15059

Regolith Breccia

1149 grams

Figure 1: Lunar breccia 15059 (bottom side). Sample is 13 cm across. NASA S71-45986.

Introduction

Ryder (1985) described 15059 as a "tough regolith breccia containing mare basalt and KREEP basalt and abundant glass, in a glassy matrix. A thin very vesicular glass coat covers most of the sample and intrudes it along fractures (figure 1)."

Petrography

Kridelbaugh et al. (1972) and Ryder (1985) give the only descriptions of 15059 and its clast assemblage. The matrix is fine-grained and very similar to the soil from the site. The matrix is cryptocrystalline and unrecrystallized, with fragments of basalt, microbreccia and glass particles of various shapes and composition. The basalt clasts in 15059 are ophitic pyroxene basalts, containing no olivine. Clasts of microbreccia are subordinate in amount to the basalt clasts and are noritic in mineralogy; the dominate minerals are orthopyroxene and calcic plagioclase (An_{87-92}), with minor high-Ca pyroxene, ilmenite, olivine and whitlockite. The matrix has cross-cutting veinlets of a highly vesicular glass. The maturity index Is/FeO, is 32-49 (McKay et al. 1984) and density is 2.19 g/cm^3 (Wentworth and McKay 1984). McKay et al. (1989) report the Is/FeO as 36 (submature soil).

Mineralogy

Glass: Kridelbaugh et al. (1972) analyzed a large number of individual glass particles in 15059 (and 15028). The glass particles are clear and homogeneous and have the same relative proportions as the soil. The distinctive mafic green glass particles have the same

composition as in the soil. Glasses with the composition of KREEP basalt, and mare basalt are present.

Chemistry

Fruchter et al. (1973), Ganapathy et al. (1973) and McKay et al. (1989) have analyzed the matrix and some clasts in 15059 (table 1, figure 2).

Other Studies

Leich et al. (1973) determined the hydrogen content as function of depth for glass-coated rock chips from top and bottom of 15059 (figure 6).

McKay et al. (1989) report the isotopic composition of rare gases from 15059.

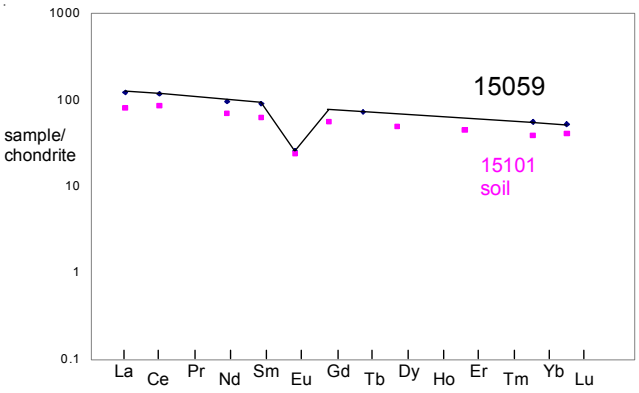


Figure 2: Normalized rare earth element diagram for 15059, compared with that of soil 15101 (data from Weismann et al. 1977).

Processing

A slab (2 cm. thick) was cut from the middle of 15059 (figure 3, 4), and was the object of study by the "Goles Consortium". Chips of 15059 were used in the encapsulated educational lunar disks.

