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Catalog of Apollo 17 Rocks

Volume 2 – Central Valley, Part 1

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Houston, Texas

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Work on these volumes was started in 1988 under the authority of John Dietrich, as Planetary Material Curator, and finished under James Gooding. To these managers and their able curatorial staffs, we express our thanks. It was not an easy task for any of us, but satisfaction comes from the completion and publication of these volumes for the planetary service community.

Larry Taylor
Clive Neal

CONTENTS

INTRODUCTION

The Catalog of Apollo 17 rocks is a set of volumes that characterize each of 334 individually numbered rock samples (79 larger than 100 g) in the Apollo 17 collection, showing what each sample is and what is known about it. Unconsolidated regolith samples are not included. The catalog is intended to be used by both researchers requiring sample allocations and a broad audience interested in Apollo 17 rocks. The volumes are arranged geographically, with separate volumes for the South Massif and Light Mantle; the North Massif; and two volumes for the mare plains. Within each volume, the samples are arranged in numerical order, closely corresponding with the sample collection stations.

Information on sample collection, petrography, chemistry, stable and radiogenic isotopes, rock surface characteristics, physical properties, and curatorial processing is summarized and referenced as far as it is known up to early 1992. The intention has been to be comprehensive-- to include all published studies of any kind that provide information on the sample, as well as some unpublished information. References which are primarily bulk interpretations of existing data or mere lists of samples are not generally included. Foreign language journals were not scrutinized, but little data appears to have been published only in such journals. We have attempted to be consistent in format across all of the volumes, and have used a common reference list that appears in all volumes.

Much valuable information exists in the original Apollo 17 Lunar Sample Information Catalog (1973) based on the intense and expert work of the Preliminary Examination Team. However, that catalog was compiled and published only four months after the mission itself, from rapid descriptions of usually dust-covered rocks, usually without anything other than macroscopic observations, and less often with thin sections and a little chemical data. In the nearly two decades since then, the rocks have been substantially subdivided, studied, and analyzed, with numerous published papers. These make the original Information Catalog inadequate, outmoded, and in some cases erroneous. However, that Catalog contains more information on macroscopic observations for most samples than does the present set of volumes. Considerably more detailed information on the dissection and allocations of the samples is preserved in the Data Packs in the Office of the Curator.

THE APOLLO 17 MISSION

On December 11, 1972, the Apollo 17 lunar excursion module "Challenger," descending from the Command Service Module "America," landed in a valley near the edge of Mare Serenitatis (Figures 1 and 2). It was the sixth and final landing in the Apollo program. Astronauts Eugene Cernan and Harrison Schmitt spent 72 hours at the site, named Taurus-Littrow from the mountains and a crater to the north. The site was geologically diverse, with the mountain ring of the Serenitatis basin and the lava fill in the valley. The main objectives of the mission were to sample very ancient material such as pre-Imbrian highlands distant from the Imbrium basin, and to sample pyroclastic materials believed pre-mission to be substantially younger than mare basalts collected on previous missions.

The crew spent more than 22 hours on the lunar surface, using the rover to traverse across the mare plains and to the lower slopes of the South and North Massifs, and over a light mantle in the valley that appeared to have resulted from a landslide from the South Massif. The traverses totalled more than 30 km, and nearly 120 kg of rock and soil were collected (Figure 3). This total sample mass was greater than on any

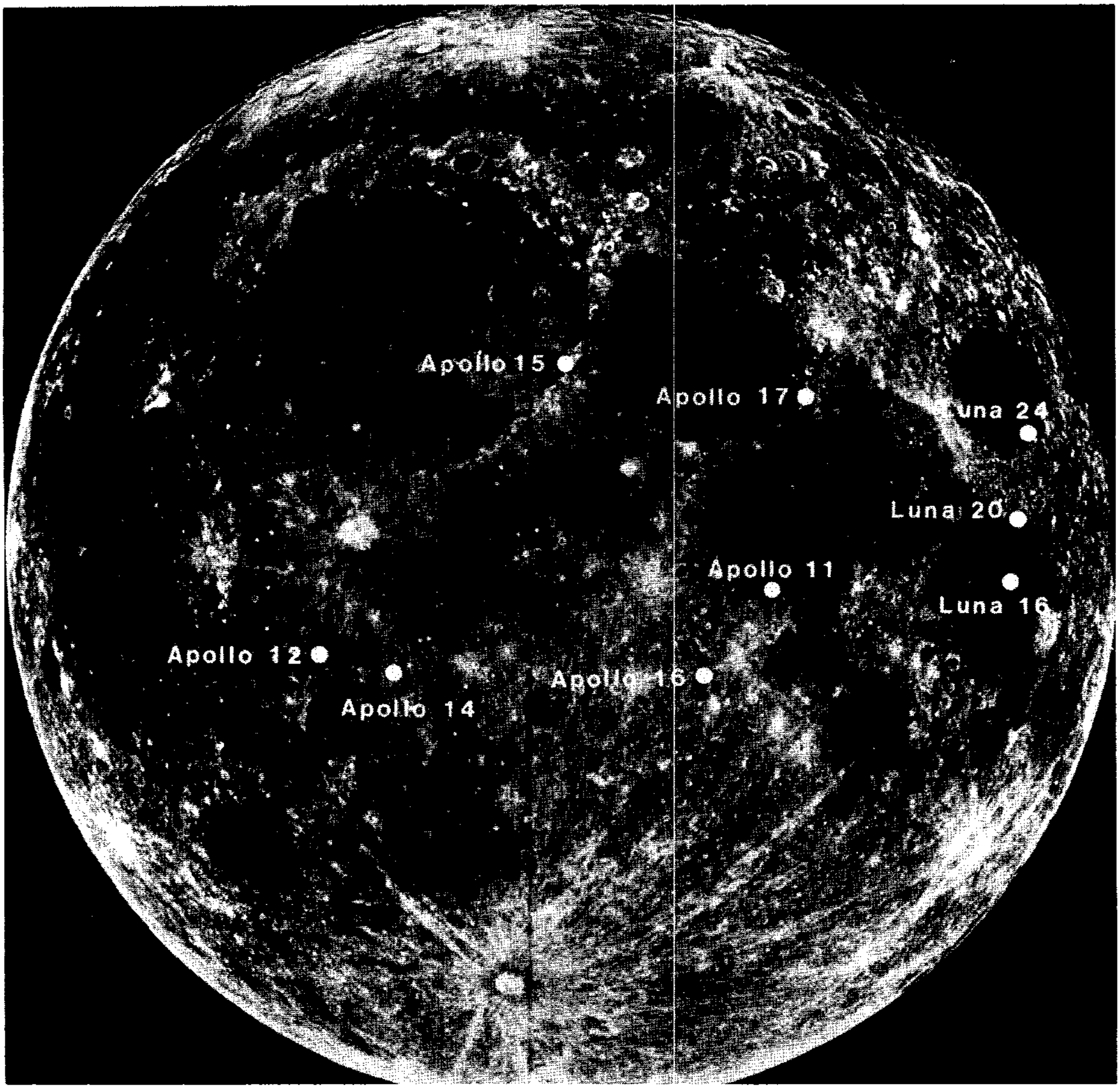


Figure 1: Apollo and Luna sampling sites on the near side of the Moon. S84-31673.

previous mission. An Apollo Lunar Surface Experiments Package (ALSEP) was set up near the landing point. Other experiments and numerous photographs were used to characterize and document the site. Descriptions of the pre-mission work and objectives, the mission itself, and results are described in detail in the Apollo 17 Preliminary Science Report (1973; NASA SP-330) and the Geological Exploration of the Taurus-Littrow Valley (1980; USGS Prof. Paper 1080), and others listed in the bibliography at the end of this section. Many of the rock samples have been studied in detail, and some, particularly massif boulders, have been studied in co-ordinated fashion in formal consortia.

The valley floor samples demonstrate that the valley consists of a sequence of high-Ti mare basalts that were mainly extruded 3.7 to 3.8 Ga ago. The sequence is of the order of 1400m thick. The sequence consists of several different types of basalt

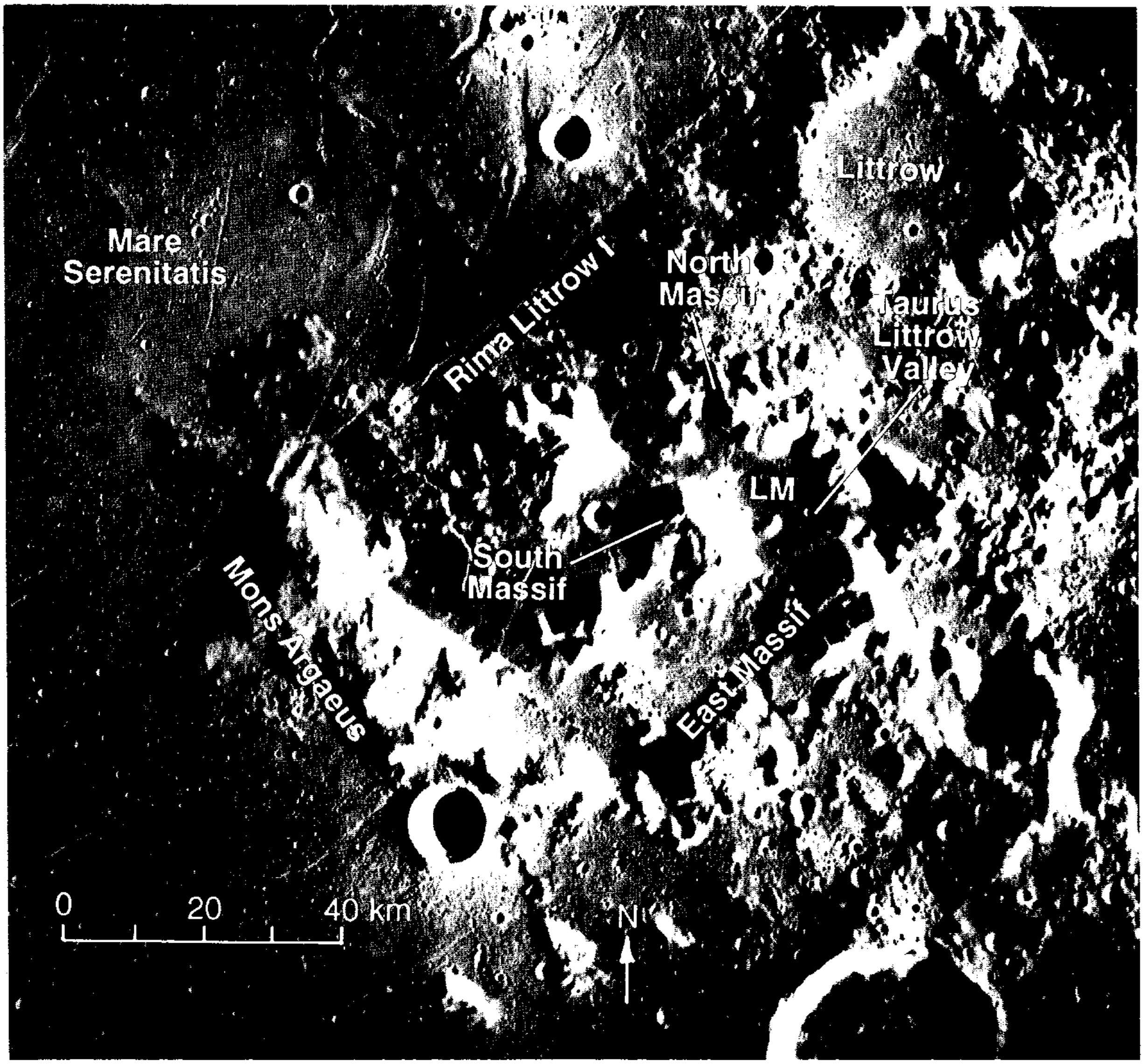


Figure 2: Apollo 17 landing site region showing major geographic features. AS17-M-447.

that cannot easily be related to each other (or Apollo 11 high-Ti mare basalts) by simple igneous processes, but instead reflect varied mantle sources, mixing, and assimilation. Orange glass pyroclastics were conspicuous, and is the unit that mantles both the valley fill and part of the nearby highlands. However, they were found to be not younger than other Apollo volcanics, but were only slightly younger than the valley fill. These glasses too are high-Ti basalt in composition. The orange glasses occur in the rocks only as components of some regolith breccias.

The sampling of the massifs was directed at coherent boulders and some rocks, and are dominated by a particular type of crystalline impact melt breccia. This is found on both massifs, and is characterized by an aluminous basalt composition and a poikilitic groundmass. The samples are widely interpreted as part of the impact melt produced by the Serenitatis basin event itself. A second type of impact melt, dark and aphanitic, is represented only by samples from the South

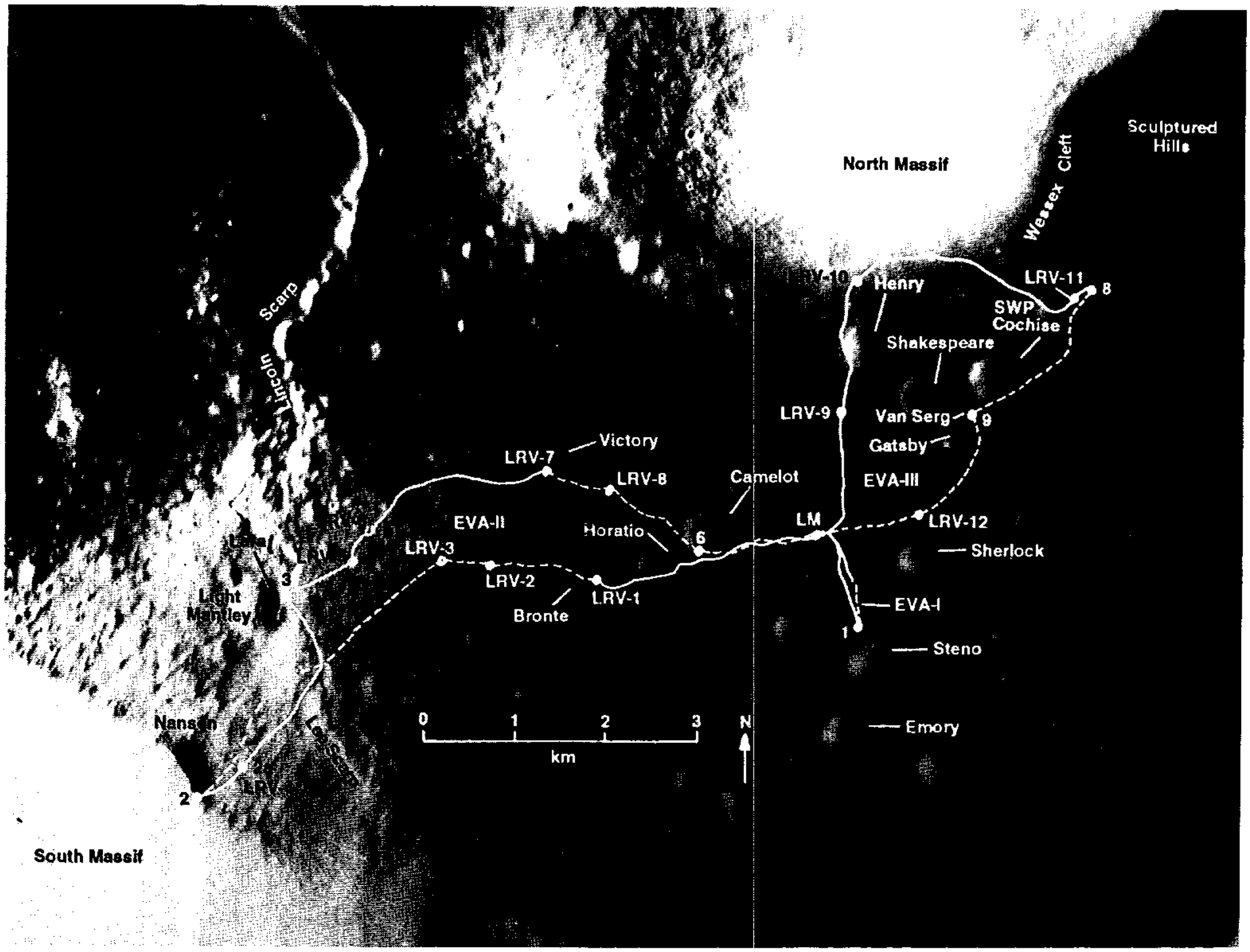
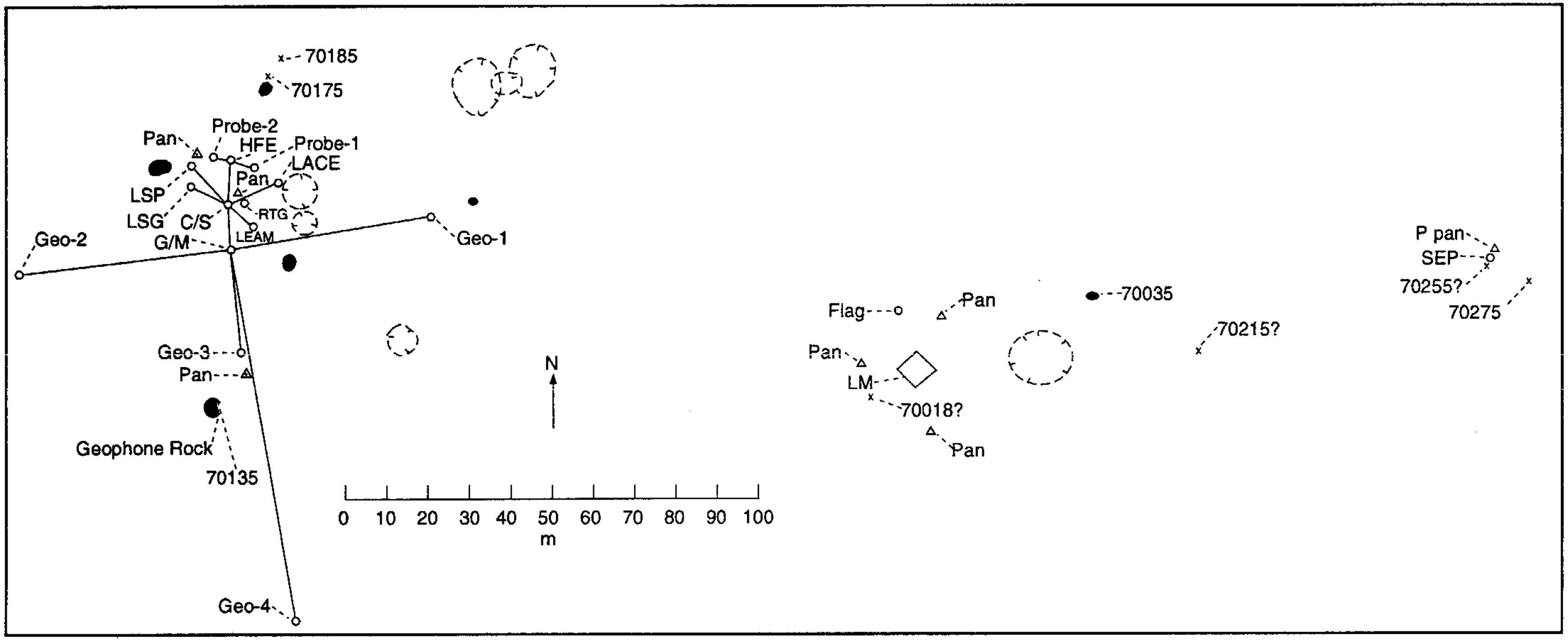


Figure 3: Apollo 17 traverse and sample collection map.

Massif stations. It is similar in chemistry to first type, but is more aluminous and much poorer in TiO_2. It contains a much greater abundance and variety of clast types. Opinion still differs as to whether these aphanites are a variant of the Serenitatis melt or represent something distinct. Both aphanitic and poikilitic melts seem to be most consistent with an age of close to 3.87 (+/- 0.2) Ga. A few rare samples of impact melt have distinct chemistry. Other rock and clasts are pristine igneous rocks, including dunite, troctolite, and norite (some of which formed meter-sized clasts or individual boulders), as well as more evolved types including gabbros and felsic/granitic fragments. Feldspathic granulites are common as clasts in the melt matrices (both aphanitic and poikilitic) and occur as a few small individual rocks. Geochronology shows that many of these granulites and pristine igneous rocks date back as far as 4.2 and even 4.5 Ga. The purer soils of the South Massif contain more alumina and only half of the incompatible element budget of the dominant impact melt rocks, demonstrating that the massifs, representing pre-Serenitatis material, have a component not well represented in the larger collected samples. Conspicuously absent, and not the "missing" component in the soil, is ferroan anorthosite, common at the Apollo 16 site and widely believed to have formed an early lunar crust.



C/S	ALSEP Central Station	LSG	Lunar Surface Gravimeter Experiment
G/M	Geophone Module	LSP	Lunar Seismic Profiling Experiment
Geo-2	Geophone Number 2	PAN △	60 mm Hasselblad Panorama
HFE	Heat Flow Experiment	RTG	Radioisotope Thermoelectric Generator
LACE	Lunar Atmosphere Composition Experiment	SEP	Surface Electrical Properties Experiment Transmitter
LEAM	Lunar Ejecta and Meteorites Experiment	●	Boulder – letters refer to large blocks on maps and pans
LM	Lunar Module	○	Crater

Figure 4: Locations of rocks collected at the LM and ALSEP stations.

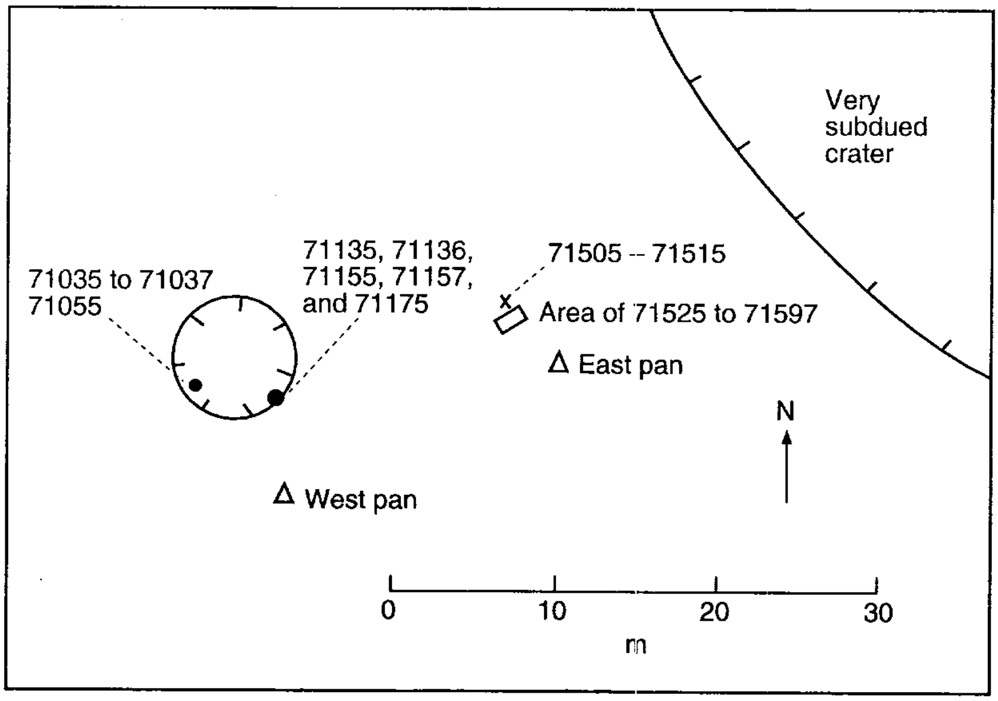


Figure 5: Locations of rocks collected at station 1.

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NUMBERING OF APOLLO 17 SAMPLES

As in previous missions, five digit sample numbers are assigned each rock (coherent material greater than about 1 cm), the unsieved portion and each sieve fraction of scooped < 1 cm material, the drill bit and each drill stem and drive tube section and each sample of special characteristics.

The first digit (7) is the mission designation for Apollo 17 (missions prior to Apollo 16 used the first two digits). As with Apollo 15 and 16 numbers, the Apollo 17 numbers are grouped by sampling site. Each group of one thousand numbers applies to an area as follows:

The first numbers for each area were used for drill stems, drive tubes, and the SESC. Drill stem sections and double drive tubes are numbered from the lowermost section upward.

The last digit is used to code sample type, in conformity with the conventions used for Apollo 15 and Apollo 16. Fines from a given documented bag are ascribed numbers according to:

7WXY0	Unsieved material (usually < 1 cm)
7WXY1	< 1 mm
7WXY2	1-2 mm
7WXY3	2-4 mm
7WXY4	4-10 mm

Sampling Site	Initial Number
LM, ALSEP, SEP, and samples collected between Station 5 and the LM	70000
Station 1A	71000
Station 2 and between it and the LM	72000
Station 3 and between it and Station 2	73000
Station 4 and between it and Station 3	74000
Station 5 and between it and Station 4	75000
Station 6 and between it and the LM	76000
Station 7 and between it and Station 6	77000
Station 8 and between it and Station 7	78000
Station 9 and between it and Station 8	79000

Rocks from a documented bag are numbered 7WXY5 - 7WXY9, usually in order of decreasing size.

Sample number decades were reserved for the contents of each documented bag. In the cases where the number of samples overflowed a decade, the next available decade was used for the overflow. For example DB 455 contained soil, numbered 71040-71044, and 6 small rocks numbered 71045-71049 and 71075.

Paired soil and rake samples for each sampling area are assigned by centuries starting with 7W500. The soil sample documented bag has the first decade or decades of the century, in conformity with the last digit coding for rocks and fines (as explained above), and the rake sample documented bag uses the following decades. For example, 71500-71509, 71515 were used for the sieve fractions and six rocks from the soil sample in DB 459. Then for the companion rake sample in DB's 457 and 458, 71520 was used for the soil, which was not sieved, and the 38 >1 cm rake fragments were numbered 71535-71539, 71545-71549, etc., to 71595-71597.

In as much as possible all samples returned loose in a sample collection bag or an ALSRC were numbered in a decade. In the cases in which rocks from several stations were put into a single collection bag however, the soil and rock fragments were assigned a decade number that conforms to the site for the largest or most friable rock. The other rocks in the same bag have numbers for their own site, generally in the second or third decade of the thousand numbers for that site.

SAMPLE INVENTORY

Sample	Type (a)	Mass grams	Station	Description	Page #
71046		3.037		High-Ti mare basalt	161
71047		2.78		High-Ti mare basalt	165
71048		2.457		High-Ti mare basalt	169
71049		1.86		High-Ti mare basalt	173
71055		669.6		High-Ti mare basalt	177
71065		28.83		High-Ti mare basalt	187
71066		19.96		High-Ti mare basalt	191
71067		4.245		High-Ti mare basalt	195
71068		4.208		High-Ti mare basalt	199
71069		4.058		High-Ti mare basalt	201
71075		1.563		High-Ti mare basalt	205
71085		3.402		High-Ti mare basalt	207
71086		3.329		High-Ti mare basalt	211
71087		2.20		High-Ti mare basalt	215
71088		2.064		High-Ti mare basalt	219
71089		1.733		High-Ti mare basalt	223
71095		1.483		High-Ti mare basalt	227
71096		1.368		High-Ti mare basalt	231
71097		1.355		High-Ti mare basalt	235
71135		36.85		High-Ti mare basalt	241
71136		25.39		High-Ti mare basalt	245
71155		26.15		High-Ti mare basalt	249
71156		5.42		High-Ti mare basalt	255
71157		1.466		High-Ti mare basalt	259
71175		207.8		High-Ti mare basalt	263
71505		29.45		High-Ti mare basalt	269
71506		12.11		High-Ti mare basalt	273
71507		3.962		High-Ti mare basalt	277
71508		3.423		High-Ti mare basalt	281
71509		1.69		High-Ti mare basalt	285
71515		1.635		High-Ti mare basalt	289

Sample	Type (a)	Mass grams	Station	Description	Page #
71525		3.90		High-Ti mare basalt	293
71526		12.91		High-Ti mare basalt	297
71527		2.19		High-Ti mare basalt	301
71528		11.25		High-Ti mare basalt	305
71529		6.025		High-Ti mare basalt	309
71535		17.71		High-Ti mare basalt	313
71536		5.32		High-Ti mare basalt	317
71537		12.25		High-Ti mare basalt	321
71538		8.04		High-Ti mare basalt	325
71539		10.90		High-Ti mare basalt	329
71545		17.26		High-Ti mare basalt	335
71546		150.70		High-Ti mare basalt	339
71547		12.54		High-Ti mare basalt	345
71548		25.46		High-Ti mare basalt	349
71549		7.90		High-Ti mare basalt	353
71555		4.55		High-Ti mare basalt	357
71556		29.14		High-Ti mare basalt	361
71557		40.35		High-Ti mare basalt	365
71558		15.81		High-Ti mare basalt	369
71559		82.16		High-Ti mare basalt	373
71565		24.09		High-Ti mare basalt	377
71566		414.4		High-Ti mare basalt	381
71567		146.0		High-Ti mare basalt	385
71568		10.02		High-Ti mare basalt	389
71569		289.6		High-Ti mare basalt	393
71575		2.113		High-Ti mare basalt	401
71576		23.54		High-Ti mare basalt	405
71577		234.7		High-Ti mare basalt	409
71578		353.9		High-Ti mare basalt	413
71579		7.94		High-Ti mare basalt	417
71585		13.86		High-Ti mare basalt	421

Sample	Type (a)	Mass grams	Station	Description	Page #
71586		26.92		High-Ti mare basalt	425
71587		41.27		High-Ti mare basalt	429
71588		48.98		High-Ti mare basalt	433
71589		6.86		High-Ti mare basalt	437
71595		25.21		High-Ti mare basalt	441
71596		61.05		High-Ti mare basalt	445
71597		12.35		High-Ti mare basalt	449

70017
High-Ti Mare Basalt
2957 g, 18 × 14 × 10 cm

INTRODUCTION

70017 is a coarse-grained high-Ti basalt. It has been one of the most widely studied of the returned lunar samples. In hand specimen, it is a tough, brownish-gray basalt with a blocky subangular shape. All surfaces are hackly with a few small glass patches. 70017 was originally described as a "holocrystalline, equigranular basalt containing some poikilitic plagioclase" (Apollo 17 Lunar Sample Information Catalog, 1973). The sample comprises 10-15% vugs (Fig. 1), in which mainly pyroxene with minor plagioclase are present. Plagioclase decreases in abundance towards these vugs. Zap pits occur mainly on B and adjacent parts of N, E, S, and W. There are none on T, which was buried. Whole-rock chemistry verifies it as a high-Ti basalt, containing 12-13.5 wt% TiO_2 (Table 1), and dating by Rb-Sr and K-Ar suggests a crystallization age of 3.7-3.8 Ga. Sample 70017 was collected near the Apollo 17 lunar module with 70011, 70012, and 70018.

PETROGRAPHY AND MINERAL CHEMISTRY

70017 has been classified as a plagioclase-poikilitic ilmenite basalt (Papike et al., 1974), a Type 1B of Brown et al. (1975) and Warner et al. (1975), or a Type III of Papike et al. (1973) and Brown et al. (1973). Longhi et al. (1974) described 70017 as a medium-grained hypidiomorphic-granular high-Ti basalt with large, equant, subhedral clinopyroxenes enclosing embayed ilmenites. Plagioclase is anhedral and poikilitically

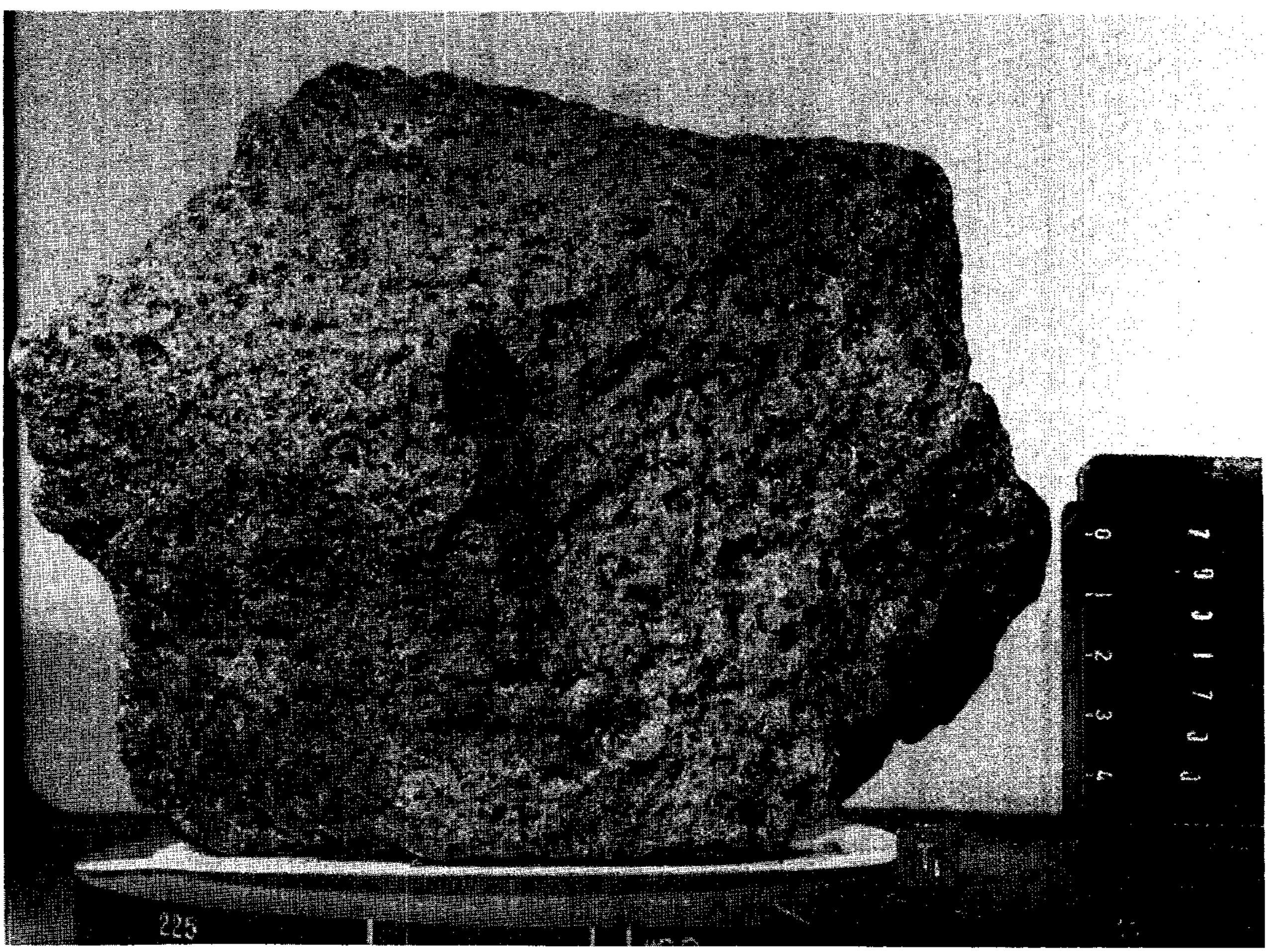


Figure 1: Hand specimen photograph of 70017,0.

encloses clinopyroxene, olivine, and ilmenite. Euhedral to subhedral ilmenite (~0.5mm) is enclosed in a matrix of clinopyroxene, which is poikilitically enclosed in plagioclase (up to 2mm long). Only minor olivine (~0.2mm) is present as cores of pyroxenes or as euhedral grains poikilitically enclosed in plagioclase. Small (<0.4mm) areas of silica occur as an interstitial phase. Minor chromite-ulvöspinel and rare interstitial glass are also present. Modal analyses have been reported by Brown et al. (1975) from 70017,109 and are 0.9% olivine, 22.8% opaques, 25.4% plagioclase, 49.3% clinopyroxene, 1.3% silica, 0.3% mesostasis. Roedder and Weiblen (1975) reported the modal mineralogy of 70017 as: 57.6% pyroxene; 19.8% plagioclase; 19.2% oxides; a trace of native Fe and sulfides; 1.6% silica; 1.4% melt/mesostasis; and 0.4% olivine.

Pyroxenes zone from subcalcic titanaugites (up to 3.6 wt% TiO_2) to Mg-pigeonites, due to the resorption of olivine (Brown et al., 1975). Later pyroxene compositions approach pyroxferroite (Fig. 2). Sung et al. (1974) reported Ti^{3+}/Ti^{4+} ratios in clinopyroxenes from 70017 as indicators of oxygen fugacity and/or depth of origin - up to 40% of the Ti present in 70017 pyroxenes is in the trivalent state. Olivine compositions range from Fo_{58} to Fo_{68}, and are relatively rich in Cr_2O_3 (up to 0.5 wt%; Brown et al., 1975). Plagioclase exhibits little zonation, commonly less than 10 An units from core-to-rim. Ilmenites often exhibit small (<0.005mm wide) exsolution lamellae of rutile and some blebs (<0.01mm) of native Fe. This reaction, in addition to the breakdown of ulvöspinel to ilmenite + Fe metal, was reported by El Goresy and Ramdohr (1975) as evidence for an endogenic late-stage reducing gas mixture during the crystallization of this basalt. Ilmenites are generally equant, almost amoeboidal (Papike et al., 1974). The Mg# of ilmenite is approximately 10-12, with Cr_2O_3 never exceeding 1 wt%. Roedder and Weiblen (1975) reported both high-K (6.27 wt% K_2O) and anomalous low-K (0.037 wt% K_2O) melt inclusions in the ilmenites of 70017. The high-K inclusions were attributed to late-stage, silicate-liquid immiscibility, but the origin of the low-K inclusions is obscure.

We found no armalcolite in the thin sections we studied (,455 and ,456), although a tan armalcolite has been reported by El Goresy et al. (1974) and Taylor and Williams (1974). El Goresy et al. (1974) concluded there were two types of titaniferous basalt present at Apollo 17 on the basis of crystallization sequence. 70017 falls into Type I of their classification. El Goresy and Ramdohr (1975) studied the opaque minerals of 70017 in order to determine the nature of subsolidus reduction in lunar basalt petrogenesis.

Pearce and Timms (1992) used laser interference microscopy to examine the plagioclase, and found no fine-scale zoning in any of the grains observed in 70017.

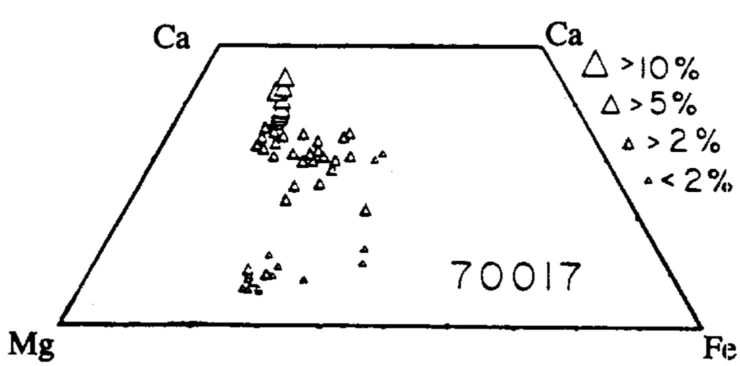


Figure 2: Pyroxene compositions of 70017 represented on a pyroxene quadrilateral.

WHOLE-ROCK CHEMISTRY

Rhodes et al. (1976) considered 70017 too coarse-grained for reliable chemical classification with the subsample size used. The relatively coarse grain size of 70017 introduced the problem of sampling errors. This may account for the fact that 70017 does not conform to the A, B, or C groups of Rhodes et al. (1976). Eleven whole-rock analyses have been reported for 70017 (Table 1). A variety of analytical methods have been employed, including XRF, INAA, and isotope dilution. The major-element compositions are similar for the seven subsamples analyzed for these elements (Rhodes et al., 1974; Brunfelt et al., 1974; Duncan et al., 1974; Miller et al., 1974; Nava, 1974; Rose et al., 1974). Sampling errors may be more apparent in the trace elements.

Table 1: Whole rock analyses of basalt 70017.
[Part A]

Ref.	1	2	3	4	5	6
	,18	,35	,35	,21	,28	,23
SiO_2 (wt%)	38.37	38.07			38.52	38.8
TiO_2	12.83	13.10		13.58	12.21	12.44
Al_2O_3	8.78	8.79		9.47	9.07	9.73
Cr_2O_3	0.577			0.518		0.45
FeO	18.71	18.07		18.32	18.19	17.6
MnO	0.247	0.27		0.254	0.233	0.232
MgO	9.41	9.81		9.13	11.95	9.89
CaO	10.43	10.30		11.48	10.36	10.04
Na_2O	0.43	0.40		0.405	0.405	0.43
K_2O	0.047	0.04		0.044		0.036
P_2O_5	0.052	0.05				0.048
S	0.175	0.15				
Nb (ppm)	18.5					
Zr	218		177			
Hf				8.0		
Ta						
U			0.06	0.088		
Th			0.198	0.17		
W				0.075		
Y	71.2					
Sr	166		153	127		
Rb	1.2		0.299	0.4		
Li			8.1			
Ba	83		45.8	55		
Cs				0.03		
Be						
Zn	<2			2		
Pb						
Cu	<3			2.8		
Ni	<3			<10		
Co	18			20.6		
V	146			156		
Sc				87		
La			3.99	4.11		
Ce			11.3	13.5		
Nd			13.2			

Table 1: (Continued)
[Part A, Concluded]

Ref.	1	2	3	4	5	6
	,18	,35	,35	,21	,28	,23
Sm			5.67	7.53		
Eu			1.49	1.77		
Gd			9.05			
Tb				1.77		
Dy			10.7	13.8		
Er			6.46			
Yb			5.98	6.3		
Lu				1.15		
F						
Cl						
C						
N						
H						
He						
Ga (ppb)				3.1		

Table 1: (Continued)
[Part B]

Ref.	7	8	8	9	9	10	11
	,23	,30	,50	,474	,474	,35	,13
SiO_2 (wt%)		38.80	38.68				
TiO_2		12.84	13.75				
Al_2O_3		8.54	7.40				
Cr_2O_3		0.49	0.49	0.58	0.54		
FeO		18.12	18.77		17.5		
MnO		0.24	0.25				
MgO		10.16	10.45				
CaO		10.56	10.05	7.14	13.4		
Na_2O		0.33	0.34	0.32	0.43		
K_2O		0.07	0.07				
P_2O_5		0.04	0.04				
S							
Nb (ppm)		23	18				
Zr	223	254	250		138		

Table 1: (Continued)
[Part B, Continued]

Ref.	7 ,23	8 ,30	8 ,50	9 ,474	9 ,474	10 ,35	11 ,13
Hf				7.4	6.0		
Ta				1.8	1.5		
U							0.0730
Th				4.8	0.14		0.2204
W							
Y	94	100					
Sr	168	217	155	172	306	153	
Rb	0.280	0.9	0.7			0.299	
Li	8.57	7.8	7.8				
Ba	43	250	180	78	68		
Cs							
Be		<1	<1				
Zn		<4	<4				
Pb		<2	<2				0.1514
Cu		28	84				
Ni		<1	24				
Co		32	32	132	22		
V		98	80		288		
Sc		80	77	75	78		
La		<10	<10	4.6	4.4		
Ce	10.7			16	15		
Nd	12.1			20	14		
Sm	5.13			6.7	71		
Eu	1.62			1.6	1.7		
Gd							
Tb				2.5	2.0		
Dy	10.2						
Er	6.31			0.71			
Yb	6.25			8.2	6.9		
Lu	0.954			1.3	1.1		
F							
Cl							
C							
N							

Table 1: (Concluded)
[Part B, Concluded]

Ref.	7 ,23	8 ,30	8 ,50	9 ,474	9 ,474	10 ,35	11 ,13
H							
He							
Ga (ppb)		5.8	5.4	21			
Ge				1.7	1.9		

References: 1) Duncan et al. (1974); 2) Rhodes et al. (1974); 3) Shih et al. (1975); 4) Brunfelt et al. (1974); 5) Miller et al. (1974); 6) Nava (1974); 7) Philpotts et al. (1974); 8) Rose et al. (1974); 9) Dickinson et al. (1989); 10) Nyquist et al. (1975); 11) Mattinson et al. (1977).

Analytical Methods Employed: 1) XRF; 2) XRF; 3) Isotope Dilution and INAA (for Co and Sc); 4) INAA; 5) INAA; 6) Semi-micro Combined Atomic Absorption and Colorimetric Spectophotometry; 7) Isotope Dilution; 8) XRF and optical emission; 9) INAA; 10) Isotope Dilution; 11) Isotope Dilution.

For example, the REE profiles (Fig. 3) of Philpotts et al. (1974) and Shih et al. (1975) have similar HREE abundances, but the REE profile of Brunfelt et al. (1974), while possessing the same overall pattern as the previous two, exhibits elevated REE abundances (Fig. 3). All three analyses exhibit LREE-depleted profiles with a negative Eu anomaly ($[Eu/Eu^*]_N$ = 0.6-0.7). There is a slight decrease in the HREE abundances relative to those of the MREE.

Most of the papers written concerning the whole-rock chemistry involve analyses of a suite of Apollo 17 high-Ti basalts, in order to deduce the petrogenesis and source region(s) of the original magmas (Duncan et al., 1974; Rhodes et al., 1974; Shih et al., 1975; Brunfelt et al., 1974; Nyquist et al., 1975; Mattinson et al., 1977). Other geochemical studies quoting the whole-rock composition of 70017 were investigations into the nature of the lunar regolith (Miller et al., 1974; Nava, 1974; Rose et al., 1974; Philpotts et al., 1974; Rhodes et al., 1976).

Dickinson et al. (1988, 1989) used 70017(,474) in a study of the germanium abundances (analyzed by RNAA) of mare basalts, in order to gain an insight into the origin and early evolution of the Moon and lunar basalts. Dickinson et al. (1988) only reported the Ge abundance, whereas Dickinson et al. (1989) report two whole-rock analyses from splits of 70017,474. These whole-rock analyses are similar (Table 1), except for Sm and Th in the first and Sr in the second are high, and these analyses have large errors associated with them. The REE profiles are LREE-depleted (Fig. 3) and have a negative Eu anomaly ($[Eu/Eu^*]_N$ ~0.6). The reported abundance of Ge in 70017 is 1.7 to 1.9 ppb. Dickinson et al. (1988, 1989) concluded that Apollo 17 basalts contain similar Ge abundances to those from the Apollo 11, 12, and 15 sites. The small variations observed are uncorrelated with other siderophile elements and cannot be explained by differences in the amount of metal segregated into the lunar core. Dickinson et al. (1988, 1989) suggested that volatile transfer of Ge by halogen-rich fluids may have generated such variations.

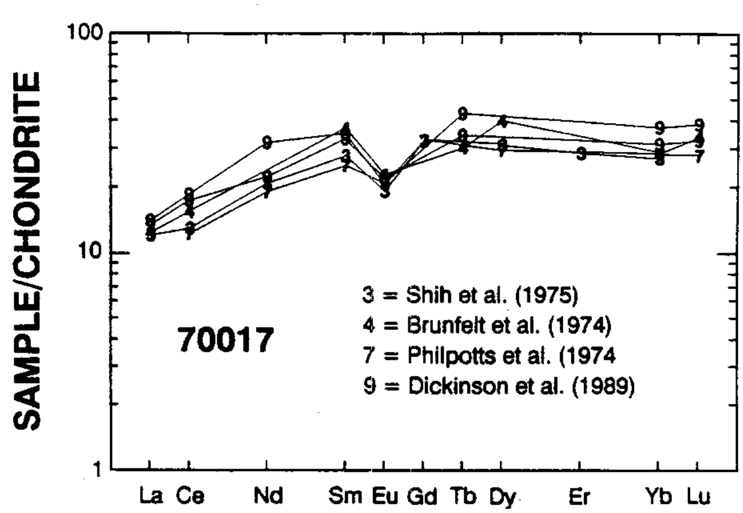


Figure 3: Chondrite-normalized rare-earth element profiles of 70017.

RADIOGENIC ISOTOPES

Basalt 70017 has been analyzed for Rb-Sr (Nyquist et al., 1975), K-Ar and Ar-Ar (Phinney et al., 1975), Oxygen (Mayeda et al., 1975), ^{22}Na-^{26}Al (Yokoyama et al., 1974), Carbon and Sulfur (Petrowski et al., 1974), Kr-Ar exposure ages (Hörz et al., 1975), and U-Pb (Mattinson et al., 1977). Results of these studies are summarized in Table 2. The Rb-Sr study of Nyquist et al. (1975) reported an age of 3.68 ± 0.18 Ga with an initial $^{87}Sr/^{86}Sr$ ratio of 0.69920 ± 4 (Fig. 4). These authors suggested that a three stage evolution model best accounted for the Sr isotope data: 1) evolution of $^{87}Sr/^{86}Sr$ in an environment with Rb-Sr > basalts; 2) production of source regions with lower but variable Rb-Sr between 4.6-3.75 Ga; and 3) extraction of these lavas at 3.75 Ga. However, the extreme requirements on analytical precision prevented definitive conclusions. The K-Ar and Ar-Ar study of Phinney et al. (1975) was concerned purely with age determinations. These authors reported ^{39}Ar-^{40}Ar and K-Ar ages of 3.80 ± 0.03 and 3.63 ± 0.03 Ga, respectively (Table 2).

The U-Pb study of Mattinson et al. (1977) demonstrates that 70017 has witnessed a somewhat different evolution from other Apollo 17 basalts (i.e., source region developed later in a two-stage model). U-Pb data for 70017 whole-rock and mineral separates plot along a chord which intersects the growth curve at 3.7 and 4.33 Ga. The 70017 data appear to plot on a different chord from 75055 and 75035, although the maximum errors on these data allow the possibility that all three plot on a common chord. This common chord corresponds to a crystallization age of 3.8 Ga and an initial radiogenic $^{207}Pb/^{206}Pb$ of 1.41. These authors cite the role of ilmenite in the fractionation of U from Th in the source regions, in order to explain the Pb isotope systematics of 70017. The results presented by Mattinson et al. (1977) are also reported by Chen et al. (1979) in order to compare with Pb isotope results from 71055.

STABLE ISOTOPES

The oxygen study of Mayeda et al. (1975) demonstrated the uniformity of $\delta^{18}O$ values at the Apollo 17 site and reported $\delta^{18}O$ values for mineral separates from 70017 (Table 2). This study was basically comparing ^{18}O compositions over the entire moon, noting little difference in oxygen isotope compositions between sites. Mayeda et al. (1975) attribute the lack of fractionation to the absence of water on the Moon.

A similar study was undertaken for carbon and sulfur in 70017 by Petrowski et al. (1974). These authors mainly concentrated upon S, presenting evidence for a complex lunar S cycle. However, whole-rock carbon (Table 2) and abundances of S are also reported by Petrowski et al. (1974) and are given in Table 2.

EXPOSURE AGE

Yokoyama et al. (1974) analyzed Apollo 17 rocks for ^{22}Na and ^{26}Al isotopes, determining that 70017 is saturated in ^{26}Al activity. The Ar exposure age of 70017 has been reported as approximately 126 Ma by Hörz et al. (1975), which is at variance with the ^{38}Ar-Ca age reported by Phinney et al. (1975) of 220±20 Ma. Phinney et al. (1975) also reported the K and Ca contents (640 ppm and 8.4%, respectively) and the Ar isotopic ratios of 70017 ($^{36}Ar/^{40}Ar = 0.006244 \pm 0.000088$; $^{37}Ar/^{40}Ar = 0.889 \pm 0.018$; $^{38}Ar/^{40}Ar = 0.00945 \pm 0.00012$; $^{39}Ar/^{40}Ar = 0.007285 \pm 0.000085$; $^{40}Ar * 10^{-8}$ cc STP/g $= 2724 \pm 20$).

MAGNETIC STUDIES

Sample 70017 has been analyzed in a number of magnetic studies in order to deduce the Fe^{o}/Fe^{2+} ratio by Mossbauer spectroscopy and magnetic measurements (Huffman et al., 1974; Brecher et al., 1974). These authors reported Fe^{o}/Fe^{2+} ratios of 0.029 and 0.01, respectively. Schwerer and Nagata (1976) reported the magnetic properties of 70017 as a ratio of the isothermal remnant magnetization - I_R, to the saturation magnetization

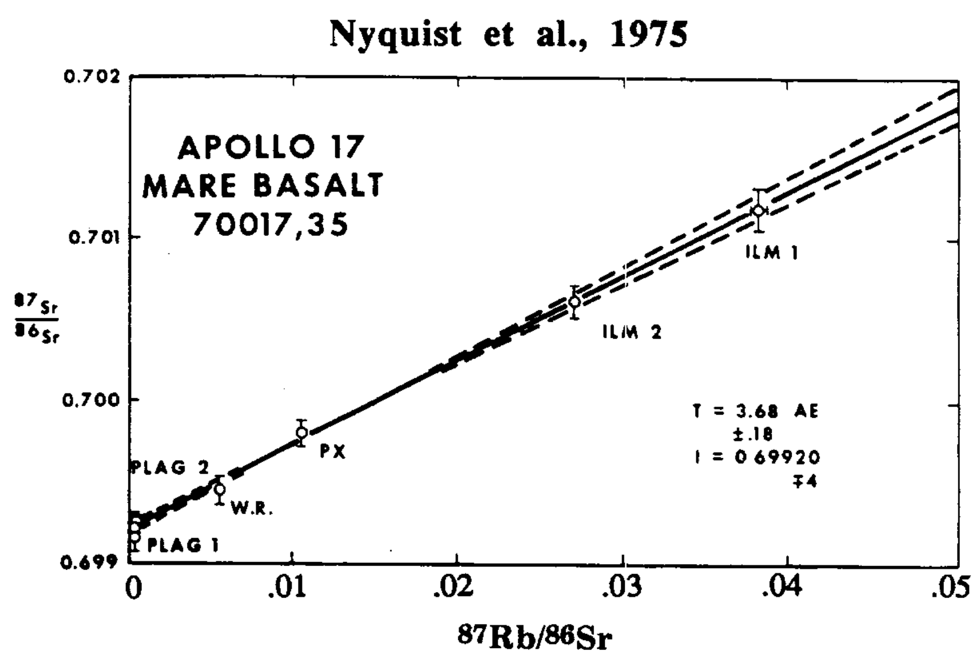


Figure 4: Rb-Sr isochron plot of 70017,35. Taken from Nyquist et al. (1975).

Table 2: Isotope analyses of basalt 70017.

Rb-Sr (Nyquist et al., 1975)

	wt(mg)	Rb (ppm)	Sr (ppm)	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$
70017,35	46.0	0.299	153.0	0.00565 ± 23	0.69945 ± 9
plag 1	4.2	0.070	528.7	0.00038 ± 2	0.69916 ± 8
ilm 1	6.8	0.410	31.3	0.0379 ± 5	0.70119 ± 13
px1	6.8	0.115	31.6	0.01050 ± 13	0.69979 ± 9
plag 2	7.1	0.0769	561.0	0.00039 ± 14	0.69922 ± 10
repeat					0.69925 ± 5
ilm 2	10.0	0.2833	0.44	0.0269 ± 3	0.70061 ± 10

AGE = 3.68 ± 0.18 AE, I = 0.69920 ± 4

K-Ar and Ar-Ar (Phinney et al., 1975)

	$^{39}Ar/^{40}Ar$	K-Ar	^{38}Ar-Ca Exposure Age
70017,65	3.80 ± 0.03AE	3.63 ± 0.03AE	220 ± 20 m.y.

Oxygen (Mayeda et al., 1975)

70017,27	Plagioclase	Pyroxene	Ilmenite
^{18}O	5.82	5.27	3.99

Carbon (Petrowski et al., 1974)

	C ppm	^{13}C o/oo PDB
70017,64	22	-22.1

Sulfur (Petrowski et al., 1974)

	S ppm	^{34}S o/oo CDT
70017,64	2283	+1.4

U-Pb (Mattinson et al., 1977)

	wt (mg)	Pb	U	Th	$^{238}U/^{204}Pb$ (u)	$^{232}Th/^{238}U$ (k)
70017,13	60.7	0.1514	0.0730	0.220	423	43.12
Px 1	26.5	0.0391	0.0732	0.2200	379	3.10
Px 2	18.5	0.1553	0.0855	0.2584	399	3.12
Px 3	10.2	0.0599	0.0275	0.0857	171	3.22
Ilm 1	16.8	0.2189	0.1252	0.2601	283	2.09
Ilm 2	20.8	0.3036	0.1749	0.4008	357	2.37
Plag 1	47.5	0.0284	0.00516	0.01590	69.1	3.10
Plag 2	48.2	0.0282	0.00467	0.01300	42.6	2.87

Table 2: (Concluded).

