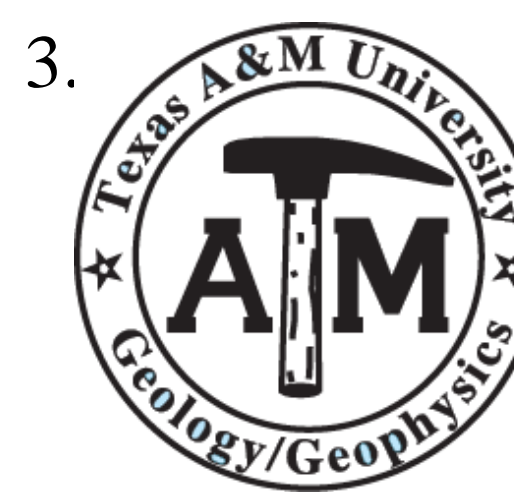
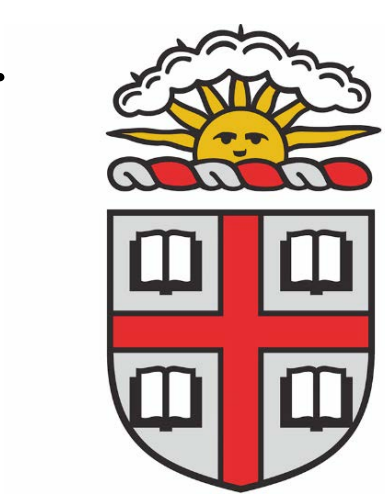


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Grain Size Dependence for Deformation of Natural Magnesites

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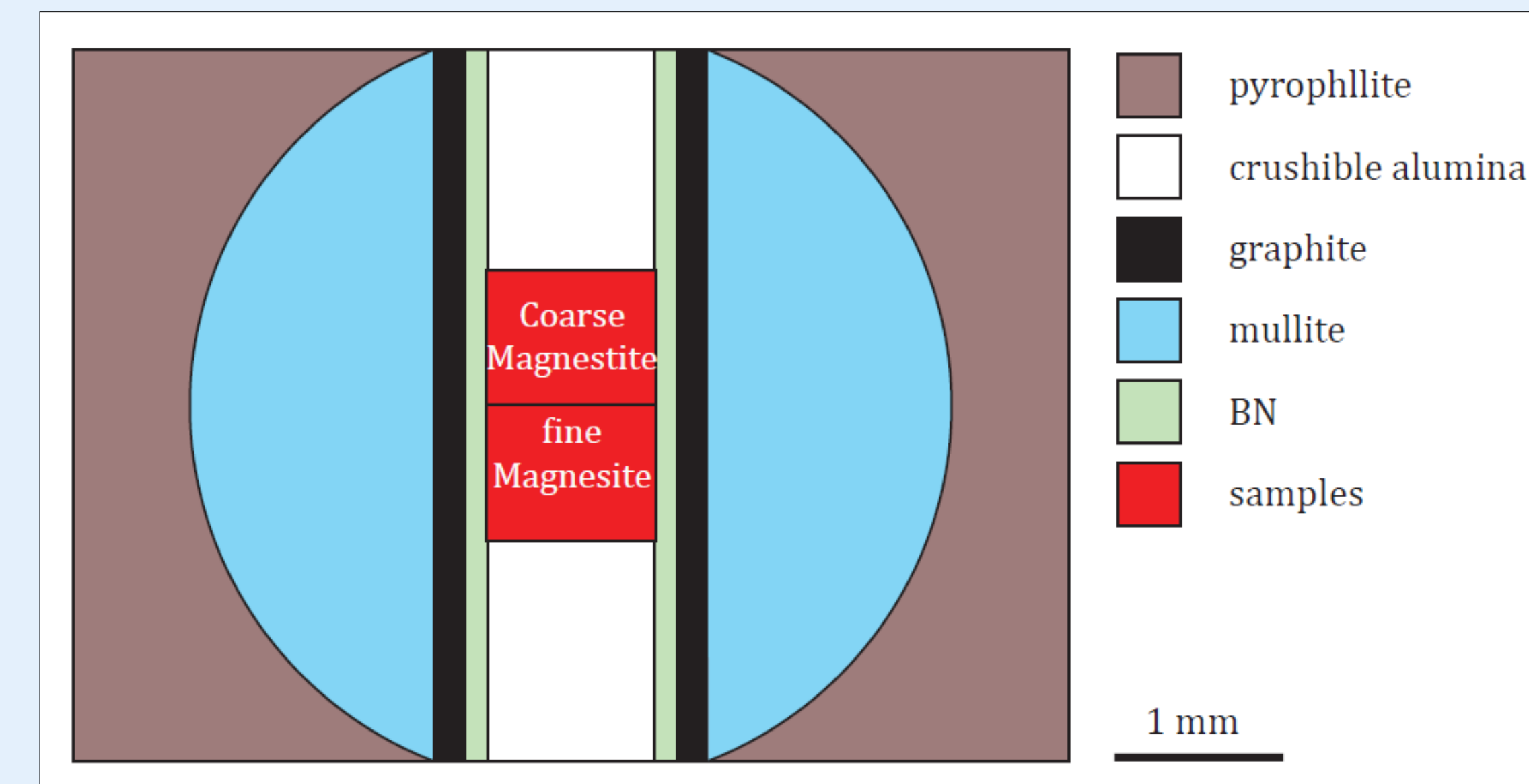


