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ADDENDUM

Experimental partitioning of Sr and Ba in Kiglapait feldspars by S.A. Morse and J. Allaz (*American Mineralogist*, November-December, vol. 98, p. 2197–2200, 2013, Article DOI: http://dx.doi.org/10.2138/am.2013.4630. Addendum DOI: http://dx.doi.org/10.2138/am.2014.641).

This Addendum addresses the issue of retrieving liquid Sr compositions from the Sr content of natural feldspars. A partition coefficient defines the equilibrium between two phases. In igneous petrology the partitioning between crystals and liquid at the liquidus may be used to calculate fractionation during crystallization. The high values for strontium partitioning between feldspar and liquid in our paper are well suited to that purpose, but we found that the feldspar compositions would not suit for inverting them to liquid compositions. They gave results that were too rich in Sr, as shown in our Figure 4. We attributed that to an excess of Sr captured by the feldspars from the rocks. This idea was unnecessary. We show here the dilution effect that occurs with crystal growth, and find another route to inverting Sr in feldspar to liquid concentrations by simply using the natural feldspars compared to the experimental melts.

The experimental feldspars contain large amounts of Sr in small amounts of experimental feldspar, 1–60% crystals as complementary to the "% glass" listed in Table 1 of the original paper. Indeed, all but two of the entries have ≤30% feldspar. Mass balance is preserved when crystals grow in a closed system. If these crystals grew to nominal fractions of the whole rock, ranging from 75% at the start of crystallization to 63% at the end, their Sr content would be distributed over the larger mass of the crystals and would approximate the bulk composition of Sr in the rocks.

This proposition is easily tested in principle by simply dividing the experimental feldspar compositions by the fraction of oxygen-normative feldspar in the Kiglapait rocks, as modeled from whole-rock compositions. When this is done (Addendum Table 1 here), the diluted Sr contents of the bulk feldspars plot among or below the natural feldspars in Figure 1 here. The reductions are a bit excessive, but the principle is clear. The experimental feldspars have not scavenged Sr from other components but are rich in Sr simply because they are small in volume. Their partition coefficients (original Fig. 2) represent what one would use to describe the infinitesimal effect of plagioclase fractionation at the liquidus.

ADDENDUM TABLE 1. Sr data for Kiglapait feldspars and glass, inversion mode

Kl SplNo.	Sample Exp.	Gl%	Fsp%	X_{An} Fsp	Fsp% Rock	Sr Fsp ppm	Red. Sr Fsp	Sr Gl ppm	D(Sr) Fsp/Gl
na	Kl-1-1	70	30	0.678	75	711	533	434	1.23
na	Kl-39-1	89	11	0.559	74	673	498	398	1.25
na	2K-14-2	40	60	0.512	52	734	382	361	1.06
na	2K-14-3	71	29	0.507	51	707	361	373	0.97
na	2K-14-1	62	38	0.424	60	678	407	354	1.15
4079	KU-44-2	90	10	0.308	62	872	541	352	1.15
4083	KU-35-1	97	3	0.297	63	948	597	342	1.74
3381	KU-44-1	90	10	0.275	63	1074	677	306	2.21
4077	KU-35-3	99	1	0.145	63	675	425	103	4.11

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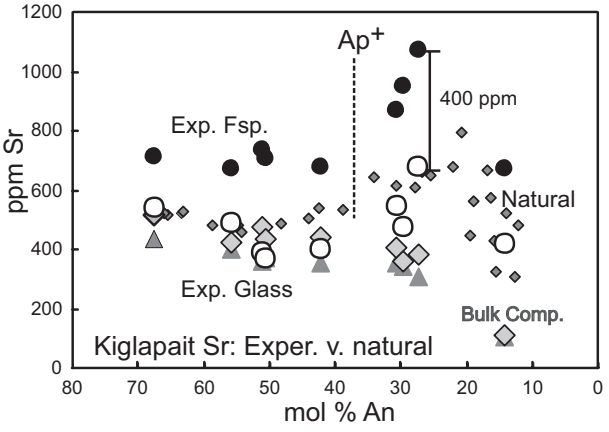
In practical application, the feldspar compositions can be inverted to liquid compositions by use of a reduced partition coefficient as suggested by Figure 1 and derived in Addendum Table 1 here. For this purpose the least loss of information will result if the natural feldspar compositions are simply ratioed to the experimental glass compositions. To do this, we describe the experimental glass compositions as a function of the An content of the crystals (listed in Morse 1982 and in Deposit Item Table 1[1] here). This is done in two equations:

$$Sr(glass) = 2.43*\%An + 256.8 \quad (An = 66–30)$$
$$Sr(glass) = 15.47*\%An + 120.43 \quad (An = 30–12)$$

[1] Deposit item AM-14-218, Supplementary Table 1. Deposit items are stored on the MSA web site and available via the American Mineralogist Table of Contents. Find the article in the table of contents at GSW (ammin.geoscienceworld.org) or MSA (www.minsocam.org), and then click on the deposit link.



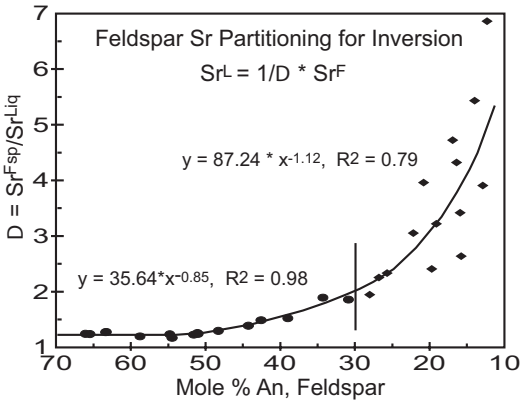
ADDENDUM FIGURE 1. Sr contents of experimental and natural Kiglapait feldspars. The experimental feldspars have approximately 200 ppm more Sr at high An (Lower Zone samples) and up to 400 ppm more after the arrival of apatite (Ap^+). The experimental glass compositions are shown as large gray triangles, illustrating that the material balance of Sr is nominally conserved; the large gray diamond symbols show the nominal bulk compositions calculated from the experimental feldspar and glass compositions. The white filled circles are the experimental feldspar compositions multiplied by the nominal fraction of feldspar in the rocks, obtained from a correlation of oxygen-normative feldspar in the model Kiglapait rocks with their An content (Table 1). They illustrate that the experimental feldspars have concentrated Sr levels owing to their small mass in the system. Fully grown feldspars in the solid rocks would have approximately the same mass of Sr distributed over a larger portion of feldspar. The larger differences between the *post-apatite group* and their natural samples are simply a result of their small feldspar volume (1–10%) in the experiments, and are essentially unrelated to the presence of apatite as suggested in the original paper.

Then the partition coefficients are formed as usual, D = Sr(fsp)/Sr(gl). These in turn are scaled to the plagioclase composition as shown in Figure 2 here. The results are best described in two equations as shown in the figure. As can be appreciated in Figure 1, at high An the natural feldspars are close to the glass compositions, yielding reduced D values near 1.2 in Fig. 2 instead of the full values near 1.8 of the original paper. They converge to 1.9 at An 30 and again rise steeply to D = 5.5 at An 12. By this exercise the natural plagioclase compositions in Sr can be inverted to liquid compositions, while the experimental values remain valid for fractionation at the liquidus.

References Cited

Morse, S.A. (1982) Kiglapait geochemistry V: Strontium. Geochimica et Cosmochimica Acta, 46, 223–234.

Morse, S.A., and Allaz, J. (2013) Experimental partitioning of Sr and Ba in Kiglapait feldspars. American Mineralogist, 98, 2197–2200.



Addendum Figure 2. Reduced partition coefficients for Sr in plagioclase based on the natural Sr concentrations in Kiglapait feldspars from Morse (1982) and the glass compositions of the experiments listed in Table 1 of Morse and Allaz (2013). The two equations shown can be used to convert the crystal compositions to their calculated parent liquids. The data for this diagram are listed in Supplementary Table 1 here.