			Observed Ratios			Corrected Ratios		
		wt (mg)	$^{208}Pb/^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{204}Pb/^{206}Pb$	$^{208}Pb/^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{204}Pb/^{206}Pb$
WR A	IC*	60.7	0.9499	0.5587	0.006530	0.8907	0.5443	0.004018
	ID*	54.6	7.369	0.5502	0.005710	.--	0.5467	0.004346
WR B	IC	29.3	0.8546	0.5372	0.003310	0.8281	0.5291	0.002206
Px 1	IC	29.2	0.9692	0.5175	0.005933	0.9048	0.4990	0.003111
	ID	26.5	6.696	0.4994	0.005206	.--	0.4860	0.002874
Px 2	IC	19.2	0.8969	0.5030	0.00547	0.8288	0.4838	0.002642
	ID	18.5	8.082	0.5097	0.00564	.--	0.4940	0.002768
Px 3	IC	11.5	1.2052	0.5980	0.01671	0.9729	0.5348	0.006637
	ID	10.2	26.437	0.5976	0.01880	.--	0.5275	0.005799
Ilm 1	IC	17.8	0.7717	0.5287	0.00710	0.6808	0.5075	0.00382
	ID	16.8	6.070	0.5076	0.00522	.--	0.4959	0.00308
Ilm 2	IC	22.8	0.7150	0.4994	0.00383	0.6936	0.4941	0.00304
	ID	20.8	3.865	0.4979	0.00386	.--	0.4939	0.00305
Plag 1	IC	43.5	1.147	1.0368	0.01531	0.9779	1.0769	0.00819
	ID	47.5	18.70	0.953	0.0139	.--	1.0050	0.00764
Plag 2	IC	48.3	1.346	0.9956	0.02324	1.1010	1.0557	0.01279
	ID	48.2	19.26	0.9736	0.01636	.--	1.0315	0.01054

* IC = determination of isotopic composition; ID = concentration. ID failed for WR B.

- I_S, as well as the Fe^o/Fe^{2+} ratio. The I_R/I_S ratio was determined between 4.2 and 300K. Two determinations were reported by Schwerer and Nagata (1976) for 70017. The I_R/I_S ratio at 4.2K was reported as 0.033 and 0.046, and at 300K was 0.0048 and 0.0068. The Fe^o/Fe^{2+} ratio was given as 0.0054. The strength of the lunar magnetic field at the time of basalt eruption was reported as Natural Remnant Magnetism (NRM) by Nagata et al. (1974), Stephenson et al. (1974), and Brecher et al. (1974). All authors concluded that 70017 has a reasonable amount of NRM ($\sim 10^{-6}$ emu/g). Stephenson et al. (1974) reported an initial NRM of 51.6×10^{-6} G cm^3 g^{-1}. Nagata et al. (1974) reported that 70017 has magnetic properties similar to those of Apollo 11 mare basalts, except for a considerably smaller value of the initial magnetic susceptibility. Furthermore, the thermomagnetic curves in the low-temperature range (4.2-295K) demonstrated that 70017 contains a considerable amount of antiferromagnetic ilmenite. One study (Nagata et al., 1975) included 70017 in an investigation of meteorite impact on the magnetic properties of Apollo lunar materials.

EXPERIMENTAL

Experimental studies involving 70017 include the determination of the liquid line of descent and crystallization sequence (Rutherford et al., 1974; Hess et al., 1975; Hodges and Kushiro, 1974; Lofgren et al., 1975). The studies by Rutherford et al. (1974) and Hess et al. (1975) also centered on the ultimate immiscibility of the residual magma after extreme fractional crystallization. These authors determined that the development of immiscibility in the residual silicate liquid, after ~95% fractional crystallization, depends upon the cooling rate and and the final temperature in the experimental cooling cycle.

Hodges and Kushiro (1974) attempted to use 70017 in order to determine the differentiation sequences in model Moon compositions and, in doing so, presented a detailed crystallization sequence for 70017. These authors proposed the following crystallization sequence: spinel, olivine, armalcolite, followed by the nearly simultaneous crystallization of plagioclase and pyroxene. Ilmenite was the last major phase to form.

Sato (1976a,b) used the solid-electrolyte method (in the temperature range of 100-1200 °C) to measure the oxygen fugacity of 70017,31. He determined that the fO_2 values of 70017,31 are only slightly higher (up to 0.15 log fO_2 unit) than the average of four Apollo 12 and 15 basalts. In terms of bulk rock fO_2, Sato (1976a,b) concluded that 70017 is indistinguishable from low-Ti mare basalts. The "FeO" activity values of 70017 also fall within the range of low-Ti mare basalts. The low Fe^o activity values determined experimentally for 70017 were explained by Sato (1976a,b) as a result of the formation of Fe-FeS melt. Nash and Haselton (1975) reported the silica activity of 70017 to be ~0.3 log a_{SiO_2} units at 1140 °C and concluded that this basalt crystallized slowly under equilibrium conditions.

Osborne et al. (1978) used 70017 in an experimental study of spectral reflectance for Ti determinations at room and elevated temperatures. High-temperature measurements revealed that slopes of the reflectance profiles in the 0.400-0.550 um region increased significantly up to 300 °C, demonstrating a decrease in intensity at elevated temperatures as a result of metal → metal (e.g., $Fe^{2+} \rightarrow Ti^{4+}$) charge transfer bands involving Ti. They concluded that techniques for mapping Ti concentrations on hot planetary surfaces should be applied cautiously if room-temperature calibration spectra are used.

PROCESSING

The initial dissection of 70017 is detailed, with subsample numbers, in Fig. 5. 70017,0 has been entirely subdivided, with 70017,8 being the largest portion left (1450.2g). As much work has been conducted on 70017, we report the many thin-section numbers (Table 3).

Table 3: Thin section numbers from 70017.

,1-6	,210-216
,107-119	,217-220
,128-132	,223-224
,157-161	,235
,194-195	,455-456
,200-201	,473
,206-207	

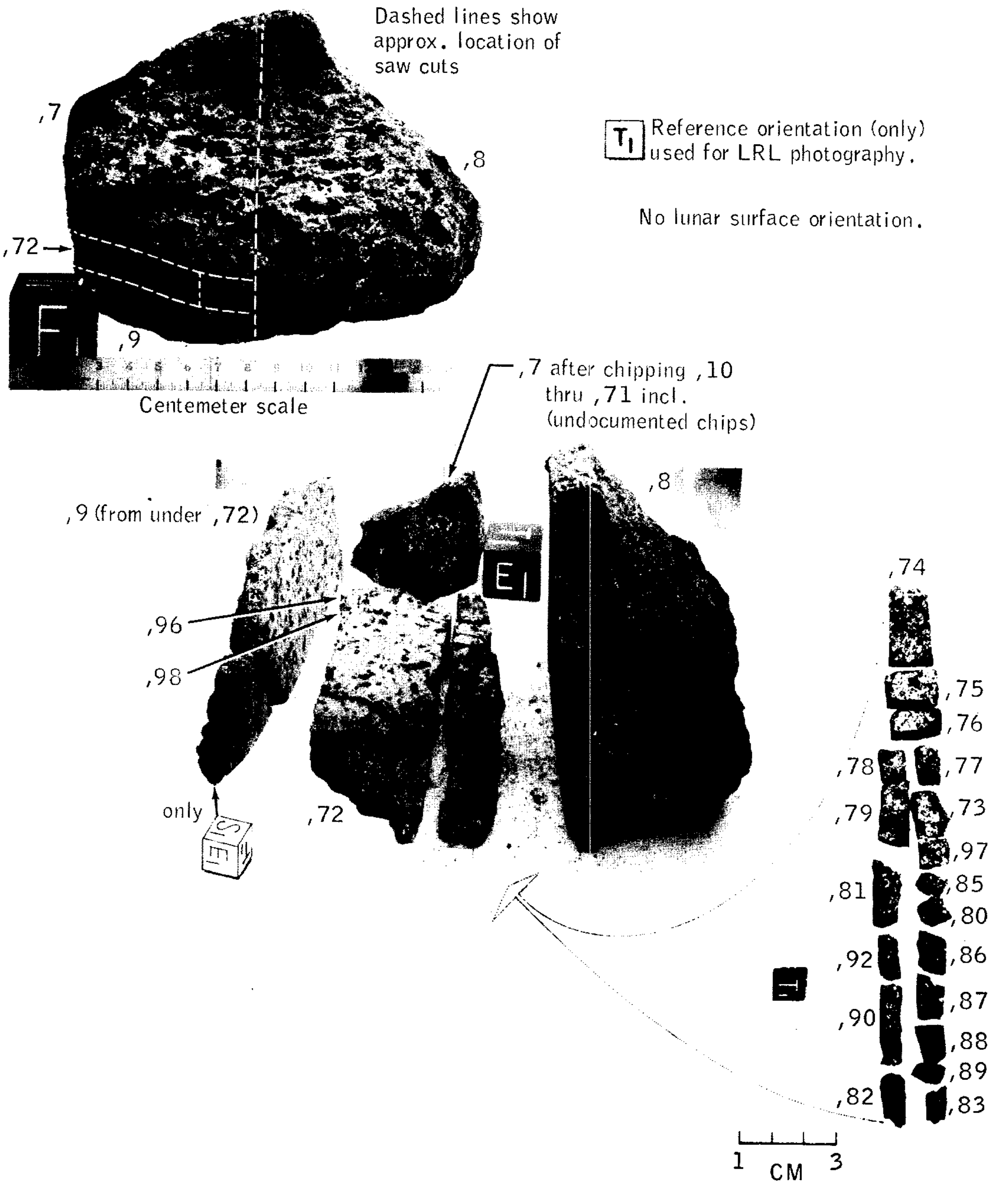


Figure 5: Diagram of the major divisions of 70017.

70018
Clastic Matrix Breccia
51.58 g, 1.8 x 4.5 x 5.5 cm

INTRODUCTION

70018 is a medium dark-gray, partly glass-coated (0.1-0.5 mm thick) breccia (Fig. 1) with a brownish tint (Apollo 17 Lunar Sample Information Catalog, 1973). B is about 90% glass coated, whereas W, S, N, E, and T are partially glass coated (40%, 10%, 30%, 10%, and 10%, respectively). At the edge of T towards N, three thin and extremely delicate glass fibers protrude from the brown glass coating. The glass coating is vesicular and imparts a metallic sheen to the specimen, whereas glass-free areas have an irregular, hackly appearance. Most of the zap pits present on this sample are on the glass-coated surfaces, whereas there are few readily apparent on the breccia surfaces. 70018 has an irregular, slabby appearance, containing rare (<1%) cavities, but with extensive, penetrative fractures. This breccia is comprised of 80% matrix (no mode has been determined), 10-15% plagioclase/anorthosite, 2% olivine, 2% black glass clasts, 2% orange glass clasts, 2-5% lithic fragments, and a trace of pyroxene (Apollo 17 Lunar Sample Information Catalog, 1973). This breccia was collected close to the lunar module along with 70011, 70012, and 70017.

No research has been conducted upon this sample.

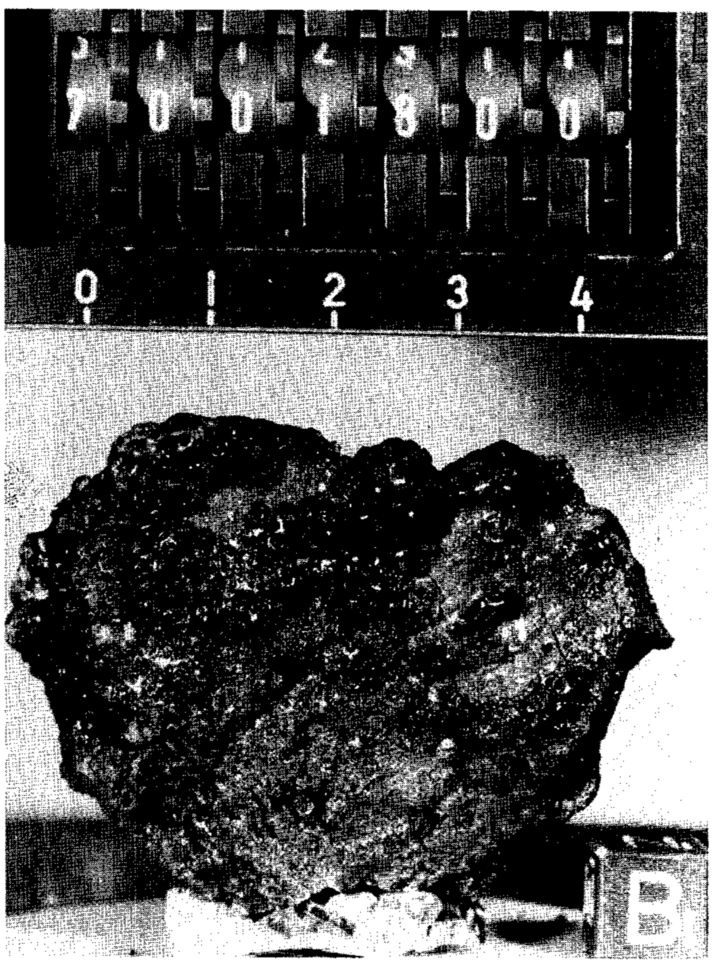


Figure 1: Hand specimen photograph of 70018.

70019
Soil Breccia – Agglutinate
159.9 g, 13 x 6 x 6 cm

INTRODUCTION

70019 is a dark-gray soil breccia with a brownish tint and an irregular shape. It is weakly coherent and variably brecciated. It is a glass-bonded agglutinate with a mass of 160 g collected from the bottom of a 3m crater near the Apollo 17 lunar module (Pearce and Chou, 1977). The appearance of the sample is controlled by a flattened rhomboidal, penetrative fracture pattern. The overall texture appears to be homogeneous and fine-grained. The entire surface possesses a glass coating of variable extent: T is finely hackly with a 20% glass coating broken by rhomboidal fracturing; S has a 70% glass coating over partially rounded fragments. Small amounts of fine dark dust adhere to smooth surfaces of the glass. The glass contains 10% vesicles of 0.5 mm diameter and 20-30% angular voids in the glass cemented between fragments of soil breccia at the W end, where fragments are present as a loosely packed aggregate (Fig. 1), and external faces are glass coated. The closely packed fragments are slightly disrupted at the E end of the sample. No zap pits are present. 70019 was collected between the Lunar Module and Station 5.

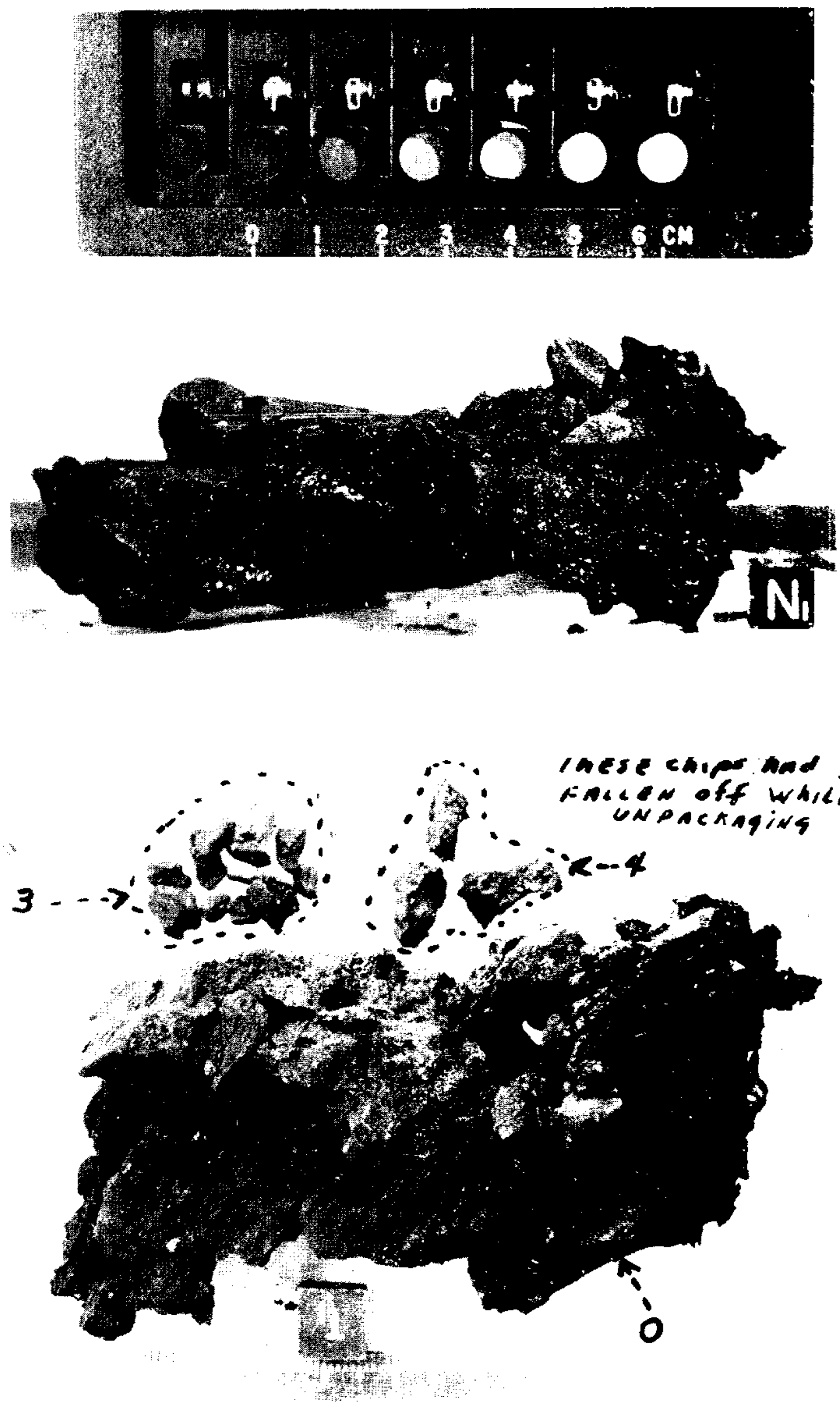


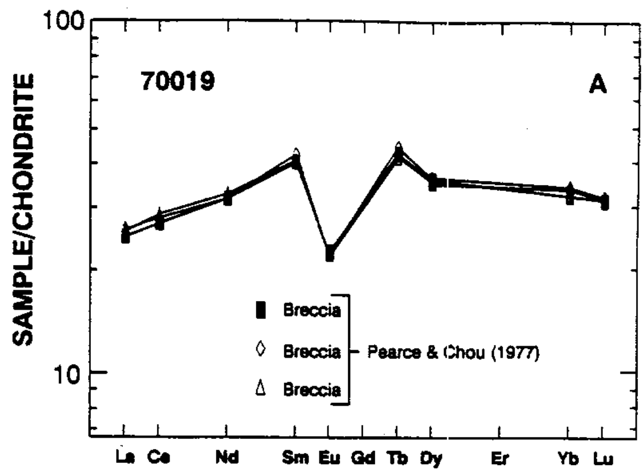
Figure 1: Hand specimen photograph of 70019.

PETROGRAPHY

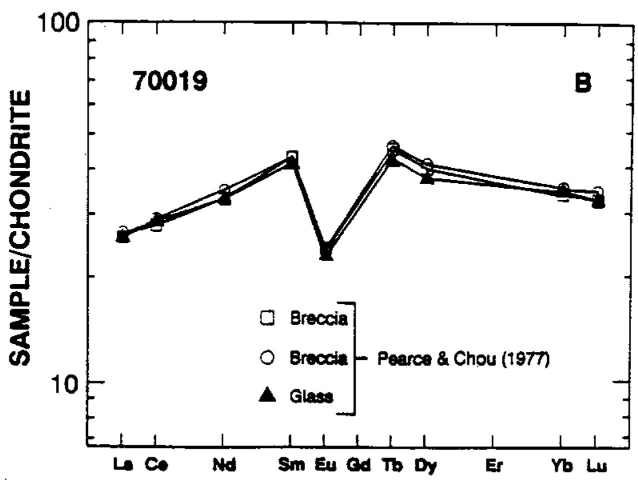
No petrographic descriptions have been reported in the literature for 70019.

WHOLE-ROCK AND GLASS CHEMISTRY

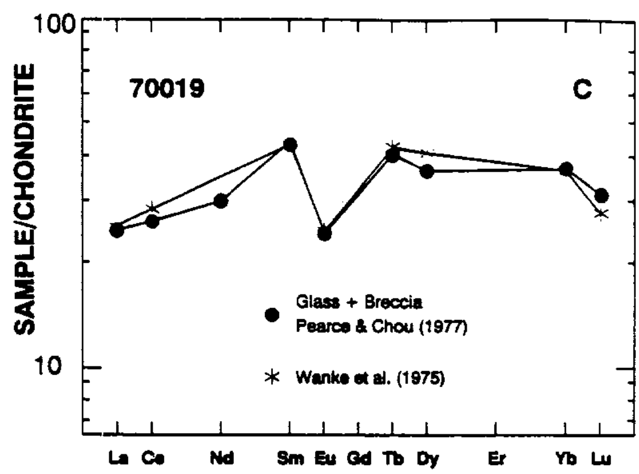
Wänke et al. (1975) used the whole-rock chemistry of 70019 in their study of the presence of "primary matter" in the lunar highlands; this determination of the REE abundances is shown in Fig. 2. This pattern is similar to that of Apollo 17 basalts, in that 70019: 1) is LREE-depleted; 2) contains MREE which reach ~ 35 times chondritic abundances; and 3) contains a negative Eu anomaly ($[Eu/Eu^*]_N = 0.63$). Pearce and Chou (1977) reported whole-rock compositions for 5 breccia samples, 1 glass sample, and 1 breccia/glass mixture from 70019. REE patterns are similar for each and to the profile of Wänke et al. (1975) (Fig. 2 a-c). A negative Eu anomaly is present ($[Eu/Eu^*]_N$ = 0.60-0.65), and the REE profiles have a convex-upward appearance with maximum abundances at either Sm or Tb (Fig. 2 a-c). These authors also concluded that the compositional similarity between the breccia and the glass (Table 2, Fig. 2) indicates that the glass was generated from material almost identical to the rock and soil components of the breccia.



2a: Breccia matrix.



2b: Two profiles of breccia matrix + one of glass.



2c: One glass + breccia profile and one whole-rock profile.

Figure 2: Chondrite-normalized rare-earth element profiles of 70019.

Jovanovic and Reed (1975ab, 1980) used Cl/Br and Cl/P_2O_5 ratios to determine whether or not 70019 represented early, primordial lunar crust. However, in light of the revealing study of Taylor and Hunter (1983), use of these data for such conclusions is not valid.

Light-element concentrations of 70019 have been reported by Petrowski et al. (1974), Leich et al. (1974), and Filleux (1977, 1978). Petrowski et al. (1974) reported C, N, S, Fe^o, and He of 142 ppm, 70 ppm, 999 ppm, 0.7 wt%, and 34 ppm, respectively (Table 1). However, no distinction between the glass and soil breccia was made. Leich et al. (1974) reported H and F abundances from the exterior and interior of 70019, noting that the exterior contained more H and F (up to 400 ppm H and 235 ppm F) than the interior (10-40 ppm H and 40-75 ppm F), concluding that the differences were due to the effect of the solar wind. Filleux (1977, 1978) reported the C abundance in 70019 using a nuclear depth profiling technique and quoted reliable abundances of 176 ± 30 ppm and 165 ± 30 ppm.

Fredriksson et al. (1974) reported three glass compositions (Table 2) and one bulk composition (Table 1) and used these analyses to compare lunar impact glasses with those from the Lonar Meteorite Crater. Their conclusions indicated that the glass from 70019 is comprised of two main components: A - local soil; and B - local basalts to which have been added more exotic varieties. They suggested that 70019 contains the products of several impacts on a variety of targets.

The glass chemistry of 70019 was also reported by Mao et al. (1975) in a study of the chemical reduction in lunar regolith samples from the Apollo 17 site (Table 3). These authors identified trapped bubbles of gas (inferred to be hydrogen) quenched into an orange glass and concluded that these samples are more reduced than any other previously identified.

STABLE ISOTOPES

Norris et al. (1983) reported both C and N isotopic ratios (Table 4) and defined a correlation between isotopically light carbon and nitrogen, implanted by ancient solar wind activity. Petrowski et al. (1974) reported a $\delta^{15}N$ composition of 70019, noting that this is one of the lightest samples analyzed from the Moon. Their result is substantially different from that of Norris et al. (1983). Petrowski et al. (1974) also reported a $\delta^{34}S$ composition for 70019 (Table 4). A similar study of N isotopes was also undertaken by Becker and Clayton (1975), who determined the N isotopic composition on two splits of 70019,10 (Table 4). The results are approximately midway between the values of Petrowski et al. (1974) and Norris et al., (1983). Becker and Clayton (1975) concluded that the N isotopic ratio has increased by ~ 15% over the last 4.5×10^8 yr due to nitrogen being implanted into the lunar regolith. This may have been due to a change in the N isotopic ratio of the solar wind with time, or it may be due to outgassing and subsequent reimplantation of an isotopically light indigenous lunar nitrogen from the lunar interior during the early history of the Moon.

A study by Grossman et al. (1974) reported the oxygen isotopic composition of 70019 (Table 4) and concluded that the Moon could not be a mixture of ordinary chondrites and Allende inclusions, nor could it be derived by fractionation of such a mixture.

RADIOGENIC ISOTOPES

Nunes (1975) and Church and Tilton (1975) noted that a substantial amount of Pb loss occurred during the agglutinization of 70019. Nunes (1975) reported Pb isotope analyses from glassy and non-glassy samples of 70019 (Table 5). Glass formation by impact, less than 200 Ma, at the Apollo 17 site was accompanied by substantial loss of Pb relative to U. The analyses of non-glassy samples of 70019 indicated that initial lead isotopic compositions, distinctly different from that defined by KREEP, are present on the Moon. Nunes (1975) further concluded that the U and Th concentrations of 70019 demonstrate that it was a mixture of comminuted mare basalt and highland material. Church and Tilton (1975) reported the Pb isotope composition of 70019,24B (Table 5). These results were used to demonstrate the presence of initial radiogenic $^{207}Pb/^{206}Pb$ ratios of 1.32, which are distinctly different from the "cataclysm lead" ratio of 1.45.

Table 1: Whole-rock analyses of 70019.

Ref.	1	2	3	4	5	6	7	8	9	10
	,29	,28	,7			,17	,17	,17	,10	
SiO_2	41.5	40.66								41.4
TiO_2	8.22	8.26								7.24
Al_2O_3	12.1	12.38								12.8
Cr_2O_3	0.44	0.43								0.46
FeO	16.6	16.38								16.3
MnO	0.22	0.24								0.26
MgO	9.61	9.50								9.95
CaO	11.4	11.03								10.6
Na_2O	0.40	0.47								0.28
K_2O	0.08	0.09								0.15
P_2O_5	0.07	0.07	0.08	0.084						<0.10
S	0.11	0.10								
Nb										
Zr										
Hf	6.94									
Ta	1.25									
U			0.29							
Th	0.68									
W										
Y										
Sr	200									
Rb										
Li			9.8							
Ba	95									
Cs										
Be										
Zn		42								
Pb										
Cu										
Ni	140	154								
Co	31.3									
V										
Sc	60.4									
La	8.44									
Ce	25									
Nd										
Sm	7.87									
Eu	1.70									

Table 1: (Concluded).

Ref.	1	2	3	4	5	6	7	8	9	10
	,29	,28	,7			,17	,17	,17	,10	
Gd										
Tb	2.00									
Dy	14.0									
Er										
Yb	7.30									
Lu	0.95									
Ga										
F						60-235				
Cl			15	15						
C					142		330±30	165±30		
N					70			60		
H					39.5					
He					34			13.3		

References: 1 = Wänke et al. (1975); 2 = Rhodes et al. (1974); 3 = Javanovic and Reed (1975); 4 = Javanovic and Reed (1980); Petrowski et al. (1974); 6 = Leich et al. (1974); 7 = Filleux et al. (1977); 8 = Filleux et al. (1978); 9 = Becker and Clayton (1975); 10 = Fredriksson et al. (1974).

Table 2: Elemental concentrations in glass and breccia fractions of 70019 (in ppm except for CaO, TiO_2, and Fe %).
Data from Pearce and Chou (1977a). Analyses by INAA.

	5-1	5-2a	5-2b	5-3	5-4	5-6	5-7
Na	3100	3080	3220	2730	3090	3180	3110
K	860	720	680	600	740	740	660
CaO	12.7	11.4	10.3	13.7	9.34	11.1	10.4
Sc	57	60	57	58	61	59	59
TiO_2	8.00	8.16	8.25	8.72	9.08	8.48	8.46
V	88	82	89	112	102	90	86
Cr	3130	3190	3230	3180	3370	3220	3230
Mn	1740	1800	1770	1840	1860	1840	1870
Fe	12.8	13.1	13.1	12.9	13.7	13.0	13.0
Co	32	35	33	32	34	33	33
Ni	113	163	123	157	170	141	141
Zr	---	270	240	240	300	290	270
Ba	---	---	120	---	---	105	---
La	7.9	8.3	8.2	8.3	8.2	8.3	8.2
Ce	22.7	23.5	24.1	23.1	24.4	23.8	23.1
Nd	19.4	19.4	20.0	20.0	21.3	19.9	18.9
Sm	7.9	8.3	8.0	8.4	8.5	8.1	8.0
Eu	1.68	1.66	1.65	1.79	1.77	1.66	1.69
Tb	1.93	2.02	1.90	2.04	2.11	1.92	1.91
Dy	11.9	12.6	11.7	13.2	13.6	12.4	12.5
Yb	6.9	7.3	7.2	7.2	7.5	7.3	7.4
Lu	1.02	1.04	1.02	1.05	1.12	1.05	1.07
Hf	6.7	7.0	6.8	7.1	7.2	6.9	7.2
Ta	1.3	1.4	1.3	1.3	1.4	1.3	1.3
Th	0.85	0.83	0.93	0.95	0.94	0.89	0.84

5-1, 5-2a, 5-2b, 5-4, and 5-6 = whole-rock analyses; 5-3 = glass analysis; 5-7 = mixture of soil and glass.

Table 3: Glass compositions from breccia 70019.
Oxides in percent; others in ppm.

Ref.	1	1	1	2	3	4
SiO_2	40.0	38.4	33.3			40.32
TiO_2	8.26	8.65	8.12			8.24
Al_2O_3	13.2	6.74	17.2			12.36
Cr_2O_3	0.46	0.71	0.40			0.50
FeO	17.3	22.2	14.6			15.18
MnO	nd	nd	nd			0.27
MgO	10.1	15.3	11.6			10.20
CaO	10.9	7.15	13.4			10.69
Na_2O	0.31	0.35	0.10			0.18
K_2O	0.11	0.19	<0.10			0.02
P_2O_5	nd	nd	nd	0.24	0.24	
Cl	7.8	7.8				
Br	93					
Li	7.6					
U	0.26					

References: 1 = Fredriksson et al. (1974); 2 = Jovanovic and Reed (1975); 3 = Jovanovic and Reed (1980); 4 = Mao et al., (1975).

Table 4: Stable isotope analyses of 70019.

Ref.	1	2	3	3	4
C (ppm)	142	116			
$S^{13}C$ o/oo PDB	+11.6	+10			
N (ppm)	70	70	62	57	
$S^{15}N$ o/oo AIR	-8.5	+49	+21.7	+22.1	
S (ppm)	999				
$S^{34}S$ o/oo CDT	+7.6				
$S^{18}O$ o/oo SMOW					+5.53
$S^{17}O$ o/oo SMOW					+3.7

References: 1 = Petrowski et al. (1974); 2 = Norris et al. (1983); 3 = Becker & Clayton (1975); 4 = Grossman et al. (1974),

Table 5: Pb isotope analyses from 70019.

NUNES (1975)	U	Th	Pb	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$
Non-glassy						
P	---	---	---	184.5	141.6	186.4
C1	0.2735	0.9819	0.9007	147.0	113.0	---
C2*	0.2612	0.9158	0.7889	123.7	88.99	---
Glass Concentrate						
P	---	---	---	169.2	128.4	173.4
C	0.2737	0.9824	0.5349	159.2	120.9	---

NUNES (1975)	$^{207}Pb/^{206}Pb$	$^{208}Pb/^{206}Pb$	$^{232}Th/^{238}U$	$^{238}U/^{204}Pb$
Non-glassy				
P	0.7671	1.010	---	135
C1	0.7691	---	3.71	107
C2*	0.7197	---	3.62	96
Glass Concentrate				
P	0.7592	1.025	---	209
C	0.7600	---	3.71	196

P = Composition run; C = Concentration run. All samples corrected for analytical blank.

CHURCH & TILTON (1975)	U	Th	Pb	$^{204}Pb/^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{208}Pb/^{206}Pb$
70019,24B	---	---	---	0.00827	0.7684	1.0758
70019,24B	0.258	0.852	0.917	0.00877	0.7582	---

MODEL AGES (m.y.)

	$^{206}Pb/^{238}U$	$^{207}Pb/^{206}Pb$
70019,24B	----	----
70019,24B	5451	4811

COSMOGENIC RADIONUCLIDES & EXPOSURE AGES

Cosmic ray studies have been conducted on 70019 by Keith et al. (1974a,b) and Fruchter et al. (1978a,b). Keith et al. (1974a,b) analyzed natural and cosmic ray induced radionuclides in 70019 by non-destructive gamma-ray spectroscopy (Table 6). These authors conclude that 70019 is unsaturated in ^{26}Al, probably because of its friability. No exposure age was reported by these authors.

Fruchter et al. (1978a,b) also used gamma-ray spectroscopy to determine the ^{26}Al and ^{53}Mn abundances from 70019,48 (51.9 ± 3.4 dpm/kg samples and 245 ± 25 dpm/kg Fe, respectively). Saturation of 70019 in these isotopes has also been calculated by these authors. According to their calculations, 70019,48 is 86% saturated in ^{26}Al and 82% saturated in ^{53}Mn. The ^{26}Al exposure age for 70019 is 2.2 ± 1.0 Ma and that for ^{53}Mn is 9 ± 2 Ma.

MAGNETIC STUDIES

Pearce et al. (1977) and Pearce and Chou (1977) reported the magnetic hysteresis properties of seven fractions of 70019,5 (Table 7). These authors noted that the saturation magnetization for both glass and breccia samples is remarkably similar (~ 5%). The similarities between these properties for the glass and whole-rock breccia, coupled with the whole-rock data also presented by Pearce and Chou (1977) (see above), suggested a common source material.

Sugiura et al. (1979a,b) used a new technique of encapsulation (Taylor, 1979) of 70019,49 (glass) for Thellier-Thellier paleointensity determination. This glass sample gave a paleointensity of about 2500 nT by such a method. Sugiura et al. (1979a,b) suggested that this field was due either to local anomalies created by strongly magnetized rock or possibly to enhancement of local fields by the shock process which produced the glass. These results for 70019,49 are reproduced in Sugiura and Strangway (1980). Also, the magnetic data of 70019 was reported by Cisowski et al. (1983) on a plot of absolute paleointensity versus normalized remanence intensity.

EXPERIMENTAL

Oxygen fugacity experiments have been conducted on 70019,4 by Sato (1976a) who reported that 70019 exhibited a noticeable shift of the log fO_2 - 1/T trace towards more reduced values during the first heating cycle at temperatures above 1000 °C (a decrease in the average -log fO_2 from 16.1 at 1000 °C to 13.4 at 1200 °C).

Uhlmann et al. (1975) used 70019 in an experiment to determine the formation of lunar breccias. These authors used viscous sintering in a stress-free environment to mimic breccia formation and assumed that crystallization and sintering were concurrent, competing processes. Their experiment made it possible to estimate the rate of breccia cooling and the minimum temperature at which the breccia particles came into contact. Uhlmann et al. (1975) presented their model, but no quantitative results, concluding that 70019 cooled on the surface of the Moon in its present form, rather than being buried in an ejecta blanket. Uhlmann and Onorato (1979) presented the results from the above model for 70019. These authors concluded that the glass on 70019 cooled at a rate of 1.8 °C/sec.

Table 6: Gamma-ray analysis of 70019.
Data from Keith et al. (1974).

Type	Breccia
Subtype	Agglutinate
Sample	70019
Weight (g)	128.0
Comments	from crater floor
Th (ppm)	1.03 ± 0.10
U (ppm)	0.23 ± 0.02
K (%)	0.0692 ± 0.0012
^{26}Al (dpm/kg)	45 ± 3
^{22}Na (dpm/kg)	110 ± 8
^{54}Mn (dpm/kg)	166 ± 12
^{56}Co (dpm/kg)	240 ± 30
^{46}Sc (dpm/kg)	59 ± 5
Th/U	4.5
K/U	3000

Table 7: Magnetic hysteresis data for 70019,5 from Pearce and Chou (1977).

Sample	J_s (emu/g)	$X_p * 10^6$ (emu/g)	J_{rs}/J_s	H_c Oe	Fe^o (%)	FeO (%)
70019,5-1	1.455	30.5	0.060	--	0.67	18.0
70019,5-2	1.442	30.7	0.063	41	0.66	18.1
70019,5-2	1.439	28.5	0.067	40	0.66	16.5
70019,5-3	1.425	24.0	0.019	43	0.65	14.1
70019,5-4	1.446	29.9	0.067	45	0.66	7.6
70019,5-6	1.495	31.1	0.067	40	0.69	18.3
70019,5-7	1.473	31.3	0.064	--	0.68	18.4

70035
High-Ti Mare Basalt
5765 g, 15 x 23 x 10 cm

INTRODUCTION

70035 is a brown microporphyritic, vesicular basalt (Apollo 17 Lunar Sample Information Catalog, 1973), which contains 5-10% vugs (average 3 mm, up to 1 cm diameter). There is a slight coarsening of grain size towards the vugs, which contain projecting crystals of silica. The bottom of the original sample (70035,0) contains patches of an injection glass. Patches of brownish debris in the glass may be powdered glass or soil retained on the surface. Zap pits are present on all surfaces, except B. 70035 was collected approximately 40 m east of the lunar module, between the LM and SEP sites. Whole-rock analysis confirmed the high-Ti nature of this basalt (~13 wt% TiO_2). Rb-Sr and K-Ar dating methods yield a crystallization age of 3.7-3.8 Ga.

PETROGRAPHY AND MINERAL CHEMISTRY

70035 is a plagioclase-poikilitic, ilmenite basalt (Papike et al., 1974), or equivalent to a Type III basalt of Papike et al. (1973) and Brown et al. (1973) or Type 1B basalt of Brown et al. (1975). Brown et al. (1974) reported spinel minerals in 70035 as having ulvöspinel rims with chromian-ulvöspinel cores and pyroxferroite-type rims to the pyroxenes, which suggested that 70035 has an affinity with the Type II Apollo 17 high-Ti basalt group described by these authors. This basalt is comprised mainly of titanaugite (1-3 mm), ilmenite (<1-2 mm), and plagioclase (1-3 mm) (Fig. 1). Euhedral to subhedral ilmenite, minor (~1%) subhedral ulvöspinel, and armalcolite (<1%) inclusions are present in subhedral titanaugites, which in turn are poikilitically enclosed in late-stage plagioclase (Fig. 1). Minor olivine (0.5-1 mm) is

Figure 1: Photomicrograph of 70035,14. Field of view = 2.7 mm.

poikilitically enclosed in the plagioclase or occurs as anhedral cores to the larger and more abundant pyroxenes (Fig. 1). Cristobalite and native Fe (<0.2 mm) form interstitial phases. Modes have been reported by Brown et al. (1975) from 70035,16 as 0.9% olivine, 23.7% opaques, 25.9% plagioclase, 47.5% clinopyroxene, 1.6% silica, and 0.4% mesostasis.

Zonation of the constituent minerals is most pronounced in the clinopyroxenes. Cores of subcalcic titanaugite grade discontinuously into Mg-pigeonite (due to olivine resorption - Brown et al., 1975), with later compositions approaching pyroxferroite (Papike et al., 1974) (Fig. 2). All pyroxene compositions possess Ti:Al ratios of 1:2 (Fig. 3). The Al/Si ratio of the pyroxenes decreases with increasing Fe/Mg ratio, reaching a constant Al/Si ratio of ~0.3 at an Fe/Mg ratio of ~1.0 (Fig. 4). The amount of Al^{VI} decreases as TiO_2 increases in the pyroxenes (Fig. 5). Papike et al. (1974) suggested that this trend was a result of slower cooling, allowing plagioclase to nucleate shortly after pyroxene such that it was in competition for Al.

Olivines which are poikilitically enclosed in plagioclase are usually more forsteritic than those forming the cores of pyroxenes. Plagioclase shows little zonation ($\sim An_{77-88}$) from core-to-rim. A study of the zonation of plagioclase in 70035 by Crawford (1973) concluded that the earliest plagioclase is characterized by low $FeO/(FeO+MgO)$ and $K_2O/(K_2O+Na_2O)$ ratios, high TiO_2 contents, and forms the cores of plagioclase grains. The core is also the most calcic region of the plagioclase in 70035, and zones smoothly outwards to more sodic-rich compositions ($\sim Ab_{20}$). Most commonly the zoning is asymmetric, reflecting longer contact with magma on one growing side of the crystal (Crawford, 1973). Delaney and Sutton (1991) studied Fe-Mn-Mg systematics in plagioclase in 70035 and found that Fe/Mn variations correlate with Fe/(Fe+Mg) variations, reflecting fractionation of a silicate magma. Further, they found that Fe/Mn variations in highland samples are offset to higher Fe/(Fe+Mg), relative to mare basalts, consistent with the highlands representing prior plagioclase separation. Delaney et al. (1992) used synchrotron-based x-ray absorption near edge spectroscopy (XANES) on 70035 plagioclase, and found that it may be possible to use this method to determine Fe^{3+}/Fe^{2+} ratios *in situ* in thin sections.

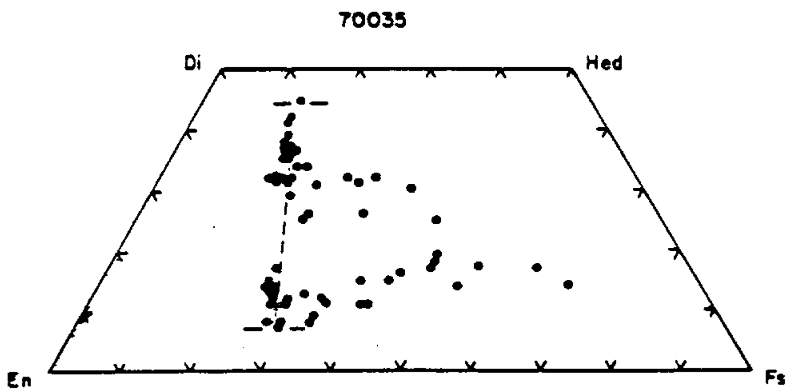


Figure 2: Quadrilateral plot for pyroxenes in plagioclase-poikilitic basalt 70035.

Ilmenites often contain small (<0.005 mm wide) exsolution lamellae of chromite and rutile and some blebs (<0.1 mm) of metallic Fe. This reaction, in addition to the breakdown of ulvöspinel to ilmenite + Fe metal, was reported by Haggerty (1973) and El Goresy and Ramdohr (1975a,b,c) as evidence for an endogenic late-stage reducing gas mixture during the crystallization of these basalts. El Goresy and Ramdohr (1975a,b,c) noted evidence for two reduction reactions in 70035. Muhich et al. (1990) found variations in Fe/Mg in ilmenite from 70035 that correlate with the amount of exsolution exhibited. They found that Mg is enriched in ilmenite with abundant exsolution relative to grains with no exsolution.

Ilmenites are generally equant, almost amoeboidal (Papike et al., 1974). The Mg# of ilmenites is approximately 10-12, with Cr_2O_3 never exceeding 1 wt%. Roedder and Weiblen (1975) reported both high-K (6.27 wt% K_2O) and anomalous low-K (0.037 wt% K_2O) melt inclusions in the ilmenites of 70035. The high-K inclusions were attributed to late-stage silicate-liquid immiscibility, but the origin of the low-K inclusions is obscure. Armalcolite in 70035 exhibits little compositional variation (Haggerty, 1973).

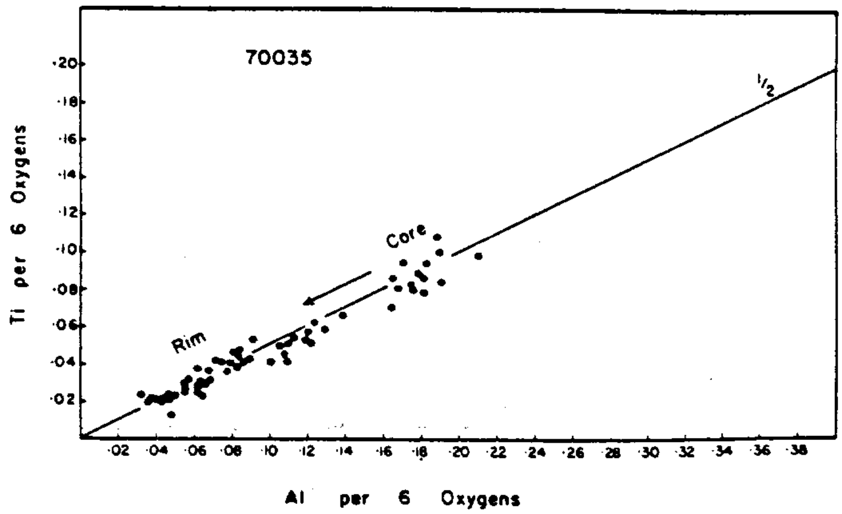


Figure 3: Ti-Al plot for pyroxenes in plagioclase-poikilitic basalt 70035.

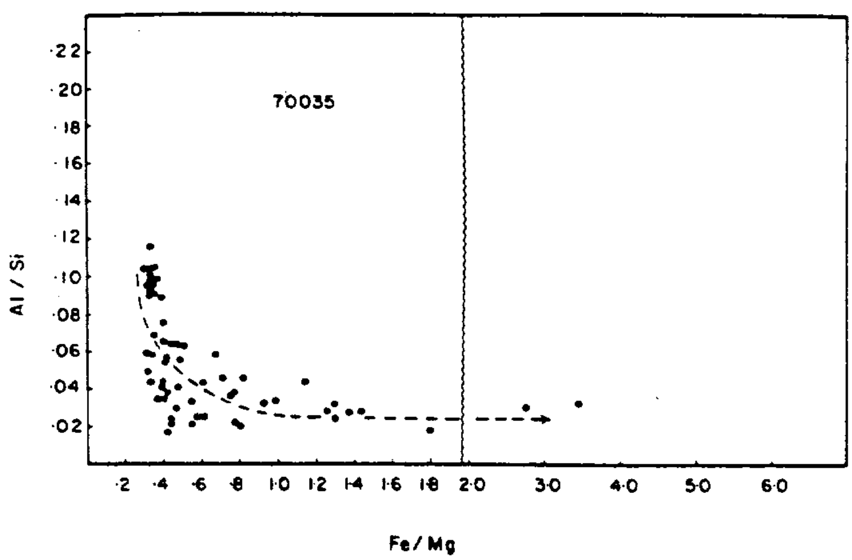


Figure 4: Al/Si-Fe/Mg plot for pyroxenes in plagioclase-poikilitic basalt 70035.

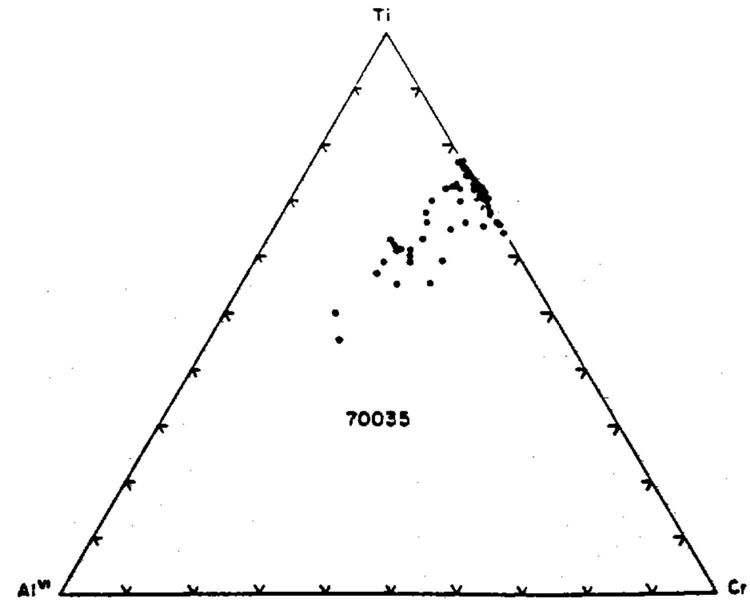


Figure 5: Ti-Cr-Al^{VI} plot for pyroxenes in plagioclase-poikilitic basalt 70035.

WHOLE-ROCK CHEMISTRY

The relatively coarse grain size of 70035 has introduced into whole-rock analysis the problem of sampling errors. This led Rhodes et al. (1975, 1976) to put 70035 into their class U (unclassifiable) of Apollo 17 basalts, as the whole rock chemistry did not conform to the A, B, and C groups delineated by finer-grained basalts. These authors used the analysis reported by LSPET (1973) (Table 1). Shih et al. (1975) only analyzed trace-element abundances from two samples of 70035 (,1 and ,6) by isotope dilution and INAA. These authors concluded that the source must be LREE-depleted with clinopyroxene, olivine, and ilmenite left in the refractory residue after ~20% partial melting. This would produce the LREE-depleted REE profile of 70035 (Fig. 6), which exhibits a negative Eu anomaly ($[Eu/Eu^*]_N \sim 0.61$) and is consistent with the low abundances of other LIL elements. The analysis of Shih et al. (1975) agrees well with that of LSPET (Table 1).

Hughes and Schmitt (1985) obtained "Zr/Hf ratios and other elemental data" for 70035 by coincidence-anticoincidence counting and normal counting techniques during INAA. However, although reporting the Zr/Hf ratio for 70035 (29.5 ± 4.7), Hughes and Schmitt only reported Hf abundances (4.9 ± 0.2 ppm). These authors concluded that significant fractionation of Zr from Hf had occurred during lunar evolution from an initial value of ~35.

The work on sulfur by Gibson and Moore (1974) reported the abundance of sulfur in 70035,1 as 1580 ± 40 µgS/g (Table 2). These authors noted that Apollo 17 high-Ti basalts contain similar sulfur abundances to Apollo 11 basalts, but much higher than those from Apollo 12 and 15. Gibson and Moore (1974) noted a negative correlation between S content and percent native Fe in Apollo 17 high-Ti basalts and concluded that a portion of the native iron may have resulted from desulfuration prior to crystallization. Gibson et al. (1976) reported the amount of metallic Fe in 70035 as 0.147%. This study was undertaken to confirm the desulfuration hypothesis of Gibson and Moore (1974). Gibson et al. (1987) reported the abundance of hydrogen in 70035 as 2.2 µgH/g. The analysis of 70035 was included in a much larger study for the purpose of pin-pointing hydrogen-rich lunar materials.

ISOTOPES AND AGE DETERMINATIONS

Basalt 70035 has been analyzed for the following isotopes: Rb-Sr (Evensen et al., 1973; Nyquist et al., 1974, 1976; Bansal et al., 1975); K-Ar and Ar-Ar (Stettler et al., 1973); Sulfur (Gibson and Moore, 1974; Gibson et al., 1975). Published isotope data are summarized in Table 2. The Rb-Sr methods dated 70035 at 3.82 ± 0.06 Ga (Evensen et al.,

Table 1: Whole-rock chemistry of 70035.

	70035,1[1]	70035,1[2]	70035,6[2]
SiO_2 (wt%)	37.84		
TiO_2	12.97		
Al_2O_3	8.85		
Cr_2O_3	0.61	0.27	0.25
FeO	18.46		
MnO	0.28		
MgO	9.89		
CaO	10.07		
Na_2O	0.35		
K_2O	0.06	0.04	0.05
P_2O_5	0.05		
S	0.15		
Nb (ppm)	20		
Zr	205	217	200
Hf			
Ta			
U		0.091	0.12
Th			
W			
Y	75		
Sr	176	174	161
Rb	0.7	0.461	0.628
Li		8.7	8.1
Ba		62.1	79.5
Cs			
Be			
Zn	4		
Pb			
Cu			
Ni	2		
Co			20.7
V			
Sc			82.5
La		4.79	7.04
Ce		16.4	23.4
Nd		18.2	25.9
Sm		7.63	10.5
Eu		1.82	1.88

Table 1: (Concluded).

	70035,1[1]	70035,1[2]	70035,6[2]
Gd		11.0	13.5
Tb			
Dy		14.1	18.8
Er		8.40	11.0
Yb		7.79	10.0
Lu			
F			
Cl			
C			
N			
H			
He			
Ga (ppb)			
Ge			
Ir			
Au			
Ru			
Os			

References: 1) LSPET (1973), also quoted in Rhodes et al. (1976);
2) Shih et al. (1975).

Table 2: Isotope data gathered from basalt 70035.

Rb-Sr (Evensen et al., 1973)

	wt (mg)	K (µg/g)	Rb (µg/g)	Sr (µg/g)	Ba (µg/g)	$^{87}Rb/^{86}Sr$ (x10^{2})	$^{87}Sr/^{86}Sr$
70035,9							
WR "A"	15.38	532.0	0.577	164.0	62.1	0.996	0.69980 ± 10
WR "B"	14.71	474.0	0.506	158.0	61.1	0.906	0.69973 ± 7
Plag	10.19	1406.0	1.041	657.0	165.4	0.448	0.69947 ± 7
Px "A"	24.12	----	0.389	56.7	----	1.94	0.70028 ± 7
Px "B"	14.58	----	0.357	57.8	----	1.75	0.70013 ± 10
Ilm	15.80	----	0.185	13.5	----	3.85	0.70134 ± 16
Glass	2.83	----	15.307	71.0	----	5.83	0.70241 ± 5

ISOCHRON AGE = 3.82 ± 0.06 AE; Initial = 0.69923 ± 3

Rb-Sr (Nyquist et al., 1974)

	wt (mg)	Rb (ppm)	Sr (ppm)	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$
70035,1	58.5	0.461	173.7	0.00772 ± 23	0.69967 ± 6
70035,6	53.2	0.628	161.3	0.01126 ± 29	0.69980 ± 6
Plag	4.4	0.0948	687.5	0.00040 ± 4	0.69924 ± 10
Ilm 1	11.9	0.8345	47.79	0.05053 ± 37	0.70195 ± 8
Px	22.7	0.3738	43.73	0.02473 ± 28	0.70059 ± 8
Px + Ilm	26.9	0.6334	52.01	0.03524 ± 39	0.70112 ± 20
Ilm 2	8.9	0.8326	6.01	0.03647 ± 50	0.70016 ± 4

ISOCHRON AGE = 3.73 ± 0.11 AE; Initial = 0.69924 ± 5

K-Ar (Settler et al., 1973)

	Age, High Temp. Plateau (10^9yr)	Ca (%)	K (ppm)
70035,6	3.72 ± 0.07	7.4	390
70035,6	3.75 ± 0.07	7.6	260

Sulfur (Gibson and Moore, 1974; Gibson et al., 1975, 1976, 1987)

	Total Sulfur				
	Combustion µgS/g	Acid Hydrolysis µgS/g	$S^{34}S$ o/oo CDT	% Fe^{0}	H (µgH/g)
70035	1580	1240	-0.2	0.147	2.2

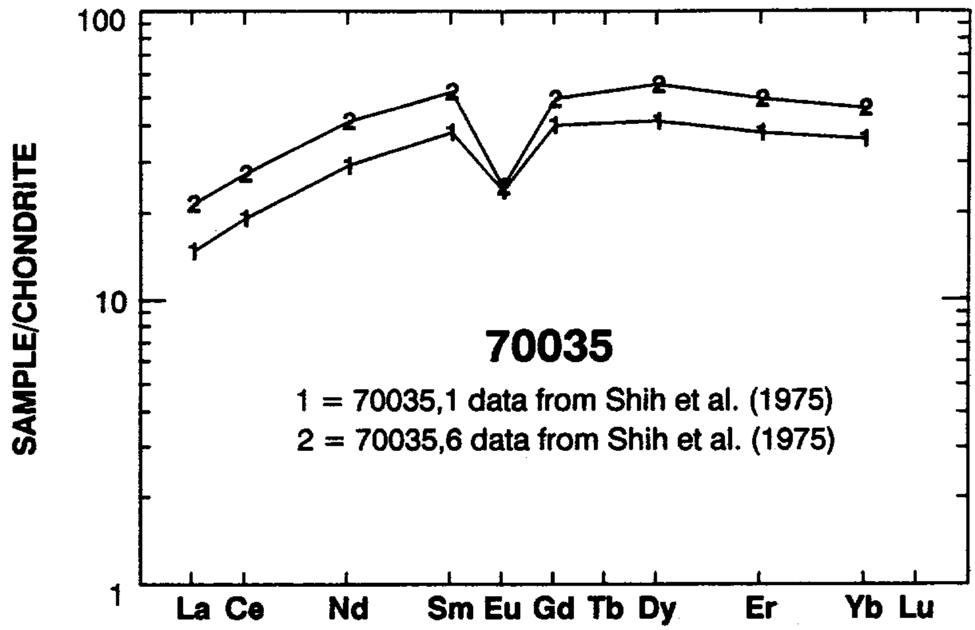


Figure 6: Chondrite-normalized rare-earth element profiles of 70035.

