American Mineralogist, Volume 100, pages 1985–2000, 2015

FLUIDS IN THE CRUST

Chemical interactions between a sedimentary diapir and surrounding magma: Evidence from the Phepane Dome and Bushveld Complex, South Africa†

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Abstract

The Phepane Dome is a circular outcrop of metasedimentary rock within the Eastern Lobe of the Bushveld Complex hypothesized to have formed as a diapir, when underlying wallrock rose into the overlying magma body. Interactions between the metasedimentary rock of the Phepane Dome and the magma of the Bushveld Complex were investigated through measurements of oxygen and lithium isotopic compositions, determination of mineral modes and major-element mineral compositions, cathodoluminescence imaging, and dihedral angle analysis. Evidence from cathodoluminescence imaging and dihedral angle analysis suggest that heat transfer during diapirism caused partial melting and complete recrystallization of the Phepane Dome metasedimentary rock. Oxygen isotope analysis of samples from traverses spanning the contact between metasedimentary and igneous rocks demonstrates that relatively minimal exchange of oxygen (over distance ~4 m) occurred across the contact between the Phepane Dome and the surrounding Bushveld magma. The lithium concentrations and isotopic compositions of metasedimentary rock are significantly different from the associated igneous rocks. Lithium isotope analysis of samples from traverses across the contact demonstrates exchange of Li over somewhat greater distances (~60 m) than oxygen, consistent with evidence that suggests a higher diffusivity of Li than most major elements. Models of oxygen diffusion through intergranular melt and aqueous fluid are used to place maximum constraints on the duration of diffusive exchange across the contact, resulting in estimates ranging from 5 kyr to 5 Myr. These values are consistent with previous estimates of the duration of crystallization of the Bushveld Complex and Phepane diapir development.

Keywords: Lithium, lithium isotopes, oxygen isotopes, partial melt, aqueous fluid, diffusion, metamorphic petrology, igneous petrology