Goldschmidt 2000
September 3rd–8th, 2000
Oxford, UK.

Journal of Conference Abstracts
Volume 5(2), 586

Fluorite and Fluids: Late Magmatic Radiogenic Behaviour in the Acid Phase of the Bushveld Complex

Judith Kinnaird (065jak@cosmos.wits.ac.za)[1], **F. Johan Kruger**[2] & **R. Grant Cawthorn**[1]

[1] Department of Geology, University of the Witwatersrand, Private Bag 3, 2050 WITS, South Africa
[2] Hugh Allsopp Laboratories, University of the Witwatersrand, Private Bag 3, 2050 WITS, South Africa

The Lebowa Granite Suite of the Bushveld Complex is a differentiated sheeted intrusion between 1.5 and 3.5 km thick and with an areal extent of some 350 x 250 km, which was emplaced at a depth of 5 km. The granite suite and the Rooiberg acid volcanics are near coeval with the mafic Layered Suite all being dated within 2057 ±3 (Kruger et al., 1987). Despite this emplacement age, a compilation of age dates show apparent ages for the granite suite from 2100 to 950 Ma (Robb et. al., 2000). Walraven et al (1990) found variable model ages typically between 918 and 1600 Ma for mineralised Zaaiplaats granite, which they ascribed to radiogenic Sr loss from feldspars due to late-stage hydrothermal fluids lowering the apparent Rb-Sr whole-rock ages. To investigate the isotope systematics and possible sources of the acid volcanics and granitic rocks, Rb-Sr and Sm-Nd analyses of fluorite from a number of different localities has been undertaken. Fluorite occurs in several styles of deposit.

(a) as centimetre size concentrations in pegmatitic pods and miarolitic cavities associated with Sn mineralisation in the roof facies of granite (Zaaiplaats); (b) as disseminations in reddened roof facies of granite (Spoedwel and Zaaiplaats); (c) in stockworks in Rooiberg felsic volcanics (Zwartkloof), and meta-sedimentary xenoliths in granite (Buffalo); and (d) as massive, disseminated or veined material in volcanic pipes cutting volcanics (Vergenoeg) and granite (Houtenbek).

The fluorite from these different styles of deposits was investigated to constrain the initial Sr ratio for the granites. Since fluorite has low Rb/Sr ratios, the $^{87}Sr/^{86}Sr$ of the fluid from which it crystallised can be determined more precisely. Sr concentrations range from 3 to 100 ppm, Rb values are consistently low from 0.3 to 2.36 ppm with Rb/Sr ratios between 0.003 and 0.18.

The disseminated fluorite and that which occurs in stockworks and volcanic pipes is regarded as magmatic in origin, where hydrothermal fluid was not retained. These fluorites have variable but low $^{87}Rb/^{86}Sr$, low $^{87}Sr/^{86}Sr$ (Figure 1.b), moderate Nd (c.100 ppm), a relatively restricted range of $^{147}Sm/^{144}Nd$ and $^{143}Nd/^{144}Nd$. The lowest initial ratio at 2050 Ma of 0.7168 ±1 obtained for the deposit at Zwartkloof in felsic volcanics is similar to that obtained on granite-hosted fluorite samples.

In contrast, for the pegmatitic type, $^{87}Rb/^{86}Sr$ is low, $^{87}Sr/^{86}Sr$ is high, with low Nd (<5 ppm) and a variable range of $^{147}Sm/^{144}Nd$, $^{143}Nd/^{144}Nd$ and Sr initial ratios. In particular, one sample of a miarolitic cavity from Zaaiplaats, shows an extreme range of Sr initial ratios varying from 0.7199 to 0.8409 and $^{147}Sm/^{144}Nd$ ratios from 0.0114 to 0.2854 for different colours of fluorite. Associated late calcite shows even more elevated $^{87}Sr/^{86}Sr$ and variable $^{87}Rb/^{86}Sr$. Such high $^{87}Sr/^{86}Sr$ initial ratios cannot be due to inclusions of a potassic phase, such as biotite or feldspar since pure grains of fluorite were hand-picked for analysis. It is possible that some enhancement of ^{87}Sr growth by ^{86}Rb decay in high Rb/Sr residual melts during a long crystallisation time span has occurred based on equations in MacCarthy and Cawthorn (1980). However, the more likely cause is that the fluorite formed from an exsolved high Rb/Sr fluid phase at high temperature, or that the $^{87}Sr/^{86}Sr$ ratio recorded at the magmatic stage was re-set by this fluid, which was retained within the cooling pluton over a long period of time.

