Electron Microprobe Analysis of the Oddanchatram Anorthosite, Southern India: A Lunar Analog

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Introduction: The lunar highlands are composed of anorthosite, a plagioclase-rich crystalline rock. The anorthosite is thought to have formed in a magma ocean where the lunar crust experienced fractional crystallization [e.g., 1]. The only anorthosite-bearing samples available for study are from six Apollo missions, two Soviet Luna missions and a number of lunar meteorites. The samples returned by these missions are geographically confined to the near side of the Moon. This lack of availability makes it necessary to identify a terrestrial analog to further understanding of lunar formation.

Chemical changes due to impact volatilization: The lunar surface is subject to continual bombardment by meteorites, dust and other particles. Analysis of Apollo 11 samples show the anorthosites are deficient in alkalis and phosphorus and is attributed to loss of these due to volatilization on the surface. Due to this observation, the best terrestrial analogs would be anorthosites that have higher alkali contents [2].

Geologic Overview: The study area (Fig. 1) is located in Southern India within the Madurai Block (Tamil Nadu). Centered on the town of Oddanchatram, the anorthosite body covers an area of about 12 mi^2 and is overlain by Cenozoic cover [3]. The other rock types in the area include granite, gneiss, quartzite, charnokite, and Banded Iron Formations.

Earlier studies on the Oddanchatram anorthosites characterize the suite into two types [3]. The first type is pure anorthosite composed of ~95% plagioclase, which occurs in two distinct crystal sizes, thought to be a results of separate crystallization events at different depths. The second type of anorthosite contains ~75% plagioclase and ~23% garnet.

Analytical Methods: Four rocks (SI04, SI05, SI07A, and SI07B) were collected from the Oddanchatram anorthosite in the Spring of 2004. Thin sections of the samples were analyzed with a research microscope at Oklahoma State University (OSU) to identify minerals and describe textures. The rocks were then X-ray element mapped (in Si, Al, K, Na, Ca, Fe, Mn, Mg, Zr) using OSU's JOEL 733 electron microprobe, and plagioclase grains within the samples were compositionally analyzed for major elements (Si, Al, K, Na, Ca, Fe) at an accelerating potential of 20kV and a primary current of 15nA.

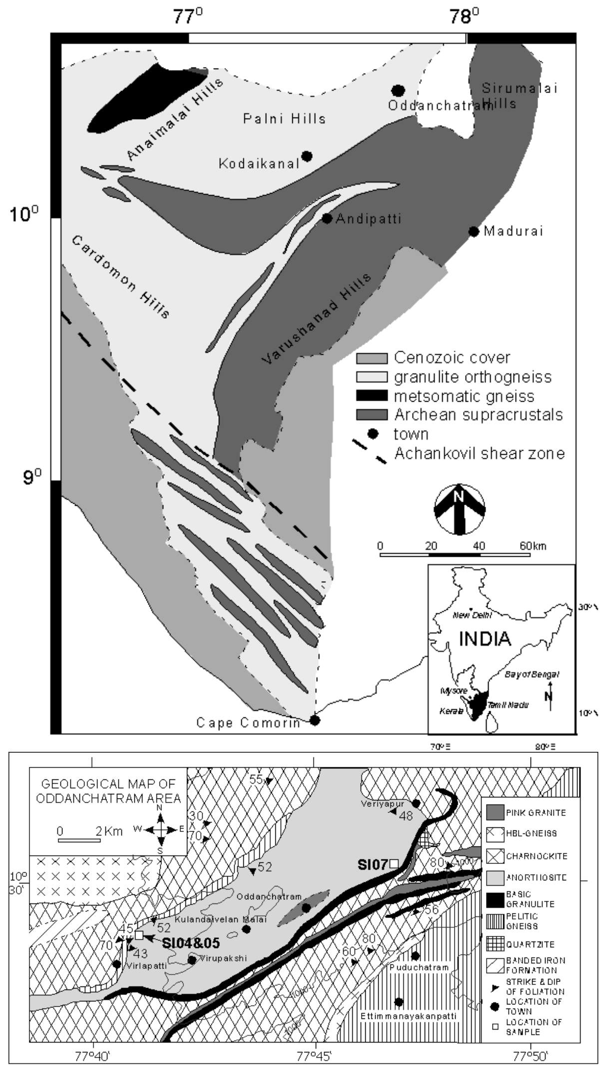

Figure 1: (Upper) Geologic map of Southern India. Inset shows the location of the map in India (after [4]) (Lower) Geologic map of the field area depicting sample locations (after [5]).

