74001 – 1072 grams
74002 – 909.6 grams

Double drive tube

68.2 cm

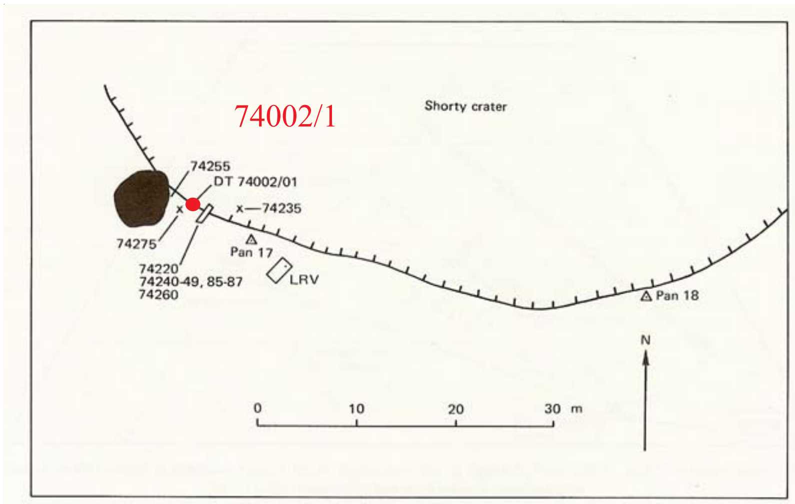

Figure 1: Map of rim of Shory Crater where core 74002/1 was taken.

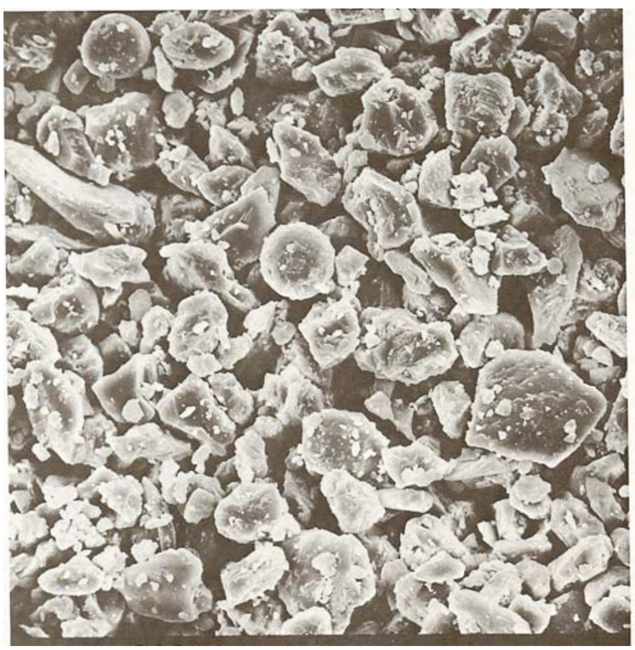

Figure 2: SEM photo of fragments in 74001 core showing that most are broken (Cirlin et al. 1978).

Transcript

CC We'd like to get the double core here.

LMP Did you want it in the orange?

CC Rodger that. Affirm.

LMP Well, it's a vertical stratigraphy. Do you want to go sideways a little with it? Or do you just want to get it as deep as you can, huh?

CC Let's go as deep as we can in the orange.

CDR The bottom will be 44, and the top will be 35.

LMP You know that we just about got to the upper edge of this little ellipsoid zone. I think we've messed up most of it. Let's try right over here. The upper portion of the core is going to be a little bit disturbed, because we've walked around the area so much.

Introduction

This core was taken adjacent to the trench were the orange soil 74220 was collected – see figure 1 in sections on 74220 and 74241. 74002 is the top section, and 74001 is the bottom. It took more than 28 hammer blows, and a lot of effort, to drive this double core into the orange-black soil (see transcript). Both the top and bottom sections were completely filled with material.

The density of the material in this core was greater than any other lunar core (Mitchell et al. 1973). The X-ray radiographs of the core showed very little structure (figure 3).

The material in 74002/1 has been exposed to cosmic rays for 17 m.y,, but also been previously exposed (for about 35 m.y.) much earlier in its history. There is the possibility that the 74002/1 is upside down compared with its original deposition (Heiken and McKay 1978).

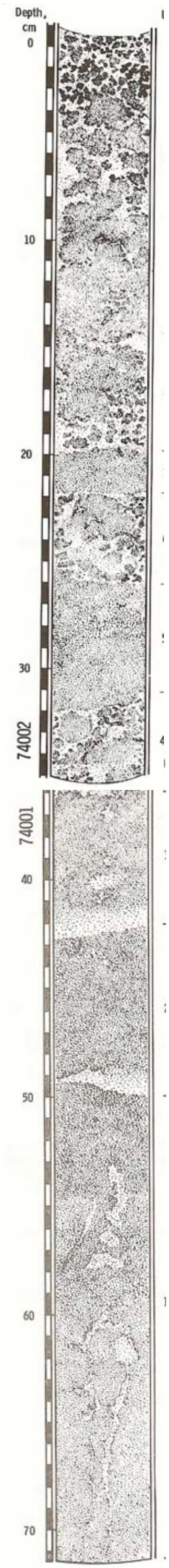

Figure 3: Artist rendition of X-ray of double drive tube 74002, 74001. Length is about 70 cm.

CDR Take your picture. That's about a far as I could shove it in.

CC Was the gray mantle over the top of this, or was this showing all the way through to the surface.

LMP No, it was over the top. It was about a half a centimeter over the top. We're getting about 3 centimeters a whack.

CC Very good.

CDR I'll tell you, it's a lot harder going in than that double core was back there. It's pretty hard.

LMP It acts like it's inherently cohesive. It breaks up in angular fragments. An essential portion of the zone actually has a crimson hue, or red hue. Outside of that it's orange. And outside of that, it's gray.

CDR I'm going up to the max here for just a minute or two. OK, let me hit some more. Ready?