Introduction

Magnesite is a carbonate mineral formed by alteration of olivine-rich peridotites in subducting slabs. Results of low pressure experiments performed on coarse-grained ($d \sim 100 \mu\text{m}$) magnesite indicate that magnesite is significantly weaker than olivine at all P-T conditions of a subducting slab (Holyoke et al. 2014). However, these experiments did not determine the grain size sensitivity of the strength of magnesite, which could affect the strength contrast between magnesite and olivine. In order to determine the grain size sensitivity of the strength of magnesite deforming at low temperatures, we performed two experiments on stacked cylinders of coarse ($d \sim 100 \mu\text{m}$), medium ($d \sim 20 \mu\text{m}$) and fine-grained ($d \sim 1 \mu\text{m}$) magnesite.

Experimental Methods

We performed two experiments at 500°C on stacked cylinders of magnesite aggregates with different grain sizes (1 vs. 100 μm and 1 vs. 20 μm). Stacked samples with a different property allows direct comparison of the strain rates of each cylinder during the experiment. The weaker sample will have a faster strain rate than the stronger sample, assuming uniform stress in the load column.

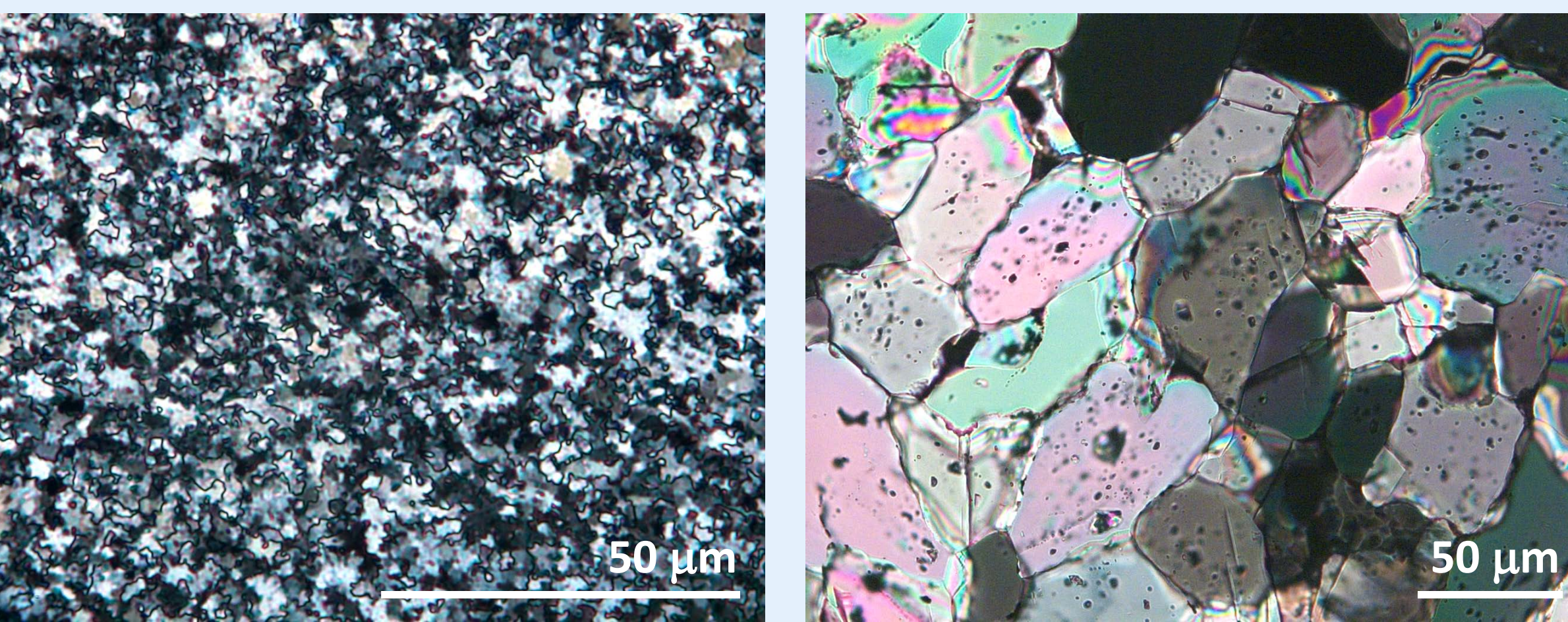


D-DIA assembly used in both experiments

Temperature was kept constant 500°C and the load piston was advanced at a constant rate. One experiment had deformation steps at three pressures (2.6, 5, and 7.4 GPa) and a second experiment had single deformation step performed at a single pressure (5 GPa). The load pistons were advanced at the same constant rate (0.003 mm/sec) in all deformation steps.

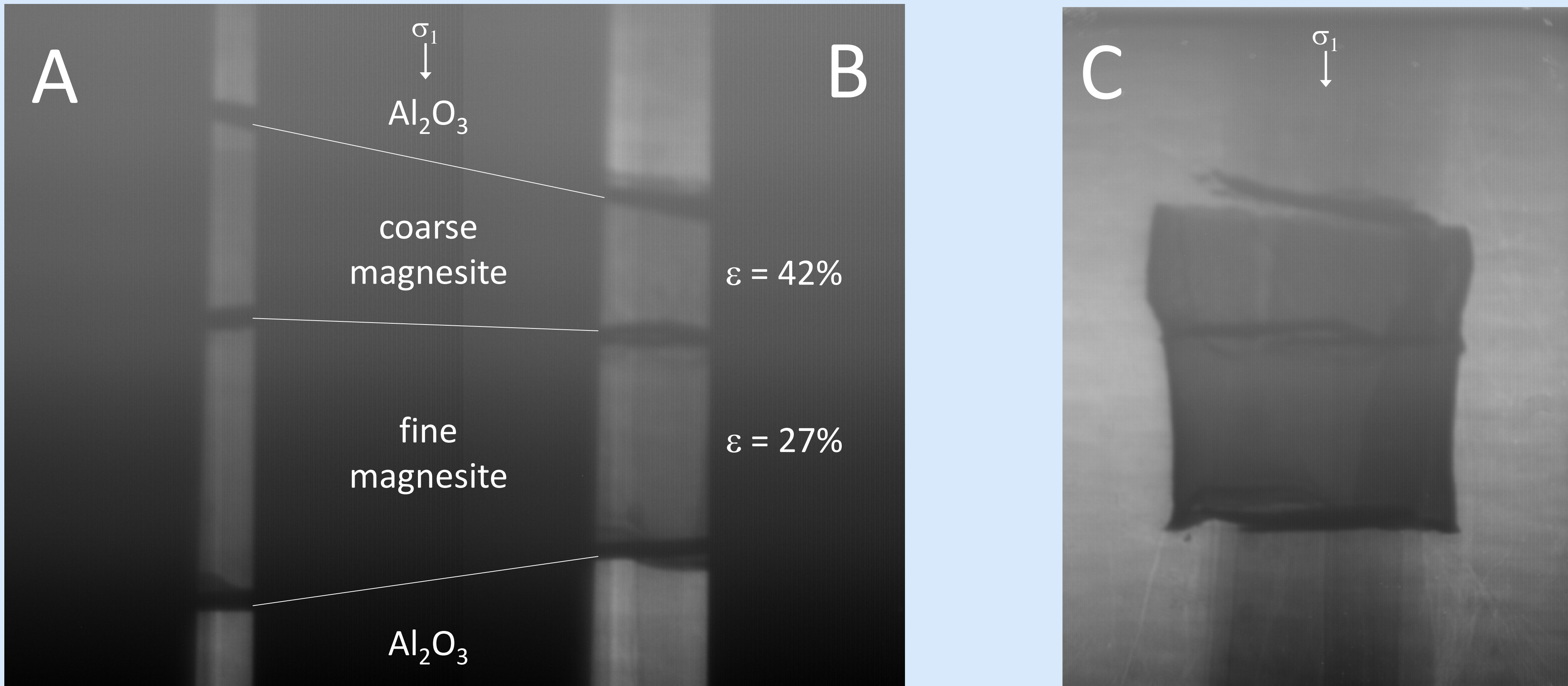
After deformation the samples were cut in half, polished, and viewed under an SEM to characterize microstructures.

