SEARCHING THE SINUS AMORIS: USING PROFILES OF GEOLOGICAL UNITS, IMPACT AND VOLCANIC FEATURES TO CHARACTERIZE A MAJOR TERRANE INTERFACE ON THE MOON

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Abstract. Geochemical profiles of surface units, impact, and volcanic features are studied in detail to determine the underlying structure in an area of extensive mare/highland interface, Sinus Amoris. This study region includes and surrounds the northeastern embayment of Mare Tranquillitatis. The concentrations of two major rock-forming elements (Mg and Al), which were derived from the Apollo 15 orbital geochemical measurements, were used in this study. Mapped units and deposits associated with craters in the northwestern part of the region tend to have correlated low Mg and Al concentrations, indicating the presence of KREEP-enriched basalt. Found along the northeastern rim of Tranquillitatis were areas with correlated high Mg and Al concentration, indicating the presence of troctolite. Distinctive west/east and north/south trends were observed in the concentrations of Mg and Al, and, by implication, in the distribution of major rock components on the surface. Evidence for a systematic geochemical transition in highland or basin-forming units may be observed here in the form of distinctive differences in chemistry in otherwise similar units in the western and eastern portions of the study region.

1. Introduction

The orbital XRF experiment which flew on the Apollo 15 and 16 missions made measurements from which the highest resolution lunar compositional maps for major rock forming elements (Al, and Mg) have been derived (Adler et al., 1972; Bielefeld et al., 1977; Clark and Hawke, 1981). The data were useful in a number of ways. First, maps have been used to show relative variations in these elements. Also, the data were correlated with ground truth; thus, orbital measurements were directly correlated to percent concentrations and major rock components of soils for all areas of orbital coverage (Clark and Hawke, 1981). Early on, we noticed the extensive heterogeneity within the major terranes (Andre et al., 1975, 1976, 1977, 1978; Clark et al., 1976, 1978), and we correlated our data with geologic map units and other remote geologically related data sets to explore the nature of the heterogeneity.

We called local heterogeneities 'anomalies', small areas with geochemical signatures distinctly different from surroundings. We considered the existence of such anomalies to be proven when similar variations were associated with a given feature on one or more adjacent orbits. Sometimes, local horizontal transport of material from nearby mapped outcrops would be an obvious explanation. One
such study involved the identification of sites of major recent ray deposits and anomalous brown glass in the Sinus Amoris region (Clark et al., 1976). At other times, we saw that the source of anomalous surface material, for which no mapped outcrop existed in a given area, was derived from underlying source units, vertically redistributed and deposited from depth by nearby impact structures. Such studies have included the uncovering of high-alumina material in a dark-mantle unit at Taurus-Littrow (Andre et al., 1975), the mapping of the distribution of subsurface basalt in Mare Crisium (Andre et al., 1978), and the evidence for buried KREEP-enriched areas in eastern and farside highlands (Clark and Hawke, 1987, 1991).

This study is an attempt to further characterize the extensive heterogeneity found in highland and mare/highland interface areas, much demonstrated and discussed by this author and other authors mentioned here and above during the last two decades (e.g., Clark et al., 1976, 1978, 1990; Clark and Hawke, 1981, 1987, 1991). Alas, we have met with little success in terms of getting most of the community of planetary scientists to recognize the validity and significance of our results. Fortunately, Belton and coworkers (1992) and members of the extended Brown/Caltech family have now come to the rescue with the recent Galileo data from the Moon which further illustrates this extensive heterogeneity. The Galileo multispectral instrument team has the ear of the community, and has brought this important observation, with major implications for pre-mare lunar history, to the forefront. Now, those of us with elemental concentration data from the lunar nearside are now in a position to drive home the point.

As a further incentive to do this work, the tools now available allow a more quantitative characterization of buried source anomalies. Andre and El-Baz (1981) published a quantitative model for estimating the change in Al and Mg concentrations for a given change in XRF measurements and for a given size crater, which is useful for characterizing the underlying source in a more quantitative manner. Isopach maps were derived for mare basins (De Hon and Waskom, 1976; De Hon, 1979). Then, De Hon (1981) determined that the depths of small to medium size (complex) craters were geographically controlled and published a crater depth contour map.

2. Approach

In this study, we asked and attempted to answer the following questions:

1. What is the relationship between geology, as indicated by geological map units, and geochemistry, as indicated by orbital XRF data, in a complex area of major terrane boundaries?
2. What major surface rock types are exposed, and how are these rocks distributed?
3. What is the nature of underlying units, based on geochemical profiles of impact and volcanic features?