14076

Fragmental Breccia

2 grams

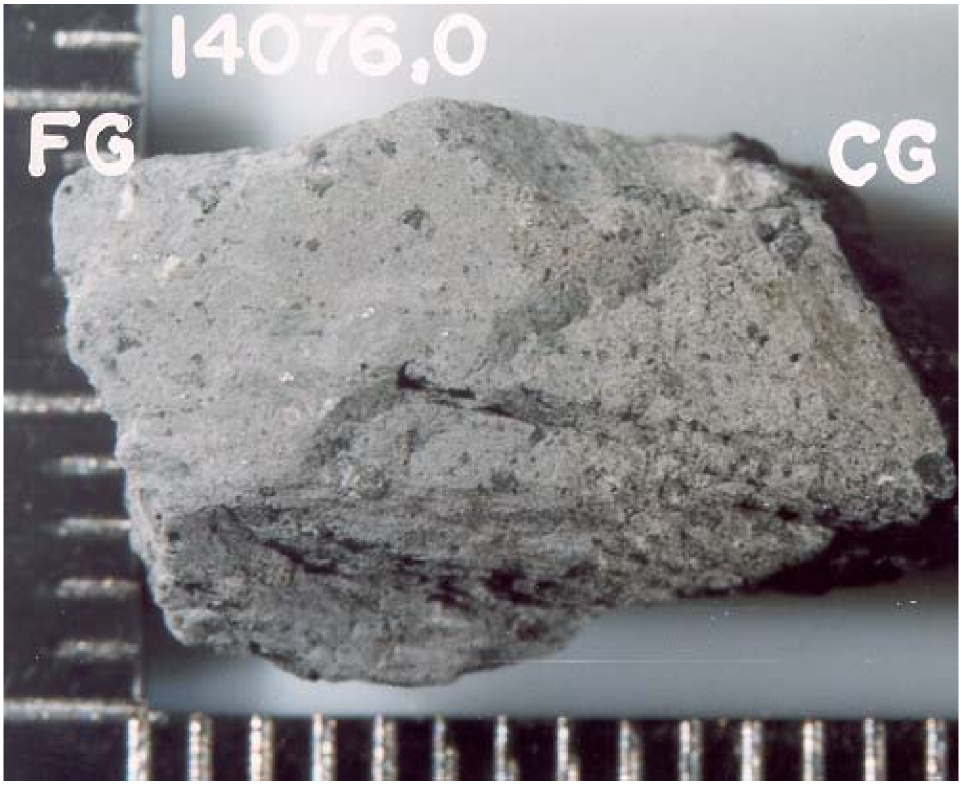


Figure 1: Photo of 14076. Scale is in mm. NASA S87-34960.

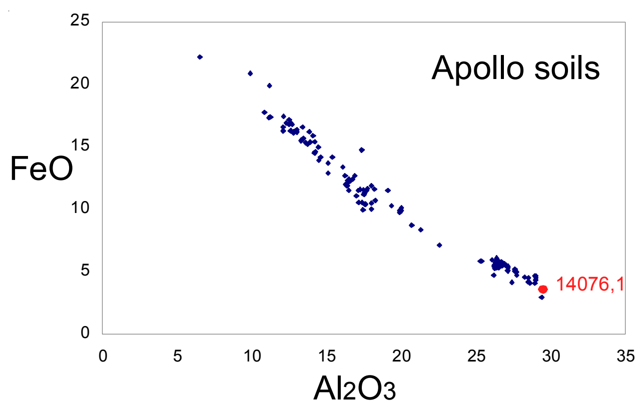


Figure 2: Chemical composition of light portion of 14076 compared with other lunar soils.

Introduction

14076 was one of 7 small rocks collected from the bottom of a 30 cm deep trench (see 14149) at station G, Apollo 14, located about 3 crater diameters from Cone Crater (Swann et al. 1977). It has two distinct lithologies with sharp contact; one is brownish like most other Apollo 14 soil breccias, and one is grayish and very aluminous. The aluminous lithology is thought to be an exotic highland regolith and is quite unusual when compared with other Apollo 14 breccias.

The aluminous part of 14076 is found to have large glass spheres and fragments of HASP (Vaniman 1990) and tiny glass spheroids of GASP (Warren 2008). A new lunar mineral, yoshiokaite, is also reported in this lithology.

