A NEWLY CHARACTERIZED GRANITE FROM THE APOLLO 12 REGOLITH. S. M. Seddio, B. L. Jolliff, R. L. Korotev, and R. A. Zeigler, Department of Earth and Planetary Sciences and McDonnell Center for the Space Sciences, Washington University and McDonnell Center for the Space Sciences, St. Louis, Missouri 63130 (sseddio@levee.wustl.edu).

Introduction: The Apollo 12 regolith is composed of a variety of mare and nonmare lithologies. Most are mare basalts, regolith breccias, and impact melt breccias. Rarer lithologies include brecciated anorthosites, granites, and alkali anorthosites. Because the site lies in the Procellarum KREEP Terrane, most of the nonmare rocks are rich in Th (Fig. 1). As part of a survey of 2–4-mm lithic fragments from the Apollo 12 regolith [1,2], we identified several unusual fragments. One such fragment is 12032,366-19, a 21-mg granite. We describe its petrography and geochemistry here.

Methods: Methods: We determined the bulk compositions of 358 2–4-mm lithic fragments from the Apollo 12 regolith by INAA (instrumental neutron activation analysis) [1,2,3] (Fig. 1). The petrography, mineral assemblage, and textures were studied using back-scattered electron (BSE) elemental x-ray imaging. Mineral compositions were determined by EMPA (electron probe micro analyses) using wavelength dispersive spectroscopy on a JEOL 8200 Superprobe.

Bulk Composition: With 5.0% FeO, 2.9% CaO, 2.1% Na_2O, 4.8% K_2O, 25 µg/g Sm, 61 µg/g Th, and <2 ng/g Ir, 12032,366-19 is similar to previously reported lunar granites and felsites [4,5,6]. Relative REE abundances are unlike those of typical Apollo 12 material (Fig. 2) but similar to other granites and felsites.

Major Phases of 12032,366-19: 12032,366-19 (Figs. 3a,b,c) is a granite which is primarily composed of graphic intergrowths of K-feldspar ($An_{1.2-6.1}$,Ab_{25-33},Or_{58-74},$Cn_{0.4-3.9}$) and silica, and to a lesser extent a graphic intergrowth of plagioclase (An_{38-48},Ab_{52-64},$Or_{0.9-1.3}$,$Cn_{0.0-0.1}$) and silica (Table 1, Fig. 3). The plagioclase is unusually sodic for a lunar rock; in fact, the An values ~35 are the lowest values that we are aware of in any lunar sample. The associated mafic assemblage is well preserved in this sample. The mafic phases are Fe-rich and consist of hedenbergite ($En_{4.6-6.2}$, Fs_{51-52}, Wo_{43-44}) and fayalite ($Fo_{2.7}$, Fa_{97}). Average compositions of the major mineral phases are in Table 2.

Table 1. Mineralogy of 12032, 366-19 determined by image analysis. All values are converted to weight percent.

Phase	Abundance
K-feldspar	54.82
Silica	24.91
Plagioclase	7.18
Pyroxene	6.44
Olivine	4.89
Ilmenite	1.13
Zirkelite	0.598
Baddeleyite	0.017
Sum	100.00

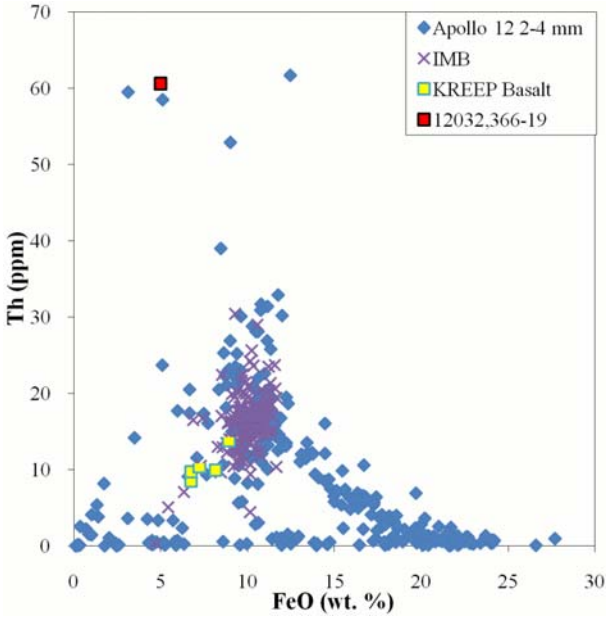

Figure 1. Bulk FeO and Th concentrations of 12032,366-19 (red) INAA. "Apollo 12 2–4 mm" refers to 358 2–4 mm particles from Apollo 12 described in [1]. "KREEP Basalt" and "IMB" points (impact-melt breccia) are from 14161 [4].