Starting Material

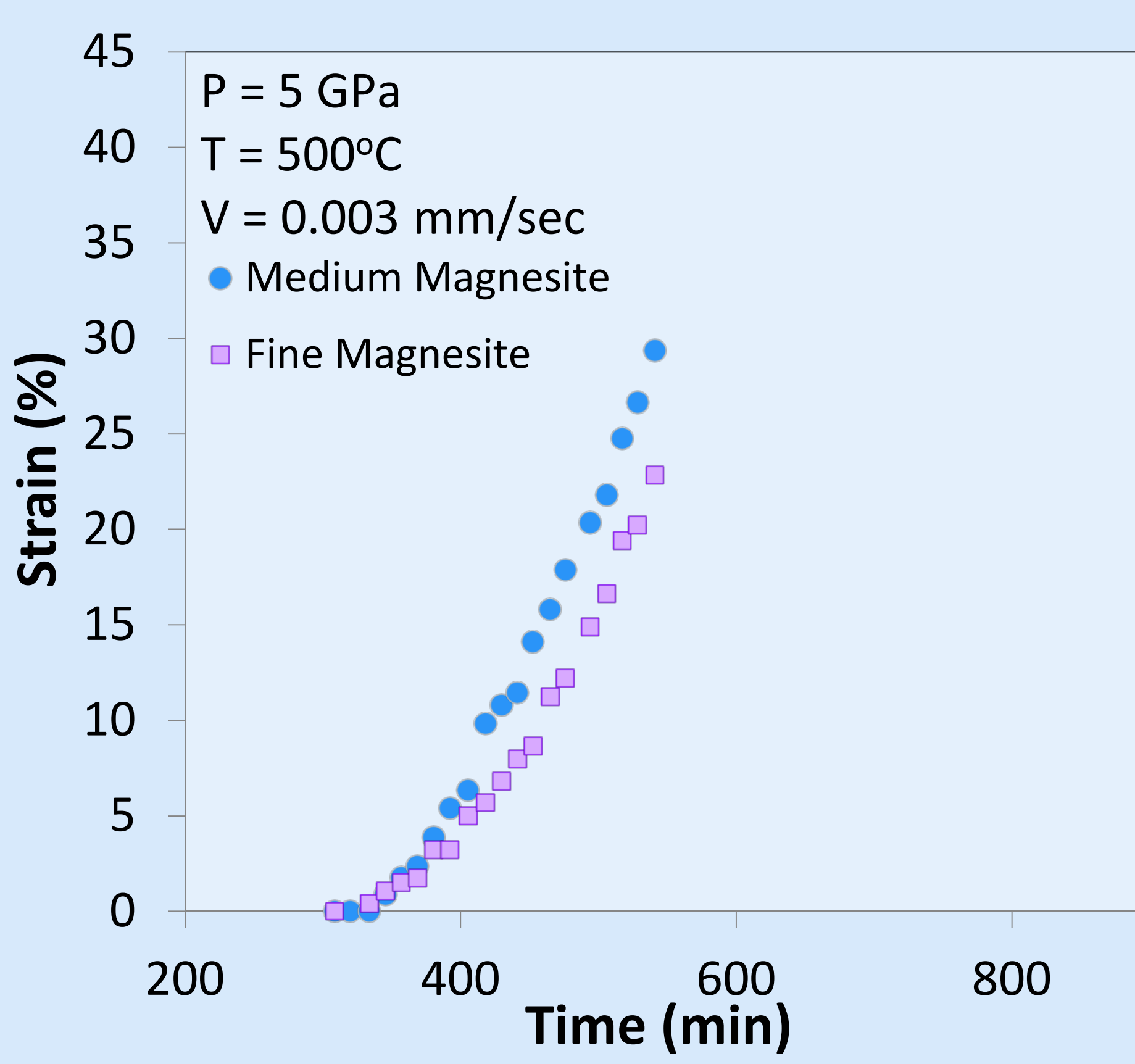