1973) and 3.73±0.11 Ga (Nyquist et al., 1974). Evensen et al. (1973) reported an initial $^{87}Sr/^{86}Sr$ ratio for 70035 of 0.69923±0.00003 (Fig. 7a) and concluded that this age represented an early age of mare flooding, which was episodic until 3.1 Ga. Nyquist et al. (1974) reported an initial $^{87}Sr/^{86}Sr$ ratio of 0.69924±0.00005 (Fig. 7b) and noted that this low initial ratio was similar to that of the source of low-K Apollo 11 basalts, but lower than that of the source of Apollo 12 and 15 basalts. Nyquist et al. (1976) proposed a two-stage evolution for the source of 70035: 1) from 4.6-4.4 Ga, the source evolved with an $^{87}Rb/^{86}Sr$ of ~0.05; 2) at 4.4 Ga, the source experienced a depletion which resulted in an $^{87}Rb/^{86}Sr$ ratio of ~0.005 until eruption at 3.7-3.8 Ga.

Two independent age determinations by Stettler et al. (1973) of 70035,6 using the K-Ar method, yielded ages of 3.72±0.07 Ga and 3.75±0.07 Ga (Fig. 8). These authors noted the similarity between the age of 70035 and those of the low-K/high-Ti basalts at Tranquility Base. Stettler et al. (1973) reported exposure ages for 70035 of 95-100 Ma (^{38}Ar). These ages were also quoted by Hörz et al. (1975). Drozd et al. (1977) reported a Kr exposure age of 122±3 Ma. Eberhardt et al. (1974) reported two $^{37}Ar/^{38}Ar$ exposure ages for 70035,6 of 95 and 100 Ma.

The sulfur isotopic composition of 70035 was reported by Gibson et al. (1975) as $\delta^{34}S$ CDT = -0.2.

MAGNETIC STUDIES

The magnetic study of Pearce et al. (1974a,b) demonstrated that 70035 is magnetically similar to basalts from other missions. However, Apollo 17 basalts as a whole contain a greater range of Fe^o contents. The magnetic data reported by Pearce et al. (1974a,b) is presented in Table 3.

EXPERIMENTAL

Green et al. (1975) demonstrated that the source region for 70035 and other high-Ti basalts was not one in which ilmenite was the refractory residual, contrary to the conclusion of Shih et al. (1975). Furthermore, at high pressure, Ti-oxide was never a liquidus phase.

Usselman et al. (1975a) compared ilmenite compositions from Apollo 17 high-Ti mare basalts with those in the FeO-TiO_2-Al_2O_3-Cr_2O_3-Fe system, using ilmenite compositions from 70035 for comparison. These authors concluded that observed ilmenite compositions only slightly reflect the composition of the original magma:

Rb–Sr ages of some mare basalts

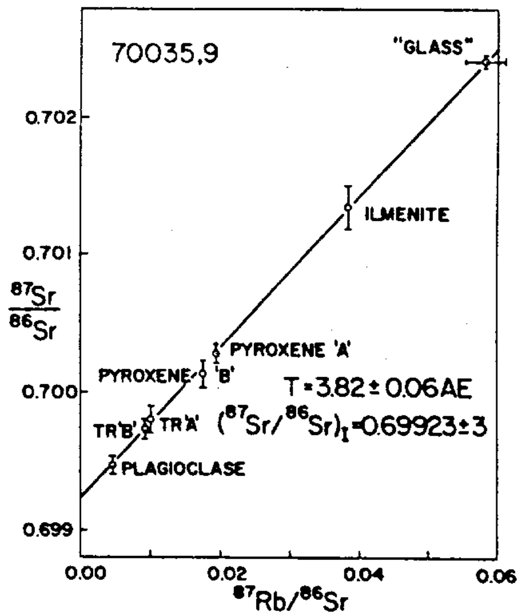


Figure 7a: Rb-Sr internal isochron for 70035. TR "A" and "B" are two total rock samples; pyroxene "A" and "B" are two aliquots of the pyroxene separate; "glass" is float in liquid of density 2.55 of plagioclase separate of 25-37μ size.

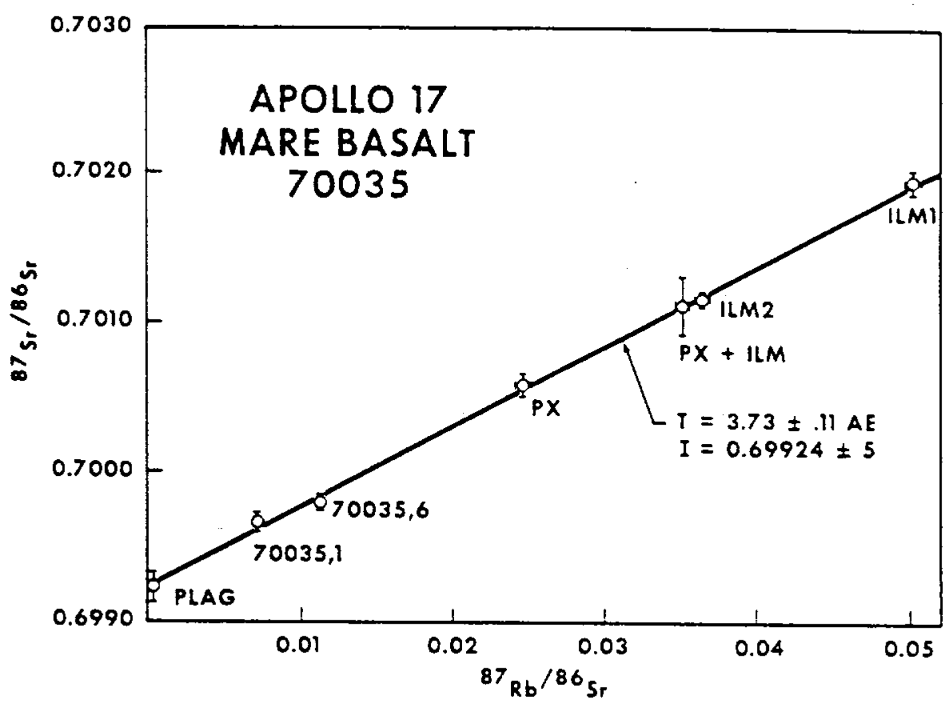


Figure 7b: Rb-Sr mineral isochron for Apollo 17 high-titanium mare basalt 70035.

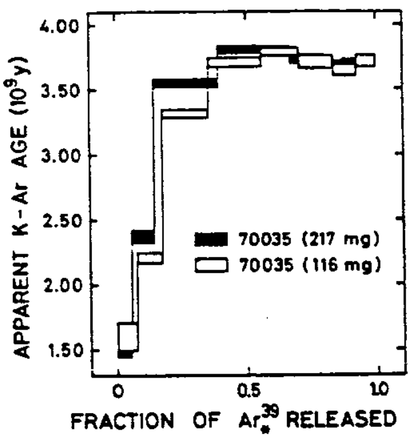


Figure 8: Ar^{40}-Ar^{39} release curves of two samples of the 70035 subfloor basalt. The age is similar to those of basalts found at Tranquility Base.

extensive re-equilibration of ilmenite with the fractionating liquid and ferromagnesian minerals has occurred. Usselman et al. (1975b), from crystallization experiments, calculated the cooling rate for 70035 to be <1 °C/hour.

PROCESSING

This sample was subdivided by sawing during the early years of the program (Figs. 9-11). Two pieces larger than 1.5 kg remain intact. Eleven thin sections have been cut from three potted butts. They are sections ,7; ,8; ,19; and ,20 from ,3; sections ,13 – ,18 from ,2; and section ,95 from ,94. Eight pieces of 70035 (ranging from 64 g to 120 g) have been mounted and allocated as long-term displays. Thin sections ,15 and ,18 are also allocated to the educational display program managed by the Public Affairs Office at the Johnson Space Center.

Table 3: Magnetic properties of 70035.
(Pearce et al., 1974).

	J_s (emu/g)	X_p (emu/g Oe) $*10^6$	X_o (emu/g Oe) $*10^4$	J_{rs}/J_s	H_c (Oe)	H_{rc} (Oe)	Equiv. wt% Fe^0	Equiv. wt% Fe^{2+}
70035,1	0.320	35.2	2.0	0.008	15	--	0.15	16.1

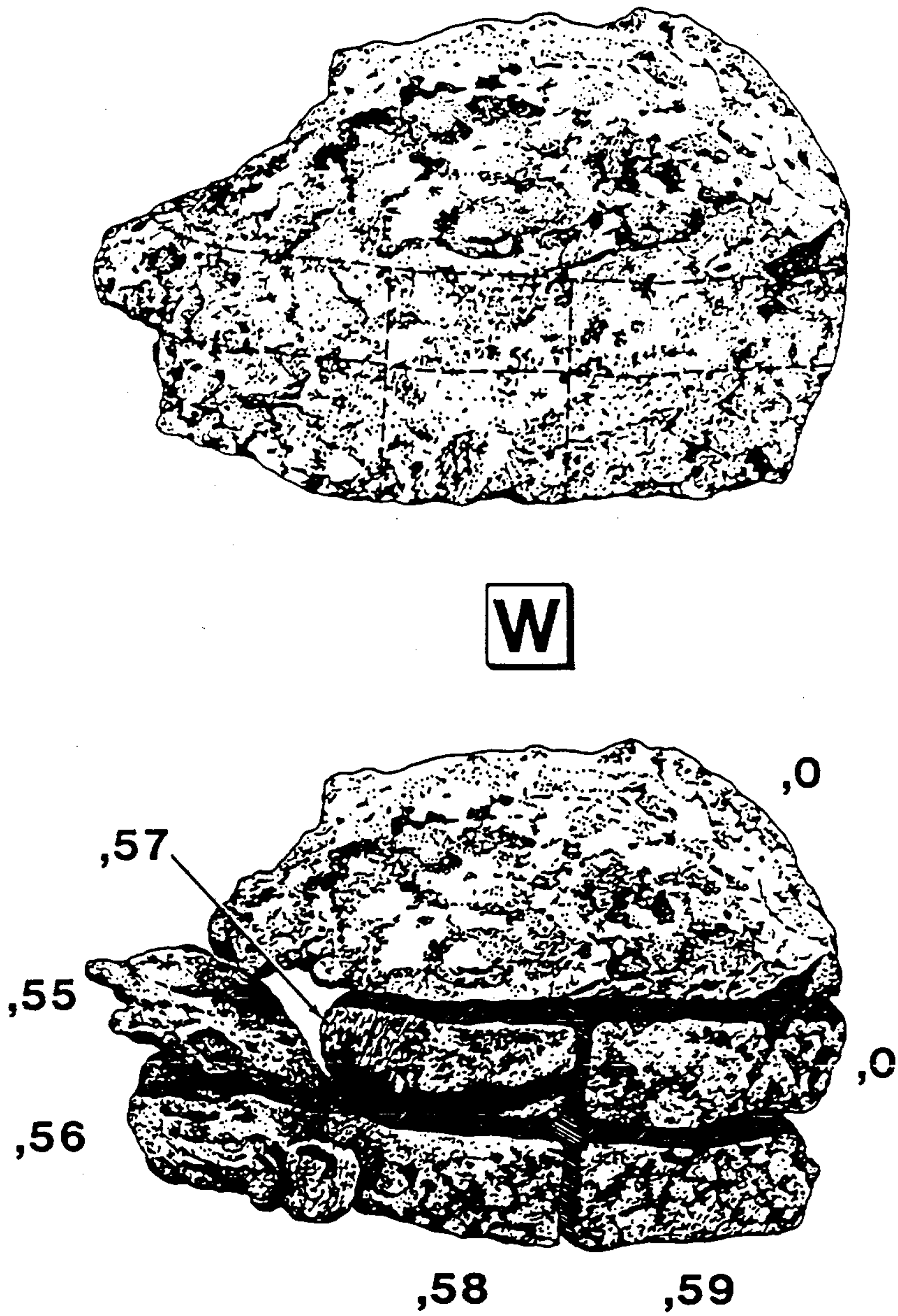


Figure 9: Major subdivisions of 70035,0.

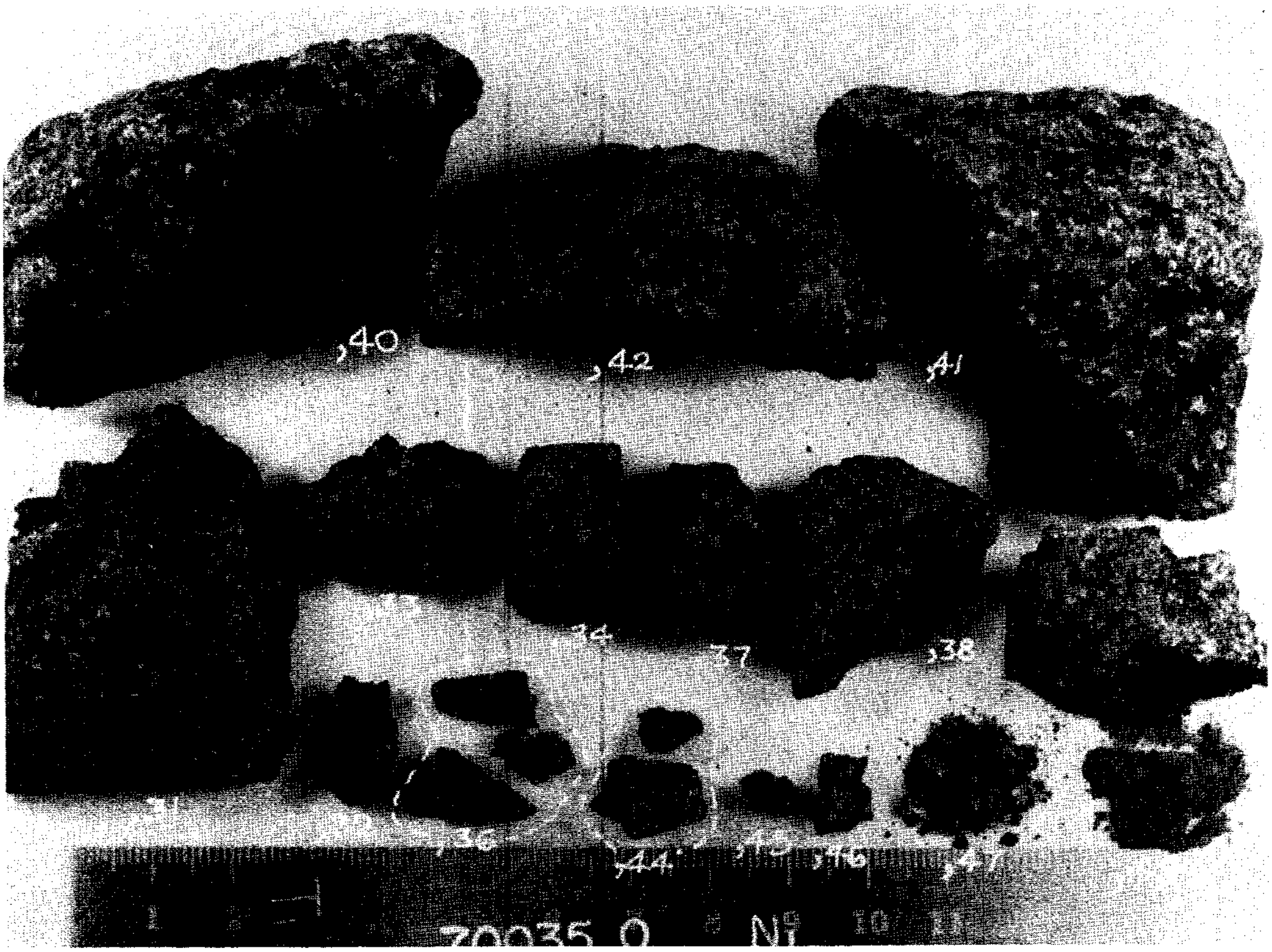


Figure 10: Major subdivisions of 70035,0.

Figure 11: Major subdivisions of 70035,0.

70075
High-Ti Mare Basalt
5.64 g, 3 × 1.7 × 1 cm

INTRODUCTION

70075 is a grayish-black, fine-grained, microporphyritic, olivine-ilmenite basalt (Figs. 1,2), containing no zap pits (Apollo 17 Lunar Sample Information Catalog, 1973). Narrow slit-like cavities (< 1%) 1-4 mm in length, <0.2 mm wide, occur throughout the rock. These are lined with plagioclase, pyroxene, and possibly ilmenite. Two areas on the surface probably represent the lining of a large vesicle. Plates of minor ilmenite/pyroxene coat these surfaces. The slit-like vesicular zones are replaced by small, randomly oriented vugs in the vicinity of these large vesicles. This sample was collected during an EVA east of the Lunar Module (EVA-1). 70075 is a high-Ti basalt containing ~ 12 wt% TiO_2.

PETROGRAPHY AND MINERAL CHEMISTRY

70075 is a fine-grained, vitrophyric basalt with microphenocrysts of olivine (0.5mm), armalcolite (0.2-0.4mm), and skeletal ilmenite (0.5mm) (Fig. 2 a,b). Minor chromite-ulvöspinel (<0.1mm) are included in the olivine microphenocrysts and are locally present in the groundmass (Warner et al., 1979). The opaque glass which forms most of the matrix is locally devitrified with plagioclase, pyroxene, and ilmenite crystallites (Fig. 2 a,b). Armalcolite has mantles of ilmenite (<0.1mm wide) which are usually continuous (Fig. 3). The Apollo 17 Lunar Sample Information Catalog (1973) gave an approximate mode of 5% olivine, 35% plagioclase, 45% clinopyroxene, and 15% opaque minerals. Olivines are ~ Fo_{70}, and Mg- and Ca-rich pyroxenes trend toward Fe enrichment. Plagioclase exhibits little variation (~ An_{85}). Armalcolites are Mg-rich (MG# ~ 50), as are the ilmenites (MG# ~ 12) and spinels (MG# ~ 20).

CHEMISTRY

Mineral and whole-rock chemical analyses are reported in Table 1. Warner et al. (1979) described 70075 as a Type A Apollo 17 high-Ti basalt, after the classification of Rhodes et al. (1976). The REE profile is LREE-depleted, with a flattening of the HREE at ~ 50 times chondritic values (Fig. 4). A negative Eu anomaly is present ($[Eu/Eu^*]_N = 0.53$). 70075,1 was used in a comprehensive petrogenetic study of Apollo 17 high-Ti basalts by Warner et al. (1979), who concluded that their compositional range was produced by fractionation of phenocryst phases.

PROCESSING

Little work has been conducted upon 70075. One thin section (70075,4) has been made, and 5.21g of 70075,0 remains.

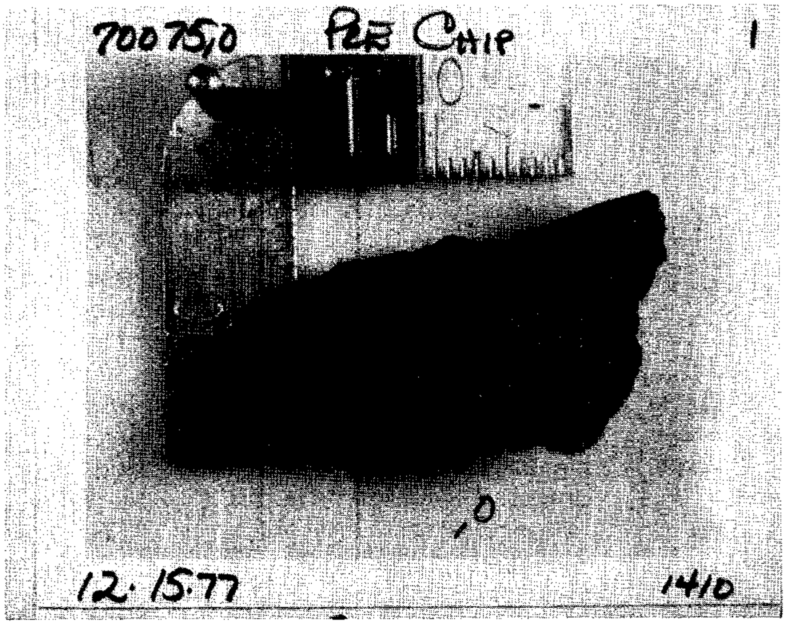


Figure 1a: Pre chip.

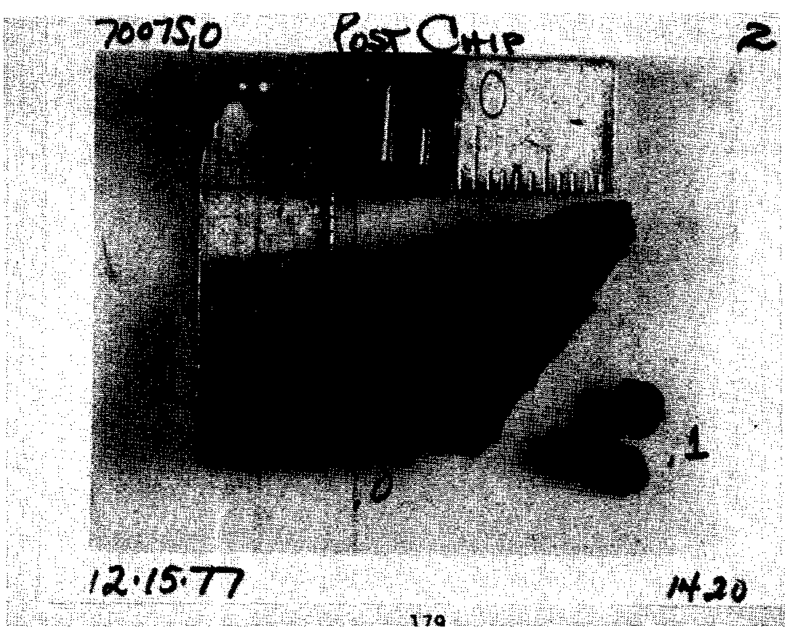


Figure 1b: Post chip.

Figure 1: Hand specimen photographs of 70075,0.

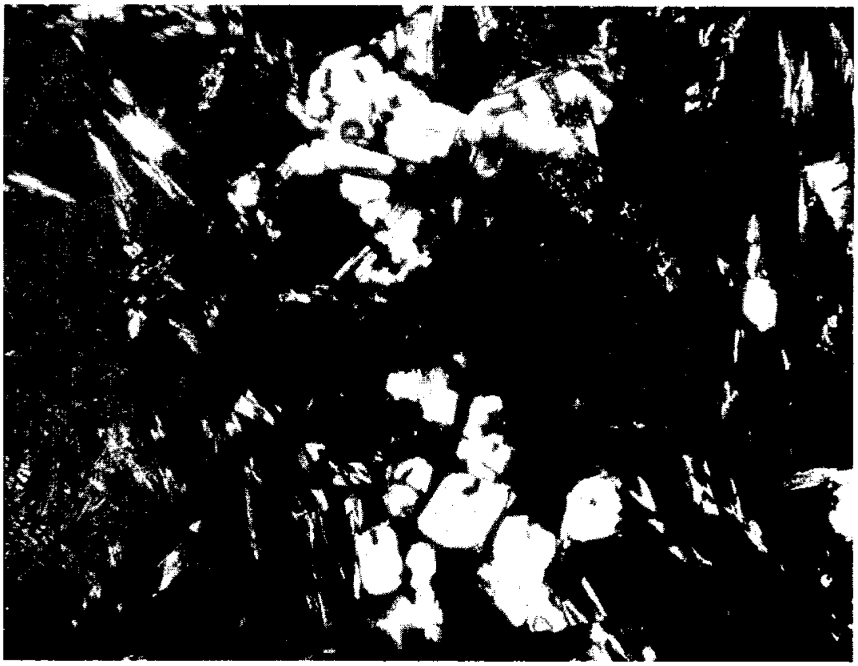


Figure 2a: Photomicrograph showing microphenocrysts of olivine, armalcolite, and skeletal ilmenite.

Figure 2b: Photomicrograph showing opaque glass with plagioclase, pyroxene, and ilmenite crystallites.

Figure 2: Photomicrographs of 70075,4. Field of view in both cases is 2.5 mm.

Figure 3: Photomicrograph of 70075,4, showing armalcolite rimmed with ilmenite.

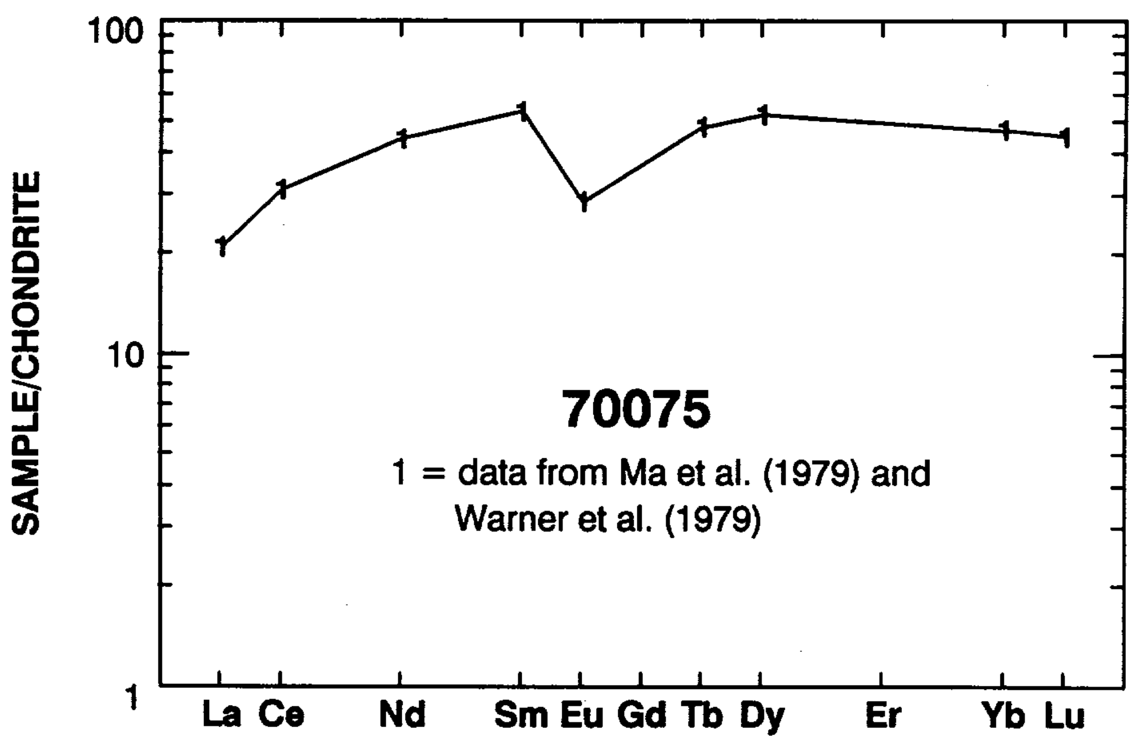


Figure 4: Chondrite-normalized rare-earth element profile of 70075.

Table 1: Whole-rock chemical composition of 70075.

	70075,1		70075,1
SiO_2 (wt%)		Zn	
TiO_2	12.1	Pb	
Al_2O_3	9.3	Cu	
Cr_2O_3	0.409	Ni	
FeO	19.4	Co	19
MnO	0.253	V	86
MgO	8	Sc	86
CaO	10.3	La	6.9
Na_2O	0.417	Ce	27
K_2O	0.067	Nd	28
P_2O_5		Sm	10.9
S		Eu	2.21
Nb (ppm)		Gd	
Zr		Tb	2.8
Hf	9.0	Dy	18
Ta	2.1	Er	
U		Yb	10.4
Th		Lu	1.53
W		Ga	
Y		F	
Sr		Cl	
Rb		C	
Li		N	
Ba		H	
Cs		He	

References and Methods: 1)Warner et al. (1979a); Ma et al. (1979); INAA.

70135
High-Ti Mare Basalt
446.3 g, 10.5 × 6 × 3.5 cm

INTRODUCTION

70135 is a blocky, brownish-gray basalt with a few zap pits on the S and T faces and irregular vugs (1-6mm) in a 1 cm band normal to S (Fig. 1). Foliation of ilmenite and plagioclase occurs on the W face in a zone ~ 3 cm wide. Twelve small chips returned in the sample bag with 70135 (70136-39; 70145-49; 70155-57) are from the same boulder. Some or all may have broken from 70135 after collection, but none could be remated. 70135 was collected from the "Geophone Rock", approximately 50m south of the Apollo Lunar Surface Experiment Package (ALSEP) central station. Samples 70135-39, 70145-49, and 70155-57 were all taken from this boulder.

PETROGRAPHY AND MINERAL CHEMISTRY

The petrography of 70135 was described by Brown et al. (1975a,b) from thin section ,58. It classified as a Type 1B by these authors (i.e., plagioclase-poikilitic). Small olivines (~ 0.1 mm) occur either as cores to large pyroxenes (up to 3 mm), or poikilitically enclosed in plagioclase (up to 4 mm) with no reaction rims. Rare armalcolite is found poikilitically enclosed in pyroxene. Euhedral, blocky ilmenites (1-2 mm) are the predominant opaque phase, containing small (<0.05 mm) exsolution lamellae of rutile. Native Fe and troilite form interstitial phases. General texture indicates development in a slow-cooling regime. Brown et al. (1975b) reported the modal mineralogy of this sample as: 2.8% olivine; 21.9% opaque minerals; 28.4% plagioclase;

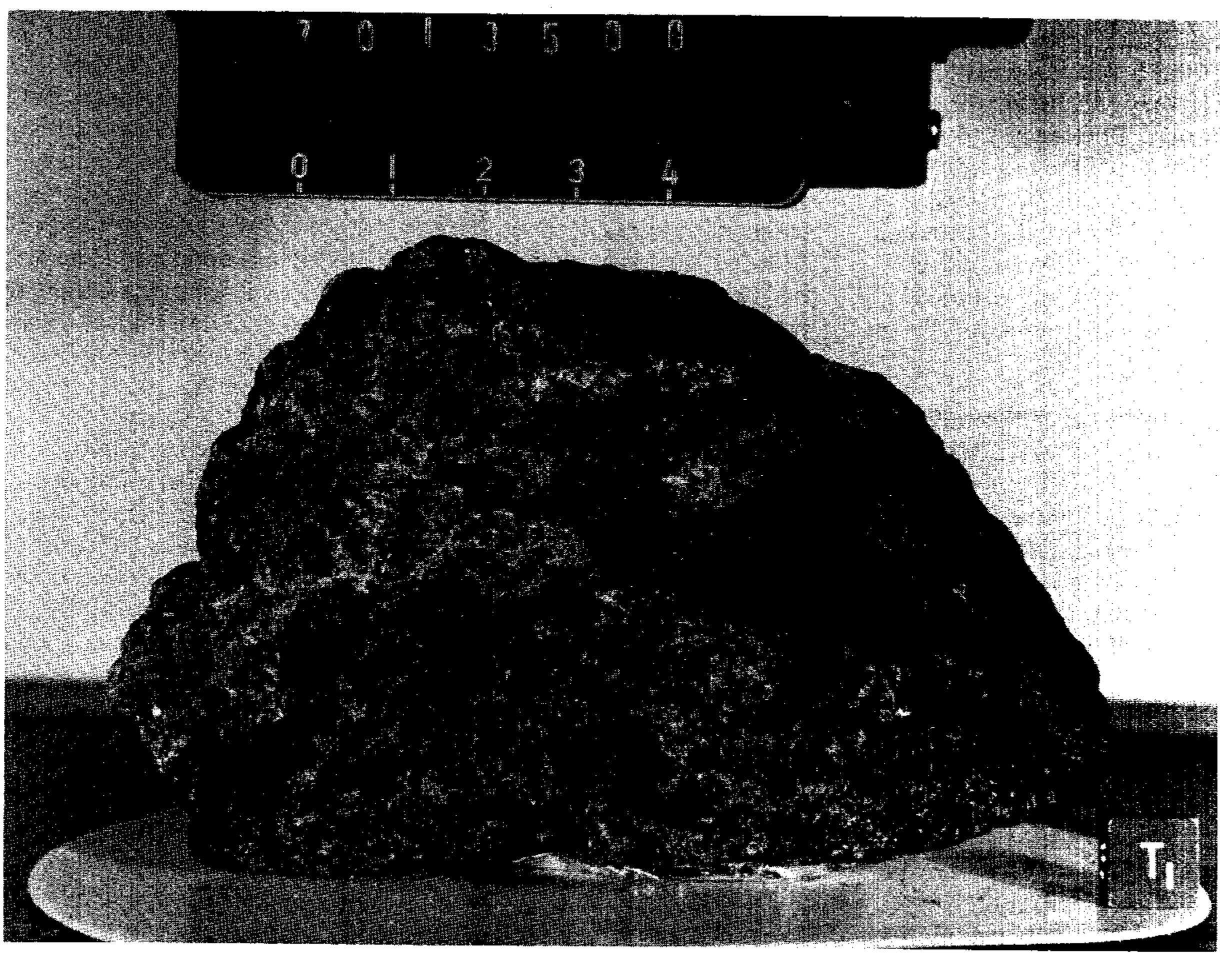


Figure 1: Hand specimen photograph of 70135.

46.2% clinopyroxene; 0.3% silica; 0.4% mesostasis. Roedder and Weiblen (1975) reported the modal mineralogy of 70135 as: 51.6% pyroxene; 23.0% plagioclase; 19.4% oxides; 0.2% native Fe and sulfides; 0.6% silica; 1.4% melt/mesostasis; and 3.8% olivine.

Olivines of approximately Fo_{70} are generally unzoned (Brown et al., 1975b). Pyroxenes zone from titan-augite towards pyroxferroite, with little evidence of pigeonite crystallization. Spinels exhibit compositions from chrome-spinel (with rutile) which is exsolved from ilmenite to late-stage ulvöspinel. Plagioclase exhibits little core-to-rim zonation (< 10 An units) with core compositions being $\sim An_{85}$. Roedder and Weiblen (1975) noted anomalous low-K, high-SiO_2 inclusions in ilmenite from 70135, but came to no satisfactory conclusion for their formation. El Goresy and Ramdohr (1975a,b,c) studied the opaque minerals of 70135 in order to determine the nature of subsolidus reduction in lunar basalts. These authors noted evidence for two reduction reactions in 70135.

WHOLE-ROCK CHEMISTRY

There have been numerous studies of 70135 detailing the whole-rock chemistry to various degrees. The most complete data sets can be found in Laul et al. (1974); Rose et al. (1975); Shih et al. (1975); Rhodes et al. (1976); and Duncan et al. (1976) (Table 1).

Laul et al. (1974) analyzed 70135(,35) (Table 1) by INAA in a comparison study with rocks from other Apollo missions. These authors suggested that two, possibly three different basalt lava flows were present at the Taurus Littrow site. However, on the basis of compatible, rare earth element abundances, and a re-evaluation of earlier chemical data, Laul et al. (1975) concluded that at least five different basalt flows exist at the Apollo 17 site.

Rose et al. (1975) analyzed 70135(,33) (Table 1) by XRF in a characterization study of rocks and soils returned by the Apollo 15, 16, and 17 missions. These authors did not specifically mention this sample in their discussion, simply stating that the "compositions of the analyzed basalts are similar to those reported earlier by Rose et al. (1974)."

Shih et al. (1975a,b) analyzed 70135,27 (Table 1) using a combination of isotope dilution and INA analytical techniques. 70135,27 contained the highest abundances of trace elements of any Apollo 17 high-Ti basalt analyzed by these authors. Shih et al. (1975 a,b) concluded that the low-K/high-Ti mare basalts were the product of extensive melting of an ilmenite-clinopyroxene cumulate followed by near-surface crystallization.

Rhodes et al. (1976) reported the major-element composition of 70135,27 analyzed by XRF (Table 1). These authors classified 70135,27 as a Class U Apollo 17 high-Ti basalt, stating that its coarse grain size precluded a representative analysis, and the available results did not conform with their A, B, C classification of finer-grained Apollo 17 basalts.

Duncan et al. (1976) reported an analysis (by XRF) of 70135,41 in a study of lunar basalt genesis. These authors concluded that variations in the ratios of the elements K, Ba, Zr, Nb, Y, and Ti could not be caused by near-surface fractionation and, therefore, provide information of basalt petrogenesis at depth. Furthermore, the results of Duncan et al. (1976) suggested that Apollo 17 low-K high-Ti basalts were generated from an ilmenite-rich cumulate, with little or no ilmenite left in the residue.

The whole-rock REE concentrations have been determined by Laul et al. (1974) and Shih et al. (1975a,b) on 70135,35 and 70135,27, resp. (Fig. 2). Both REE profiles are LREE-depleted and convex upwards, but Laul et al. (1974) reported higher REE abundances (MREE ~ 90 times chondritic values) than those of Shih et al. (1975) (MREE ~ 70 times chondrite values). Both patterns contain negative Eu anomalies of approximately the same magnitude ($[Eu/Eu^*]_N$ = 0.43). The pattern of Laul et al. (1974) was determined on only 12.6 mg of sample, whereas that of Shih et al. (1975) was determined on 52 mg. Therefore, considering the coarse-grained texture of this sample, it is probable that the REE profile of Laul et al. (1974) is subject to greater sampling errors than that of Shih et al., 1975a,b); the latter analysis is probably the most representative of the whole-rock composition among these two analyses.

Warner et al. (1975) used an unreferenced analysis of 70135 for comparison with 18 new analyses of Apollo 17 high-Ti basalts. These authors attempted to define three groups of Apollo 17 high-Ti basalts on the basis of Sm and TiO_2

Table 1: Whole-rock analyses of 70135.

Ref.	1	2	3	4	5	6	6
Sample	,35	,33	,27		,41	,74	,74
SiO_2 (wt%)		38.60		37.85	37.68		
TiO_2	13.8	13.33		13.34	13.83		
Al_2O_3	7.0	8.88		7.34	7.83		
Cr_2O_3	0.506	0.49		0.55	0.636	0.63	0.54
FeO	21.8	18.97		19.68	19.74	14.71	16.38
MnO	0.27	0.29		0.29	0.26		
MgO	9	9.45		9.29	10.00		
CaO	8.7	9.82		10.18	9.80	11.48	10.96
Na_2O	0.40	0.36		0.34	0.40	0.28	0.31
K_2O	0.11	0.06	0.06	0.09	0.05		
P_2O_5		0.04		0.07	0.077		
S				0.15	0.191		
Nb (ppm)	<10			29.1			
Zr		230	319		319		190
Hf	14					8.9	8.6
Ta	2.6					1.4	1.8
U							
Th	0.3					1.7	0.44
W							
Y		99			118		
Sr		152	186		223		
Rb		<1	0.819		1.5		
Li		11	11.4				
Ba	210	210	105		126		86
Cs							
Be		<1					
Zn		4.1			<2		
Pb		6.4					
Cu					<2		
Ni		<1			<2		
Co	20	29	16.6		13	15	17
V	120	65			19	339	480
Sc	82	86	81.7			77	75
La	12.6	<10	8.49			3.8	7.5
Ce	52		29.4			12	25
Nd	50		31.6			32	23
Sm	18.0		13.0			6.3	11
Eu	2.84		2.30			1.3	1.8

Table 1: (Concluded).

Ref.	1	2	3	4	5	6	6
Sample	,35	,33	,27		,41	,74	,74
Gd			19.6				
Tb	4.5					1.9	3.0
Dy	29		22.6				
Er			13.2			0.59	
Yb	16	10	18.9			6.9	9.3
Lu	2.2					1.1	1.5
Ga		7.0				16	
F							
Cl							
C							
N							
H							
He							
Ir (ppb)							
Ge						1.0	2.0
Au							
Ru							
Os							

References: 1 = Laul et al. (1974); 2 = Rose et al. (1975; 3 = Shih et al. (1975); 4 = Rhodes et al. (1976); 5 = Duncan et al. (1976); 6 = Dickinson et al. (1989).

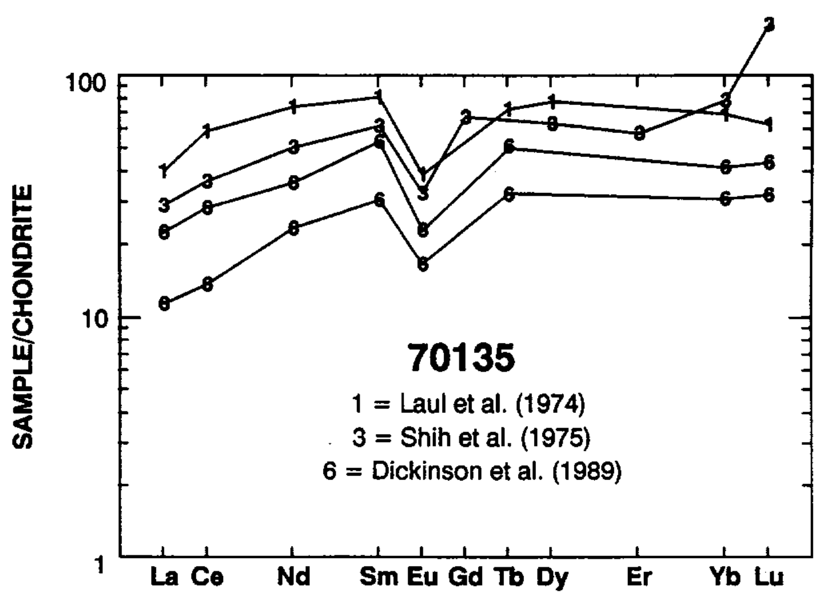


Figure 2: Chondrite-normalized rare-earth element profiles of 70135.

abundances and suggested that 70135 was not related to these Sm and TiO_2 "clusters" by partial melting of an identical cumulate (70135 possesses higher Sm and TiO_2 abundances).

Korotev and Haskin (1975) used the coarse grain size of 70135 to demonstrate the problems of getting a representative whole-rock analysis of such a sample. These authors showed the variability of trace-element abundances with different size fractions of this basalt (Table 2; Fig. 3 a-e). Korotev and Haskin (1975) suggested that these sampling errors can be minimized if an ~ 1 g sample is uniformly crushed to a fine powder. This study reflected on the compositions of different size fractions of lunar soil as products of comminution.

Other studies have concentrated on specific elements, such as the radio-elements (Eldridge et al. (1974), Ge (Dickinson et al., 1988, 1989), and Cl, P, Re, and Os (Jovanovic and Reed, 1975a,b). Eldridge et al. (1974) reported K, Th, and U abundances of 70135 (Table 2) in a study of 13 basalt and 14 soil samples from Apollo 17. Their results for 70135 are: K = 500 ± 30 ppm; Th = 0.31 ± 0.02 ppm; U = 0.12 ± 0.01 ppm. They concluded that there is geochemical evidence for layering in the subfloor basalt flows, along with the possibility of magmatic fractionation of the K/U ratio as a function of depth.

Dickinson et al. (1988, 1989) used 70135(,74) in a study of germanium abundances (analyzed by RNAA) of mare basalts in order to gain an insight into the origin and early evolution of the Moon and lunar basalts. Dickinson et al. (1988) only reported the Ge abundance, whereas Dickinson et al. (1989) reported two whole-rock analyses from splits of 70135,74. These whole-rock analyses are similar (Table 1), but variations of certain elements between these two splits are due to large errors associated with one or other of the analyses. The REE profiles are LREE-depleted (Fig. 2) and have negative Eu anomalies ($[Eu/Eu^*]_N$ = 0.44-0.54). The two REE profiles for 70135 reported by Dickinson et al. (1989) plot below those of Laul et al. (1974) and Shih et al. (1975a,b) (Fig. 2); the sample sizes analyzed were 200mg and 207mg. These relatively large sample sizes may yield compositions more representative of the actual whole-rock composition than the analyses of Laul et al.(1974) and Shih et al. (1975a,b). The reported abundance of Ge in 70135 is 1.0 to 2.0 ppb. Dickinson et al. (1988, 1989) concluded that Apollo 17 basalts contain similar Ge abundances to those from the Apollo 11, 12, and 15 sites. The small variations observed are uncorrelated with other siderophile elements and cannot be explained by differences in the amount of metal segregated into the lunar core. Dickinson et al. (1988, 1989) suggested that volatile transfer of Ge by halogen-rich fluids may have generated such variations.

Gibson et al. (1976) analyzed the sulfur and metallic iron (Fe^o) contents of 70135 in a study of sulfur in Apollo 17 high-Ti basalts. These authors reported 1680 ± 60 μgS/g and 0.163 equivalent wt% Fe^o for 70135. They concluded that the source regions of Apollo 17 high-Ti basalts were saturated with respect to S, whereas those of low-Ti basalts from Apollo 12 and 15 were not.

Jovanovic and Reed (1975a) attempted to analyze 70135 for Cl and P_2O_5 in order to obtain a ratio of these elements, but in this paper they reported that the Cl contents were too low for reliable measurement. A P_2O_5 content of 0.04 wt% was reported here for 70135. However, Jovanovic and Reed (1975b,c) reported 0.52 ppm leachable Cl from 70135,29 with 2.2 ppm left in the residue. Furthermore, these authors also reported 13 ppb Br both in the leach and residue with 0.33 ppm I in the leach (iodine was not detected in the residue). Jovanovic and Reed (1975b) also reported a U concentration of 0.1 ppm for 70135,29. Jovanovic and Reed (1980) again reported these earlier data, stating that 70135 falls into their second group based on Cl/P_2O_5 contents. However, in light of the revealing study of Taylor and Huntert (1983), use of these data for such conclusions was not valid. In a change of emphasis, Jovanovic and Reed (1976a,b) analyzed 70135,29 for Ru and Os contents. The contents reported for 70135 are <2 ppb Ru and 0.1 ppb Os.

ISOTOPES

The isotope determinations conducted have dealt with cosmogenic radionuclides and exposure ages (Arvidson et al., 1976; O'Kelley et al., 1973, 1974a,b; Yokoyama et al., 1974; see Table 4 and radiogenic (primarily Sr) isotopes (Bansal et al., 1975; Murthy et al., 1976; Nyquist et al., 1975a,b, 1976a,b. See Table 5.

Table 2: Compositional variation of trace elements with size fraction analyzed.
Data from Korotev and Haskin (1975).

	Weighted Average	
	< 500 μm	**1-2 mm**
Na_2O (wt%)	0.406	0.397
FeO	19.0	18.7
Sc (ug/g)	79.4	84.3
Cr	4515	4730
Co	22.7	19.0
La	3.64	4.94
Ce	15.1	19.2
Sm	6.48	8.16
Eu	1.72	1.72
Tb	1.94	2.46
Yb	7.02	7.92
Lu	1.04	1.06
Hf	6.7	7.4
Ta	1.66	1.56

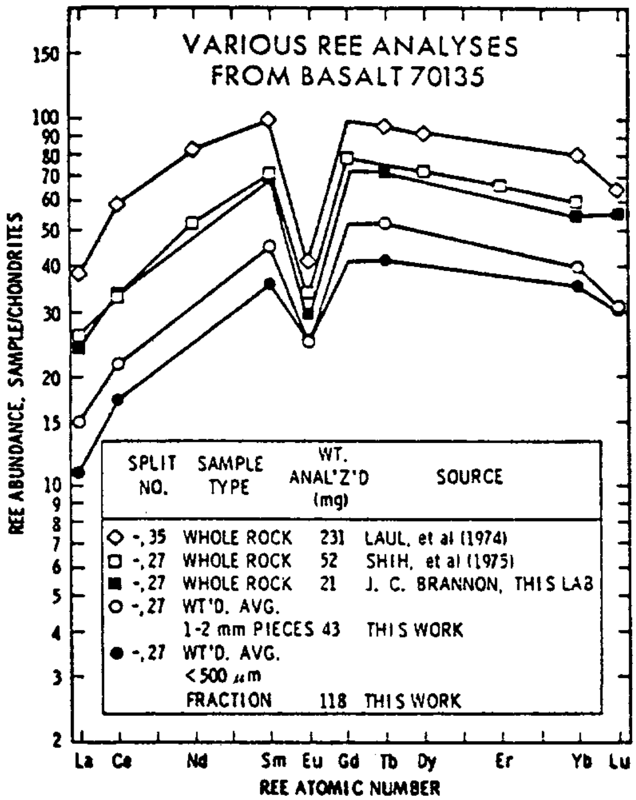


Figure 3a: REE chondrite diagram for various analyses of 70135, taken from Korotev and Haskin (1975). The samples of Shih, et al. (1975) and Brannon were taken from the same homogenized stock. The weighted average of seven <500μm fractions is probably a reasonable approximation to a "whole rock" analysis for the chip of 70135,27 crushed in this experiment.

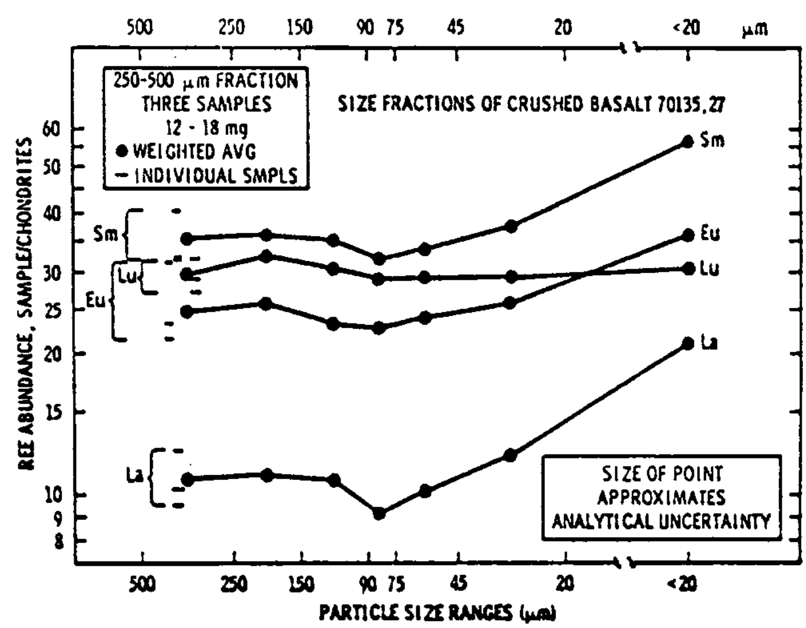


Figure 3b: Chondrite normalized REE abundances as a function of particle size. The numbers plotted on the abscissa are the sieve hole sizes.

Figure 3: Chondrite-normalized REE abundances for various fractions of 70135.

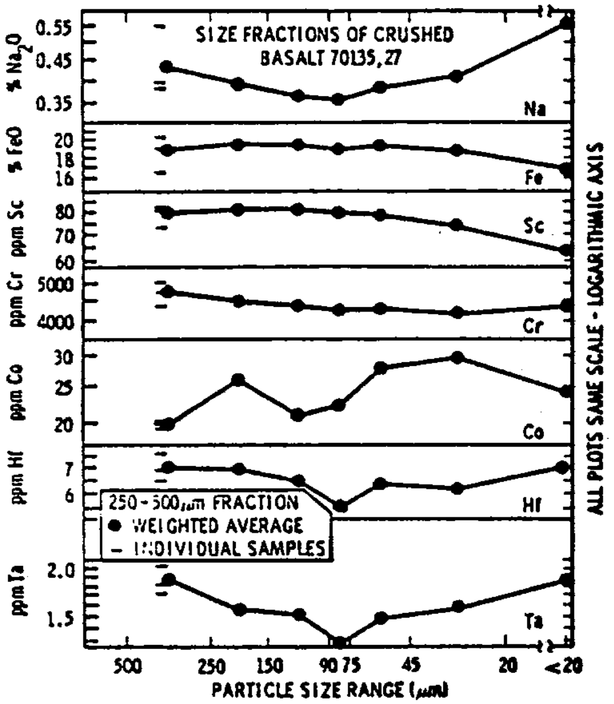


Figure 3c: Other element abundances as a function of particle size.

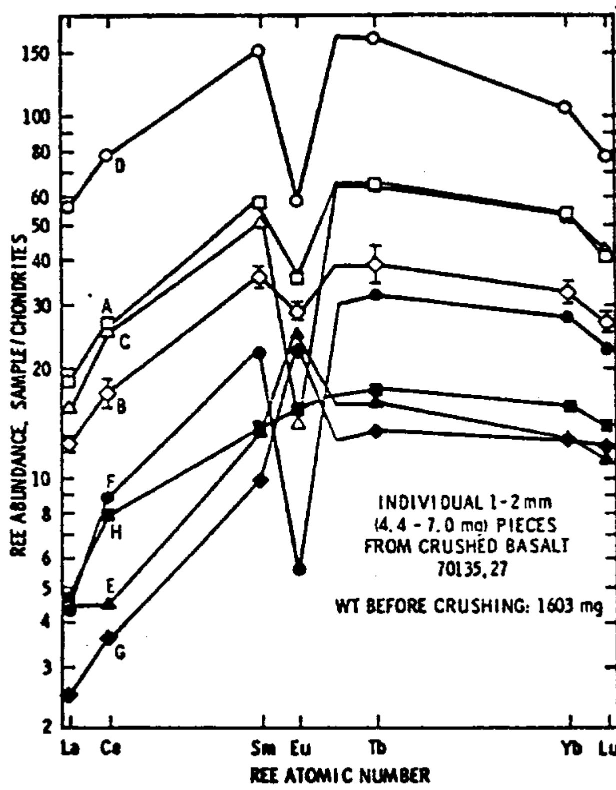


Figure 3d: REE chondrite diagram for eight individual 1-2 mm particles from 70135.

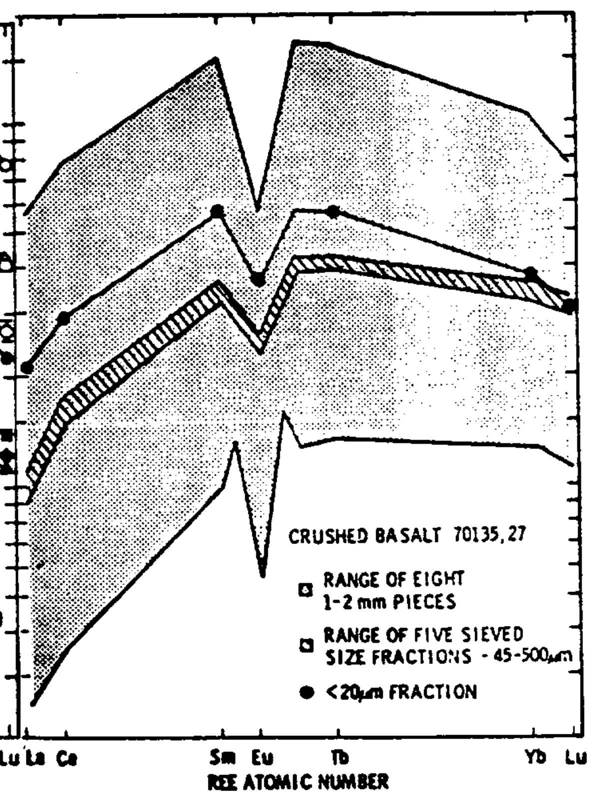


Figure 3e: Range of REE abundances in the size fractions superimposed on the range in the 1-2 mm particles.

