Texture Development in Silicate Perovskite and Implications for Seismic Anisotropy in the Earth's Lower Mantle (Advanced Photon Source Activity Report)

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In summer 2003 Rudy Wenk and Jenny Pehl did their first diamond anvil (DAC) experiment with the challenging goal to transform olivine to ringwoodite and then to perovskite and periclase and at the same time observe in situ development of preferred orientation. We were extremely lucky (especially to have such great mentors as Dave Mao and Guoyin Shen) and could document phase transformations and associated anisotropy changes by analyzing radial DAC images. We were reporting first results at AGU (Pehl et al. 2003) and a first paper has appeared in EPSL (Wenk et al. 2004a). Two different texture types were observed in perovskite, one which we attributed to mechanical twinning and the second to dislocation glide. The data analysis was extremely difficult because of high background produced by large boron-expoxy gaskets. We developed a Rietveld technique for direct texture analysis from diffraction images (Lonardelli et al. 2004, Ischia et al. 2005) that we can now apply routinely to diamond anvil experiments. In summer 2004 we had a second chance, again on GSECARS (13-ID). This time the goal was to transform enstatite to perovskite. Results were mixed: We could document texture changes with time, i.e. a creep behavior and also texture changes and coarsening during heating, i.e. dynamic recrystallization. But a small beam size and rather coarse grain size limited grain statistics and thus quantitative texture analysis. Here HPCAT, sector 16, came to our rescue.

In November, on short notice, Rudy Wenk, Jenny Pehl and Sergio Speziale had their first session with radial diffraction on HPCAT (16-ID-B), again transforming enstatite to perovskite with a larger beam, reduced grain size and an improved gasket design. A near disaster – failure of the HPCAT laser system – was averted through a last minute help from GSECARS. This time results were excellent and we could analyze the images practically on line with our Rietveld code MAUD. Results revealed a third texture type in perovskite, also attributed to dislocation glide. The results just came in time to be included in our presentation at AGU (Wenk et al. 2004b). The results will be part of Jenny Pehl's PhD thesis (Pehl, 2005) and we are preparing a publication. More experiments are needed to understand the differences in texture development. Also in November Sebastien Merkel performed some experiments on iron to document texture changes during phase transformations. The data are presently being analyzed but a first qualitative assessment already reveals that for the bcc-hcp transformation Burger's relationship applies with strong variant selection and texture memory (see also Merkel et al. 2003 and Wenk et al. 2004c).

Acknowledgements

Financial support from NSF and CDAC is gratefully acknowledged. Help from beamline scientists was invaluable, as well as use of all the facilities of HPCAT and GSECARS. Use of APS was supported by the U.S. Department of Energy, Office of Basic Energy Sciences, under Contract Number W-31-109-ENG-38.

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