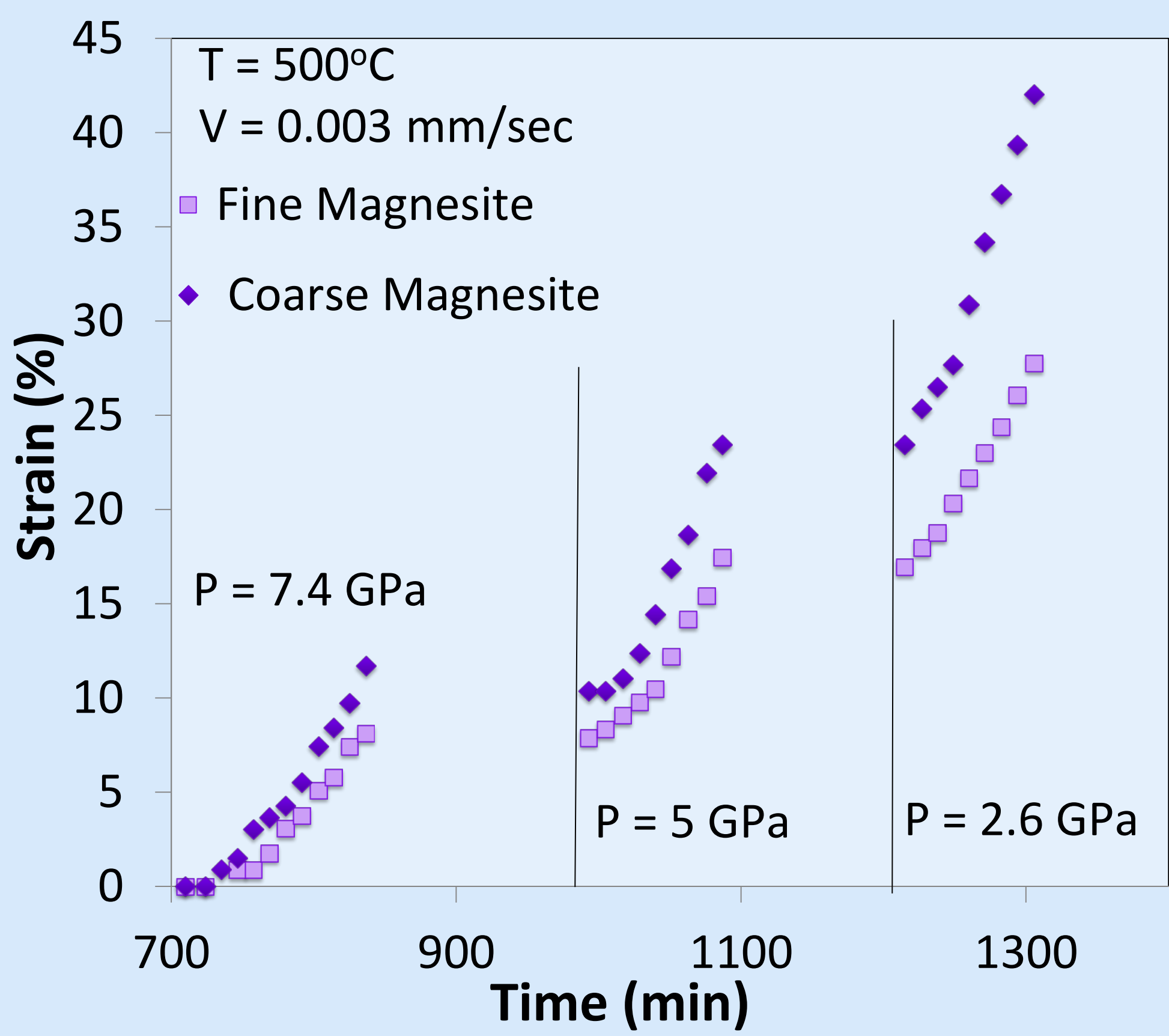


