ALTERATION IN ARCHEAN ANORTHOSITE COMPLEXES; D. A. Morrison, Johnson Space Center; L. Haskin and Qiu Y.-Zh., Department of Earth and Planetary Sciences, Washington University, St. Louis; W. C. Phinney, Johnson Space Center; D. Maczuga, LEMSCO, Houston.

Anorthositic rocks composed of equant plagioclase megacrysts, typically of An80 composition, are common in Archean terrains where they are associated with mafic intrusives and supracrustals (1). In all of the occurrences, the megacrysts are altered to varying degrees, and primary trace and minor element compositions have been modified. We have analyzed plagioclase megacrysts from the Bad Vermilion Lake complex (2) in an attempt to remove the affects of alteration and to determine their primary rare earth composition.

The Bad Vermilion Lake anorthosite complex (2) is a spectacular representative of Archean plagioclase cumulates. It is located on the Minnesota-Ontario border about 80 km east of International Falls, Minn. The complex is 30 km long, 6 km thick at the thickest, and consists of over 100 km^2 of anorthosite, gabbroic anorthosite and gabbros. The anorthosite fraction of the complex extends the full 30 km of the intrusion, and is as much as 5 km thick, probably as a consequence of tectonic thickening. Relatively undisturbed sections of anorthosite total about 2 km across strike.

The complex has been extensively altered to greenschist facies mineralogies. Megacrysts have been altered to assemblages of epidote group minerals, minor amphiboles and accessory calcite and white mica. Matrix mineralogies consist of amphiboles, chlorite, calcite, quartz and sodic plagioclase. Some megacrysts have rims, distinct in both outcrop and thin section, which form a small fraction of the total megacryst volume. The megacrysts are An79 to 83 and homogeneous in An content (2), exclusive of rims.

Individual megacrysts and associated matrix material from four localities representing the least altered parts of the intrusion were analyzed by neutron activation.

The samples were slabbed and the least altered megacrysts selected for analysis. These megacrysts were then slabbed to produce several samples per megacryst. The slabs of the megacrysts were broken and four different samples representing varying degrees of alteration were taken from each by hand-picking. An content and FeO wt% of apparently unaltered plagioclases were measured by microprobe.

Typical results are shown in Fig. 1. Alteration increases heavy rare earths relative to the lights, producing a positive slope in some cases. Yb concentrations are increased sharply in more altered samples but Tb concentrations decrease in several samples. The light rare earths are increased modestly and their slope decreases. The Sm to Eu ratio tends to decrease. Sm appears to be least effected by alteration. FeO and Sc increase whereas Na2O of the megacrysts decreases or remains constant. Whole crystal samples generally fall between the most altered and least altered aliquots of each sample set, but there are exceptions, particularly in the case of Tb. Samples of rims of megacrysts have higher rare earth contents, with one exception, and less systematic relationships than interior samples. Two samples of matrix plagioclases are comparable in rare earth content to the most altered fraction of the associated megacrysts.

The variations observed are broadly correlative with FeO and Sc. However, two element plots of FeO versus the rare earths show that there is considerable diversity between megacrysts from the same hand sample and between samples of the same megacryst. Individual megacrysts form 3-point arrays as shown in Fig. 2, and the arrays form a fan-shaped distribution. Megacrysts from the same rock do not fall on the same line. Some arrays are non-linear reflecting large increases in FeO or Sc with no correlative increase in rare earths. The linear arrays tend to converge to common values of the rare earths at the level of FeO determined by probe to be indigenous, but they differ by as much as a factor of two in their intercept values. Plots of Sc versus rare earths have less scatter but show the same inconsistencies as FeO versus rare earths. These data show that the alteration process behaves in a manner analogous to igneous processes. The alteration assemblage redistributes rare earths according to the bulk distribution coefficient of the assemblage, which changes significantly from place to place within megacrysts and between megacrysts. Recovering the initial rare earth contents of altered plagioclase requires multiple samples.

