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A technique for measuring 3D crystal-size distributions of prismatic microlites in obsidian

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ABSTRACT

We describe a technique for determining the 3D size, shape, and number density of prismatic microlites in obsidian. The procedure involves collecting a series of optical photomicrographs at successive levels in a transparent thin section with a petrographic microscope and digital camera. These images are combined to form 3D stacks with *NIH Image* software. The number, position, orientation, and projection length of each microlite in the stack are then determined, and these data are used to calculate the true length and number density. Crystal-size distribution (CSD) based on direct measurements exhibit asymptotic, lognormal, and near-lognormal profiles. These forms, in addition to broad variations in crystal aspect ratio suggest that microlites experienced a range of growth rates. Textural parameters (e.g., total crystal number density and volume) determined from regressions of linear CSDs under the assumption of constant growth rate compare well with directly measured parameters.

We compared CSDs based on 3D measurements with those based on 2D measurements of intersection length and area number density. Stereological conversions of 2D data are necessary owing to the cut-section effect and intersection probability problem. We performed corrections with three widely used algorithms and, thus, our comparisons test the accuracy of these correction methods as applied to prismatic microlites in obsidian. CSDs based on 3D measurements are linear over most of the size range. In contrast, conversion programs produce kinked CSDs, with large positive errors in population density at small crystal size. Errors in population density are caused by shape (aspect ratio) variability in the sample population. Conversion programs, which assume a constant shape, overestimate the number of small crystals owing to a large number of intersections along the short crystal dimension. In the real population, these intersections correspond to a wide range of true lengths. Consequently, CSDs constructed from intersection lengths are kinked rather than linear. Kinked and curved CSDs have been interpreted to result from mixing of distinct crystal populations, sharp variations in growth and/or nucleation rate, or from crystal settling. Our results suggest that nonlinear CSDs in some cases may also arise as an artifact of shape variability in the natural population.