Pressure dependence of olivine grain growth at upper mantle conditions

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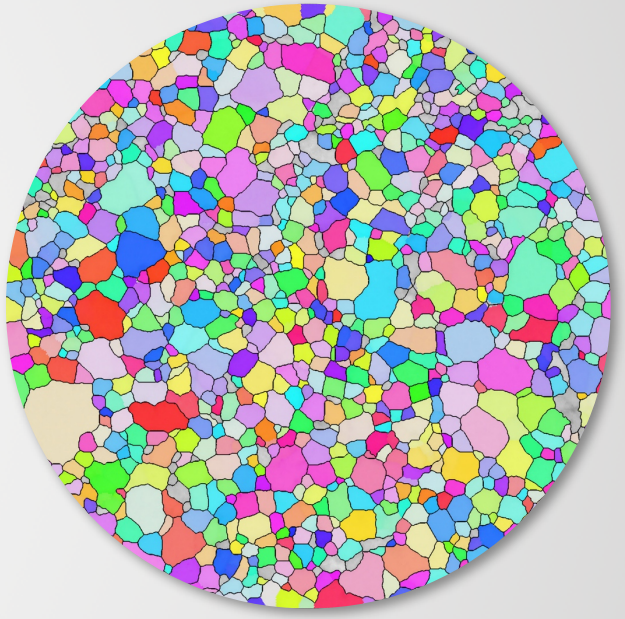
Introduction

- **Grain size** is one of the main factors affecting **viscosity** in rocks.
- The grain size in the Earth's mantle is controlled by grain size reduction via dynamic recrystallization, phase transitions and **grain growth**.
- All **previous studies** on **olivine grain growth** were conducted at much lower pressures (up to **1.2 GPa**) than those found at deeper regions of the Earth's Upper mantle.
- Here we investigate grain growth kinetics of olivine at temperatures spanning from 1050 °C to 1520 °C and pressures from **1 GPa to 12 GPa**, that is, covering **pressure and temperature conditions** found in most of the **Earth's upper mantle.**

Methods

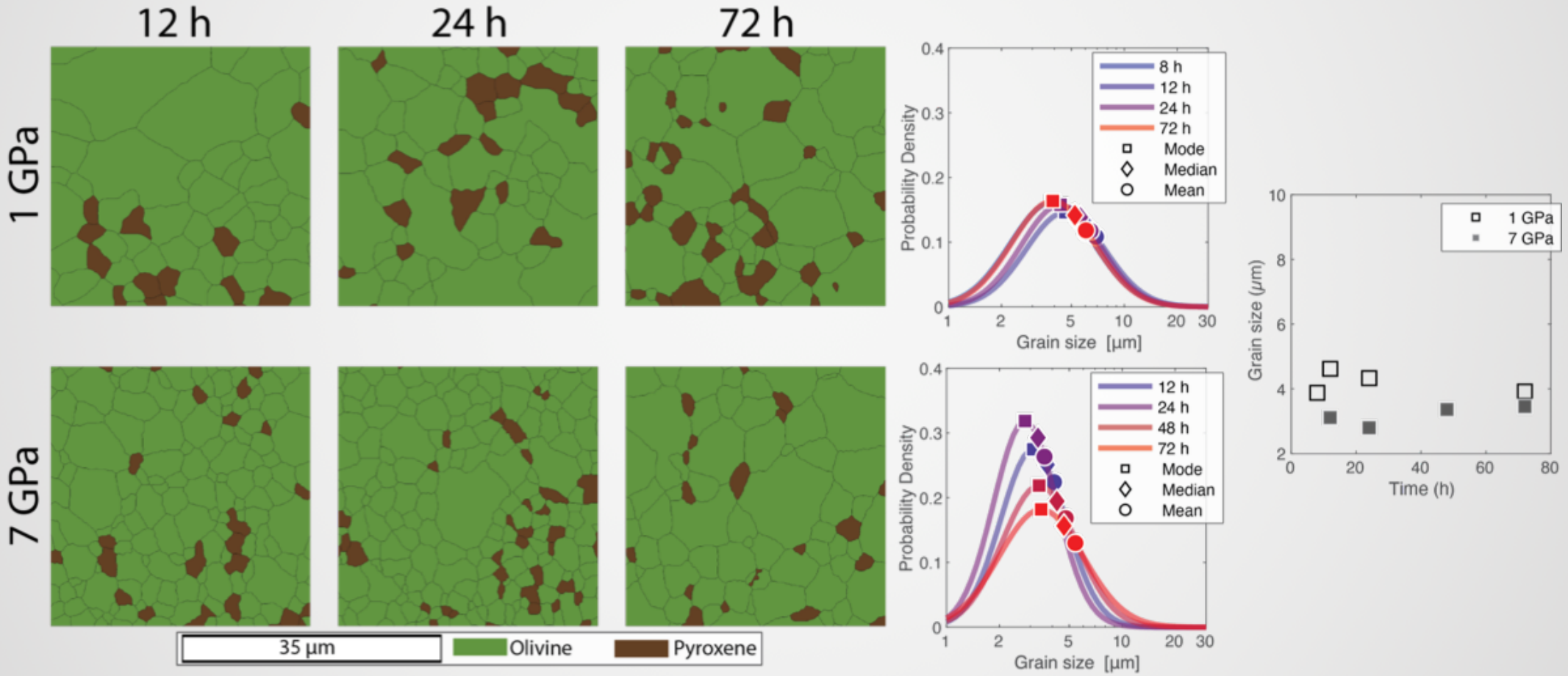
Hot-pressed **sol-gel olivine** (Fo_{90}) plus **4 and 10 vol. % of pyroxene (Px)** was used as starting material (average diameter: **2 µm**).

