DRAFT

Luna 24170

VLT Basalt

~ 199 mg.

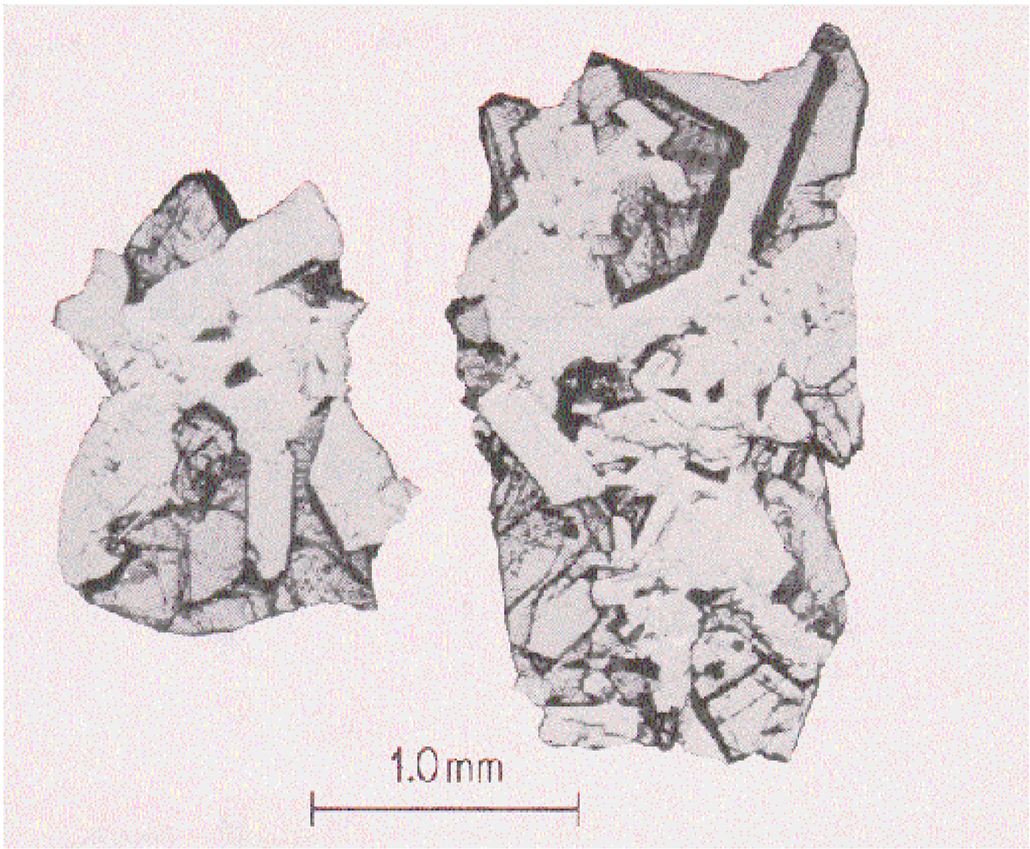

Figure 1: Thin section of basalt grains from Luna 24 , depth 170 cm. (from Lunatic Asylum 1978).

Introduction

Lunar sample 24170 represents a portion of a layer of rather coarse particles (>1 mm) from the upper portion of Unit IV of the Luna 24 core that was collected, automatically, from Mare Crisium. It has been interpreted as a piece of coarse basalt (gabbro?) that was crushed during the coring operation (Barsukov 1978; Ryder et al. 1977) and has been studied by Tarasov et al. (1977), FOCUS (1977), the Lunatic Asylum (1978), Unruh and Tatusomoto (1978), Ryder et al. (1977) and others. It was successfully dated by the Lunatic Asylum (1978) at 3.3 b.y.

Additional fragments of VLT (very low titanium) ferrobasalt were studied from the Luna 24 core. Papike and Vaniman (1978) describe these particles as ophitic, with olivine and pyroxene phenocrysts, small euhedral chromite, subhedral ulvospinel and residual patches of ilmenite, silica, Fe-pyroxene and K-enriched glass.

Petrography

Most of the mineral fragments from the coarse layer at depth 170 cm in the Luna 24 core are apparently broken from a relatively coarse (~ 1mm), ophitic, mare basalt (figures 1, 2). The minerals are Fe-rich, so the term "ferrobasalt" seems appropriate. The pyroxene and plagioclase grains are highly, and complexly, zoned, so the term "micrograbbro" (often used) does not seem appropriate. Estimates of the mineral mode for this layer are given in the table.

