GEOCHEMICAL MIXING-MODEL STUDIES OF EJECTA FROM LUNAR FARSIDE BASINS: IMPLICATIONS FOR CRUSTAL MODELS.

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INTRODUCTION. Geochemical mixing models have been shown to be useful tools in investigating regional petrologic compositions and variations within the lunar highlands [1,2]. Such studies are particularly helpful in deciphering geologic conditions surrounding large impact basins. When they are combined with information on basin size and pre-impact crustal thickness (derived from both seismic [3] and gravity [4] data), minimum depths of basin excavation may be inferred. In turn, these depths constrain models of basin formation [5]. This study extends previous work on nearside basins [1,6] to selected basins on the lunar farside covered by adequate orbital geochemical and geophysical data.

METHOD. A modified least-squares mixing model described by [7] was used in these calculations. All elements were given equal weight in determining a solution and recalculated to sum to 100 percent. Elemental data were provided by the La Jolla Consortium library [8], including revised solar-corrected X-ray data [9] and the gamma-ray data of [10,11]; X-ray data were available for only the Smythii basin. End members were selected from both the chemically mixed rock types of [12] and representative "pristine" plutonic rock compositions cataloged by [13]. The six basins studied (Table 1) were selected on the basis of availability of chemical information and on their dominance by recognizable basin ejecta. From east to west, the basins span most of the farside hemisphere.

RESULTS. Smythii is a large pre-Nectarian basin [14] on the lunar east limb. Well-preserved basin ejecta are not evident, but rugged highlands NW of Pasteur appear to be unaffected by subsequent basin events and mare-flooding and therefore may represent basin ejecta. Crustal thickness in the target region was about 60 km, a value typical of many nearside basins [5]. Its ejecta contains the highest percentage (20%) of low-K Fra Mauro basalt of the basins studied, a proportion comparable to those of the Crisium and Nectaris basins [1]. This resemblence suggests that the crustal structure of these basins is similar. Smythii ejecta appear to be petrologically similar to those of nearside basins of comparable diameter and target conditions.

Milne is a small pre-Nectarian double-ring basin 300 km southwest of Tsiolkovsky. Crustal thickness in this region is 70 to 80 km [4]. More than 90 percent of Milne basin ejecta is anorthositic gabbro composition, suggesting that this impact was not of sufficient size to excavate lower crustal materials.

Mendeleev is a Nectarian basin, filled by thick light plains material [15]. Ejecta on the east side was analyzed. The basin is small, and crustal thickness in this region is greater than 90 km [4]. Although the dominant composition is anorthositic, a substantial norite component is present (Table 1), suggesting the possibility of a near-surface noritic source region.

Freundlich-Sharonov is a pre-Nectarian basin centrally located on the farside hemisphere [16]. Crustal thicknesses in this region are 60 to 70 km [4], comparable to average nearside values. A substantial noritic component is present (Table 1); this basin is the only one of those studied where KREEP appears to be required for a solution.

Korolev is a Nectarian multi-ring basin in one of the thickest crustal sections on the Moon (>100 km; [4]). The ejecta appear to be highly anorthositic and no significant mafic component is evident.

Hertzsprung is a large Nectarian basin, about 400 km northwest of Orientale, in a moderately thick crust (80 to 90 km; [4]). Anorthositic components dominate and the fraction of LKFM is minor.

A substantial portion of mare basalt is seen in all mixing model results except those from Korolev; its abundance has been thought to reflect the presence of an unknown mafic highlands component [2]. However, evidence from photogeologic [17] and theoretical [18] modelling and from sample studies [19] suggests that mare volcanism was extensive early in lunar history; large regions of the highlands may have an abundant mare basalt component within the megaregolith.

CONCLUSIONS. It was proposed in [5] that the composition of ejecta from a given basin is dependent upon both basin size and crustal thickness in the target region. Our study of ejecta from five lunar farside basins support this hypothesis. Ejecta of small basins (Milne, Korolev) formed where the crust is thick are strongly dominated by anorthositic chemistries. Ejecta of larger basins (Smythii, Freundlich-Sharanov) where crustal thickness approaches average nearside values consist of both anorthositic and noritic components. Thus, the entire lunar crust may be layered on a gross scale, with anorthositic rocks composing roughly the upper half of the crust and noritic/KREEP-rich rocks making up the lower half. Exceptions to this general rule should be noted, as ejecta from both Serenitatis and Imbrium appear to be dominated by "lower" crustal materials [1,6]. Therefore, both the "layer" models of [20,21] and the "lateral intrusion" models of [22,23] may be necessary to explain the crustal structure of the Moon. To acquire detailed knowledge of which crustal regions possess noritic intrusions, we must await acquisition of global geochemical data; examination of the composition of multi-ring basin ejecta may provide a three-dimensional reconstruction of the ancient lunar crust.

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Table 1. Mixing Model Results- Lunar Farside Basins

BASIN	DIA.(km)	REGION	AN	GABAN	ANGAB	NOR	LKFM	KREEP	17MB	Raw	S.E.
Smythii	740	6°S,100°E	-	28	42	-	20	-	10	99.3	0.000
Milne	270	22°S,115°E	-	-	93	-	-	-	7	100.9	0.079
Mendeleev	330	9°N,150°E	-	73	-	15	-	-	12	110.7	0.025
Freundlich-Sharonov	600	10°N,170°E	-	63	-	21	-	1	15	100	0.030
Korolev	440	12°S,153°W	-	84	11	-	5	-	-	98.3	0.003
Hertzsprung	570	8°N,137°W	52	-	25	-	5	-	18	98.1	0.000

AN-anorthosite (15415); GABAN- gabbroic anorthosite; ANGAB- anorthositic gabbro; NOR- norite (78535); LKFM- low-K Fra Mauro basalt; KREEP- medium-K Fra Mauro basalt (15386); 17MB- Apollo 17 high-Ti mare basalt.

Where no sample number given, composition taken from [12].

Raw- raw solution; S.E.- standard error.