Abundances of the 14 Rare Earth Elements Plus 22 Major, Minor and Trace Elements in Ten Apollo 12 Rock and Soil Samples

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Abundances of major and minor elements (Si, Ti, Al, Fe, Mg, Ca, Na, K, Mn, Cr and Ba) and trace elements (14 REE (rare-earths), Y, Cd, In, V, Rb, Cs, Sc, Co, Zr, Hf and Th) have been determined by instrumental and radiochemical neutron and bremsstrahlung activation analysis in five Ap 12 (Apollo 12) igneous rocks (12004,20,51,63 and 75), one breccia (12034) and four soils (12032,33,37 and 70). In general, comparative Al, Ca and Mn abundances are similar in the soils of Ap 11 and 12 and in the rocks of Ap 11 and 12. Ti is reduced by a factor of ~2.5 in Ap 12 soil and ~3.5 in Ap 12 rocks relative to Ap 11 soil and rocks, respectively.

Alkali elemental abundances vary within a factor range of 2-4 in four soil samples. Na and K are higher by factors of 1-2 and 1-4 times, respectively, in Ap 12 soils relative to Ap 11 soil. Rb and Cs are enriched by factors of 1-4 and 2-4, respectively, in Ap 12 soils relative to Ap 11 soil. Na is reduced by a factor of ~2 and K is about the same in Ap 12 rocks relative to Ap 11 low alkali rocks. Rb is about the same and Cs is ~2 times higher in Ap 12 rocks relative to Ap 11 low alkali rocks.

All elemental abundance data of this work are consistent with a crystalline rock classification into two magma types 1 and 2, by J. L. Warner (1970). Type 2 rocks, 12051 and 63, are enriched in Ti, Ca, Na and REE abundances by a factor of ~1.3-2 and depleted in V by a factor of ~1.5 relative to type 1 rocks 12004, 20 and 75.

Indium abundances are 2±1 ppb in two Ap 12 soils and four rocks, and are similar to the lowest In abundances found in Ap 11 rocks. Abundances of Cd are at least 5 times lower in Ap 12 rocks relative to Ap 11 rocks.

Total REE + Y abundances in Ap 12 soils vary from 390-720 ppm, compared to ≈300 ppm in Ap 11 soil. The chondritic normalized REE + Y distribution patterns are very similar for all four Ap 12 soils and one breccia rock. Relative to REE in Ap 11 soil, the light REE in Ap 12 soil are progressively enriched from Sm to La. The chondritic normalized patterns are similar for the heavy REE in both Ap 11 and 12 soils and rocks. REE abundances in Ap 12 igneous rocks are 3-5 times less abundant than in Ap 12 soil, and Ap 11 soil and igneous rocks. The chondritic normalized REE patterns are rather similar for Ap 11 and 12 igneous rocks, Eu excluded.

Sm/Eu ratios in Ap 12 soil and igneous rocks are 9.7 and 4.8, respectively, which may be compared to average ratios of 7.4±0.4 in Ap 11 soil and 9.3±0.6 and 6.9±0.8 in Ap 11 high and low alkali rocks, respectively. Relative to chondritic meteorites, Eu has been depleted by 71% and 43% in Ap 12 soil and igneous rocks, respectively, and by 63%, 70% and 60% in Ap 11 soil and high and low alkali igneous rocks, respectively. Varying degrees of plagioclase precipitation or partial melting may be invoked for Eu fractionation. Three or four distinct lava flows could account for the observed Ap 12 elemental abundance data, two flows for the igneous rocks and perhaps two for the rocks from which the soils were derived by impact fragmentation. Chemical histories of the Ap 11 and 12 rocks are quite different, as are the corresponding soils.