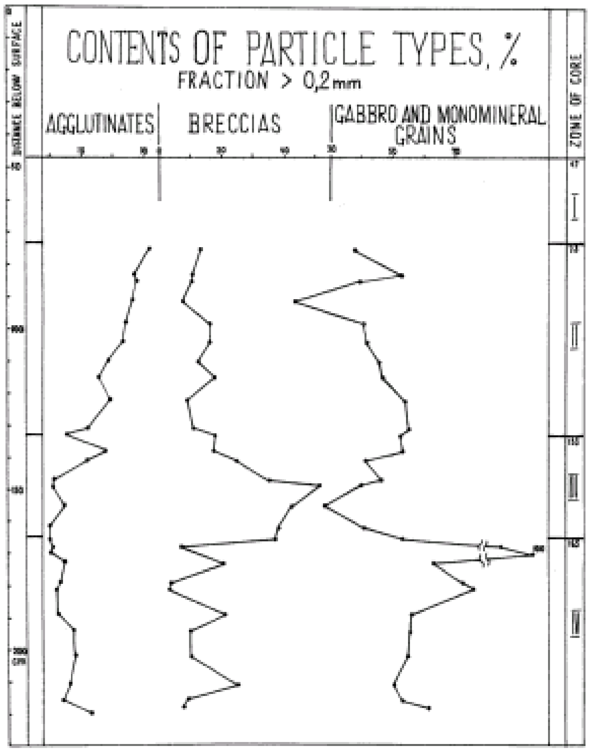

Figure 2: Distribution of rock types along depth in Luna 24 core (from Barsukov et al. 1977). The top was apparently left behind on the moon. At 170 cm, the sample as nearly 100% coarse basalt.

Mineralogy

Pyroxenes: The pyroxene grains in L24170 were analyzed by numerous teams including: Tarasov et al. (1977), Bence et al. (1977), Ryder et al. (1977), Taylor et al. (1978) and the Lunatic Asylum (1978). They are found to be highly zoned from Fe-rich pigeonite and clinopyroxene to hedenbergite and a "final" pyroxene $Wo_{20}En_5Fs_{75}$ (Papike and Vaniman 1978)(figure 3).

Olivine: Olivine is abundant in this layer (10%) and found to be chemically zoned from Fo_{58} to Fo_5 (figure 3).

Plagioclase: The feldspar in L24170 is ophitically intergrown with both olivine and pyroxene. It is zoned from An_{90} to An_{86} (Papike and Vaniman 1978).

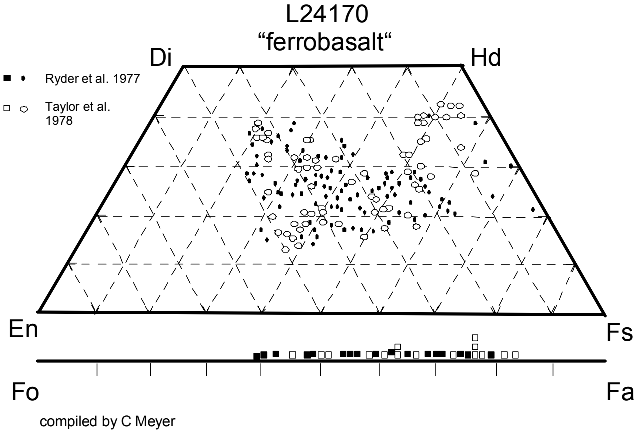

Figure 3: Pyroxene and olivine composition of the coarse-grained, "ferro-basalt", layer at 170 cm. (data replotted from Ryder et al. 1977 and Taylor et al. 1978). Similar data is found in Lunatic Asylum (1977) and Bence and Papike (1977).

Spinels: The opaques in L24170 were studied by Haggerty (1978). The spinels are split in two end-member compositions ulvospinel and chromite.

Chemistry

The chemical composition of this layer was determined by Barsukov (1977) (table 1). Ma et al. (1978) determined the composition of mineral separates (figure 4). Comparison with other lunar basalt compositions is made in figures 5 and 6.

Radiogenic age dating

The Lunatic Asylum (1978) was able to successfully date this basalt by Sm-Nd internal mineral isochron (figure 7) and concordant argon release plateau (figure 8) as 3.3 ± 0.4 b.y. However, attempts to date small amounts of this fragmented material by Rb-Sr and U-Pb generally proved unsuccessful (see table).

