H_2O using multi anvil apparatuses. We analysed major, minor and trace elements of phase compositions by electron microprobe analyses. Synchrotron FTIR were employed to determine small amounts of H_2O and related substitution mechanism of H_2O incorporation in eclogitic NAMs. Fe^{3+} were determined in eclogitic garnets, using Micro-XANES at the Fe K-edge. Experiments on GA1+H_2O yield well-crystallised assemblages of garnet ± clinopyroxene ± coesite/stishovite ± rutile ± phengite ± melt ± vapour, with average grain sizes of 10 to 20 μm (Fig. 1), big enough for analysis by synchrotron FTIR microscopy, and Micro-XANES. Similar to previous studies[7-11], the stability of phengite varies as a function of pressure, temperature, buffering mineral paragenesis and bulk H_2O concentration. Runs at 6 GPa and up to ~900°C, runs at 8 GPa and up to ~1000°C, and runs at 9 GPa and up to ~1050°C are subsolidus, while towards higher temperatures small melt fractions appear. At 6 GPa, at 950°C and 1050°C, phengite co-exists with small melt fractions for bulk H_2O contents of 0.4-1.0 wt% before it disappears completely towards higher temperatures. Phengite breaks down above 9 GPa (~300 km depth).

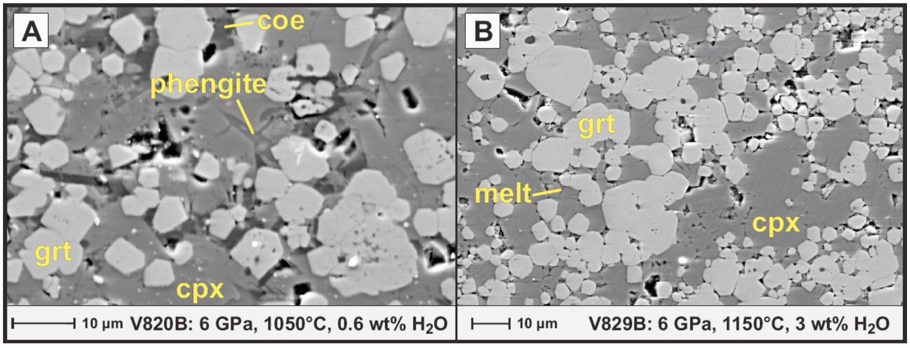

Figure 1. Scanning electron microscope images of representative run products of GA1+H2O at 6 GPa. grt, garnet; cpx, clinopyroxene; coe, coesite.

Eclogitic NAMs and phengite also break down at subsolidus conditions in the presence of excess hydrous fluids (Fig. 2).

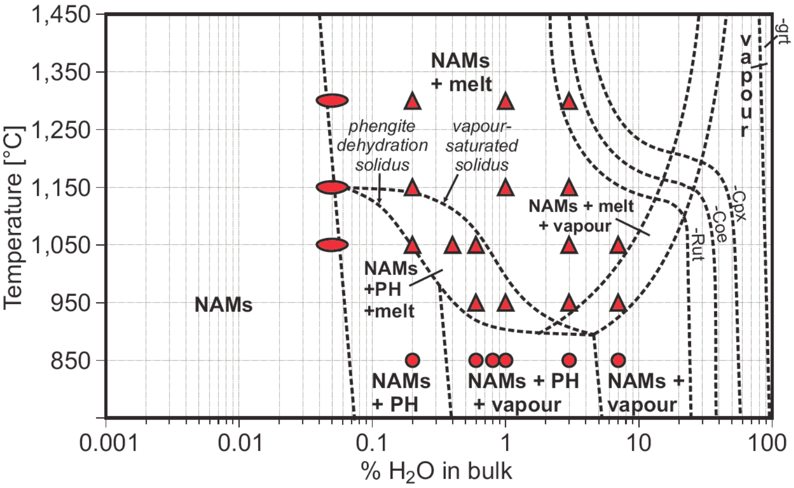

Figure 2. *Schematic phase diagram (based on [10 & 11]) at ~6 GPa showing the phase stabilities of eclogitic NAMs and phengite (hydrous phase) as a function of H_2O [wt%] and T. If the H_2O storage of phengite and the eclogitic NAMs is exceeded at subsolidus conditions, vapour will form in association with phengite and NAMs. Strikingly, runs with 7 wt.% H2O are phengite-free. Towards higher temperatures instead, melt in association with phengite will appear at the phengite dehydration solidus until phengite is completely exhausted at the vapoursaturated solidus of GA1+H_2O. Ph, phengite.*

For instance, K_2O in phengite and clinopyroxene decreases with increasing bulk H_2O content at subsolidus conditions at given pressure and temperature, suggesting a leaching role of K_2O by a vapour-rich fluid. At 9 GPa, 1400°C, residual eclogitic clinopyroxene (34%) and garnet (43%) incorporate 1280±192 and 33±10 ppm H_2O, respectively (Fig. 3), suggesting that near-solidus residual eclogite may only able to accommodate ~0.045 wt% H_2O at these mantle conditions. Towards deeper mantle levels, at 10 GPa, 1400°C, residual eclogitic clinopyroxene (30%) and garnet (44%) take up even less H_2O, i.e. 256±77 and 29±9 ppm H_2O, respectively, prompting into the incorporation of only ~0.009 wt% H_2O into residual eclogite at these conditions.

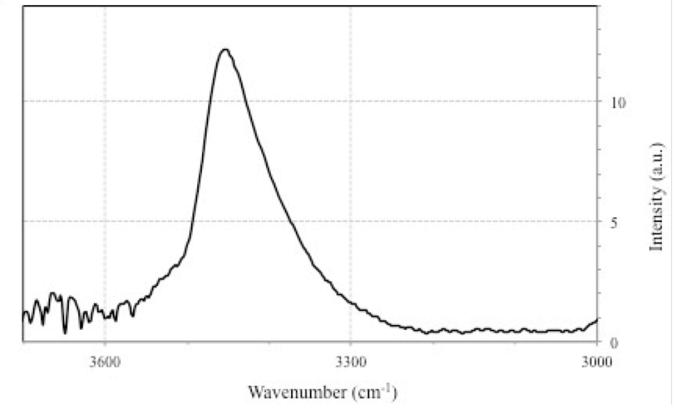

Figure 3. *Synchrotron-FTIR spectra for clinopyroxene of run H3840B (9 GPa, 1400°C, 7 wt.% H_2O in bulk). The absorbance peak at 3460 cm^{-1} is attributed to O-H stretching mode of H-substitution in clinopyroxene. The average unpolarized spectra is normalised to 1 cm thickness.*

Conclusions and further work: Obtained data will be compared with earlier studies, which concentrated on the direct measurement of H_2O in single mineral phases only, which where not in equilibration with the bulk phase assemblage (i.e. subducted crustal material). Considering the strong influence of volatiles on mantle melting processes, including redox melting, obtained data will then be also used to understand the behaviour of volatiles in subducted material along subduction zones, and subsequent recycling and mantle melting processes. The data obtained during ES240 are currently be written up as a manuscript for publications.

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