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IN SITU EXPERIMENTAL STUDY OF BASALT – COH SYSTEM AT THE UPPER MANTLE CONDITIONS

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Experimental investigation of the complex systems involving silicate and C-O-H components at simultaneous high temperatures and high pressures is a challenging task, since volatile components can easily change aggregate state and escape upon quenching and opening of the sample chamber. Recent technological advances provide an opportunity to observe and analyze such systems *in situ*, directly at the pressure and temperature conditions of interest (e.g., Chertkova and Yamashita, 2015; Thompson et al., 2016; Masotta and Keppler, 2017; Mysen, 2018).

In the present work, we applied a lever-type diamond anvil cell with an external heater to study interaction between basaltic (MORB) and C-O-H components at the conditions of cold subduction zones. The starting material was first compressed in the diamond anvil cell, which was placed under the microscope, connected to a highly confocal Photon Design Raman system, and then heated to temperatures exceeding 900°C. Visual observations of the sample and Raman measurements were performed *in situ* during heating (Fig. 1).

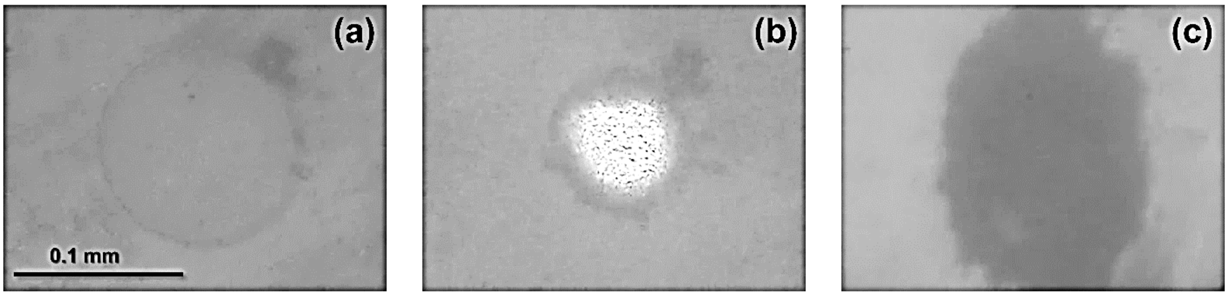

Fig. 1. Microphotographs of the sample (80 wt.% basalt + 20 wt.% $C_2H_2O_4$), taken during experiment in the diamond anvil cell: (a) compressed mixture at 25 °C and 0.8 GPa; (b) decomposition of oxalic acid, 395 °C and 4.0 GPa; (c) coexistence of opaque polymeric phase and silicate phases at 900 °C and 4.7 GPa.

In the chosen basalt – $C_2H_2O_4$ system, an appearance of polymeric phase with the dominant *G* bond-stretching mode and *D* breathing mode in the Raman spectra, common for carbon materials (Ferrari and Robertson, 2000), was detected at temperatures above 600 °C and pressures above 4 GPa along with the silicate minerals (Fig. 1c). This observation indicates that $C_2H_2O_4$ compound is not suitable as a fluid source at the mentioned experimental conditions. In the future work, water-rich compounds with lower carbon content will be used for experiments, modeling fluid and rock interaction in the geological settings of subduction zones.

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PETROLOGICAL AND VOLATILE EVOLUTION OF THE NORRA KÄRR LANTHANOID (REE) DEPOSIT

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Lanthanoids or 'Rare Earths' are critical to a range of advanced technologies; however, the formation processes that result in concentrated economic deposits of lanthanoids remain enigmatic. This research has focused on the evolution of the Norra Kärr syenite which has measured ore grades up to 0.61% TREO (of which 52.6% are HREO) and an indicated resource of 31.1 Mt at 0.4% TREO cut-off grade (Saxon et al. 2015) making it mainland Europe's largest lanthanoid resource. Core samples and analytical data kindly supplied by Tasman Metals Ltd. has provided an unrivalled opportunity to further investigate the evolution of this complex and to build on the previous studies of Sjöqvist et al. (2013) and Atanasova et al. (2017). Using a combination of detailed petrographic, geochemical, and structural data this study has shown that the Norra Kärr complex represents two separate intrusive phases, each with its own petrological and volatile fractionation sequence which in turn influences the evolution of the lanthanoid concentrations within specific minerals.

Mössbauer analysis was used to determine the Fe^{2+}/Fe^{3+} ratios of minerals within bulk-rock powders from different lithologies within Norra Kärr. This analysis revealed that the two intrusive phases have distinct redox properties. The first intrusive phase comprises of the ore bearing magma which was oxidised and rich in Fe^{3+}. The second intrusive phase was non-ore bearing and more reduced than the first phase with minerals from included enclaves being the richest in Fe^{2+}.

The differences between the two intrusive phases has been further highlighted by petrographic work and electronprobe (EPMA) analysis. This has shown that the overall crystallisation sequence of each lithology (aegirines followed by zirconosilicate phases and finally feldspars) also contains separate trends in volatile and lanthanoid evolution. These trends can be picked out using data from amphiboles, biotites and zirconosilicates. Previous modelling work by Andersen et al. (2013) has shown that the order in which these phases form in an alkaline magma is controlled by the relative activity of a given volatile (F^-, Cl^-, OH^-) in the magma. Future work will involve modelling the relationship between the volatile and lanthanoid trends and synthesising the available data into a holistic ore-deposit model for exploration purposes.