LMP Have at it. He's still getting a centimeter a whack, poor guy. I better get a locator.

CDR The only thing I question is our ability to get it out. Man, That's really hit bottom. Pull slowly. Slowly so I can cap it all right. Let me get a cap. OK, vry slowly. Even the core tube is red! The bottom one's black – black and orange, and the top one's gray and orange!

LMP The fact is, the bottom of the core is very black compared to anything we've seen.

CDR Hey, we must have gone through the red soil because it's filled, but it's filled with back material. Dark gray, almost a very fine grained - -

LMP That might be magnetite. God, it is black isn't it?

CDR Yes. Boy, it is black and is it contrasted to that orange stuff. Very black. We, not very black. It's a good dark gray. Very dark bluish gray. Why don't you take a picture of the hole, while you've got a camera there?

LMP Well the hole's mostly in shadow.

CDR The bottom of the upper core is also dark. And, like you might expect, the top of the bottom core is dark, too.

LMP If I ever saw a classic alteration halo around a volcanic crater, this is it. It's ellipsoidal. It appears to be zoned. There's one sample we didn't get. We didn't get the more yellow stuff, we got the center portion.

\- - -

LMP The lower core is chunky-jam full. I don't think we budged that thing. Hey, bob, thoise core didn't feel like the follower went down at all. Shouldn't it have gone a little bit?

CC Not necessarily, if it's pretty compact stuff. You were having a hard time getting it in.

LMP Well, I thought there was a little space up there, but maybe I just didn't feel it.

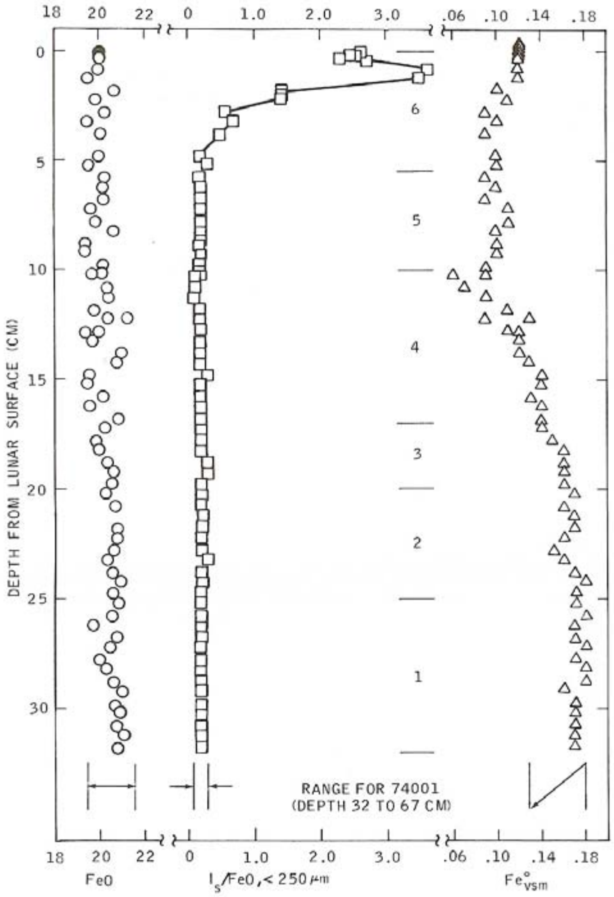

Figure 4: Maturity index for top of double drive tube (Morris et al. 1978).

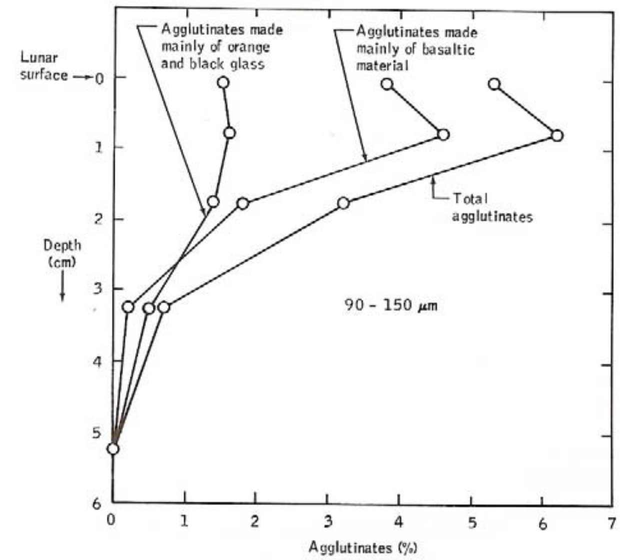

Figure 5: Agglutinates, of different origin, in top few centimeters of 74002 (McKay et al. 1978).

Petrography

The overall description of the Orange Soil samples from Shorty Crater is compiled in the sections for 74220 and 74241 – here I discuss the double drive tube in greater detail.

74002 was first opened and described in 1977 and 74001 was studied in 1981, although two grams of material from the bottom of the core were examined by the PET (LSPET 1973). The initial description was that the material from the bottom of the core was "unusually cohesive and consists of very dark to black opaque spheres and conchoidally fractured fragments".

Pieters et al. (1980) studied the variation in color of 74002 using multispectral (vidiocon) techniques to try to map the stratigraphy. However, it is hard to discern what was learned from this effort (see montage in their paper).

Cirlin et al. (1978) and McKay et al. (1978) found that most of the glass particles in the core were broken fragments (figure 2). This can also be seen in the thin sections of the core. On average, about 20 % of the particles are whole, 7 % are chipped and 73 % are broken. The reason the core is black is because most of the glass is devitrified, with olivine needles coated with ilmenite (Haggerty 1974).

McKay et al. (1978) and Krahenbuhl (1980) studied the grain size distribution (figure 6) for several depth intervals *(be aware that sieving may not always have been complete, and could be the cause for variation).* They make the point that this sample is, on average, finer than any other lunar soil studied by them. The average grain size along the entire depth of the core is only 40 ± 5 microns.

