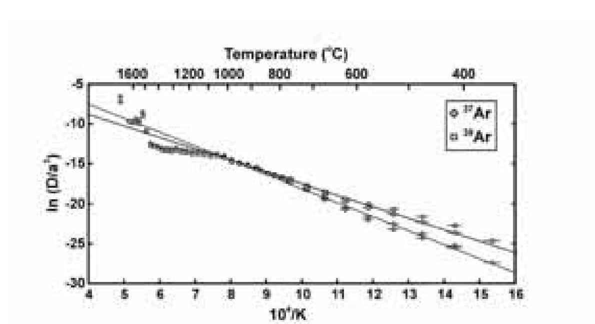
^{39}Ar and ^{37}Ar diffusion in plagioclase

W.S. CASSATA[1]*, P.R. RENNE[1,2] AND D.L. SHUSTER[2]

[1]University of California – Berkeley, CA 94720, USA (*correspondence: cassata@berkeley.edu)
[2]Berkeley Geochronology Center, Berkeley, CA 94720, USA (prenne@bgc.org, dshuster@bgc.org)

Despite being the most abundant mineral in the Earth's crust and one commonly used for $^{40}Ar/^{39}Ar$ geochronology, plagioclase has been little studied with respect to Ar diffusion kinetics. We present results of ^{39}Ar and ^{37}Ar diffusion experiments and $^{40}Ar/^{39}Ar$ geochronometry on intercumulus plagioclase from a gabbro in the Rustenburg Layered Series of the Bushveld Complex (BC). The plagioclase is relatively uniform compositionally, typically ranging from An_{60}-An_{70}. Age spectra are variably discordant, having profiles consistent with degassing of the 2.06 Ga BC by the ~1.3 Ga Pilanesberg Complex. Single ~400μm neutron-irradiated plagioclase crystals were wrapped in platinum packets and incrementally heated with a diode laser between 400 and 1600 °C. Temperature was controlled and monitored with an optical pyrometer, calibrated to ± 10°C (1σ). We calculated diffusion coefficients (D/a^2) from fractional release data assuming a spherical geometry. The calculated values yield ~linear arrays in Arrhenius plots. From least-squares regression of the low temperature values (<1000°C; the first ~10-20% of the total ^{37}Ar and ^{39}Ar released), we quantified the diffusion parameters E_a and D_o/a^2. Between 400 and 800 °C, $^{37}Ar_{Ca}$ and $^{39}Ar_K$ behave somewhat differently: $^{37}Ar_{Ca}$ has an apparently higher E_a (36-42 kcal/mol) than $^{39}Ar_K$ (27-40 kcal/mol). However, at higher T, the calculated coefficients D/a^2 for each isotope are equivalent, and both share the same apparent kinetic function.

Four experiments (one is shown below) with different heating schedules yield closure temperatures, T_C (calculated for dT/dt = 1000 °C/Ma), of 305-339°C and 214-319°C for $^{37}Ar_{Ca}$ and $^{39}Ar_K$, respectively. The $^{37}Ar_{Ca}/^{39}Ar_K$ spectra and microprobe data suggests that the lower T_C determined for $^{39}Ar_K$ may be an artifact of K-rich inclusions or exsolution lamellae, or grain-scale compositional zoning. We conclude that the $^{37}Ar_{Ca}$ results are more indicative of natural Ar diffusion in this plagioclase.



Primitive andesite magmas as restite-melt metatexitic systems from ascending cold diapirs

A. CASTRO[1]*, T. GERYA[2], I. MORENO-VENTAS[1]
C. FERNÁNDEZ[3] AND A. GARCÍA CASCO[4]

[1]Dpto. de Geología, U. de Huelva, 21071, Huelva, Spain (*correspondence: dorado@uhu.es)
[2]ETH Zurich, Switherland
[3]Dpto. de Geodinámica y Paleont., U. de Huelva, Spain
[4]Dpto. de Mineralogía y Petrología, U. de Granada, Spain

Primitive andesites are characterized by high silica contents (SiO2 > 54 wt.%) and Mg# > 60 according to Kelemen´s definition. Melting experiments from a mantle source, with water or not, only reproduce compositions of basaltic andesites and Mg-andesites, but they fail to produce melts with the composition of primitive andesites, A common feature of andesites is the disequilibrium found in the phenocryst assemblages for which a magma mixing origin is oftenly proposed. The most intriguing feature of andesites is that if they were derived by crystallization of a melt, an andesite melt, the conditions for generation require temperature of more than 1200 °C for lithospheric pressures. According to numerical experiments, temperatures of the order of 1000 °C and higher are reached in ascending cold diapirs composed of fertile subducted materials, oceanic crust and sediments. According to our experiemtnal results, these subducted mélanges are the more plausible source material for andesites: the average composition of a melange composed of approximately the same proportion of greywacke sediments and oceanic crust fairly match the whole composition of primitive andesites. However, the total melting of these sources for the production of an andesite liquid seems to be unlike in the core of mantle wedge plumes, because higher T are needed. The high content in phenocryst of andesites (20-40 vol.%) and the characteristic disequilibrium that these show with the groundmass, point to a restitic derivation for these phenocrysts, which may have been partially reequilibrated with the melt.

Our view, supported by laboratory experiments is that andesites may have been produced at relatively low temperatures of about 950 to 1100 °C at lithospheric pressures. These experiments fairly reproduce and andesite magma with 50% crystals and 50% melt. The phenocryst assemblage is fairly coincident with that of primitive andesites (Opx and Pl), The scenario of mantle wedge plumes is the most plausible for primitive andesite magma generation.