DRAFT

Luna 24

Drill Core

170 grams

Introduction

In 1974, after successfully entering earth orbit, flying to the moon, entering lunar orbit, and descending toward the surface, the Luna 23 spacecraft was damaged during landing in Mare Crisium (Sea of Crises). The sample collecting apparatus could not operate and no samples were returned. The lander continued transmissions for three days after landing. Then in 1976, Luna 24 successfully collected a drill core sample from Mare Crisium and returned it to Earth automatically. According to Barsukov (1977) the drill penetrated into the regolith 225 cm on an angle with a vertical depth of ~ 200 cm. However, the actual length of the returned core was 160 cm, with total weight of 170 grams. Samples were exchanged with the US, Great Britain, India and other countries.

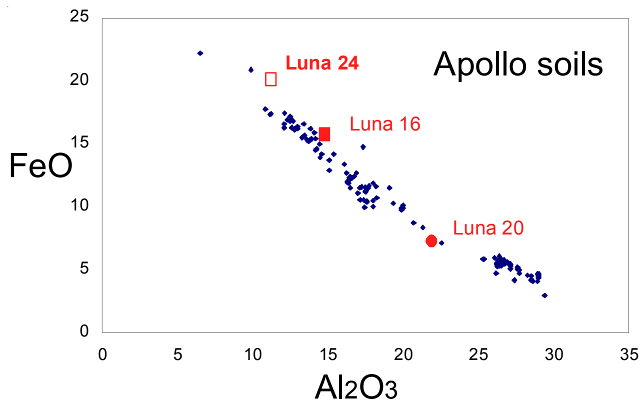


Figure 1: Chemical composition of lunar soils collected robotically.

Duke (1976) wrote: "The samples were obtained with a rotary drill which could be driven alternately by percussion if the core became lodged. The material flowed through the bit, which was 8 mm in diameter, into a plastic liner that was slightly wider. When drill was complete, the liner was extracted from the drill by pulling on a series of strips attached to the inside of the liner along its length. The liner, which

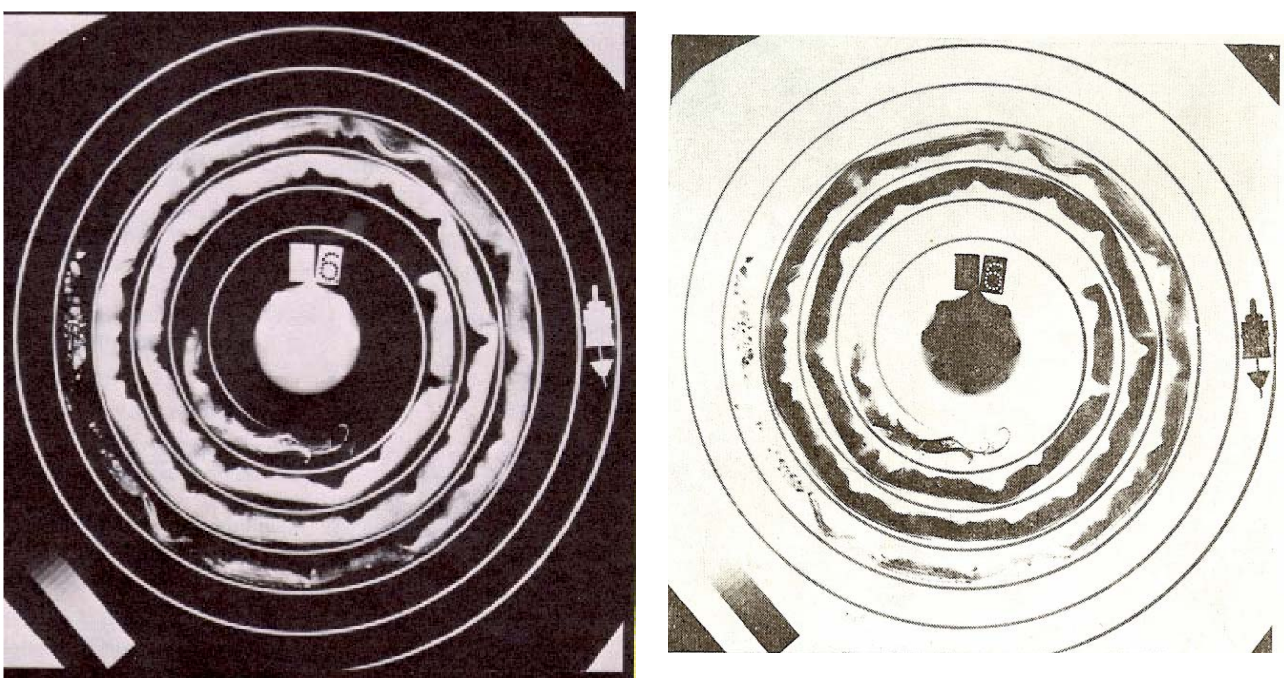


Figure 2: X-ray of Luna 24 core as it was coiled on the "snail" (from Barsukov 1977).

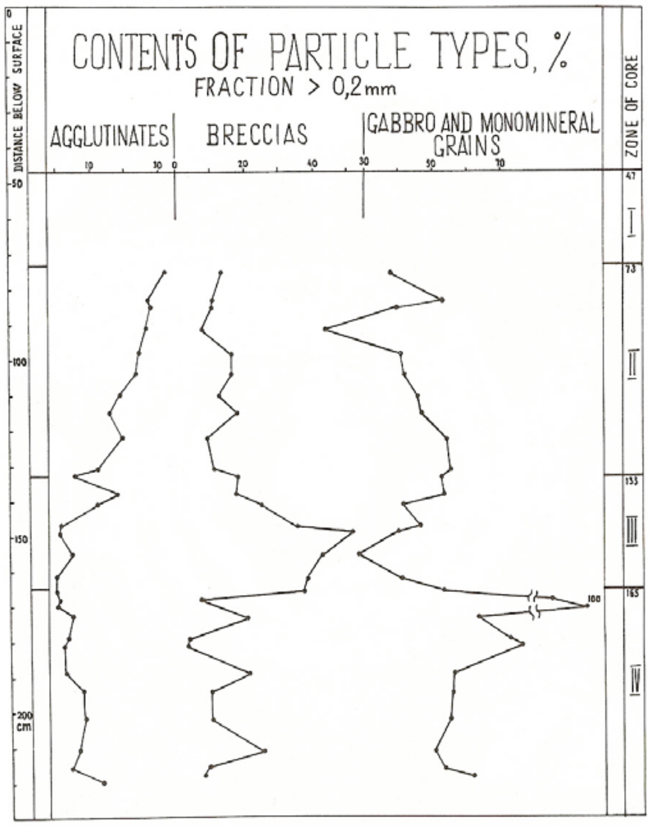


Figure 2: Particle type as function of depth in Luna 24 core. (Barsukov 1977).

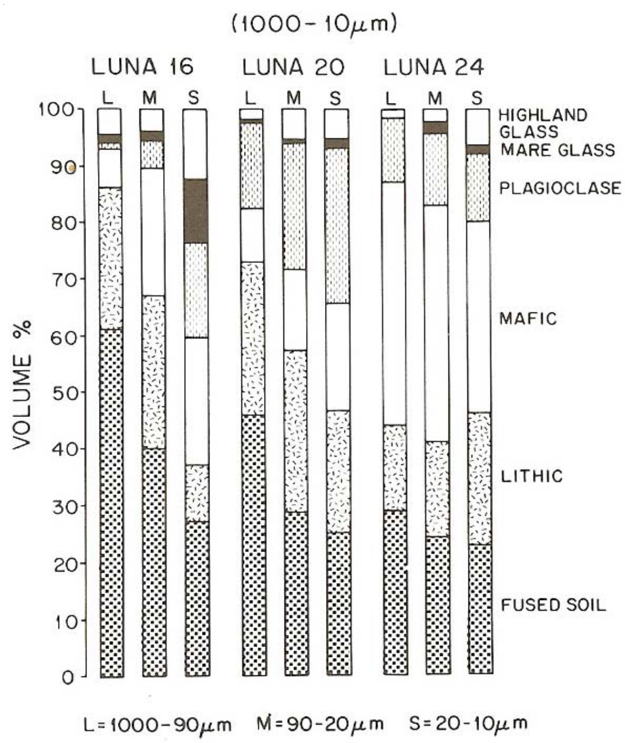


Figure 3: Modal mineralogy of three Luna cores (Simon et al. 1981).

was flexible, was wound onto a drum on a spiral track , similar to winding onto a fishing reel. This device was inserted into a vacuum-sealed canister for return to the Earth."

Mineralogical Mode for 24999

Simon et al. 1981	90-20	20-10 micron
Lithic fragments	16.3	23.3 %
Agglutinates and DMB	23.4	22.6
Pyroxene	30.1	23.9
Plagioclase	12.2	12
Olivine	10.2	9.7
Opaques	0.6	0.3
Silica	1.0	0.3
Mare Glass	2.0	1.3
Highland Glass	2.2	6.2

Relative proportions of Luna 24 lithic fragments (250-500 microns).

Taylor et al. 1978

split	24077	24109	24149	24182	24174	24210
Agglutinates	23.9%	16.5	1.3		7.7	6.7
Soil breccias	10.1	21	48	9.1	12.8	22.2
Aphanitic frags.	2.8	2.3	4		3.7	4.4
Glasses	4.6	1.7			0.7	2.2
Mare basalt						
"gabbros"	7.3	8	5.3	18.2	12.4	
fine-grained	9.2	8.5	8	9.1	7	8.9
metabasalts	2.8		2.7	13.6	4	
Nonmare lithic frags.	0.9	0.6		4.5	1.1	6.7
Other lithic frags.	2.8	1.7			1.1	8.9
Mineral frags.						
plag.	8.3	9.1	6.7	13.6	11.4	15.6
pyx.	24.8	25.6	21.3	22.7	30	17.8
olivine	2.8	4.5	2.7	9.1	7.7	6.7
other		0.6			0.4	

Figure 4: Photo of Russian drill on Luna 24.