Mineralogical Mode of L24170 (estimated)

	Bence et al. 1977	**Bence & Grove 1978**	**Lunatic Asylum 78**	**Taylor et al. 1977**
Olivine	9.5 vol. %	8.3	5 wt. %	13
Pyroxene	52.2	45.6	65	61
Plagioclase	33.7	29.4	30	24
Silica	3	2.6		0.3
Opaque	0.6	0.5		0.3

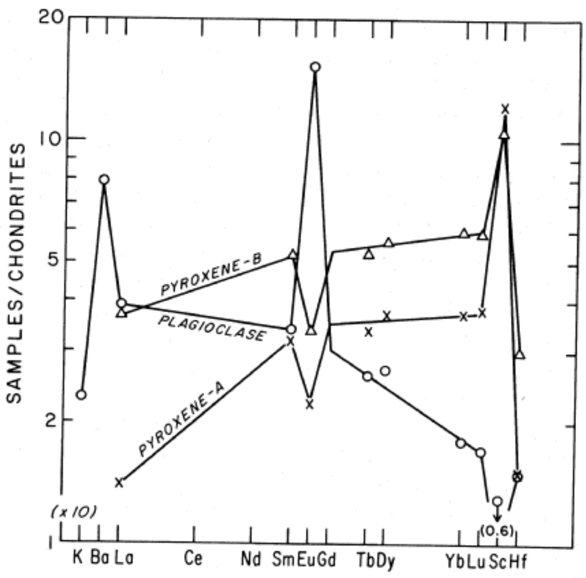

Figure 4: Normalized rare-earth-element composition diagram for mineral separates from Luna 24170 (from Ma et al. 1977).

Other Studies

Numerous other studies were conducted on Luna 24 samples. Most of these are reported in the book titled Mare Crisium.

Processing

This unique sample was collected automatically as a long drill (~200 cm) from Mare Crisium. The fiber-enforced core liner was wound around a drum, during which most of the top 60 cm were lost (on the Moon). The samples was processed in the USSR (figure 10), followed by a trade with the US and other countries. Each of the US splits (except this layer) was sieved and cataloged by Nagle and Walton (1977). A conference was held and a whole book written titled Mare Crisium: The view from Luna 24 (eds. Papike and Merrill)

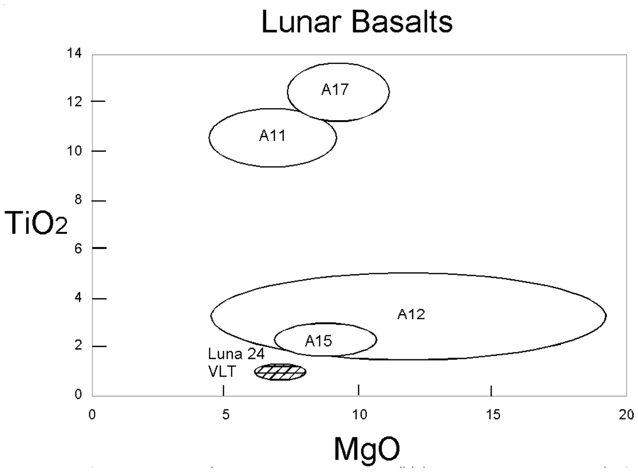

Figure 5: Composition of Luna 24 VLT basalts conmpared with other lunar basalts (after Ryder et al. 1977).

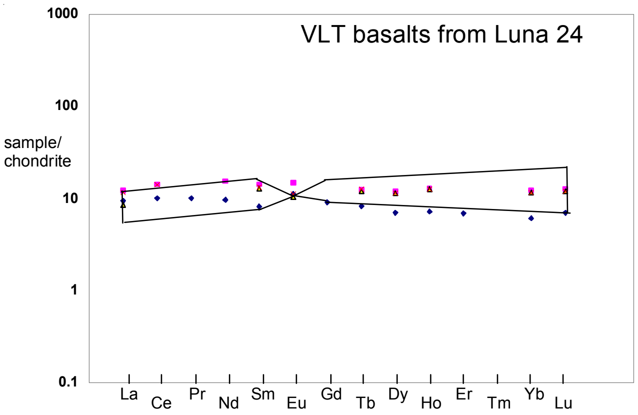

Figure 6: Range of compositions of Luna 24 VLT basalts (data from table 1 and Laul et al. 1978).

It would seem important to chronicle and analyze the steps taken in the collection and study of these small samples, with the hope of documenting "lessons learned" for possibly future unmanned sampling missions.