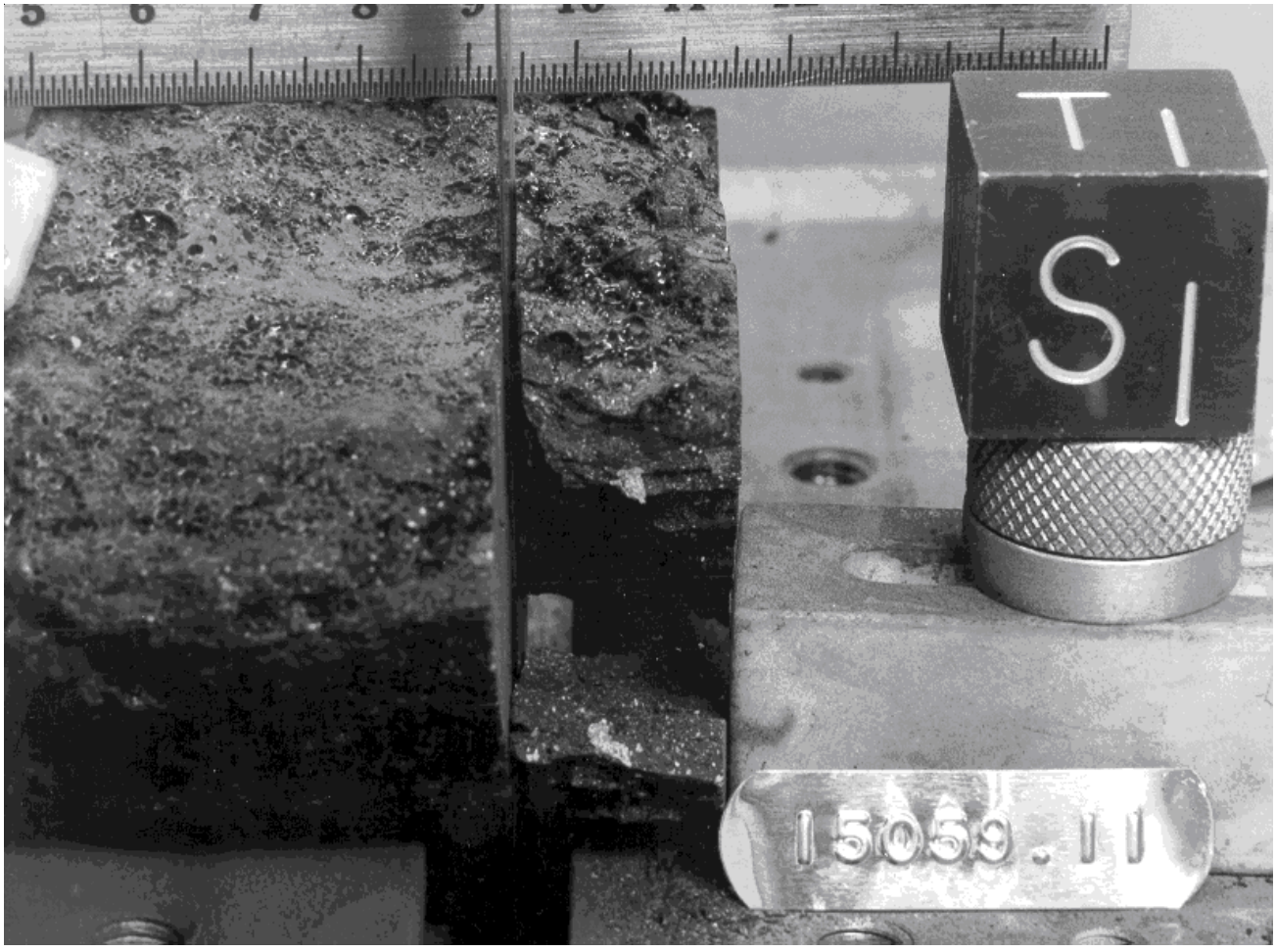


Figure 3: Second band saw cut of 15059 producing slab 2 cm. thick. NASA S72-16050. Cube is 1 inch.