Results: *SI04*. Sample SI04 is a garnetiferous anorthosite (Fig. 2). Minerals within the sample include garnets of up to 8mm in diameter, plagioclase, K-feldspar appearing in exsolution textures, quartz, muscovite, and large (100 μm-sized) compositionally-zoned zircons. X-ray element maps showed that the majority of the plagioclase is unzoned. The plagioclase compositions range between 67.7 and 84.7% anorthite (average 73.8±2.8).

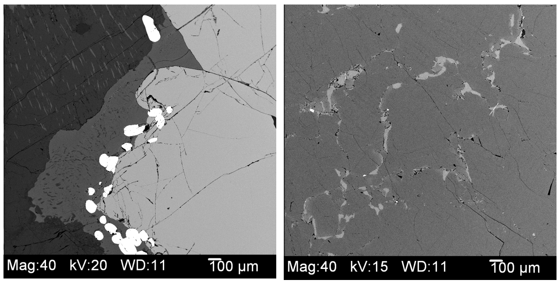

Figure 2: Backscattered electron (BSE) images of Indian anorthosite SI04 (left) and SI05 (right).

SI05. Sample SI05 is composed of almost entirely coarse-grained plagioclase with minor amounts of quartz (Fig. 2). The grains range in composition from 39.6-62.7% anorthite (average 55.1±3.0) .

SI07A Sample SI07A is a coarse-grained anorthosite which contains plagioclase, olivine, quartz, biotite, pyrite, and calcite in veins (Fig. 3).

SI07B Sample SI07B is similar in composition and mineral assemblage as SI07A, but contains plagioclase, quartz and pyrite (Fig. 3).

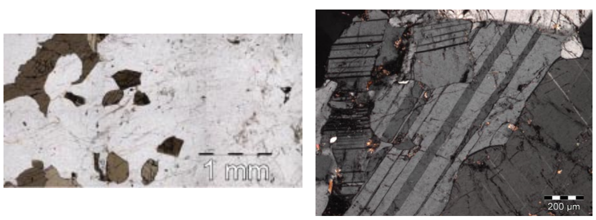

Figure 3: Photomicrographs of sample SI07A in plane light (left) and SI07B in crossed polarized light (right).

Conclusions: Compared to the lunar anorthosites, the Oddanchatram anorthosites are lower in anorthite (by 13.6-62.7%) and higher (by 57.7-84.7%) in albite content (Fig. 4).

The difference in compositions could be a result of (1) volatilization and loss of alkalis due to bombardment of lunar samples while on the surface and/or (2) differences in magma processes that created the lunar and Indian samples. To eliminate the influence of (1), future lunar sampling localities should focus on collection of fresh samples unaffected by bombardment of meteorites or ionizing radiation.

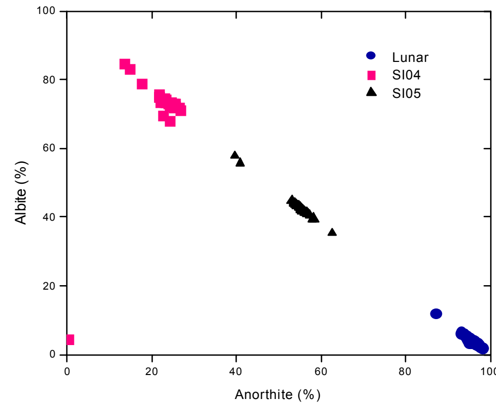

Figure 4: Plot of anorthite versus albite content of samples in study compared to lunar values [6-13].

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