McKay et al. (1978) determined the modal mineralogy for the top 5 cm of the core. There were a few basalt fragments and a few agglutinates in the top (figure 5).

The glass in 74002/1 contains olivine phenocrysts Fo_{81}. Only a few glass particles have vesicles.

Clanton et al. (1978), Butler and Meyer (1976) and Cirlin and Housley (1979) studied the surface coatings on glass beads from this core (verifying the conclusion of Meyer et al. 1975) that these were sublimates produced during fire fountaining.

Table 1. Chemical composition of 74002/1

	74001,11		74001,5														
reference	Philpotts74		Morgan74		Blanchard78				Nunes74			Morgan79				Krahenbuhl79	
depth	~ 40 cm				average	0 - 2 cm	2 - 68 cm					upper	middle	lower	base	ave of 4 depths	
SiO2 %																	
TiO2					8.9	8.8	8.9	(c)									
Al2O3					6.1	6.7	5.8	(c)								7.5	(c)
FeO					23.4	22.5	23.7	(c)								22.1	(c)
MnO					0.27	0.26	0.27	(c)									
MgO					15	14	15	(c)									
CaO					7.8	8.6	7.6	(c)									
Na2O					0.43	0.45	0.42	(c)								0.4	(c)
K2O	0.07	(a)															
P2O5																	
S %																	
sum																	
Sc ppm					48	49	48	(c)								47	(c)
V					114			(c)									
Cr					5200	5063	5200	(c)									
Co					64	60	66	(c)								62	(c)
Ni			68	(b)	80			(c)			66	51	53	68	(b)		
Cu																	
Zn			148	(b)	194			(c)			178	185	151	148	(b)	~ 140	(b)
Ga																	
Ge ppb			105	(b)							144	179	122	105	(b)	~170	(b)
As																	
Se			350	(b)							380	490	353	350	(b)		
Rb	0.814	(a)	0.76	(b)													
Sr	203	(a)															
Y																	
Zr	223	(a)															
Nb																	
Mo																	
Ru																	
Rh																	
Pd ppb											1.1	1.3	1.7		(b)		
Ag ppb			72	(b)							82	116	75	72	(b)		
Cd ppb			25	(b)							59	18.5	8.7	25	(b)	~40	(b)
In ppb											10.5	13.7	6.3		(b)	~20	(b)
Sn ppb																	
Sb ppb			1.16	(b)							1.25	0.73	0.77	1.16	(b)		
Te ppb			38	(b)												~70	(b)
Cs ppm			0.037	(b)													
Ba	73.8	(a)															
La					6	6.4	5.9	(c)								6	(c)
Ce	18.4	(a)			21	24	21	(c)								29	(c)
Pr																	
Nd	17.8	(a)															
Sm	6.61	(a)			7	7.4	6.9	(c)								6.7	(c)
Eu	1.86	(a)			1.87	1.85	1.88	(c)									
Gd	8.52	(a)						(c)									
Tb					1.6	1.7	1.6	(c)									
Dy	9.01	(a)															
Ho																	
Er	4.68	(a)															
Tm																	
Yb	4	(a)			4.3	4.5	4.2	(c)								4	(c)
Lu	0.617	(a)			0.61	0.66	0.59	(c)									
Hf					6.2	5.9	6.3	(c)									
Ta					1.2	1.3	1.2	(c)									
W ppb																	
Re ppb			0.213	(b)							0.014	0.016	0.024	0.02	(b)		
Os ppb											0.045	0.049	0.035				
Ir ppb			0.021	(b)							0.042	0.048	0.016	0.03	(b)	~0.9	(b)
Pt ppb																	
Au ppb			0.705	(b)							0.67	1.04	0.73	0.71	(b)	~1	(b)
Th ppm					0.4	0.5	0.4	(c)	0.466	(a)							
U ppm			0.141	(b)					0.139	(a)	0.143	0.15	0.151	0.14	(b)	0.14	(b)

