Catalysis of Orthopyroxene in the Phase Transformation of Olivine to its High Pressure Polymorphs

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Introduction: Olivine, with a composition close to $(Mg_{1.8}Fe_{0.2})SiO_4$ is the most abundant mineral in the Earth's upper mantle, and reaches more than 80% in the lithospheric mantle due to the extraction of basaltic components from a more primitive mantle composition. It has been argued that the transformation of olivine to its high pressure polymorphs will be kinetically inhibited in the subducted lithosphere where temperature might be as low as 500-600ºC at a depth of 400 km. Therefore, olivine might survive as a metastable phase to a greater depth. The olivine metastability has a number of geophysical and geodynamic consequences. Consequently, the kinetics of these phase transformations has attracted great interest in last 30 years. However, the effect of orthopyroxene (opx) on the kinetics of olivine transformation has been generally ignored. As the major portion of subducted slab is harzbergitic (that is, olivine and opx are coexisting in the slab, and opx can locally reach as high as 40%.), it is necessary to study the kinetics of olivine transformation in the presence of opx.

Methods and Materials: The starting materials included San Carlos olivine and hydrothermally synthesized opx (En_{90}). Pure olivine powder and a mixture of olivine and opx (4:1) were loaded in the same cell for a comparison run. Powder NaCl was used as the pressure standard. After the sample was compressed to the target pressure (*P*) using the multi-anvil press SAM85 coupled with a T-Cup device, temperature (*T*) was increased to the desired value. The phase transformations were monitored by collecting time-resolved X-ray diffraction patterns while the sample remained under the constant *P*, *T* conditions.

Results: Time-resolved diffraction patterns were collected for both samples. The patterns were analyzed using a fitting program, and the volume fraction of high pressure phase (ringwoodite) in each sample was calculated based on the peak intensities. The variation of beam intensity has been taken into account. The volume fraction of ringwoodite as a function of reaction time was obtained for each sample (Fig. 1).

Conclusions: The presence of orthopyroxene can greatly facilitate the olivine phase transformation. Therefore, opx enhances the reaction kinetics. Future models for the metastability of olivine in the subduction zones must consider the effect of opx. The mechanism of catalysis is still under investigation.

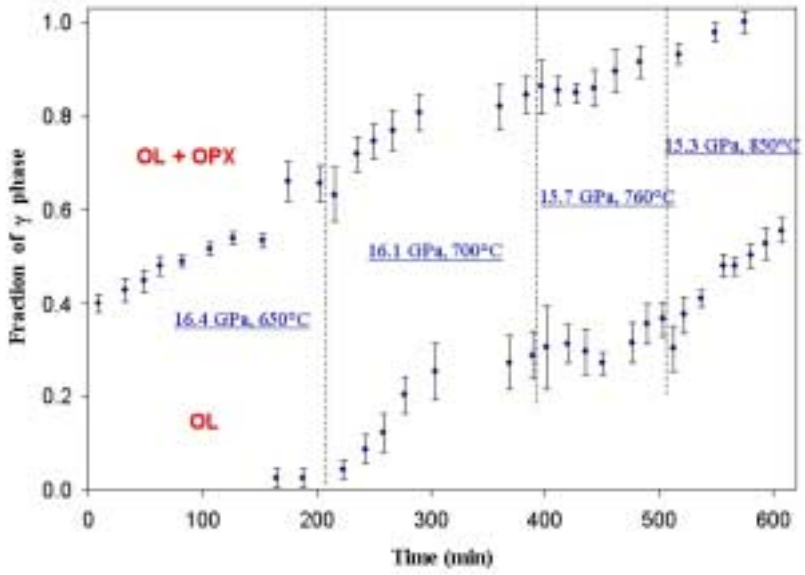

Figure 1. The relationships between the volume fraction of ringwoodite and reaction time for two samples [pure olivine (OL) and a mixture of olivine and opx (OL+OPX)].