Petrography

The aluminous part of Apollo 14 regolith breccia 14076 has been found to contain a diverse suite of complementary silicate condensates (figures 4 and 5). A early description of this rock is reported in Jerde et al. (1990) "the finer-grained end - - - contains only 5-

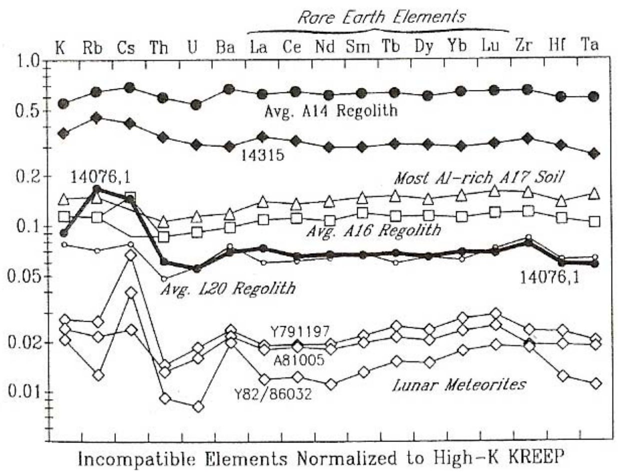


Figure 3: Spider diagram for trace element content of 14076,1 compared wtih 14315, Apollo 14 soils, Apollo 16 soil and some lunar meteorites (Jerde et al. 1990).

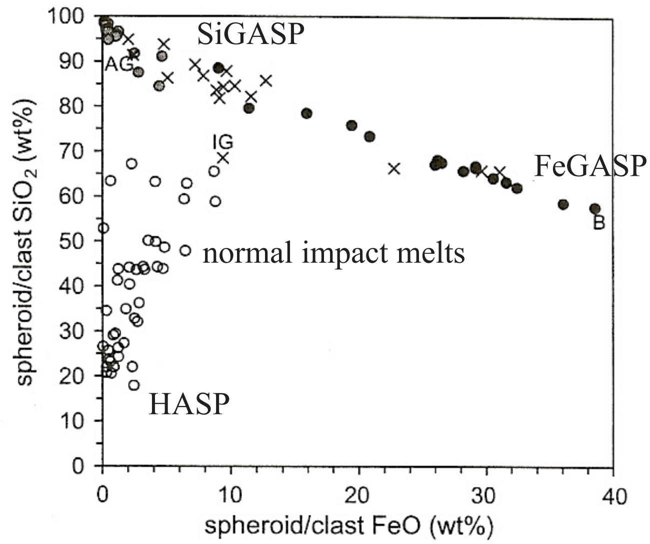


Figure 4: Fe and Si content of small glass spheres in 14076. X are non-sphere. Warren 2008.

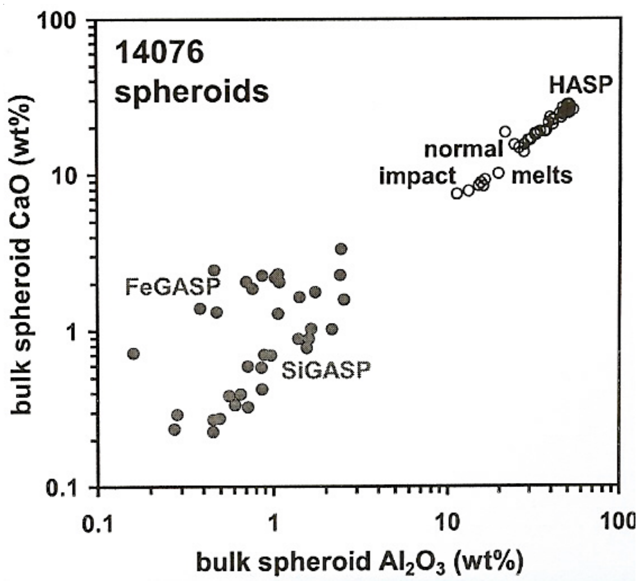


Figure 5: Ca vrs Al analysis of very small glass spheres in 14076 (Warren et al. 2007).

10% clasts > 0.5 mm across. In contrast, the coarser-grained end contains ~ 30% clasts. The matrices were also noted to be of different colors: "medium brown-grey in one lithology and "light medium grey" in the other".

