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RARE-EARTH ABUNDANCES IN AN ANORTHOSITE AND A MANGERITE

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The association in Precambrian areas of anorthosite and mangerite is well known. At the present time, however, there is considerable controversy concerning the consanguinity of these rock-types. The problem has been reviewed recently by Philpotts (1). Because trace element variations might be particularly illuminating, we are studying rare-earth abundances in anorthosite associations. This preliminary note reports determinations of these elements in an anorthosite sample from Tchitogama Lake, Quebec, and in a quartz-mangerite sample (Analysis 9 (1)) from Grenville Township, Quebec.

The rare-earth analyses were performed by mass-spectrometric stable-isotope dilution (2). The technique consists of dissolving the sample, adding isotopic "spikes" of the rare-earth elements, and concentrating the rare-earths by passing the solution through an ion exchange column. No attempt was made to separate the rare-earths from each other or from other elements with similar partition coefficients. A triple-filament, solid-source mass-spectrometer was used in the isotopic analysis.

The results of the rare-earth analyses are given in Table 1. The precisions ($\bar{\sigma}$) shown are only internal in that they are the standard deviation of the mean of the number of determinations (n), each determination being calculated from two scans of the appropriate mass region. The data have been normalized to hypothetical chondritic abundances based on a comparison of neutron-activation analyses of rare-earths in eucritic meteorites by Schmitt _et al_. (3,4) with our unpublished analyses. These "chondrite" normalized abundances of the rare-earths in the anorthosite and the mangerite are shown in Fig. 1, the error bars being plus and minus two standard deviations of the mean.

The anorthosite has a "chondrite" normalized rare-earth pattern of the non-inflexional, fractionated type expected for a log-liquid (5), that is, a liquid derived from material with a non-inflexional pattern by extreme fractional crystallization of a solid for which the partition coefficients differ regularly by a constant amount throughout the rare-earth group. The log-liquid pattern is of interest in view of Buddington's (6) hypothesis of an anorthositic melt. However, no material, terrestrial or meteoritic, has yet been found with rare-earth abundances appropriate to either the residual solid or the parent for such a log-liquid anorthosite. It therefore seems more probable that the anorthosite is a crystal cumulate.

The anorthosite is composed largely (>90%) of plagioclase (An_{51}) and hence its rare-earth pattern is presumeably dominated by the plagioclase contribution. In support of this, the europium anomaly, undoubtedly caused by the presence of Eu^{+2}, is almost identical to that for plagioclase (An_{55}) from the San Marcos gabbro (7). Published data (7) and our own unpublished results indicate that the relative abundances of the heavy rare-earths are about the same in a whole-rock as in the constituent plagioclase. It therefore seems probably that the same relationship would hold between melt and plagioclase phenocrysts. If this is the case, then the anorthosite represents a crystal cumulate from a melt with a non-inflexional, fractionated type of rare-earth pattern. A pattern for such a melt is shown in Fig. 1. It was obtained by applying the rare-earth partition coefficients between the whole-rock San Marcos gabbro and its constituent plagioclase to the rare-earth abundances in the anorthosite. Although the absolute abundances of the rare-earths in this calculated melt are almost certainly wrong, the relative abundances may not be too much in error. Available data (8) indicate that igneous rocks with such patterns are quite rare.

Most igneous rocks display patterns with low slopes for the heavy rare-earths, and many have inflexions in the region of gadolinium. However, there are continental rocks (e.g., Columbia Plateau tholeiite (4)), oceanic rocks (e.g., Kilauea Iki-22 basalt (3)), and meteorites (Nakhlites (4)) which would seem to have suitable patterns to be parental melts from which the anorthosite could have accumulated.

The rare-earth pattern of the mangerite is shown in Fig. 1. The pattern is of the inflexional type typical of most sedimentary rocks (8). A North American shale composite (8) is shown for comparison. Carlsbad twins in the feldspars and basal exsolution lamellae in the inverted pigeonite, both indicate, however, that the mangerite is clearly of igneous origin (1). The large europium anomaly in the anorthosite and the lack of an anomaly in the mangerite indicate that a direct genetic relationship between such rock-types is unlikely, as does the dissimilarity in the overall rare-earth patterns. Mangerite and anorthosite might belong, therefore, to separate igneous suites as suggested by Buddington (6). If they are cogenetic, then considerable assimilation of rocks with "normal" europium abundances could explain both the lack of an anomaly in the mangerite and the dissimilarity in rare-earth patterns; such a relationship has been suggested by Philpotts (1).