Fluorite which has formed from fluids which interacted with the felsic volcanics (types c and d) has Sr initial ratios which are comparable to those for granite-hosted fluorite. It is therefore concluded that both granite and felsic volcanics have similar initial ratios of c. 0.72. Late stage mineral assemblages with anomalously high and variable initial ratios resulted from gaining the ^{87}Sr lost from feldspar, during prolonged rock-fluid interaction.

Journal of Conference Abstracts
Volume 5(2), 587

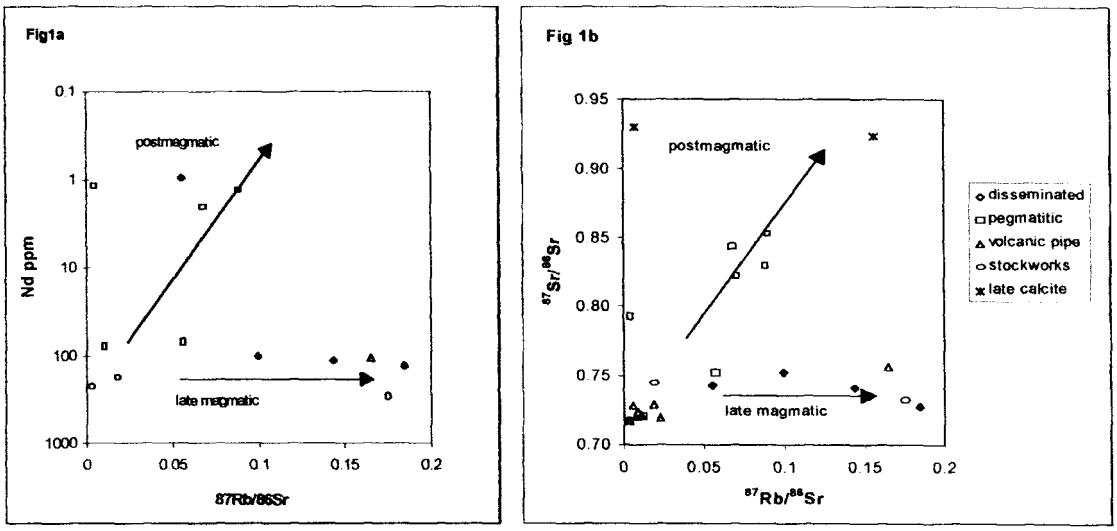

Figure 1: $^{87}Rb/^{86}Sr$ ratios for fluorite samples from the Bushveld Complex (a) plotted against Nd abundance in ppm; and (b) plotted against $^{87}Sr/^{86}Sr$, showing late magmatic trends where fluids were lost and post-magmatic trends where fluids were retained to lower temperatures. Symbols are the same in both plots

Kruger FJ, Cawthorn RG & Walsh, K.L 1987, *Earth and Planetary Science Letters*, **84**, 51-58, (1987).

MacCarthy TS & Cawthorn RG, *Journal of Petrology*, **21,2**, 254-264, (1980).

Robb LJ, Freeman LA & Armstrong RA, *Transactions of the Royal Society of Edinburgh: Earth Sciences. The fourth Hutton symposium on the origin of granites and related rocks.*, **in prep**, (2000).

Walraven F, Strydom JH & Strydom N, *South Africa. Journal of Geochemical Exploration*, **37**, 333-350, (1990).