Figure 3: Chondrite-normalized REE abundances for various fractions of 70135.

O'Kelley et al. (1973, 1974) analyzed 70135 nondestructively for cosmogenic radionuclides using gamma-ray spectrometers with high sensitivity and low background. Abundances of ^{26}Al, ^{22}Na, ^{54}Mn, ^{56}Co, ^{46}Sc, and ^{48}V were determined for 70135 (Table 3). Yokoyama et al. (1974) analyzed 155 rocks from Apollo 11 and 17 missions for ^{22}Na and ^{26}Al. These were classified according to saturation in ^{26}Al. These authors agreed with the supposition of O'Kelley et al. (1973, 1974) that 70135 was shielded from solar flares, concluding that all ^{22}Na and ^{26}Al in this sample were produced by galactic cosmic rays. No tabulated data were presented by Yokoyama et al. (1974), but Figure 4 illustrates the relative proportions of ^{22}Na and ^{26}Al in 70135.

Table 3: Abundances of cosmogenic radionuclides in 70135.
Data from O'Kelley et al. (1973, 1974).

	70135
^{26}Al	38 ± 2
^{22}Na	33 ± 3
^{54}Mn	56 ± 6
^{56}Co	56 ± 6
^{46}Sc	32 ± 3
^{48}V	10 ± 5

The only exposure age reported for 70135 was by Arvidson et al. (1976). This ^{81}Kr-Kr exposure age is 106 ± 4 Ma. These authors suggested that such an age correlated with an influx of crater debris from the formation of Tycho.

Bansal et al. (1975) reported the Rb-Sr systematics of 70135, in a study of Rb-Sr ages and initial $^{87}Sr/^{86}Sr$ ratios of Apollo 17 mare basalts. These authors suggested a three-stage evolutionary model for 70135: 1) evolution of $^{87}Sr/^{86}Sr$ in an environment with Rb/Sr greater than in the basalts; 2) production of mare basalt source regions of lower but variable Rb/Sr sometime in the interval 4.6-3.8 Ga; and 3) extraction of lavas from these sources with little or no fractionation of Rb/Sr at 3.8 Ga. Nyquist et al. (1975a,b) reported a mineral isochron for 70135,27 (Table 4) which yielded an age of 3.75 ± 0.09 Ga with an initial $^{87}Sr/^{86}Sr$ ratio of 0.69924 ± 0.00003 (Fig. 5). The conclusions of these authors were essentially the same as those reported by Bansal et al. (1975). Nyquist et al. (1976) reported their 1975 Rb-Sr analysis of 70135 in conjunction with others from Apollo 17 high-Ti basalts in order to demonstrate the relatively large range in Rb/Sr with initial $^{87}Sr/^{86}Sr$. This observation was used in constructing the three-stage model for Sr isotopic evolution of Apollo 17 mare basalts (see above), and was used to demonstrate that the Rb/Sr of Type C Apollo 17 high-Ti basalts was increased at the time of magma generation. Murthy and Coscio (1976) used the Rb-Sr analysis of Nyquist et al. (1975) for 70135 in a comparative study of the Sr isotopic composition of Apollo 17 basalts. These authors applied a correction factor to this analysis in order to accommodate inter-laboratory bias. Therefore, the initial $^{87}Sr/^{86}Sr$ ratio of 70135 was quoted as 0.69912 ± 4.

No stable isotope analyses have been undertaken on 70135.

MAGNETICS

70135 has been examined in two magnetic studies to date. Brecher (1977a,b) used 70135,17 (described by Brecher as a "typical subfloor vesicular gabbroic basalt") to study the relationships between magnetization directions, magnetic fabric, and petrographic features. Her results are presented in Table 5 and Figure 6. 70135,17 contained vug-rich layers which could be seen nearly parallel to the "horizontal" B and T cube faces (feature B in Fig. 6) with scalloped "flow fronts" evident on cleaved faces (Brecher, 1977a). In these planes, dark and lighter-gray striations and glass-filled cracks parallel to the N-S axis could be seen (feature C in Fig. 6). A coarsely defined light-dark vertical banding was also observed, perpendicular to the vugs and crack elongation (A in Fig. 6). The NRM of 70135,17 was described by Brecher (1977a,b) as quite soft (6.14×10^{-5} emu/g), only 7% surviving cleaning to 100 Oe. The NRM and cleaned directions have high inclinations, clustering about a roughly vertical lineation axis of elongated vugs, contained in dark-light (shear-banding?) layers (Brecher, 1977a). The magnetic anisotropy is rather low (~ 5%) with dominant lineation, but comparable foliation. The NRM directions lie closer to the minimum susceptibility axis, paralleling trains of elongated vesicles.

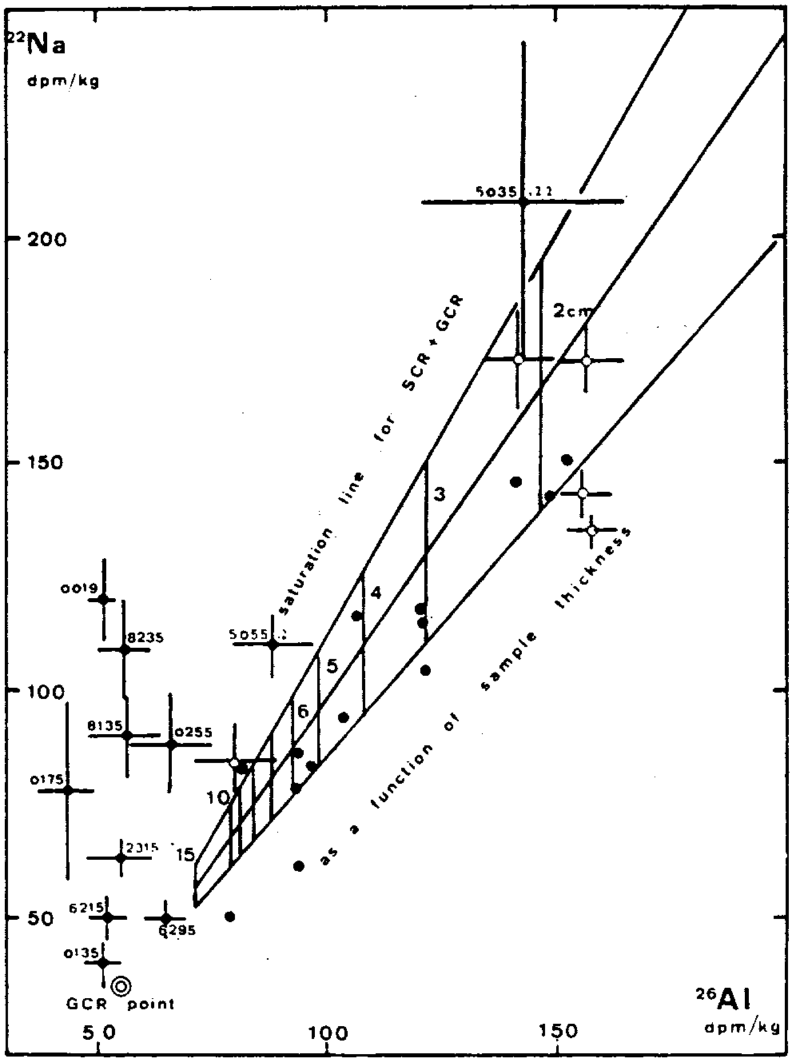


Figure 4: $^{22}Na-^{26}Al$ correlation diagram for Apollo 17 samples. Open circles with error bars represent soils, solid circles represent rocks saturated in ^{26}Al, and solid circles with error bars represent rocks either unsaturated in ^{26}Al or uncertain. The first digit (7) of the LRL number of sample is omitted. Saturation lines correspond to the production of ^{22}Na and ^{26}Al by GCR + SCR with SCR parameters of $J = 260 \pm 50$ protons ($E_p >$ 10MeV)/cm^2-sec-4π and $R_0 = 100$ MV for ^{22}Na and $J = 70$ protons ($E_p >$ 10MeV)/cm^2-sec-4π with $R_0 = 150$ MV for ^{26}Al. The determination of these SCR parameters was given in the previous paper (Yokoyama et al., 1973). The approximate sample thickness corresponding to the saturated activity is also indicated along the saturation line.

Table 4: Rb-Sr data from 70135,27.
(Nyquist et al., 1975).

	Wt. (mg)	Rb (ppm)	Sr (ppm)	$^{87}Rb/^{86}Sr_a$	$^{87}Sr/^{86}Sr_b$	T_B	T_L
70135,27	51.8	0.819	186	0.0127±3	0.69995±5	7.7±0.4	5.0±0.4
plag 1	7.3	0.126	731	0.00050±1	0.69920±11		
Repeat					0.69927±3		
ilm 1	12.1	0.676	46.5	0.0421±4	0.70148±7		
px	7.7	0.39	165.7	0.0172±2	0.70010±8		
plag 2	6.2	0.124	698	0.00051±1	0.69923±7		
ilm 2	18.8	0.771	48.2	0.0463±4	0.70172±6		

Table 5: Magnetic data from 70135.
Brecher (1977a); Cisowski et al. (1983)
(all values in Gcm^2/gm).

	Sample 70135,17
Rock type	Vesicular Gabbroic Basalt
NRM	3.6 * 10^{-5}
NRM (200)	4.7 * 10^{-7}
Mass (g)	9.465
IRM_s(9 KOe)	1.8 * 10^{-3}
NRM (x10^5 emu/g)	6.14
IRM_s(200)	2.4 * 10^{-4}
NRM_{100}/NRM	0.068
K x 10^3 emu/Oe cc	4.9
(K_{max}-K)x10^5	0.49
Lineation	3
Foliation	2
Total anisotropy (%)	5.3
Petromagnetic correlation?	Strong

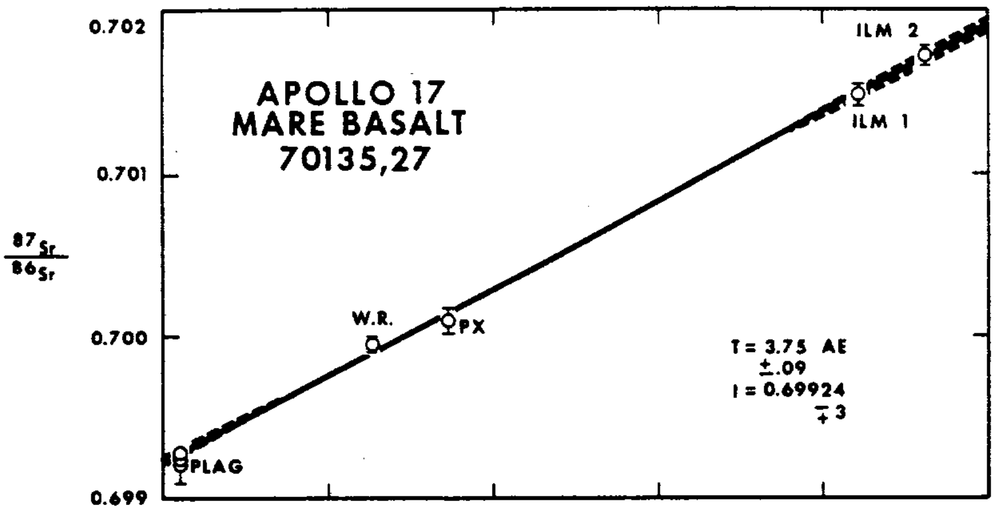


Figure 5: Isochron plot of $^{87}Sr/^{86}Sr$ versus $^{87}Rb/^{86}Sr$ for 70135,27. Taken from Nyquist et al. (1975).

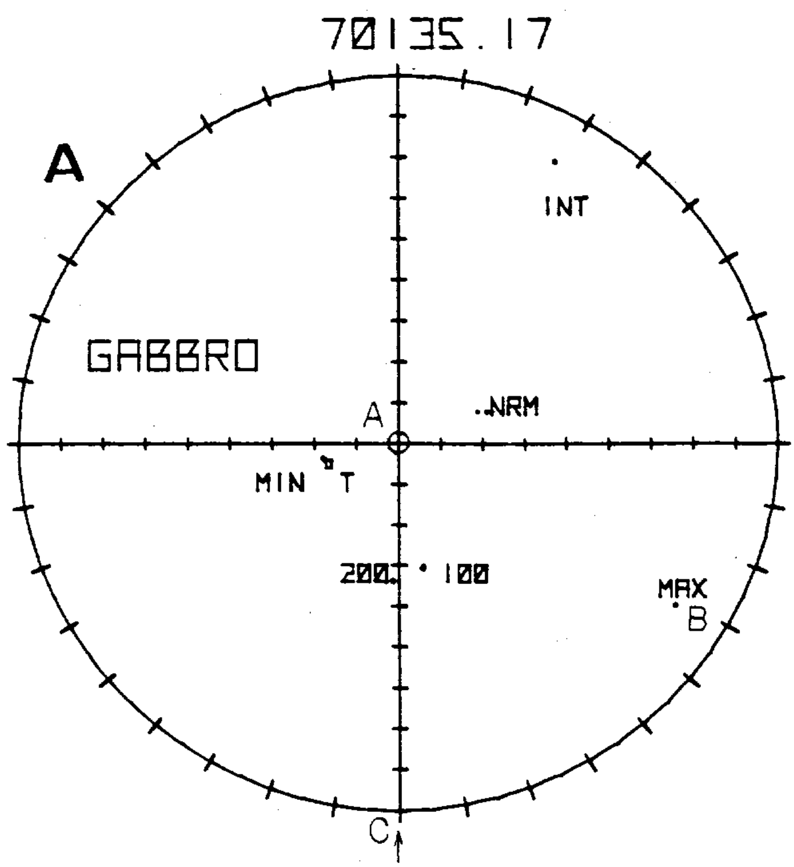


Figure 6: Magnetic data of 70135,17 taken from Brecher (1977). The high-inclination NRM and cleaned directions in basalt 70135 are grouped about the roughly vertical lineation axis of elongated vugs (A), contained in the plane of layering (C). The magnetic fabric plane nearly coincides with vug-rich "horizontal" layers (B).

Cisowski et al. (1983) reported the magnetic intensity of 70135 in their review of paleointensity data in a study of lunar magnetism. These authors used the magnetic remanence data for 70135 (Table 5) to evaluate the origin of the lunar magnetic field. The conclusions of Cisowski et al. (1983) are somewhat vague, stating that only rocks within a certain limited age range contain magnetic intensities similar to those on Earth. They also stated that the origin of these intensities was uncertain.

EXPERIMENTAL

70135 has been used in one experimental study, that by Rutherford and Hess (1975). the experiments were designed to demonstrate the origins of lunar granites as immiscible liquids. These authors reported a major element whole-rock analysis for 70135, and the residual liquid composition after extreme (85-90%) fractional crystallization (Table 6). The fractionated residual reported by Rutherford and Hess (1975) did not experience liquid immiscibility, but did experience moderate Fe enrichment.

Osborne et al. (1978) used the major-element whole-rock analysis of 70135 reported by Rhodes et al. (1976) and the modal analysis of Roedder and Weiblen (1975) for 70135 in an experimental study of spectral reflectance for Ti determinations at room and elevated temperatures. High temperature measurements revealed that slopes of the reflectance profiles in the 0.400-0.550 µm region increased significantly up to 300°C, demonstrating a decrease in intensity at elevated temperatures as a result of metal → metal (e.g., Fe^{2+} → Ti^{4+}) charge transfer bands involving Ti. Osborne et al. (1978) concluded that techniques for mapping Ti concentrations on hot planetary surfaces should be applied cautiously if room-temperature calibration spectra are used.

PROCESSING

The major subdivisions of 70135 can be found in Figure 6 (Cutting and Chipping of Lunar Rock 70135). 70135,0 has been entirely subdivided. The largest portion of this basalt remaining is 289.1g (70135,9). Ten thin sections have been made, and the sample numbers are 70135,57-66.

Table 6: Major-element analyses of 70135,34 compositions after silicate liquid immiscibility after the extreme fractional crystallization experiments of Rutherford et al. (1975).

	70135,34	
	Low-Si	High-Si
SiO_2	38.84	50.88
TiO_2	12.74	3.99
Al_2O_3	9.16	9.59
Cr_2O_3		
FeO	17.96	22.07
MnO	0.26	0.50
MgO	10.44	1.77
CaO	10.67	10.30
Na_2O	0.25	0.24
K_2O	0.02	0.18
P_2O_5	0.14	0.03
TOTAL	100.48	99.55

70136
High-Ti Mare Basalt
10.65 g, 1.5 × 2 × 2.5 cm

INTRODUCTION

70136 has been described as a brownish-gray, medium-grained, high-Ti mare basalt, with one slickensided face and containing ~5% vugs (Apollo 17 Lunar Sample Information Catalog, 1973) (Fig. 1). No zap pits are present. This sample was collected from the "Geophone Rock", 50 m south of the ALSEP central station, the same site as 70135.

PETROGRAPHY AND MINERAL CHEMISTRY

70136 was described by Warner et al. (1979) as a coarse-grained, plagioclase-poikilitic, high-Ti mare basalt. This corresponds to the Type 1B of Brown et al. (1975). 70136 contains abundant blocky, euhedral, and interstitial ilmenites (up to 1 mm) and clinopyroxenes exhibiting the "bow-tie" texture (Fig. 2). Ilmenite contains rutile exsolution lamellae (<0.005 mm wide). Minor amounts of opaque glass are associated with the ilmenite. Plagioclase (up to 4 mm) poikilitically encloses these minerals. Olivine is rare, usually found in the cores of pyroxenes. Rare armalcolites (~0.1 mm) and Cr-ulvöspinels are present only as poikilitic inclusions in pyroxene. Native Fe and troilite form interstitial phases. Mineral chemistry is similar to 70135, but was not specifically reported by Warner et al. (1979).

WHOLE-ROCK CHEMISTRY

The whole-rock composition (major and trace elements) of 70136 was analyzed by Ma et al. (1979) and reported by Warner et al. (1979), both quoting the same analysis (Table 1). The REE pattern (Fig. 3) is typical of Apollo 17 high-Ti basalts, inasmuch as it is LREE-depleted with a negative Eu anomaly. However, both MREE and HREE reach only ~30 times chondritic values, and the magnitude of the negative Eu anomaly is diminished ($[Eu/Eu^*]_N = 0.78$). Warner et al. (1979) and Ma et al. (1979) used the whole-rock analysis of 70136 in a comprehensive study of Apollo 17 high-Ti basalt petrogenesis. These authors used the A, B, C, U (U = Unclassifiable) classification of Rhodes et al. (1976). Warner et al. (1979) suggested that this basalt was too coarse-grained to yield a representative analysis, and consequently assigned 70136 to Class U (Unclassifiable).

PROCESSING

There remains 8.7 g of 70136,0 and 1.02 g of 70136,2. 70136,1 was irradiated (for analysis of Ma et al., 1979), and the thin section 70136,5 was made from this irradiated sample.

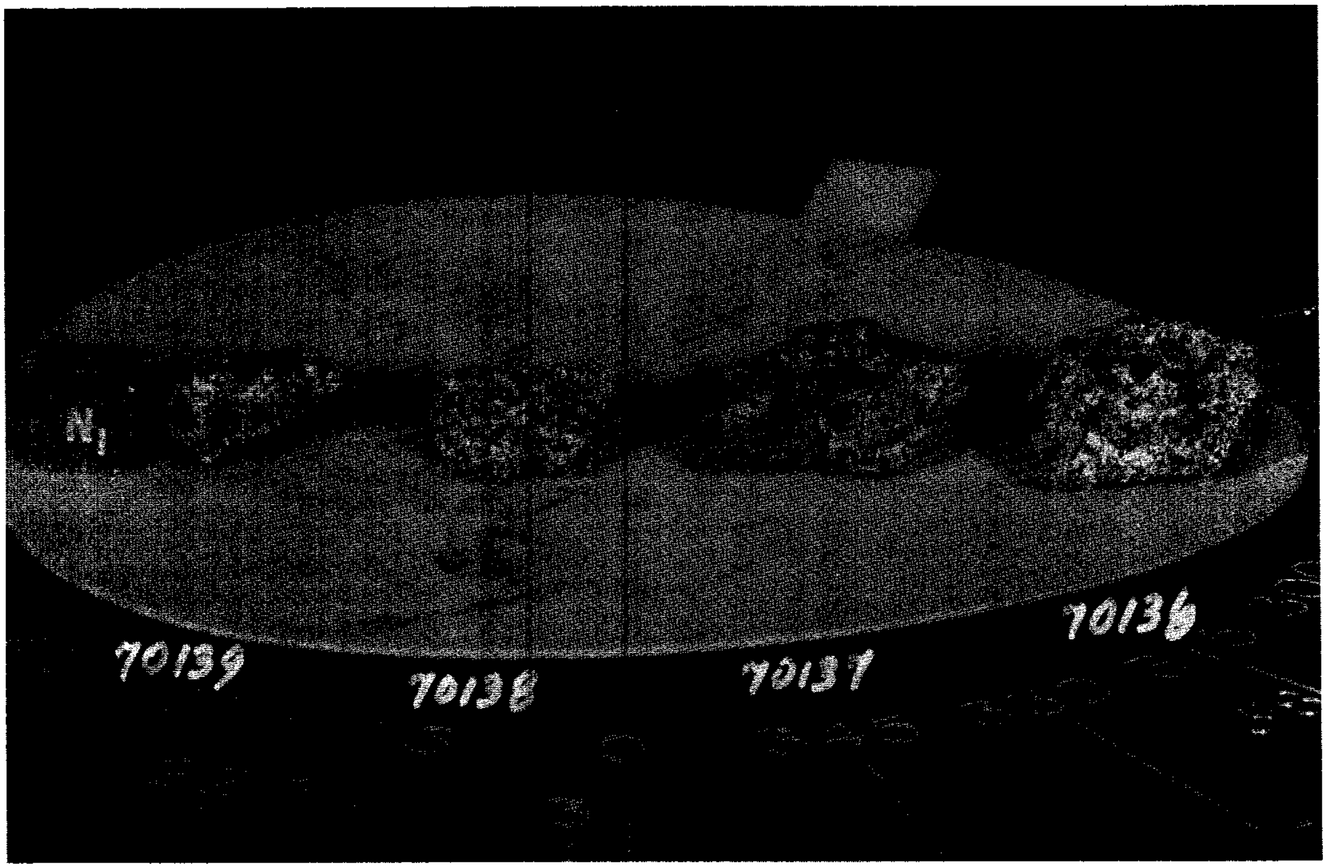


Figure 1: Hand specimen photograph of 70136, 70137, 70138, and 70139.

Figure 2: Photomicrograph of 70136,5. Field of view = 2.5 mm.

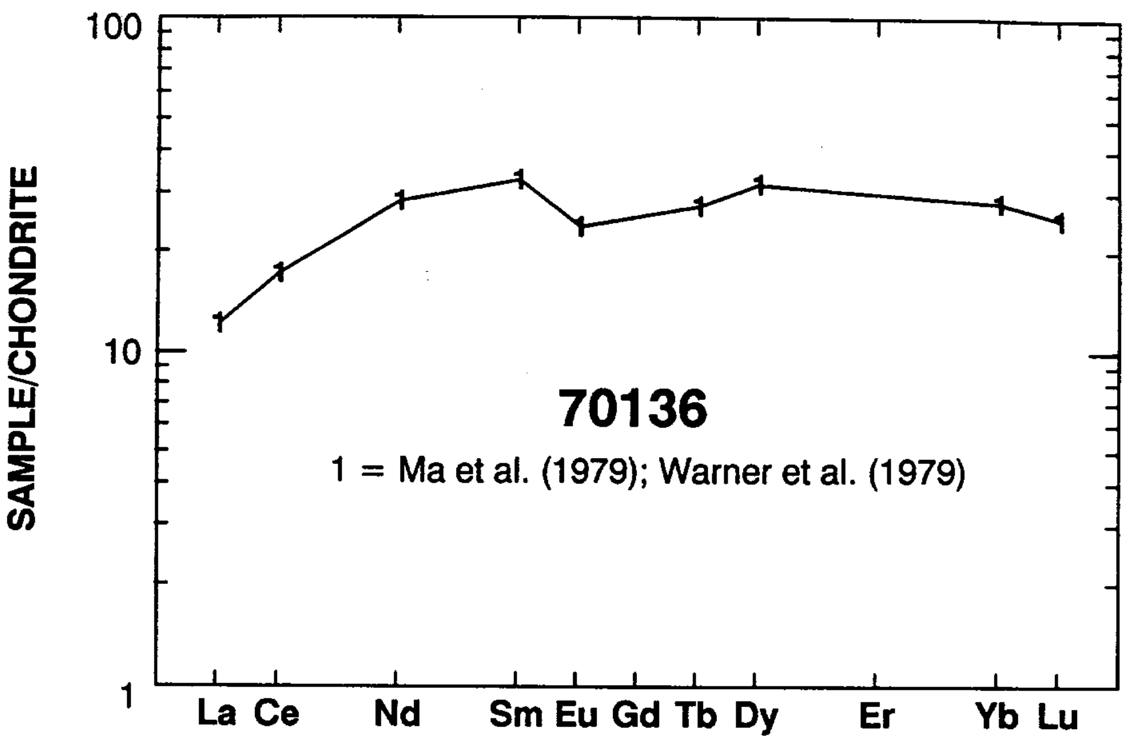


Figure 3: Chondrite-normalized rare-earth element profile of 70136.

Table 1: Whole-rock composition of 70136,1.
Data from Ma et al. (1979) and reported by Warner et al. (1979).

	70136,1		70136,1
SiO_2 (wt%)		Cu	
TiO_2	11.3	Ni	
Al_2O_3	11.1	Co	18
Cr_2O_3	0.492	V	128
FeO	17.2	Sc	72
MnO	0.218	La	4.0
MgO	9	Ce	15
CaO	10.1	Nd	18
Na_2O	0.486	Sm	6.7
K_2O	0.045	Eu	1.85
P_2O_5		Gd	
S		Tb	1.6
Nb (ppm)		Dy	11
Zr		Er	
Hf	6.7	Yb	6.2
Ta	1.4	Lu	0.85
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by INAA.

70137
High-Ti Mare Basalt
6.16 g, 2.7 × 1.5 × 1 cm

INTRODUCTION

70137 has been described as a brownish-gray, medium-grained, high-Ti mare basalt with a granular fabric, and containing ~5% vugs (Fig. 1) (Apollo 17 Lunar Sample Information Catalog, 1973). No zap pits are present. It was collected from the "Geophone Rock", 50 m south of the ALSEP central station.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1979) described 70137 as a coarse-grained, plagioclase-poikilitic, high-Ti mare basalt, corresponding to the Type 1B of Brown et al. (1975). Large (up to 1 mm) euhedral, blocky, and interstitial ilmenites occur "overlaying" large clinopyroxenes (up to 3 mm) and plagioclases (up to 3 mm) (Fig. 2). Ilmenite contains exsolution lamellae of chromite and rutile (<0.005 mm). Olivines are rare, usually present as cores to the clinopyroxenes. Armalcolite and spinel minerals are also rare, present only as poikilitic inclusions in pyroxene. Native Fe and troilite form interstitial phases. Mineral chemistry is similar to 70135, but was not specifically mentioned by either Ma et al. (1979) or Warner et al. (1979).

WHOLE-ROCK CHEMISTRY

Ma et al. (1979) analyzed the whole-rock major- and trace-element composition of 70137,1 (Table 1). This analysis was also reported by Warner et al. (1979). The REE pattern (Fig. 3) is very similar to that of 70136 in absolute abundances. The magnitude of the negative Eu anomaly is somewhat increased relative to 70136 ($[Eu/Eu^*]_N$ = 0.72 vs. 0.78). Warner et al. (1979) and Ma et al. (1979) used the whole-rock analysis of 70137 in a comprehensive study of Apollo 17 high-Ti basalt petrogenesis. These authors used the A, B, C, U (U = Unclassifiable) classification of Rhodes et al. (1976). Warner et al. (1979) suggested that 70137 was too coarse-grained to yield a representative whole-rock analysis, and classified this sample in Class U.

PROCESSING

There remains 4.57 g of 70137,0. 70137,1 was irradiated, and thin section 70137,4 was taken from this irradiated sample. Figure 4 shows the major divisions of this sample.

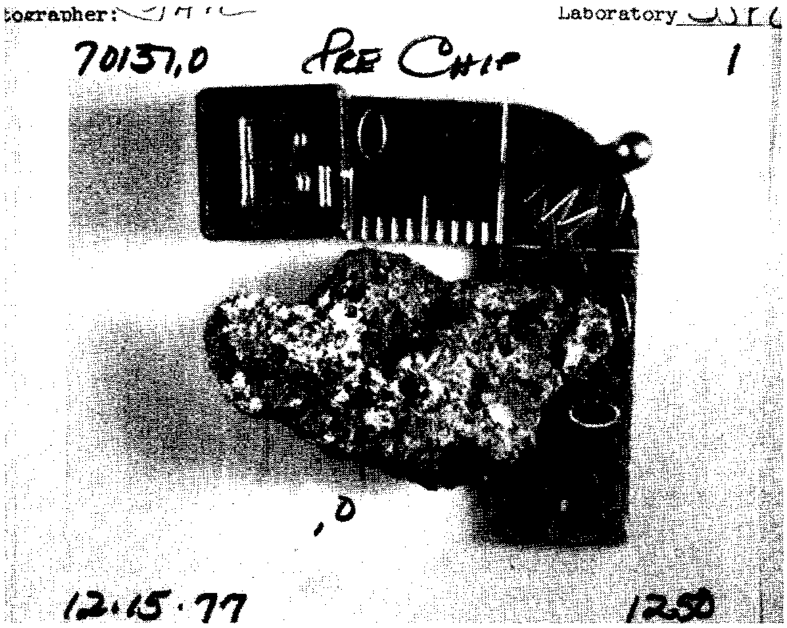


Figure 1: Hand specimen photograph of 70137,0.

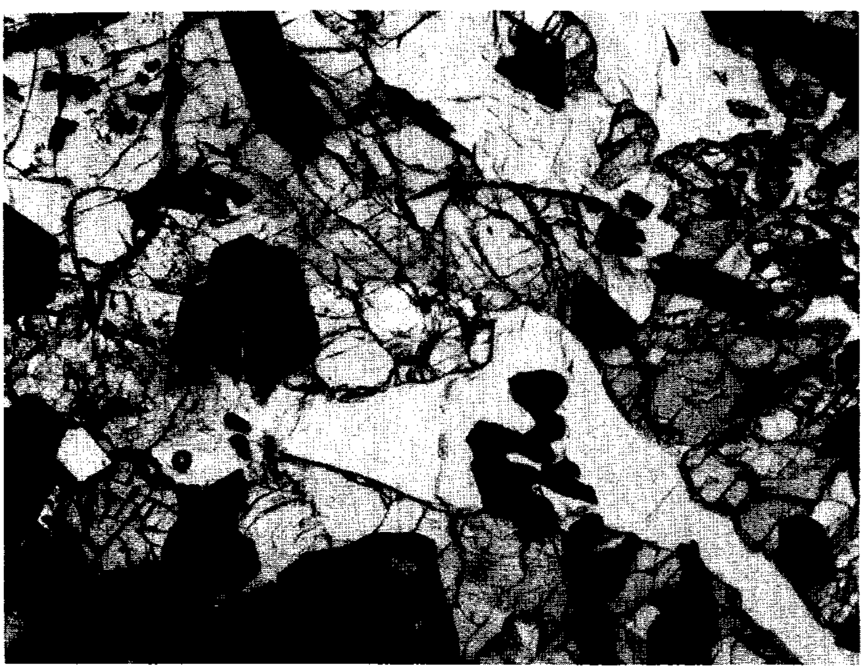


Figure 2: Photomicrograph of 70137,4. Field of view = 2.5 mm.

Table 1: Whole-rock composition of 70137.
Data from Ma et al. (1979) and reported by Warner et al. (1979).

	70137,1		70137,1
SiO_2 (wt%)		Cu	
TiO_2	12.0	Ni	
Al_2O_3	9.2	Co	21
Cr_2O_3	0.534	V	132
FeO	18.0	Sc	77
MnO	0.226	La	4.0
MgO	10	Ce	17
CaO	10.3	Nd	19
Na_2O	0.421	Sm	7.0
K_2O	0.048	Eu	1.63
P_2O_5		Gd	
S		Tb	1.6
Nb (ppm)		Dy	11
Zr		Er	
Hf	6.7	Yb	6.6
Ta	1.5	Lu	0.93
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by INAA.

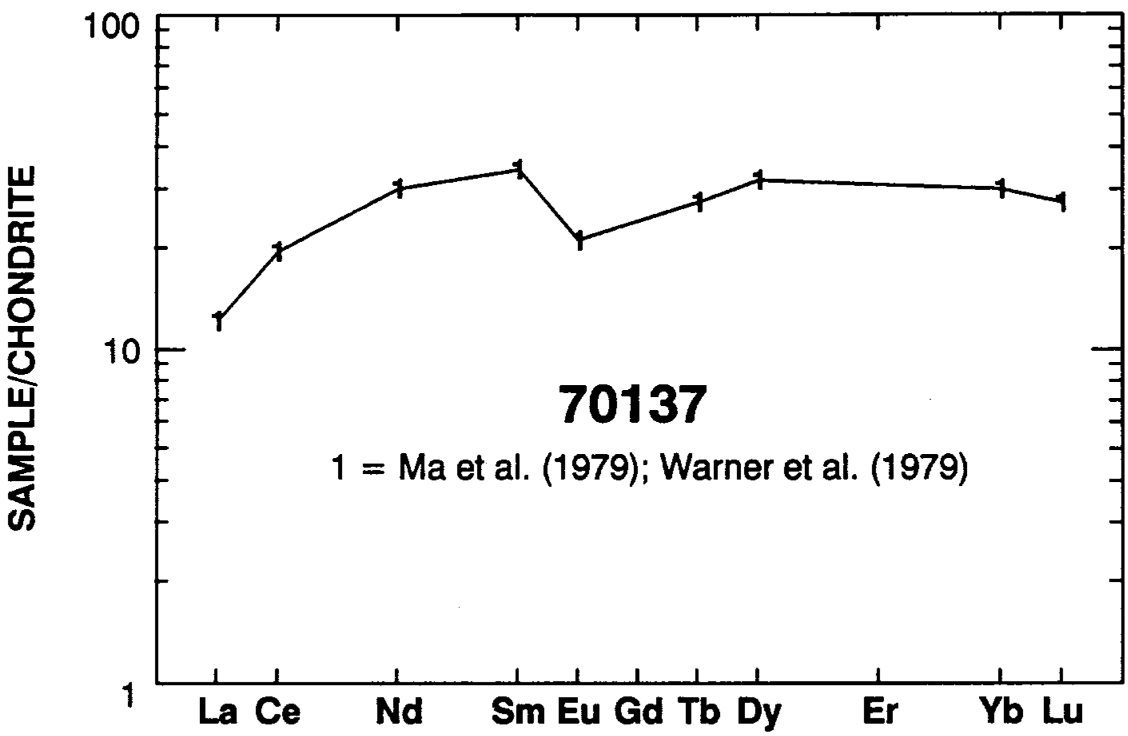


Figure 3: Chondrite-normalized rare-earth element profile of 70137.

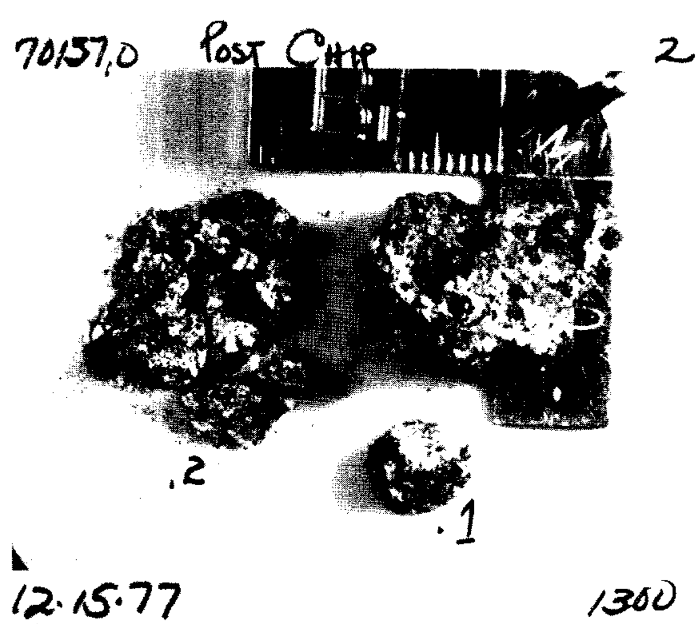


Figure 4: Major subdivisions of 70137,0.

70138

High-Ti Mare Basalt
3.66 g, 2 × 1.3 × 1 cm

INTRODUCTION

70138 has been described as a brownish-gray, medium-grained, high-Ti mare basalt (Fig. 1), containing ~5% vugs and one slickensided face with smeared out and pulverized ilmenite (Apollo 17 Lunar Sample Information Catalog, 1973). No zap pits are present. This sample was collected from the "Geophone Rock", 50 m south of the ALSEP central station.

PETROGRAPHY AND MINERAL CHEMISTRY

Thin section 70138,3 was studied by Neal et al. (1989), who described this sample as a plagioclase-poikilitic, high-Ti mare basalt (see 70135). Modal analysis of 70138 showed: 49.7% clinopyroxene; 22.2% plagioclase; 3% olivine; 21.1% ilmenite; 1% native Fe and troilite; and 3% armalcolite, with trace amounts of rutile and chromite, present mainly as exsolution lamellae (both <0.005 mm) in ilmenite. Olivine is present either as cores to clinopyroxenes, or as inclusions in plagioclase, where the olivine has no pyroxene rim. Armalcolite is present as ilmenite-free inclusions in pyroxene and plagioclase.

Olivine compositions range in Fo content from 48 to 69. However, individual grains are homogeneous. Plagioclase exhibits little variation (An_{84-89}), but the rims are usually more sodic. Pyroxenes range from titan-augites to pigeonites, with both varieties exhibiting Fe enrichment (Fig. 2). An unusual feature of this basalt is that core-to-rim zonations in the largest clinopyroxenes trend toward pigeonite from titan-augite. This is probably a result of olivine resorption. Cr_2O_3 decreases with Fe enrichment and Al/Ti ratios are constant at ~2. Ilmenite exhibits a large range in MG# (5-23), whereas armalcolite exhibits little variation (MG# = 43-45).

WHOLE-ROCK CHEMISTRY

70138 (Table 1) is a Type A high-Ti mare basalt (Neal et al., 1990), on the basis of the classification used by Rhodes et al. (1976) and Warner et al. (1979). The REE pattern is LREE-depleted and convex-upward, with a negative Eu anomaly (Fig. 3 and Table 1) with $[Eu/Eu^*]_N = 0.62$. The MREE reach ~40-45 times chondritic values. Neal et al. (1990) have used the whole-rock composition of 70138 to refine previous petrogenetic models and formulate a new one for the Type A Apollo 17 high-Ti basalts. This model involved up to 80% fractional crystallization of observed phenocryst phases, although the majority of Type A high-Ti basalts are generated after 40% fractional crystallization.

ISOTOPES

Rb-Sr and Sm-Nd isotopic data for 70138,7 was reported by Paces et al. (1991) (Tables 2 and 3). These analyses were part of a larger study aimed at the isotopic characterization of the Apollo 17 high-Ti basalts.

PROCESSING

There is 2.89 g of 70138,0 remaining. Approximately 0.75 g was irradiated for INA analysis, and a further 0.01 g was used in the preparation of thin section 70138,3.

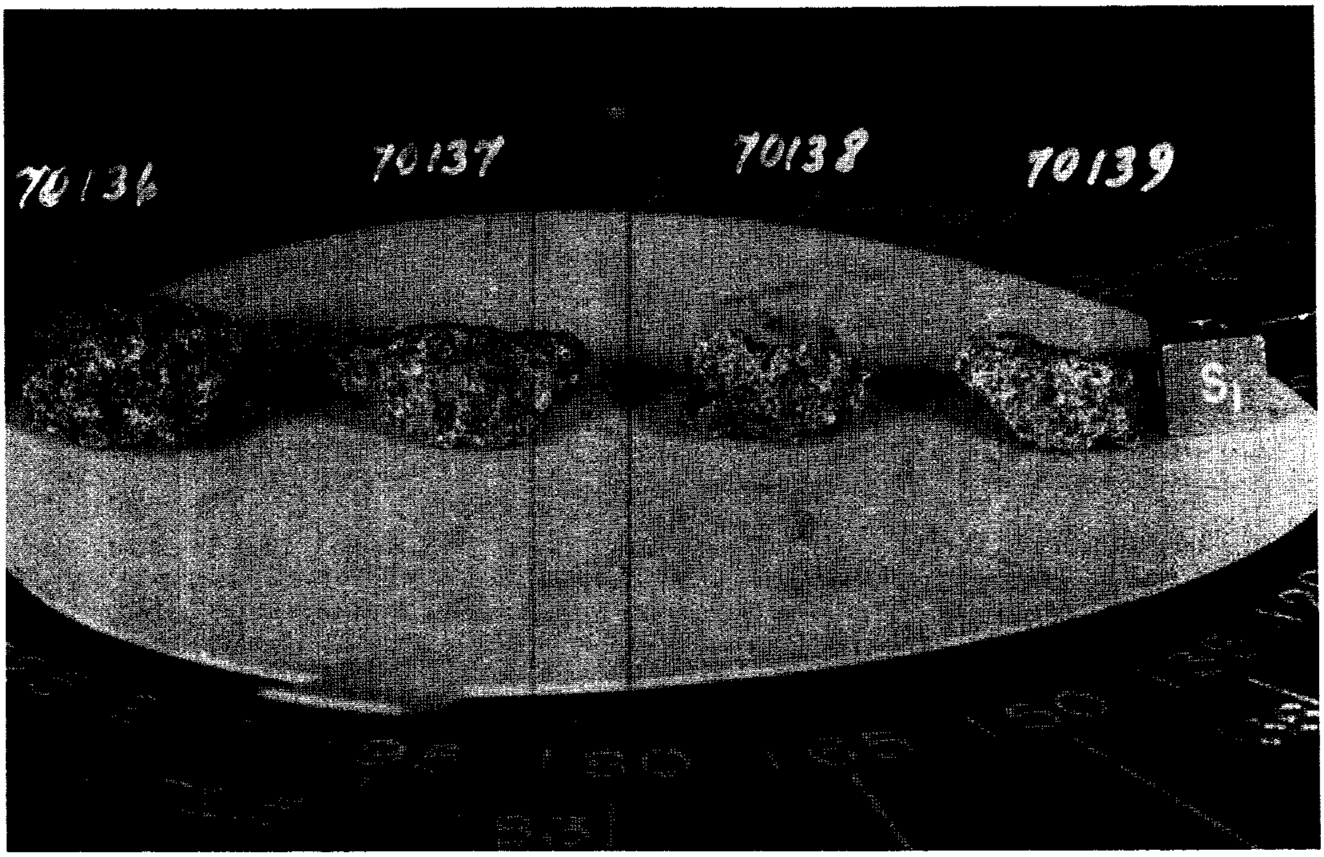


Figure 1: Hand specimen photograph of 70136, 70137, 70138, and 70139.

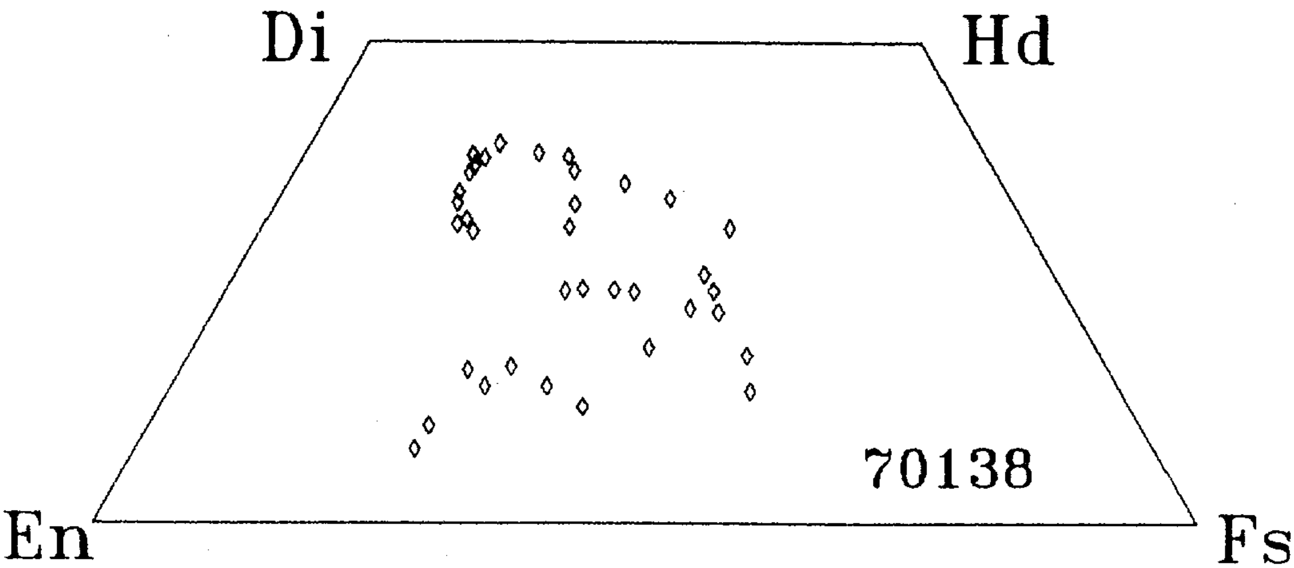


Figure 2: Pyroxene compositions of 70138 represented on a pyroxene quadrilateral.

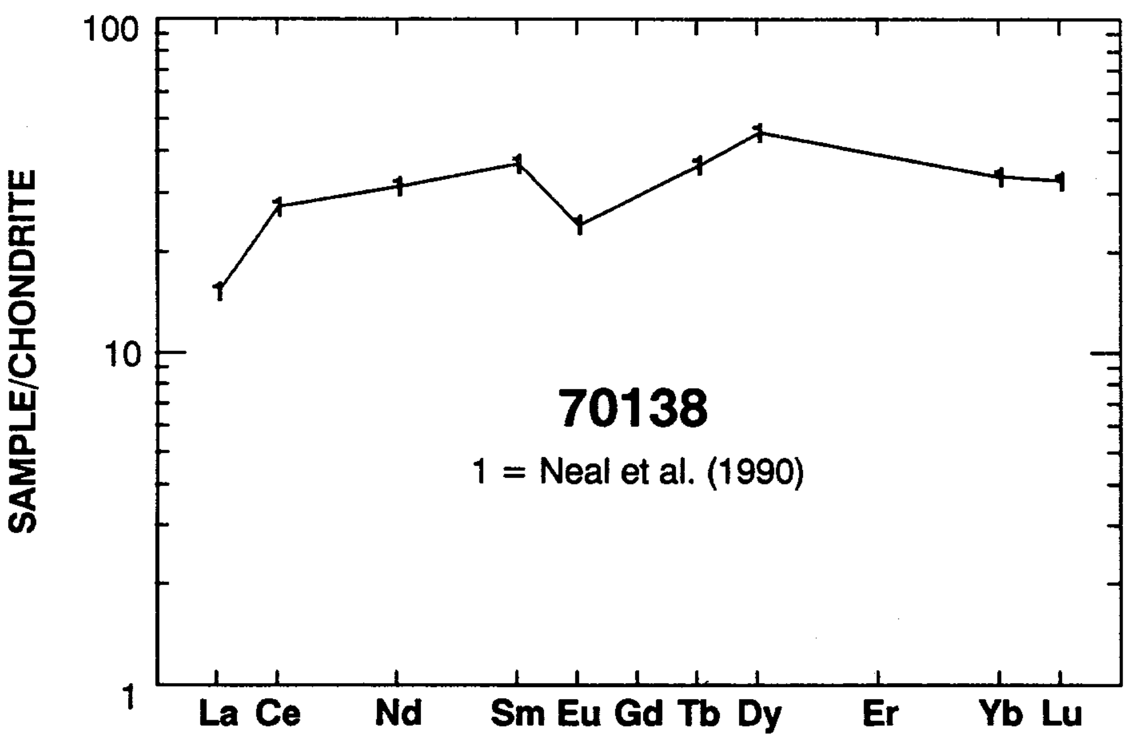


Figure 3: Chondrite-normalized rare-earth element profile of 70138.

Table 1: Whole-rock composition of 70138,4.
Data from Neal et al. (1990).

	70138,4		70138,4
SiO_2 (wt%)		Cu	
TiO_2	12.5	Ni	4
Al_2O_3	8.49	Co	19.8
Cr_2O_3	0.501	V	134
FeO	17.9	Sc	77
MnO	0.237	La	5.05
MgO	8.2	Ce	24
CaO	9.5	Nd	20
Na_2O	0.39	Sm	7.56
K_2O	0.05	Eu	1.88
P_2O_5		Gd	
S		Tb	2.13
Nb (ppm)		Dy	15.8
Zr	230	Er	
Hf	7.29	Yb	7.49
Ta	1.57	Lu	1.12
U	0.17	Ga	
Th		F	
W		Cl	
Y		C	
Sr	170	N	
Rb		H	
Li		He	
Ba	65	Ge (ppb)	
Cs	0.11	Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by INAA.

Table 2: Rb-Sr isotopic data for 70138,7.
Data from Paces et al. (1991).

Rb (ppm)	0.647
Sr (ppm)	182
$^{87}Rb/^{86}Sr$	0.001020 ± 10
$^{87}Sr/^{86}Sr$	0.699793 ± 14
$I(Sr)^a$	0.699235 ± 20
$T_{LUNI}{}^b$ (Ga)	5.2

[a]Initial Sr isotopic ratios calculated at 3.75 Ga using ^{87}Rb decay constant = 1.42×10^{-11} yr^{-1}.

[b]Model age relative to I(Sr) = LUNI = 0.69903 (Nyquist et al., 1974; Shih et al., 1986).

$T_{LUNI} = 1/\lambda * \ln[((^{87}Sr/^{86}Sr - 0.69903)/^{87}Rb/^{86}Sr) + 1]$.

Table 3: Sm-Nd isotopic data for 70138,7.
Data from Paces et al. (1991).

Sm (ppm)	11.5
Nd (ppm)	27.8
$^{147}Sm/^{144}Nd$	0.24990 ± 50
$^{143}Nd/^{144}Nd$	0.514277 ± 10
$I(Nd)^a$	0.508072 ± 22
$\varepsilon_{Nd}(t)^b$	6.3 ± 0.4
$T_{CHUR}{}^c$ (Ga)	4.6

[a]Initial Nd isotopic ratios calculated at 3.75 Ga using ^{147}Sm decay constant = 6.54×10^{-12}yr^{-1}.

[b]Initial ε_{Nd} calculated at 3.75 Ga using present-day chondritic values of $^{143}Nd/^{144}Nd = 0.512638$ and $^{147}Sm/^{144}Nd = 0.1967$.

[c]Model age relative to CHUR reservoir using present-day chondritic values listed above.

$T_{CHUR} = 1/\lambda * \ln[((^{143}Nd/^{144}Nd - 0.512638)/(^{147}Sm/^{144}Nd - 0.1967) + 1]$.

70139
High-Ti Mare Basalt
3.16 g, 2 × 1.4 × 0.8 cm

INTRODUCTION

70139 (see Fig. 1 of 70138) was described as a brownish-gray, medium-grained high-Ti mare basalt, containing ~2% vugs (Apollo 17 Lunar Sample Information Catalog, 1973). No zap pits are present. One face is darkened with smeared out and pulverized ilmenite. It was collected from the "Geophone Rock", 50 m south of the ALSEP central station.

PETROGRAPHY AND MINERAL CHEMISTRY

This basalt was described as plagioclase-poikilitic by Neal et al. (1989). Ilmenite (0.1-1 mm) is subhedral-euhedral and blocky in appearance, occurring in both clinopyroxene (0.12-0.86 mm) and plagioclase (0.24-4 mm). Olivine is present either as cores in pyroxenes or as pyroxene-free inclusions in plagioclase. No armalcolite is present. Chromite and rutile exsolution lamellae (both <0.005 mm) occur in ilmenite. Native Fe, troilite, and silica occur as interstitial phases. Modally, 70139 is comprised of: 35.8% pyroxene; 41.6% plagioclase; 15.8% ilmenite; 2.4% native Fe and troilite; 1.9% silica; 2.5% olivine. Chromite and rutile are present in trace amounts.

Olivines are generally unzoned, but range in composition from Fo_{55} to Fo_{69}. Plagioclase exhibits limited zonation (An_{81-88}) although rare examples contain An_{71}. The rims of the plagioclase are always more sodic. Pyroxene compositions range from pigeonite to titan-augite, each exhibiting Fe enrichment trends (Fig. 1). Cr_2O_3 contents decrease with progressive Fe enrichment, and Al/Ti ratios are constant at ~2. The MG# of ilmenite ranges from 10-23.

WHOLE-ROCK CHEMISTRY

70139 (Table 1) is a Type B Apollo 17 high-Ti mare basalt (Neal et al., 1990), using the classification of Rhodes et al. (1976) and Warner et al. (1979). The REE pattern (Fig. 2) is LREE-depleted, typical of the Apollo 17 basalt suite, with a slight convex-upwards profile. The MREE reach ~30 times chondritic values. A negative Eu anomaly is present ($(Eu/Eu^*]_N = 0.70$). Neal et al. (1990) used the whole-rock composition of 70139,4 in a comprehensive study of Apollo 17 high-Ti basalt petrogenesis. These authors defined two groups of Type B basalts - B1 and B2, on the basis of whole-rock chemistry. Each group is generated by fractional crystallization of observed phenocryst phases. 70139,4 is a Type B1 Apollo 17 high-Ti basalt, which was generated after 50% fractional crystallization.

ISOTOPES

Rb-Sr and Sm-Nd isotopic data has been reported by Paces et al. (1991) for 70139,6 whole-rocks (Tables 2 and 3) and mineral separates (Tables 4 and 5). They reported internal isochrons giving a best-estimate age for 70139 of 3.71 ± 0.12 Ga.

PROCESSING

There is approximately 2.60 g of 70139,0 remaining, of the original 3.16 g. About 0.55 g was used for the INA analysis and 0.01 g for thin section 70139,3.