technique: (a) IDMS, (b) RNAA, (c) INAA

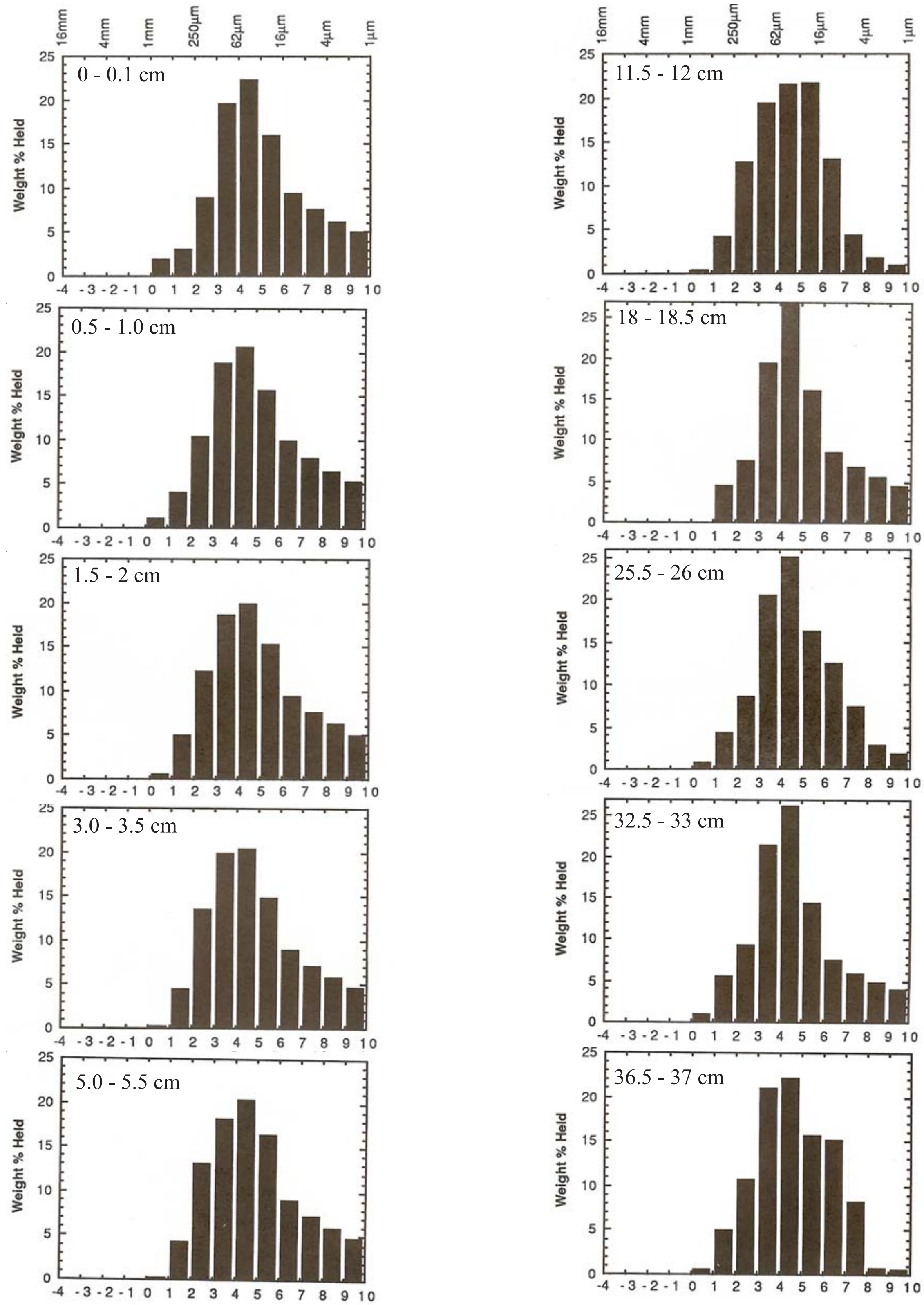

Figure 6a: Grain size distribution for 74002 - 74001 (Graf 1993, from data by McKay et al. 1978).

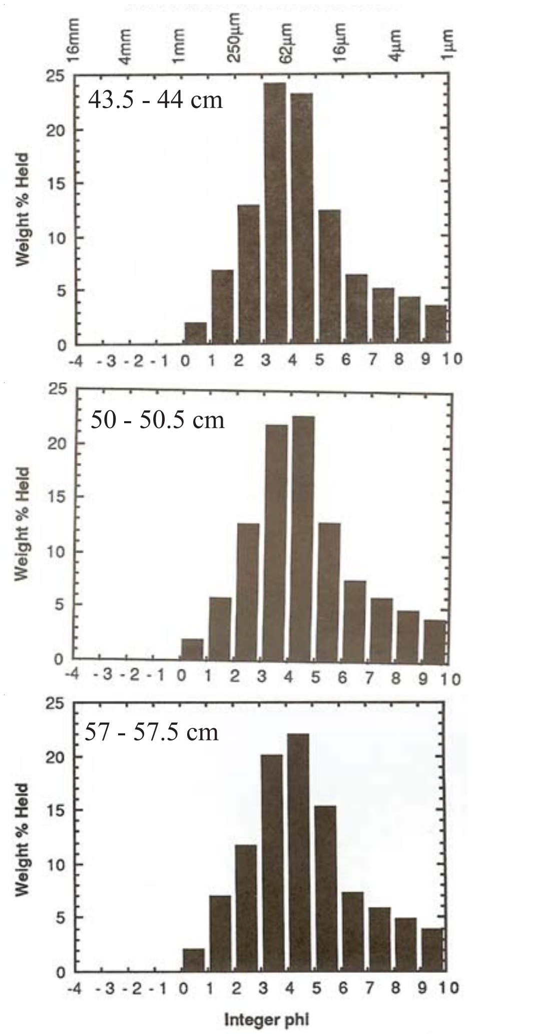

Figure 6b: Grain size distribution for 74002 - 74001 (Graf 1993, from data by McKay et al. 1978).

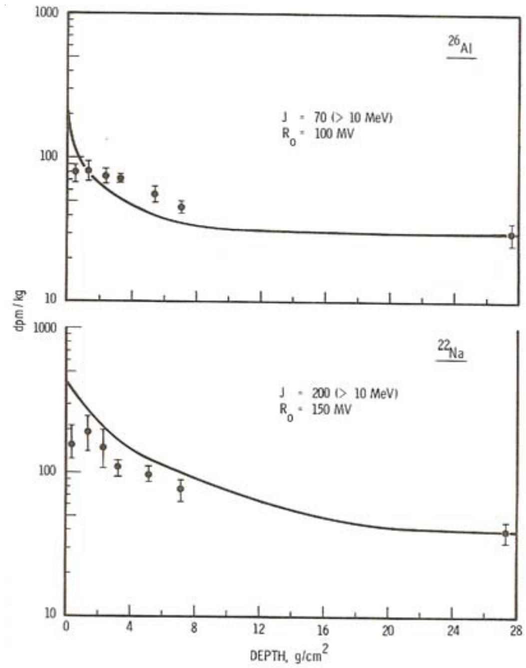

Figure 7: 22Na and 26Al profiles with depth in upper portion of core (Fruchter et al. 1978).

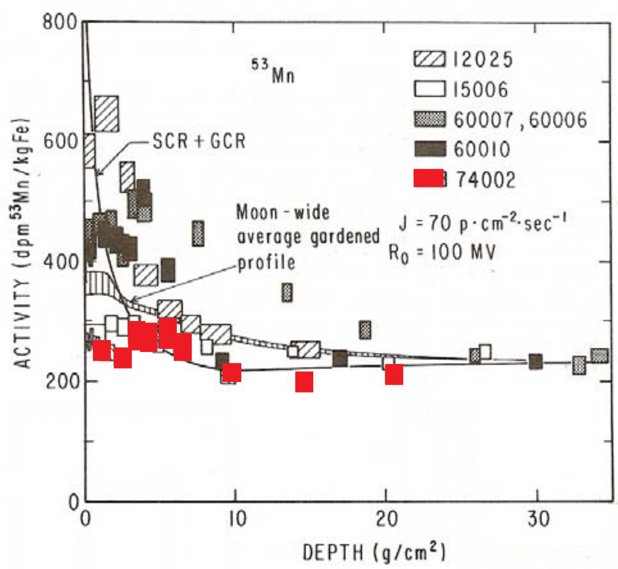

Figure 8: 53Mn profile of 74002/1 compared with other cores and with theoretical curves (Murrell et al. 1979).