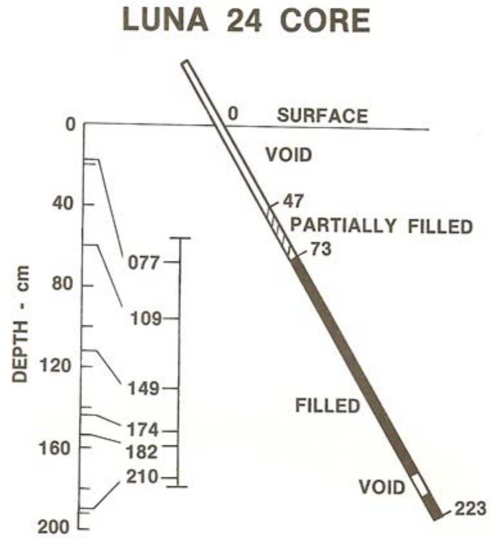


Figure 5:   Corrected depth scale for Luna 24 core (Bogard and Hirsch 1978).

"On opening in the laboratory, it was found that the upper 50-60 cm of the liner was empty - -
- The Russians tentatively identified approximately 20 horizons on the basis of soil color, granularity, etc. The uppermost portion of the core may be relatively more disturbed than the lower. At the top of the core, a concentration of millimeter-sized fragments of soil and agglutinaceous material occur, apparently devoid of fines. The explanation for this is unclear. In the lower portion of the core, some very sharply defined boundaries exist. At 170 cm, a uniform layer of crushed gabbroic rocks, 2 cm thick, with sharp boundaries both above and below, is conspicuously lighter than the soil."

Following transfer to the US, Luna 24 samples were processed and described in a catalog by Nagle and Walton (1977) and then distributed to US investigators. A conference on Luna 24 was documented in a book titled "Mare Crisium: The view from Luna 24".

The geologic setting for Luna 24 is outlined in Butler and Morrison (1977) and also presented, *in Cyrillic*, by Florensky et al. (1980) and Head et al. (1980).

The main finding of Luna 24 was that a very-low Ti basalt was extruded at 3.3 b.y. (considerably after the basin formation).

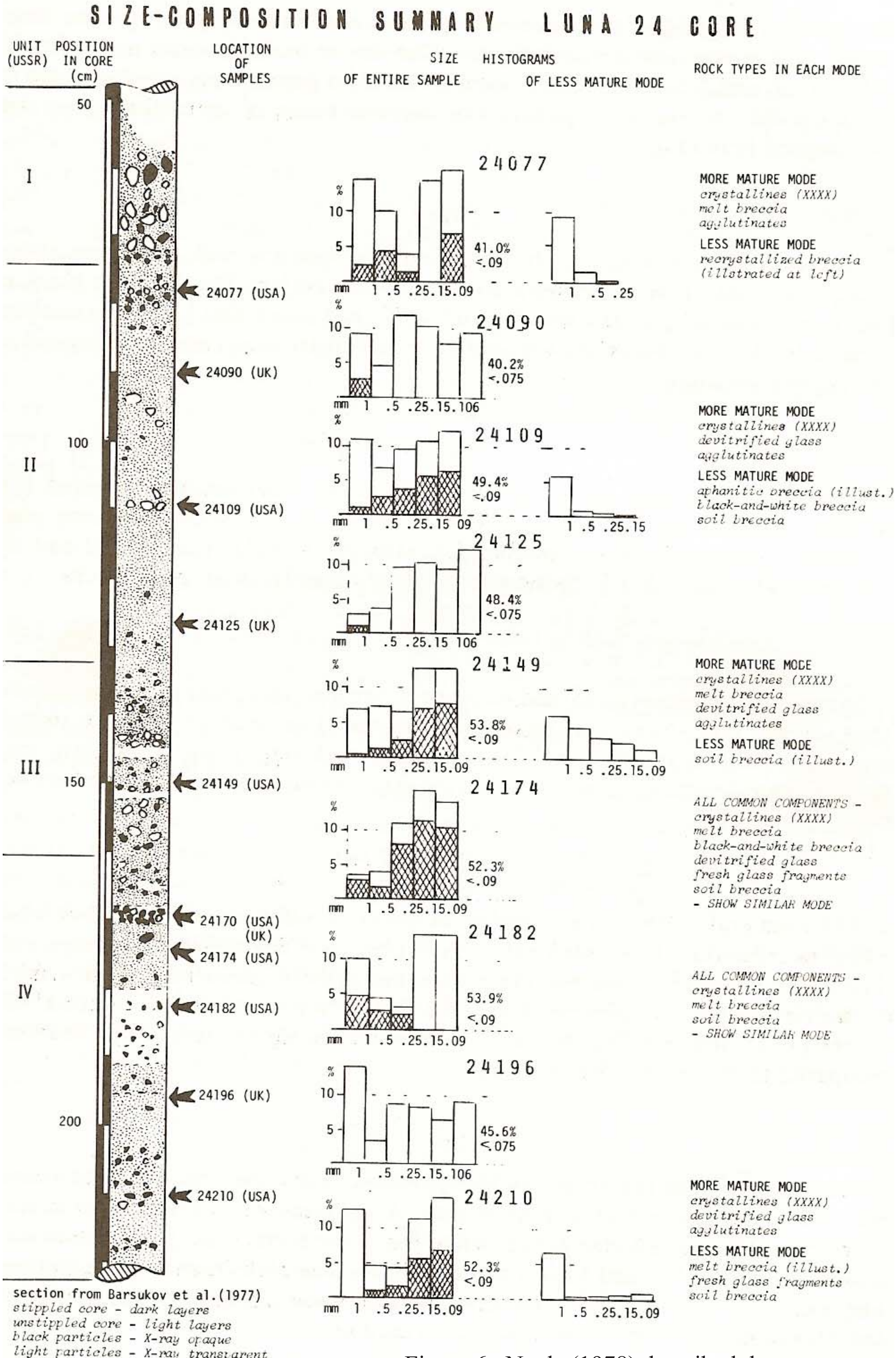


Figure 6: Nagle (1978) described the core.

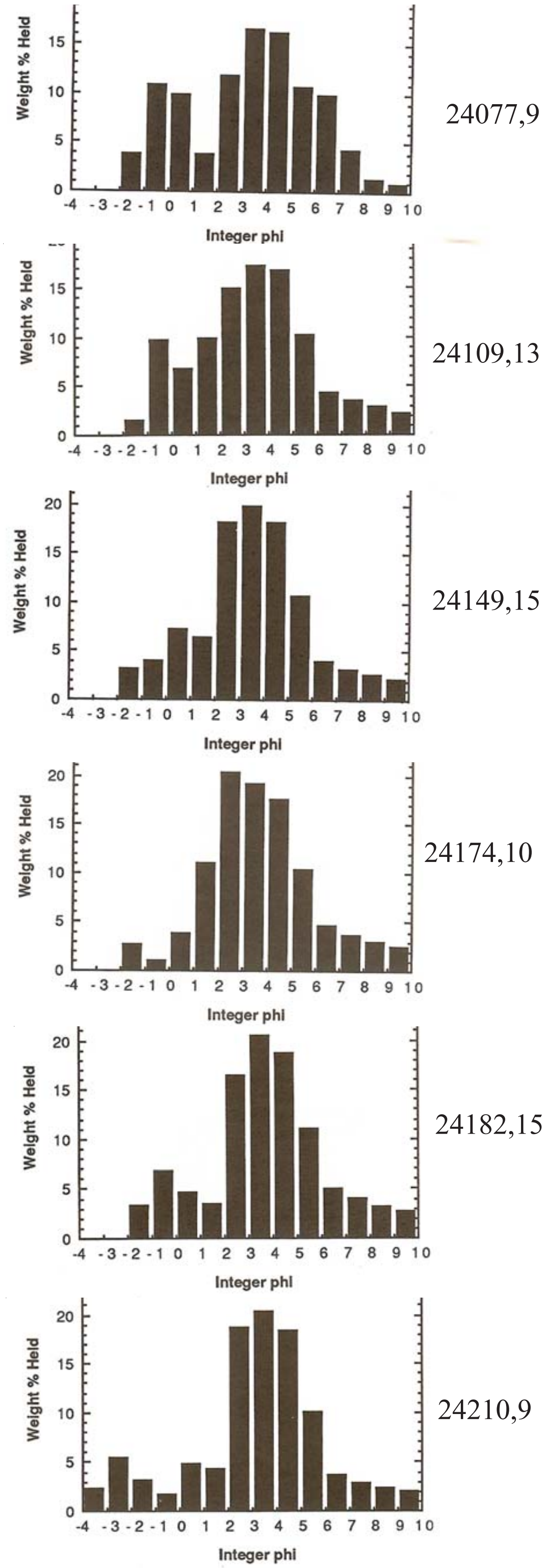


Figure 7: Grain size distribution of Luna 24 soils as function of depth in core (from Graf 1993).

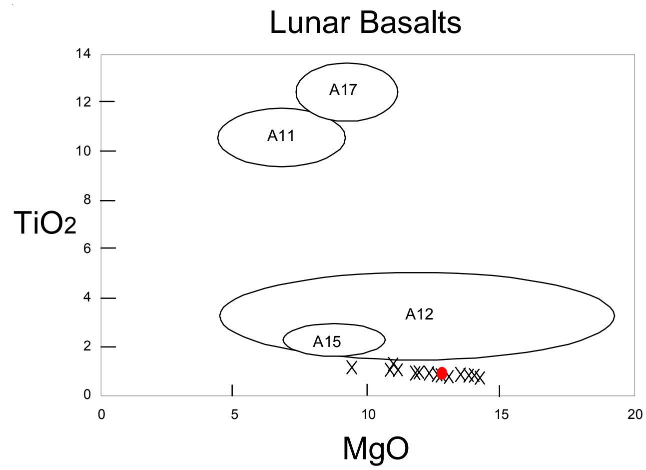


Figure 8: Chemical composition of basalts and brown glass found along the length of the Luna 24 core (see tables). Note that they are all very low Ti compared to other lunar missions, hence the term VLT basalt.

Petrography

The Luna 24 core tube was found to contain an abundance of small basalt fragments with unusual low Ti content (Ryder et al. 1978, Taylor et al. 1978). These became known as VLT basalts (see separate essay on 24170). Tables 2 -5 give the composition of some of these basalt fragments (figure 8). In addition to the VLT basalt, there are a number of other different basalt types present, including an abundant brown glass (table 6) which might be volcanic liquid sprayed up into the sky.