The starting materials for these experiments were two natural magnesite aggregates from Nevada, USA ($d \sim 1 \mu\text{m}$ above left; $d \sim 100 \mu\text{m}$ above right, cross polarized images). The intermediate grain size starting material ($d \sim 20 \mu\text{m}$ not pictured) was made by performing a 24 hour hydrostatic experiment in the Griggs apparatus at 850°C.

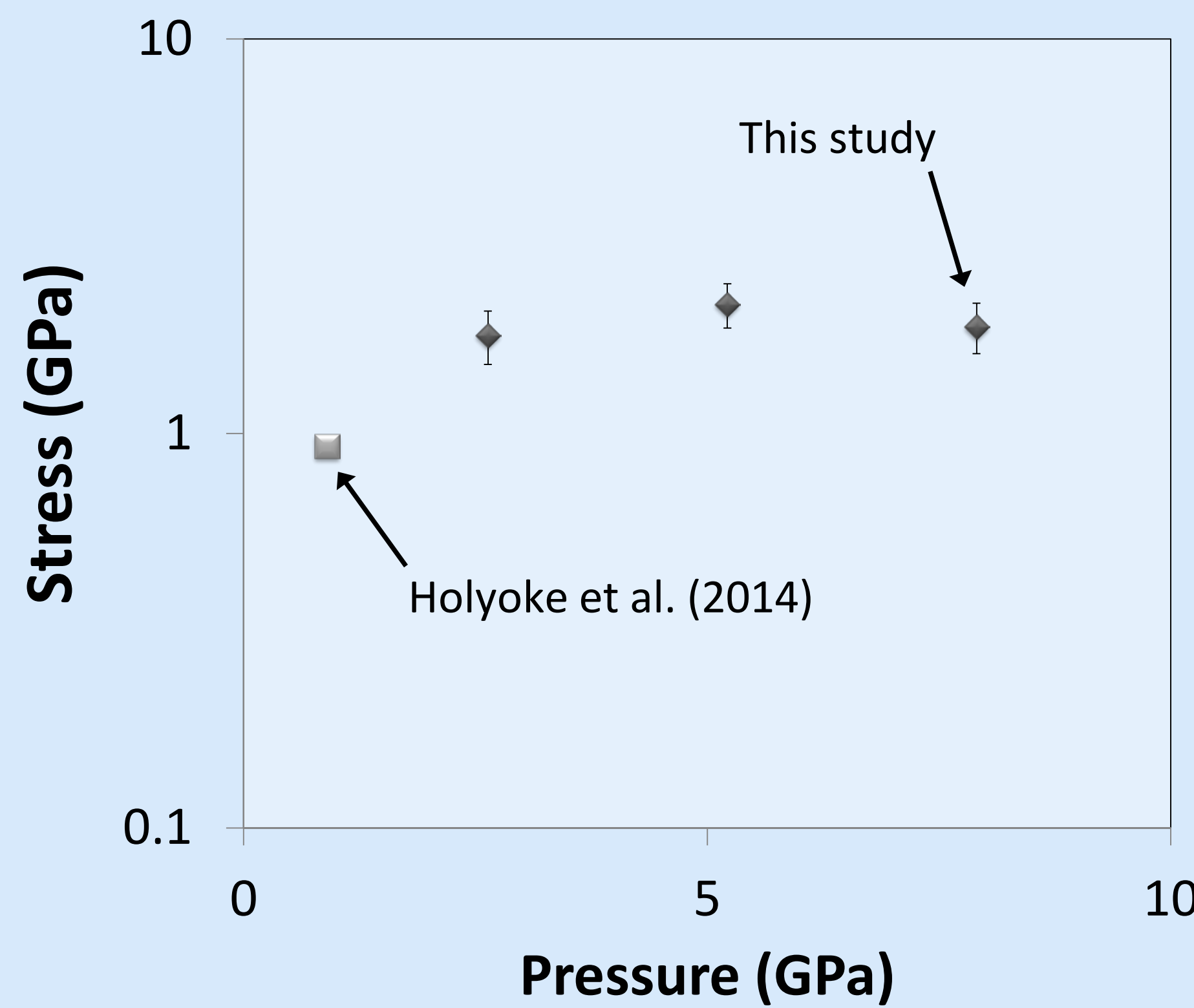
Mechanical Data



X-radiographs of the samples are collected every 600 seconds. The light grey areas are the material in the load column, while the very dark zones are the WC anvils and Re foil used to mark the ends of samples. The coarse magnesite deformed significantly (15%) more than the fine magnesite (*X-radiographs of assembly before (A) and after (B/C) deformation, ~35% total strain. Image C collected after removing WC anvils.*)