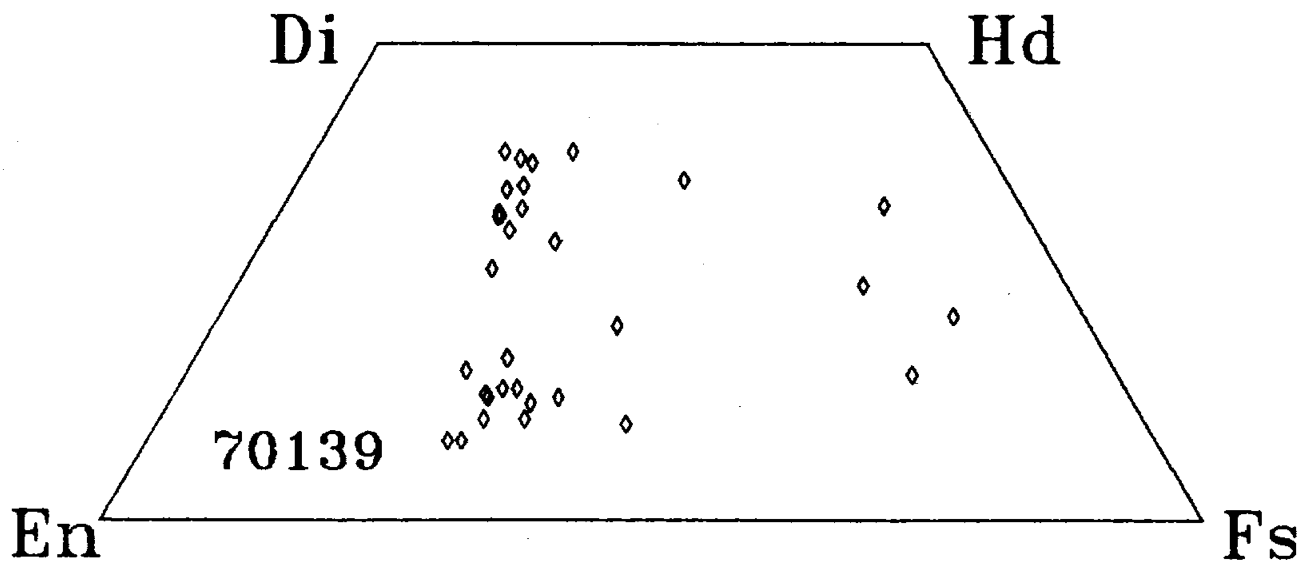


Figure 1: Pyroxene compositions of 70139 represented on a pyroxene quadrilateral.

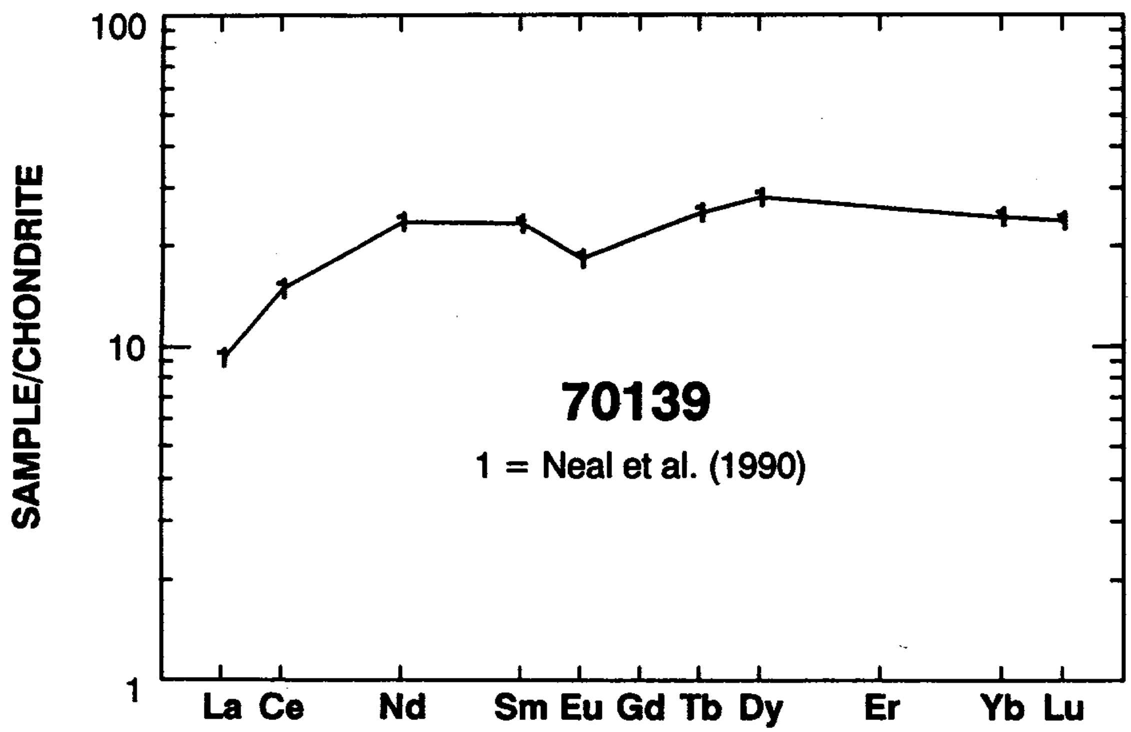


Figure 2: Chondrite-normalized rare-earth element profile of 70139.

Table 1: Whole-rock composition of 70139,4.
Data from Neal et al. (1990).

	70139,4		70139,4
SiO_2 (wt%)		Cu	
TiO_2	13.1	Ni	31
Al_2O_3	8.32	Co	26.2
Cr_2O_3	0.557	V	143
FeO	17.6	Sc	79.9
MnO	0.232	La	3.05
MgO	9.6	Ce	13
CaO	10.0	Nd	15
Na_2O	0.36	Sm	4.78
K_2O	0.04	Eu	1.42
P_2O_5		Gd	
S		Tb	1.47
Nb (ppm)		Dy	9.7
Zr	160	Er	
Hf	5.65	Yb	5.40
Ta	1.16	Lu	0.81
U	0.05	Ga	
Th	0.28	F	
W		Cl	
Y		C	
Sr	180	N	
Rb		H	
Li		He	
Ba	67	Ge (ppb)	
Cs	0.02	Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by INAA.

Table 2: Rb-Sr isotopic data for 70139,6.
Data from Paces et al. (1991) [two analyses].

Rb (ppm)	0.281	0.282
Sr (ppm)	146	146
$^{87}Rb/^{86}Sr$	0.005515±55	0.005542±55
$^{87}Sr/^{86}Sr$	0.699511±14	0.699518±17
I(Sr)[a]	0.699214±17	0.699220±20
T_{LUNI}[b] (Ga)	6.0	6.0

[a]Initial Sr isotopic ratios calculated at 3.69 Ga using ^{87}Rb decay constant = 1.42×10^{-11} yr^{-1}.

[b]Model age relative to I(Sr) = LUNI = 0.69903 (Nyquist et al., 1974; Shih et al., 1986).

$T_{LUNI} = 1/\lambda*\ln[((^{87}Sr/^{86}Sr - 0.69903)/^{87}Rb/^{86}Sr) + 1]$.

Table 3: Sm-Nd isotopic data for 70139,6.
Data from Paces et al. (1991) [two analyses].

Sm (ppm)	5.30	5.38
Nd (ppm)	12.3	12.4
$^{147}Sm/^{144}Nd$	0.26021±52	0.26234±52
$^{143}Nd/^{144}Nd$	0.514547±11	0.514605±15
I(Nd)[a]	0.508191±24	0.507197±28
$\varepsilon_{Nd}(t)$[b]	7.0±0.5	7.2±0.5
T_{CHUR}[c] (Ga)	4.5	4.5

[a]Initial Nd isotopic ratios calculated at 3.69 Ga using ^{147}Sm decay constant = $6.54\times10^{-12}yr^{-1}$.

[b]Initial ε_{Nd} calculated at 3.69 Ga using present-day chondritic values of $^{143}Nd/^{144}Nd$ = 0.512638 and $^{147}Sm/^{144}Nd$ = 0.1967.

[c]Model age relative to CHUR reservoir using present-day chondritic values listed above.

$T_{CHUR} = 1/\lambda*\ln[((^{143}Nd/^{144}Nd - 0.512638)/(^{147}Sm/^{144}Nd - 0.1967) + 1]$.

Table 4: Rb-Sr analyses for whole-rocks and mineral separates from 70139,6.
Data from Paces et al. (1991).

	Rb (ppm)	Sr (ppm)	$^{87}Rb/^{86}Sr^a$	$^{87}Sr/^{86}Sr^b$
WR1	0.281	146	0.005515±55	0.699511±14
WR2	0.282	146	0.005543±55	0.699518±17
F Plg	0.0886	514	0.004956±20	0.699244±27
Ilm	0.313	23.1	0.03903±39	0.701312±31
Px	0.143	30.2	0.01364±14	0.699922±32
Mag[c]	0.478	87.9	0.01564±16	0.700013±28
NMag[c]	0.0882	270	0.000939±18	0.699297±25

[a]Uncertainties reported for parent/daughter ratios reflect the magnitude of the blank correction, mass spectrometer precision, and corrections for the quality of spiking.

[b]Normalized to $^{86}Sr/^{88}Sr = 0.1194$. Quoted errors include 2-sigma run precision for whole-rock analyses plus an additional uncertainty of 0.00001 (2-sigma) reflecting corrections for fractionation and spike contributions in total-spiked mineral separates.

[c]Non-pure mineral separates consisting of predominantly "nonmagnetic" plagioclase and pyroxene in NMag and "magnetic" pyroxene and ilmenite in Mag.

Table 5: Sm-Nd analyses for whole-rocks and mineral separates from 70139,6.
Data from Paces et al. (1991).

	Sm (ppm)	Nd (ppm)	$^{147}Sm/^{144}Nd^a$	$^{143}Nd/^{144}Nd^b$
WR1	5.30	12.3	0.26021±52	0.514547±11
WR2	5.38	12.4	0.26234±52	0.514605±15
F Plg				
Ilm	3.49	8.54	0.24726±49	0.514230±23
Px	4.85	9.72	0.3020±15	0.515571±29
Mag[c]	9.17	21.5	0.2574±26	0.514457±25
NMag[c]	1.82	3.89	0.28250±56	0.515098±26

[a]Uncertainties reported for parent/daughter ratios reflect the magnitude of the blank correction, mass spectrometer precision, and corrections for the quality of spiking.

[b]Normalized to $^{146}Nd/^{144}Nd = 0.7219$. Quoted errors include 2-sigma run precision for whole-rock analyses plus an additional uncertainty of 0.00001 (2-sigma) reflecting corrections for fractionation and spike contributions in total-spiked mineral separates. Nd was measured as the metal ion.

[c]Non-pure mineral separates consisting of predominantly "nonmagnetic" plagioclase and pyroxene in NMag and "magnetic" pyroxene and ilmenite in Mag.

70145
High-Ti Mare Basalt
3.07 g, 2 × 1 × 1 cm

INTRODUCTION

70145 (Fig. 1) was described as a medium gray, equigranular, high-Ti mare basalt, containing ~5% marialitic cavities lined with plagioclase, pyroxene, and ilmenite (Apollo 17 Lunar Sample Information Catalog, 1973). No zap pits are present. This sample was collected from the "Geophone Rock", 50 m south of the ALSEP central station.

PETROGRAPHY AND MINERAL CHEMISTRY

Neal et al. (1989) described 70145 as a plagioclase-poikilitic high-Ti basalt. Anhedral, blocky ilmenites (0.1-1.1 mm) form an intersertal texture with pyroxene (0.1-0.9 mm) and plagioclase (0.2-4.2 mm). Ilmenite contains chromite and rutile exsolution lamellae (<0.005 mm). Rare discrete chromite-ulvöspinels are present (~0.2 mm). Olivine may be found in cores of pyroxenes or as discrete grains (~0.1 mm) in plagioclase. Armalcolite is found without ilmenite rims and enclosed in plagioclase. Native Fe and troilite form interstitial phases. Modal analysis resulted in: 42.7% pyroxene; 32.5% plagioclase; 20.6% ilmenite; 2.5% armalcolite; 2% olivine; 1.3% native Fe and troilite; and 1% chromite-ulvöspinel. Rutile is present only in trace amounts.

Individual olivine grains are typically unzoned, but compositions vary between grains (Fo_{60-73}). Plagioclase exhibits little zonation (An_{85-92}), but the rims are usually more sodic. Pyroxenes vary in composition from pigeonite to titan-augite, with no evidence of Fe enrichment (Fig. 2). Cr_2O_3 contents decrease with decreasing pyroxene MG#, and Al/Ti ratios have a constant value of ~2. Spinel grains are zoned (core-to-rim) from chromite to more ulvöspinel-rich compositions. Cr/(Cr + Al) ratios vary from 68-83 and MG# from 13 to 26. Ilmenite exhibits a greater variation in MG# (10-26) than does armalcolite (42-48).

WHOLE-ROCK CHEMISTRY

Neal et al. (1990) described basalt 70145 as a Type A variant (Table 1) using the classification of Rhodes et al. (1976) and Warner et al. (1979). The REE profile is LREE-depleted and convex-upwards (Fig. 3). The MREE values reach ~50 times chondritic values. A negative Eu anomaly is present ($[Eu/Eu^*]_N = 0.56$). Neal et al. (1990) have used the whole-rock composition of 70145,4 to refine previous petrogenetic models and formulate a new one for the Type A Apollo 17 high-Ti basalts.

PROCESSING

Of the original 3.07 g, approximately 2.49 g of 70145,0 remains; 0.573 g was irradiated for INA analysis, and a thin section, 70145,3, required 0.01 g.

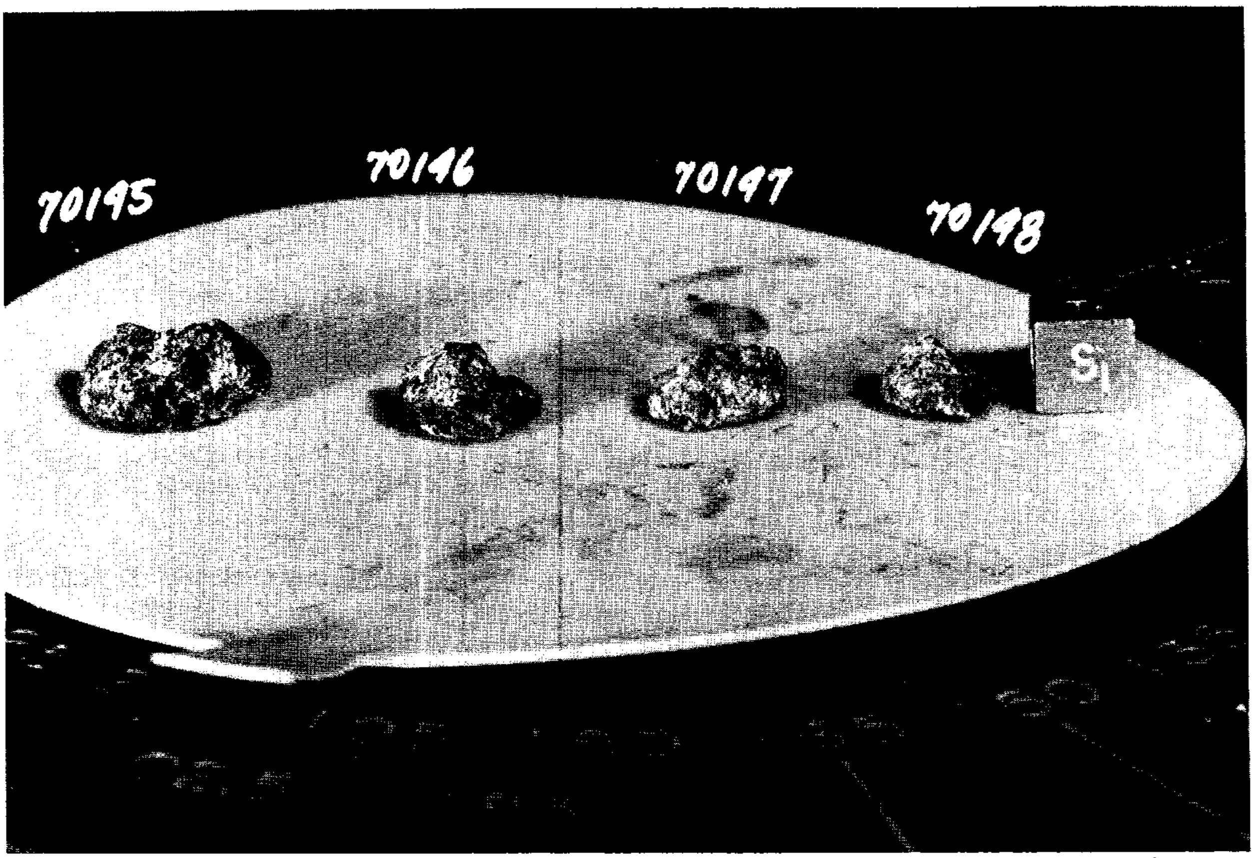


Figure 1: Hand specimen photograph of 70145, 70146, 70147, and 70148.

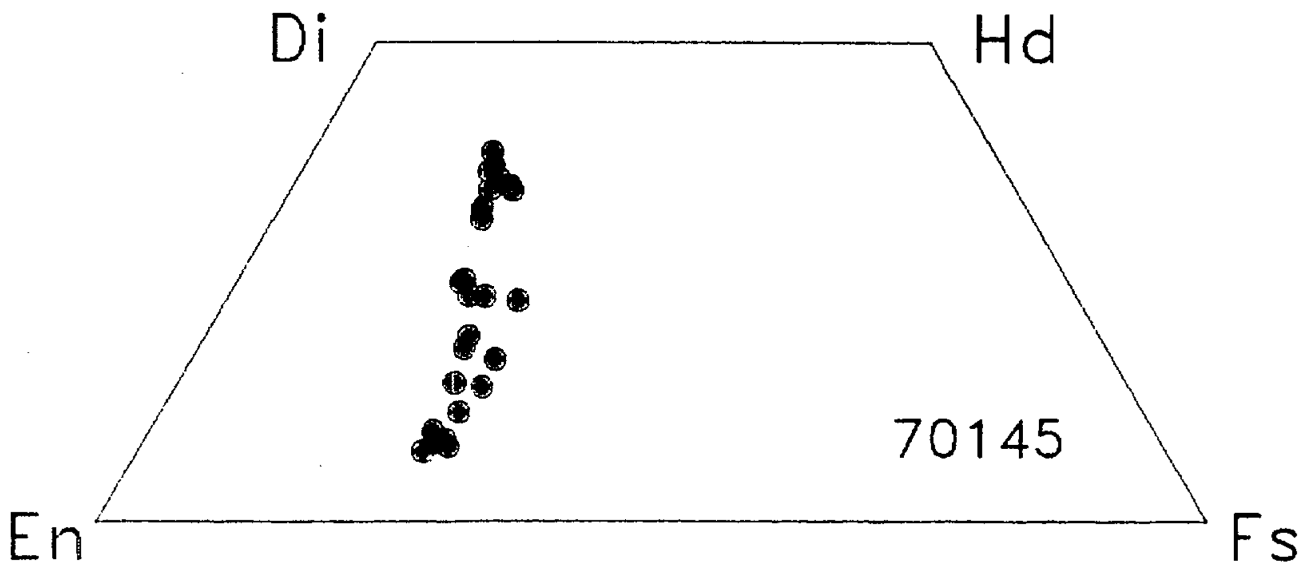


Figure 2: Pyroxene compositions of 70145 represented on a pyroxene quadrilateral.

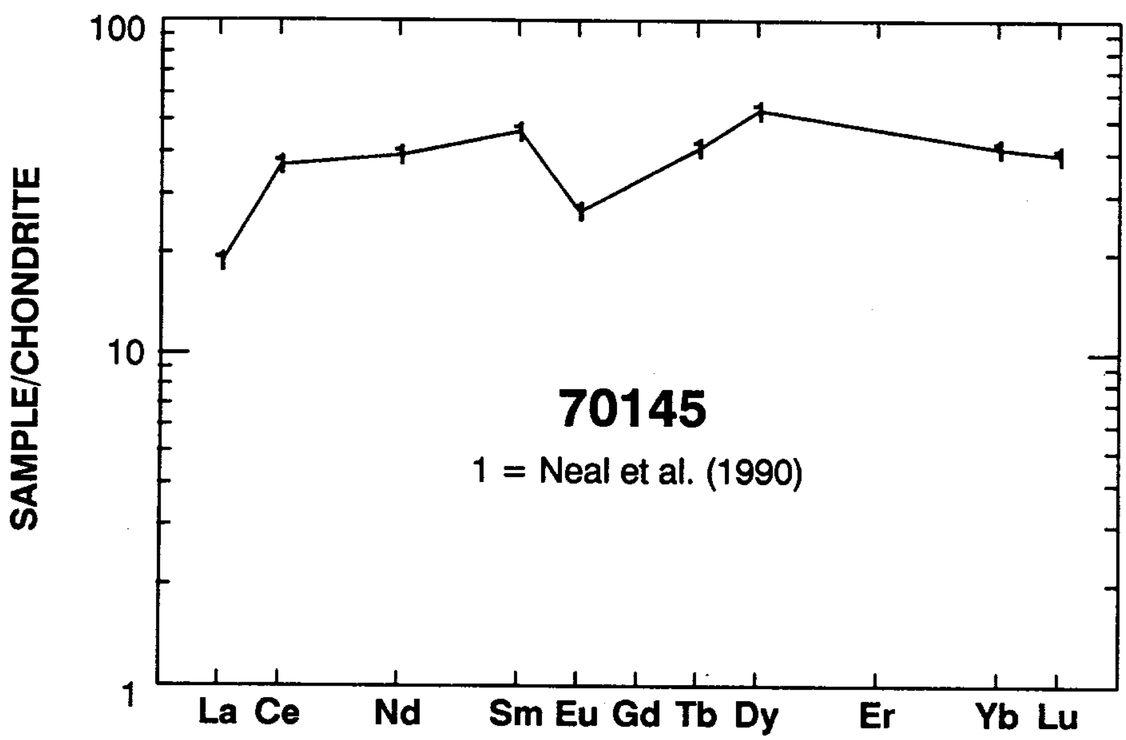


Figure 3: Chondrite-normalized rare-earth element profile of 70145.

Table 1: Whole-rock composition of 70145,4.
Data from Neal et al. (1990).

	70145,4		70145,4
SiO_2 (wt%)		Cu	
TiO_2	13.5	Ni	19
Al_2O_3	7.76	Co	18.4
Cr_2O_3	0.503	V	130
FeO	19.0	Sc	82
MnO	0.256	La	6.24
MgO	8.5	Ce	32
CaO	9.2	Nd	25
Na_2O	0.36	Sm	9.46
K_2O	0.08	Eu	2.08
P_2O_5		Gd	
S		Tb	2.42
Nb (ppm)		Dy	18.5
Zr	180	Er	
Hf	8.72	Yb	9.17
Ta	1.69	Lu	1.35
U	0.48	Ga	
Th	0.25	F	
W		Cl	
Y		C	
Sr	240	N	
Rb		H	
Li		He	
Ba	103	Ge (ppb)	
Cs	0.11	Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by INAA.

70146
High-Ti Mare Basalt
1.71 g, 1.3 x 1.3 x 0.8 cm

INTRODUCTION

70146 was described as a medium gray, subangular, high-Ti mare basalt, containing ~5% marialitic cavities lined with plagioclase, pyroxene, or ilmenite. N, T, and S are fracture surfaces. No zap pits are present. The glazed surface of the pyroxene is dark and finely hackly. It is possible that there is a thin skin of dark glass coating part of the surface (Apollo 17 Lunar Sample Information Catalog, 1973) (Fig. 1). This sample was taken from the "Geophone Rock", 50 m south of the ALSEP central station.

PETROGRAPHY AND MINERAL CHEMISTRY

Neal et al. (1989) described 70146 as a plagioclase-poikilitic or Type 1B Apollo 17 high-Ti basalt. Anhedral and blocky ilmenite (0.1-0.8 mm) forms an intersertal texture with plagioclase (0.2-3.7 mm) and pyroxene (0.1-1.5 mm). Chromite and rutile exsolution lamellae (< 0.005 mm wide) are present in the ilmenite. Olivine forms cores to the large pyroxenes. Armalcolite is found without ilmenite rims as inclusions in pyroxene and plagioclase. Native Fe and troilite form interstitial phases. Point counting indicated this sample is comprised of: 41.5% pyroxene; 33.3% plagioclase; 19.6% ilmenite; 3% native Fe and troilite; 2.1% olivine; and 0.5% armalcolite.

Olivine exhibits little zonation either within or between grains (Fo_{66-68}). Plagioclase exhibits a somewhat larger range in composition (An_{72-88}), with the margins of grains being more sodic. Pyroxenes range in composition from pigeonite to titan-augite, with a continuum of compositions between the two (Fig. 2). All pyroxenes exhibit Fe enrichment towards the margins. Al/Ti ratios are constant at ~2, and Cr_2O_3 decreases as the MG# of the pyroxene decreases. Ilmenite exhibits a larger range in MG# (3-19) than does armalcolite (43-45).

WHOLE-ROCK CHEMISTRY

Neal et al. (1990) reported the composition of 70146 (Table 1) as a Type A variant of Apollo 17 high-Ti basalts, using the classification of Rhodes et al. (1976) and Warner et al. (1979). The REE pattern (Fig. 3) is LREE-depleted, with a general convex-upward appearance, with the MREE contents reaching ~55 times chondritic values. A negative Eu anomaly is present ($[Eu/Eu^*]_N = 0.42$). Neal et al. (1990) have used the whole-rock composition of 70146,0 to refine previous petrogenetic models and formulate a new one for the Type A Apollo 17 high-Ti basalts.

PROCESSING

Approximately 1.29 g of 70146,0 remains; 0.41 g was irradiated for INAA, and 0.01 g was used to make thin section 70146,4.

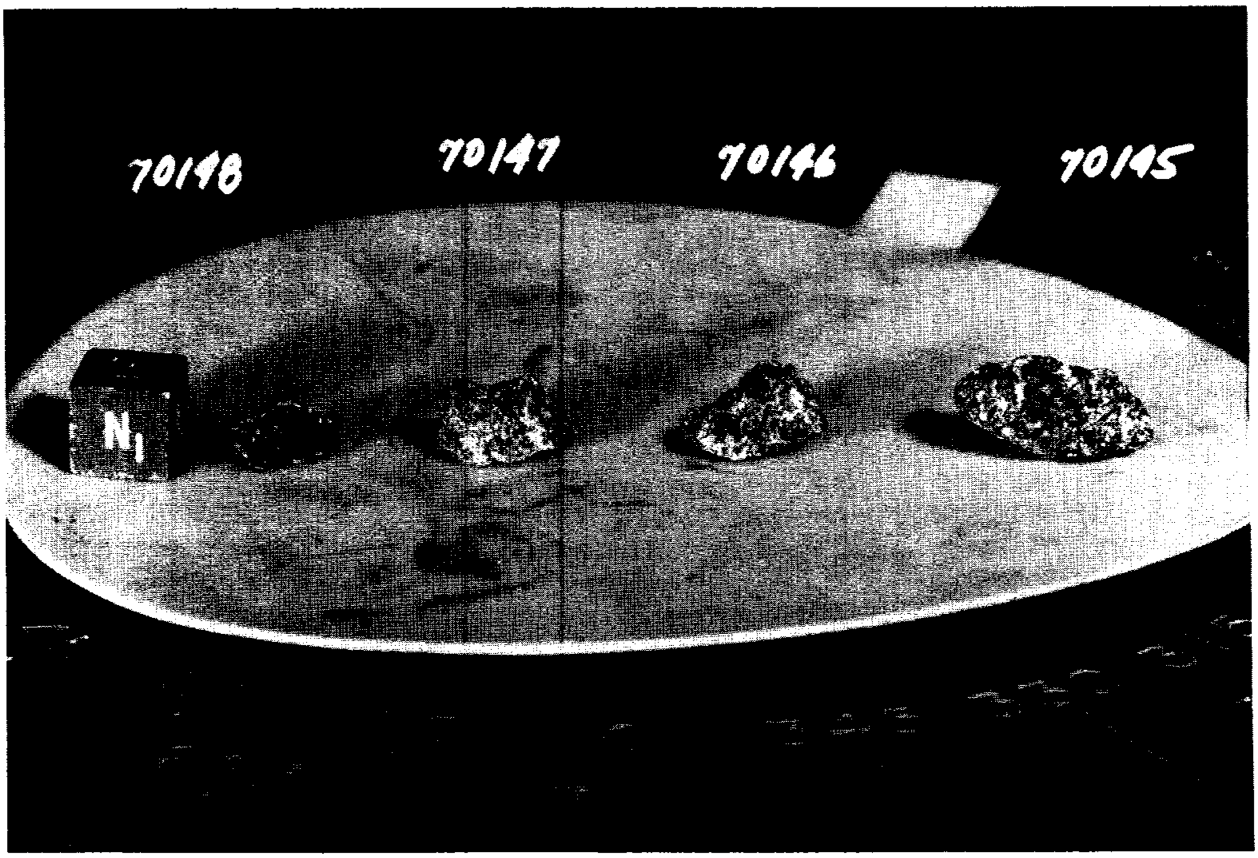


Figure 1: Hand specimen photograph of 70145, 70146, 70147, and 70148.

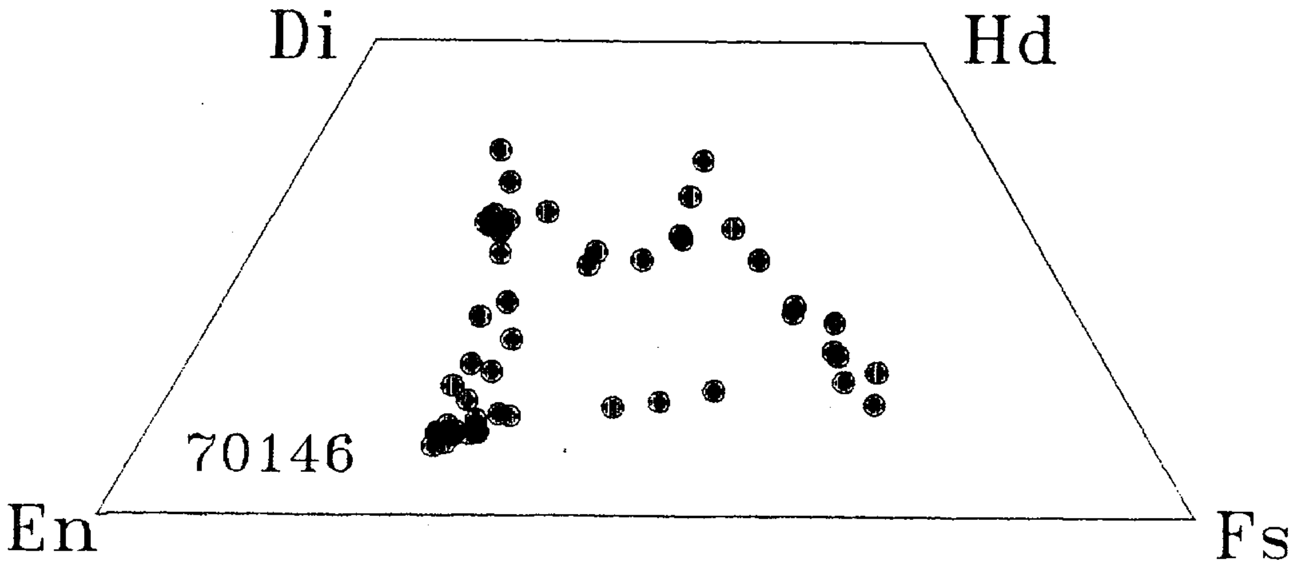


Figure 2: Pyroxene compositions of 70146 represented on a pyroxene quadrilateral.

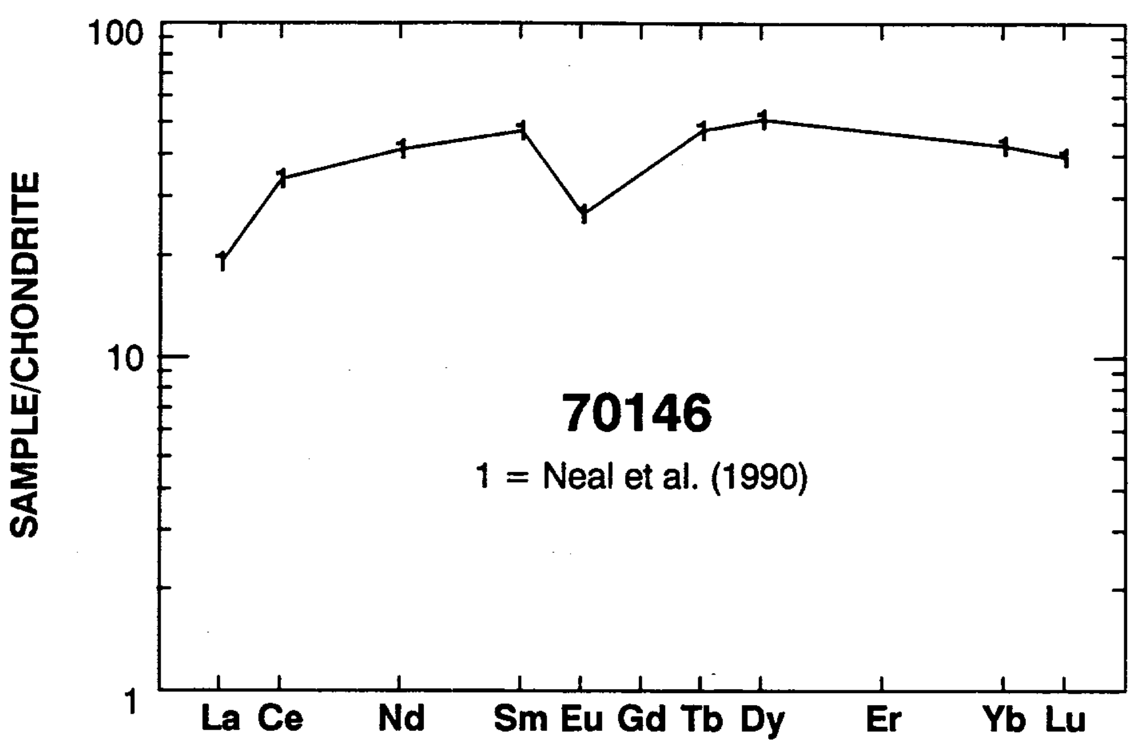


Figure 3: Chondrite-normalized rare-earth element profile of 70146.

Table 1: Whole-rock composition of 70146,0.
Data from Neal et al. (1990).

	70146,0		70146,0
SiO_2 (wt%)		Cu	
TiO_2	13.1	Ni	5
Al_2O_3	7.61	Co	21.6
Cr_2O_3	0.504	V	126
FeO	19.6	Sc	85
MnO	0.255	La	6.25
MgO	8.8	Ce	29
CaO	9.7	Nd	26
Na_2O	0.36	Sm	9.53
K_2O	0.05	Eu	2.04
P_2O_5		Gd	
S		Tb	2.73
Nb (ppm)		Dy	17.4
Zr	250	Er	
Hf	8.83	Yb	9.35
Ta	1.76	Lu	1.33
U	0.10	Ga	
Th	0.10	F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba	104	Ge (ppb)	
Cs	0.07	Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by INAA.

70147
Clast-Rich Impact Melt
379.2 g, 18 × 14 × 10 cm

INTRODUCTION

70147 (see Fig. 1 of 70146) was described as medium gray, subangular, high-Ti mare basalt which contains no cavities. All surfaces apart from E are fractures. No zap pits are present. This sample was collected from the "Geophone Rock", 50 m from the ALSEP central station.

PETROGRAPHY AND MINERAL CHEMISTRY

Neal et al. (1989) described 70147 as a plagioclase-poikilitic basalt, containing no olivine. Anhedral and blocky ilmenite (0.1-0.8 mm) forms an intersertal texture with plagioclase (0.3-2.7 mm) and pyroxene (0.1-2.8 mm). Ilmenite contains chromite and rutile exsolution lamellae (<0.005 mm). Rare discrete chromite-ulvöspinel grains (~0.1 mm) are present, usually included in pyroxene. Armalcolite (~0.1 mm) without ilmenite rims is present as inclusions in pyroxene. Native Fe, minor silica, and troilite form interstitial phases. Point counting revealed that this sample is comprised of: 48.2% pyroxene; 29.4% plagioclase; 16.7% ilmenite; 4.5% native Fe and troilite; 0.5% armalcolite; 0.5% chromite-ulvöspinel; and 0.2% silica.

Plagioclase exhibits moderate core-to-rim variation (An_{76-90}), with the rims being more sodic. Pyroxene compositions range from pigeonite to titan-augite, with both variants zoning to a common, more Fe-rich composition (Fig. 1). Al/Ti ratios are constant at ~2, and Cr_2O_3 decreases with decreasing pyroxene MG#. The chromite-ulvöspinel grains exhibit little core-to-rim variation [(Cr/(Cr + Al) = 64-69; MG# = 20-24). However, armalcolite exhibits wide variations between grains (MG# = 39-48), greater than that in ilmenite (MG# = 6-13).

WHOLE-ROCK CHEMISTRY

Neal et al. (1990) described 70147,0 as a Type A high-Ti basalt, using the classification of Rhodes et al. (1976) and Warner et al. (1979) (Table 1). This sample possesses a convex-upward REE profile, with the MREE contents reaching ~40 times chondritic values (Fig. 2). A negative Eu anomaly is present ($[Eu/Eu^*]_N = 0.59$). Neal et al. (1990) have used the whole-rock composition of 70147,0 to refine previous petrogenetic models and formulate a new one for the Type A Apollo 17 high-Ti basalts.

PROCESSING

Approximately 0.7 g of 70147,0 remains; 0.64 g was irradiated for INAA, and 0.01 g was used for thin section 70147,4.

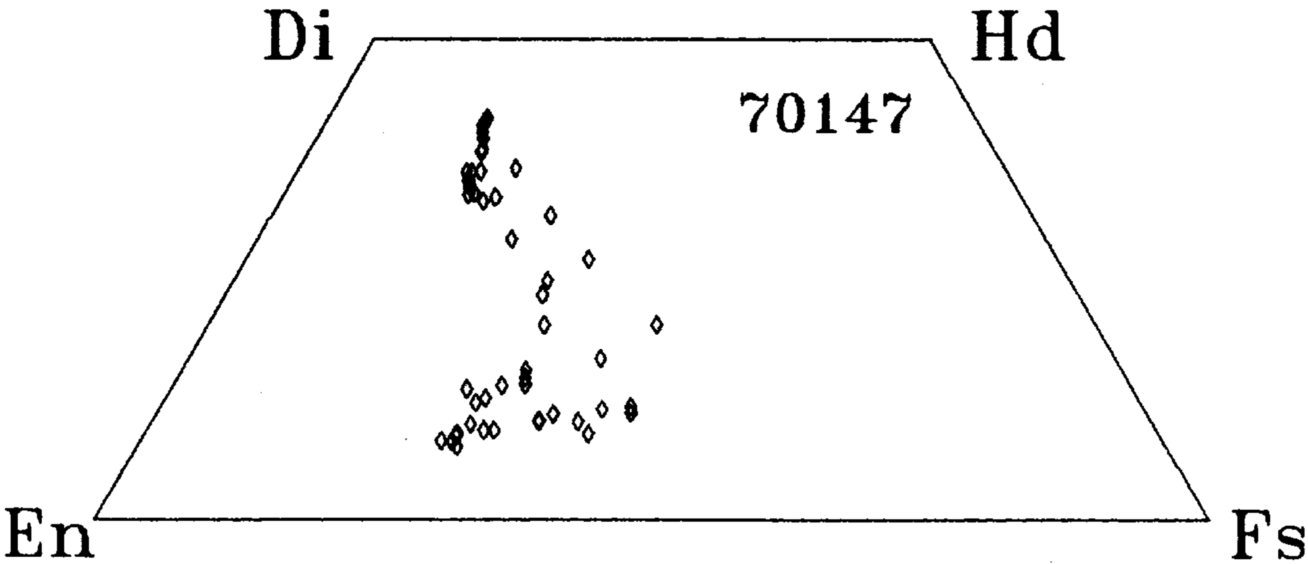


Figure 1: Pyroxene compositions of 70147 represented on a pyroxene quadrilateral.

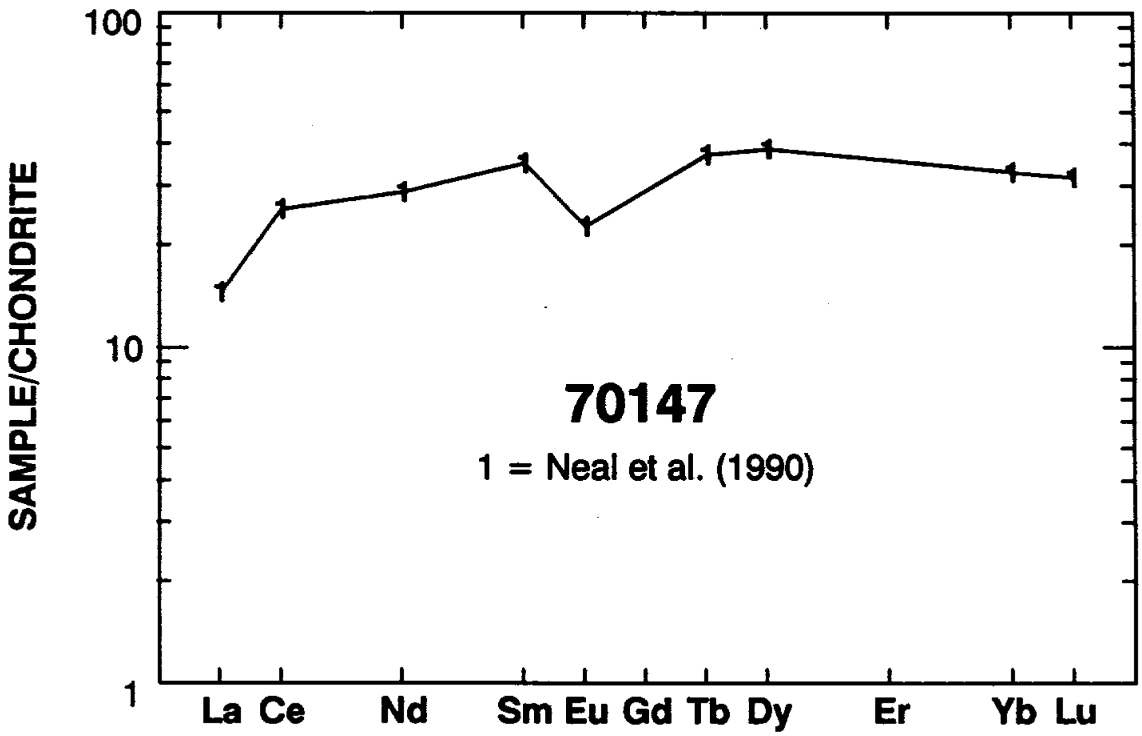


Figure 2: Chondrite-normalized rare-earth element profile of 70147.

Table 1: Whole-rock composition of 70147,0.
Data from Neal et al. (1990).

	70147,0		70147,0
SiO_2 (wt%)		Cu	
TiO_2	13.0	Ni	6
Al_2O_3	8.38	Co	22.8
Cr_2O_3	0.516	V	131
FeO	17.9	Sc	77
MnO	0.231	La	4.75
MgO	8.8	Ce	22
CaO	9.2	Nd	18
Na_2O	0.39	Sm	7.09
K_2O	0.06	Eu	1.74
P_2O_5		Gd	
S		Tb	2.14
Nb (ppm)		Dy	13.2
Zr	210	Er	
Hf	6.87	Yb	7.19
Ta	1.43	Lu	1.07
U	0.06	Ga	
Th	0.15	F	
W		Cl	
Y		C	
Sr	140	N	
Rb		H	
Li		He	
Ba	76	Ge (ppb)	
Cs	0.04	Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by INAA.

70148
High-Ti Mare Basalt
0.92 g, 1 × 1 × 0.7 cm

INTRODUCTION

70148 (see Fig. 1 of 70146) is a medium gray, subangular, high-Ti mare basalt with no cavities or zap pits (Apollo 17 Lunar Sample Information Catalog, 1973). This sample was collected from the "Geophone Rock", 50 m south of the ALSEP central station.

PETROGRAPHY AND MINERAL CHEMISTRY

70148 was described as a plagioclase-poikilitic basalt by Neal et al. (1989). This basalt contains interstitial, anhedral, and blocky ilmenite (0.1-1.4 mm) set in plagioclase (0.5-2.4 mm) and pyroxene (0.1-1.8 mm). Rutile and chromite exsolution lamellae (<0.005 mm) are present in ilmenite. Olivine is found as inclusions in plagioclase. Rare, discrete chromite-ulvöspinel grains (~0.1 mm) are present in pyroxene and ilmenite-free armalcolite (~0.1 mm) within plagioclase or pyroxene. Anhedral troilite, native Fe, and silica are interstitial phases. Point counting indicated 70148 is comprised of: 40.9% pyroxene; 30.5% plagioclase; 17.9% ilmenite; 4.3% silica; 4% native Fe and troilite; 1% olivine; 1% armalcolite; and 0.5% chromite-ulvöspinel.

Olivine exhibits little chemical variation either within or between grains (Fo_{63-66}). Plagioclase exhibits moderate core-to-rim variation for Apollo 17 high-Ti basalts (An_{76-89}). Pyroxene compositions range from pigeonite to titan-augite, although there are no intermediate compositions between these "end members" (Fig. 1). Both compositions trend towards extreme Fe enrichment, exhibiting a decrease in both Mg and Ca (Fig. 1). Al/Ti ratios are constant at ~2, and Cr_2O_3 decreases with decreasing MG#. The spinel minerals exhibit little core-to-rim or inter-grain variations (Cr/(Cr + Al) = 69-70; MG# = 24-25). Armalcolite is essentially unzoned (MG# = 44-46), and ilmenite exhibits moderate inter-grain variation (MG# = 4-11).

WHOLE-ROCK CHEMISTRY

The whole-rock chemistry of 70148,0 was defined by Neal et al. (1990) (Table 1) and was described as a Type B (classification of Rhodes et al., 1976; Warner et al., 1979) high-Ti Apollo 17 basalt. The REE pattern (Fig. 2) is slightly convex-upward and displaying the characteristic LREE depletion of Apollo 17 high-Ti basalts. The MREE contents attain ~30 times chondritic levels, and a negative Eu anomaly is present ($[Eu/Eu^*]_N = 0.70$). Neal et al. (1990) used the whole-rock composition of 70148,0 in a comprehensive study of Apollo 17 high-Ti basalt petrogenesis. These authors defined two groups of Type B basalts - B1 and B2, on the basis of whole-rock chemistry. Each group is generated by fractional crystallization of observed phenocryst phases. 70148,0 is a Type B1 Apollo 17 high-Ti basalt.

PROCESSING

Approximately 0.35 g of 70148,0 remains; 0.56 g was irradiated for INAA, and 0.01 g was used for thin section 70148,3.

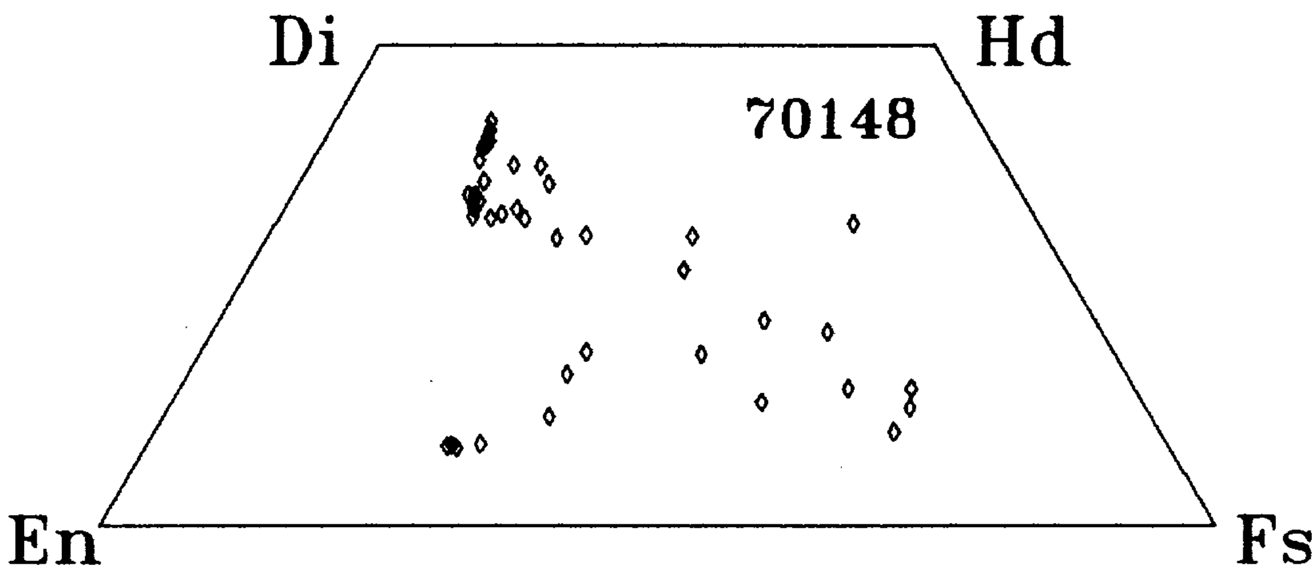


Figure 1: Pyroxene compositions of 70148 represented on a pyroxene quadrilateral.

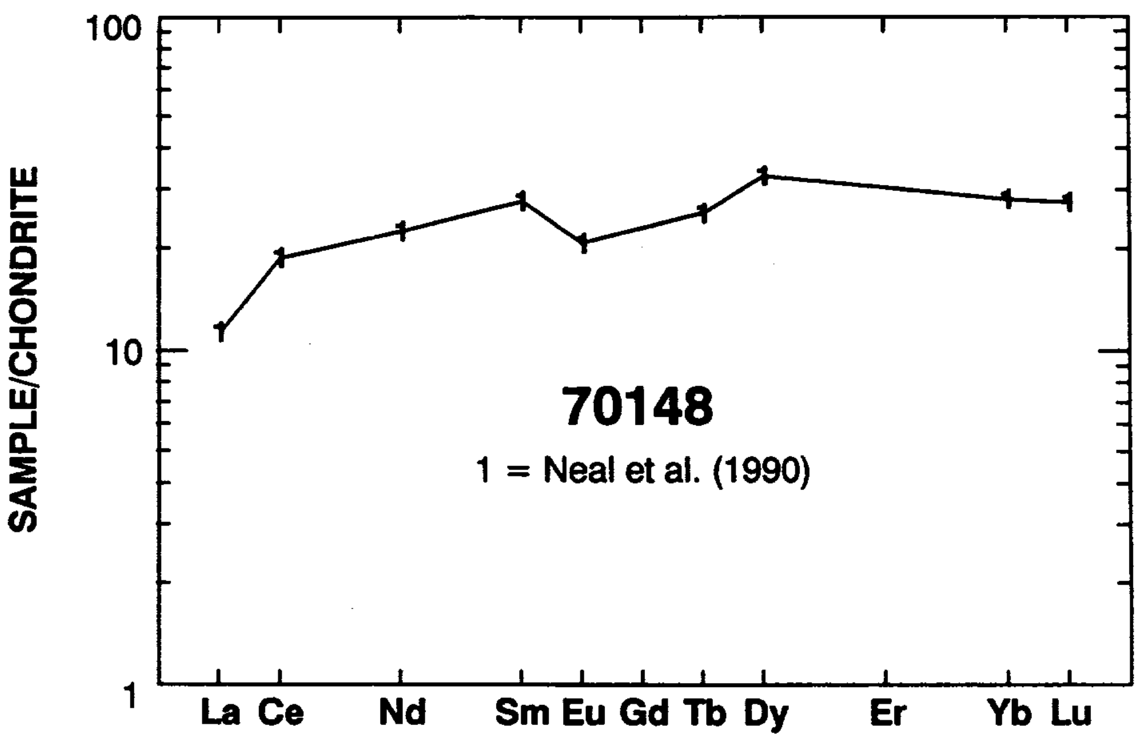


Figure 2: Chondrite-normalized rare-earth element profile of 70148.

Table 1: Whole-rock composition of 70148,0.
Data from Neal et al. (1990).

	70148,0		70148,0
SiO_2 (wt%)		Cu	
TiO_2	12.5	Ni	9
Al_2O_3	8.12	Co	21.6
Cr_2O_3	0.544	V	132
FeO	18.2	Sc	79
MnO	0.237	La	3.68
MgO	8.8	Ce	16
CaO	9.7	Nd	14
Na_2O	0.36	Sm	5.55
K_2O	0.05	Eu	1.58
P_2O_5		Gd	
S		Tb	1.46
Nb (ppm)		Dy	11.2
Zr	110	Er	
Hf	6.17	Yb	6.09
Ta	1.37	Lu	0.92
U	0.25	Ga	
Th	0.13	F	
W		Cl	
Y		C	
Sr	170	N	
Rb		H	
Li		He	
Ba	67	Ge (ppb)	
Cs	0.11	Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by INAA.

70149
High-Ti Mare Basalt
0.95 g, 0.6 × 0.6 × 0.4 cm

INTRODUCTION

70149 was described as a brownish gray, inequigranular, high-Ti mare basalt (Fig. 1), containing vugs of 0.1 mm (Apollo 17 Lunar Sample Information Catalog, 1973). This sample was collected from the "Geophone Rock", 50 m south of the ALSEP central station.

PETROGRAPHY AND MINERAL CHEMISTRY

Thin section 70149,1 was descibed by Wilshire (Apollo 17 Lunar Sample Information Catalog, 1973), and thin sections 70149,2 and 70149,3 were studied in the preparation of this catalog. Wilshire described 70149 as a coarse-grained poikilitic basalt with large plagioclase plates enclosing pyroxene and opaque minerals. Prismatic clinopyroxenes have normal zoning; other forms show complex zoning. Olivine occurs in clusters of tiny anhedral grains in clinopyroxene.

70149,3 exhibits minor brecciation, but still maintains a poikilitic texture. Ilmenites (up to 0.5 mm) are interstitial, either blocky or lath-like, set in plagioclase (up to 1.5 mm) and pyroxene (up to 1 mm). These ilmenites contain chromite and rutile exsolution lamellae (<0.005 mm). Olivine forms ~0.1 mm cores to pyroxene. Minor mesostasis glass is present. Cristobalite, native Fe, and troilite form interstitial phases. Point counting of 70149,1 by Wilshire and Brett (Apollo 17 Lunar Sample Information Catalog, 1973) demonstrated that 70149 is comprised of: 49% pyroxene; 27% plagioclase; 23% opaque minerals (almost all ilmenite, no armalcolite or discrete spinel); 1% cristobalite; and trace amounts of olivine and mesostasis.

No mineral chemistry has been determined for this sample.

WHOLE-ROCK CHEMISTRY

No whole-rock chemsitry has been determined for this sample.

EXPERIMENTAL

In a study of fO_2 controlled cooling rates and textures of lunar basalts, Usselman et al. (1975) reported the cooling rate of 70149 to have been <1 °C per hour. This estimate was based upon comparison of natural textures with those experimentally produced.

PROCESSING

Approximately 0.92 g of 70149,0 remains. Three thin sections (,1, ,2, and ,3) are available.

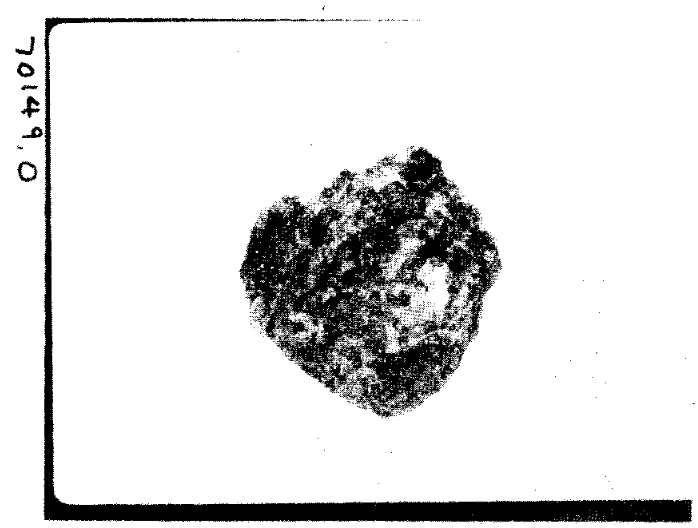


Figure 1: Hand specimen photograph of 70149,0.

70155
High-Ti Mare Basalt
0.77 g, 1 x 0.8 x 0.8 cm

INTRODUCTION

70155 was described as a medium gray, subangular basalt, containing no zap pits and 1% marialitic (0.5 mm diam.) cavities (Fig. 1) with pyroxene, plagioclase, and ilmenite infillings (Apollo 17 Lunar Sample Information Catalog, 1973). This basalt was collected from the "Geophone Rock", 50 m south of the ALSEP central station.

