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Synthesis and application of water-bearing large single crystals by slow cooling of hydrous melt at deep mantle pressure

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The presence of water in the deep mantle of the Earth is an issue of increasing interest in the field of high-pressure mineral physics. An anticipated task for advancing the relevant research is to create homogeneous single crystals of candidate deep-mantle water-bearing minerals of 1 mm or larger in sizes, which is necessary for applying them for the Time-of-Flight (TOF) single-crystal Laue diffraction method at a third-generation pulsed neutron source. In the present study, we applied a significantly slower growth rate over a maximum period up to 24 h to successfully produce these sample crystals. We grew the crystals from a homogeneous silicate melt batch with a volume as large as possible to enable continuous buffering of chemical composition of the crystals. The temperature of the cell slowly decreased during the long heating durations so that the crystals were almost kept in chemical equilibrium with the silicate melt throughout the growth process. This slow-cooling method has been successfully applied at pressures to 24 GPa and at temperatures to about 1800 deg C, respectively, for the crystal growth of deep-mantle hydrous mineral phases. Successfully synthesized crystals include dense hydrous magnesium silicate phase E, hydrous wadsleyite, hydrous ringwoodite, and bridgmanite. These product crystals were confirmed to be inclusion free and crystallographically homogeneous. Compositional homogeneities were better than 3 % among intracrystals and intercrystals within each recovered sample capsule (Okuchi et al., in press). The product single crystals are being used for neutron diffraction as well as for another state-of-the-art mineral physics research requiring high-quality sample crystals (Goncharov et al., in press)

References

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