Grain growth experiments were performed using **Piston Cylinder** (19 mm assembly) and **Multi-Anvil** apparatus (18/11 assembly).



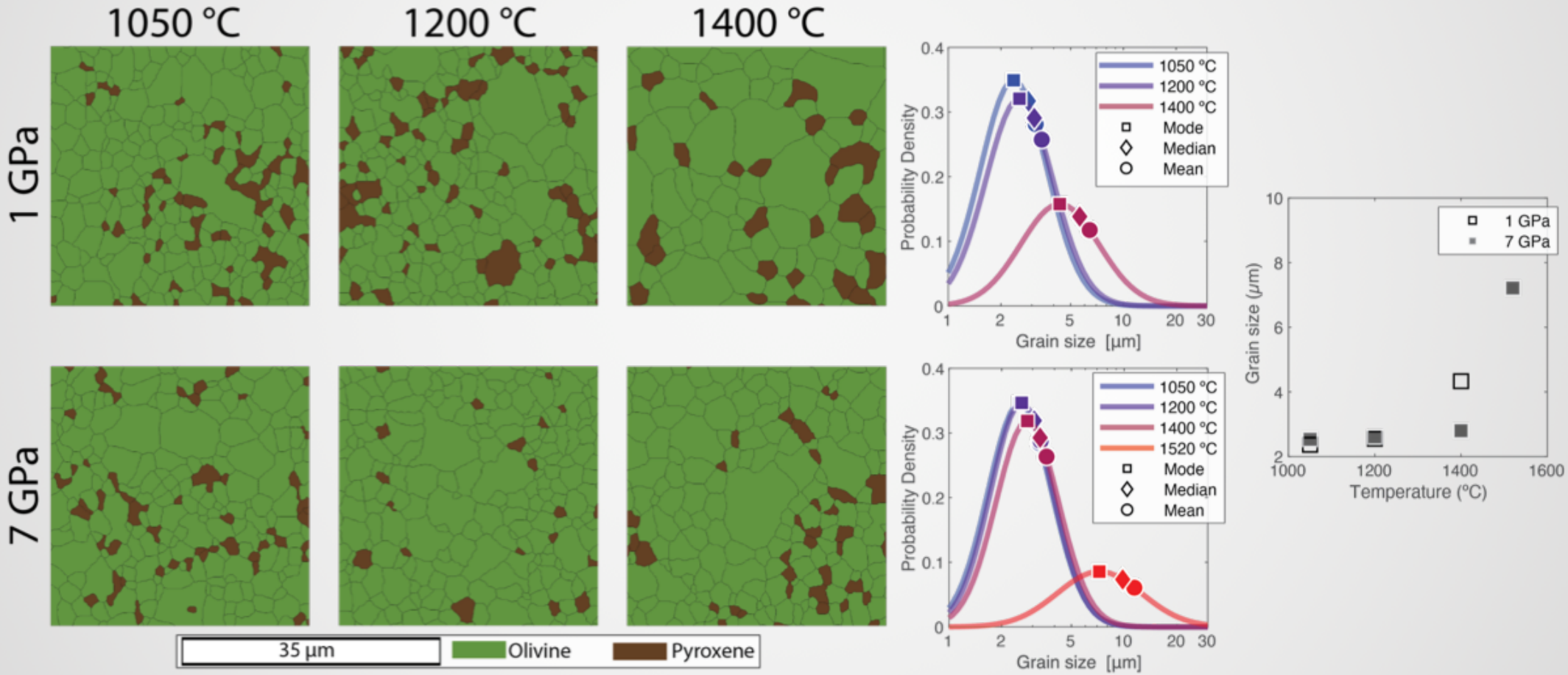
Grain size distribution was evaluated from **EBSD** data.