PETROGRAPHY AND MINERAL CHEMISTRY

70155 was described as a plagioclase-poikilitic basalt, with interstitial, blocky, and anhedral ilmenites (0.1-0.8 mm) set in pyroxene (0.2-1 mm) and plagioclase (0.3-4.2 mm) (Neal et al., 1989). Plagioclase also contains pyroxene, olivine (~ 0.1 mm), and armalcolite (~ 0.1 mm) inclusions. Ilmenite exhibits both rutile and spinel exsolution lamellae (<0.05 mm) and rare, discrete spinels (~ 0.1 mm) occur, usually in pyroxene. Interstitial phases present are silica, native Fe, and troilite. Point counting reveals that this sample is composed of: 47% pyroxene; 29.6% plagioclase; 16.3% ilmenite; 2.8% native Fe and troilite; 1.9% olivine; 1.5% armalcolite; 0.6% spinel; and 0.3% silica.

70155 contains olivines which are usually unzoned, but exhibit moderate inter-grain variations (Fo_{58-67}). Plagioclases are moderately zoned, and also exhibit inter-grain variations (An_{72-90}). Pyroxene compositions range from titan-augite to pigeonite (Fig. 2), with pigeonite crystallizing only after significant olivine resorption. Both types of pyroxene exhibit Fe enrichment, although there are no compositional intermediates between the two (Fig. 2). Al/Ti ratios are constant at ~ 2, and Cr_2O_3 decreases with decreasing MG#. The spinel minerals are essentially unzoned (Cr/(Cr + Al) = 77-78;

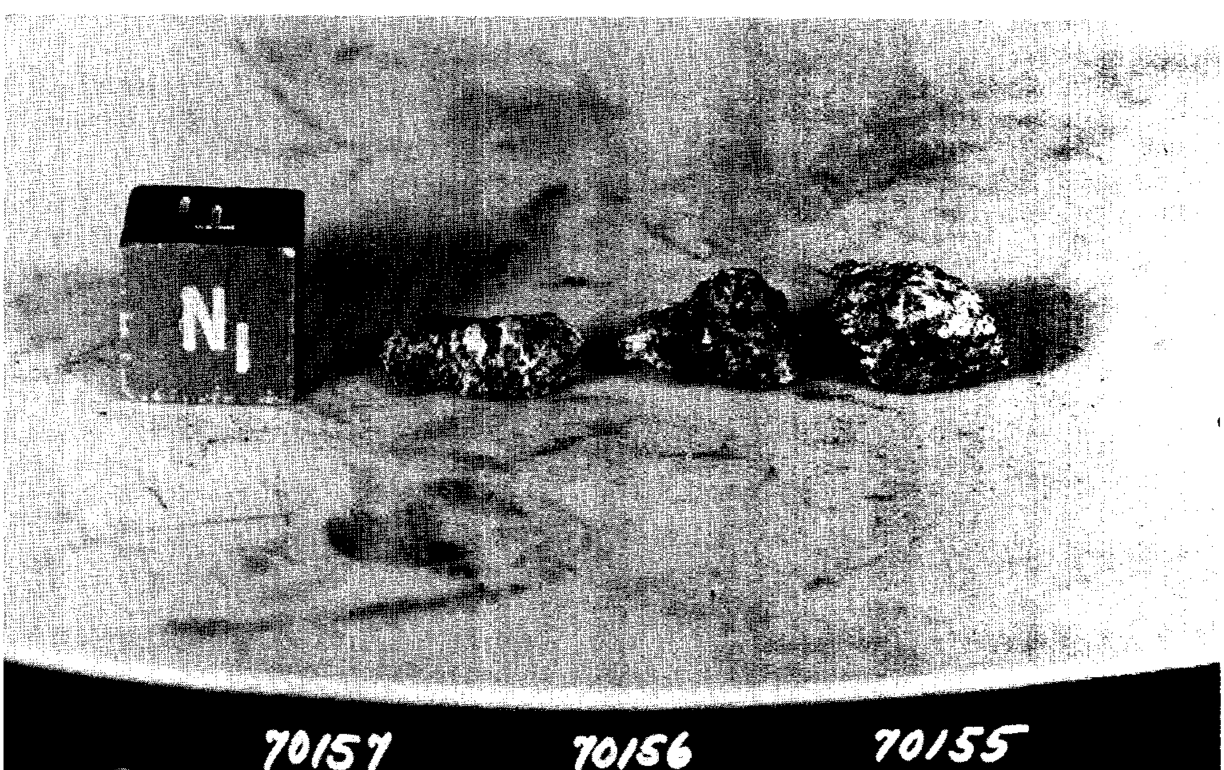


Figure 1: Hand specimen photograph of 70155, 70156, and 70157.

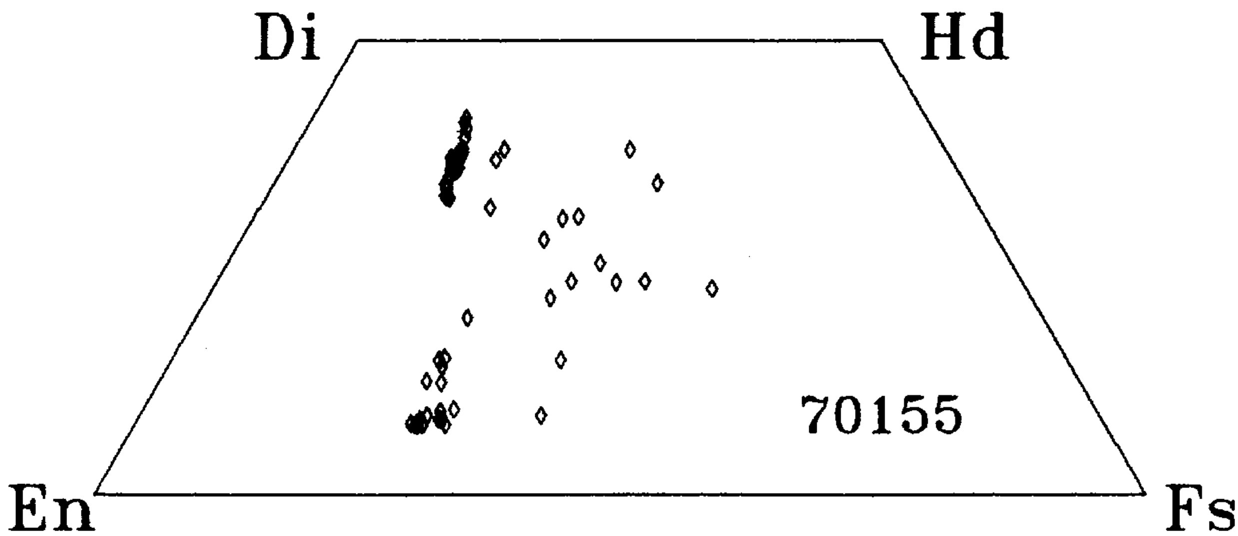


Figure 2: Pyroxene compositions of 70155 represented on a pyroxene quadrilateral.

MG# = 11-12). Armalcolite exhibits slight core-to-rim and inter-grain variations (MG# = 43-46), whereas ilmenite grains are essentially homogeneous, but inter-grain variations occur (MG# = 7-14).

WHOLE-ROCK CHEMISTRY

The whole-rock chemistry of 70155,0 was determined by Neal et al. (1990) (Table 1). 70155,0 falls into the Type B of Rhodes et al. (1976) and Warner et al. (1979). This basalt is LREE-depleted, with a steady decrease in chondrite-normalized values from the HREE (Fig. 3). The HREE reach 25 times chondritic values. A small negative Eu anomaly is present ($[Eu/Eu^*]_N = 0.92$). Neal et al. (1990) used the whole-rock composition of 70155,0 in a comprehensive study of Apollo 17 high-Ti basalt petrogenesis. These authors defined two groups of Type B basalts - B1 and B2, on the basis of whole-rock chemistry. Each group is generated by fractional crystallization of observed phenocryst phases. 70155,0 is a Type B1 Apollo 17 high-Ti basalt.

PROCESSING

Approximately 0.34g of 70155,0 remains out of the original 0.77g. 0.42g was irradiated for INAA, and 0.01g was used for thin section 70155,3.

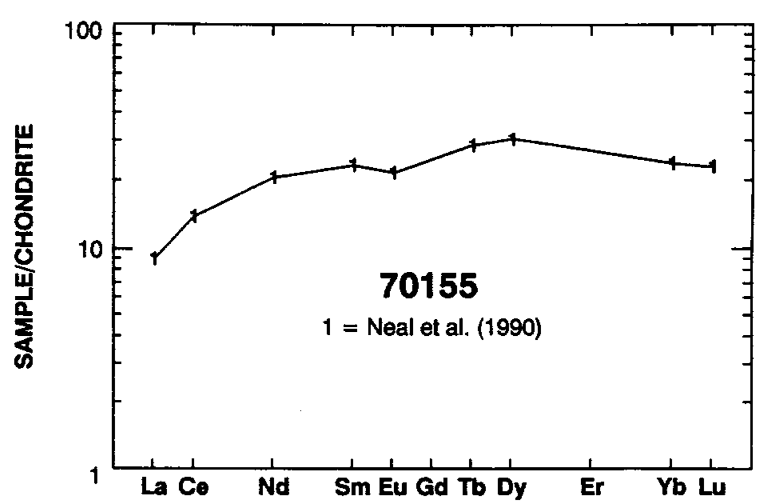


Figure 3: Chondrite-normalized rare-earth element profile of 70155.

Table 1: Whole-rock composition of 70155,0.
Data from Neal et al. (1990).

	70155,0		70155,0
SiO_2 (wt %)	---	Cu	
TiO_2	12.4	Ni	--
Al_2O_3	10.16	Co	21.3
Cr_2O_3	0.494	V	130
FeO	17.2	Sc	72
MnO	0.232	La	2.95
MgO	8.7	Ce	12
CaO	9.6	Nd	13
Na_2O	0.44	Sm	4.76
K_2O	0.03	Eu	1.67
P_2O_5		Gd	
S		Tb	1.66
Nb (ppm)		Dy	10.5
Zr	130	Er	
Hf	5.44	Yb	5.27
Ta	1.23	Lu	0.78
U	0.20	Ga	
Th	0.12	F	
W		Cl	
Y		C	
Sr	210	N	
Rb	--	H	
Li		He	
Ba	35	Ge (ppb)	
Cs	0.11	Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by INAA.

70156
High-Ti Mare Basalt
0.63 g, 1 x 0.7 x 0.5 cm

INTRODUCTION

70156 was described as a medium gray, subangular, and homogeneous basalt (Fig. 1), containing no zap pits or cavities (Apollo 17 Lunar Sample Information Catalog, 1973). The S surface was exposed and all other surfaces are fresh. This basalt was collected at the "Geophone Rock", 50 m south of the ALSEP central station.

PETROGRAPHY AND MINERAL CHEMISTRY

70156 was described as a poikilitic high-Ti mare basalt (Neal et al., 1989), containing interstitial, anhedral ilmenite (0.1-1.1 mm) set in pyroxene (0.4-2.7 mm) plagioclase (0.3-1 mm). Ilmenite contains both rutile and spinel exsolution lamellae (<0.005 mm). Ilmenite-free armalcolite inclusions (~ 0.1 mm) are found in pyroxene. Olivine is found only as ~ 0.15 mm cores to pyroxene grains. Native Fe and troilite form interstitial phases. Point counting reveals that 70156 is comprised of: 65.2% pyroxene; 19.7% ilmenite; 7.7% plagioclase; 2.9% armalcolite; 2.3% olivine; and 2.2% native Fe.

Olivine exhibits little compositional variation either within or between grains (Fo_{68-70}). Likewise, plagioclase exhibits little compositional variablility (An_{77-81}). Unlike other Apollo 17 high-Ti basalts, 70156 does not contain an Mg-pigeonite (Fig. 2). Titan-augite predominates, zoning towards ferrosilite and Fe pigeonite. Al/Ti ratios are constant at ~ 2, and Cr_2O_3 decreases with decreasing pyroxene MG#. Armalcolite exhibits greater compositional variability than ilmenite (MG# = 27-46 and 5-14, resp.).

WHOLE-ROCK CHEMISTRY

The whole-rock chemistry of 70156 has been reported in Neal et al. (1990) (Table 1). This basalt is a Type B Apollo 17 high-Ti basalt, using the classification of Rhodes et al. (1976) and Warner et al. (1979). 70156 is a LREE-depleted

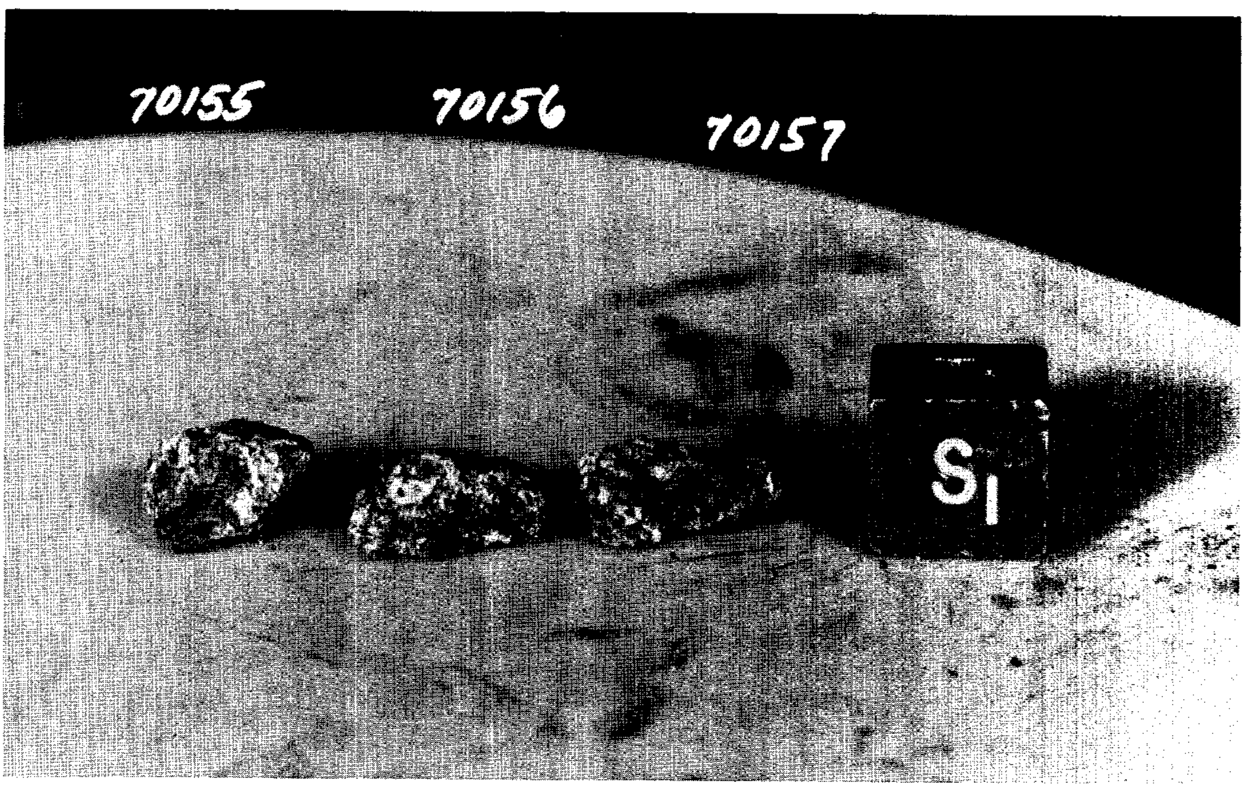


Figure 1: Hand specimen photograph of 70155, 70156, and 70157.

Table 1: Whole-rock composition of 70156,0.
Data from Neal et al. (1990).

	70156,0		70156,0
SiO_2 (wt%)	---	Cu	
TiO_2	13.4	Ni	--
Al_2O_3	9.50	Co	21.6
Cr_2O_3	0.571	V	149
FeO	18.0	Sc	82
MnO	0.239	La	3.13
MgO	9.8	Ce	14
CaO	10.5	Nd	14
Na_2O	0.39	Sm	5.23
K_2O	0.05	Eu	1.52
P_2O_5		Gd	
S		Tb	1.55
Nb (ppm)		Dy	11.3
Zr	60	Er	
Hf	5.60	Yb	5.63
Ta	1.23	Lu	0.85
U	0.08	Ga	
Th	0.13	F	
W		Cl	
Y		C	
Sr	170	N	
Rb	--	H	
Li		He	
Ba	65	Ge (ppb)	
Cs	0.16	Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by INAA.

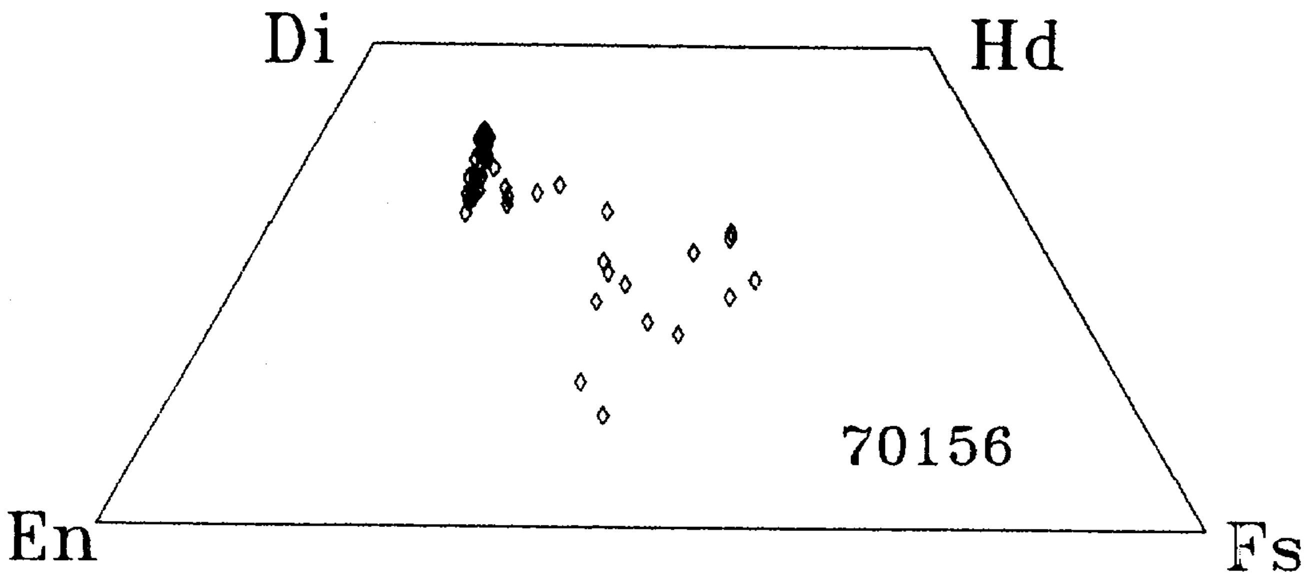


Figure 2: Pyroxene compositions of 70156 represented on a pyroxene quadrilateral.

basalt, with a convex-upward profile (Fig. 3). The MREE reach ~ 30 times chondritic values (Fig. 3) and a small, negative Eu anomaly is present ([Eu/Eu*]N = 0.72). Neal et al. (1990) used the whole-rock composition of 70156,0 in a comprehensive study of Apollo 17 high-Ti basalt petrogenesis. These authors defined two groups of Type B basalts - B1 and B2, on the basis of whole-rock chemistry. Each group is generated by fractional crystallization of observed phenocryst phases. 70156,0 is a Type B1 Apollo 17 high-Ti basalt.

PROCESSING

Approximately 0.39g of 70156,0 remains of the original 0.63g. 0.23g was irradiated for INAA, and 0.01g was used for thin section 70156,4.

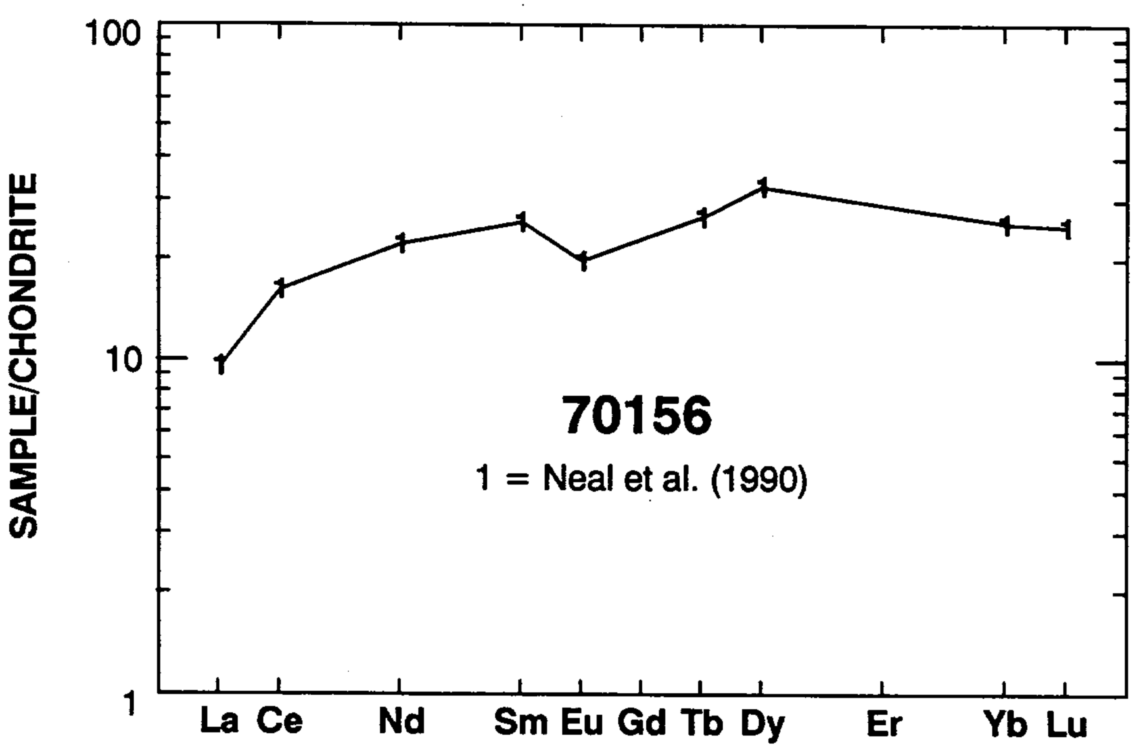


Figure 3: Chondrite-normalized rare-earth element profile of 70156.

70157
High-Ti Mare Basalt
0.57 g, 1.2 x 0.8 x 0.5 cm

INTRODUCTION

70157 was described as a medium gray, sub- to intergranular basalt (see Fig. 1 of 70156), containing no zap pits and only one marialitic cavity (Apollo 17 Lunar Sample Information Catalog, 1973). All surfaces are fresh with no discernable exterior faces. This sample was collected from the "Geophone Rock", 50 m south of the ALSEP central station.

PETROGRAPHY AND MINERAL CHEMISTRY

70157 was described as a plagioclase-poikilitic basalt by Neal et al. (1989). Anhedral and blocky ilmenite (0.1-0.6 mm) forms an intersertal texture with pyroxene (0.1-1.8 mm) and plagioclase (0.3-1.6 mm). Ilmenite contains rutile and spinel exsolution lamellae (< 0.005 mm). Armalcolite (~ 0.1 mm) is present as ilmenite-free inclusions in pyroxene and olivine forms 0.05-0.1 mm cores to pyroxene. Native Fe and troilite are interstitial phases. No discrete spinel minerals are present. Point counting reveals that this sample is composed of: 55.2% pyroxene; 24.7% plagioclase; 16% ilmenite; 2.7% native Fe and troilite; 1% armalcolite; and 0.4% olivine.

Olivine exhibits moderate variation, although individual grains are usually homogeneous. Plagioclase shows little zoning or inter-grain variation (An_{84-89}). Pyroxene compositions exhibit little Fe enrichment, although there is a continuum of compositions between titan-augite and pigeonite (Fig. 1). Al/Ti ratios are constant at ~ 2, and Cr_2O_3 contents decrease with decreasing pyroxene MG#. Both armalcolite and ilmenite exhibit wide ranges in composition (MG# = 27-46 and 8-29, resp.), but only armalcolite displays core-to-rim zonation (Fe enrichment).

WHOLE-ROCK CHEMISTRY

The whole-rock chemistry of 70157 has been reported by Neal et al. (1990) (Table 1). These authors described 70157,0 as a Type B Apollo 17 high-Ti mare basalt, using the classification of Rhodes et al. (1976) and Warner et al. (1979). The REE profile of 70157,0 (Fig. 2) is convex-upward, but LREE-depleted. The MREE reach ~ 40 times chondritic values and a small

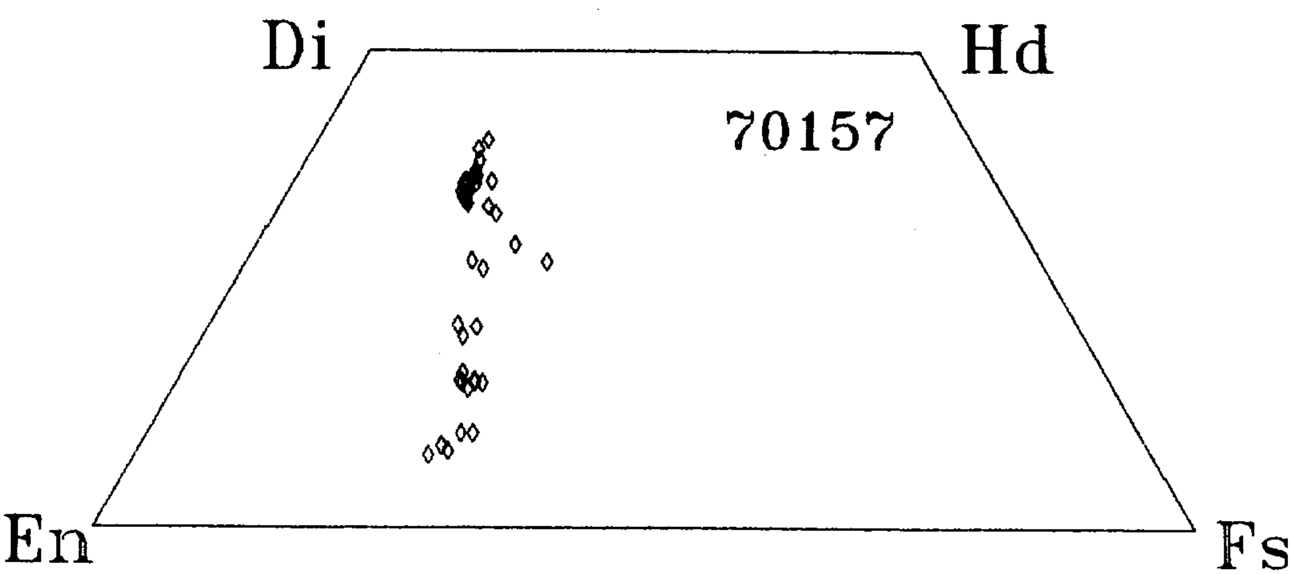


Figure 1: Pyroxene compositions of 70157 represented on a pyroxene quadrilateral.

negative Eu anomaly is present ($[Eu/Eu^*]_N = 0.68$). Neal et al. (1990) used the whole-rock composition of 70157,0 in a comprehensive study of Apollo 17 high-Ti basalt petrogenesis. These authors defined two groups of Type B basalts - B1 and B2, on the basis of whole-rock chemistry. Each group is generated by fractional crystallization of observed phenocryst phases. 70157,0 is a Type B1 Apollo 17 high-Ti basalt.

PROCESSING

Approximately 0.25g of 70157,0 remains of the original 0.57g. 0.31g was irradiated for INAA, and 0.01g was used for thin section 70157,4.

Table 1: Whole-rock composition of 70157,0.
Data from Neal et al. (1990).

	70157,0		70157,0
SiO_2 (wt %)	---	Cu	
TiO_2	13.4	Ni	---
Al_2O_3	9.80	Co	19.3
Cr_2O_3	0.536	V	136
FeO	17.1	Sc	77
MnO	0.237	La	4.41
MgO	9.1	Ce	16
CaO	11.1	Nd	18
Na_2O	0.44	Sm	6.77
K_2O	0.06	Eu	1.90
P_2O_5		Gd	
S		Tb	1.93
Nb (ppm)		Dy	13.4
Zr	170	Er	
Hf	6.65	Yb	6.84
Ta	1.41	Lu	0.99
U	---	Ga	
Th	0.21	F	
W		Cl	
Y		C	
Sr	130	N	
Rb	---	H	
Li		He	
Ba	82	Ge (ppb)	
Cs	0.12	Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by INAA.

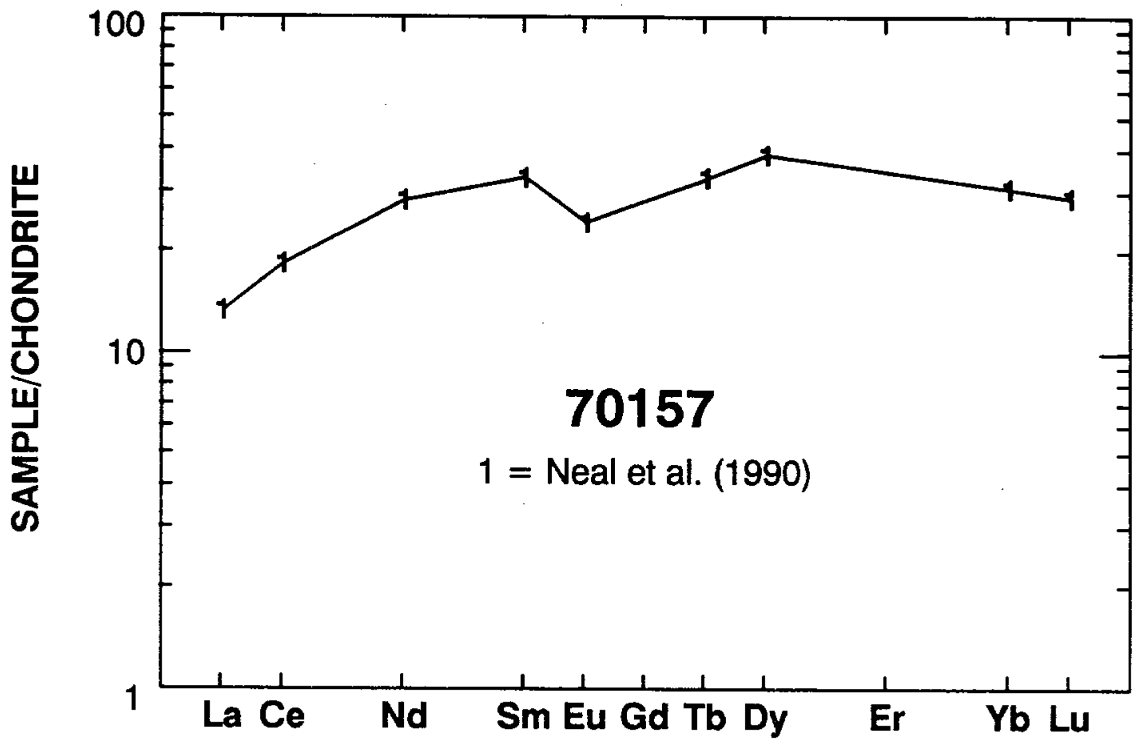


Figure 2: Chondrite-normalized rare-earth element profile of 70157.

70165
High-Ti Mare Basalt
2.143 g, 1.7 x 1.5 x 0.8 cm

INTRODUCTION

70165 was described as a brownish gray, medium- to coarse-grained glomeroporphyritic basalt (Fig. 1), containing no zap pits and <10% small, irregular cavities. This sample was collected from the ALSEP central station.

PETROGRAPHY AND MINERAL CHEMISTRY

70165 was described as a plagioclase-poikilitic basalt by Neal et al. (1989). Anhedral and blocky ilmenite (0.1-0.6 mm) is set interstitially to pyroxene (0.1-1.0 mm) and plagioclase (0.4-1.8 mm). Chromite and rutile exsolution lamellae (<0.005 mm) are present in ilmenite. No armalcolite or discrete spinels are present. Olivine (<0.1 mm) forms cores to pyroxene and discrete inclusions in plagioclase. Silica, native Fe, and troilite form interstitial phases. Opaque mesostasis glass is present. Point counting reveals that this sample is composed of: 40.3% pyroxene; 33.8% plagioclase; 13.7% ilmenite; 6.3% native Fe and troilite; 2.3% silica; 2.8% glass; and 0.9% olivine.

Olivine is usually unzoned, but exhibits a wide compositional range due to inter-grain variations (Fo_{49-64}). Plagioclase exhibits moderate core-to-rim and inter-grain variations (An_{78-92}). Both pigeonite and titan-augite are present, with compositional intermediates (Fig. 2). Both exhibit core-to-rim Fe enrichment (Fig. 2). Al/Ti ratios are constant at ~ 2, and Cr_2O_3 contents decrease with decreasing pyroxene MG#. Ilmenite exhibits significant inter-grain variation (MG# = 3-19).

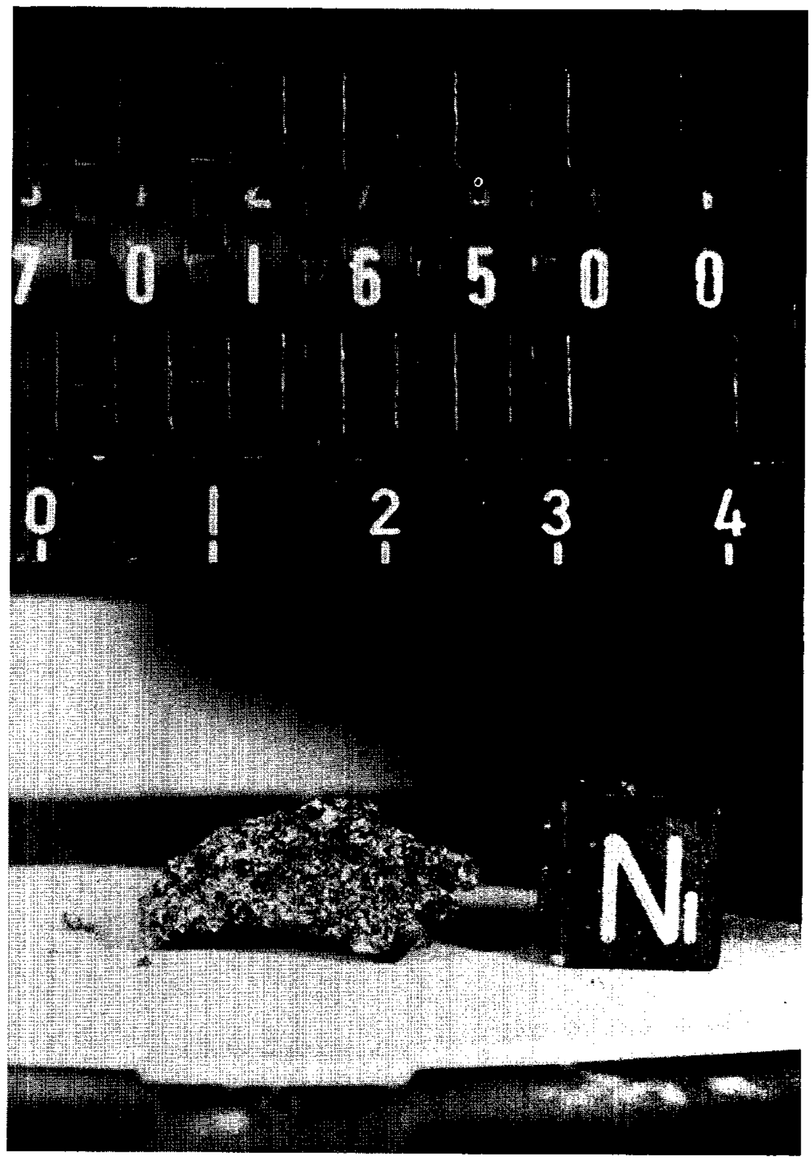


Figure 1: Hand specimen photograph of 70165,0.

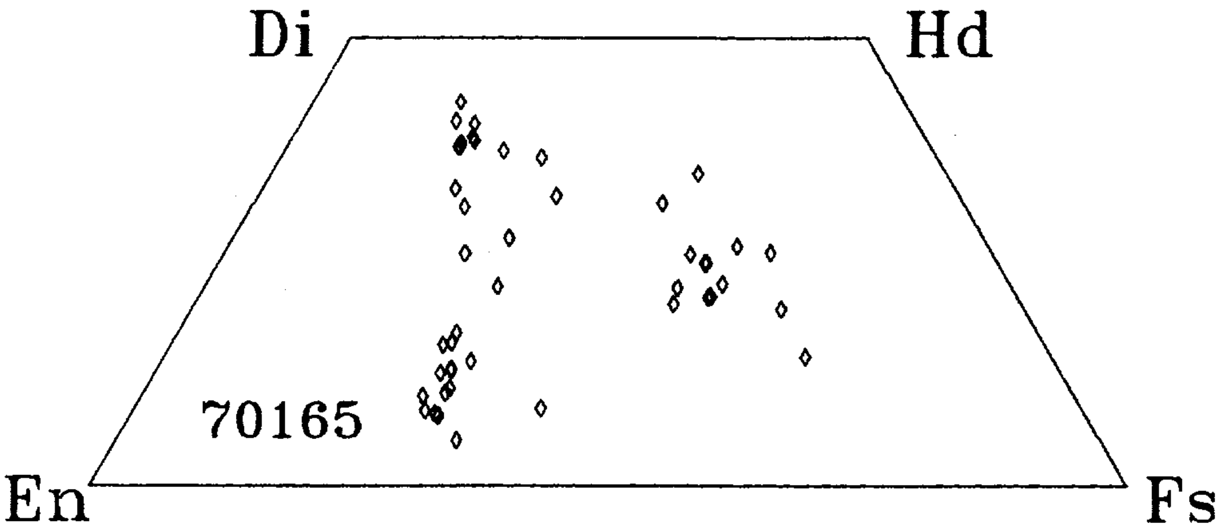


Figure 2: Pyroxene compositions of 70165 represented on a pyroxene quadrilateral.

WHOLE-ROCK CHEMISTRY

70165 was described as a Type A Apollo 17 high-Ti mare basalt (Table 1) by Neal et al. (1990), using the classification of Rhodes et al. (1976) and Warner et al. (1979). The REE profile of 70165,4 is LREE-depleted, although it possesses an overall convex-upward shape (Fig. 3). The MREE reach ~ 50 times chondritic values and a negative Eu anomaly is present ($[Eu/Eu^*]_N = 0.51$). Neal et al. (1990) have used the whole-rock composition of 70165,4 to refine previous petrogenetic models and formulate a new one for the Type A Apollo 17 high-Ti basalts.

PROCESSING

Approximately 1.6g of 70165,0 remains of the original 2.143g. 0.531g was irradiated for INAA, and 0.01g was used for thin section 70165,3.

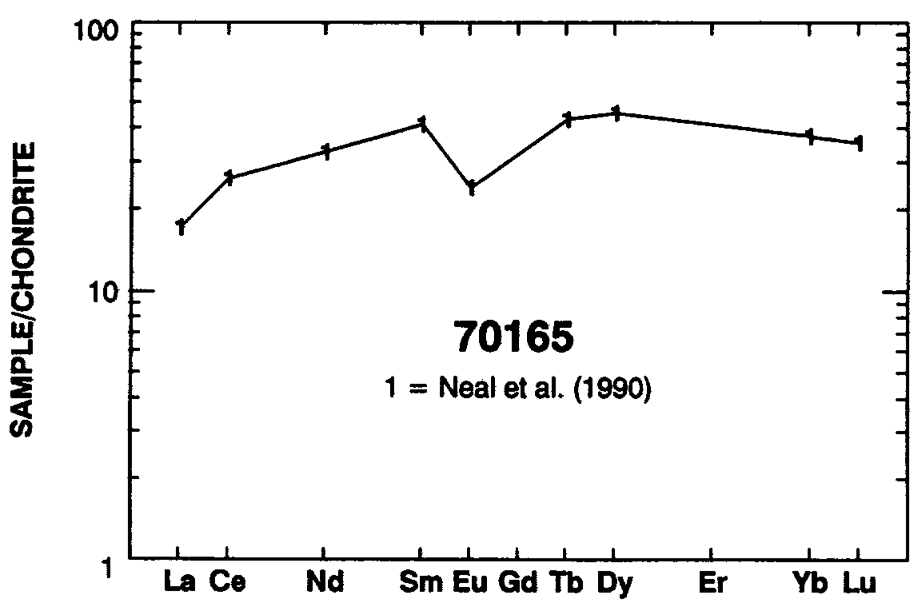


Figure 3: Chondrite-normalized rare-earth element profile of 70165.

Table 1: Whole-rock composition of 70165,4.
Data from Neal et al. (1990).

	70165,4		70165,4
SiO_2 (wt%)	---	Cu	
TiO_2	12.7	Ni	---
Al_2O_3	8.40	Co	18.0
Cr_2O_3	0.459	V	114
FeO	17.9	Sc	82
MnO	0.247	La	5.74
MgO	8.7	Ce	23
CaO	10.2	Nd	21
Na_2O	0.38	Sm	8.56
K_2O	0.06	Eu	1.89
P_2O_5		Gd	
S		Tb	2.55
Nb (ppm)		Dy	15.9
Zr	130	Er	
Hf	7.94	Yb	8.38
Ta	1.50	Lu	1.22
U	0.14	Ga	
Th	0.14	F	
W		Cl	
Y		C	
Sr	160	N	
Rb	---	H	
Li		He	
Ba	111	Ge (ppb)	
Cs	0.13	Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by INAA.

70175
Glass-Rich Microbreccia
339.6 g, 9 × 6 × 6 cm

INTRODUCTION

70175 was described as a brownish black, homogeneous, glass-rich microbreccia (Fig. 1 a,b), with many zap pits which are glass lined (Apollo 17 Lunar Sample Information Catalog, 1973). T is hackly with many small, sealed fractures. N is cut by many open fractures which are perpendicular to B and usually glass coated. W is an uneven surface controlled by fractures and contains a glass splash ~1 cm^2 (droplets, rays, etc.). Glass occurs in small dots, spheres, and angular fragments; black on exterior surfaces. S is broken by many small fractures and contains an area ~2 × 3 cm which is distinctly more feldspathic. E is an apex which exhibits many intersecting fractures. This sample was collected approximately 30 m north of the ALSEP central station.

PETROGRAPHY AND MINERAL CHEMISTRY

No thin section is available, but the Apollo 17 Lunar Sample Information Catalog (1973) reported that 70175 is comprised of: 75% brown/black matrix; 5% mineral clasts; 15% orange/brown and black glass; and 5% lithic clasts. Simon et al. (1989) described 70175 as a compacted orange/black glass deposit.

WHOLE-ROCK CHEMISTRY

70175 is as yet unanalyzed for whole-rock chemistry.

ISOTOPES

Much of the work conducted upon 70175 was focused on cosmic ray activity (Keith et al., 1974a,b; LSPET, 1973; Yokoyama et al., 1974). LSPET (1973) reported cosmic ray abundances of 70175 (Table 1), and Yokoyama et al. (1974) determined that this sample was unsaturated with respect to ^{26}Al. Keith et al. (1974a,b) reported the same analysis as in the Apollo 17 Preliminary Science Report (1973) of radionuclides using gamma-ray analysis (Table 1). The nitrogen abundance of 70175 has been determined, but Carr et al. (1985) only stated that it was low.

PROCESSING

Because of the lack of work conducted upon 70175, a large proportion of 70175,0 remains. Samples of < 1 g size have been used in gamma-ray analyses outlined above.

Table 1: Abundances of radionuclides in 70175. Data from Apollo 17 Preliminary Science Report (1973) with the same analysis reported by Keith et al. (1974a,b).

	70175
Th (ppm)	0.4 ± 0.04
U (ppm)	0.105 ± 0.007
K (%)	0.055 ± 0.002
^{26}Al (dpm/kg)	42 ± 5
^{22}Na (dpm/kg)	76 ± 18
^{54}Mn (dpm/kg)	156 ± 9
^{56}Co (dpm/kg)	300 ± 70
^{46}Sc (dpm/kg)	39 ± 5
^{48}V (dpm/kg)	17 ± 5
^{60}Co (dpm/kg)	0.29 ± 0.08
Th/U	3.8 ± 0.5
K/U	5200 ± 400

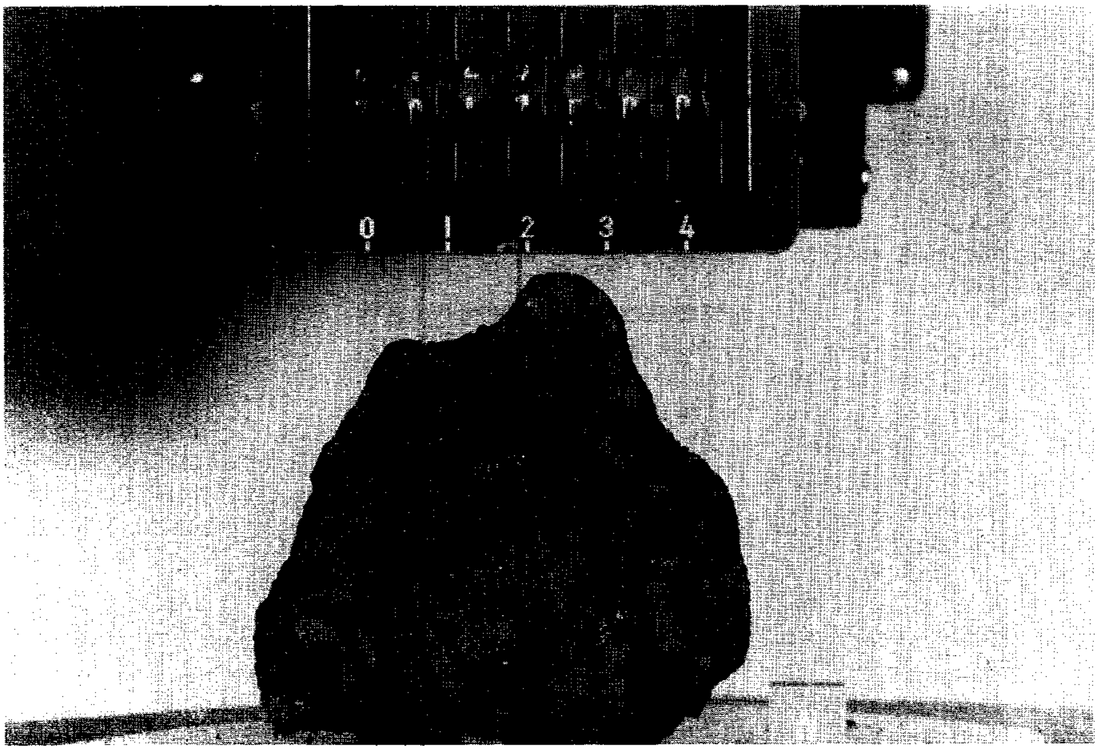


Figure 1a: Photograph of "W" surface of 70175,0.

Figure 1b: Photograph of "N" surface of 70175,0.

Figure 1: Hand specimen photographs of 70175,0.

70185
High-Ti Mare Basalt
466.6 g, 9 x 7.5 x 5.5 cm and 3.2 x 2.3 x 1.5 cm

INTRODUCTION

70185 was described as a medium gray, irregular, but intergranular mare basalt (Fig. 1), containing many zap pits (Apollo 17 Lunar Sample Information Catalog, 1973). The grain size and number of cavities varies over the sample. During return, this sample split into two pieces forming 70185,0 and ,1 (Fig. 2). On 70185,1, the grain size is coarser than on ,0, with plagioclase laths reaching up to 2.5 mm. 70185 was collected approximately 40 m north of the ALSEP central station.

PETROGRAPHY AND MINERAL CHEMISTRY

70185,29 was studied by Brown et al. (1975a,b), who described this basalt as a Type IB, or plagioclase poikilitic. This basalt is composed of: 47.6% pyroxene; 24% plagioclase; 23.9% opaque minerals; 4.1% silica; 0.4% olivine. The specific petrography and mineral chemistry of 70185 is not mentioned by Brown et al. (1975a,b), rather they are described within the general context of Type IB basalts. In the compilation of this catalog, we studied thin sections 70185,30 and ,31. These exhibited essentially the same petrographic relations. Large (up to 1 mm) ilmenite laths overlay pyroxene (up to 1.2 mm) and plagioclase (up to 1.5 mm). Rare armalcolite inclusions occur in pyroxene, and ilmenite possesses both chromite and rutile exsolution lamellae (<0.005 mm wide). Olivine usually forms the cores

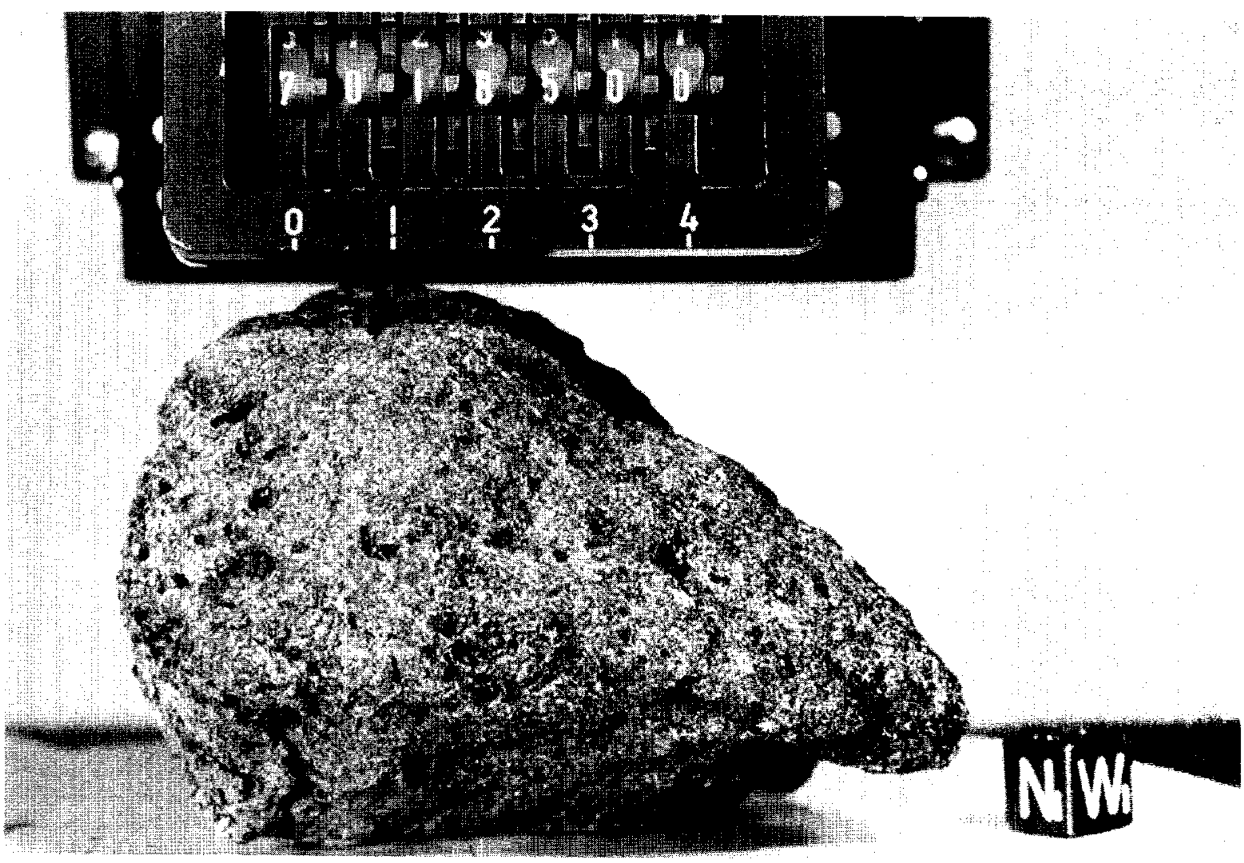


Figure 1: Hand specimen photograph of 70185,0.

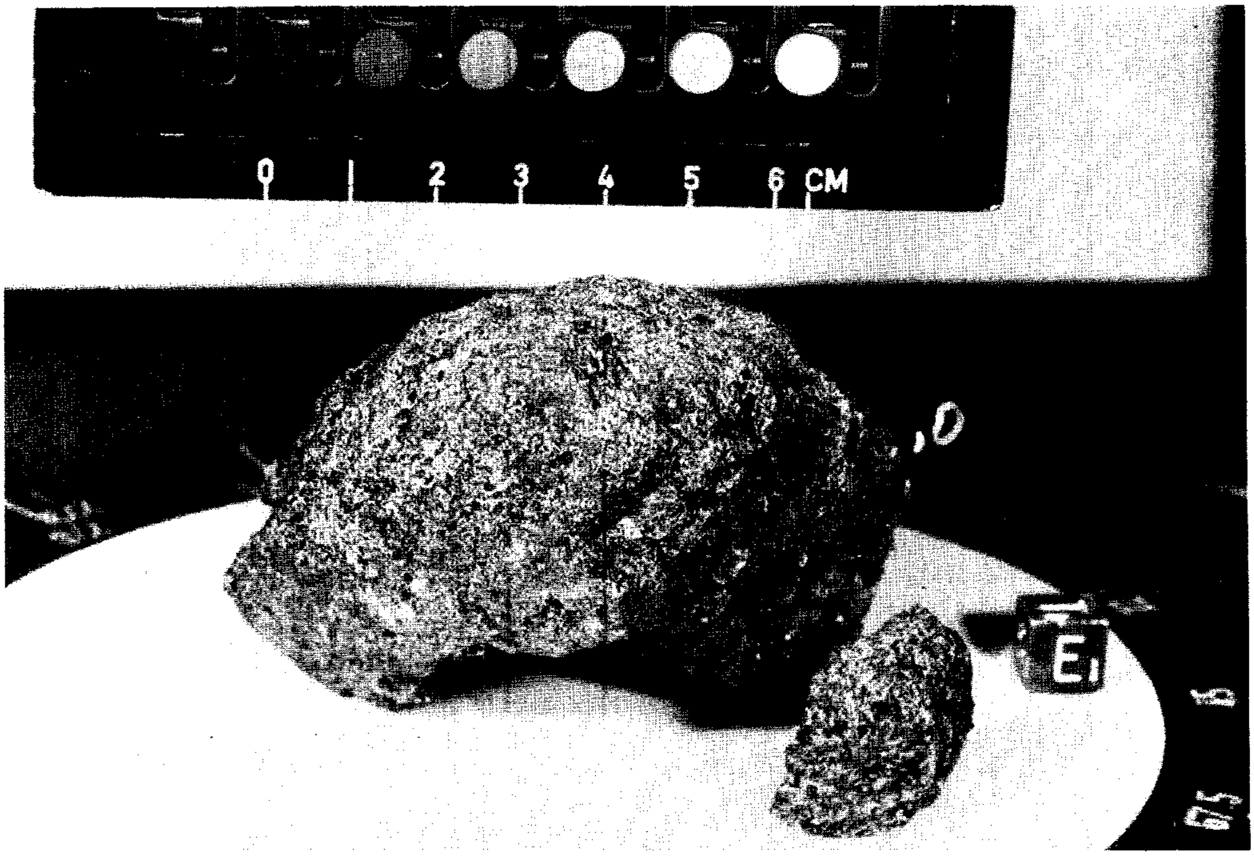


Figure 2: Subdivision of 70185,0.

of the large pyroxenes. Silica, native Fe, and troilite form interstitial phases.

WHOLE-ROCK CHEMISTRY

The whole-rock chemistry for 70185 has been determined by Warner et al. (1975) and Rhodes et al. (1976) from sub-samples 70185,5 and 70185,32, respectively (Table 1). Both Warner et al. (1975) and Rhodes et al. (1976) class this basalt as a Type U (Unclassifiable), suggesting the coarse-grained nature of this sample precludes obtaining a representative analysis. This is witnessed in Figure 3, where the REE contents of 70185 reported by Warner et al. (1975) are elevated relative to those reported by Rhodes et al. (1976). However, both are LREE-depleted with a convex-upward profile. Furthermore, the magnitudes of the negative Eu anomaly are similar ($[Eu/Eu^*]_N = 0.54$ and 0.51, resp.). Whole-rock analyses for specific elements have also been reported. Gibson et al.

