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Dear Editorial Board,

We submit the manuscript *Validation of subgrain-size piezometry as a tool for measuring stress in polymineralic rocks* in consideration for publication in *Journal of Geophysical Research: Solid Earth.* In this article we report experiments in which we deformed mixtures of olivine and orthopyroxene in a Deformation-DIA apparatus, situated on a synchrotron beamline, to test the application of subgrain-size piezometry to polymineralic rocks.

Piezometry remains the only real approach to obtain direct estimates of the differential stress supported by rocks in the deep portions of continental (e.g., Behr & Platt, 2011) and oceanic (e.g., Mehl & Hirth, 2008; Hansen et al., 2013) fault zones. Most traditional stress estimates come from piezometers that are based on the grain size of a rock. However, such analysis is limited to rocks that are made up of a single phase, while polyphase shear zones are found in the field to be much weaker, typically taking up most of the displacement during deformation.

Subgrains offer an alternative piezometer to grain size and, being intragranular features, are inferred to be unaffected by the presence of secondary phases. The recent calibration of a generalised subgrain-size piezometer for electron backscatter diffraction data (Goddard et al., 2020) provides an up-to-date tool for microstructural studies. However, how accurately subgrains record the stress within polymineralic rocks has never actually been tested. In addition, while recent publications have focused on how grain-size piezometry responds to the non-steady state stresses one expects in nature (e.g., Kidder et al., 2016; Soleymani et al., 2020), the equivalent work for subgrain-size piezometry is sparce and inconsistent (e.g., Ross et al., 2020; Qin et al., 2003).

Our work expands on that by Goddard et al., (2020), focusing on the application of subgrain-size piezometry to natural rocks. The work advances the field of solid-Earth geology in two main ways. First, to the best of our knowledge it is the only study to provide direct evidence that subgrain sizes reflect the stresses within individual phases deformed in an aggregate. Second, the work demonstrates the extent to which stresses within an individual phase relates to the bulk stress, thereby giving important information on how to interpret piezometric measurements in multi-phase rocks. We believe, therefore that this study sits well within the remit of Journal of Geophysical Research: Solid Earth, which has extensively published on the strength of olivine and orthopyroxene (e.g., Abramson et al., 1997; Angel & Hugh-Jones, 1994; Chai et al., 1997; Hansen et al., 2019), as well as the weakening effects of phase mixing (e.g., Handy 1990; Hansen & Warren, 2015), and piezometry itself (e.g, Kohlstedt & Weathers, 1980).

This manuscript has not previously been published and is not under consideration for publication elsewhere. Included in our submission are the main text, which consists of eleven figures, four tables, two appendices including four appendix figures, and supplementary material, which consists of one text, three figures, and four tables.

Yours sincerely,

Rellie Goddard

on behalf of Kathryn Kumamoto, Lars Hansen, David Wallis, Andrew Cross, and Christopher Thom