doi:10.1017/S1431927611010518
Microsc. Microanal. 17 (Suppl 2), 2011

Investigation of Mineral Transformations in Wet Supercritical CO2 by Electron Microscopy

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The capture and storage of carbon dioxide and other greenhouse gases in deep geologic formations represents one of the most promising options for mitigating the impacts of greenhouse gases on global warming. In this regard, mineral-fluid interactions are of prime importance since such reactions can result in the long term sequestration of CO_2 by trapping in mineral phases. Recently it has been recognized that interactions with neat to water-saturated non-aqueous fluids are of prime importance in understanding mineralization reactions since the introduced CO_2 is likely to contain water initially or soon after injection and the supercritical CO_2 ($scCO_2$) is less dense than the aqueous phase which can result in a buoyant $scCO_2$ plume contacting the isolating caprock. As a result, unraveling the molecular/microscopic mechanisms of mineral transformation in neat to water saturated $scCO_2$ has taken on an added important. In this study, we are examining the interfacial reactions of the olivine mineral forsterite (Mg_2SiO_4) over a range of water contents up to and including complete water saturation in $scCO_2$. The surface precipitates that form on the reacted forsterite grains are extremely fragile and difficult to experimentally characterize. In order to address this issue we have developed experimental protocols for preparing and imaging electron-transparent samples from fragile structures. These electron-transparent samples are then examined using a combination of STEM/EDX, FIB-TEM, and helium ion microscope (HIM) imaging (Figures 1-3). This combination of capabilities has provided unique insight into the geochemical processes that occur on $scCO_2$ reacted mineral surfaces. The experimental procedures and protocols that have been developed also have useful applications for examining fragile structures on a wide variety of materials.

This research was performed using EMSL, a national scientific user facility sponsored by the Department of Energy's Office of Biological and Environmental Research located at Pacific Northwest National Laboratory.

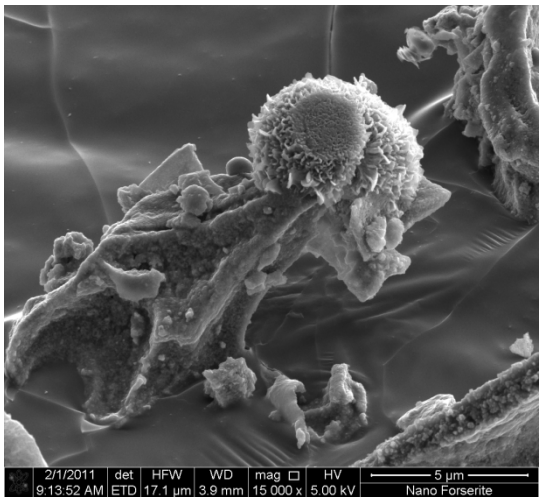

Fig. 1: SEM Image Forsterite and crystal formation after CO2 reaction

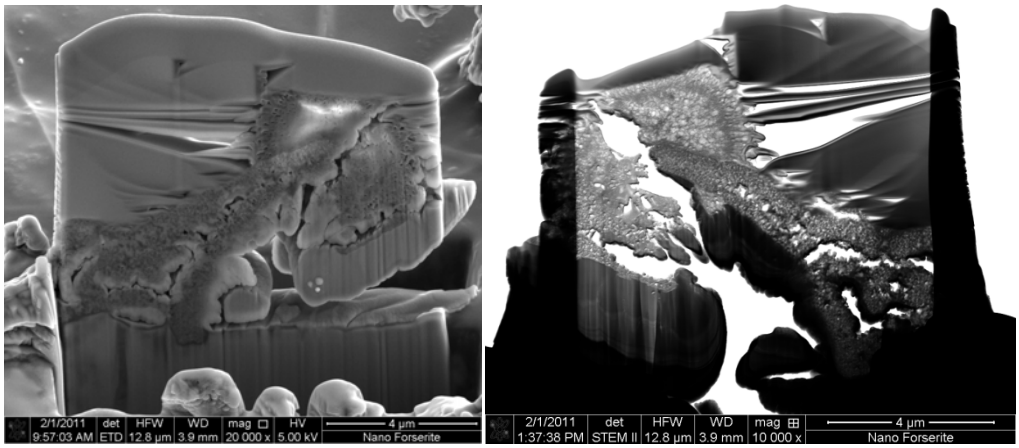

Fig. 2 FIB-SEM Thin section showing the mineral and crystal are attached

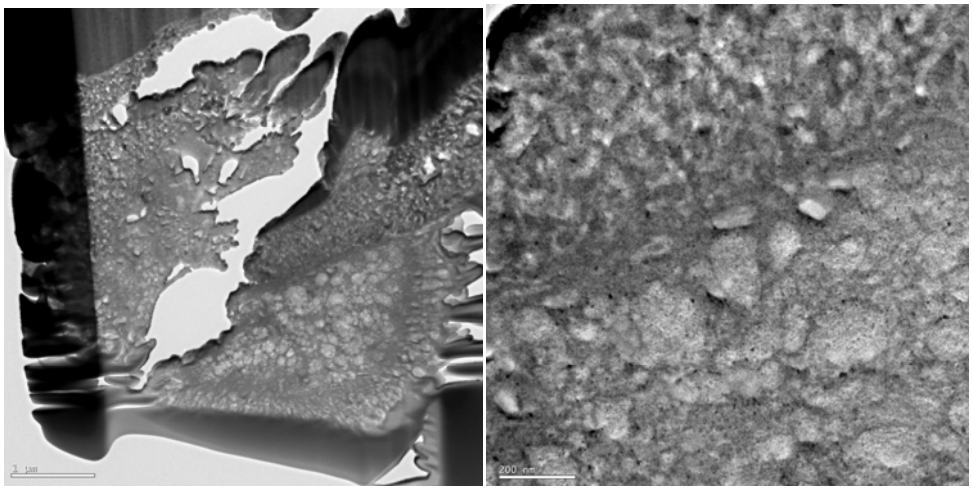

Fig. 3: TEM Images the mineral and crystal interface area.

https://doi.org/10.1017/S1431927611010518 Published online by Cambridge University Press