THE LUNA 20 REGOLITH. Randy L. Korotev, Department of Earth and Planetary Sciences and McDonnell Center for the Space Sciences, Washington University, Saint Louis MO 63130 (rlk@levee.wustl.edu).

The Russian Luna 20 mission landed in the lunar highlands on ejecta-basin deposits between Mare Fecunditatis (older) and Mare Crisium (younger), 33 km from the nearest exposure of mare basalt in Mare Fecunditatis [1–2]. Mare Fecunditatis and Mare Crisium were the sites of the Luna 16 and 24 missions. On all three missions small regolith samples were collected robotically and brought to Earth.

As expected, rock fragments from Luna 16 and 24 are mainly mare basalts and regolith breccias composed largely of mare basalt. In contrast, most lithic fragments in the Luna 20 regolith are either breccias with compositions of troctolitic and noritic anorthosite, anorthositic norite and troctolite, and spinel troctolite, or more mafic rocks that were called highland basalt or high-Al basalt in older literature but which are probably impact-melt rocks and breccias of noritic or basaltic composition. Many of these lithologies have recrystallized or metamorphic textures. Fragments of mare basalt and rocks of KREEP composition are rare (Fig. 1, [3–10]). Nevertheless, relative concentrations of incompatible elements in the regolith are in ratios characteristic of KREEP, although absolute concentrations are lower than those of nonmare regoliths from Apollo sites (Fig. 1).

Petrographic studies show that the Luna 20 regolith differs from the Apollo 16 regolith in several ways. At Luna 20 (1) mafic rocks are not as rich in K, P, and Th, (2) fragments of highly feldspathic (>90% plagioclase) anorthosite are uncommon, and (3) MgO-rich spinel

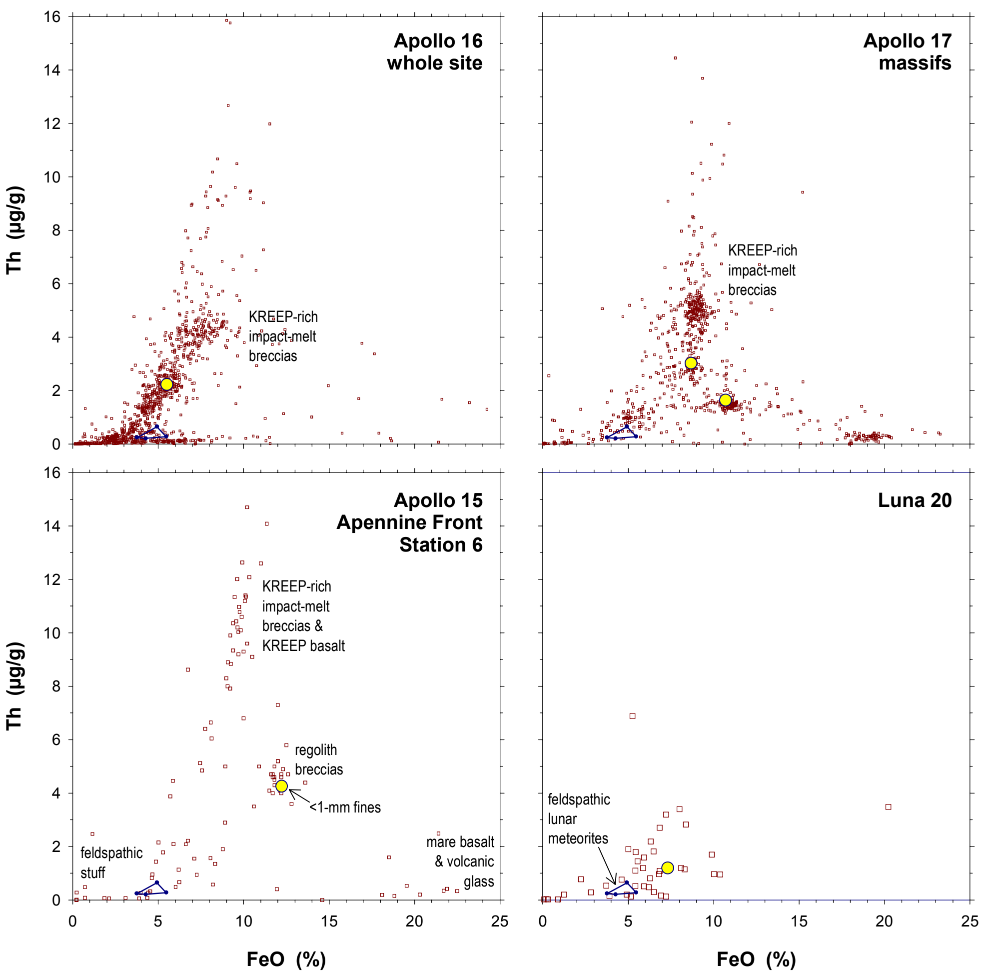

Figure 1. Comparison of FeO and Th concentrations in regolith particles from nonmare regions of 3 Apollo sites (1–4 mm) and Luna 20 (0.4–1 mm). Each of the Apollo regoliths contains feldspathic lithologies, KREEP-rich lithologies, mare basalt and glass, and regolith breccias with soil-like compositions (yellow circles). None of 40 particles from the Luna 20 regolith corresponds to a KREEP-like composition or mare basalt (the two anomalous particles are apparently rich in whitlockite, but do not have KREEP-like proportions of other incompatible elements). All Apollo data from this lab [15–18 and unpubl. data]. All data for Luna 20 "rocks" are plotted [19–22]; Th concentration in the 6 particles of [19] were estimated from REE concentrations.

