N94-16327

COMPOSITION AND MATURITY OF THE 60013/14 CORE;

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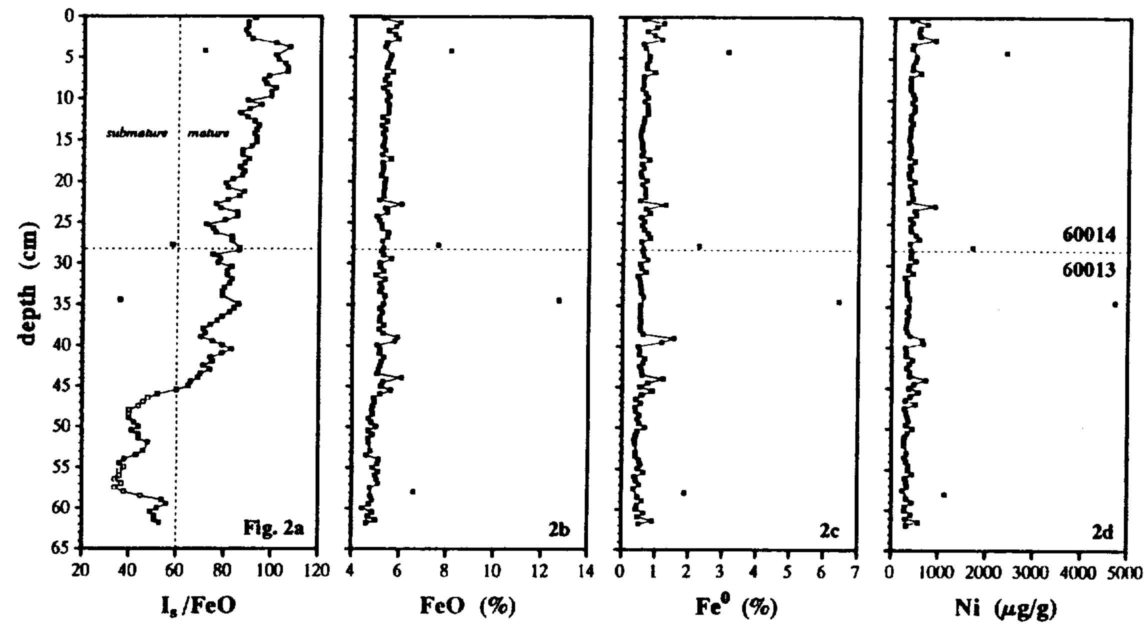
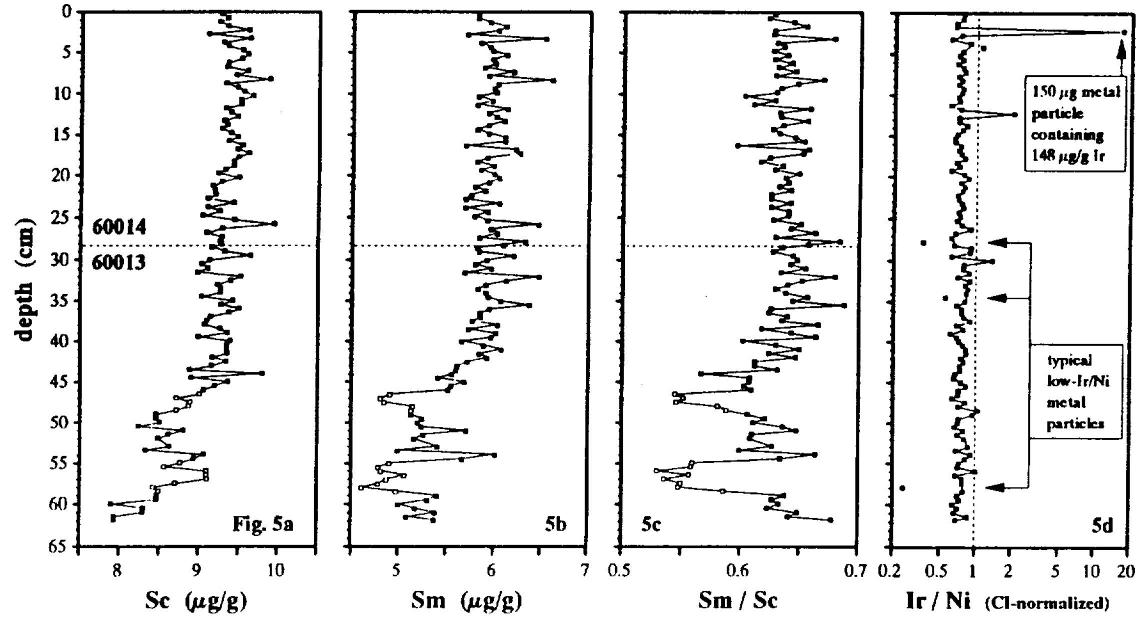
The 60013/14 double drive tube (62 cm deep) is one of three regolith cores taken 35-40 m apart in a triangular array on the Cayley plains at station 10' (LM/ALSEP), Apollo 16 (Fig. 1). This trio, which includes double drive tube 60009/10 (59 cm deep) and deep drill core 60001-7 (220 cm), is the only such array of cores returned from the Moon [1,2]. The top 45 cm of 60013/14 is mature (Fig. 2a), as is surface reference soil 60601 taken nearby. Maturity generally decreases with depth, with soil below 45 cm being submature. The zone of lowest maturity ($34 \leq I_s/FeO < 50$) extends from 46 to 58 cm depth, and corresponds to the distinct region of light-colored soil observed during core processing [3]. In the other two cores, most of the compositional variation results from mixing between fine-grained, mature soil with 10-11 μg/g Sc and coarse-grained ferroan anorthosite consisting of >99% plagioclase with <0.5 μg/g Sc [1]. This is most evident in 60009/10 which contains a high abundance of plagioclase at about 54 cm depth (minimum Sc: 3-4 μg/g; Fig. 3); a similar zone occurs in 60001-7 at 17-22 cm (MPU-C [1]), although it is not as rich in plagioclase (minimum Sc: 6-7 μg/g). Compositional variations are less in 60013/14 than in the other two cores (range: 7.9-10.0 μg/g Sc; Figs. 4,5a), but are generally consistent with the "plagioclase dilution" effect seen in 60009/10, i.e., most 60013/14 samples plot along the mixing line of 60009/10 (Fig. 4). However, a plagioclase component is not the cause of the lower maturity and lighter color of the unit at 46-58 cm depth in 60013/14. Many of the samples in this zone (hollow symbols in figures) have distinctly lower Sm/Sc ratios than typical LM-area soils and plot off the mixing trend defined by 60009/10 (Figs. 4,5c). This requires a component with moderately high Sc, but low-Sm/Sc, such as feldspathic fragmental breccia (FFB) or granulitic breccia [4]. A component of Descartes regolith, such as occurs at North Ray crater (NRC) and which is rich in FFB, could account for the composition of these soils (i.e., a 3:1 mixture of 60601 and NRC soil; Fig. 3). It seems unlikely that NRC ejecta would occur half a meter deep at the LM station [5], thus this low-Sm/Sc component may result from an older, local crater that penetrated the Cayley surface layer and excavated underlying Descartes material, as did North Ray crater. There is no evidence for such a unit or component in the other two cores. Soil below the light-colored unit (58-62) cm has 'typical' Sm/Sc ratios, but the lowest absolute Sc concentrations (Figs. 4,5), i.e., it is compositionally equivalent to a mixture of surface soil and plagioclase such as that in ferroan anorthosite. This is the only soil that might be related to the plagioclase-rich units in the other two cores. Except for the mature soil at the top of each core and, perhaps, the plagioclase-rich layers, there is little compositional evidence for any common unit among the three cores. Soil corresponding to the mare-glass-bearing unit (MPU-B) and regolith-breccia-bearing unit (MPU-A) of 60001-7 do not occur in 60013/14 or 60009/10 [1].