Jerde et al. (1990) and Wentworth and McKay (1991) showed that the light-grey portion of 14076 was highly aluminous when compared with other Apollo 14 samples. The maturity index (Is/FeO) is low, perhaps due to growth of iron grains (Jerde et al. 1990).

The thin section of the light-grey lithology (14076,1) contains at least four large more-or-less intact spherules and many smaller object that appear to be broken spherules. The thin section lacks recognizable agglutinates, has only moderate porosity, and all of its glasses have been extensively devitrified (Jerde et al. 1990). Several unusual (devitrified) glass types are present: One common type is similar to HASP, seen before in some Apollo 16 samples. A new Ca, Al rich silicate mineral termed "*Yoshiokaite*" is has been found in this lithology. Most recently Warren et al. (2007) and Warren (2008) have reported tiny spheres and large masses of complementary Si- and Fe-rich glass, dubbed GASP (table 1, figure 5). These supposed condensates are not unlike the volatile-rich alumina poor glasses and coatings first observed by Keller and McKay (1992) in an Apollo 16 soil (61181).

HASP: HASP stands for **h**igh-**a**lumina, **s**ilica-**p**oor glass and has been seen before (Nancy et al. 1976). It is, perhaps, the residue of high-temperature vaporization of lunar highland material.

GASP: GASP stands for **g**as-**a**ssociated **s**pheroidal **p**recipitates (Warren et al. 2007).

VRAP: VRAP is an acronym that stands for volatile-rich alumina poor condensates (Keller and McKay 1992).

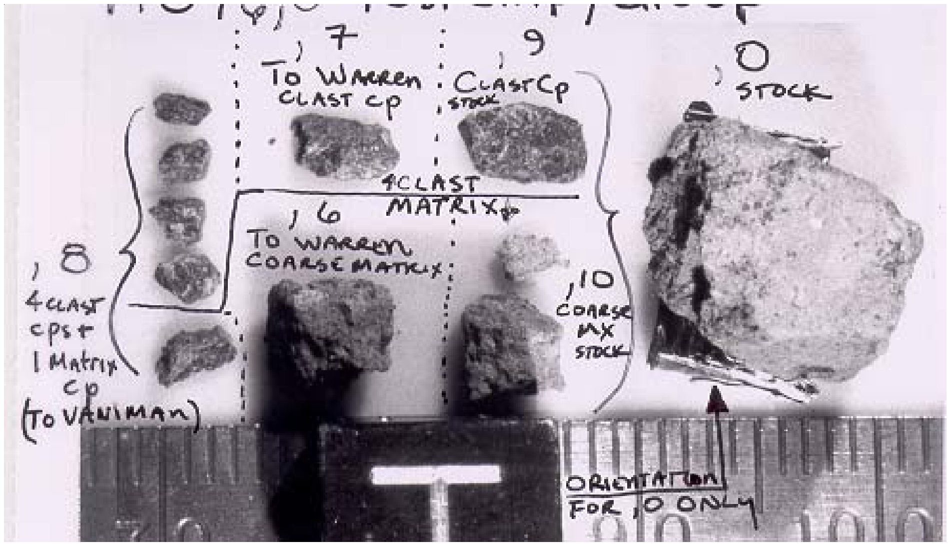
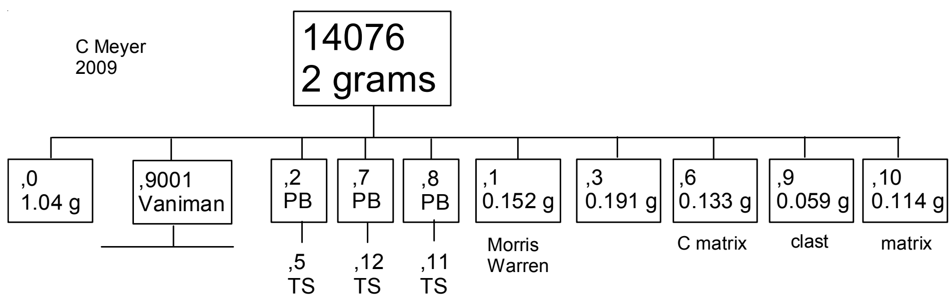


Figure 6: Photo from "data pack" for 14076.



Yoshiokaite: Vaniman and Bisch (1990) reported a new Ca, Al-silicate mineral in the aluminous part of 14076. It occurs as shocked crystal fragments an in devitrified highly-aluminous glasses. It has a hexagonal nepheline-like structure and is metastable. Analyses of yoshiokaite are given in table 1.