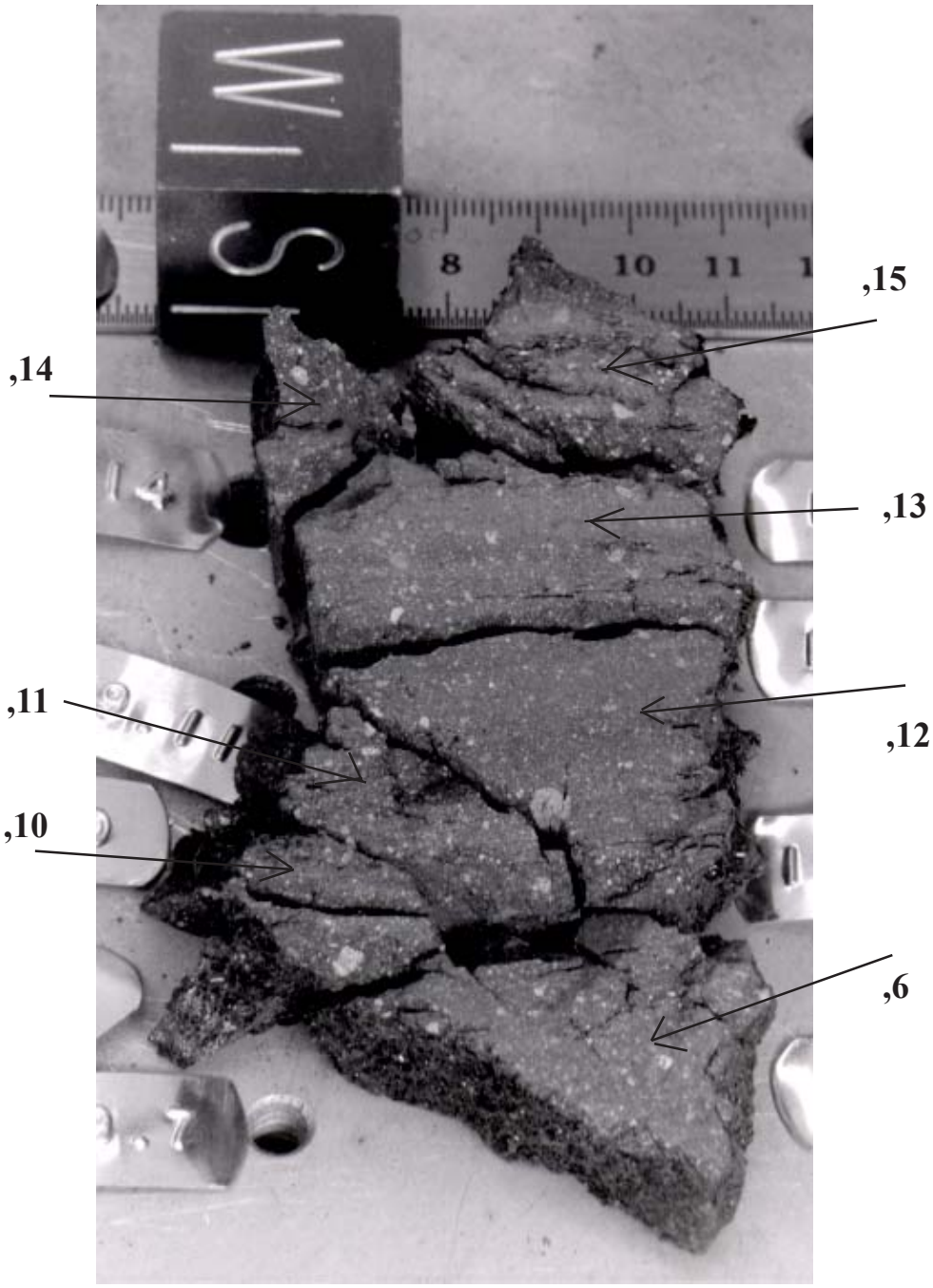


Figure 4: Slab cut from middle of 15059. Cube is 1 inch. NASA # S712-16064.

List of Photo #s for 15059

S71-45722 – 736	B&W mug
S71-45745 – 761	B&W mug
S71-50755 – 778	color ,1
S71-44212 – 217	color
S71-45971 – 972	color
S71-55985 – 988	color
S71-48798 – 799	B&W
S72-16748	slab
S72-16767	,4 B&W
S72-16044 – 066	cutting
S72-16064	slab
S75-20884	,4 color
S88-44527 – 534	,0

Figure 5: Sawn surface of 15059,0. NASA photo # S88-44534.
11 cm. long

Table 1. Chemical composition of 15059.