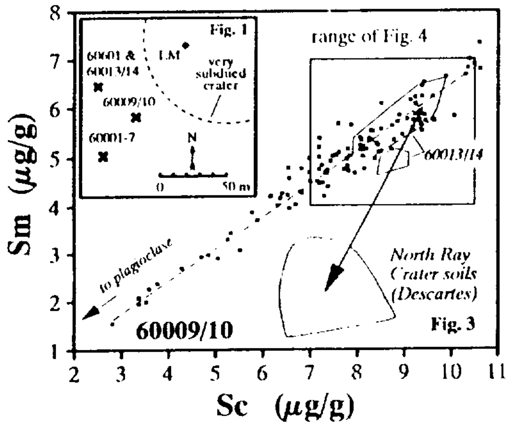
Metal nuggets. Concentrations of metallic iron (Fe^0) are highly correlated with those of Ni ($R^2 = 0.983$) because Fe-Ni metal containing about 6% Ni is the major carrier of both constituents in samples with high metal concentration (Fig. 2) [1]. Some samples (50-60 mg each) contain 'nuggets' of metal grains, leading to anomalously high concentrations of Fe^0, Ni, and FeO (total Fe as FeO). With 6.4% Fe^0 and 4740 μg/g Ni, the sample at 35 cm depth has the greatest concentration of metal we have observed in more than 1000 lunar soil samples (i.e., a 4-mg nugget). In Apollo 16 soils, Ni, Ir, and Au are carried subequally by a chondritic micrometeorite component and by the Fe-Ni metal, which derives from ancient impact-melt breccias that are a major constituent of the soil. The Ir/Ni ratio of the metal is low compared to chondritic meteorites [6]. Thus, most soil samples have Ir/Ni ratios intermediate to those of the metal and chondrites, and samples with high Fe^0 and Ni concentrations (Figs. 2c,d) typically have anomalously low Ir/Ni ratios (Fig. 5d). The Ni-rich sample at 4 cm depth has approximately chondritic Ir/Ni (Fig. 5d) and Co/Ni (not shown) ratios, thus this sample probably contains a fragment of metal from an ordinary chondrite.