At the 24170-174 layer there was a coarse-grained, lighter-colored area that was termed “gabbro”, which might have been a friable rock that was broken up. Throughout the core small “gabbros” have been reported (e.g. Lu et al. 1989). These fragments are probably basalts, because the pyroxene is zoned in composition.

In addition to VLT basalt, there is another kind of basaltic particle in Luna 24 fines that was not seen in Apollo sample. It is termed “metabasalt” and is characterized by a fine-grained granular texture and Fe-rich pyroxene exsolution trend (figure 9). It has the same bulk composition as the igneous textured basalts.

Barsukov (1978), McKay et al. (1978), Nielson and Drake (1978), Taylor et al. (1978), Basu et al. (1978)

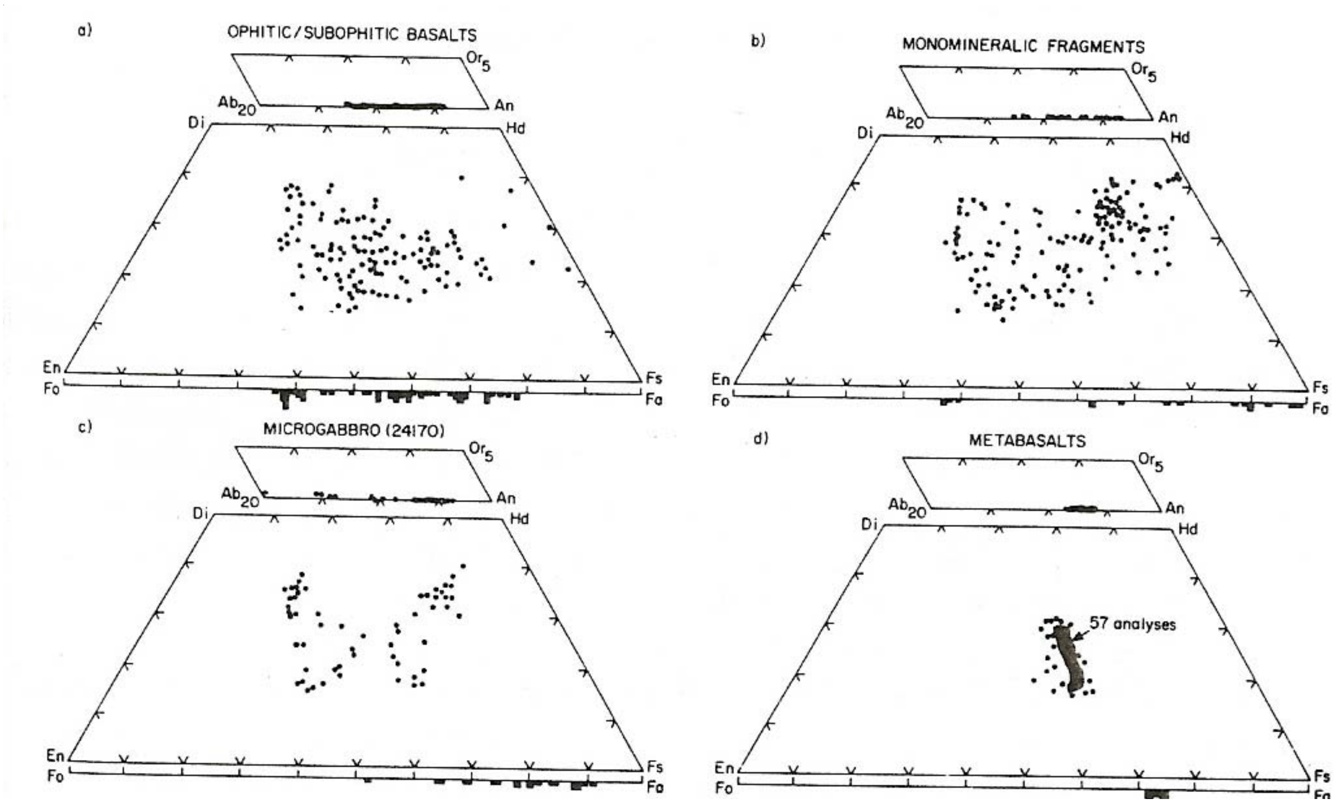


Figure 9a: Chemical composition of pyroxene, olivine and plagioclase in various basalt fragments in Luna 24 soil (Ryder et al. 1977). Note that the microgabbro (24170) is similar to other basalts, and is not a true gabbro.

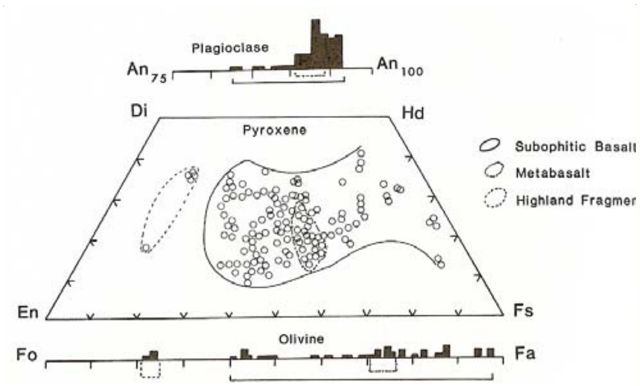


Figure 9b: Pyroxene, olivine and plagioclase from Luna 24 (Coish and Taylor 1977).

and others determined the mode along the length of the core. Simon et al. (1981) compares the mode of the bulk Luna 24 core tube with that of other missions (figure 3). The mode reported by Taylor et al. is the most interesting in that it is based on study of a significant number of large particles (see table). Bence and Grove (1978) carefully counted the numbers and types of highland fragments which make up about 2% of the Luna 24 soil.

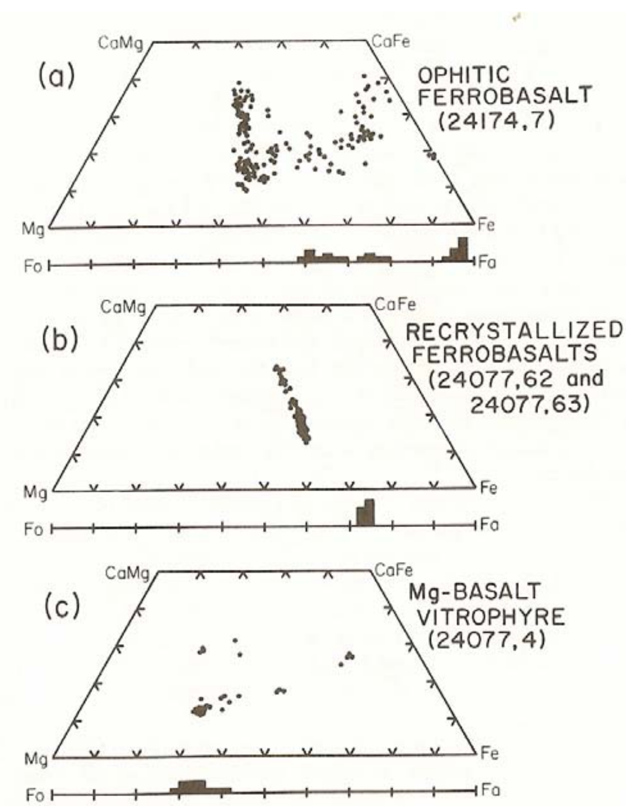


Figure 9c: Composition of pyroxene and olivine in Luna 24 basalts (Laul et al. 1977).

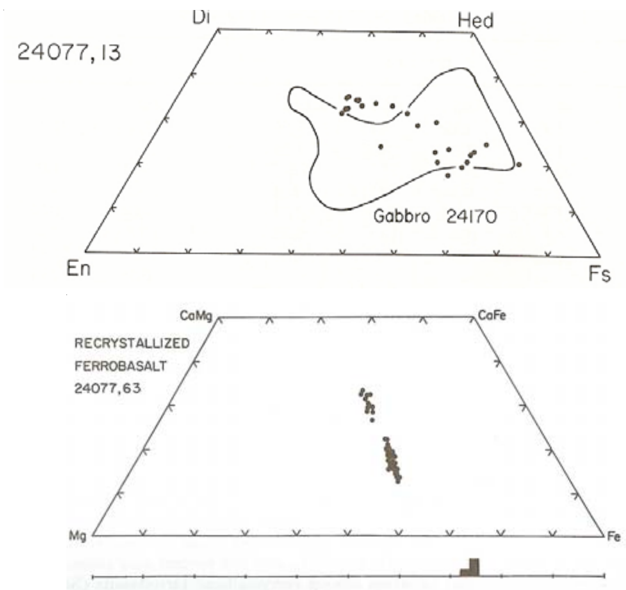


Figure 9d: Pyroxene in Luna 24 fragments studied by Schaeffer et al. 1977.

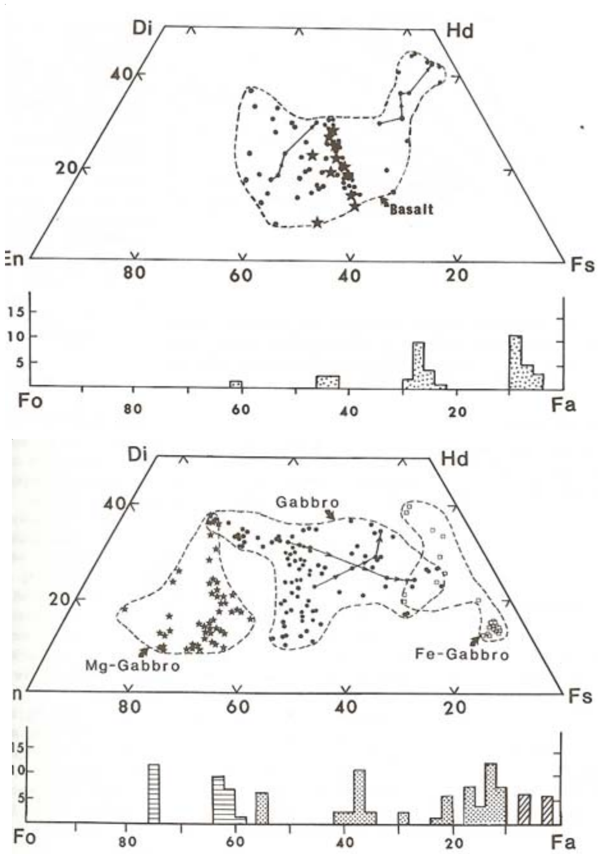


Figure 9f: Pyroxene and olivine composition of basalt fragments from 24088 and 24105 as determined by Lu et al. 1989.