Results: Time series (1400 °C, 10 vol.% Px.)



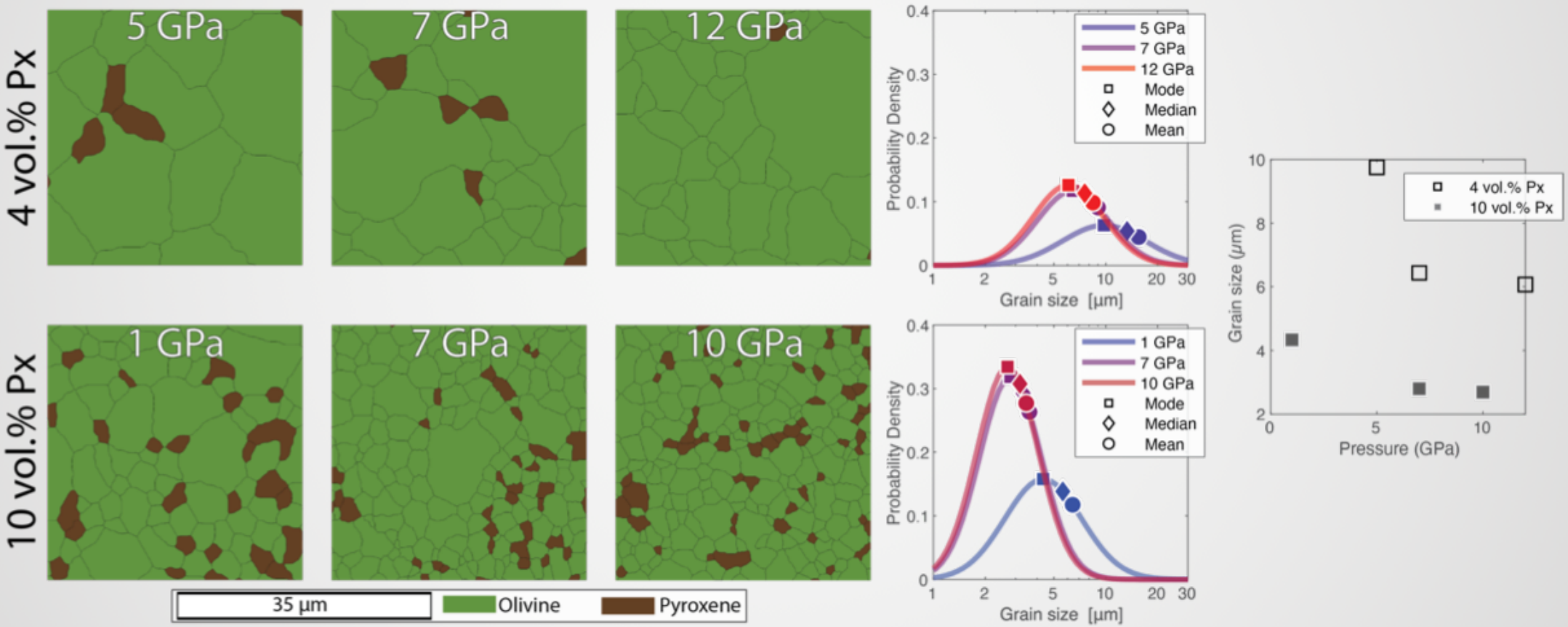
Grain growth is slower at higher pressures: Grain size distribution at 1 GPa and 12h is similar to the one at 7GPa and 72 h.