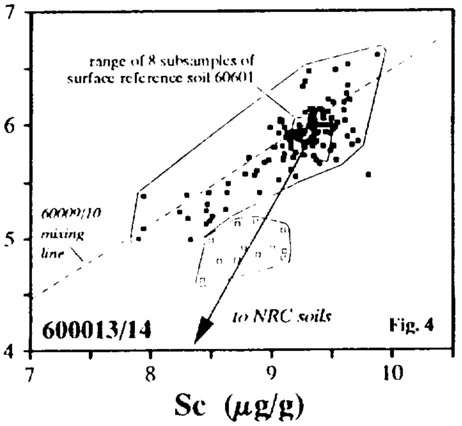
Iron micrometeorite. The sample at 2.0-2.5 cm depth (split of 60014,19) is highly unusual in having 427 ng/g Ir, but normal concentrations of Fe, Ni, Co, and Au. This leads to an exceedingly high chondrite-normalized Ir/Ni ratio of 17 (Fig. 5d). The cause of this anomaly is an iron micrometeorite containing *148 μg/g Ir* which is discussed more fully in a companion abstract [7].

References. [1] Korotev R. L. (1991) PLSC21, 229-289. [2] Gose W. A. and Morris R. V. (1977) *PLSC8*, 2909-2928. [3] Schwarz C. (1992) In *Lunar and Planetary Science XXIII*, pp. 1249-1250. [4] Korotev R. L. (1992) In *Lunar and Planetary Science XXIII*, pp.721-722. [5] Stöffler D., Ostertag R., Reimold W. U., Borchardt R., Malley J., and Rehfeldt A. (1981) *PLPSC12B*, 185-207. [6] Korotev R. L. (1987) *PLSC17*, E447-E461. [7] Jolliff B. L., Korotev R. L., and Haskin L. A. This volume.


depth (cm)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
submature
mature
Fig. 2a
20
40
60
80
100
120
I_s/FeO
2b
4
6
8
10
12
14
FeO (%)
2c
0
1
2
3
4
5
6
7
Fe^0 (%)
60014
60013
2d
0
1000
2000
3000
4000
5000
Ni (µg/g)


depth (cm)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
60014
60013
Fig. 5a
8
9
10
Sc (µg/g)
5b
5
6
7
Sm (µg/g)
5c
0.5
0.6
0.7
Sm / Sc
150 µg metal particle containing 148 µg/g Ir
typical low-Ir/Ni metal particles
5d
0.2
0.5
1
2
5
10
20
Ir / Ni (CI-normalized)


Sm (µg/g)
1
2
3
4
5
6
7
8
Fig. 1
60601 & 60013/14
LM
very subdued crater
60009/10
60001-7
N
0
50 m
range of Fig. 4
60013/14
to plagioclase
North Ray Crater soils (Descartes)
60009/10
Fig. 3
2
3
4
5
6
7
8
9
10
11
Sc (µg/g)


4
5
6
7
range of 8 subsamples of surface reference soil 60601
60009/10 mixing line
to NRC soils
600013/14
Fig. 4
7
8
9
10
Sc (µg/g)