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PETROGENESIS OF CALCIC PLAGIOCLASE MEGACRYSTS IN ARCHEAN ROCKS;

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Anorthositic complexes with large (up to 20 cm across) equidimensional plagioclase grains of highly calcic composition (An₈₀₋₉₀) occur in nearly all Archean cratons. Similar plagioclase occurs as megacrysts in many Archean sills, dikes, and volcanic flows. In the Canadian Shield these units occur throughout the Archean portions of the entire shield and are particularly common as dikes over an area of a few 100,000 km² in Ontario and Manitoba during a period of at least 100 my (between 2.6 and 2.8 by) in many different rock types and metamorphic grades. In Ontario megacrysts occur in the Matachewan dikes (1) which intrude tonalitic gneisses, greenstones, and granites. In Manitoba low grade greenstone belts that contain anorthosites can be traced into equivalent units in high grade granulite terrain that contains similar anorthosite (2). In addition, large inclusions of anorthosites of potentially Archean age occur in younger Precambrian intrusions of northeastern Minnesota and central Wisconsin (3). In summary, these occurrences indicate a common, widespread, long-term igneous process in the Archean at crustal to sub-crustal levels.

Because the anorthositic complexes are clearly crystal segregations and the megacrysts in the sills, dikes, and flows are generally not in equilibrium with their matrices, the nature of the melt from which the calcic plagioclase formed has remained elusive. Attempts to determine the melt composition through REE distribution coefficients are hindered by the fact that REE concentrations, especially the heavy REE, are quite low in plagioclase and may be significantly enriched (see Fig. 1) by alteration, contamination, and recrystallization, all of which are common in Archean anorthosites. For the very few megacrysts that appear relatively fresh and from attempts to subtract contaminants or alteration from suites of plagioclase, the most recent REE distribution coefficients for plagioclase-basalt equilibrium indicate a parent melt with a somewhat light depleted REE pattern at about 10-20X chondrites, similar to the range of REE patterns of the less fractionated tholeiites in Archean greenstone belts. In essentially all intrusive anorthositic complexes the original mafic material has been completely, or almost completely, recrystallized generally to amphiboles or mixtures of amphibole and chlorite thereby eliminating any opportunity to use distribution coefficients with any mineral other than plagioclase.

The plagioclase generally occurs in three modes: as inclusions in mafic intrusions at various stages of fractionation (4), as crystal segregations in anorthosite complexes (5), or as megacrysts in fractionated sills, dikes, and flows (6). Most occurrences suggest that the plagioclase was formed elsewhere before being transported to its present location. Generally, the large plagioclase grains are quite uniform in composition at An₈₀ to An₈₅, although individual grains may differ in a single thin section. However, in many dikes, sills, and flows there are many grains with very thin rims of a much lower An content approaching that of the matrix plagioclase (see Table 1). This relationship holds regardless of the grain size of the matrix whether it be very fine-grained basalt or medium-grained gabbro. In the Bird River area of SE Manitoba An₈₅ megacrysts occur in matrices that are coarse-grained and contain homogeneous plagioclase that may be An₃₅ in one unit and An₈₅ in another. In a few of the occurrences, however, the bulk of the large plagioclase grains may be homogeneous at An₈₀ to An₈₅ but their outer rims are complexly zoned. In the Bird River area there are discrete steps in the zoning

of these outer rims with the steps being at An 73-75, An55-57, An38-40, and An23-25. The number and sequence of steps varies from grain to grain, even between adjacent grains, thereby suggesting a complex set of infusions of interstitial melt or significant stepwise changes in fugacities of volatiles.

The evidence seems to be quite clear that occurrences of these types of calcic plagioclases require: 1) ponding of a relatively undifferentiated Archean tholeiitic melt at some depth, 2) isothermal crystallization of large, equidimensional homogeneous plagioclase crystals, 3) separation of the plagioclase crystals from any other crystalline phases, 4) further fractionation of melt, 5) transport of various combinations of individual plagioclase crystals and clusters of crystals by variously fractionated melts, and 6) emplacement as various types of igneous intrusions or flows. It is quite possible that intrusions of this type could deposit their plagioclase crystals as anorthosite while most of the melt continues to shallower or surface levels or, alternatively, the melt could crystallize as gabbros amongst the previously formed plagioclase to form an anorthositic complex.

The major remaining question is the location of plagioclase crystal formation when the melt is first ponded. The most likely location for ponding is at a density barrier that could trap rising melts in a stratified density sequence. Such possible density barriers could occur at the crust-mantle boundary or at changes in metamorphic mineral assemblages in the lower crust. As the ponded melt cools and crystallizes, the high density mafic phases would sink to become parts of the uppermost mantle or lower crust and the lower density plagioclase, being less dense than essentially all mafic melts at these depths, would float or remain in suspension in the melt. As the melt density decreased during differentiation, or fractures developed from tensional stresses during doming, rifting, or other tectonic processes, the melts would rise with entrained plagioclase as crystals, clots, or anorthosite fragments to form flows, sills, or dikes containing megacrysts, complexes of anorthositic rocks, or inclusions of anorthosite.

References

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Table 1

Matachewan Dikes: Plag. Compositions

LOCATION	CRYSTS			MATRIX LATHS	
	main cryst	inner rim	outer rim	core	rim
Sta 8	An79-81	An56	An42-49	An61-64	An47
9-11	80-82	66-69	54	65-69	54
10	75-78	61-62	54	58-61	45-50
16	81-84		62-67	68-70	52-53
16	82-84		64-65	64-66	46-53
16	83-85		72-76	71-72	66-69
18	Too Altered			50-54	33
34	81-83			No laths	
35	81-83		78-80	61-63	51-54

UTIK LAKE

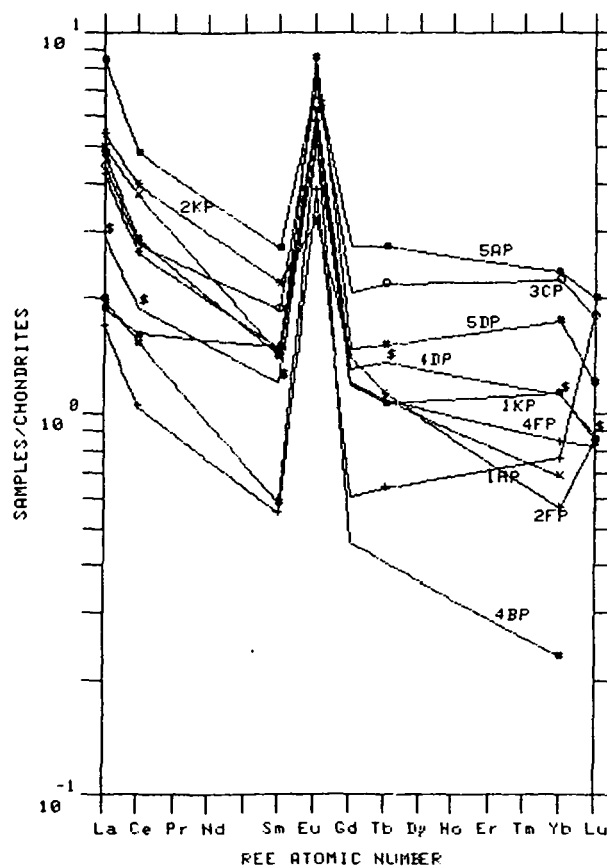


Figure 1. REE patterns for plagioclase megacrysts from flows and sills at Utik Lake, Manitoba.