American Mineralogist, Volume 107, pages 262–273, 2022

Improving grain size analysis using computer vision techniques and implications for grain growth kinetics

Isra S. Ezad[1,2,*], Joshua F. Einsle[3], David P. Dobson[2], Simon A. Hunt[4,†], Andrew R. Thomson[2], and John P. Brodholt[2]

[1]Department of Earth and Environmental Sciences, Macquarie University, New South Wales 2109, Australia
[2]Department of Earth Sciences, University College London (UCL), Gower Street, London, WC1E 6BT, U.K.
[3]School of Geographical and Earth Sciences, University of Glasgow, Glasgow, G12 8QQ, U.K.
[4]Department of Materials, University of Manchester, Sackville Street Building, Manchester, M1 3BB, U.K.

Abstract

Earth's physical properties and mantle dynamics are strongly dependent on mantle grain size, shape, and orientation, but these characteristics are poorly constrained. Experimental studies provide an opportunity to simulate the grain growth kinetics of mantle aggregates. The experimentally determined grain sizes can be fit to the normal grain growth law $(G^n - G_0^n) = k_0 t \cdot \exp(-\Delta H/\mathrm{R}T)$ and then be used to determine grain size throughout the mantle and geological time. The grain growth dynamics of spinel-orthopyroxene mixtures in the upper mantle are modeled here by experimentally producing small grain sizes in the range of 0.5 to 2 μm radius at pressures and temperatures equivalent to the spinel lherzolite stability field. To accurately measure the sizes of these small grains, we have developed a computer vision workflow; using a watershed transformation, which rapidly measures 68% more grains and produces a 20% improvement in the average grain size accuracy and repeatability when compared with manual methods. Using this automated approach, we have been able to identify a significant proportion of small grains, which have been overlooked when using manual methods. This additional population of grains, when fit to the normal grain growth law, highlights the influence of improved accuracy and sample size on the estimation of grain growth kinetic parameters. Our results demonstrate that automatic computer vision enables a systematic, fast, repeatable method of grain size analysis, across large data sets, improving the accuracy of experimentally determined grain growth kinetics.

Keywords: Grain growth kinetics, advanced image processing, watershed algorithm, grain size analyses