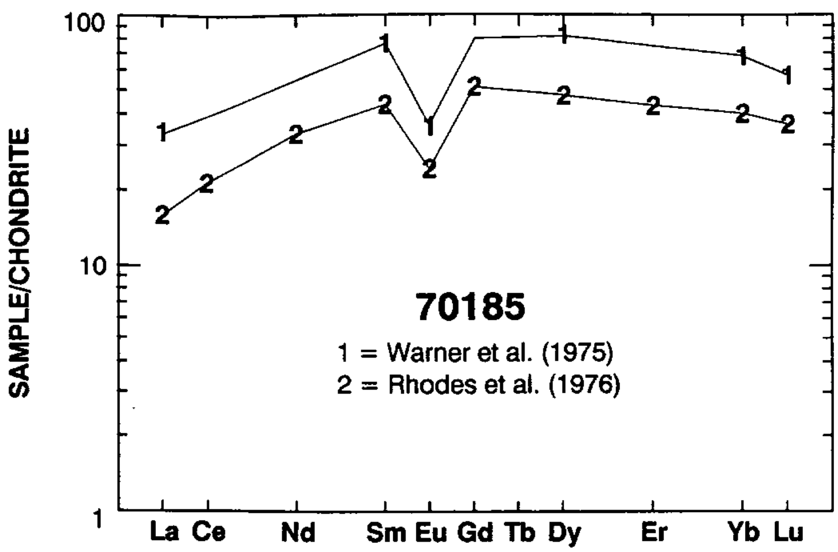


Figure 3: Chondrite-normalized rare-earth element profile of 70185.

Table 1: Whole-rock compositions of 70185.

	70185	
	1	2
SiO_2 (wt %)		40.18
TiO_2	9.6	11.52
Al_2O_3	10.2	9.04
Cr_2O_3	0.353	0.40
FeO	18.9	17.64
MnO	0.237	0.26
MgO	8.1	8.11
CaO	11.1	11.95
Na_2O	0.433	0.39
K_2O	0.093	0.04
P_2O_5		0.02
S		0.17
Nb (ppm)		
Zr		
Hf		8.2
Ta		
U		
Th		
W		
Y		
Sr		173
Rb		0.49
Li		9.6
Ba		66.3
Cs		
Be		
Zn		
Pb		
Cu		
Ni		
Co	15.9	19.7
V	72	---
Sc	84	84
La	11.1	5.24
Ce		18.5
Nd		21.1
Sm	15.4	8.83
Eu	2.74	1.87

Table 1: (Concluded).

	70185 1	70185 2
Gd		14.0
Tb		
Dy	28	16.0
Er		9.52
Yb	14.7	8.67
Lu	1.9	1.21
Ga		
F		
Cl		
C		
N		
H		
He		
Ge (ppb)		
Ir		
Au		
Ru		
Os		

1 = Warner et al. (1975); 2 = Rhodes et al. (1976).

(1976a,b) analyzed 70185 for sulfur and noted that this basalt contained 1850 ± 50 μg/g of total sulfur, with an equivalent weight of Fe^{o} of 0.120%. Eldridge et al. (1974a,b) determined the primordial radioelement concentrations in 70185 by gamma-ray spectrometry. 70185 contains 420 ppm K, 0.3 ppm Th, and 0.1 ppm U.

ISOTOPES

70185 has been analyzed for Sr isotopes by Nyquist et al. (1976). Only a whole-rock determination was reported and no dating was undertaken. 70185 contains a present day $^{87}Sr/^{86}Sr$ ratio of 0.69954 ± 8. Results of this study are presented in Table 2. Cosmogenic radionuclides were determined by LSPET (1973) with the same analysis also reported by O'Kelley et al. (1974a,b) and are presented in Table 3. Yokoyama et al. (1974) reported that 70185 was saturated with ^{26}Al.

PROCESSING

Approximately 449 g of 70185,0 remains. Most of the splitting has occurred on 70185,1, of which 9.09 g remains. Four thin sections have been prepared - 70185,9, ,29, ,30, ,31.

Table 2: Isotopic composition of 70185.
Data from Nyquist et al. (1976).

	70185 (whole-rock)
wt. (mg)	51
Rb (ppm)	0.495
Sr	173
$^{87}Rb/^{86}Sr$	0.0083 + 3
$^{87}Sr/^{86}Sr$	0.69954 + 8
T_B	3.72 + 0.81
T_L	4.29 + 0.81

T_B = Model age assuming I = 0.69910 (BABI + JSC bias); T_L = Model age assuming I = 0.69903 (Apollo 16 anorthosites for T = 4.6 Ga).

Table 3: Cosmogenic radionuclide abundances for 70185.
Data from the Apollo 17 Preliminary Science Report (1973).

	70185
Th (ppm)	0.30 + 0.03
U (ppm)	0.10 + 0.02
K (%)	0.042 + 0.004
^{26}Al (dpm/kg)	70 + 4
^{22}Na (dpm/kg)	50 + 4
^{54}Mn (dpm/kg)	95 + 10
^{56}Co (dpm/kg)	105 + 10
^{44}Sc (dpm/kg)	47 + 5
Th/U	3.0 + 0.7
K/U	4200 + 900

70215
High-Ti Mare Basalt
8110 g, 23 x 13 x 10.5 cm

INTRODUCTION

70215 was described as a medium dark gray (with a brownish tint), fine-grained basalt (Fig. 1), containing zap pits on all faces and rare vugs up to 3mm in diameter (Apollo 17 Lunar Sample Information Catalog, 1973). These vugs contain projecting plates and prisms of ilmenite and pyroxene. The fabric is intersertal to intergranular and the shape blocky to subangular with one flat surface. Surface T is slickensided. This sample was collected approximately 60m east of the Lunar Module.

PETROGRAPHY AND MINERAL CHEMISTRY

Wilshire (Apollo 17 Lunar Sample Information Catalog, 1973) described 70215,7 as a fine-grained, subvariolitic basalt with microphenocrysts of ilmenite, olivine, and clinopyroxene (Fig. 2ab). Sheafs of plagioclase laths are locally developed. Phenocrysts make up 52% of this thin section. Rutile and chromite exsolution lamellae (< 0.005mm) occur in ilmenite, and ilmenite lamellae occur in ulvöspinel. Ilmenite also occurs as rims on ulvöspinel.

Longhi et al. (1974) described thin section 70215,149 as a spherulitic, fine-grained, high-Ti basalt with a texture suggesting disequilibrium crystallization during a period of rapid cooling. These authors reported a mode of 7% olivine, 42% clinopyroxene, 29% plagioclase, 18% opaque

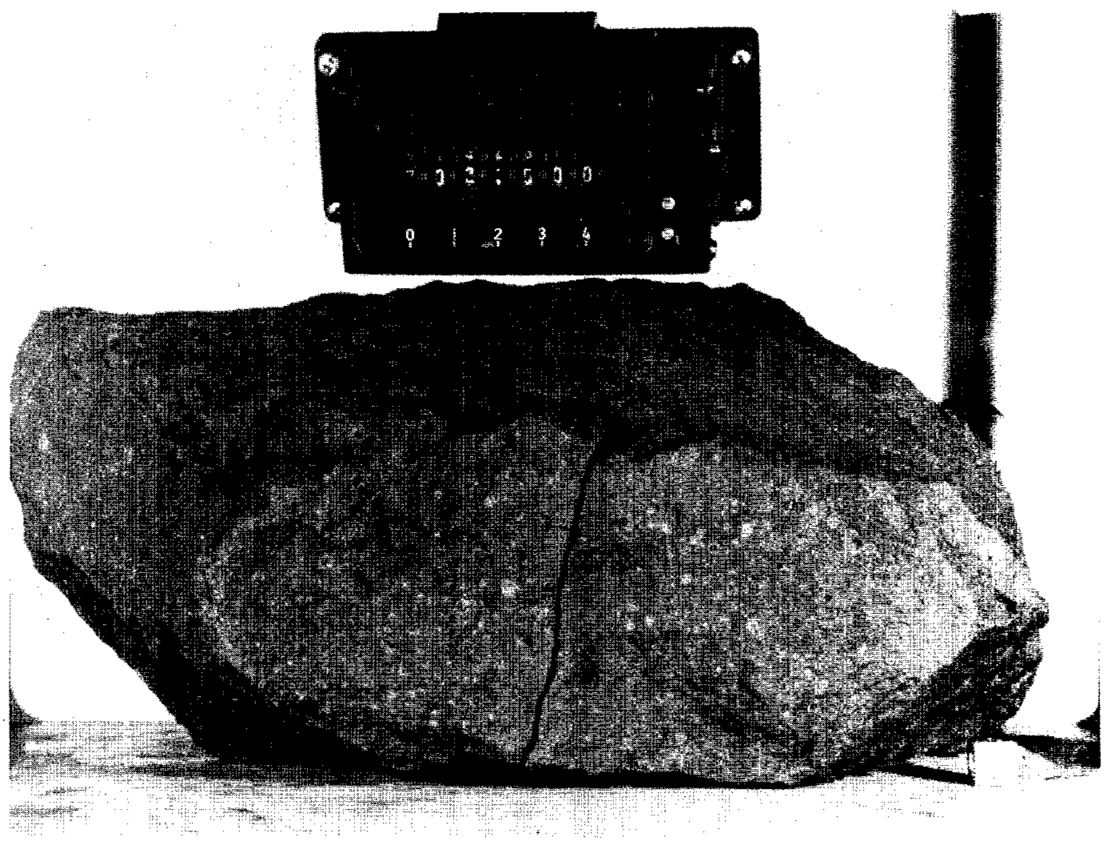
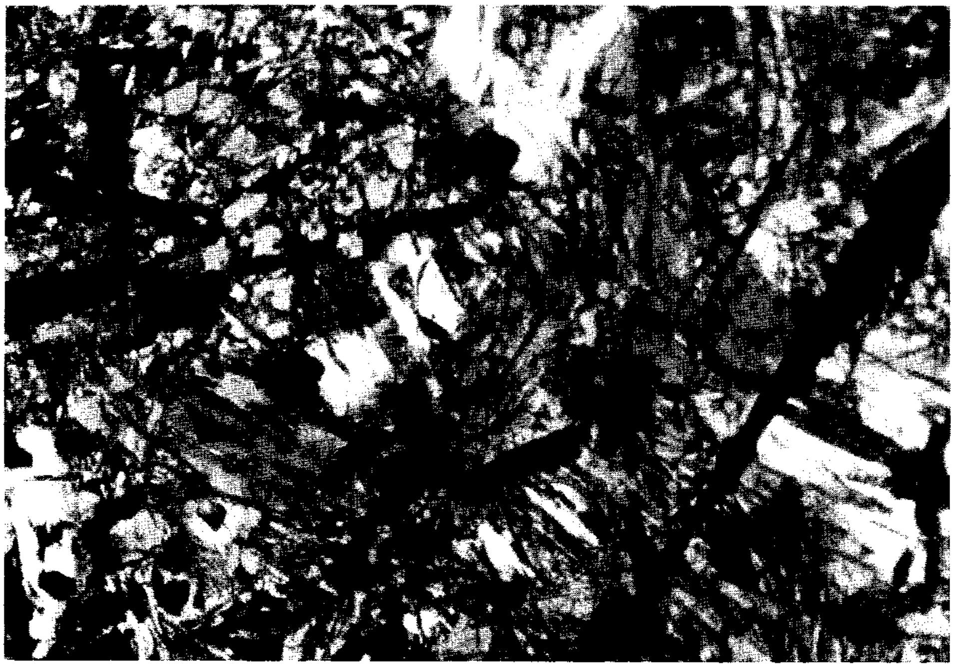


Figure 1: Hand specimen photograph of 70215,0.



2a: Transmitted light.

2b: Reflected light.

Figure 2: Photomicrographs of 70215. Fields of view in both cases are 2.5 mm.

minerals (mostly ilmenite), and 4% silica phase. Two textural domains exist. In the first, olivine and ilmenite phenocrysts (containing numerous inclusions) are set in a groundmass of smaller olivines, ilmenites, and 0.3mm "bowtie" spherulites of clinopyroxene and plagioclase. Interstitial silica, native Fe, and troilite are present. In the second, coarser domain, ilmenite and pink titan-augite form a subophitic texture with spherulites of augite and skeletal plagioclase.

Brown et al. (1975) described 70215,142 as a Type IA Apollo 17 high-Ti basalt, containing 9.2% olivine, 37% opaques, 12.8% plagioclase, and 41% clinopyroxene. The texture of this sample is discussed within the confines of the general Type IA group defined by Brown et al. (1975).

Dymek et al. (1975) studied 70215,158, describing it as a fine-grained porphyritic basalt comprised of clinopyroxene (58%), plagioclase (18%), ilmenite (13%), olivine 6%), and SiO_2 (4%), with minor amounts of armalcolite, Cr-ulvöspinel, rutile, troilite, and native Fe. A small amount of K-rich mesostasis is present. 70215,158 is characterized by abundant phenocrysts of olivine, ilmenite, and clinopyroxene set in a texturally variable groundmass. Approximately three quarters of the groundmass consists of a variolitic intergrowth of acicular grains of plagioclase, SiO_2, and ilmenite, with blocky to acicular clinopyroxene. The remainder consists of tiny needles of ilmenite that alternate with fan spherulites of plagioclase and clinopyroxene. Olivine phenocrysts are skeletal (i.e., rapid crystallization), some intergrown with ilmenite. An overgrowth of pyroxene is usually present. Cr-ulvöspinel inclusions may be present. Most ilmenites occur as skeletal needles with "sawtooth" edges, although blocky, anhedral types occur. Rare armalcolites are rimmed with rutile-bearing ilmenite. Furthermore, occasional phenocrysts of Cr-ulvöspinel contain oriented lamellae of ilmenite. Plagioclase occurs as elongate untwinned grains scattered throughout the groundmass.

Mineral chemistry is generally similar between the different thin sections described above. Brown et al. (1975) described the mineral chemistry of 70215 within the general context of Type IA basalts. Dymek et al. (1975) noted olivine compositions from Fo_{65-75} with only minor core-to-rim zonation, whereas Longhi et al. (1974) noted a larger olivine range (Fo_{50-75}) with no core-to-rim zonation. Ilmenite composition is related to crystal habit. Those with "sawtooth" margins have generally higher Mg contents (Fe/(Fe + Mg) = 0.84-0.89) than the blocky, subequant (Fe/(Fe + Mg) = 0.88-0.93) and groundmass (Fe/(Fe + Mg) = 0.95) types. Muhich et al. (1990) reported variations in ilmenite composition in 70215 which correlated with the degree of exsolution. Ilmenites with abundent exsolution were richer in Mg relative to those without exsolution. Armalcolite exhibits only a minor range in composition (Fe/(Fe + Mg) = 0.48-0.53) and spinel compositions are generally uniform (Fe/(Fe + Mg) = 0.82). Pyroxene compositions range from titan-augite to augite (phenocrysts) to more Fe-rich varieties (groundmass). No pigeonite is present (Fig. 3; Px quad of Longhi et al., 1974). As Fe increases, Al, Ti, and Cr decrease. Al/Ti ratios are generally constant at ~ 2, although some of the aluminous titan-augites contain Al/Ti ratios > 2, indicating the presence of Al^{VI}. Plagioclase exhibits little variation (An_{75-81}).

The proposed crystallization sequence for 70215 is generally olivine + armalcolite → ilmenite + rutile → cpx → plagioclase + Fe-rich pyroxene + ilmenite + silica. Armalcolite and olivine react with the magma to form ilmenite and clinopyroxene, respectively. Longhi et al. (1974) concluded that spinel

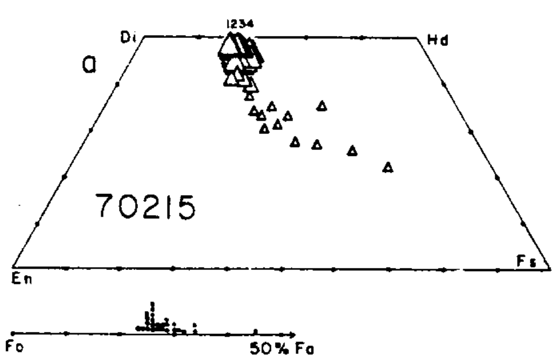


Figure 3: Pyroxene and olivine compositions of 70215.

crystallized between ilmenite and cpx, whereas Dymek et al. (1975) indicated that spinel crystallized with olivine. El Goresy et al. (1974ab, 1977ab) studied the opaque mineralogy of 70215 in detail. These authors concentrated upon the sub-solidus equilibration of the spinel-ilmenite assemblage and inverted zoning in chromian-ulvöspinel.

WHOLE-ROCK CHEMISTRY

The whole rock composition of 70215 has been reported by many authors. Rhodes et al. (1976) classified 70215 as a Type B high-Ti basalt. 70215 is further classified as a Type B2 basalt using the criteria of Neal et al. (1990). The major element composition of 70215 has been reported by Rhodes et al. (1974, 1976), Rose et al. (1974), LSPET (1973), Wänke et al. (1975), Shih et al. (1975), Duncan et al. (1974), and Dickinson et al (1989) (Table 1). LSPET (1973) report that 70215 is olivine-normative. Selected trace elements (Table 1) have been reported by LSPET (1973), Rhodes et al. (1974), Rose et al. (1974), Duncan et al. (1974), Brunfelt et al. (1974), Masuda (1974), Shih et al. (1975), Wänke et al. (1975), and Dickerson et al. (1989). There is some variation between different analyses for both major and trace element abundances (Table 1).

The REE profile of 70215 has been determined by four different authors (Brunfelt et al., 1974, Masuda et al., 1974; Wänke et al., 1975; Shih et al., 1975). The four profiles are similar (Fig. 4) although that determined by Brunfelt et al. (1974) is the least smooth. The profiles are all LREE-depleted, with a slight decrease in the HREE relative to the MREE. The negative Eu anomaly is of the same magnitude in each case ($[Eu/Eu^*]_N$ = 0.52-0.58). The MREE reach 30-35 times chondritic values. Shaffer et al. (1990) used the La/Sm value of 70215 in a discussion of mafic cumulate fractionation in an initial lunar magma.

70215 has also been used in more specialized studies of bulk composition. Hydrogen concentrations have been reported by Merlivat et al. (1974, 1976) as 0.62 - 0.75 µmole/g, whereas Gibson et al. (1986) report 2.3 µg/g H in 70215. Gibson et al. (1974, 1975, 1976) reported the sulfur content in 70215 as 2210 µg/g, whereas Petrowski et al. (1974) reported 1689 ppm and Moore et al. (1974) 2040 µg/g S. Nitrogen contents for 70215 have been reported as < 8 to 3 ppm by Müller (1974, 1976), 88 µg/g by Moore and Lewis (1976), and 16-23 ppm by Goel et al. (1975). Carbon abundances for 70215 have been determined by Moore et al. (1974) and Moore and Lewis (1976) at 31 µg/g.

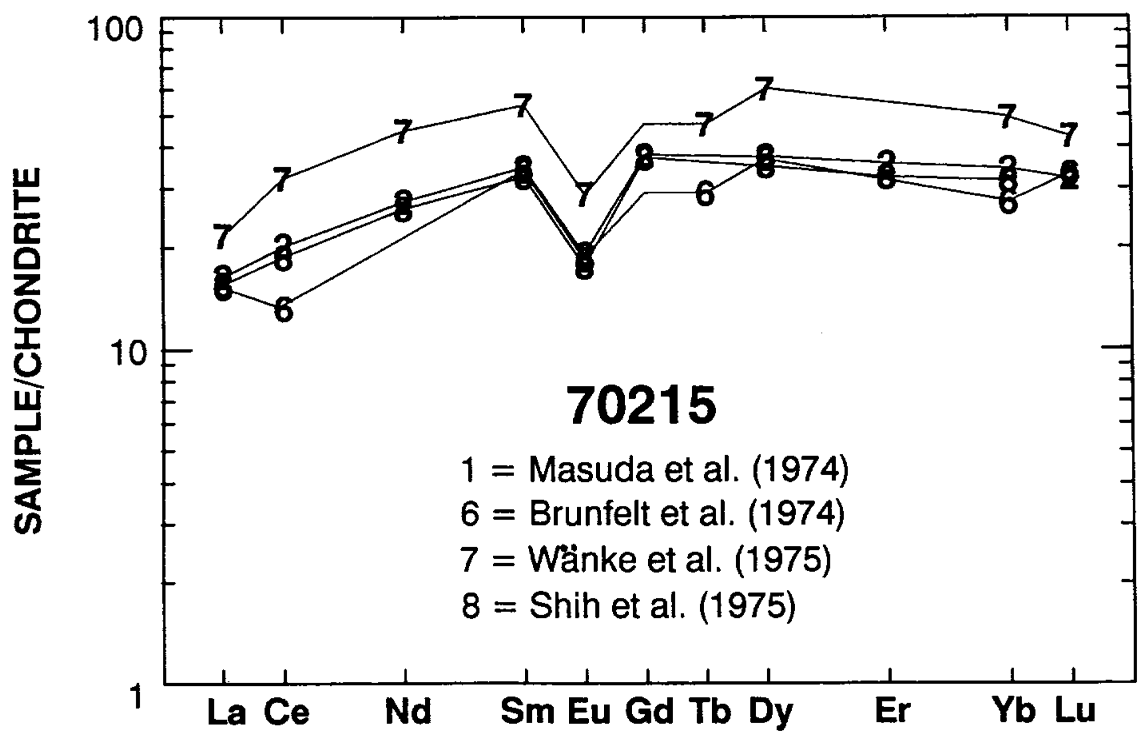


Figure 4: Chondrite-normalized rare-earth element profiles of 70215.

Table 1: Whole-rock chemistry of 70215.

Ref.	1	2	3	4	5	6	7	8	9
	X	I	X	X	X	N	N	I	R, N
SiO_2 (wt %)	37.19		37.91	37.62	38.46				
TiO_2	13.14		13.08	13.20	12.48	13.08			
Al_2O_3	8.67		8.86	8.79	9.01	9.11			
Cr_2O_3	0.42		0.43	0.41	0.39	0.37			0.35, 0.34
FeO	19.62		19.96	19.22	19.40	19.09			16.2, 20.1
MnO	0.28		0.26	0.27	0.29	0.27			
MgO	8.52		7.99	9.34	7.91	7.47			
CaO	10.43		10.77	10.82	10.94	10.92			12.9, 13.3
Na_2O	0.32		0.38	0.31	0.42	0.43			0.34, 0.39
K_2O	0.04		0.04	0.08	0.05	0.05			
P_2O_5	0.09		0.11	0.07	0.10				
S	0.18		0.19		0.17				
Nb (ppm)	20		20.8	20	21		22		
Zr	183		192	223	185		271		160
Hf						8.3	8.82		7.6, 6.4
Ta						1.6	1.78		1.5, 1.6
U						0.072		0.13	
Th						0.21			0.38, 0.39
W						0.075			
Y	75		63.6	73	69		93		
Sr	121		122	170	123	127	195	121	
Rb	<0.2		<1	1.0	0.9	0.3		0.356	
Li				11			8.3		
Ba		61.8	77	475		48	85	56.9	47, 65
Cs						0.02			
Be				<1					
Zn	5		<2	<4	6	2			59
Pb				<2					
Cu			<3	22		4.2			
Ni	2		<3	<1	4	<10			
Co			23	33		20.4	19.5		15, 22
V			50	64		117			349, 320
Sc				92		89	84.0		77, 88
La		5.35		<10		4.96	7.08	5.22	4.7, 5.8
Ce		17.3				11.3	27.5	16.5	13, 17
Nd		17.0					28	16.7	22
Sm		6.98				6.79	10.8	6.69	6.0, 6.9
Eu		1.45				1.40	2.19	1.37	1.3, 1.4

Table 1: (Concluded).

Ref.	1	2	3	4	5	6	7	8	9
	X	I	X	X	X	N	N	I	R, N
Gd		10.3						10.4	
Tb						1.66	2.7		1.7, 2.0
Dy		12.7				12.5	20.5	12.2	
Er		7.91						7.40	0.62
Yb		7.45				5.9	10.7	7.04	6.7, 7.2
Lu		1.07				1.11	1.44		1.1, 1.2
Ga				6.3		3.1			20
F							49		
Cl							3.5		
Br							0.011		
C									
N									
H									
He									2.2, 2.4
Ge (ppb)									
Ir									
Au									
Ru									
Os									

References: 1 = LSPET (1973); 2 = Masuda et al. (1974); 3 = Duncan et al. (1974); 4 = Rose et al. (1974); 5 = Rhodes et al. (1974); 6 = Brunfelt et al. (1974); 7 = Wänke et al., 1975); 8 = Shih et al. (1975); 9 = Dickinson et al (1989) [Two anal.].

Analyses by: X = XRF; I = Isotope Dilution; N = INAA; R = RNAA.

Germanium abundance in 70215 was determined at 2.2 ppb by Dickinson et al. (1988) (Table 1). Garg and Ehmann (1976) and Hughes and Schmitt (1985) reported Zr and Hf abundances for 70215. Garg and Ehmann (1976) measured 213-215 ppm Zr and 6.72-6.96 ppm Hf in 70215,46, and Hughes and Schmitt (1985) reported 70215,78 as containing 6.2 ± 0.2 ppm Hf with a Zr/Hf ratio of 28.3 ± 4.6.

ISOTOPES

Rb-Sr isotope data for 70215 have been reported by Bansal et al. (1975), and Nyquist et al. (1975, 1976) (Table 2). These authors report a present day $^{87}Sr/^{86}Sr$ ratio of 0.69965 ± 7 for the whole-rock. A meaningful isochron was not obtained from the mineral separates due to the small range in $^{87}Sr/^{86}Sr$ ratio. No Sm-Nd or Pb isotope data has been obtained from 70215.

^{39}Ar-^{40}Ar age dating has been conducted on 70215 using whole-rock (Kirsten and Horn, 1974) (Table 3) and laser (Schaeffer et al., 1977)

Table 2: Sr isotopic composition of 70215.
Data from Nyquist et al. (1975, 1976) and Bansal et al. (1975).

	Rb (ppm)	Sr (ppm)	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$	T_B	T_L
70215,2	0.356	121	0.0085 ± 4	0.69965 ± 7	4.51 ± 0.8	5.06 ± 0.82
"floats"	0.571	181	0.0091 ± 1	0.69965 ± 6		
$p > 4.3$	0.168	34.9	0.0139 ± 1	0.70023 ± 4		
$p < 2.85$	0.60	322	0.0054 ± 4	0.69944 ± 6		

B = Model age relative to BABI
L = Model age relative to LUNI

Table 3: Ar-Ar and K-Ar data from 70215,21.
Data from Kirsten and Horn (1974). Gas released in 10^{-8} ccSTP/g.

^{40}Ar	1710
^{39}Ar	15.9
^{38}Ar	12.3
^{37}Ar	1725
^{36}Ar	1.31
K (ppm)	345 ± 25
Ca (%)	7.2 ± 0.5
Exposure Age (m.y.)	100 ± 12
Total Ar Age (b.y.)	3.77 ± 0.10
Plateau Age (b.y.)	3.84 ± 0.04

techniques (Table 4). Schaeffer et al. (1977) reported mineral ages ranging from 3.63-3.85 Ga in 70215,182, whereas Kirsten and Horn (1977) reported a whole-rock plateau age of 3.84 ± 0.04 Ga and an exposure age of 100 ± 12 Ma (Table 3).

Other radiogenic isotopes measured in 70215 include $^{39}K/^{41}K$ and $^{42}K/^{40}K$ (13.859 and 575.9, resp.) by Garner et al. (1975). Calcium isotopes have also been analyzed by Russell et al. (1977), who reported 70215 to contain a $\delta(^{40}Ca/^{44}Ca)$ value of -1.1 ± 0.2. Drozd et al. (1977) report a Kr-Kr exposure age of 126 ± 3 Ma for 70215.

Carbon and sulfur represent the only stable isotope determinations made upon 70215. Petrowski et al. (1974) reported a $\delta^{13}C$ (‰ PDB) of -39.3 and Des Marais (1978) reported a $\delta^{13}C$ of -23.5 for 70215. The $\delta^{34}S$ (‰ CDT) has been reported as + 1.5 (Petrowski et al., 1974), 0.0 (Gibson et al., 1975), and + 0.6 (Rees and Thode, 1974).

EXPERIMENTAL

70215 has been used in a variety of experiments ranging from crystallization sequences to electrical properties. Ahrens et al. (1977ab) used 70215 to study the shock compression and dynamic properties of 70215. Their results implied that either previous mare cratering ages were overestimated, or that the integrated meteoroid influxes may have undergone an even sharper decline during the first

Table 4: Laser Ar-Ar data from 70215,182.
Data from Schaeffer et al. (1977). Units in 10^{-12} cm^3.

	Temp (°C)	^{40}Ar	^{39}Ar	^{38}Ar	^{37}Ar	^{36}Ar	^{40}Ar/^{39}r	Age (Ga)
Olivine	----	473.0±16.5	7.70±0.49	8.10±3.62	648.3±186.2	6.45±6.45	61.3±4.47	3.63±0.10
Pyroxene	----	830.2±15.4	12.74±0.57	12.39±4.60	1710.8±222.1	10.62±7.86	65.01±3.15	3.72±0.07
Plag-Px Aggregates	----	1145.9±28.9	18.46±0.74	12.37±5.58	1028.5±281.6	10.59±8.05	62.00±2.94	3.65±0.07
Armal-Ilm Intergrowth	----	714.9±25.6	11.02±0.66	10.81±6.26	593.2±362.2	11.07±7.86	64.64±4.53	3.72±0.10
Pyroxene	----	370.2±4.3	5.19±0.33	2.94±2.94	655.3±5.0	4.79±4.79	71.07±4.62	3.85±0.09
Pyroxene	600	516.5±5.1	7.56±0.14	2.32±1.47	854.9±4.3	3.63±2.87	68.16±1.46	3.78±0.04
Plag-Px Aggregates	600	444.0±5.5	6.47±0.17	2.83±1.47	624.9±3.7	10.39±2.40	67.86±2.13	3.78±0.05
Plag-Px Aggregates	600	799.0±8.3	11.35±0.20	2.94±2.94	1004.6±8.2	2.87±2.87	70.34±1.45	3.83±0.04
Armal-Ilm Intergrowth	600	738.7±8.1	10.56±0.31	3.36±1.57	866.2±8.4	4.79±4.79	69.81±2.19	3.82±0.05

1.5 Ga of lunar history than previously thought.

Mizutani and Osako (1974ab) analyzed elastic wave velocities and thermal diffusivities in 70215. These authors demonstrated the different thermal conductivities between highland and mare regions.

Tittman et al. (1975ab, 1976, 1978) reported the internal friction quality factor from 70215,85 under varying pressures. Results demonstrated the effect of adsorbed volatiles upon the internal friction quality factor (Q) and explains, in part, the differences between terrestrial and lunar seismic profiles through lack of adsorbed H_2O on the Moon.

Blank et al. (1981, 1984) used 70215,159 to examine the trace element partitioning between ilmenite and armalcolite, noting that Zr was preferentially partitioned into armalcolite. Other partitioning experiments were conducted on 70215 by Longhi et al. (1978) in order to determine the distribution of Fe and Mg between olivine and lunar basaltic liquids.

Longhi et al. (1974), Green et al. (1974, 1975ab), Walker et al. (1974, 1975ab), and O'Hara and Humphris (1975) used 70215 in melting experiments in order to determine source mineralogy, degree of partial melting, and post-melting evolution. Green et al. (1974, 1975ab) noted that at low pressures, olivine, armalcolite, and ilmenite are liquidus phases, whereas at high-pressures the high-Ti parental magma is not saturated with an Fe-Ti oxide phase. Longhi et al. (1974) concluded that 70215 can be generated by partial melting of an olivine + cpx + Fe-Ti oxide source at depths of 100-150 km.

Walker et al. (1974, 1975ab, 1976) concluded that the source region for titaniferous basalts was a late-stage ilmenite-rich cumulate produced from the residual liquid of the primordial differentiation of the outer portions of the Moon. According to this model, the ilmenite rich layer was sandwiched between the lunar feldspathic crust and a complementary cumulate.

MAGNETIC STUDIES

70215 has been used for a variety of magnetic studies. These have primarily concentrated upon: the intensity of, and changes in, ancient lunar magnetic fields (Cisowski et al., 1977; Collinson et al., 1975); remanent magnetism of specific lunar samples (Runcorn et al., 1974; Nagata et al., 1974b; Pearce et al., 1974b; Sugiura and Strangeway, 1980ab; Hargraves and Dorety, 1975;

Stephenson et al., 1974, 1975); Fe distribution and the metallic Fe - ferrous Fe ratio (Huffmann et al., 1974; Schwerer and Nagata, 1976); the effect of meteorite impact upon magnetic fields (Nagata etal., 1974a, 1975; Pearce et al., 1974a).

PROCESSING

To date, 26 thin sections have been made of 70215. These sample numbers are ,7-9, ,89, ,128, ,141-149, ,150-160, ,251. 70215,0 has been entirely subdivided, but 4487.4g of 70215,3 and 2769.0g of 70215,4 remain.

70255
High-Ti Mare Basalt
277.2 g, 5.5 x 3.5 x 3 cm; 7.5 x 5.5 x 4.5 cm

INTRODUCTION

70255 was described as a blocky, subangular, homogeneous, medium dark gray basalt, containing 1-2% of vugs up to 9mm diameter (Fig. 1). These vugs are lined by irregular mats of ilmenite needles with scarce plagioclase, olivine, and pyroxene crystals. 70255 broke into 70255,0 (larger) and 70255,1 (smaller - Fig. 2) during return to Earth. This sample was collected from the SEP station, approximately 115m east of the lunar module.

PETROGRAPHY AND MINERAL CHEMISTRY

Brown et al. (1975ab) described the petrography of 70255,27 as a Type IA Apollo 17 high-Ti basalt. Although this specific sample was only discussed within the general confines of this textural group, 70255 is a fine- to medium-grained, olivine porphyritic basalt. Modes determined by Brown et al. (1975a) indicate this sample is composed of: 5% olivine; 30.9% opaque minerals; 14.8% plagioclase; 47.7% clinopyroxene; and 1.6% silica.

During the preparation of this catalog, we studied thin sections 70255,28 and ,29. Pyroxene and plagioclase form "bow-tie" intergrowths (up to 0.5mm). Ilmenite (with chromite and rutile exsolution lamellae <0.005mm), rare armalcolite (with ilmenite rims), and Cr-spinel are obvious phenocryst phases (up to 0.9mm), but resorbed olivine phenocrysts (0.5mm) are also present with pyroxene reaction rims. Some

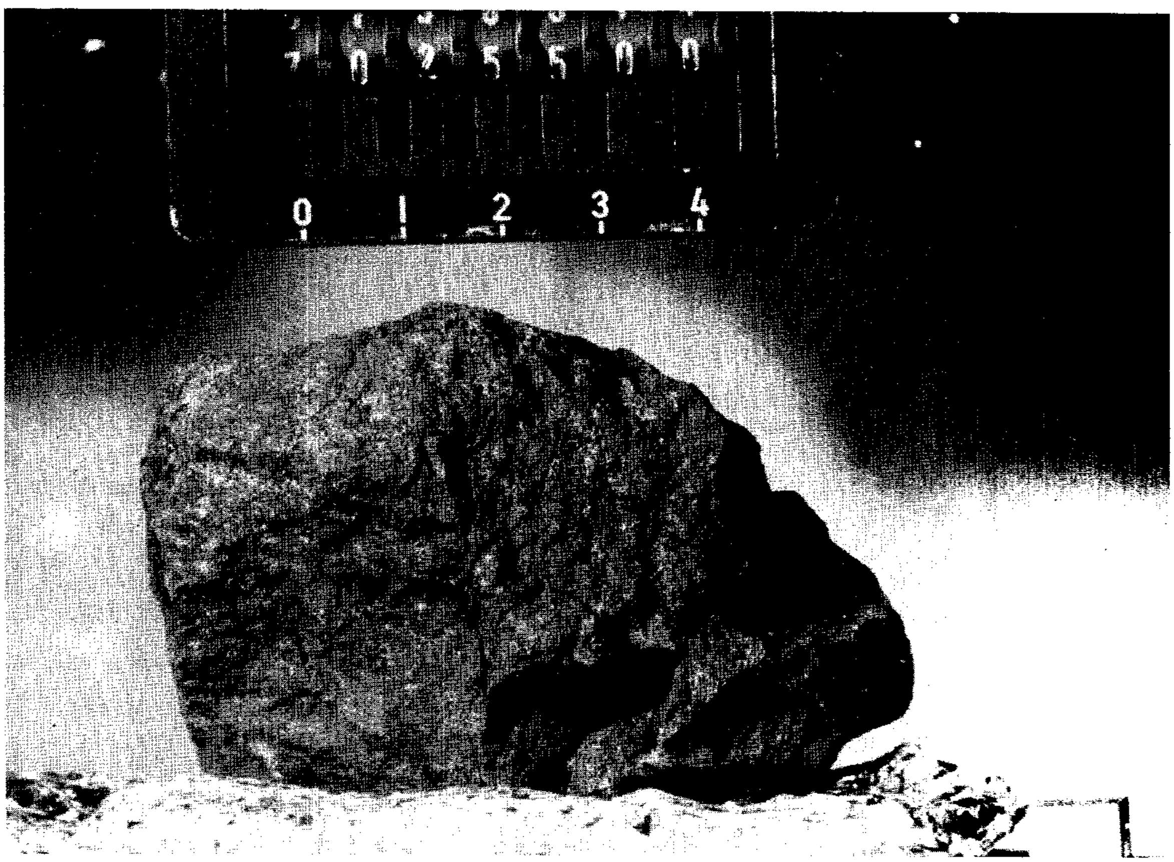


Figure 1: Hand specimen photograph of 70255,0.

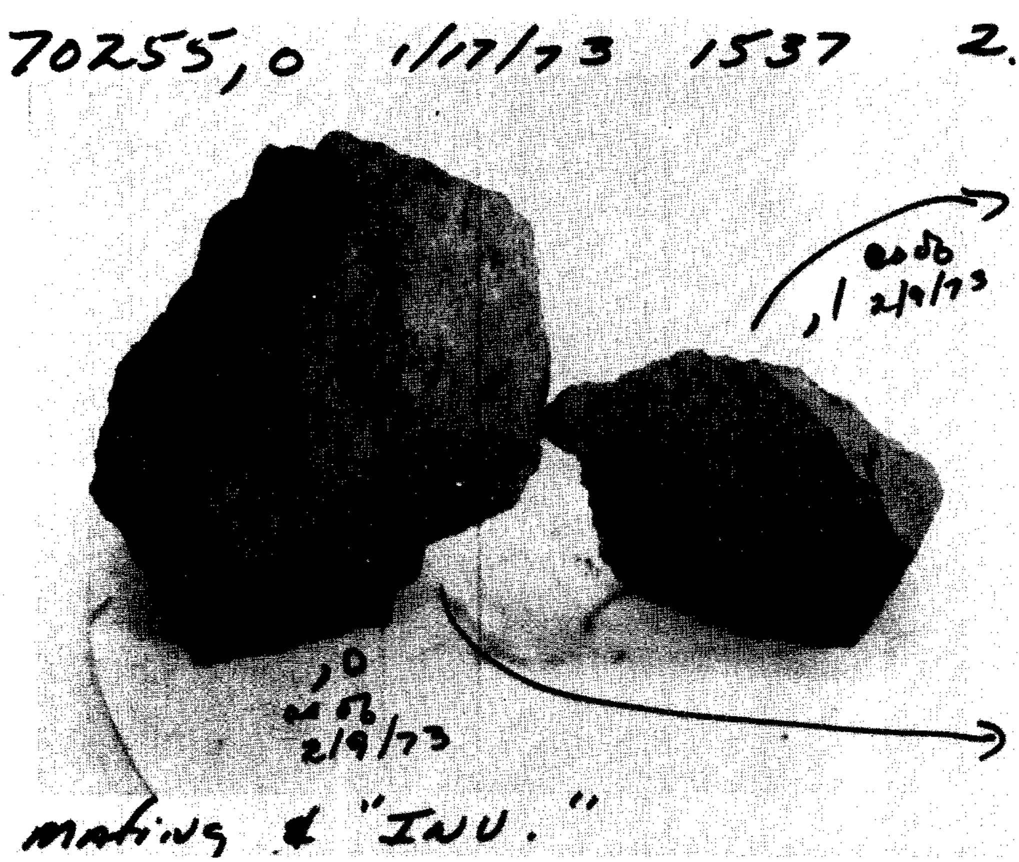


Figure 2: Subdivision of 70255,0.

olivines form small (< 0.1mm) cores to larger pyroxenes. The groundmass (0.1-0.3mm) is comprised of plagioclase, pyroxene, ilmenite, and silica. Native Fe and troilite form interstitial phases.

As with the petrography, the mineral chemistry of 70255 has only been discussed within the broad context of the Type IA group of Brown et al. (1975ab). Olivine compositions range from Fo_{68} to Fo_{75}, exhibiting minor core-to-rim zonation. Pyroxenes are generally calcic (titan-augite to augite), exhibiting Fe enrichment towards the margins. No pigeonite is present. Plagioclase exhibits only minor compositional variations (approximately An_{84-89}).

WHOLE-ROCK CHEMISTRY

The whole-rock chemistry of 70255 has been determined on sub-samples 70255,39 (Warner et al., 1975) and 70255,3 (Rhodes et al., 1976) (Table 1). The major elements are comparable, except the FeO value of Warner et al. (1975) is markedly elevated over that of Rhodes et al. (1976) (20.3 wt% and 18.73 wt%, resp.). 70255 is classified as a Type A Apollo 17 high-Ti basalt using the classification scheme of Rhodes et al. (1976) and Warner et al. (1979). Trace elements are also comparable, although the analysis of Warner et al. (1975) contains slightly lower abundances of the REE (Fig. 3). Both REE profiles are LREE-depleted with a slight enrichment of the MREE over the HREE (Fig. 3). The magnitude of the negative Eu anomaly measured by Rhodes et al. (1976) is slightly deeper than that of Warner et al. (1975) ($[Eu/Eu^*]_N$ = 0.48 and 0.52, resp.). The MREE reach ~ 50 times chondritic values. Hughes and Schmitt (1985) reported a Hf abundance of 9.6 ± 0.3 ppm for 70255,43 with a Zr/Hf ratio of 28.7 ± 3.3.

ISOTOPES

Nyquist et al. (1976ab) reported the present day Sr isotope composition of 70255,3 (Table 2). No age dating was undertaken and no initial $^{87}Sr/^{86}Sr$ ratio

Table 1: Whole-rock chemistry of 70255.

	,39 1 N	,3 2 X,N		,39 1 N	,3 2 X,N
SiO_2 (wt %)		40.11	Cu		
TiO_2	11.3	11.41	Ni		
Al_2O_3	9.1	9.02	Co	19.5	17.5
Cr_2O_3	0.376	0.34	V	76	
FeO	20.3	18.73	Sc	90	80
MnO	0.249	0.29	La	6.4	7.05
MgO	8.0	7.63	Ce		24.7
CaO	10.6	11.3	Nd		27.3
Na_2O	0.387	0.39	Sm	10.0	11.4
K_2O	0.077	0.04	Eu	2.20	2.23
P_2O_5		0.04	Gd		17.6
S		0.19	Tb		
Nb (ppm)			Dy	18	20.2
Zr			Er		12.1
Hf		9.7	Yb	10.0	11.8
Ta			Lu	1.4	1.48
U			Ga		
Th			F		
W			Cl		
Y			C		
Sr		199	N		
Rb		0.65	H		
Li		10.4	He		
Ba		85.3	Ge (ppb)		
Cs			Ir		
Be			Au		
Zn			Ru		
Pb			Os		

1 = Warner et al. (1975); 2 = Rhodes et al. (1976).

Analyses by: N = INAA; X = XRF.

Table 2: Sr isotope composition of 70255,3.
Data from Nyquist et al. (1976).

	70255,3
wt. (mg)	49
Rb (ppm)	0.652
Sr (ppm)	199
$^{87}Rb/^{86}Sr$	0.0095 + 3
$^{87}Sr/^{86}Sr$	0.69979 + 13
T_B	5.0 + 1.1
T_L	5.5 + 1.1

B = Model age relative to BABI
L = Model age relative to LUNI

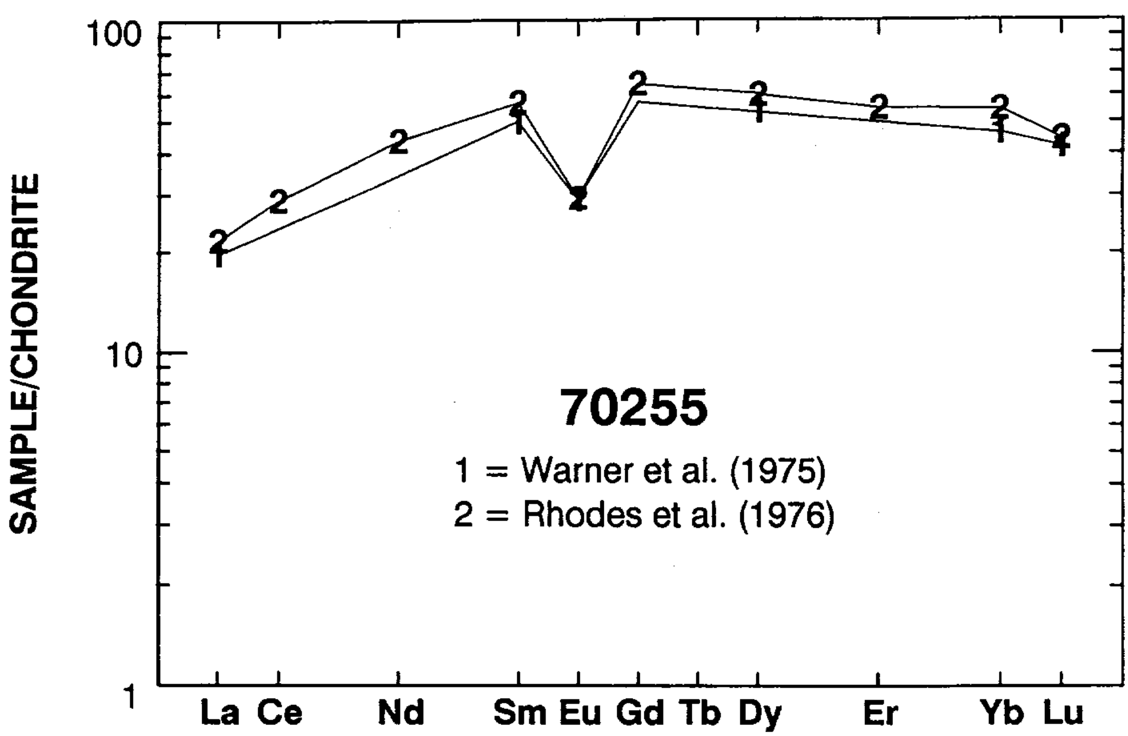


Figure 3: Chondrite-normalized rare-earth element profiles of 70255.

determined. No Sm-Nd or Pb isotope work has been undertaken on this sample. Schaeffer and Schaeffer (1977ab) determined the crystallization age of 70255,36 by $^{39}Ar/^{40}Ar$ dating technique. These authors report a crystallization plateau age of 3.84 + 0.02 Ga and a total K-Ar age of 3.67 + 0.01 Ga. No stable isotope work has been conducted upon 70255.

Analysis of cosmic ray induced radionuclides have been conducted by Keith et al. (1974ab), LSPET (1973), and Yokoyama et al. (1974). Abundances are reported in Table 3. Yokoyama et al. (1974) indicated that 70255 is unsaturated with respect to ^{26}Al.

EXPERIMENTAL

Usselman et al. (1975) used experiments which reproduced high-Ti basalt textures and mineralogies to calculate the cooling rate of 70255. These authors concluded that 70255 cooled at a rate of 2-5 °C per hour.

PROCESSING

Of the original 277.2g of 70255,0, a total of 224.9g remains. Most of the sub-samples used in research have come from 70255,1, which has now been entirely subdivided. Five thin sections have been made, the numbers being 70255,4-5 and ,27-29.

Table 3: Cosmic ray abundances in 70255.
Data from LSPET (1973) and Keith et al. (1974).

Th (ppm)	0.31 + 0.03
U (ppm)	0.107 + 0.008
K (%)	0.048 + 0.004
^{26}Al (dpm/kg)	49 + 6
^{22}Na (dpm/kg)	72 + 7
^{54}Mn (dpm/kg)	137 + 15
^{56}Co (dpm/kg)	211 + 19
^{46}Sc (dpm/kg)	63 + 6
^{48}V (dpm/kg)	< 30
Th/U	2.9
K/U	4500

70275
High-Ti Mare Basalt
171.4 g, 6.5 x 5.0 x 3.5 cm

INTRODUCTION

70275 was described as a medium gray to light brownish gray, intergranular, and blocky to subrounded basalt (Fig. 1), containing many zap pits on all surfaces and 2-3% vugs up to 2-3mm diameter (Apollo 17 Lunar Sample Information Catalog, 1973). The fabric is intergranular to plumose with a variable texture. All surfaces are weathered and finely lumpy. 70275 was collected approximately 10m south-east of the SEP station, 120m east of the Lunar Module.

PETROGRAPHY AND MINERAL CHEMISTRY

70275 was described as a Type IA Apollo 17 high-Ti basalt by Brown et al. (1975ab), who described this basalt as being comprised of: 13.8% olivine; 25.7% opaque minerals; 17.2% plagioclase; 45% clinopyroxene; and 1.7% silica. 70275 is a fine-grained basalt with olivine phenocrysts up to 1.5mm in diameter. All olivines exhibit a reaction with the groundmass, being embayed and sometimes with pyroxene overgrowths. These olivine phenocrysts are set in a groundmass of plagioclase and pyroxene which are intergrown into "bow-tie" structures and ilmenite (all range from 0.1-0.3mm). Areas of coarser grain size are present where olivine is diminished in size and contains larger overgrowths of pyroxene. The pyroxenes and plagioclase in

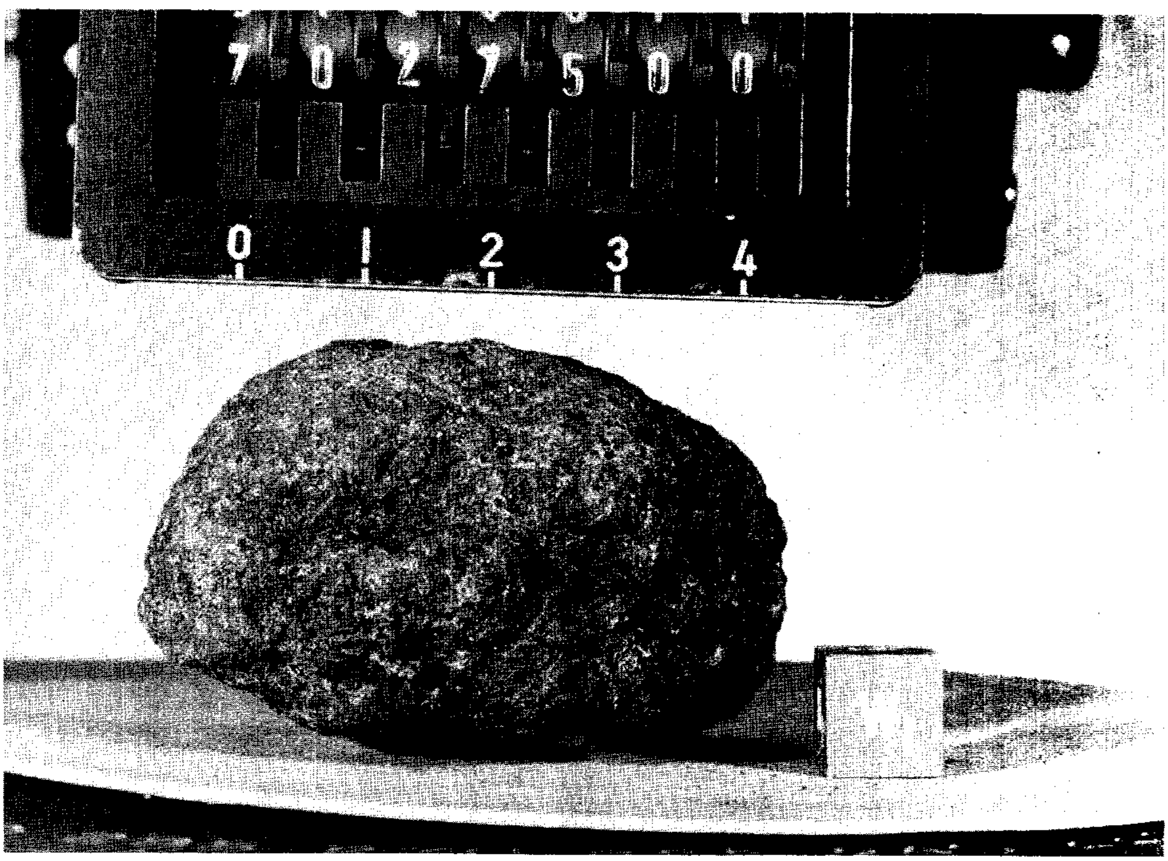


Figure 1: Hand specimen photograph of 70275,0.

these coarser areas reach up to 0.5mm. Ilmenite occurs either as a groundmass or phenocryst phase. Ilmenite laths have "sawtooth" margins, indicative of rapid cooling. No chromite or rutile exsolution is observed in the ilmenites. Cr-spinel is also present (0.1-0.2mm), but armalcolite is rare. Native Fe, troilite, and silica form interstitial phases.

Bell et al. (1975) described an olivine-spinel intergrowth from 70275. These authors noted that the olivines in 70275 contained minute (1-2μm) high-Cr grains, having a high index of refraction, occurring in straight or curved subparallel rows. These high-Cr grains are considered to decorate existing dislocations within the olivine. This type of intergrowth was termed "Type F" by Bell et al. (1975).

Brown et al. (1975ab) described the mineral chemistry of 70275 within the context of their Type IA basalts, not specifically mentioning this sample. From the general classification of Brown et al. (1975ab), olivines range from Fo_{70-80}, and pyroxenes are typically titan-augites containing up to 9.4 wt% Al_2O_3 and 8.5 wt% TiO_2. Little zonation is present within these clinopyroxenes. Cr-spinels, armalcolite, and ilmenite are generally homogeneous.

WHOLE-ROCK CHEMISTRY

Rhodes et al. (1976) reported the major element composition of 70275 (Table 1), noting that it contained 11.9 wt% TiO_2 and a MG# of 36.8. These authors described 70275 as a Type B Apollo 17 high-Ti basalt. This sample can be further classified as a Type B2 basalt using the criteria of Neal et al. (1990). Shih et al. (1975) reported the trace element contents of this basalt (Table 1). The REE profile (Fig. 2) is convex-upward with a negative Eu anomaly ($[Eu/Eu^*]_N = 0.47$). The MREE reach approximately 45-50 times chondritic values. Gibson et al. (1976ab) reported the sulfur abundance in 70275 as being 1850 ± 30 μg S/g.