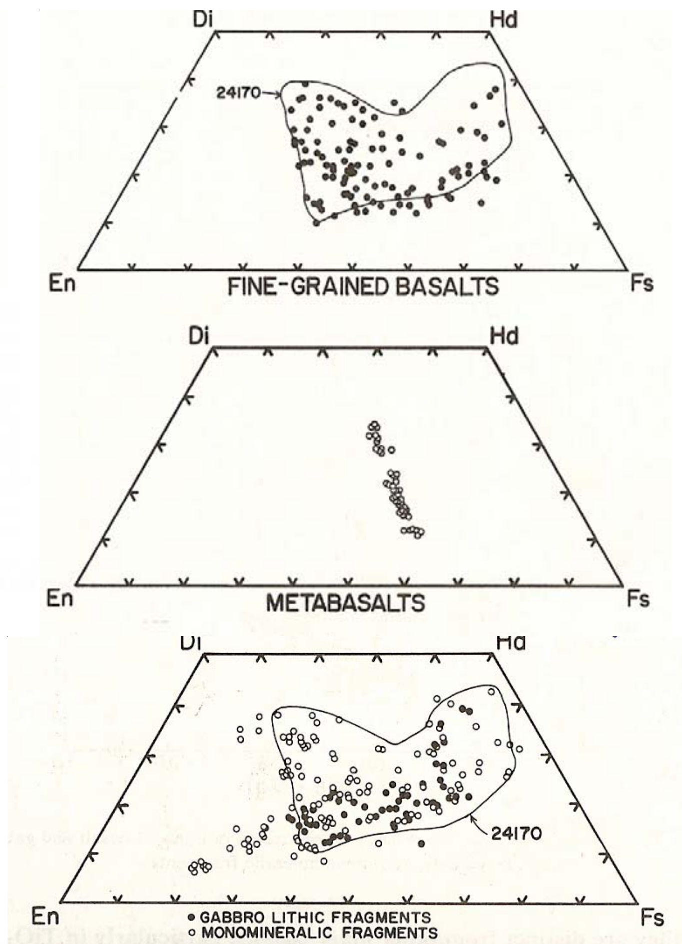


Figure 9e: Pyroxene composition for basalt fragments and loose pyroxenes from Luna 24 soil (Tayler et al. 1978).

Morris R.V. (1978) found that the maturity of Luna 24 samples was submature to immature, decreasing with depth. McKay et al. (1978) and Taylor et al. (1978) found a similar decrease in agglutinate content with depth. Basu et al. (1978) determined the grain size distribution (figure 7).

KREEP is rare at Luna 24. Three individual particles have been reported (Blanchard et al. 1978, Ma et al. 1978 and Kurat and Kracker 1981), but there is no evidence for significant KREEP in the REE pattern of the soil (figure 11).

Chemistry

Ma et al. (1978) showed that the Luna 24 core is homogeneous from top to bottom (figure 11). The best average composition of Luna 24 is probably the one obtained by Laul et al. (1981) from a combined sample 24999 (table 1).

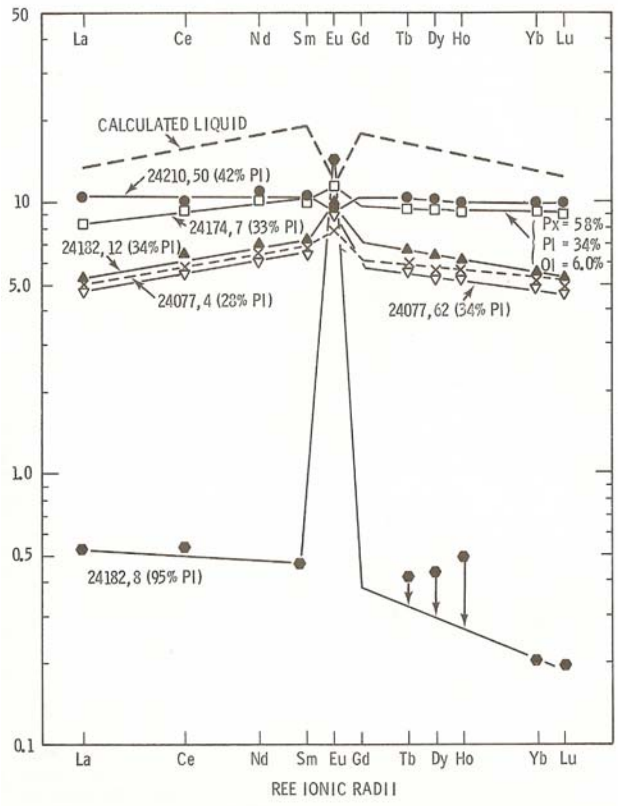


Figure 10a: Normalized rare-earth-element diagram for Luna 24 soil and selected particles (Laul et al. 1977).

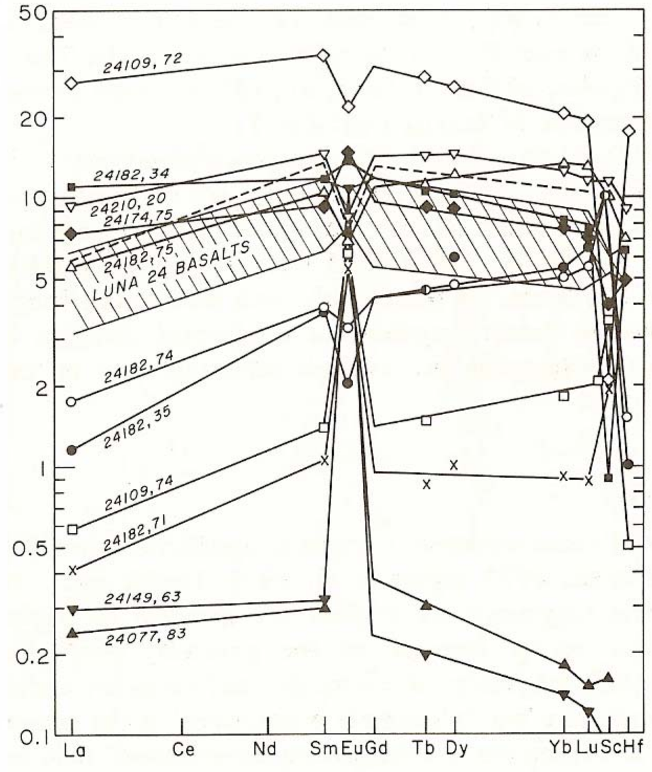


Figure 10b: Normalized rare-earth-element diagram for Luna 24 soil and selected particles (Ma et al. 1977).

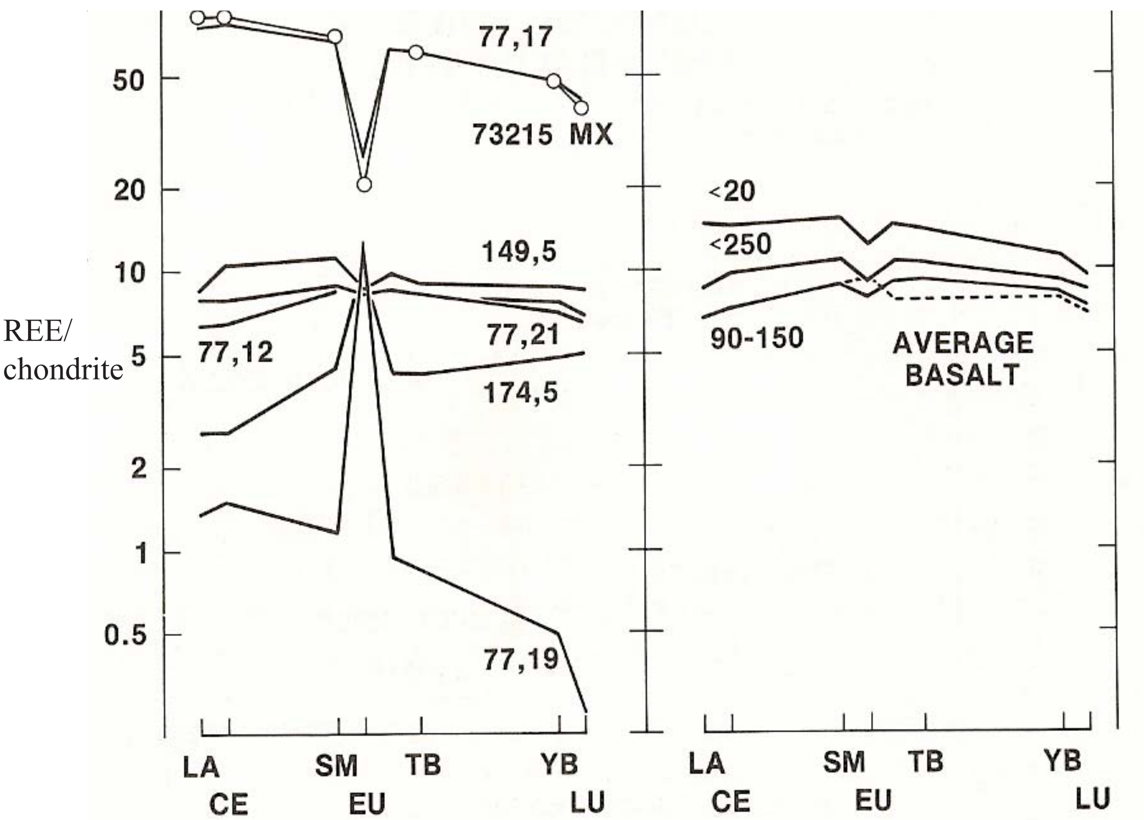


Figure 10c: Normalized rare-earth-element diagram for Luna 24 particles and soil (Blanchard et al. 1977).

