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Universal scaling of grain size distributions during dislocation creep

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Grain size distributions are major sources of information about the mechanisms involved in ductile deformation processes and are often used as paleopiezometers (stress gauges).
Several factors have been claimed to influence the stress vs grain size relation, including the water content (Jung & Karato 2001), the temperature (De Bresser et al., 2001), the crystal orientation (Linckens et al., 2016), the presence of second phase particles (Doherty et al. 1997; Cross et al., 2015), and heterogeneous stress distributions (Platt & Behr 2011). However, most of the studies of paleopiezometers have been done in the laboratory under conditions different from those in natural systems. It is therefore essential to complement these studies with observations of naturally deformed rocks.

We have measured olivine grain sizes in ultramafic rocks from the Leka ophiolite in Norway and from Alpine Corsica using electron backscatter diffraction (EBSD) data, and calculated the corresponding probability density functions. We compared our results with samples from other studies and localities that have formed under a wide range of stress and strain rate conditions. All distributions collapse onto one universal curve in a log-log diagram where grain sizes are normalized by the mean grain size of each sample. The curve is composed of two straight segments with distinct slopes for grains above and below the mean grain size. These observations indicate that a surprisingly simple and universal power-law scaling describes the grain size distribution in ultramafic rocks during dislocation creep irrespective of stress levels and strain rates.

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