

Surface area and porosity of primary silicate minerals

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ABSTRACT

Surface area is important in quantifying mineral-water reaction rates. Specific surface area (SSA) was measured to investigate controls on this parameter for several primary silicate minerals (PSM) used to estimate rates of weathering. The SSA measured by gas adsorption for a given particle size of relatively impurity-free, laboratory-ground samples generally increases in the order: quartz \approx olivine \approx albite $<$ oligoclase \approx bytownite $<$ hornblende \approx diopside. Reproducibility of BET SSA values range from $\pm 70\%$ (SSA $<$ 1000 cm²/g) to $\pm 5\%$ (SSA $>$ 4000 cm²/g) and values measured with N₂ were observed to be up to 50% larger than values measured with Kr. For laboratory-ground Amelia albite and San Carlos olivine, SSA can be calculated using log (SSA, cm²/g) = $b + m \log (d)$, where d = grain diameter (μ m), $b = 5.2 \pm 0.2$ and $m = -1.0 \pm 0.1$. A similar equation was previously published for laboratory-ground quartz. Some other samples showed SSA higher than predicted by these equations. In some cases, high SSA is attributed to significant second phase particulate content, but for other laboratory-ground samples, high SSA increased with observed hysteresis in the adsorption-desorption isotherms. Such hysteresis is consistent with the presence of pores with diameters in the range 2 to 50 nm (mesopores). In particular, porosity that contributes to BET-measured SSA is inferred for examples of laboratory-ground diopside, hornblende, and all compositions of plagioclase except albite, plus naturally weathered quartz, plagioclase, and potassium feldspar. Previous workers documented similar porosity in laboratory-ground potassium feldspar.

Surface area measured by gas adsorption may not be appropriate for extrapolation of interface-limited rates of dissolution of many silicates if internal surface is present and if it does not dissolve equivalently to external surface. In addition, the large errors associated in measuring SSA of coarse and/or impurity-containing silicates suggest that surface area-normalized kinetics in both field and laboratory systems will be difficult to estimate precisely. Quantification of the porosity in laboratory-ground and naturally weathered samples may help to alleviate some of the discrepancy between laboratory- and field-based estimates of weathering rate.