Although imperfect, the correlations observed allow some estimate of the indigenous rare concentrations of the megacrysts to be made. If treated as indigenous, the concentrations, when referred to the distribution coefficients of McKay (3) indicate that the parent liquid of the megacrysts was light rare earth depleted, and basaltic (Fig. 1). Three of the four localities analyzed, representing more than a km of section, have similar rare earth and FeO concentrations in their megacrysts. The fourth, stratigraphically lower in the section, has megacrysts with somewhat higher rare earths but anomalously lower FeO (0.4%).

1.) Phinney W.C.(1982) LPI Tech Rept., 82-01, Lunar and Planetary Institute, Houston. (2.) Ashwal L.D.,Morrison D.A., Phinney W.C. and Wood J. (1983), Cont. Minerl and Petrol., 82, p. 259-273. (3.) McKay G.(1982) Lunar and Planet. Sci. Conf. XIII, Lunar and Planetary Institute, Houston.

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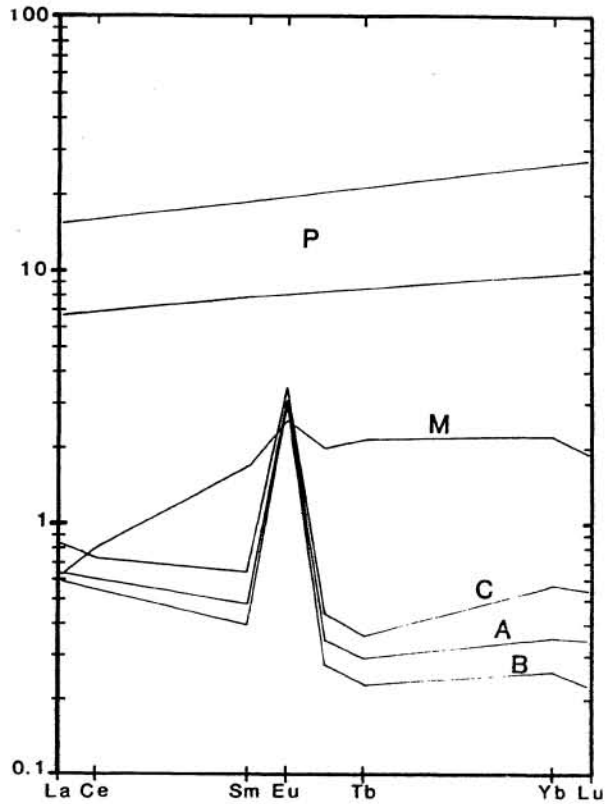

Fig. 1. Typical rare earth patterns from altered megacrysts. A = whole crystal, B = least altered, C = most altered, M = matrix, P = possible range for equilibrium liquids.

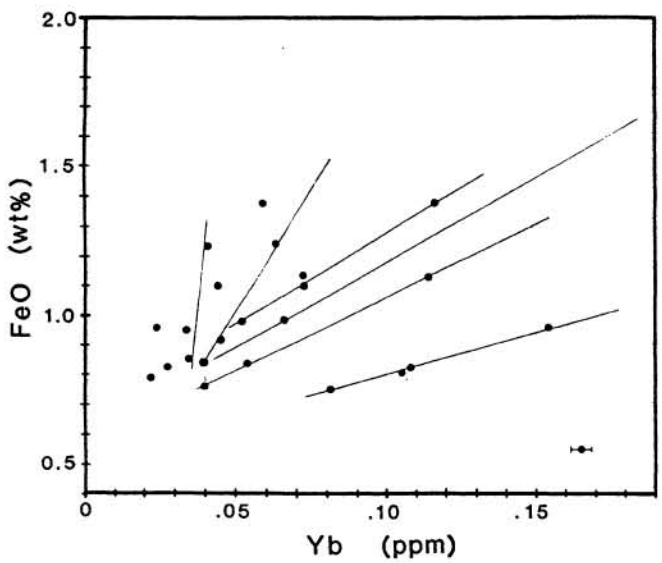

Fig. 2. FeO vs. Yb. Lines correspond to individual megacrysts. Initial FeO in the megacrysts is 0.6%. The lower array corresponds to 3 megacrysts with lower FeO but higher rare earths.

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