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TABLE 1

Rare Earth Abundances in an Anorthosite and a Mangerite

	Anorthosite				Mangerite			
	ppm	$\bar{\sigma}$	n	"Chondrite" Normalized	ppm	$\bar{\sigma}$	n	"Chondrite" Normalized
Ce	4.3	0.4	4	5.5	-	-	-	-
Nd	2.16	0.04	8	3.31	50.1	0.20	8	76.8
Sm	0.35	0.009	5	1.67	10.8	0.21	12	52.1
Eu	0.65	-	2	9.17	2.85	0.19	4	40.1
Gd	0.29	-	2	1.13	-	-	-	-
Dy	0.16	0.013	6	0.54	8.54	0.08	4	28.2
Er	-	-	-	-	5.05	0.05	4	27.8
Yb	0.023	0.002	6	0.122	4.81	0.06	6	25.6

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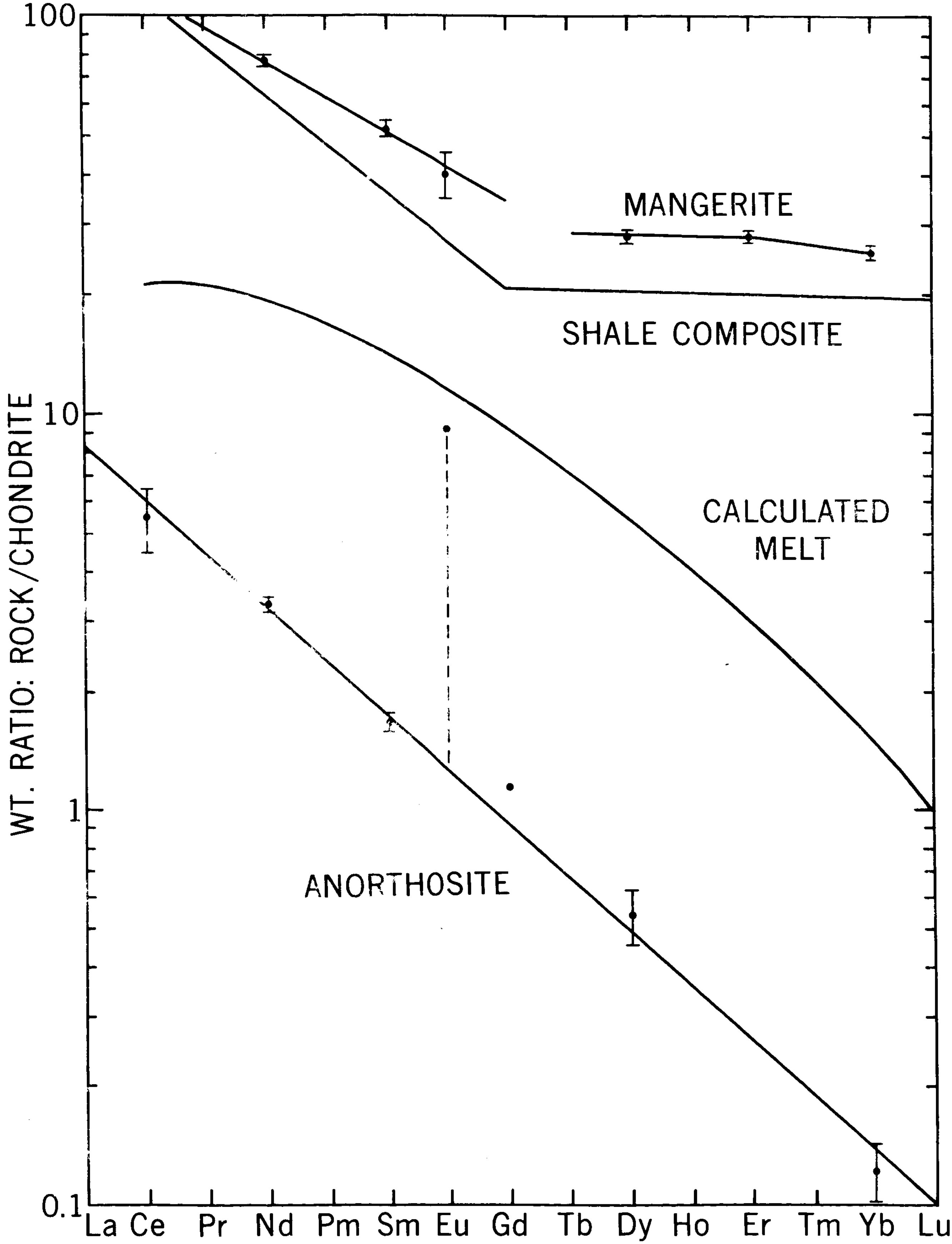
FIGURE CAPTIONS

Figure 1 Chondrite-normalized rare-earth abundances in an anorthosite, a mangerite, a calculated melt, and a North-American shale composite.



100
10
1
0.1
WT. RATIO: ROCK/CHONDRITE
MANGERITE
SHALE COMPOSITE
CALCULATED
MELT
ANORTHOSITE
La Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb Lu