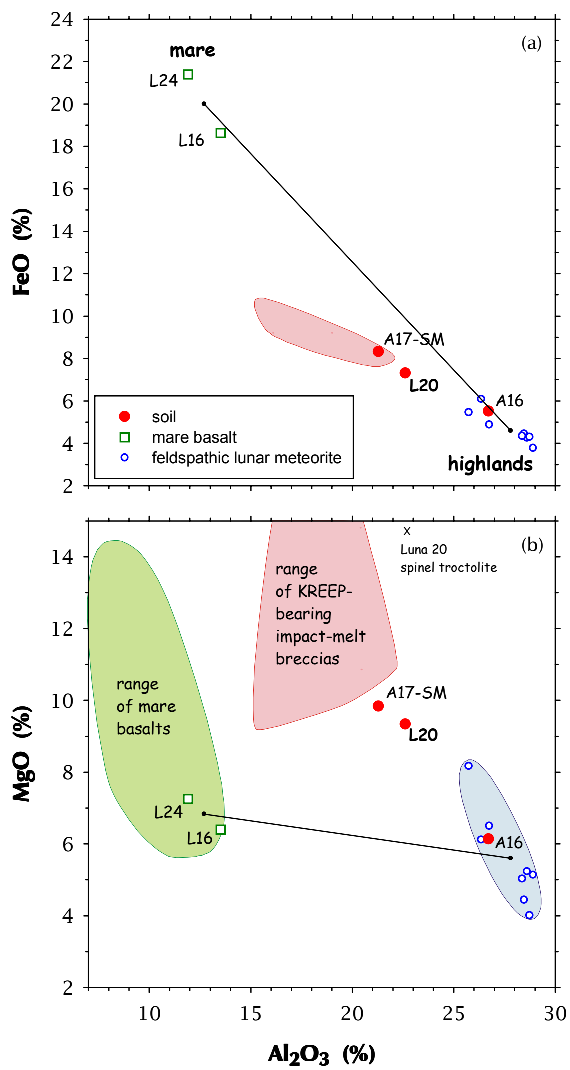

Figure 2. (a) On the basis of FeO and Al_2O_3, the Luna 20 regolith appears to be a mixture typical feldspathic highlands, as represented by the feldspathic lunar meteorites [12], and mare basalt or KREEP-bearing impact-melt breccia (pink field), as are the soils from the South Massif of Apollo 17 [24]. (b) However, the Luna 20 regolith contains no KREEP (Fig. 1) and it is much richer in MgO than is any mixture (line) of local mare basalt and typical feldspathic material of the highlands surface. The regolith must contain moderately mafic, high-Mg/Fe, low-KREEP lithologies such as spinel troctolite

troctolites are common [3–11]. Compositionally, the Luna 20 regolith is more mafic than either the Apollo 16 regolith or the feldspathic lunar meteorites; the latter appear to represent well the surface composition of typical feldspathic highlands [12]. Because of the component of spinel troctolite and because other mafic lithologies have high Mg/Fe ratios, the Luna 20 soil has a distinctly greater concentration of MgO than does any other feldspathic, nonmare regolith, including ALHA81005 (a regolith breccia), the most Mg-rich of the feldspathic lunar meteorites (Fig. 1b; also Figs. 2b and 4 of [7]). However, the composition of the Luna 20 regolith is not substantially different from the composition of the nonmare portion of the regolith of the South Massif at Apollo 17, except that concentrations of incompatible elements are only 35–40% as great (Fig. 2).

The Crisium impactor excavated a greater fraction of the way into the crust did than most basin-forming impactors [13]. Much to most of the material of the Luna 20 regolith is ejecta from the Crisium basin and the Luna 20 regolith may provide our best samples of middle to lower crustal material in a region of typical feldspathic highlands. Because K- and P-rich lithologies are rare in the Luna 20 regolith, it is likely that the moderate levels of incompatible elements (e.g., 1.2 ppm Th, Fig. 2) compared to the feldspathic lunar meteorites (0.2–0.4 ppm Th) are not the result of contamination by Imbrium ejecta [14] or some other source of high-K, high-Th KREEP, but are an inherent property of Crisium ejecta. In other words, unlike impact-melt breccias from the Apollo sites, especially Apollo 16 [12], the Luna 20 breccias are probably not mixtures of low-Th and high-Th rocks. The rocks of the Crisium ejecta deposit are moderately rich in incompatible elements because the plutonic rocks from which they derive contain trapped residual liquid with a KREEP-like incompatible-element signature. We might expect rocks of similar composition in and around the South Pole-Aitken basin [23]. The Luna 20 regolith suggests that either there was no layer of KREEP beneath the feldspathic crust in the vicinity of the Crisium impact or that the impact did not excavate to the base of the crust.

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