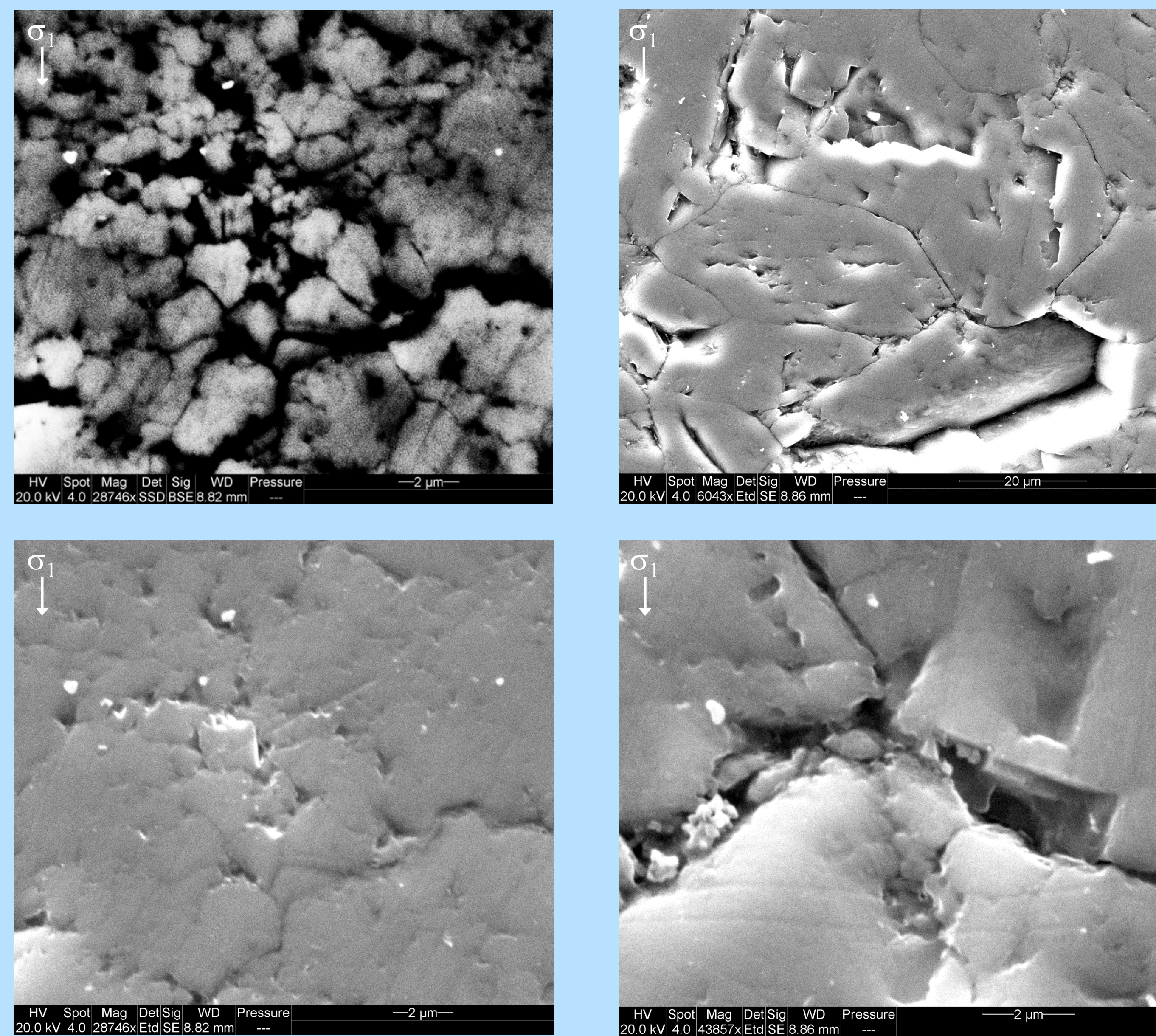


Strain rates in the coarse-grained magnesite aggregate are greater than in the fine-grained magnesite aggregate at all pressures (*above left*). The strain rate of the medium-grained magnesite aggregate is also faster than the fine-grained magnesite aggregate (*above right*). However, the difference in strain rate between the coarse/fine and medium/fine grained aggregates is greater at equivalent strains, indicating that the coarse grained aggregate is weaker than the medium grained aggregate.



The strength of magnesite in these experiments does not change much with decreasing pressure. This result is inconsistent with other results of magnesite experiments (Blasko et al., 2017, *this session*) or calcite (deBresser, 2002). A possible reason for this inconsistency is that the first deformation step was at high pressure and high differential stress. The short periods at a relatively low temperature (500°C) between deformation steps may not have been sufficient to anneal the high density of tangled dislocations that were generated in the first high pressure step. Deforming from low to high pressure may yield a different result.