Results: Temperature series (24 h, 10 vol.% Px.)



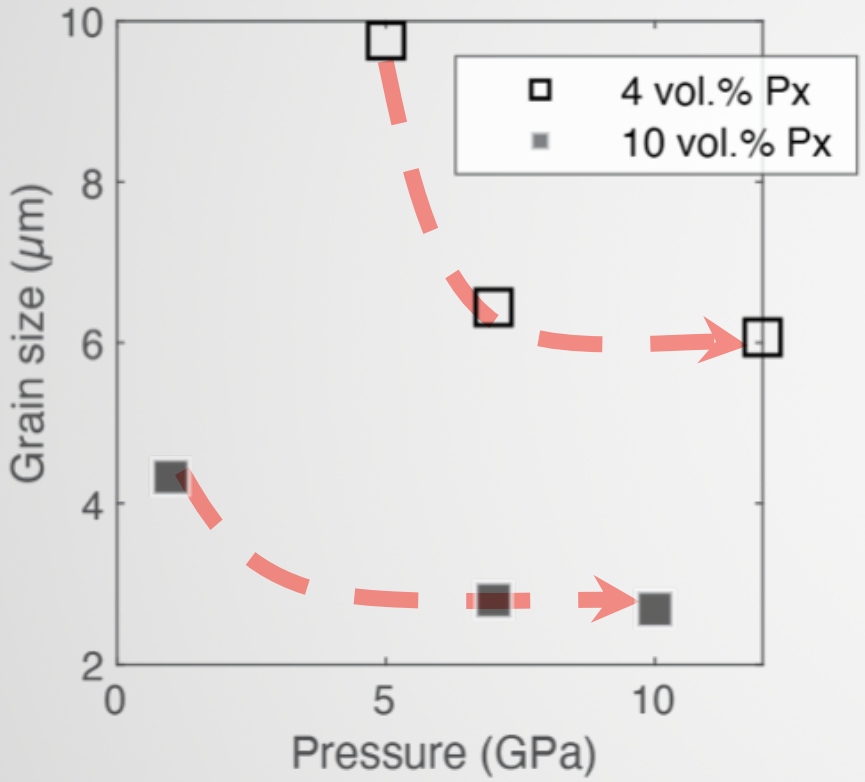
Grain growth is slow at low temperatures (≤ 1200 °C). At 1400 °C, grain growth rate is substantially higher at 1 GPa than at 7GPa.

Results: Pressure series (1400 °C, 24 h)



Olivine grain growth rate decreases at higher pressures, irrespective of the pyroxene content.

Preliminary conclusions



Arrows show the pressure effect on olivine grain growth

- Olivine grain growth rate decreases for increasing pressure.
- A possible explanation: Decreasing in the grain boundary diffusivity for increasing pressure (Fei et al., 2016).
- As grain growth and diffusion creep are proposed to be controlled by grain boundary diffusion (Nakakoji and Hiraga , 2018), we anticipate that strain rates of olivine deformed in the diffusion creep regime are also reduced for increasing pressure.

References

- Fei, H., Koizumi, S., Sakamoto, N., Hashiguchi, M., Yurimoto, H., Marquardt, K., Miyajima, N., Yamazaki, D., Katsura, T., 2016. New constraints on upper mantle creep mechanism inferred from silicon grain-boundary diffusion rates. Earth and Planetary Science Letters 433, 350–359. https://doi.org/10.1016/j.epsl.2015.11.014
- Nakakoji, T., Hiraga, T., 2018. Diffusion Creep and Grain Growth in Forsterite +20 vol% Enstatite Aggregates: 2. Their Common Diffusional Mechanism and Its Consequence for Weak-Temperature-Dependent Viscosity. Journal of Geophysical Research: Solid Earth 123, 9513–9527. https://doi.org/10.1029/2018JB015819