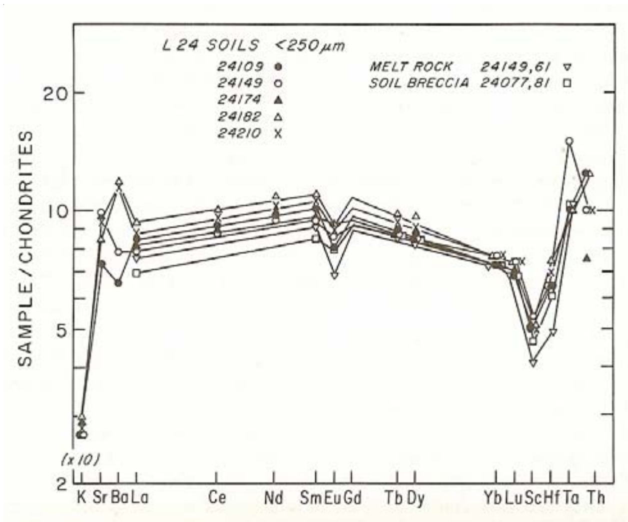


Figure 11: Spider diagram for soil samples different depths in Luna 24 core (Ma et al. 1978).

Ebihara et al. (1992), Ma and Schmitt (1977) , Blanchard et al. (1978) analyzed several small rock fragments from Luna 24 (table 2, figure 10).

Radiogenic age dating

Schaeffer et al. (1978), Wasserburg et al. (1978), Stettler and Albarede (1978) and Birck et al. (1977) reported ages for Luna 24 basalt particles (figure 12). The Sm/Nd age (3.3 ± 0.05 b.y.) is probably the most accurate, but it is based on only two points! However, it is concordant with the Ar/Ar age. Additional samples need to be measured.

Other Studies

Rare gases were measured by Bogard and Hirsch (1978) along the length of the core, concluding that the material represented by the core did not have any simple exposure nor depositional history.

The density of fossil nuclear tracks from solar and cosmic rays was determined from many mineral grains along the core, but no buried exposure horizon could be found (figure 13). Goswami et al. (1978), Kashkarov et al.(1978), Blanford and Wood (1978), Chaillou et al. (1978), Crozaz (1978), Poupeau et al.(1978) and others reported track distributions, generally finding that material at the bottom of the core had less exposure to solar wind that material at the top. Again, no simple history for this core.

Processing

The initial processing of Luna 24 core is described by Tarasov et al. (1980) *in Cyrillic.* The core liner, made of plastic, was unwound from the spacecraft "drum" and wound in a coil (snail) for X-ray (figure 2). It was then placed in sections in 6 trays where each segment was slit lengthwise and dumped into the tray, such that relative depth orientations was maintained (figure 15). Luna 24 samples were processed in a more advanced cabinet than was used for Luna 16 and 20.

Many samples, from different depths were, provided to the US, England, France, India and the Czech republic (figure 14). The initial samples transferred to the US, were sieved, split and cataloged by Nagle and Walton (1977) and also described by Nagle (1978)(figure 6). Two additional samples were obtained by Larry Taylor in 1987 (Lu et al. 1989).

Please locate the figure in this report that shows how sample 24999 was prepared for the Consortium led by Jim Papike.

Summary of Age Data for Luna 24

	Ar/Ar	Rb/Sr	Sm/Nd
Schaeffer et al. 1978	3.26 ± 0.04		
	3.33 ± 0.21		
Stettler, Albarede 1978	3.65 ± 0.12		
Wasserburg et al. 1977	3.30 ± 0.04		3.3 ± 0.05
Birck et al.	?		

Ages not corrected for change in decay constants.

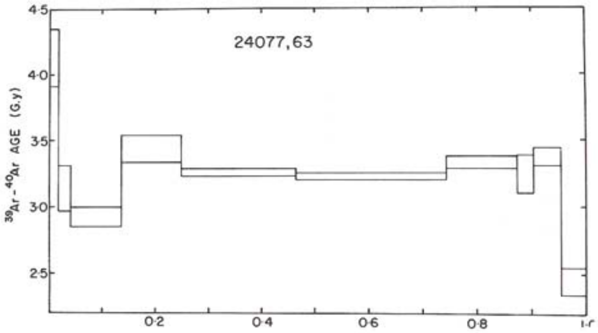


Figure 12a: Ar/Ar plateau age for small (Schaeffer et al. 1978).

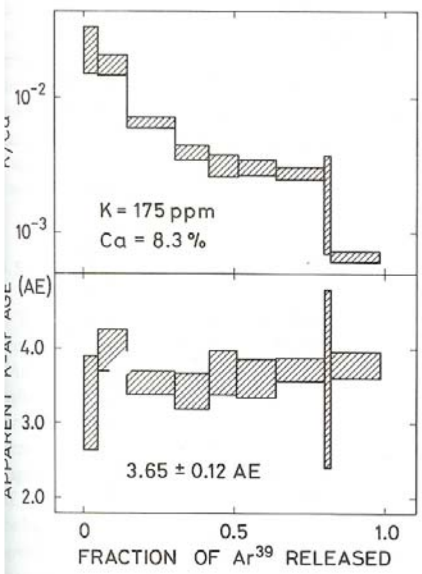


Figure 12b: Ar/Ar plateau age for particle from Luna 24 (Stettler and Albarede 1978).

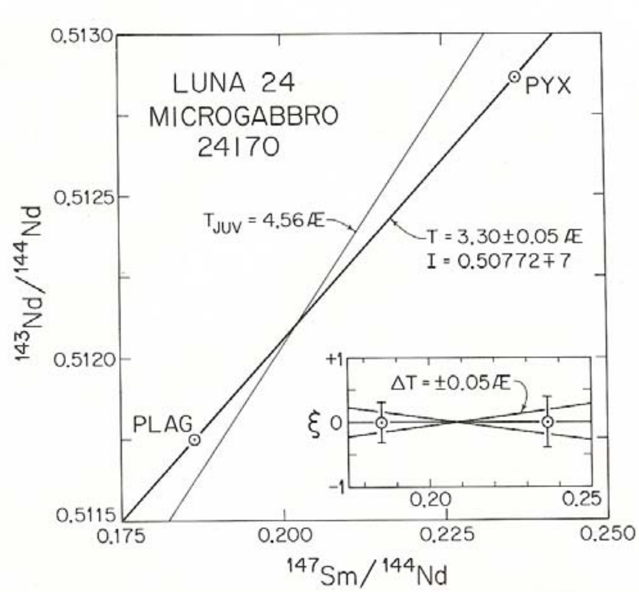


Figure 12c: Sm/Nd isochron of coarse grain basalt (2 point) by Wasserburg et al. 1978.

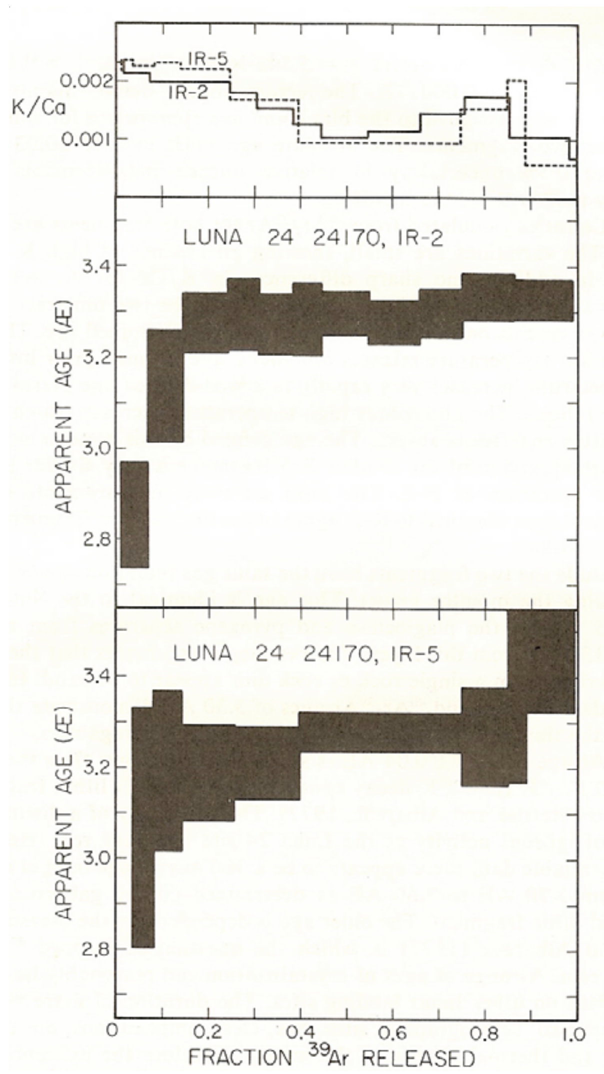


Figure 12d: Ar/Ar plateau diagram for gabbbro fragments from Luna 24 (Wasserburg et al. 1978).

Table 1a. Chemical composition of Luna 24 soil.