Chemistry

Since the double drive tube was taken immediately adjacent to the Orange Soil sample 74220, one can assume that the composition is the same.

Blanchard and Budahn (1978) analyzed 13 layers along the double core 74002/1 and found the core to be uniform in composition, except, perhaps the top 2 centimeters, which were either gardened or disturbed. They also analyzed the fine fraction (0 – 20 microns), finding that it was enriched in Zn (302 ppm) and proving that it was surface correlated. Krahenbuhl (1980) analyzed four layers @12, 25, 38 and 55 cm for 7 different grain sizes, showing that Zn, Hg, Ge and Au were enriched in the finer fraction, proving that the volatile and chalcophile elements are on the surfaces (figures 10 and11). Morgan and Wandless (1979) claimed they could tell what kind of meteorite caused the crater (which?).

Gibson and Andrawes (1978) determined the sulfur content along the core finding that it was evenly distributed at about 550 ppm Simple heating removed most of the sulfur, consistent with the idea that the sulfur is a surface coating. Cirlin et al. (1978) showed conclusively that Pb, Zn and Cd were surface deposits. Jovanovic and Reed (1979) reported Hg and Br.

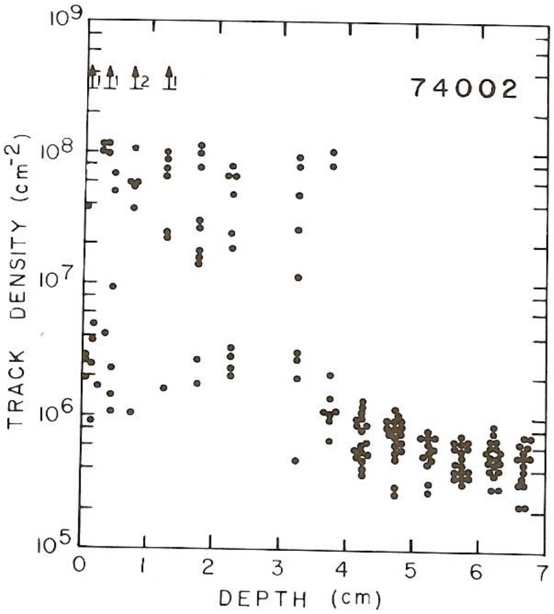

Figure 9: Density of fossil tracks in olivine phenocrysts in top 7 cm of core 74002 (Crozaz 1979).

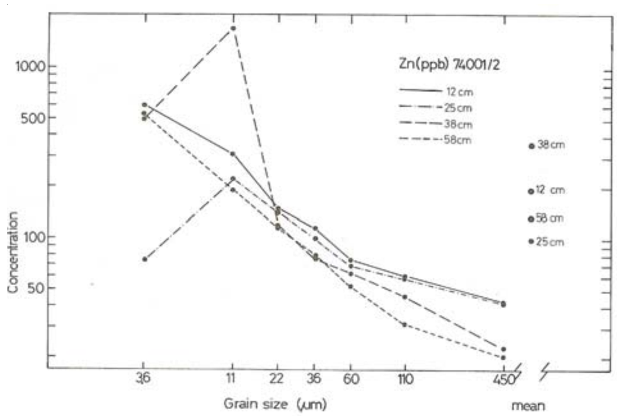

Figure 10: Zn content as function of grain size (Krahenbuhl 1979).

Radiogenic age dating

The age of Shorty Crater is 17 m.y., based on exposure age of 74255. The age of the glass beads in the Orange Soil are 3.7 b.y. (Eberhardt et al. 1975) and or 3.66 b.y. (Saito and Alexander 1979). Eugster et al. (1979) also used a unique U – fission Xe dating technique to obtain n age of 3.7 b.y.

Nunes et al. (1974) reported data for U-Th-Pb, but no age can be ascertained from this.

Cosmogenic isotopes and exposure ages

Fruchter et al. (1978) determined the cosmic-ray-induced activity of ^{22}Na and ^{26}Al (figure 7). Murrell et

