Maas, R. 2003. Acid leaching of micas: improved Rb-Sr geochronology of disequilibrated rocks from zones of alteration and deformation.
Journal of the Virtual Explorer **13**, 81-82.

Acid leaching of micas: improved Rb-Sr geochronology of disequilibrated rocks from zones of alteration and deformation.

ROLAND MAAS[1]

[1]*School of Earth Sciences, University of Melbourne, Melbourne, 3010, Australia.*

Abstract: Rb-Sr dating of micas is commonly employed in reconnaissance geochronology of igneous and metamorphic rocks, and for dating fluid/rock interaction and deformation. High Rb/Sr-micas can be used to determine single mineral Rb-Sr model cooling ages, provided their $^{87}Sr/^{86}Sr$ is high enough to make the analysis insensitive to any errors in the choice of its initial $^{87}Sr/^{86}Sr$ (Sri). If the Rb/Sr ratio of the mica is low, e.g. due to low Rb or due to the presence of Sr-rich impurities, a second phase (host rock or another cogenetic mineral) is needed to constrain Sri. Problems may arise if the mica is not in isotopic equilibrium with other minerals in the rock, such as in ore-related alteration, in shear zones and skarns, in unequilibrated metamorphic assemblages, or in igneous rocks showing mineral disequilibria caused by magma mixing.

OVERVIEW

Initial experiments were done on biotite using a hot 1-hour leach step with 6M HCl, aimed at removal of soluble Sr carriers (e.g. apatite). Leaching with 2M HCl had previously proved beneficial in improving sample purity (and quality of Rb-Sr ages) of kimberlitic phlogopite contaminated with Sr-rich carbonate (Brown *et al.,* 1989). The biotites were from Phanerozoic granites, a Triassic phonolitic dike (rich in Sr), and a Precambrian granite gneiss. Somewhat unexpectedly, our leach solutions contained the bulk of the Rb and radiogenic ^{87}Sr (had very high Rb/Sr) while the residues had much lower Rb/Sr and unradiogenic Sr. This is the opposite of what would be expected if apatite or some other component rich in common Sr was leached out. The effect is reproducible and does not seem to depend strongly on grainsize or acid type (we tried 6M HCl and conc. aqua regia). Mass balance closely restores the Rb-Sr characteristics of the bulk biotite. In the Rb-Sr isochron plot, the leachate and residue fractions and the unleached biotite are always colinear as would be expected in a simple unmixing scenario and in the absence of leaching artifacts. Ages derived from these unmixing lines are very precise due to the increased dispersion in Rb/Sr and are identical within error to the known or inferred ages of their host rocks.

The co-leaching of Rb and radiogenic ^{87}Sr suggests removal of these components from the interlayer sites where Rb proxies for K. Most of our biotites were low in ^{86}Sr, indicating that Sr-rich impurities were unimportant. In biotites with significant Sr-rich impurities, the dissolution of soluble Sr carriers would compete with the interlayer effect, by adding common Sr to the leach solution. This was observed for the phonolitic biotite which is riddled with Sr-apatite inclusions. Chemical analyses of leach solutions indicate significant quantities of Fe and Mg from the octahedral sites are also leached from the biotite, depending on leach duration and acid strength. However, even where weight loss from biotite during leaching reaches 50% (after 3 hours with hot 6M HCl, grainsize ca. 300 micrometers), the radiogenic, high Rb-Sr signature of the leachate remains. Further work is underway (SEM, chemical and isotopic) and will be reported.

Leaching experiments on muscovite were less successful. Only one of 4 leaching experiments achieved a useful separation of common-radiogenic Sr. In this particular experiment (a paragneiss from Papua New Guinea with Miocene metamorphic cooling age), a 1-hour leach removed small (1%) amounts of Rb and ^{87}Sr from the muscovite, but the pattern of radiogenic leachate vs unradiogenic residue remained. The three muscovite data points (unleached, residue, leachate) define an age of 18.9±0.1 Ma, well within the range of $^{40}Ar/^{39}Ar$ muscovite ages of 16-20 Ma for this and other rocks of the area. By contrast, the conventional muscovite-whole rock age is 23.1±0.7 Ma. The discrepancy suggests some isotopic diseqilibrium in this complex polymetamorphic rock. The sluggish dissolution behaviour of muscovite is known from other dissolution studies and we estimate that at least 102 longer leach times will be required to achieve material loss rates similar to those observed for biotite.

In summary, this study documents a somewhat unexpected but systematic unmixing behaviour with quantitative co- leaching of Rb and correlated ^{87}Sr from the interlayer sites of acid-leached micas. Leachates tend to be considerably higher in Rb/Sr than in the unleached mica. The resulting (residue-leachate) unmixing lines in the Rb- Sr isochron diagram appear to have age significance, at least in the rocks we have studied and where this can be verified confidently. Significantly, this suggests that biotite, and perhaps also muscovite, may be used to produce single-mineral isochron ages, analogous to the single-mineral Pb-Pb isochron ages produced by step-leaching (Frei & Kamber, 1995; Berger & Braun, 1997). The ability to do this would be most valuable in disequilibrium situations such as those mentioned above, where mica can not be assumed to be in isotopic equilibrium with other phases and/or the whole rock, or where several generations of mica exist. Modern techniques, which allow as little as 1 ng Sr or less to be analysed with adequate precision (Miller *et al.,* 1998), would enable single mica flakes to be dated individually, using the residue-leachate two-point isochron method. While single-flake Rb-Sr dating of mica is not new (Cliff, 1994), the method has the advantage that it could be applied even to low-Rb/Sr mica flakes without the need for regression with other, perhaps unequilibrated, phases.

APPLICATIONS

The technique described above was used to date constrain a period of pan-African intraplate deformation in eastern Antarctica (Boger *et al.,* 2002). Another application illustrating the technique was from the shear zone in coasteal exposures of the Gawler Craton.

REFERENCES

Frei R. & Kamber B.S., 1995, Single mineral Pb-Pb dating. Earth Planet. Sci. Lett., 129, 261-268

Frei R. *et al.*, 1996, Single mineral dating by the step-leaching method: Assessing the mechanisms. Geochim. Cosmochim. Acta 61, 393-414.

Berger M. & Braun I., 1997, Pb-Pb dating of apatite by a stepwise dissolution technique. Chem. Geol. 142, 23-40

Brown et al., 1989, Improved precision of Rb-Sr dating of kimberlitic micas: An assessment of a leaching technique. Chem. Geol. 79, 125-136

Davis W.J. & Kjarsgaard B.A., 1997, A Rb-Sr isochron age for a kimberlite from the recently discovered Lac de Gras Field, Slave Province, Northwest Canada. J. Geol. 105: 503-509

Müller *et al.*, 1998, Dating deformation using microsampling techniques. EOS 79, F951

Cliff R.A., 1994, Rb-Sr dating of white mica – new potential in metamorphic geochronology. ICOG 8 Abstracts, USGS Circular 1107, 62

Boger SD *et al.*, 2002, Pan-African intraplate deformation in the northern Prince Charles Mountains, east Antarctica. Earth Planetary Science Letters 195: 195-210.