	24999,6		McKay													
reference	Laul 81		Sourcebook		Blanchard 78								Barsukov77			
weight	bulk		ave.		24077	24109	24149	24174	24182	24210	Ave.		24092	24118	24143	24184
SiO2 %			43.9	(c)	45.9	44.1	44.6	45.5	44.5	47.5	45.4	(d)	43.3	43.5	43.6	43.7
TiO2	1	(a)	1.3	(c)	0.9	1	1.3	0.9	1.3	1	1.1	(d)	1.13	1.09	1.13	1.23
Al2O3	11.7	(a)	12.5	(c)	11.8	11.3	11	11.1	11.5	9.7	11.1		15.2	15.5	15.9	16
FeO	20.2	(a)	19.8	(c)	19.9	20.6	20.3	20.9	20.2	21.1	20.5	(d)	16.3	16.2	16.2	16.1
MnO	0.27	(a)	0.25	(c)									0.22	0.21	0.23	0.22
MgO	9.7	(a)	9.4	(c)	9.7	10.3	10.1	9.7	10	11.3	10.2	(d)	8.69	8.87	8.8	8.75
CaO	11.1	(a)	12.3	(c)	11.2	11	10.8	10.8	11.1	10.8	11	(d)	13.1	12.9	13.3	13.1
Na2O	0.27	(a)	0.31	(c)	0.29	0.27	0.28	0.29	0.29	0.25	0.28	(d)	0.42	0.51	0.25	0.43
K2O	0.03	(a)	0.04	(c)	0.03	0.02	0.03	0.03	0.04		0.03	(d)	0.04	0.04	0.04	0.06
P2O5			0.11	(c)									0.14	0.13	0.13	0.12
S %			0.14	(c)									0.13	0.15	0.08	0.09
sum																
Sc ppm	44	(a)	34	(c)	41	43	43	44	42	44	43	(a)	32	33	34	36
V	150	(a)														
Cr	3195	(a)	2190	(c)	3830	4242	4041	3352	3421	3079	3558	(d)	2160	2110	2290	241
Co	47	(a)			51	52	51	50	48	54	51	(a)	40	42	42	46
Ni	110	(a)			160	230	100	130	90		140	(a)	130	80	100	130
Cu													3.8	2.2	3.6	3.6
Zn													6.5	8.7	7.1	7.1
Ga													1	0.7	0.9	0.6
Ge ppb																
As																
Se																
Rb													1.4	1.3	1.3	1.1
Sr	80	(a)														
Y													25	20	20	25
Zr													95	100	105	105
Nb																
Mo																
Ru													0.004	0.005	0.004	0.005
Rh																
Pd ppb																
Ag ppb													0.02	0.03	0.03	0.02
Cd ppb																
In ppb																
Sn ppb													0.3	0.4	0.4	0.3
Sb ppb													0.09	0.09	0.09	0.09
Te ppb																
Cs ppm													0.07	0.07	0.1	0.1
Ba	40	(a)											80	80	90	90
La	2.4	(a)	5	(c)	3.1	3.22	2.32	2.74	3.24	2.64	2.88	(a)	5.2	5.1	5.2	5.2
Ce	6.1	(a)			8.9	9.7	7.3	8.5	9.9	6.8	8.53	(a)	11.2	12	11.3	12.1
Pr													1.6	1.5	1.6	1.5
Nd	5	(a)											9.2	9	10	9.2
Sm	1.7	(a)			2	2.04	1.73	1.95	2.09	1.74	1.93	(a)	2.6	2.4	2.6	2.7
Eu	0.59	(a)			0.66	0.66	0.6	0.63	0.7	0.54	0.63	(a)	0.56	0.54	0.57	0.58
Gd													3.5	3.4	3.6	3.4
Tb	0.43	(a)			0.49	0.49	0.4	0.46	0.56	0.51	0.49	(a)	0.58	0.54	0.58	0.52
Dy	2.7	(a)											3.4	3.3	3.2	3.1
Ho													0.8	0.9	0.9	0.8
Er													2.4	2.3	2.4	2.4
Tm																
Yb	1.75	(a)			1.76	1.78	1.63	1.89	1.93	1.81	1.8	(a)	2.2	2	2.1	2
Lu	0.27	(a)			0.273	0.272	0.263	0.299	0.298	0.27	0.28	(a)	0.34	0.32	0.34	0.32
Hf	1.2	(a)			0.41	0.25	0.26	0.24	0.4	0.3	0.31	(a)	2.2	1.7	2	2
Ta	0.17	(a)											0.21	0.24	0.25	0.25
W ppb													90	90	100	90
Re ppb													.			
Os ppb													8	6	7	8
Ir ppb													4.7	5	4.2	4
Pt ppb													6	7	7	9
Au ppb																
Th ppm	0.4	(a)	1.1	(c)	0.41	0.25	0.26	0.24	0.4	0.3	0.31	(a)	0.95	1	1	1.05
U ppm			0.26	(c)									0.3	0.32	0.3	0.3

technique: (a) INAA, (b) RNAA, (c) Russian data, (d) AA

Table 1b. Chemical composition of Luna 24 soil.

reference	Ma77, 78						Nyquist78					
weight	24109	24149	24174	24182	24210		24077,36	24210,12	24182,20	24109,17	24149,9	
SiO2 %												
TiO2	1	1.1	0.8	1.2	*0.1*	(a)	0.98	0.97	1.08	1.07	1.1	(b)
Al2O3	12.1	12.1	12.1	12.3	12	(a)	13.6	11.2	12.3	12	11.8	
FeO	18.7	19.6	19.1	19.6	19.8	(a)	18.65	19.2	18.4	18.6	19	(b)
MnO	0.267	0.257	0.245	0.245	0.254	(a)						
MgO	10	10	9	10	10	(a)	9.4	10.2	9.7	9.7	9.7	(b)
CaO	10.8	11.1	11.3	11.4	10.8	(a)	11.4	11	11.3	11.3	11.3	(b)
Na2O	0.27	0.28	0.28	0.3	0.28	(a)						
K2O	0.027	0.027	0.029	0.03	0.028	(a)	0.03	0.03	0.035	0.03	0.027	(b)
P2O5												
S %												
sum												
Sc ppm	40	43	41	41	40	(a)						
V	155	159	139	147	159	(a)						
Cr	2600	2602	2655	2670	3051	(a)						
Co	46	60	46	50	42	(a)						
Ni	155	175	125	145	145	(a)						
Cu												
Zn												
Ga												
Ge ppb												
As												
Se												
Rb							0.545	0.581	0.699	0.549	0.468	(b)
Sr	81	109	108	93	103	(a)	94.2	86.9	96.9	90.1	90.6	(b)
Y												
Zr	70	60	50	50	50	(a)	44	36	49	38	44	(b)
Nb												
Mo												
Ru												
Rh												
Pd ppb												
Ag ppb												
Cd ppb												
In ppb												
Sn ppb												
Sb ppb												
Te ppb												
Cs ppm												
Ba	25	30		45	45	(a)	37	36	45	37	35	(b)
La	2.9	2.7	2.8	3.2	3	(a)	3.09	2.94	3.72	3.11	3	(b)
Ce	7.8	7.5	7.6	8.6	8.1	(a)	7.99	7.5	9.55	7.64	7.38	(b)
Pr												
Nd	6.3	6	6.3	7	6.6	(a)	5.74	5.44	7.02	5.6	5.59	(b)
Sm	1.96	1.83	1.87	2.14	2.05	(a)	1.87	1.78	2.23	1.83	1.86	(b)
Eu	0.59	0.63	0.67	0.67	0.66	(a)	0.687	0.637	0.738	0.662	0.671	(b)
Gd							2.47	2.37	2.9	2.44	2.43	(b)
Tb	0.42	0.41	0.41	0.46	0.44	(a)						
Dy	2.9	2.8	2.8	3.2	3	(a)	2.95	2.88	3.53	2.95	3.02	(b)
Ho												
Er							1.85	1.8	2.14	1.86	1.91	(b)
Tm												
Yb	1.6	1.7	1.6	1.7	1.7	(a)	1.66	1.65	1.92	1.68	1.69	(b)
Lu	0.23	0.25	0.24	0.25	0.25	(a)	0.243	0.239	0.273	0.25	0.249	(b)
Hf	1.3	1.3	1.3	1.5	1.4	(a)						
Ta	0.2	0.3		0.2	*0.5*	(a)						
W ppb												
Re ppb												
Os ppb												
Ir ppb												
Pt ppb												
Au ppb												
Th ppm	0.5	0.4	0.3	0.5	0.4	(a)						
U ppm							0.12	0.12		0.08	0.13	(b)

technique: (a) INAA, (b) IDMS

Table 2. Chemical composition of small rocks in Luna 24.

	basalt	breccia	gabbro	agg.	soil bx.	gabbro		ferrobasalt	metabas.	metabas.	metabas.	ferrobas.	
reference	Blanchard78							Ma 78					
weight	24077,12	24077,17	24077,19	24077,21	24149,5	24174,5		24109,78	24077,63	24109,76	24149,29	24149,69	
SiO2 %													
TiO2								1.3	1.1	1.1	1.3	2.3	(a)
Al2O3								11.6	12.8	11.1	11.4	14.2	(a)
FeO	22.1	7.6	0.77	16.3	20.3	16.6	(a)	22.4	21.1	20.8	20.9	15.8	(a)
MnO								0.258	0.247	0.229	0.246	0.246	(a)
MgO								7	8	7	8	6	(a)
CaO								12.3	13.5	11.5	11.7	11.7	(a)
Na2O	0.29	0.66	0.63	0.31	0.27	0.38	(a)	0.29	0.24	0.25	0.24	0.55	(a)
K2O													
P2O5													
S %													
sum													
Sc ppm	47	13.3	2	36	47	36	(a)	47	43	41	42	42	(a)
V								177	178	179	154	131	(a)
Cr	2874	1260	123	3147	3490	1368	(a)	3208	1642	1683	1478	609	(a)
Co	46	20.2	2.04	46	51	30	(a)	36	38	37	40	30	(a)
Ni		180	20	180	150		(a)	80		*50*	*50*	*50*	(a)
Cu													
Zn													
Ga													
Ge ppb													
As													
Se													
Rb													
Sr													
Y													
Zr													
Nb													
Mo													
Ru													
Rh													
Pd ppb													
Ag ppb													
Cd ppb													
In ppb													
Sn ppb													
Sb ppb													
Te ppb													
Cs ppm													
Ba													
La	2.08	25	0.45	2.6	2.8	0.86	(a)	2	1.1	1.9	1.6	2.1	(a)
Ce	5.7	68	1.3	7	9.2	2.33	(a)						
Pr													
Nd													
Sm	1.53	12.1	0.21	1.6	2	0.8	(a)	1.9	1.2	1.5	1.3	2.4	(a)
Eu	0.63	1.74	0.84	0.58	0.59	0.7	(a)	0.58	0.63	0.58	0.64	0.75	(a)
Gd													
Tb	0.34	2.9		0.38	0.43	0.2	(a)	0.44	0.25	0.33	0.29	0.51	(a)
Dy								2.8	1.5	2.1	1.7	3.6	(a)
Ho													
Er													
Tm													
Yb	1.55	9.7	0.1	1.4	1.75	0.96	(a)	1.9	1	1.3	1.2	2.1	(a)
Lu	0.24	1.4	0.01	0.22	0.29	0.17	(a)	0.29	0.15	0.17	0.18	0.3	(a)
Hf	0.9	9.9	0.79	1	1.3	0.88	(a)	1.1	0.9	1	1.1	1.3	(a)
Ta		4.8			0.3		(a)	0.1	0.1	0.1	0.2	0.3	(a)
W ppb													
Re ppb													
Os ppb													
Ir ppb													
Pt ppb													
Au ppb													
Th ppm		1.4					(a)						
U ppm													

technique: (a) INAA

Table 3. Chemical composition of Luna 24 basalts.

