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Estimation of volume fractions of liquid and vapor phases in fluid inclusions, and definition of inclusion shapes

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Abstract

The molar volume (V_m) and chemical composition (x) of saline aqueous inclusions and gas inclusions in minerals can be calculated satisfactorily from microthermometric and other analytical data. For complex gas-bearing aqueous inclusions, however, calculation of $V_m - x$ properties requires additional input of the volume-fractions of the inclusion phases (φ). Traditional estimation of φ in non-fluorescing inclusions involves measuring area-fractions of the phases projected in the microscope and then making rough corrections for the third dimension. The uncertainties in the results are unknown and therefore the accuracies of the calculated $V_m - x$ properties are also unknown.

To alleviate this problem we present a new, routine method to estimate φ using the petrographic microscope in conjunction with a spindle-stage. Inclusions in normal thick-sections are rotated stepwise and their projected areas and area-fractions are plotted against rotation angle. The resulting data arrays are systematically related to inclusion orientation, to inclusion shape, and to φ. The dependency on orientation is minimized when area fractions are measured at the position where the inclusions project their largest total areas. The shape dependency is accounted for using a new objective classification of inclusion projections, based on parameters from digital image processing. The method has been verified with synthetic fluid inclusions of known φ. For individual liquid + vapor inclusions with regular (not "negative-crystal") shapes, the new procedure yields φ with a relative accuracy of ±4%. This degree of accuracy permits $V_m - x$ properties of gas-bearing, aqueous fluid inclusions to be calculated with sufficient certainty for many geochemical applications. Even better accuracy (e.g., down to ±0.6%) can be obtained by combining results from several inclusions in the same homogeneously trapped petrographic assemblage.

Keywords: fluid inclusions, new technique, shape definition, spindle stage, fluid phase, volume fractions