			clasts								
reference	Fruchter 73							Ganapathy 73		McKay 89	
weight	matrix	glass	basalt	basalt	norite	norite		matrix		matrix	
SiO2 %											
TiO2	1.98	2	1.6	1.89	2.8	2.09	(a)			1.73	(a)
Al2O3	13.3	12.2	3.19	9.96	15.5	16.06	(a)			13.6	(a)
FeO	14.8	14.8	21.74	17.5	13.5	11.3	(a)			15	(a)
MnO										0.2	(a)
MgO										10.4	(a)
CaO										10.2	(a)
Na2O	0.46	0.47	0.17	0.32	0.81	0.73	(a)			0.45	(a)
K2O	0.2	0.21	0.04	0.13	0.53	0.37	(a)				
P2O5											
S %											
sum											
Sc ppm	30	30	27	30	29	24	(a)			28.9	(a)
V										105	(a)
Cr	2890	2880	4600	4300	2400	2550	(a)			2840	(a)
Co	42	44	73	57	30	28	(a)			61.6	(a)
Ni										615	(a)
Cu											
Zn								13.5	(b)		
Ga											
Ge ppb								306	(b)		
As											
Se								0.167	(b)		
Rb								5.8	(b)		
Sr										165	(a)
Y											
Zr										420	(a)
Nb											
Mo											
Ru											
Rh											
Pd ppb											
Ag ppb								5.4	(b)		
Cd ppb								35.5	(b)		
In ppb								2.7	(b)		
Sn ppb											
Sb ppb								0.99	(b)		
Te ppb								3.4	(b)		
Cs ppm								0.245	(b)	0.28	(a)
Ba	300	270			820	670	(a)			287	(a)
La	27	26	6.2	17	75	55	(a)			28.8	(a)
Ce	73	68		50	189	140	(a)			72	(a)
Pr											
Nd	45	45			120	100	(a)			44	(a)
Sm	13.4	13	3.5	9.1	36.7	27.3	(a)			13.4	(a)
Eu	1.48	1.42	0.66	1.18	2.91	2.14	(a)			1.46	(a)
Gd											
Tb	2.2	2.2	0.6	1.6	5.6	4.4	(a)			2.65	(a)
Dy											
Ho											
Er											
Tm											
Yb	9.1	8.3	2.3	5.1	24	15	(a)			9.1	(a)
Lu	1.38	1.42	0.38	0.86	3.48	2.59	(a)			1.28	(a)
Hf	10	9.4	2.5	6.3	25.5	19.3	(a)			10.7	(a)
Ta	1.2	1.2			3	2.1	(a)			1.31	(a)
W ppb											
Re ppb								0.55	(b)		
Os ppb											
Ir ppb								7	(b)	6.2	(a)
Pt ppb											
Au ppb								2.45	(b)	<4	
Th ppm	4.8	4.2	1.1	2.9	13.4	9.7	(a)			4.9	(a)
U ppm										1.35	(a)

technique: (a) INAA, (b) RNAA

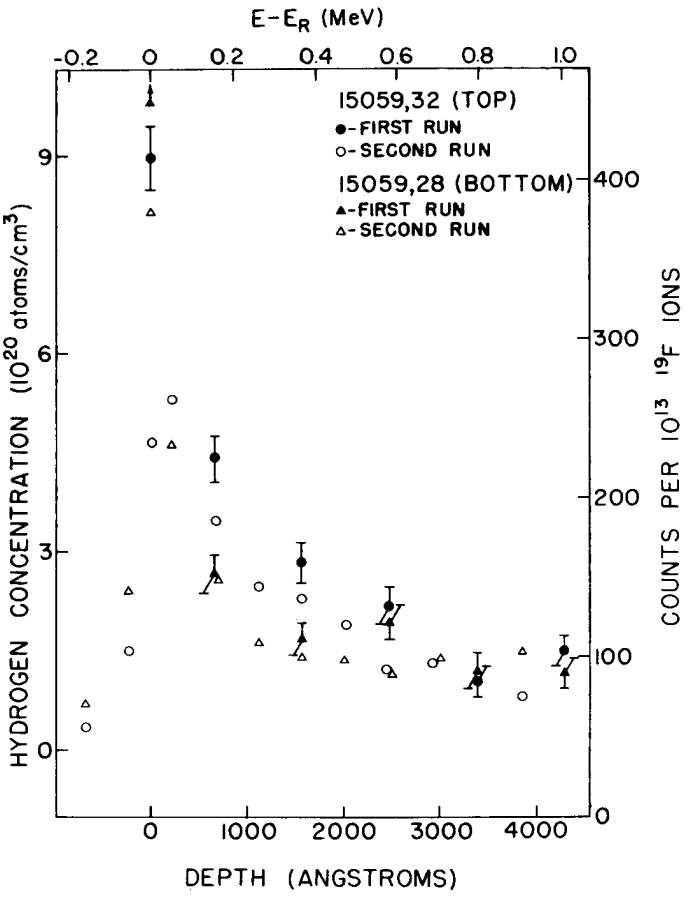
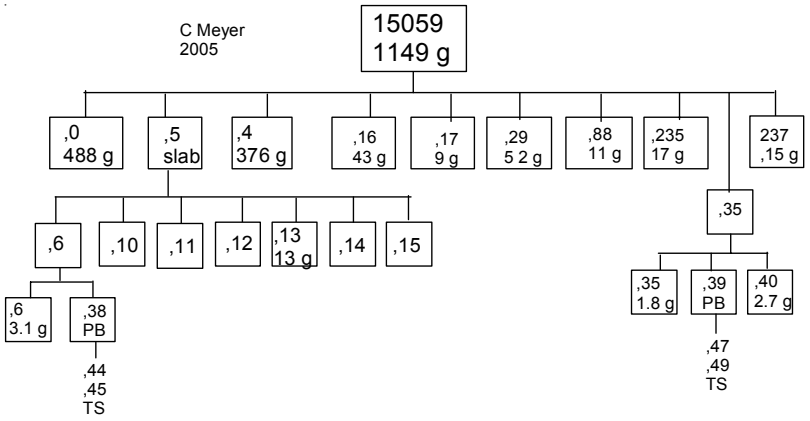


Figure 6: Hydrogen content as function of depth for glass-coated rcok chips from top and bottom of 15059 (Leich et al. 1973).