Summary of Age Data for L24170

	39/40 Ar	Rb/Sr	Sm/Nd	U/Pb	
Lunatic Asylum 1978	3.3 ± 0.04 b.y.	3.7 ± 0.6	3.3 ± 0.05		
Unruh and Tats 1978				??	
Other VLT reported					
Schaeffer et al. 1978	3.24 ± 0.06				24077
	3.33 ± 0.21				24077
Birck et al. 1977		3.74 ± 0.28			24171
Stettler and Albarede 1977	3.65 ± 0.12				24096

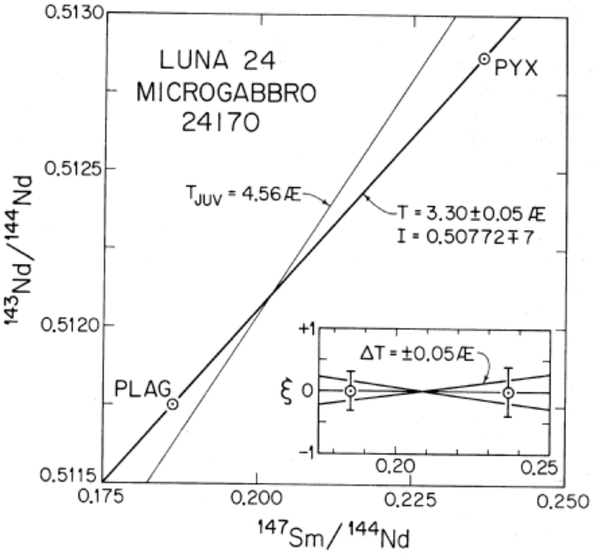

Figure 7: Sm-Nd mineral isochron for L24170 (from Lunatic Asylum 1978).

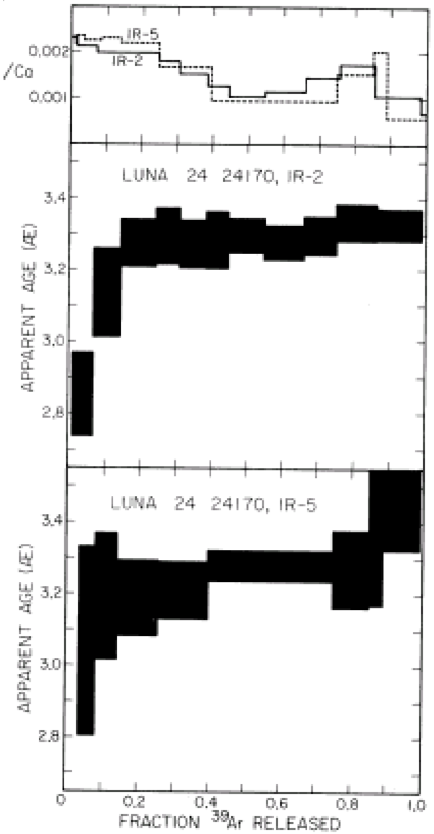

Figure 8: Argon plateau age for L24170 (from Lunatic Asylum1978).

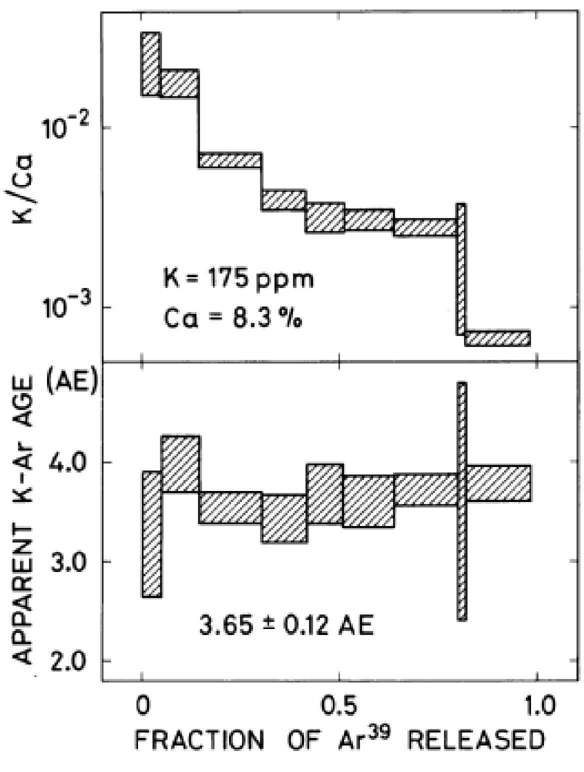

Figure 9: Argon age plateau for L24 VLT basalt particle 24096 (from Stettler et al. 1977).