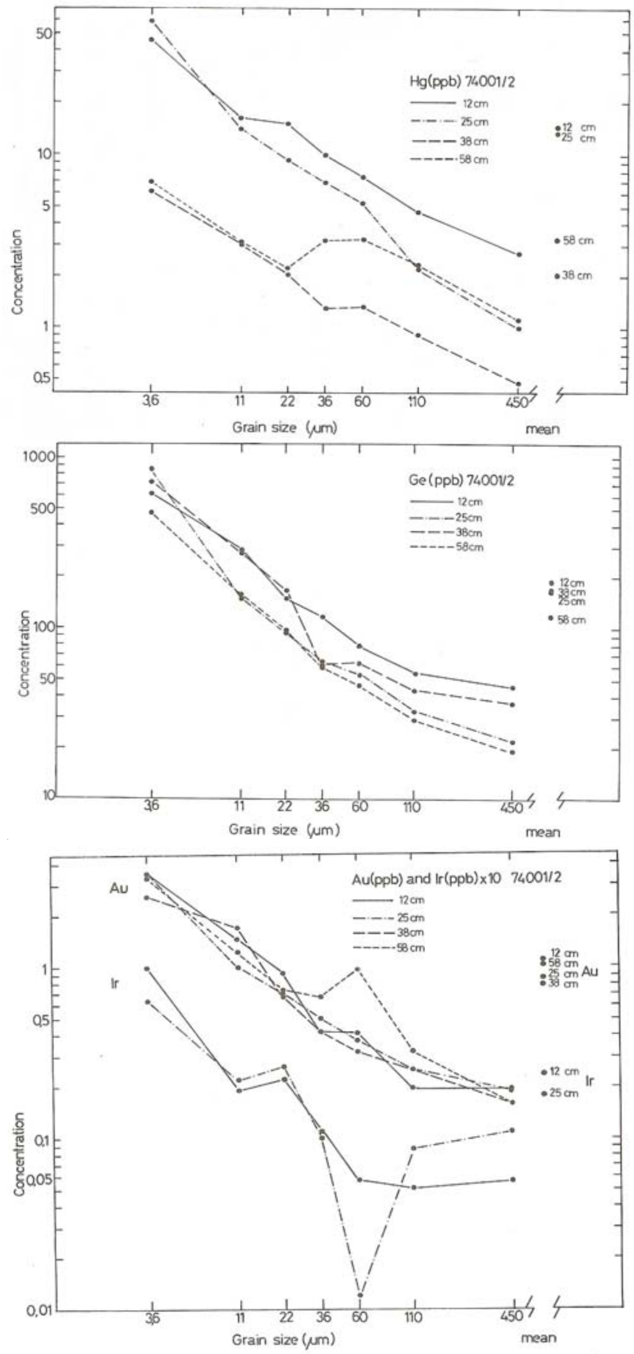

Figure 11: Hg, Ge, Au and Ir as function of grain size (Krahenbuhl 1979).

al. (1979) and Nishiizumi et al. (1983) presented a profile for cosmic-ray-induced ^{53}Mn (figure 8). Nishiizumi et al. found a best fit to the theoretical curve if ~ 4 g/cm^2 was removed from the top.

Other Studies

Eugster et al. (1977, 1978, 1979) and Bogard and Hirsch (1978) have studied the rare gas isotopes in the

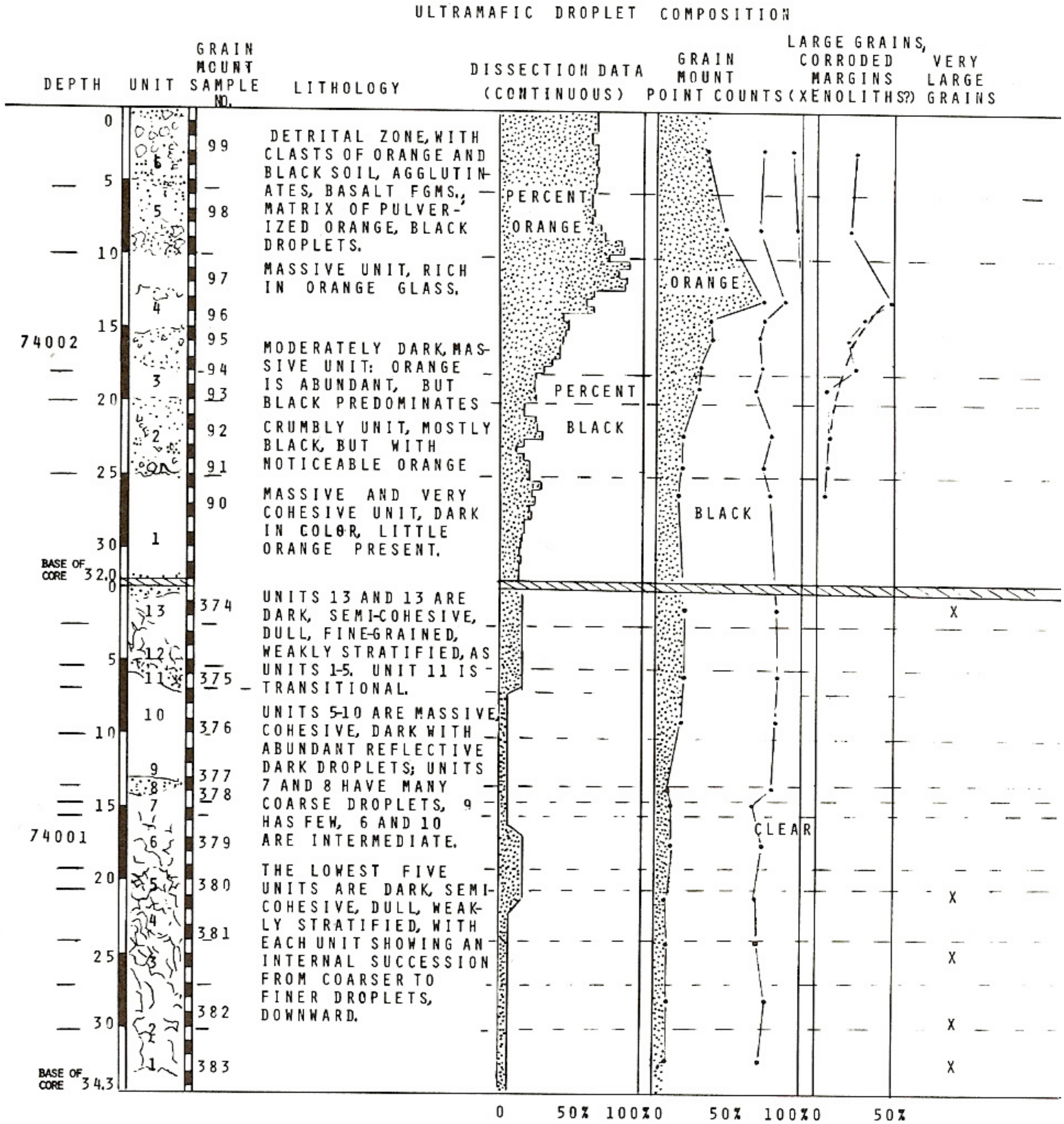

Figure 12: Nagle's summary of 74002/1.

double drive tube. Kerridge et al. (1991) studied the nitrogen isotopes.

Crozaz (1978, 1979) determined the fossil nuclear tracks as function of depth (figure 9).

