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# Characterization of porosity in sulfide ore minerals: A USANS/SANS study

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## Abstract

Porosity plays a key role in the formation and alteration of sulfide ore minerals, yet our knowledge of the nature and formation of the residual pores is very limited. Herein, we report the application of ultra-small-angle neutron scattering and small-angle neutron scattering (USANS/SANS) to assess the porosity in five natural sulfide minerals (violarite, marcasite, pyrite, chalcopyrite, and bornite) possibly formed by hydrothermal mineral replacement reactions and two synthetic sulfide minerals (violarite and marcasite) prepared experimentally by mimicking natural hydrothermal conditions. USANS/SANS data showed very different pore size distributions for these minerals. Natural violarite and marcasite tend to possess less pores in the small size range (<100 nm) compared with their synthetic counterparts. This phenomenon is consistent with a higher degree of pore healing or diagenetic compaction experienced by the natural violarite and marcasite. Surprisingly, nanometer-sized (<20 nm) pores were revealed for a natural pyrite cube from La Rioga, Spain, and the sample has a pore volume fraction of ~7.7%. Both chalcopyrite and bornite from the massive sulfide assemblage of the Olympic Dam deposit in Roxby Downs, South Australia, were found to be porous with a similar pore volume fraction (~15%), but chalcopyrite tends to have a higher proportion of nanometer-size pores centered at ~4 nm while bornite tends to have a broader pore size distribution. The specific surface area is generally low for these minerals ranging from 0.94 to 6.28 $m^2/g$, and the surfaces are generally rough as surface fractal behavior was observed for all these minerals. This investigation has demonstrated that USANS/SANS is a very useful tool for analyzing porosity in ore minerals. We believe that with this quantified porosity information a deeper understanding of the complex fluid flow behavior within the porous minerals can be expected.

**Keywords:** SANS, USANS, sulfide ore minerals, porosity, mineral replacement reactions