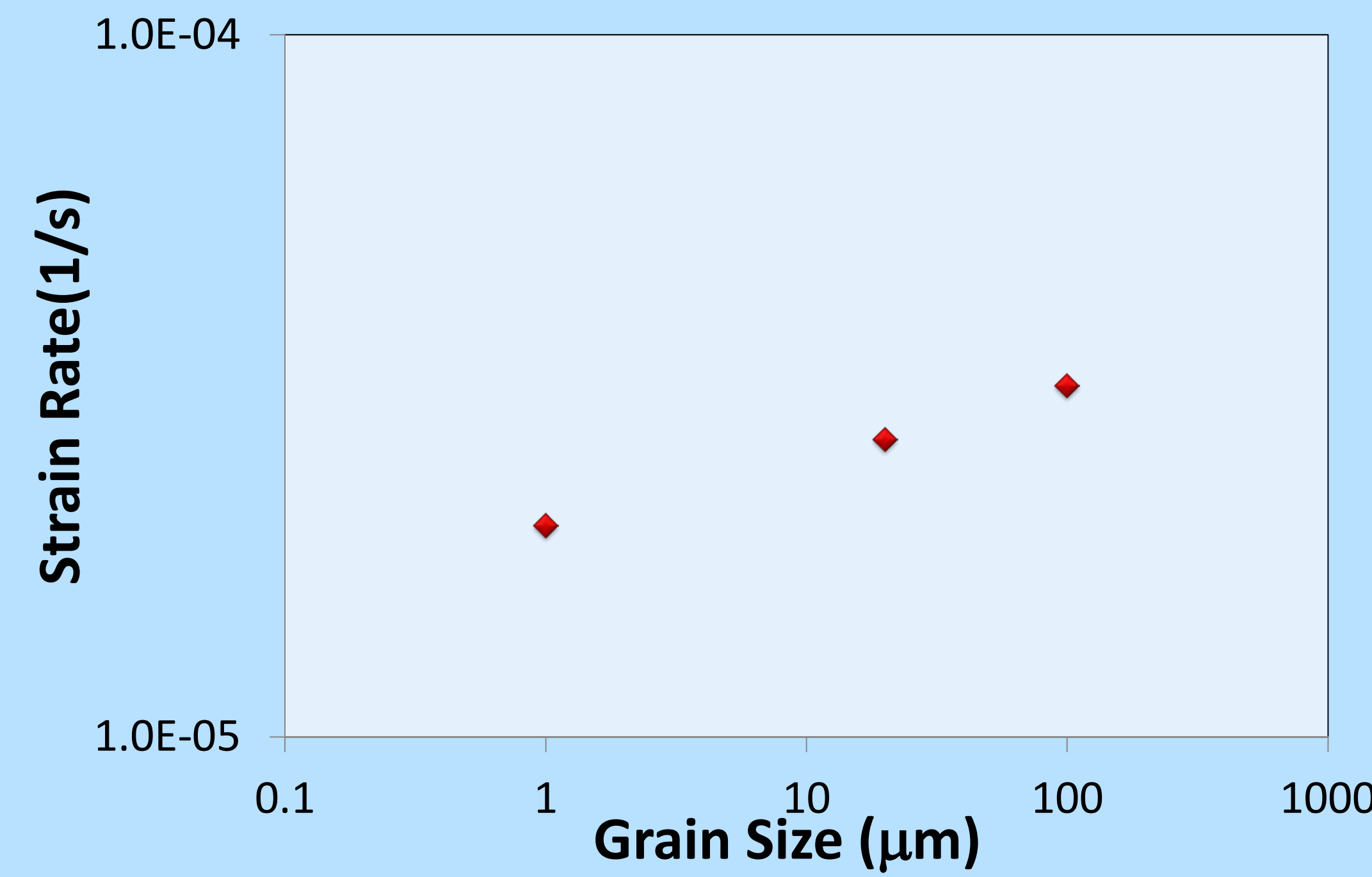
Microstructures



Grains in the fine-grained magnesite do not appear significantly flattened relative to the starting material (*both left images*). However, many of the grains in the coarse-grained magnesite aggregate are flattened relative to the compression direction (*top right*) and there are some fine grains at grain boundaries in the coarse-grained magnesite indicating a limited amount of recrystallization occurred (*bottom right*).

Grain Size Dependence

Strain rates in magnesite aggregates increase as the grain size of the aggregate increases. These results are consistent with those of calcite aggregates (limestones and marbles) deformed at low temperatures (Olsson, 1974).



Conclusions

- 1) Strain rates in magnesite aggregates become faster as grain size increases, which is consistent with results of experiments performed on calcite.
- 2) Coarse-grained magnesite aggregates undergo limited recrystallization during low temperature plastic deformation. Other recovery processes, such as dislocation climb, are also likely limited at these conditions.
- 3) The strength of these magnesite aggregates does not appear to be related to pressure. However, this result could be due to work hardening of the aggregate in the first deformation step at the highest pressure.