Minor Phases of 12032,366-19: Elongate ilmenite, zirkelite, and baddeleyite are present in measurable amounts. Baddeleyite is found only in association with fayalite. Zirkelite is scattered throughout the section and occurs as very-fine-grained, elongate 'strings' and in one coarser (~0.1 mm), irregular grain (top of Fig. 3a, bright green). Zirkelite contains significant concentrations of HfO_2 (0.6), Nb_2O_5 (7), Ta_2O_5 (0.3), ThO_2 (2), UO_2 (0.7), PbO (0.5), Y_2O_3 (9), RE_2O_3 (~10) (all in wt%, average of 10 analyses), and 28–29% ZrO_2.

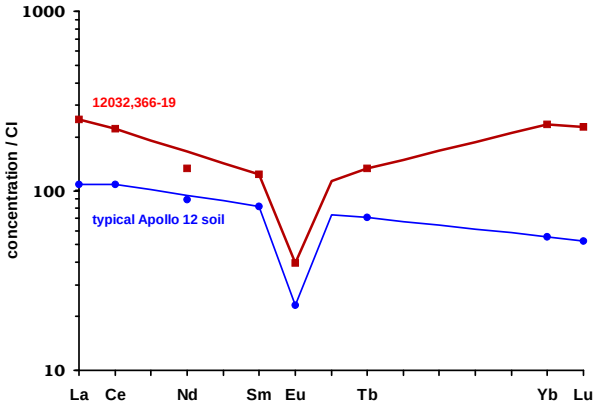

Figure 2. Comparison of REE abundances in the 12032,366-19 with typical Apollo 12 regolith.