Processing

Lunar photographs of the core were unsuccessful (a shame). The cores were X-rayed in 1974, again in 1976, extruded in 1977-1978 and described in newsletters # 13 and 16. Nagle (1978) summarized his findings in figure 12. Several large "clumps" were removed during dissection. Two complete sets of thin sections were prepared, but have never been described.

So what we have here is an important core that hasn't been properly described, nor analyzed, with an abundance of samples ready to study!

References for 74001-2 core

Blanchard D.P. and Budahn J.R. (1978) Chemistry of orange/black soils from core 74001/2. *Proc. Lunar 9th Planet. Sci. Conf.* 1969-1980.

Bogard D.D. and Hirsch W.C. (1978) Depositional and irradiational history and noble gas contents of orange-black droplets in the 74002/1 core from Shorty Crater. *Proc. 9th Lunar Sci. Conf.* 1981-2000.

Butler P. (1973) Lunar Sample Information Catalog Apollo 17. Lunar Receiving Laboratory. MSC 03211 Curator's Catalog. pp. 447.

Butler P. (1978) Recognition of lunar glass droplets produced directly from endogenous liquids: The evidence from S-Zn coatings. *Proc. 9th Lunar Planet. Sci. Conf.* 1459-1471.

Butler P. and Meyer C. (1976) Sulfur prevails in coatings on glass droplets: Apollo 15 green and brown glasses and Apollo 17 orange and black (devitrified) glasses. *Proc. 7th Lunar Sci. Conf.* 1561-1581.

Cirlin E.H., Housley R.M. and Grant R.W. (1978) Studies of volatiles in Apollo 17 samples and their implications to vapor transport processes. *Proc. 9th Lunar Planet. Sci. Conf.* 2049-2063.

Cirlin E.H. and Housley R.M. (1979) Scanning Auger microprobe and atomic absorption studies of lunar volcanic volatiles. *Proc. 10th Lunar Planet. Sci. Conf.* 341-354.

Clanton U.S., McKay D.S., Watts G. and Fuhrman R. (1978) Sublimate morphology on 74001 and 74002 orange and black glassy droplets. *Proc. 9th Lunar Planet. Sci. Conf*. 1945-1957.

Crozaz G. (1978) Regolith depositional history at Shorty Crater. *Proc. 9th Lunar Planet. Sci. Conf.* 2001-2009.

Crozaz G. (1979) Regolith reworking at Shorty Crater. *Proc. 10th Lunar Planet. Sci. Conf.* 1381-1384.

Duke M.B. and Nagle J.S. (1976) Lunar Core Catalog. JSC09252 rev. Curators' Office

Fryxell R. and Heiken G. (1974) Preservation of lunar core samples: Preparation and interpretation of three-dimensional stratigraphic sections. *Proc. 5th Lunar Sci. Conf.* 935-966.

Eugster O., Eberhardt P., Geiss J., Grögler N., Jungck M. and Mörgeli M. (1977) The cosmic-ray exposure history of Shorty Crater samples; the age of Shorty Crater. *Proc. 8th Lunar Sci. Conf.* 3059-3082.

Eugster O., Grögler N., Eberhardt P. and Geiss J. (1979) Double drive tube 74001/2: History of the black and orange glass; Determination of a pre-exposure 3.7 AE ago by $^{136}Xe/^{235}U$ dating. *Proc. 10th Lunar Planet. Sci. Conf.* 1351-1379.

Eugster O., Grögler N., Eberhardt P. and Geiss J. (1980) Noble gases trapped 3.7 AE ago in orange and black glasses from drive tubes 74001/2 (abs). *Lunar Planet. Sci.* **XI**, 268-270. Lunar Planetary Institute, Houston.

Eugster O., Grögler N., Eberhardt P. and Geiss J. (1980) Double drive tube 74001/2: Composition of noble gases trapped 3.7 AE ago. *Proc. 11th Lunar Planet. Sci. Conf.* 1565-1592.

Eugster O., Grögler N., Eberhardt P., Geiss J. and Kiesl W. (1981) Double drive tube 74001/2: A two-stage exposure model based on noble gases, chemical abundances and predicted production rates. Proc. *12th Lunar Planet. Sci. Conf.* 541-558.

Fruchter J.S., Rancitelli L.A., Evans J.C. and Perkins R.W. (1978) Lunar surface processes and cosmic ray histories over the past several million years. *Proc. 9th Lunar Planet. Sci. Conf.* 2019-2032.

Gibson E.K. and Andrawes F.F. (1978b) Sulfur abundances in the 74001/74002 drive tube from Shorty Crater Apollo 17. *Proc. 9th Lunar Sci. Conf.* 2011-2017.

Graf J.C. (1993) Lunar Soils Grain Size Catalog. NASA Reference Pub. 1265, March 1993

Haggerty S.E. (1974) Apollo 17 orange glass: Textural and morphological characteristics of devitrification. *Proc. 5th Lunar Sci. Conf.* 193-205.

Heiken G.H., McKay D.S. and Brown R.W. (1974) Lunar deposits of possible pyroclastic origin. *Geochim. Cosmochim. Acta* **38**, 1703-1718.

Heiken G.H. and McKay D.S. (1977) A model for the eruption behavior of a volcanic vent in eastern Mare Serenitatis. *Proc. 8th Lunar Planet. Sci. Conf.* 3243-3255.

Heiken G.H. and McKay D.S. (1978) Petrology of a sequence of pyroclastic rocks from the valley of Taurus-Littrow (Apollo 17 landing site). *Proc. 9th Lunar Planet. Sci. Conf.* 1933-1943.

Herzog G.F., Moynier F., Albarede F. and Brezhnoy A.A. (2009) Isotopic and elemental abundances of copper and zinc in lunar samples - - . *Geochim. Cosmochim. Acta* **73**, 5884-5904.

Jovanovic S. and Reed G.W. (1979) Regolith layering processes based on studies of low-temperature volatile elements in Apollo core samples. *Proc. 10th Lunar Planet. Sci. Conf.* 1425-1435.