References for 15059.

Butler P. (1971) Lunar Sample Catalog, Apollo 15. Curators' Office, MSC 03209

Fruchter J.S., Stoeser J.W., Lindstrom M.M. and Goles G.G. (1973) Apollo 15 clastic materials and their relationship to local geologic features. *Proc. 4th Lunar Sci. Conf.* 1227-1237.

Fruland R.M. (1983) Regolith Breccia Workbook. Curatorial Branch Publication # 66. JSC 19045.

Ganapathy R., Morgan J.W., Krahenbuhl U. and Anders E. (1973) Ancient meteoritic components in lunar highland rocks: Clues from trace elements in Apollo 15 and 16 samples. *Proc. 4th Lunar Sci. Conf.* 1239-1261.

Kridelbaugh S.J., Grieve RAF and Weill D.F. (1972) Glass compositions in breccias 15028 and 15059. *In* **The Apollo 15 Lunar Samples**, 123-125.

Leich D.A., Tombrello T.A. and Burnett D.S. (1973) The depth distribution of hydrogen and fluorine in lunar samples. *Earth Planet. Sci. Lett.* **19**, 305-314.

Leich D.A., Tombrello T.A. and Burnett D.S. (1973) The depth distribution of hydrogen and fluorine in lunar samples. *Proc. 4th Lunar Sci. Conf.* 1597-1612.

LSPET (1972a) The Apollo 15 lunar samples: A preliminary description. Science 175, 363-375.

LSPET (1972b) Preliminary examination of lunar samples. Apollo 15 Preliminary Science Report. NASA SP-289, 6-1—6-28.

McKay D.S., Morris R.V. and Wentworth S.J. (1984) Maturity of regolith breccias as revealed by ferromagnetic and petrographic indicies (abs). *Lunar Planet. Sci*. **XV**, 530-531. Lunar Planetary Institute, Houston.

McKay D.S., Bogard D.D., Morris R.V., Korotev R.L., Wentworth S.J. and Johnson P. (1989) Apollo 15 regolith breccias: Window to a KREEP regolith. *Proc. 19th Lunar Sci. Conf.* 19-41. Lunar Planetary Institute, Houston.

Ryder G. (1985) Catalog of Apollo 15 Rocks (three volumes). Curatoial Branch Pub. # 72, JSC#20787

Ryder G. and Norman M.D. (1979a) Catalog of pristine non-mare materials Part 1. Non-anorthosites, revised. NASA-JSC Curatorial Facility Publ. JSC 14565, Houston. 147 pp.

Ryder G. and Norman M.D. (1979b) Catalog of pristine non-mare materials Part 2. Anorthosites. Revised. Curators Office JSC #14603

Swann G.A., Hait M.H., Schaber G.C., Freeman V.L., Ulrich G.E., Wolfe E.W., Reed V.S. and Sutton R.L. (1971b) Preliminary description of Apollo 15 sample environments. U.S.G.S. Interagency report: 36. pp219 with maps

Swann G.A., Bailey N.G., Batson R.M., Freeman V.L., Hait M.H., Head J.W., Holt H.E., Howard K.A., Irwin J.B., Larson K.B., Muehlberger W.R., Reed V.S., Rennilson J.J., Schaber G.G., Scott D.R., Silver L.T., Sutton R.L., Ulrich G.E., Wilshire H.G. and Wolfe E.W. (1972) 5. Preliminary Geologic Investigation of the Apollo 15 landing site. In Apollo 15 Preliminary Science Rpt. NASA SP-289. pages 5-1-112.

Wentworth S.J. and McKay D.S. (1984) Density and porosity calculations for Apollo 15 and 16 regolith breccias (abs). *Lunar Planet Sci*. **XV**, 906-907. Lunar Planetary Institute, Houston.