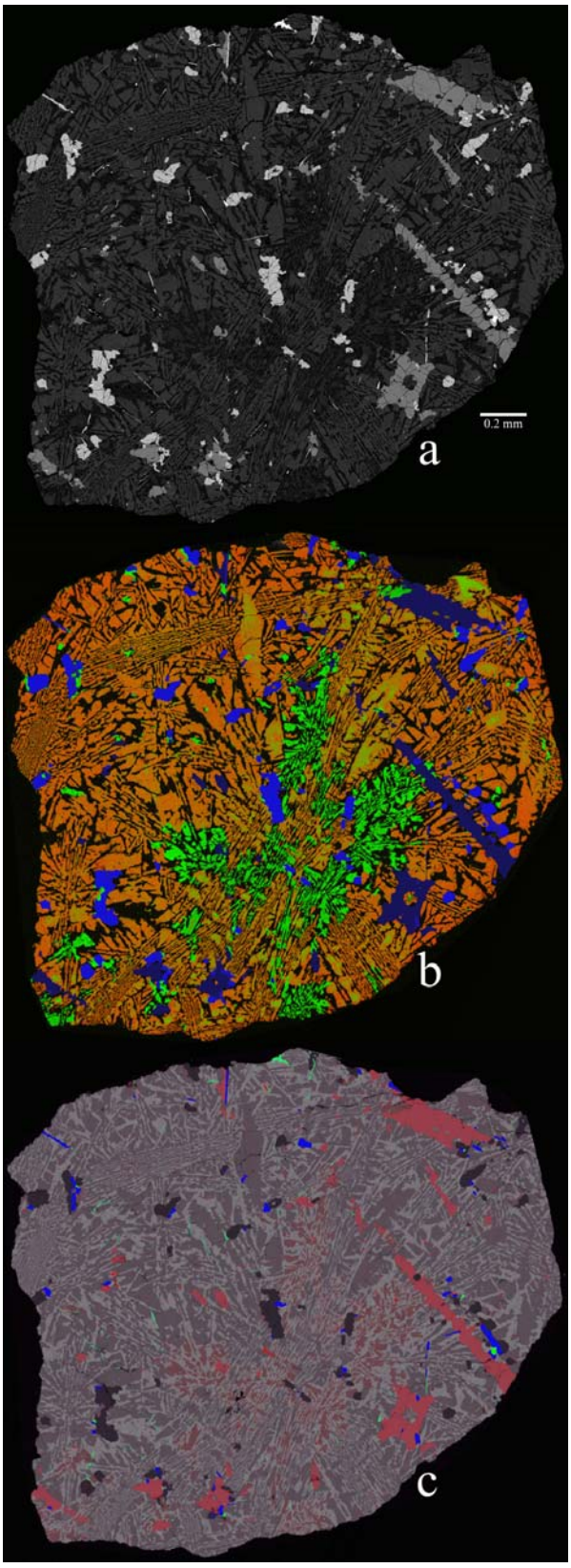

Table 2. Average compositions of quantitatively analyzed phases. *N* is the number averaged of analyses. All values are reported in mass percent (oxide).

	K-spar	Plag	Px	Ol	Il	Glass Incl.	Zirk
N	7	4	6	5	1	1	
SiO_2	66.3	58.9	47.6	29.4	<0.03	78.3	1.4
TiO_2	0.063	<0.04	0.92	0.13	51.1	0.13	24.1
Al_2O_3	19.2	25.9	0.69	<0.02	<0.02	12.4	0.1
Cr_2O_3	<0.04	<0.04	<0.04	<0.04	<0.04	<0.03	<0.03
FeO	0.16	0.22	29.3	68.6	47.4	1.10	9.1
MnO	<0.04	<0.04	0.34	0.83	0.43	<0.04	0.1
MgO	<0.02	<0.02	1.65	1.06	0.12	<0.01	<0.02
CaO	0.42	8.42	19.2	0.17	<0.02	0.48	4.4
BaO	1.51	<0.04	<0.05	<0.04	<0.05	0.079	na
Na_2O	2.74	6.70	0.10	<0.05	<0.05	0.86	<0.05
K_2O	10.4	0.20	<0.01	<0.01	<0.01	2.95	na
P_2O_5	<0.01	0.017	<0.01	<0.01	<0.01	<0.01	na
Sum	100.8	100.5	99.8	100.1	100.2	96.4	

Ilmenite also contains ~1% Nb_2O_5; for zirkelite 'others' see text.

The baddeleyite analyses have relatively high concentrations of Hf (2.8 wt%) and measureable FeO (1.1 wt%) TiO_2 (0.8 wt%), and Nb_2O_5 (0.5 wt%). Apatite and RE-merrillite are also present but only as fine specks scattered throughout the sample.

Other Lunar Granites: Sample 12032,366 is a pristine granite that does not contain impact-generated glass or brecciated material, as do many other lunar granites [7,8]. It has concentrations of REE at the low end of the range of lunar rocks identified as granite or felsite It contains the highest concentration of Ba (0.61 %) of which we are aware and it contains a substantial proportion of Zr-bearing minerals, especially zirkelite. To our knowledge, the texture and mineral assemblage of this sample is unique among studied lunar samples.

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References: [1] Korotev R. L. et al. (2002) *LPS XXXIII*, Abstract #1395. [2] Korotev R. L. et al. (2000) *LPS XXXI*, Abstract #1363. [3] Seddio et al., this conf. [4] Jolliff B. L. et al. (1991) *LPS XXI*, 193–219. [5] Warren P. H. et al. (1983) *PLPSC14*, B151–B164. [6] Warren P. H. et al. (1987) *PLPSC17*, E303–E313. [7] Warren P. H. et al. (1983) *EPSL, 64*, 175–185. [8] Morris R. W. et al. (1990) *PLPS20*, 61–75.

Figure 3a. (At left) BSE mosaic of 12032,166-19. **b.** X-ray maps of K, Na, and Fe in 12032,366-19 converted into an RGB image. Orange is K-feldspar, while the lighter orange is K-feldspar that has more Na. Bright green is plagioclase. Bright blue is olivine, and navy blue is pyroxene. Silica is represented as black. **c.** X-ray maps of Ca, Zr, Ti, and Si in 12032,366-19 converted into an RGBGray image. The large, pink phases are pyroxene. The bright, blue phases are ilmenite. The green phases are zirkelite and baddeleyite.