Kerridge J.F., Eugster O., Kim J.S. and Marti K. (1991) Nitrogen isotopes in the 74001/74002 double drive tube from Shorty Crater, Apollo 17. *Proc. 21st Lunar Planet. Sci. Conf.* 291-299.

Korotev R.L. and Kremser D. (1992) Compositional variations in Apollo 17 soils and their relationships to the geology of the Taurus-Littrow site. *Proc. 22nd Lunar Planet. Sci. Conf.* 275-301.

Krahenbuhl U. (1980) Distribution of volatile and non volatile elements in grain-size fractions of Apollo 17 drive tube 74001/2. *Proc. 11th Lunar Planet. Sci. Conf.* 1551-1564.

Krahenbuhl U., von Gunten H.R., Jost D, Meyer G. and Wegmuller F. (1979) Major and trace elements in four strata of Apollo 17 drive tube 74001/2. *Meteoritics* **14**, 461-463.

LSPET (1973a) Apollo 17 lunar samples : Chemical and petrographic description. *Science* **182**, 659-690.

LSPET (1973c) Preliminary examination of lunar samples. Apollo 17 Preliminary Science Report. NASA SP-330, 7-1—7-46.

McKay D.S., Fruland R.M. and Heiken G.H. (1974) Grain size and the evolution of lunar soils. *Proc. 5th Lunar Sci. Conf.* 887-906.

McKay D.S., Heiken G.H. and Waits G. (1978) Core 74001/2: Grain size and petrology as a key to the rate of in-situ reworking and lateral transport on the lunar surface. *Proc. 9th Lunar Planet. Sci. Conf.* 1913-1932.

Meyer C., McKay D.S., Anderson D.H. and Butler P. (1975) The source of sublimates on the Apollo 15 green and Apollo 17 orange glass samples. *Proc. 6th Lunar Sci. Conf.* 1673-1699.

Mitchell J.K., Carrier W.D., Costes N.C., Houston W.N., Scott R.F. and Hovland H.J. (1973) 8. Soil-Mechanics. *In* Apollo 17 Preliminary Science Rpt. NASA SP-330. pages 8-1-22.

Morgan J.W., Ganapathy R., Higuchi H., Krahenbuhl U. and Anders E (1974a) Lunar basins: Tentative characterization of projectiles, from meteoritic dements in Apollo 17 boulders. *Proc. 5th Lunar Sci. Conf.* 1703-1736.

Morgan J.W. and Wandless G.A. (1979b) 74001 drive tube: Siderophile elements match IIB iron meteorite pattern. *Proc. 10th Lunar Planet. Sci. Conf.* 327-340.

Morris R.V. and Gose W.A. (1977) Depositional history of core section 74001: Depth profiles of maturity, FeO and metal. *Proc. 8th Lunar Sci. Conf.* 3113-3122.

Morris R.V., Gose W.A. and Lauer H.V. (1978) Depositional and surface history of the Shorty Crater core 74001/2: FMR and magnetic studies. *Proc. 9th Lunar Planet. Sci.* 2033-2048.

Muehlberger W.R. and many others (1973) Preliminary Geological Investigation of the Apollo 17 Landing Site. In Apollo 17 Preliminary Science Report. NASA SP-330.

Muehlberger W.R. and many others (1973) Geologic exploration of Taurus-Littrow: Apollo 17 landing site. *Science* **182**, 672-680.

Murrell M.T., Nishiizumi K. and Arnold J.R. (1979) ^{53}Mn profile 74001/2: Comments on the recent history of the core (abs). *Lunar Planet. Sci.* **X**, 881-883. Lunar Planetary Institute, Houston.

Nagle J.S. (1978a) A comparison of a lunar and a terrestrial volcanic section. *Proc. 9th Lunar Planet. Sci. Conf.* 1509-1526.

Nagle J.S. (1978b) The detrital zone in the Shorty Crater cores. *The Moon* **18**, 499-517.

Nishiizumi K., Murrell M.T. and Arnold J.R. (1983) ^{53}Mn profiles in four Apollo surface cores. *Proc. 14th Lunar Planet. Sci. Conf.* in J. Geophys. Res. 88, B211-B219.

.Nunes P.D., Tatsumoto M. and Unruh D.M. (1974b) U-Th-Pb systematics of some Apollo 17 lunar samples and implications for a lunar basin excavation chronology. *Proc. 5th Lunar Sci. Conf.* 1487-1514.

Papike J.J., Simon S.B. and Laul J.C. (1982) The lunar regolith: Chemistry, Mineralogy and Petrology. *Rev. Geophys. Space Phys.* **20**, 761-826.

Philpotts J.A., Schuhmann S., Kouns C.W., Lum R.K.L. and Winzer S. (1974a) Origin of Apollo 17 rocks and soils. *Proc. 5th Lunar Sci. Conf.* 1255-1267.

Pieters C.M., Hawke B.R., Butler P., Waltz S. and Nagle S. (1980) Multispectral imaging of the lunar regolith core samples: Preliminary results for 74002. *Proc. 11th Lunar Planet. Sci. Conf.* 1593-1608.

Saito K. and Alexander E.C. (1979) ^{40}Ar-^{39}Ar studies of lunar soil 74001 (abs). *Lunar Sci.* **X**, 1049. Lunar Planetary Institute, Houston.

Stone C.D., Taylor L.A., McKay D.S. and Morris R.V. (1982) Ferromagnetic resonance intensity: A rapid method for determining lunar glass bead origin. *Proc. 13th Lunar Planet. Sci. Conf.* in J. Geophys. Res. **87**, A182-A196.

Wolfe E.W., Bailey N.G., Lucchitta B.K., Muehlberger W.R., Scott D.H., Sutton R.L and Wilshire H.G. (1981) The geologic investigation of the Taurus-Littrow Valley: Apollo 17 Landing Site. US Geol. Survey Prof. Paper, 1080, pp. 280.