Large (up to 20 cm), equidimensional, commonly euhedral, plagioclase mega-
crysts of highly calcic composition (An$_{80-90}$) occur commonly in all Archean
cratons in one or more of three distinct associations:
1) as cumulate crystal segregations of anorthosite or as megacrysts in basalt-
 tic dikes, sills, and flows in greenstone belts that vary in metamorphic grade
from greenschist to granulite. Throughout 100's of thousands of square kilo-
meters of northwestern Ontario and Manitoba the plagioclase megacrysts occur
in pillowed and massive flows, sills, dikes, large inclusions in dikes, and
intrusive anorthositic complexes (Fig. 1) with areas of up to a few 100 km$^2$
and spanning a period of at least 100 m.y. in the 2.7 to 2.8 b.y. time frame,
2) as basaltic dike swarms in stable cratonic areas forming parallel to sub-
parallel patterns over hundreds of thousands of square kilometers intruding
both granitic gneisses and supracrustal belts including greenstones. These
swarms include the Ameralik-Saglek system at 3.1 to 3.4 b.y. (Fig. 2) [1], the
Matachewan system at 2.5 to 2.6 b.y. [2], and the Beartooth-Bighorn system at
2.2 to 2.3 b.y. [3], and
3) as anorthositic complexes associated with marbles and quartzites (Sittam-
pundi, India and Messina, South Africa) in granulite grade terrains.

Initial attempts to correlate tectonic settings of similar modern cryst-
bearing units with their Archean counterparts were only partially successful.
Plagioclase phenocrysts of An$_{80-90}$ occur in basaltic volcanic flows in oceanic
crust at spreading ridges, hotspots, aseismic ridgets, and fracture zones [4].
These recent occurrences, however, normally involve only small phenocrysts up
to a few millimeters in size and usually more lathy than equidimensional in
shape [5]. In contrast to these normal occurrences, volcanic flows over the
Galapagos hotspot display more equidimensional crystals up to 3 cm across [4].
Although these oceanic environments might be satisfactory tectonic analogs for
many greenstone occurrences, they certainly are not satisfactory for the exten-
sive dike swarms in stable cratonic masses. Thus we turn for clues to a more
detailed understanding of the petrogenesis of the crystals and related melts.

The crystals are quite homogeneous, varying by little more than one to two
An units over several centimeters thereby suggesting nearly isothermal crystal-
lization at nearly constant melt composition over the time required to grow
crystals commonly 6 to 8 cm across and up to 20 cm across and accumulate them
in large masses. Thin, more sodic rims on the order of 100 to 200 µm wide are
common on large crystals when the groundmass plagioclase laths are more sodic
than the large crystals. The rims normally approach the composition of the
plagioclase in the groundmass (Table 1).

The nature of the parent melts, or melts in equilibrium with the large
crystals, has been an open question because: 1) the anorthositic complexes are
clearly cumulates with bulk compositions too rich in Al$_2$O$_3$ and CaO to repres-
ent melts [6], and 2) the disparity in composition between plagioclase crystals
and plagioclase of the matrix suggests a lack of equilibrium between crystals
and the melt represented by their matrix.

Initial attempts to determine melt compositions by use of REE concentra-
tions in megacrysts in conjunction with distribution coefficients for plagio-
clase and basaltic melts were fraught with problems resulting from modification
of plagioclase REE concentrations by alteration, recrystallization, and
tiny inclusions. By utilizing several splits from each crystal in several
samples from the BVL anorthosite, mixing lines were determined and the least
modified REE concentrations were calculated for pristine plagioclases [7]. These values in conjunction with the most recent distribution coefficients indicate melts with nearly flat REE patterns at 10X to 20X chondrites with perhaps a slight depletion in the light REE's. The calculated patterns compare well with several crystal-bearing basalts in greenstone belts (Fig. 3) as well as with the non-crystal-bearing basalts. These patterns are those of the least enriched tholeiitic basalts which are very common in greenstone belts. Comparison of these basalts with those in the cratonic dike swarms shows many similarities (Fig. 3, Table 2) but the initial data suggests that the crystal dikes are slightly enriched in SiO₂, K₂O, and light REE. It is tempting to attribute these differences to contamination of the melts as they rise through continental crust but the melts of the Galapagos when compared with MORB show some of the same enrichments (Table 2) which in this case cannot be attributed to continental contaminants. Further work on the pristine REE contents of plagioclase megacrysts is underway and should help determine whether megacrysts in enriched melts formed from the more enriched or less enriched tholeiitic melts, or both.

At present the petrogenetic data require, at a minimum, isothermal crystallization of plagioclase megacrysts from tholeiitic melts (the least enriched ones in greenstone belts) followed by segregation of the plagioclase crystals which then become entrained in rising melts to form intrusions or volcanic flows. Furthermore, the occurrences seem to require large volumes of melt at similar temperatures for long periods of time over huge areas having both oceanic and cratonic associations. Continual generation of similar melt and continuous addition of the melt to extensive networks of crystallizing chambers is also strongly implied. The major remaining questions with significant implications for the setting and evolution of greenstone belts are: 1) Does the crystal-producing melt have the same composition and crystallize under the same conditions beneath greenstone belts, stable cratons, and current oceanic crust? 2) Where do the plagioclase crystals form and accumulate; in low or high pressure environments? 3) Is there a systematic change in the time of megacryst emplacement across large areas such as might be produced by plates overriding zones of melt production or other such time-dependent mechanisms?


<table>
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<tr>
<th>Table 1. Matrix of Crystal-Bearing Phases</th>
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Plagioclase Crystals and Greenstones
Phinney, W. C., Morrison, D. A. and Maczuga, D.

Fig. 1

Fig. 2

Fig. 3