Chemistry

There are three analyses of different parts of 14076 (Table 1). The brownish lithology has high trace element content and is very like other Apollo 14 regolith breccias.

However, the grayish, aluminous lithology of 14076,1 is low in trace element content. It has significant Ir and Au and is thought to be a sample of a highland regolith (Warren 2008). The grayish, aluminous lithology is found to be exotic to Apollo 14 and low in trace element content (figure 3). It is somewhat similar to the Apollo 16 soils (except that they do not have abundant HASP).

The third analysis by Jerde et al. (1990) is of a small clast in 14076.

Processing

14076, along with parent soil 14149, was returned in documented bag #20 in ALSREC 1006. Figure 6 shows how 14076 was divided. Documentation of the splits and their respective thin sections is found in the papers by Warren, Jerde etc.

Compilers note: *It would seem that one should search all samples with HASP, for small spheroids of GASP and/or thin coatings of VRAP. One can only guess what the next acronym will be!*

Table 1. Chemical composition of 14076.

reference	Jerde et al. 1990				Warren2008	Keller92	Warren08	Vaniman90							
weight	,1	,6	,7		ave GASP	HASP	VRAP	Yoshiokaite							
SiO2 %	44	47.7		(c)	86.6	26	64	18.2	28	22.6	21.6	20.6	18.4	15.8	(d)
TiO2	0.33	1.6	0.88	(c)	0.03	0.7		0.08	0.07	0.02	0.08	0.14	0.14	0.12	(d)
Al2O3	30.4	18.3	24.2	(c)	0.38	45	1	51.9	45.9	50	52.2	51.4	53.3	56.3	(d)
FeO	3.78	9.5	6.2	(c)	7.64	1.8	25	0.02	0.18	0.07		0.08	0.05	0.41	(d)
MnO	0.058	0.13	0.075	(c)	0.16		0.5								(d)
MgO	3.33	10.3	5.3	(c)	4.5	5.5	1.9	0.41	0.98	0.27	0.09	0.3	0.02	0.4	(d)
CaO	16.8	11	14.4	(c)	0.55	21	1.3	28.8	25.5	27.7	26.5	28.3	27.8	27.8	(d)
Na2O	0.44	0.74	0.59	(c)	0.03		1	0.02		0.02	0.02			0.09	(d)
K2O	0.088	0.65	0.26	(c)	0.02		2.9	0.01			0.01			0.01	(d)
P2O5															
S %															
sum															
Sc ppm	7.8	20.3	12.7	(a)											
V	17	37	34	(a)											
Cr	500	1250	880	(a)											
Co	15.8	36	20.1	(a)											
Ni	231	370	234	(a)											
Cu															
Zn	6.9		33	(a)											
Ga	10.8	6.7	3.1	(a)											
Ge ppb	260			(b)											
As															
Se															
Rb	3.7	16	6.8	(a)											
Sr	175	189	150	(a)											
Y															
Zr	108	1060	470	(a)											
Nb															
Mo															
Ru															
Rh															
Pd ppb															
Ag ppb															
Cd ppb															
In ppb															
Sn ppb															
Sb ppb															
Te ppb															
Cs ppm	0.146	1.8	0.25	(a)											
Ba	90	850	350	(a)											
La	8	80	31	(a)											
Ce	18.2	192	80	(a)											
Pr															
Nd	11.9	119	47	(a)											
Sm	3.17	32.2	12.5	(a)											
Eu	1.09	2.7	1.47	(a)											
Gd															
Tb	0.67	6.6	2.8	(a)											
Dy	4.2	43	16.3	(a)											
Ho	0.73		3.5	(a)											
Er															
Tm															
Yb	2.5	24	9.9	(a)											
Lu	0.34	1.37	3.5	(a)											
Hf	2.22	26.4	9.9	(a)											
Ta	0.29	2.9	1.1	(a)											
W ppb															
Re ppb	0.54			(b)											
Os ppb	7.3			(b)											
Ir ppb	8	12.6	11.3	(b)											
Pt ppb															
Au ppb	8.8	8	8	(b)											
Th ppm	1.34	14.1	6.2	(a)											
U ppm	0.34	3.4	1.6	(a)											

technique: (a) INAA, (b) RNAA, (c) e. probe, fused bead, (d) elec. Probe

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