Geophysical Research Abstracts, Vol. 9, 05603, 2007
SRef-ID:

Textural evolution in peridotite systems: a time-resolved experimental study on grain growth

M. Segata and P. Fumagalli
Dipartimento di Scienze della Terra, Università di Milano, Milano, Italy

Mantle rheology is strongly controlled by textural features: grain size and grain growth rates affect viscosity, fluid permeability and seismic velocities. The study of the textural evolution as a function of pressure, temperature and kinetic mechanisms via experimental simulations is crucial for the understanding of mantle dynamics in a variety of geological environments.

In order to attempt a quantitative textural characterization, time-resolved high pressure and temperature experiments have been performed using a single stage piston cylinder apparatus. Peridotite compositions have been modelled in the chemical system CaO-Na_2O-FeO-MgO-Al_2O_3-SiO_2-Cr_2O_3-TiO_2. Temperature conditions range from 900˚C to 1150˚C, pressure from 5 to 10 Kbar (within both the plagioclase and spinel stability field). In order to follow the textural evolution on a time scale, run durations from 10^3 to 10^6 seconds have been considered. Run products have been preliminarily identified by X-ray powder diffraction, carefully inspected by BSE images, TEM images and by EDS/WDS microprobe.

Powder X-ray diffraction at synchrotron radiation (ESRF, Grenoble) provide information on phase abundances and coarsening of major phases. The modal abundances of phases obtained with X-Ray diffraction analysis are in agreement with natural peridotites (olivine 52 wt%, orthopyroxene 32 wt%, clinopyroxene 15 wt%, spinel 1 wt%); the weight proportion of phases does not show any dependence on time suggesting that nucleation occurs at the very beginning and that the main time dependent process involves a textural rearrangement.

Run products developed in the spinel and in the plagioclase stability field show a different textural evolution: the spinel-bearing assemblage of the longest run (10^6 seconds) is characterized by polygon aggregates of orthopyroxene, clinopyroxene, olivine and spinel while plagioclase bearing experiments show a framework of the major phases with interstitial plagioclase. Furthermore both spinel grain size and spinel grain spatial distribution change significantly with time. In shorter runs spinel presents a bimodal grain size distribution: 1) fine dispersed grains clustered distributed, 2) relatively large grains randomly distributed. The major phases follow the same bimodal distribution suggesting a pinning effect on grain boundary by the fine-dispersed spinel grains. In longer runs spinel grains are up to 3.5μm of size and randomly distributed.

A quantitative textural analysis have been performed by image processing technique on high resolution BSE images on time resolved experiments run within the spinel stability field (10 Kbar, 1100˚C). The average grain size of spinel at 10^5, $10^{5.5}$ and 10^6seconds time duration yields 0.5, 0.7, 1.1 μm respectively. As in the 10^4 seconds-run a texture not resoluble at the SEM scale develops, TEM investigations have been alternatively used to characterize the average grain size of spinel (approximately 4 nm). These data show an asymptotic trend of the growth up to a maximum average grain size and a progressive decrease in the grain growth rate suggesting grain boundaries impingement and pinning. The Crystal Size Distributions (CSDs) slopes decrease with time and rotate about a point (approximately at 1.5 μm) revealing, on the other hand, a ripening process: crystals smaller than this value are reabsorbed to promote the coarsening of large crystals in agreement with the Communicating Neighbours (CN) theory.

Preliminary results on spinels indicate that the textural evolution in spinel peridotites is characterized by a combined effect of grain coarsening and grain boundary pinning and encourage the usage of image processing as a quantitative tool on experimental charges to reproduce natural textural evidences.