	24067-3201		67-3202	24067-3801		67-3802	24,170	170-11			
reference	Ma80	Ma80	Ebihara92	Ma80	Ma 80	Ebihara92	Wasser78	Ebihara92		Haskin 78	
weight											
SiO2 %											
TiO2	0.7	0.7		0.9	0.8						
Al2O3	13.2	10.8		12.3	10.8						
FeO	18.9	20.1		19.6	19.2					21	(c)
MnO	0.24	0.28		0.23	0.26						
MgO	7.7	8.8		6.5	7						
CaO	13.7	14		13	11.3						
Na2O	0.27	0.34		0.23	0.26					0.24	(c)
K2O	0.017	0.04		0.017	0.018						
P2O5											
S %											
sum											
Sc ppm	52	66		41	38					43	(c)
V	157	164		177	157						
Cr	2039	1957		1540	1806						
Co	38	37		36	38					38	(c)
Ni			18			18		124	(b)		
Cu											
Zn			2.06			2.33		7.77	(b)		
Ga											
Ge ppb			8			7		30	(b)		
As											
Se			117			110		87	(b)		
Rb			0.525			0.295		0.62	(b)		
Sr											
Y											
Zr											
Nb											
Mo											
Ru											
Rh											
Pd ppb			7			9		104	(b)		
Ag ppb			2.5			1.8		2.7	(b)		
Cd ppb			18			159		206	(b)		
In ppb			21			2.6		20	(b)		
Sn ppb											
Sb ppb			53			37		526	(b)		
Te ppb			17			18		176	(b)		
Cs ppm			0.015			0.009		0.047	(b)		
Ba											
La	2.4	5.3		1.7	0.95					1.22	(c)
Ce	6.6	14.2		4.7							
Pr											
Nd											
Sm	1.57	3.54		1.24	0.97					1.25	(c)
Eu	0.76	1.25		0.63	0.89					0.6	(c)
Gd											
Tb	0.38	0.82		0.26							
Dy	2.6	5.6		1.9	1.5						
Ho											
Er											
Tm											
Yb	1.5	3.6		1.1	0.96					1.06	(c)
Lu	0.24	0.56		0.17	0.16					0.16	(c)
Hf	1	5.9		0.9							
Ta	0.15			0.13							
W ppb											
Re ppb			0.024			0.024		0.26	(b)		
Os ppb			0.5			0.5		4	(b)		
Ir ppb			0.062			0.015		0.18	(b)		
Pt ppb											
Au ppb			0.036			0.077		0.042	(b)		
Th ppm	0.24			0.11							
U ppm			0.117			0.038		0.095	(b)		

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

Table 4. Chemical composition of Luna 24 basalts.

reference	Vaniman77		Taylor77		Barsukov77			and	Tarasov77						Taylor78	
weight					24170										ave. basalt	ave. metabas.
SiO2 %	46.2	45.2	48	(a)	43.9	45.5	45.3	47.3	47.6	41.1	47.1	44.8	46.9	(a)	46.5	46.4
TiO2	0.83	0.89	1	(a)	0.74	0.96	1.16	0.37	0.2	0.58	1.27	0.82	0.8	(a)	0.67	0.79
Al2O3	13.9	13.8	13.1	(a)	19	13.9	12.4	26.8	9.94	10.4	12.8	11.1	13	(a)	13.3	13.7
FeO	17.5	20.5	19.5	(a)	16.6	18.4	20.3	6.99	14.7	24.9	17.6	21.9	19.3	(a)	17.2	18.5
MnO	0.3	0.27	0.31	(a)	0.19	0.24	0.27	0.11	0.25	0.38	0.25	0.29	0.28	(a)	0.29	0.3
MgO	7.77	6.35	5.2	(a)	5.2	6.3	7.5	1.03	13	11.6	7.16	10.4	6.53	(a)	7.2	6.5
CaO	13.2	12.7	13.1	(a)	14	13.3	12.2	17.1	12.2	8.64	12.9	9.94	13.1	(a)	13.1	13.3
Na2O	0.2	0.24	0.29	(a)	0.5	0.37	0.37	0.66	0.21	0.29	0.3	0.32	0.44	(a)	0.3	0.28
K2O		0.01	0.04	(a)	0.06	0.02	0.03	0.04	0.03	0.02	0.04	0.18	0.23	(a)	0.04	0.04
P2O5					0.11		0.02							(a)	0.02	
S %					0.05	0.04	0.09	0.11			0.17			(a)		
sum																

technique (a) Elec. Microprobe

Table 5. Chemical composition of more basalt fragments in Luna 24.

reference	Ryder et al. 1977										Tayler 1978			
weight	subophitic basalt				metabasalts						olivine-rich basalts			
SiO2 %	46.6	48.3	44.6	46.1	42.8	43.8	44.3	46	46.4	47.8	45.4	43.1	44.2	(a)
TiO2	0.86	1.06	0.8	1.14	0.3	0.35	0.09	0.84	0.28	0.31	0.66	0.15	0.62	(a)
Al2O3	12.9	12	12.7	11.9	16.4	12.7	11.6	15.8	15.8	14.8	8.9	6.9	7.7	(a)
FeO	17.4	18.1	17.8	17.4	15.3	20.3	20.5	15.5	16.3	15.8	19.2	20.1	21.6	(a)
MnO	0.2	0.25	0.26	0.24	0.24	0.3	0.3	0.15	0.17	0.25	0.37	0.25	0.43	(a)
MgO	6.3	6.8	6.5	6.2	6.2	8	7.6	5.8	5.8	5.9	15.4	20.8	18.2	(a)
CaO	13.3	12.7	13.7	12.8	15.3	13.5	12.7	13.9	13.9	13.9	8.9	6.9	7	(a)
Na2O	0.31	0.4	0.29	0.02	0.41	0.36	0.36	0.3	0.34	0.32	0.2	0.12	0.15	(a)
K2O	0.04	0.04	0.03	0.04	0.06	0.05	0.04	0.03	0.03	0.03	0.05	0.03	0.05	(a)
P2O5	0.04	0.02	0	0.02	0.01	0.02	0.05	0.04		0.03			0.03	(a)

technique: (a) broad beam e-probe

Table 6. Chemical composition of brown glass cluster at Luna 24.

reference	Norman78	Warner78		Ryder78	Bell78					
weight	ave.	ave.	ave.	indiviual	indiviual					
SiO2 %	44.2	45.08		46.6	46.6	46.46	46.36	46.69	46.84	47.16
TiO2	0.95	0.96		1.1	1.02	1	0.95	0.96	0.96	0.99
Al2O3	12.6	12.6		13.1	12.08	12.16	11.89	11.96	11.84	12
FeO	19.04	18.36		19.7	20.8	20.82	19.34	19.46	19.04	20.55
MnO		0.26		0.3	0.32	0.33	0.35	0.33	0.29	0.32
MgO	6.85	10.21		6.7	6.85	6.86	6.69	6.85	6.93	7.04
CaO	12.32	11.43		12.5	12.38	12.28	12.15	12.19	12.32	12.81
Na2O	0.31	0.18		0.33			0.28	0.28	0.28	
K2O	0.01	0.04		0.02						
P2O5		0.02								
S %		0.11								
sum										

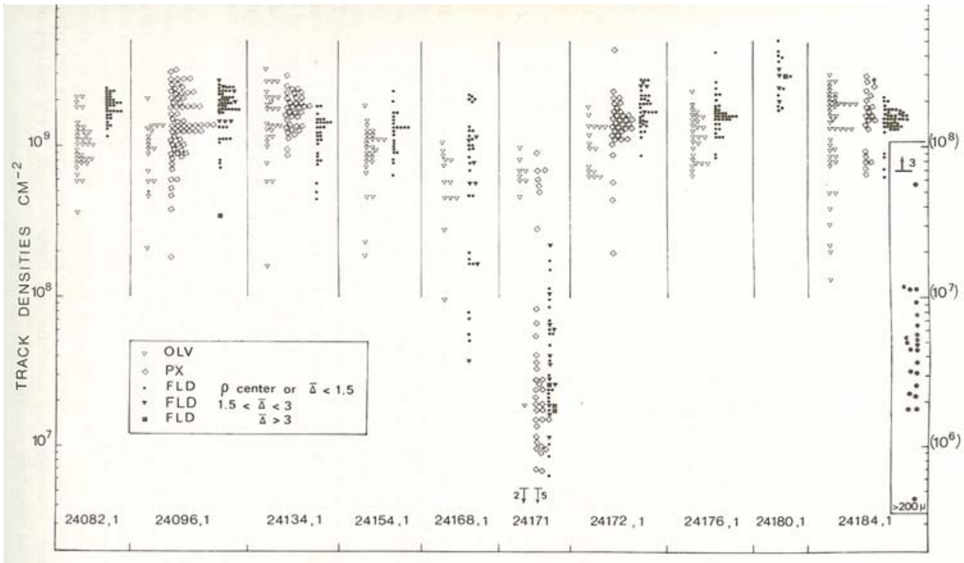
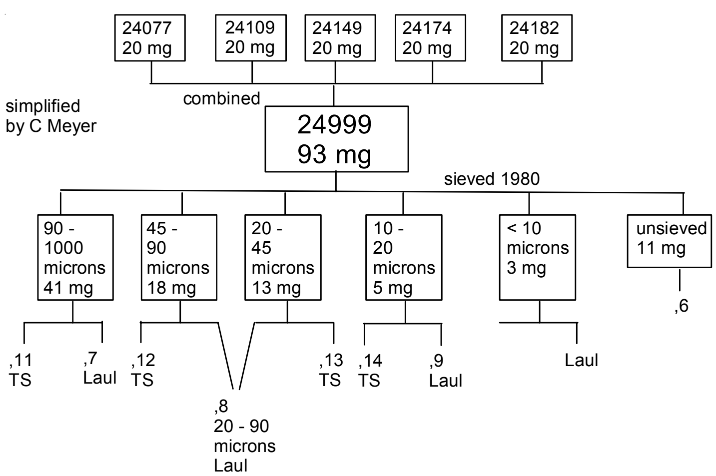


Figure 13: The density of nuclear tracks were measured in an impressive number of grains from Luna 24 (Chaillou et al. 1978).