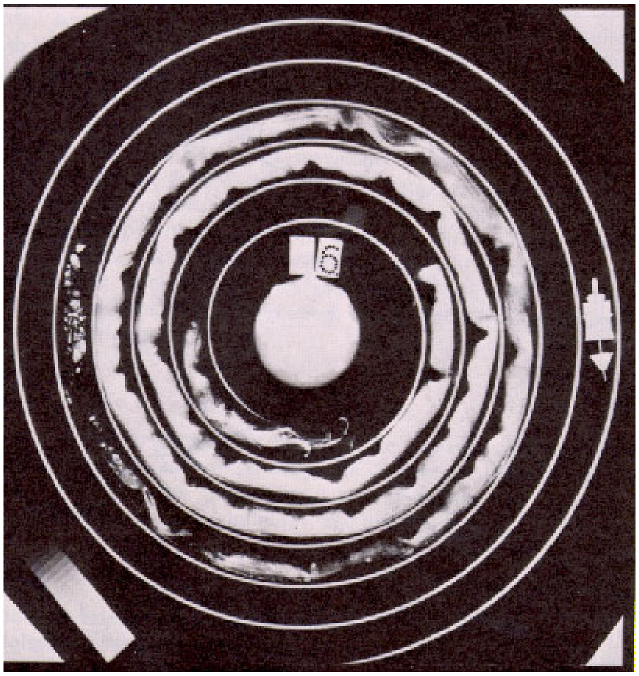

Figure 10: X-ray of Luna 24 core as it was coiled on the "snail" (from Barsukov 1977).

Table 1. Chemical composition of Luna 24170 and VLT basalt.

			Tarasov 77			s. frag.	soil	soil	
reference	*Taylor 78*		Barsukov 77	Laul 78	Ma 78	Blanchard 78			
weight	*24170*		24170	24174,7	24109,78	24174	24174	24174	
SiO2 %	*47.9*	*(b)*	43.9	46				45.5	
TiO2	*0.71*	*(b)*	0.74	1.1				0.9	
Al2O3	*12.3*	*(b)*	19	12.1				11.1	
FeO	*17.9*	*(b)*	16.6	22.1		16.6	20.9	20.9	
MnO			0.19	0.28					
MgO	*7.1*	*(b)*	5.2	6				9.7	
CaO	*13.7*	*(b)*	14	11.6				10.8	
Na2O	*0.23*	*(b)*	0.5	0.265		0.38	0.287	0.29	
K2O	*0.01*	*(b)*	0.06					0.03	
P2O5			0.11						
S %			0.05						
sum									
Sc ppm			34	57	47	35.8	43.9		(a)
V				140	177				(a)
Cr			1500	2053		1368	3352	3352	(a)
Co			34	43.3		29.7	50.4		(a)
Ni			<120	30	80		130		(a)
Cu			9						
Zn			15						
Ga			3						
Ge ppb									
As									
Se									
Rb									
Sr				110					
Y			20						
Zr			37	50					
Nb									
Mo									
Ru									
Rh									
Pd ppb									
Ag ppb			12						
Cd ppb									
In ppb									
Sn ppb			1.6						
Sb ppb			83						
Te ppb									
Cs ppm			0.052						
Ba			36	50					
La			2.2	2.87	2	0.86	2.74		(a)
Ce			6.1	8.6		2.33	8.5		(a)
Pr			0.9						(a)
Nd			4.4	7					(a)
Sm			1.2	2.1	1.9	0.8	1.95		(a)
Eu			0.63	0.83	0.58	0.7	0.63		(a)
Gd			1.8						(a)
Tb			0.3	0.45	0.44	0.2	0.46		(a)
Dy			1.7	2.9	2.8				
Ho			0.4	0.71					
Er			1.1						
Tm									
Yb			1	2	1.9	0.96	1.89		(a)
Lu			0.17	0.31	0.29	0.17	0.299		(a)
Hf			0.9	1.4	1.1	0.88	1.47		(a)
Ta			0.18	0.24					(a)
W ppb			40						
Re ppb									
Os ppb									
Ir ppb			4.3						
Pt ppb			9						
Au ppb			2	<0.4					
Th ppm			0.55	0.2			0.24		(a)
U ppm			0.18						

technique (a) INAA, (b) calculated