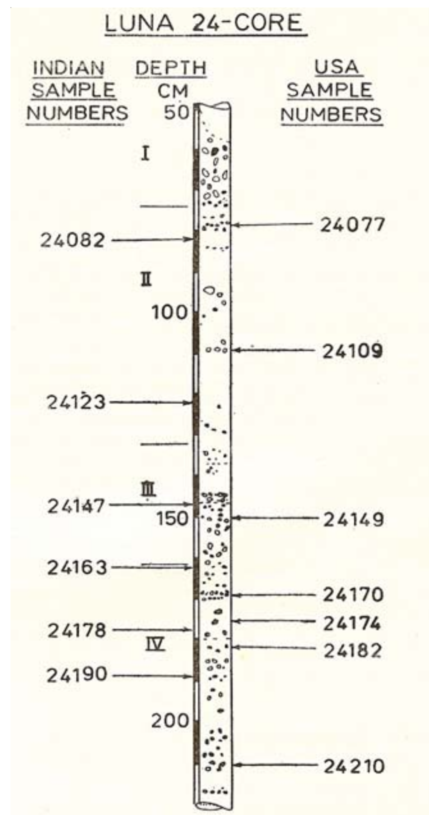


Figure 14: Location of samples presented to India (Murali et al. 1979).

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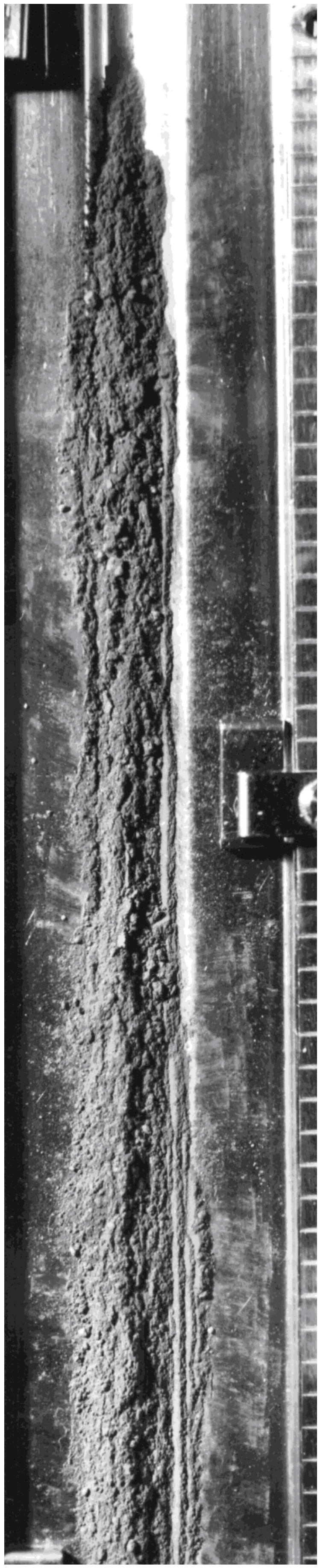
Figure 15: Luna 24 trays (4-9) (scale is cm, but this is not depth). Clunker at the top are not explained.

top

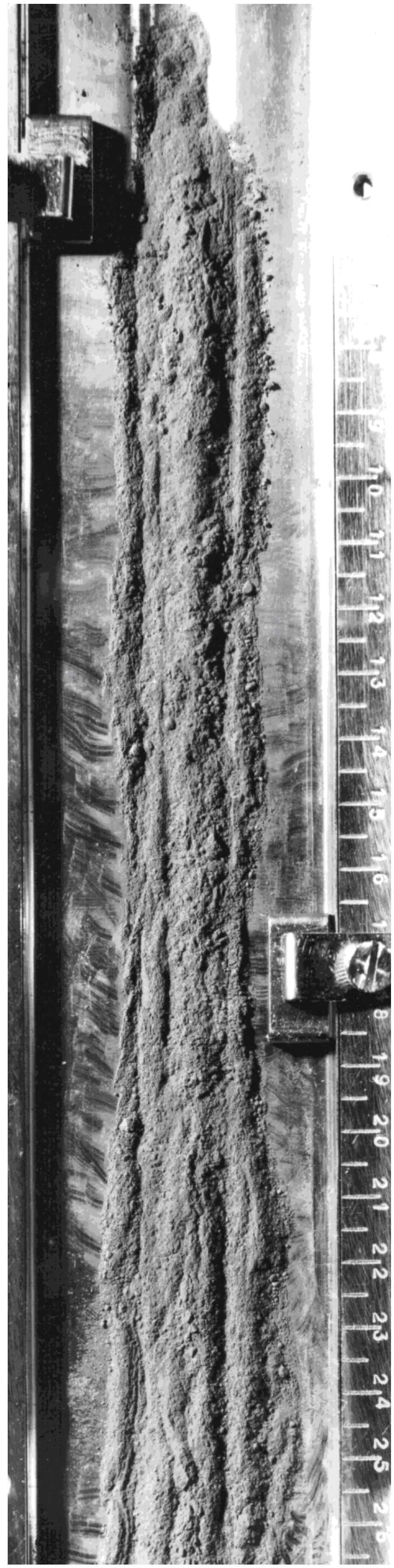
~ 75 cm

~ 77 cm



~ 97 cm

~102 cm

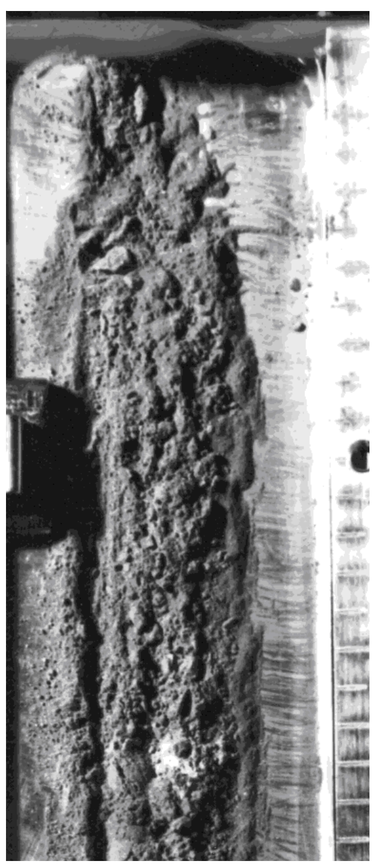


~ 125 cm

~127 cm

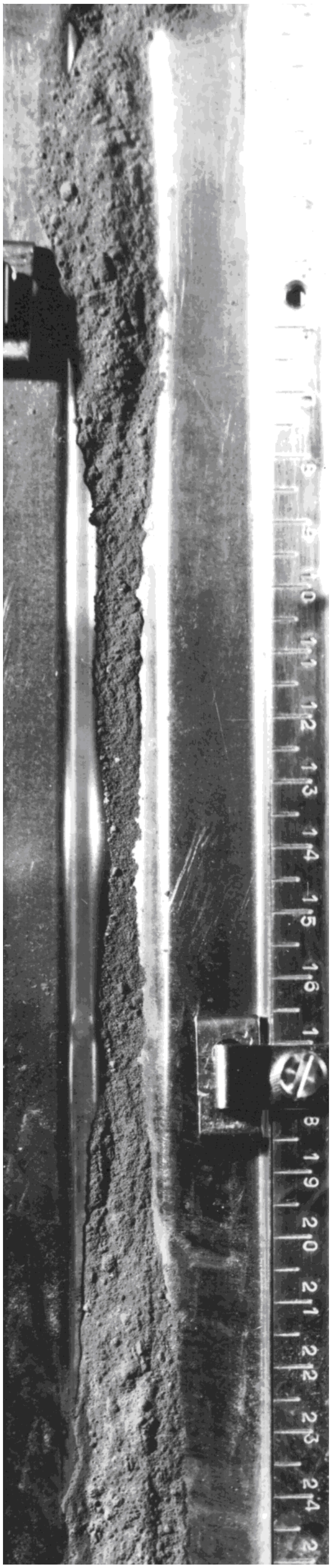
157 cm

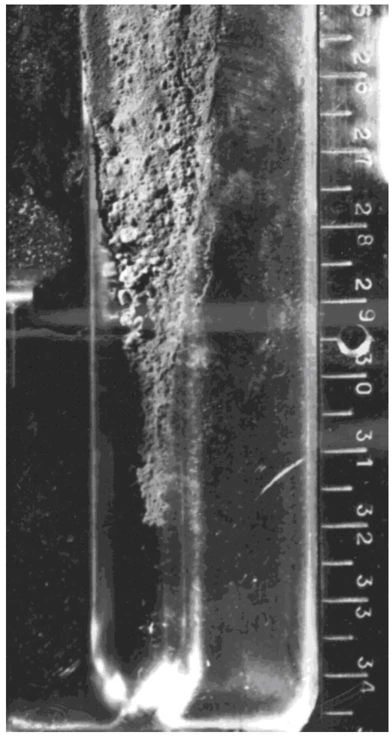
157 cm



~ 190 cm

~ 190 cm





bottom
220 cm

Luna24

Tray	depth	weight
4	47-75 cm	6.3 gr.
5	75-100	21.6
6	100-126	33.6
7	126-157	45.6
8	157-190	49.3
9	190-220	13.7
Total		170.1 grams

List of Luna Samples received from USSR as of 9/25/87

Luna24

US number	weight	location	date rec
24067	0.098		3/20/79
24077	0.520		3/9/77
24088	0.503		3/14/87
24105	0.49		3/14/87
24109	0.5		3/9/77
24149	0.5		3/9/77
24170	0.2		3/9/77
24174	0.5		3/9/77
24182	0.51		3/9/77
24210	0.3		3/9/77

List of Luna Samples provided to Royal Soc. London 8/77

24090	0.35
24125	0.3352
24170	0.009
24196	0.3102

List of India	0.802 gm total		3/77
24087		35 cm	
24123		66	
24148		87	
24163		100	
24179		114	
24190		124	