ISOTOPES

The present day $^{87}Sr/^{86}Sr$ ratio of 70275 has been reported by Nyquist et al. (1975) (see Table 2). No age dating or other radiogenic isotope determinations have been conducted on this sample. Also, no stable isotope work has been carried out on 70275. Much of the isotope work undertaken on this basalt was concerned with cosmic-ray induced radionuclide abundances (Drozd et al., 1977; Keith et al., 1974ab; LSPET, 1973; Yokoyama et al., 1974) (Table 3). Drozd et al. (1977) reported an exposure age for 70275 of 109 ± 2 Ma and Yokoyama et al. (1974)

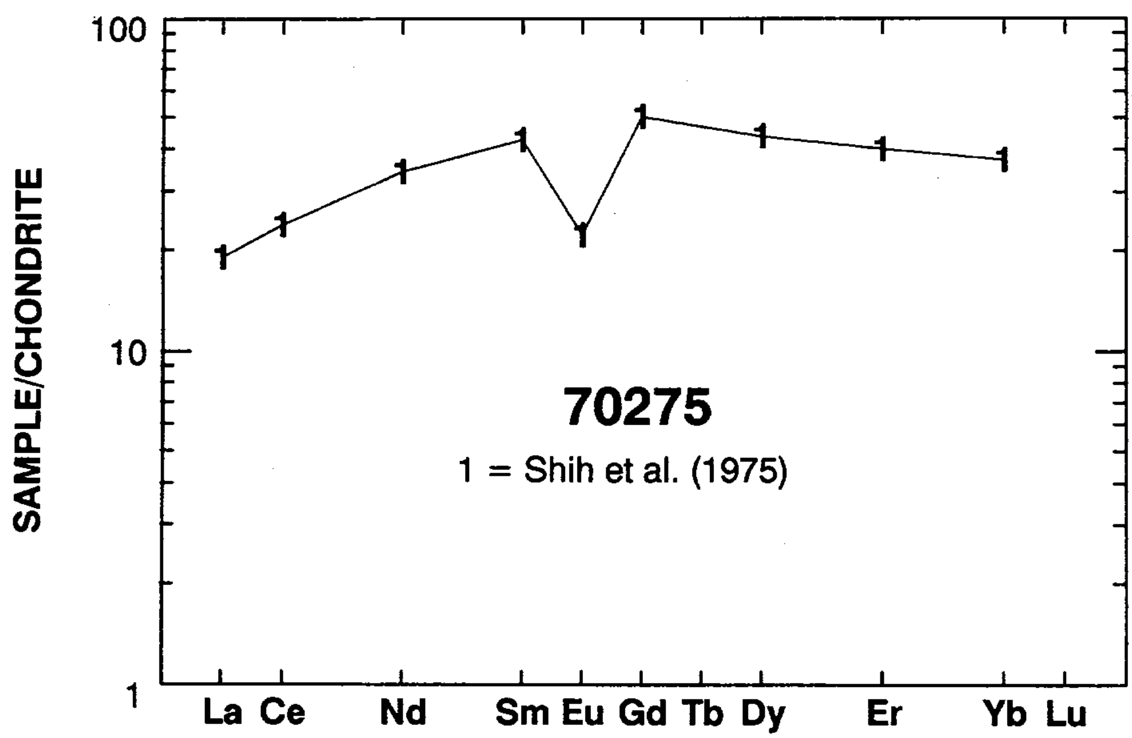


Figure 2: Chondrite-normalized rare-earth element profile of 70275.

Table 1: Whole-rock chemistry of 70275.

	,3 1 I,N	,3 2 X		,3 1 I,N	,3 2 X
SiO_2 (wt %)		39.37	Cu		
TiO_2		11.90	Ni		
Al_2O_3		10.23	Co	15.7	
Cr_2O_3		0.26	V		
FeO		18.61	Sc	85.0	
MnO		0.28	La	6.32	
MgO		6.09	Ce	20.8	
CaO		11.65	Nd	21.8	
Na_2O		0.38	Sm	8.75	
K_2O	0.04	0.06	Eu	1.73	
P_2O_5		0.08	Gd	14.0	
S		0.15	Tb		
Nb (ppm)			Dy	15.2	
Zr	219		Er	9.14	
Hf			Yb	8.3	
Ta			Lu		
U	0.14		Ga		
Th			F		
W			Cl		
Y			C		
Sr	153		N		
Rb	0.454		H		
Li	8.7		He		
Ba	73.5		Ge (ppb)		
Cs			Ir		
Be			Au		
Zn			Ru		
Pb			Os		

1 = Shih et al. (1975); 2 = Rhodes et al. (1976).

Analyses by: N = INAA; I = Isotope Dilution; X = XRF.

Table 2: Sr isotope composition of 70275.
Data from Nyquist et al. (1975).

	70275,3
wt. (mg)	50
Rb (ppm)	0.454
Sr (ppm)	153
$^{87}Rb/^{86}Sr$	0.0086 ± 3
$^{87}Sr/^{86}Sr$	0.69955 ± 6
T_B	3.7 ± 0.6
T_L	4.2 ± 0.6

B = Model age relative to BABI
L = Model age relative to LUNI

Table 3: Cosmic ray abundances 70275.

	1	2
Th (ppm)	0.42 ± 0.04	0.43 ± 0.04
U (ppm)	0.107 ± 0.008	0.120 ± 0.013
K (%)	0.0421 ± 0.0018	0.043 ± 0.006
^{26}Al (dpm/kg)	92 ± 9	91 ± 5
^{22}Na (dpm/kg)	90 ± 16	84 ± 5
^{54}Mn (dpm/kg)	190 ± 50	180 ± 30
^{56}Co (dpm/kg)	200 ± 20	220 ± 20
^{46}Sc (dpm/kg)	35 ± 4	83 ± 20
^{48}V (dpm/kg)	32 ± 15	32 ± 15
^{60}Co (dpm/kg)	0.17 ± 0.08	
Th/U	3.9 ± 0.5	3.6
K/U	3900 ± 300	3600

1 = LSPET (1973); 2 = Keith et al. (1974).

demonstrated that 70275 was saturated with respect to ^{26}Al.

EXPERIMENTAL

O'Hara and Humphries (1975) conducted melting and crystallization experiments upon 70275 in order to determine the phase chemistry. They noted that this sample crystallized plagioclase at a higher temperature, and native Fe at higher oxygen fugacities than any other previously analyzed Apollo 17 high-Ti basalt.

PROCESSING

Of the original 171.4g of 70275, 125.1g remains of 70275,0 and 28.96g of 70275,1. Most of the subdivisions have been carried out on 70275,2, ,6 (entirely subdivided), and ,7 (entirely subdivided). Eight thin sections have been made, their numbers being 70275,18 ,32-38.

70295
Dark Matrix Breccia
361.2 g, 12 x 6 x 4.8 cm

INTRODUCTION

70295 has been described as a homogeneous, wedge shaped, medium-gray breccia (Fig. 1a), with B mostly glass coated and fresh (Fig. 1b). The fabric is clastic. Zap pits are present on all faces except B (Apollo 17 Lunar Sample Information Catalog, 1973). B is mostly glass coated and partly fresh. There is a slickensided smooth surface near the E end, whereas N, S, E, and W are rounded. No cavities are visible, but low density of 70295 indicates the presence of abundant fine pores. The Apollo 17 Lunar Sample Information Catalog (1973) described 70295 as being comprised of 90% medium gray matrix, 6% lithic clasts, 2% plagioclase, and 2% of yellow,green, and brown mafic clasts. 70295 was collected from the SEP station, approximately 110m east of the Lunar Module.

PETROGRAPHY AND MINERAL CHEMISTRY

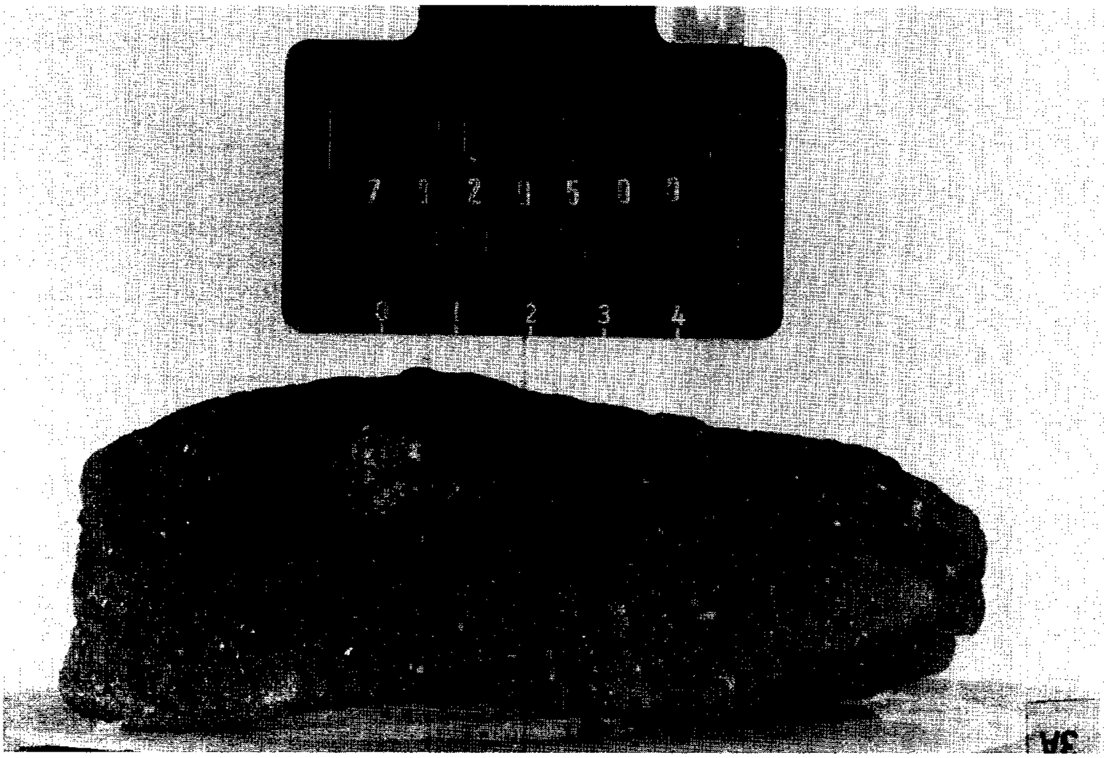
Neither the petrography or mineral chemistry of this sample has been reported. However, Shearer et al. (1991) analyzed individual glass beads from 70295,5 and 70295,26 using a secondary ion mass spectrometer (SIMS). They report VLT, orange Type-I, orange Type-II, and orange 74220-Type glasses in 70219.

WHOLE-ROCK CHEMISTRY

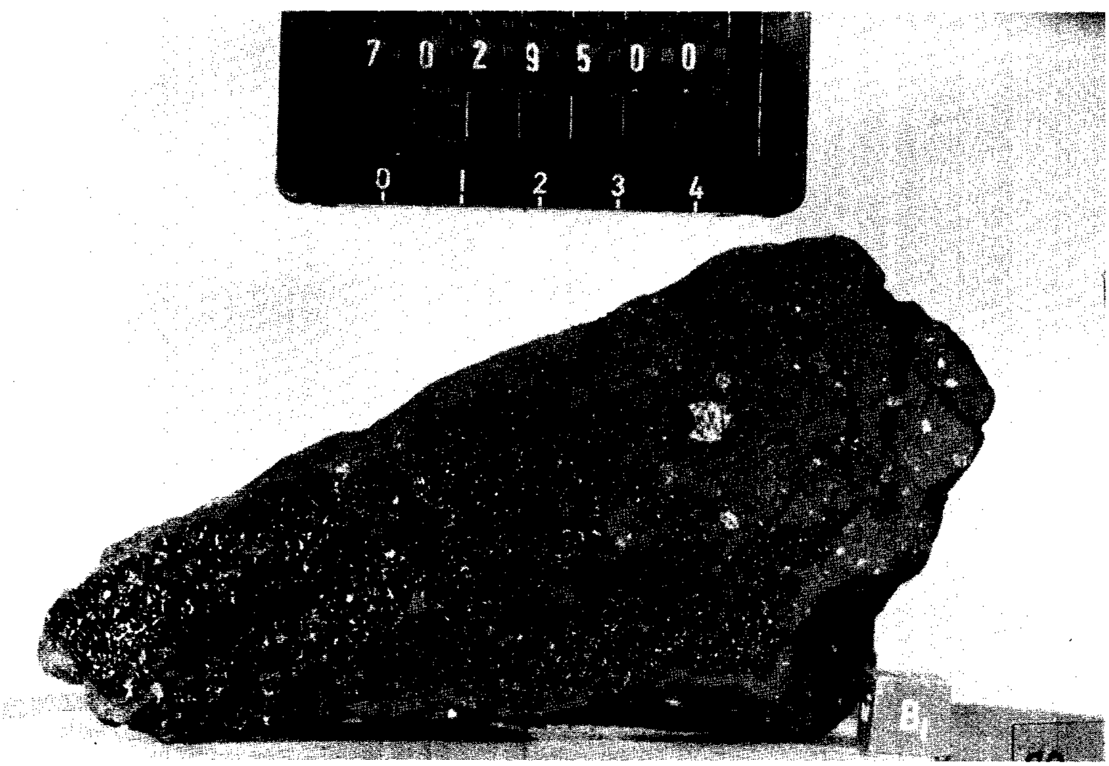
Only the abundance of nitrogen has been determined for 70295, although the results have been somewhat ambiguously reported (Carr et al., 1985). These authors state that this breccia has low total N contents.

ISOTOPES

Carr et al. (1985) reported the nitrogen isotopic composition of 70295 as being $\delta^{15}N_{air} \sim +10$ to -30 o/oo. Yields were only in the 35% range, although Carr et al. (1985) suggested 70295 exhibits a hint of light nitrogen.



1a: Photograph of the "N" surface of 70295,0.



1b: Photograph of the "B" surface of 70295,0.

Figure 1: Hand specimen photographs of 70295,0.

70315
High-Ti Mare Basalt
148.6 g, 5 x 4.5 x 4.5 cm

INTRODUCTION

70315 was described as a white, black, and brown high-Ti mare basalt (Apollo 17 Lunar Sample Information Catalog, 1973), with 5-10% vugs (up to 1cm diameter) homogeneously distributed throughout (Fig. 1). The fabric is primarily intergranular with local development of glomeroporphyritic clots of pyroxene and ilmenite - the largest is 3mm. This basalt was collected from LRV 12.

PETROGRAPHY AND MINERAL CHEMISTRY

70315 was described as a Type IB Apollo 17 high-Ti basalt by Brown et al. (1975ab), composed of: 0.7% olivine; 25.5% opaque minerals; 22.0% plagioclase; 50.6% clinopyroxene; 0.6% silica; and 0.6% mesostasis. These authors described the petrography and mineral chemistry within the general context of Type IB basalts, without specifically mentioning 70315.

In the preparation of this catalog, we examined thin section 70315,27. This basalt is coarse grained (2-3mm), with ilmenite (up to 0.5mm) and rare armalcolite (~ 0.1mm) included in pyroxene (up to 1.2mm), and plagioclase (2-3mm) poikilitically including all other minerals. Occasionally, pyroxene and plagioclase are intergrown forming "bow-tie" structures (Fig. 2). Ilmenite may also be interstitial. Small (<0.1mm), rare olivines form the cores of pyroxenes. Silica, native Fe, and troilite form interstitial phases.

WHOLE-ROCK CHEMISTRY

Ma et al. (1979) and Warner et al. (1979) reported the same whole-rock analysis for 70315,10. This basalt was classified as a Type U by Warner et al. (1979). 70315 contains 13.1 wt% TiO_2 (Table 1) with a MG# of 49.9. The REE profile (Fig. 3) is LREE depleted with the HREE reaching ~ 25 times chondritic values. There is a negative Eu anomaly present ($[Eu/Eu^*]_N = 0.67$). Garg and

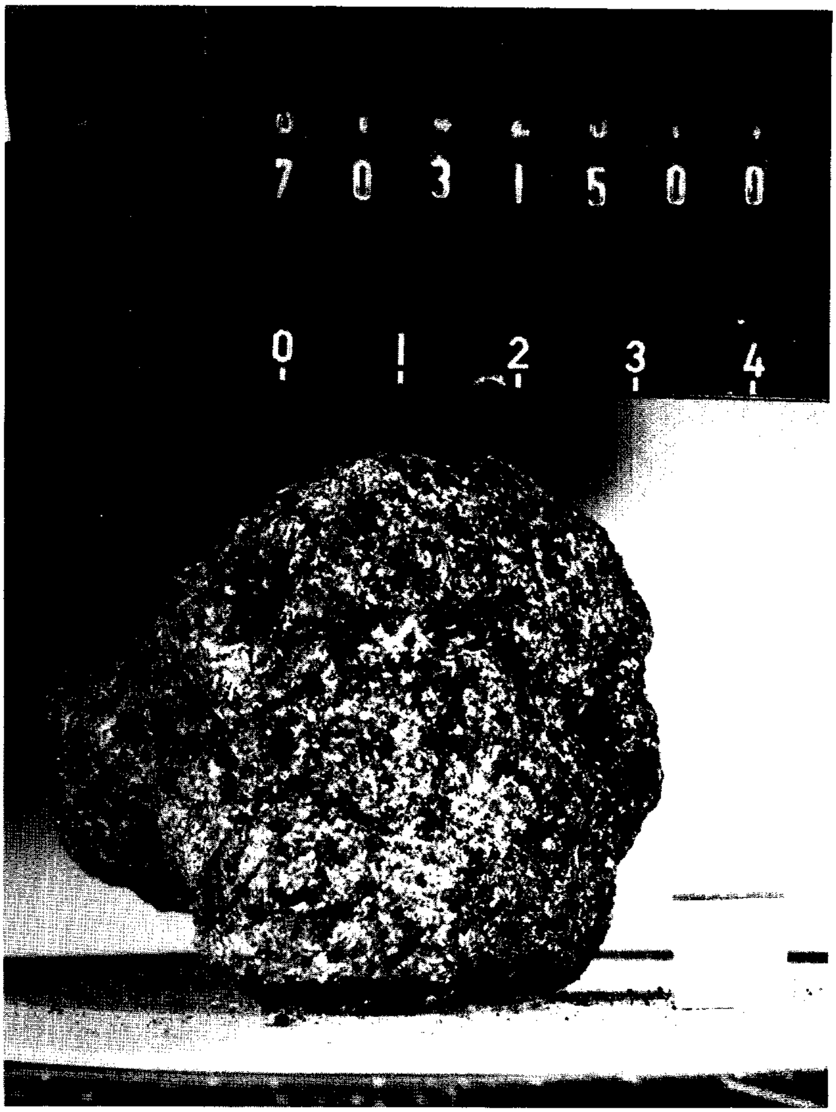


Figure 1: Hand specimen photograph of 70315,0.

Figure 2: Photomicrograph of 70315,14. Field of view is 2.5 mm.

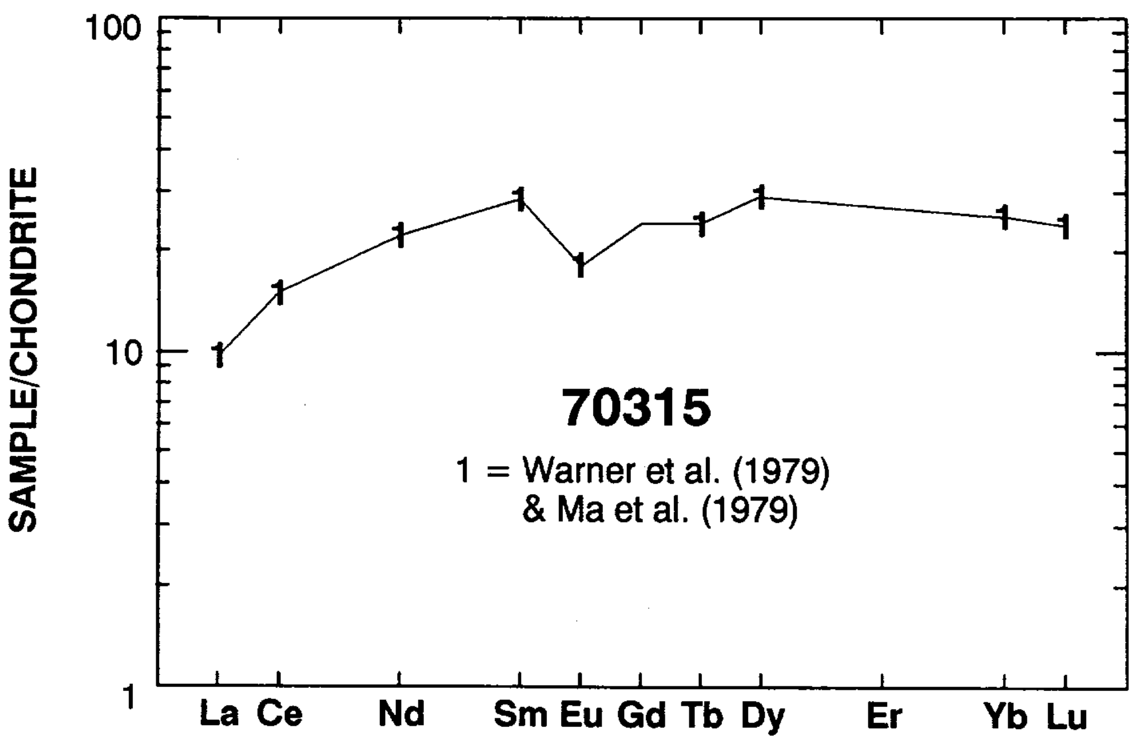


Figure 3: Chondrite-normalized rare-earth element profile of 70315.

Table 1: Whole-rock chemistry of 70315.
Data from Ma et al. (1979) and Warner et al. (1979) (same analysis).

	70315,10 I		70315,10 I
SiO_2 (wt %)		Cu	
TiO_2	13.1	Ni	
Al_2O_3	9.3	Co	20
Cr_2O_3	0.547	V	148
FeO	17.9	Sc	81
MnO	0.240	La	3.2
MgO	10	Ce	13
CaO	10.2	Nd	14
Na_2O	0.387	Sm	5.8
K_2O	0.039	Eu	1.40
P_2O_5		Gd	
S		Tb	1.4
Nb (ppm)		Dy	10
Zr		Er	
Hf	5.7	Yb	5.6
Ta	1.3	Lu	0.81
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

I = Analysis by INAA.

Ehmann (1976) reported Zr (~ 205 ppm) and Hf (~ 8 ppm) contents of 70315. The Hf abundance reported by these authors is ~ 2 ppm greater than that reported by Warner et al. (1979) and Ma et al. (1979).

ISOTOPES

Only cosmic-ray induced radionuclide abundances (Table 2) have been determined for 70315 (Eldridge et al., 1975ab). No radiogenic or stable isotope studies have been undertaken on this sample.

PROCESSING

Of the original 148.6g, 131.5g of 70315,0 remains. Four thin sections have been made (70315,14, ,26-28) and two irradiations for INAA (70315,4 and ,10). The largest subsample of 70315,0 is 70315,3, which has in turn been extensively subdivided.

Table 2: Cosmogenic radionuclide and radioelement abundances of 70315.
Data from Eldridge et al. (1975ab).

Th (ppm)	0.27+0.02
U (ppm)	0.10+0.01
K (ppm)	400+20
^{22}Na	82+8
^{26}Al	67+8
^{54}Mn	165+10
Th/U	2.70+0.34
K/U	4000+450

71035
High-Ti Mare Basalt
144.8 g, 8 x 5 x 2.5 cm

INTRODUCTION

71035 was described as a medium gray, intergranular, medium-grained porphyritic basalt, containing up to 40% subrounded to irregular vugs (Fig. 1) ranging from 0.2-1cm diameter (Apollo 17 Lunar Sample Information Catalog, 1973). The predominant mineral in these vugs is ilmenite. The fabric is medium-grained/porphyritic. B and S are fresh, T, N, E, and W are rounded and dusty. Zap pits are sparse and only found on T, N, E, and W. This basalt was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

Brown et al. (1975ab) described 71035 as a Type IB in their classification of Apollo 17 high-Ti mare basalts. They reported modes of this sample as: 1.4% olivine; 23.6% opaque minerals; 23.7% plagioclase; 47.5% clinopyroxene; and 3.8% silica. These authors described the texture and mineral chemistry of 71035 within the general confines of their textural groups, not specifically mentioning this sample. However, during the preparation of this catalog, we examined thin sections 71035,26 and ,28, finding it to be a medium- to coarse-grained plagioclase poikilitic basalt. Pyroxenes reach 1mm and plagioclase 1.5-2mm. Occasional olivine cores (< 0.1mm) are present in pyroxene. Rare armalcolite inclusions (~ 0.1mm) are seen in the pyroxene. Ilmenite (up to 0.5mm) is interstitial and

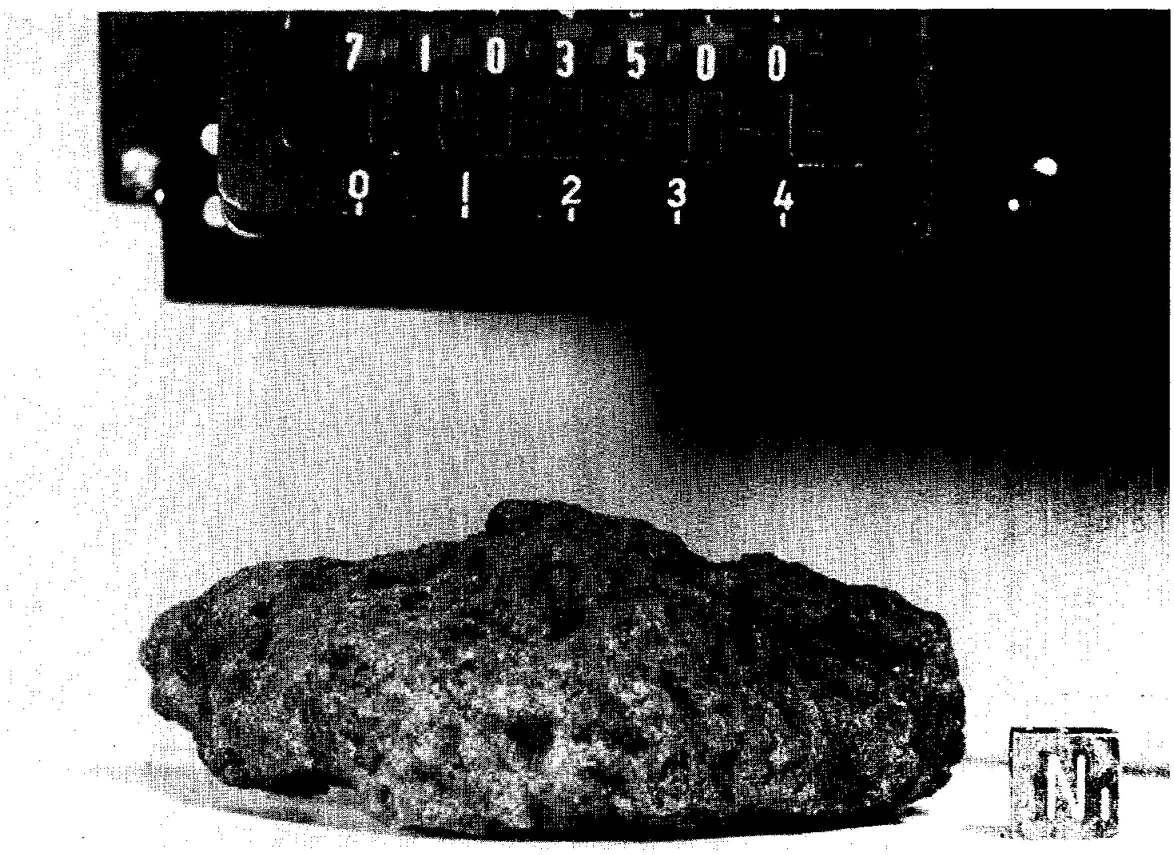


Figure 1: Hand specimen photograph of 71035,0.

blocky. Silica (up to 0.3mm), native Fe, and troilite form interstitial phases.

Brown et al. (1975ab) have only reported pyroxene compositions for 71035. These range from titan-augite to pyroxferroite. No pigeonite is present.

WHOLE-ROCK CHEMISTRY

The whole-rock chemistry of 71035 was reported by Rhodes et al. (1976) (Table 1). These authors noted that 71035 contained 13.1 wt% TiO_2 with a MG# of 41.9 and described it as a Type B Apollo 17 high-Ti basalt. 71035 can be further classified as a Type B2 basalt using the criteria of Neal et al. (1990). The REE profile (Fig. 2) is LREE-depleted, but the HREE are depleted relative to the MREE, giving the profile a convex-upward aspect. A negative Eu anomaly is present ($[Eu/Eu^*]_N = 0.49$). Gibson et al. (1976ab) reported sulfur abundances in 71035 as 1660 µgS/g with an equivalent wt% of Fe^o of 0.132%. Hughes and Schmitt (1985) reported Zr (29.9 ppm) and Hf (6.5 ppm) abundances in 71035.

ISOTOPES

Nyquist et al. (1976) reported the whole-rock Sr isotopic composition of 71035 (Table 2). No Sm-Nd or Pb or stable isotope work has been undertaken on this sample. Other reported isotopic abundances are concerned with cosmic-ray induced radionuclides (LSPET, 1973; Rancitelli et al., 1974; Yokoyama et al., 1974).

PROCESSING

Little work has been undertaken on this basalt. Of the original 144.8g, only 3 g has been used having 141.8g of 71035,0. Three thin sections have been made - 71035,28-30.

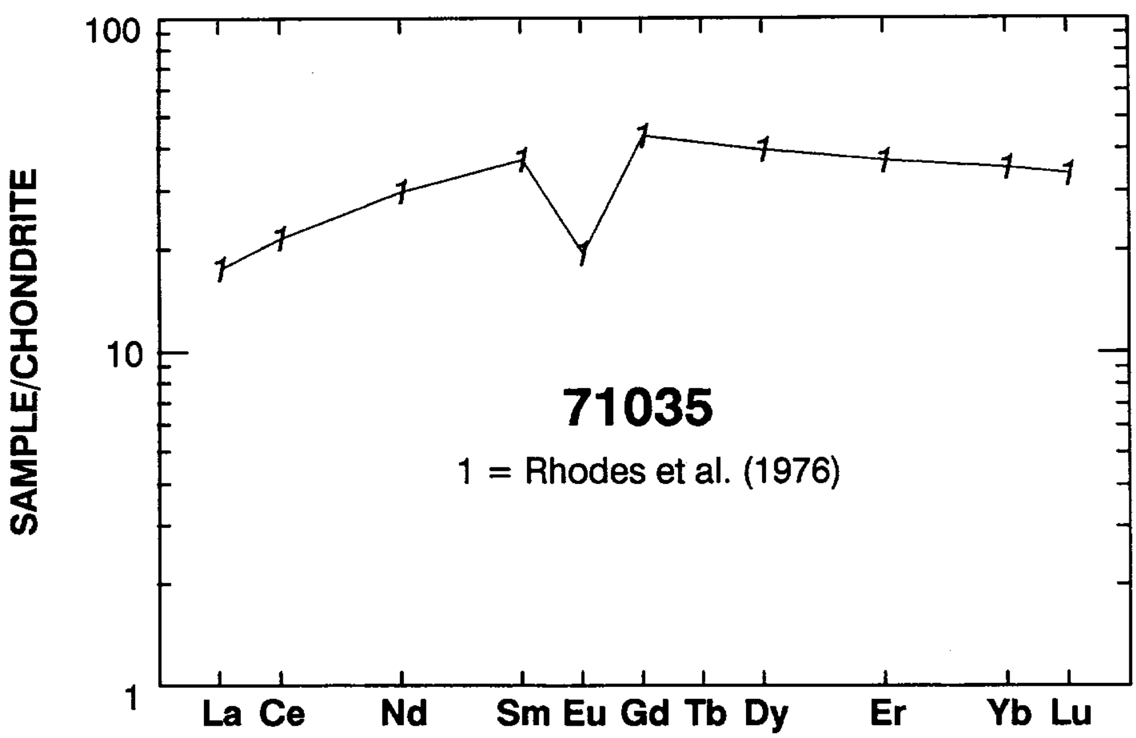


Figure 2: Chondrite-normalized rare-earth element profile of 71035.

Table 1: Whole-rock chemistry of 71035.
Data from Rhodes et al. (1976).

	71035,4 X,I		71035,4 X,I
SiO_2 (wt %)	38.25	Cu	
TiO_2	13.06	Ni	
Al_2O_3	8.77	Co	19.0
Cr_2O_3	0.39	V	
FeO	19.74	Sc	87
MnO	0.29	La	5.77
MgO	7.98	Ce	18.7
CaO	10.87	Nd	18.8
Na_2O	0.38	Sm	7.50
K_2O	0.03	Eu	1.50
P_2O_5	0.10	Gd	12.1
S	0.39	Tb	
Nb (ppm)		Dy	13.6
Zr		Er	8.27
Hf	7.0	Yb	7.71
Ta		Lu	1.14
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr	130	N	
Rb	0.41	H	
Li	7.6	He	
Ba	66.3	Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Table 2: Sr isotope composition of 71035.
Data from Nyquist et al. (1976).

	71035,4
wt. (mg)	50
Rb (ppm)	0.406
Sr (ppm)	130
$^{87}Rb/^{86}Sr$	0.0090 ± 4
$^{87}Sr/^{86}Sr$	0.69967 ± 5
T_B	4.42 ± 0.59
T_L	4.99 ± 0.59

B = Model age relative to BABI
L = Model age relative to LUNI

Table 3: Cosmogenic radionuclide and radioelement abundances of 71035,0.

	1	2
Th (ppm)	0.32 ± 0.06	0.36 ± 0.03
U (ppm)	0.11 ± 0.02	0.096 ± 0.011
K (ppm)	460 ± 100	200 ± 20
^{26}Al (dpm/kg)	37 ± 8	79 ± 3
^{22}Na (dpm/kg)	45 ± 9	92 ± 4
^{54}Mn (dpm/kg)	42 ± 10	164 ± 15
^{56}Co (dpm/kg)	59 ± 20	279 ± 14
^{46}Sc (dpm/kg)	30 ± 10	87 ± 5
^{60}Co (dpm/kg)		<4.6
Th/U	2.9 ± 0.8	4.00
K/U	4200 ± 1200	2450

1 = LSPET (1973); 2 = Rancitelli et al. (1974).

71036
High-Ti Mare Basalt
118.4 g, 8.5 x 3 x 4 cm

INTRODUCTION

71036 was described as a medium-grained porphyritic, medium dark gray, intergranular basalt (Apollo 17 Lunar Sample Information Catalog, 1973), containing 30% vugs of irregular shape (0.5-5mm long) (Fig. 1). These vugs contain euhedral crystals of ilmenite, pyroxene, rare olivine, and plagioclase up to 1mm long. A few zap pits are present on all surfaces. S, T, and E are fresh fractures, W is a partly exposed surface and partly chipped; B is exposed. This sample was probably collected from the same boulder as 71035, at Station 1A, although the nature of the vugs are distinctly different.

PETROGRAPHY AND MINERAL CHEMISTRY

No thin section has been taken from this basalt.

WHOLE-ROCK CHEMISTRY

The whole-rock chemistry has not been determined for 71036.

PROCESSING

No work has been carried out on 71036. Therefore, 118.4g remains of 71036,0. However, it is in "cold-storage" in a refrigerator at JSC.

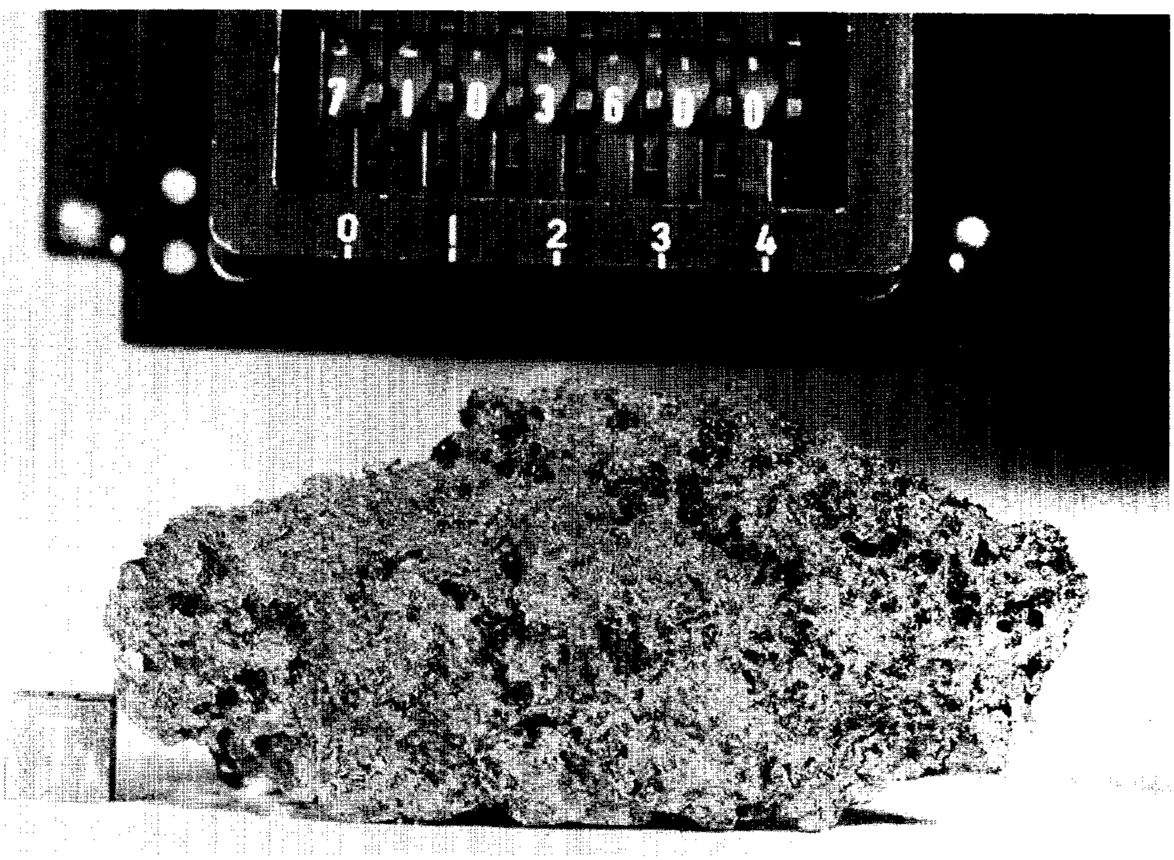


Figure 1: Hand specimen photograph of 71036,0.

71037
High-Ti Mare Basalt
14.39 g, 2.5 x 2 x 2 cm

INTRODUCTION

71037 was described as a homogeneous, medium-grained, porphyritic, medium dark gray, intergranular basalt (Apollo 17 Lunar Sample Information Catalog, 1973), containing irregular vugs up to 5mm long (Fig. 1). The large vugs are concentrated in one zone. All surfaces are dusty, having been exposed at the lunar surface. Generally, this basalt is similar to 71035 and 71036. 71037 was collected from Station 1A, near 71035 and 71036.

PETROGRAPHY AND MINERAL CHEMISTRY

The general petrography and mineral chemistry of 71037 has been described by Warner et al. (1979) within the confines of their whole-rock classification. 71037 was not mentioned specifically. During the preparation of this catalog, we examined thin section 71037,5 and found it to contain ilmenite and olivine phenocrysts (up to 2mm) set in a groundmass of pyroxene, plagioclase, ilmenite, and rare Cr-spinel (Fig. 2). Armalcolite is also rare. Ilmenites exhibit "sawtooth" margins, indicative of rapid cooling. Olivines contain very few pyroxene overgrowths. Plagioclase and pyroxene are intergrown into "bowtie" structures. Small (< 0.1mm), euhedral chromite inclusions are present in the olivine phenocrysts. Apollo 17 Lunar Sample Information Catalog (1973) states that 71037 is comprised of 35% plagioclase, 45% pyroxene, 20% ilmenite, and < 1% olivine.

WHOLE-ROCK CHEMISTRY

The whole-rock chemistry has been reported by Ma et al. (1979) and Warner et al. (1979). These authors have published the same analysis (Table 1). 71037 was described as a Type B Apollo 17 high-Ti basalt by Warner et al. (1979). 71037 is further classified as a Type B2 basalt using the criteria of Neal et al. (1990). This basalt contains 11.2 wt% TiO_2 with a MG# of

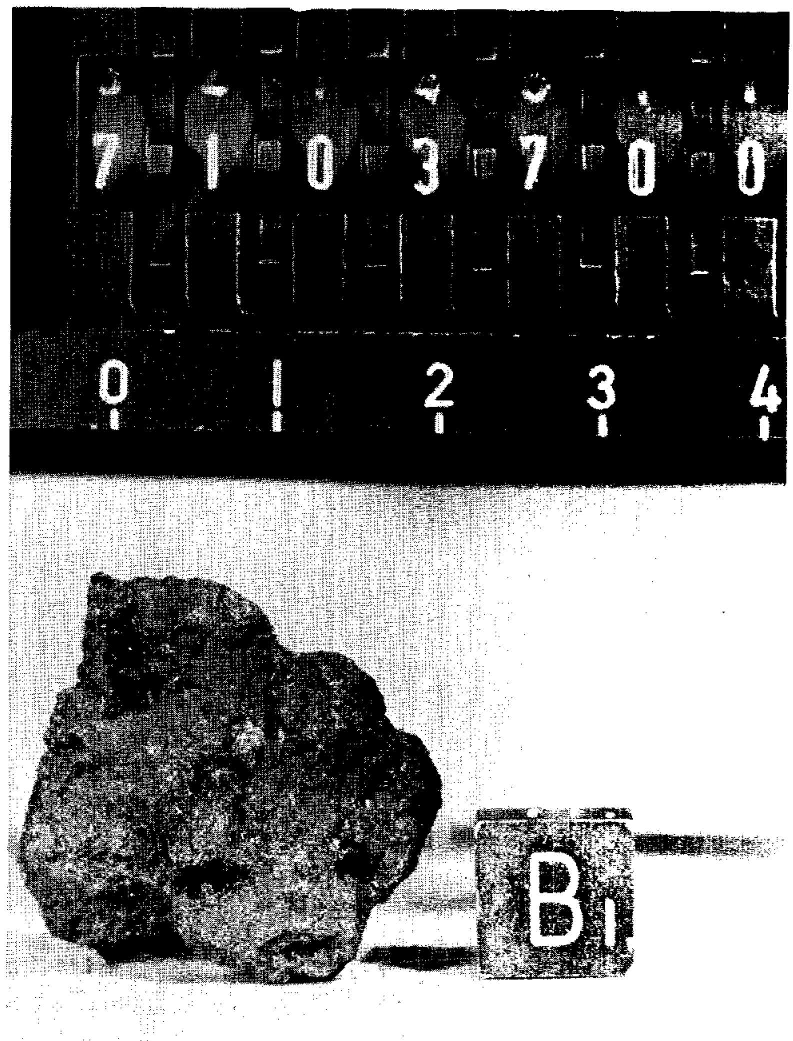


Figure 1: Hand specimen photograph of 71037,0.

Figure 2: Photomicrograph of 71037,5 showing olivine phenocrysts and variolitic texture. Field of view is 2.5 mm.

39.1. The REE profile (Fig. 3) is LREE-depleted, with approximately constant MREE and HREE values at 30-35 times chondritic values. A negative Eu anomaly is present ($[Eu/Eu^*]_N = 0.56$).

PROCESSING

Of the original 14.39g of 71037,0, only 13.78g remains. 71037,1 was irradiated for INAA, and 71037,5 is a thin section taken from this irradiated sample.

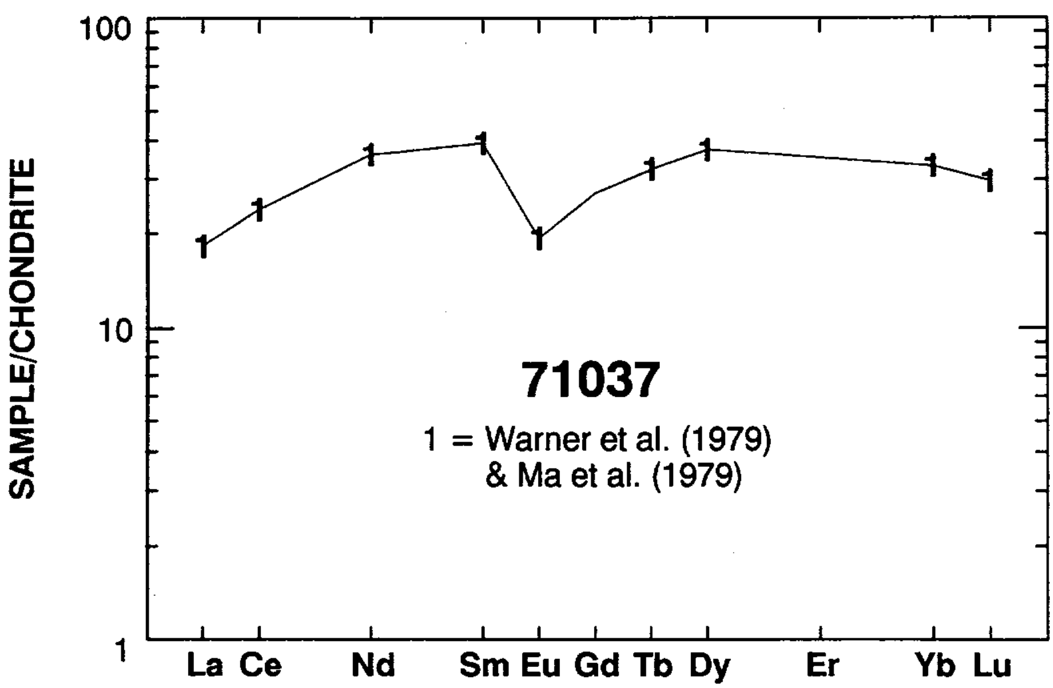


Figure 3: Chondrite-normalized rare-earth element profile of 71037.

Table 1: Whole-rock chemistry of 71037.
Data from Ma et al. (1979) and Warner et al. (1979) (same analysis).

	71037,1 I		71037,1 I
SiO_2 (wt %)		Cu	
TiO_2	11.2	Ni	
Al_2O_3	8.9	Co	20
Cr_2O_3	0.310	V	73
FeO	19.4	Sc	85
MnO	0.246	La	6.1
MgO	7	Ce	21
CaO	11.2	Nd	23
Na_2O	0.425	Sm	8.1
K_2O	0.046	Eu	1.51
P_2O_5		Gd	
S		Tb	1.9
Nb (ppm)		Dy	13
Zr		Er	
Hf	7.0	Yb	7.4
Ta	1.7	Lu	1.02
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

I = analysis by INAA.

71045
High-Ti Mare Basalt
11.92 g, 2.5 × 2 × 1.5 cm

INTRODUCTION

71045 was described as a medium dark gray (with brownish tint), poikilitic, intergranular basalt (Fig. 1), containing 5% vugs (2-7mm diameter) (Apollo 17 Lunar Sample Information Catalog, 1973). Minerals projecting into these vugs are scarce. 71045 has a blocky to subangular shape with a poikilitic fabric. No zap pits are present. This basalt was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1979) reported the mineralogy and petrography of Warner et al. (1979) reported the mineralogy and petrography of 71045 within the general confines of their whole-rock classification (see below). However, 71045 was not specifically mentioned. This sample is a plagioclase poikilitic basalt (Fig. 2), with plagioclase reaching 3mm and pyroxene 2mm. Ilmenite (up to 1mm) is blocky and interstitial (Fig. 2). Rare ilmenite-free armalcolite and Cr ulvöspinel inclusions (~ 0.1mm) are present in pyroxene. Silica, native Fe, and troilite are interstitial phases. Olivine is only found as small (< 0.05mm) cores in pyroxene. The Apollo 17 Lunar Sample Information Catalog (1973) states that 71045 is comprised of 30-35% plagioclase, ~40% pyroxene, 15-20% opaque minerals, 5-10%

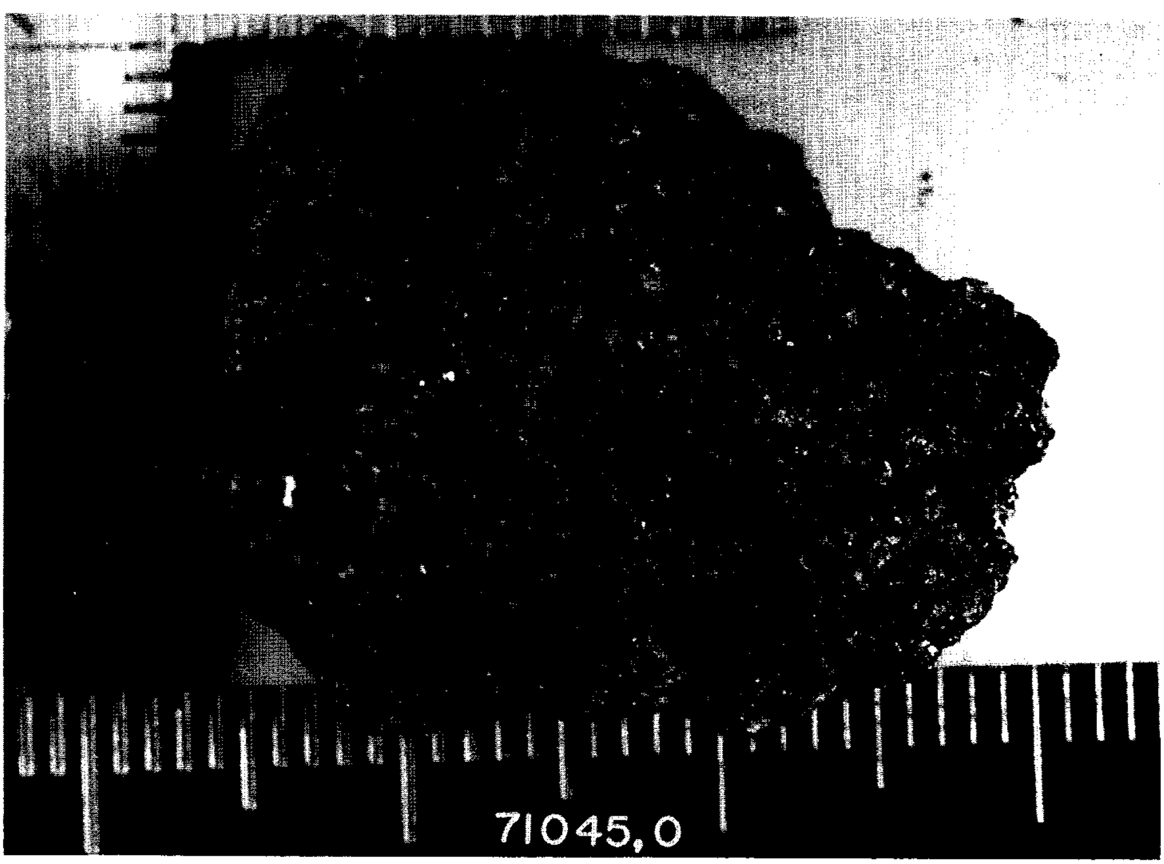


Figure 1: Hand specimen photograph of 71045,0.

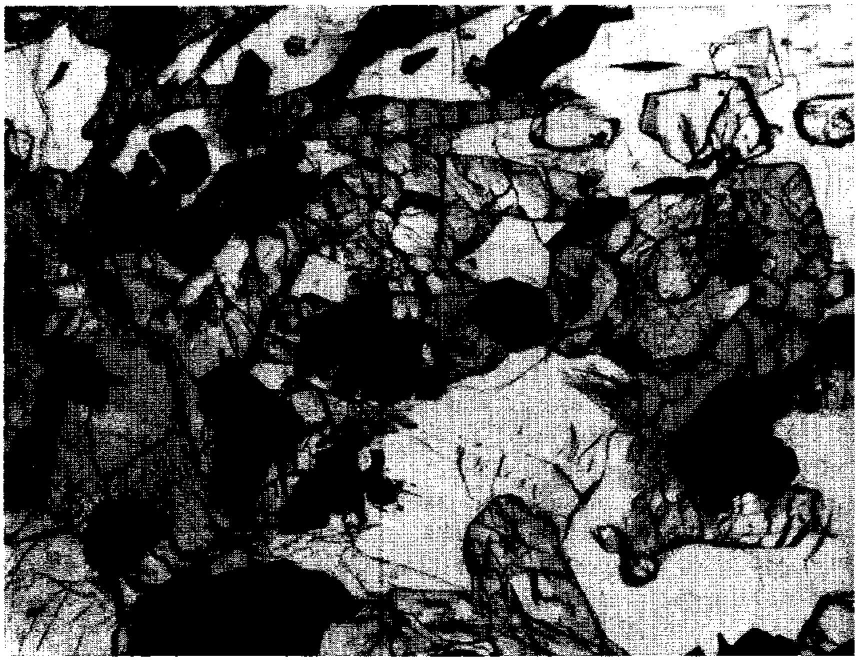


Figure 2: Photomicrographs of 71045,3. Field of view is 2.5 mm.

ilmenite-pyroxene "clots", 1% silica, and < 1% olivine.

WHOLE-ROCK CHEMISTRY

Both Ma et al. (1979) and Warner et al. (1979) report the same whole-rock analysis for 71045 (Table 1). 71045 contains 12.7 wt% TiO_2 with a MG# of 48.9 (Warner et.al., 1979). The REE profile (Fig. 3) is LREE-depleted with flat HREE at approximately 25-30 times chondritic levels. A negative Eu anomaly is present ($[Eu/Eu^*]_N = 0.67$).

PROCESSING

Of the original 11.92g of 71045,0, 11.43g remains. 71045,1 was irradiated for INAA, and 71045,3 is a thin section taken from this irradiated sample.

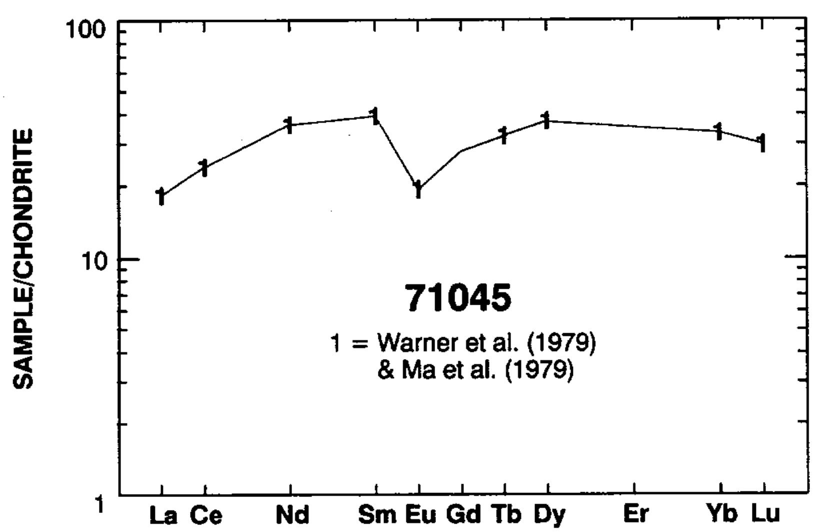


Figure 3: Chondrite-normalized rare-earth element profile of 71045.

Table 1: Whole-rock chemistry of 71045.
Data from Ma et al. (1979) and Warner et al. (1979) (same analysis).

	71045,1 I		71045,1 I
SiO_2 (wt %)		Cu	
TiO_2	11.2	Ni	
Al_2O_3	8.9	Co	20
Cr_2O_3	0.310	V	73
FeO	19.4	Sc	85
MnO	0.246	La	6.1
MgO	7	Ce	21
CaO	11.2	Nd	23
Na_2O	0.425	Sm	8.1
K_2O	0.046	Eu	1.51
P_2O_5		Gd	
S		Tb	1.9
Nb (ppm)		Dy	13
Zr		Er	
Hf	7.0	Yb	7.4
Ta	1.7	Lu	1.02
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Eu	
Pb		Os	

71046
High-Ti Mare Basalt
3.037 g, 2 x 1.5 x 0.5 cm

INTRODUCTION

71046 is a medium dark gray (with a brownish tint) basalt possessing a subangular, slabby shape and an equigranular fabric (Apollo 17 Lunar Sample Information Catalog, 1973) (Fig. 1). Zap pits are present on all faces, in variable numbers. 71046 also contains 2-3% vugs 1-2 mm in diameter. It was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

Ma et al. (1979) described 71046 as an olivine-microporphyritic basalt. During the preparation of this catalog, thin section 71046,5 was examined. 71046,5 is a fine- to medium-grained (0.2-0.4 mm) interlocking basalt with minor "bow-tie" intergrowths of plagioclase and pyroxene. It is dominated by pink, blocky pyroxene (up to 0.6mm) with interstitial ilmenite phenocrysts (up to 1 mm) (Fig. 2). Occasional exsolution of chromite and rutile are seen in the larger ilmenites. Ragged olivines occasionally form cores to these pyroxenes, and rare corroded olivine phenocrysts (up to 0.8 mm) are present. No armalcolite or Cr-ulvöspinel was identified. Minor interstitial phases, SiO_2, native Fe, and troilite (< 0.1mm), are disseminated throughout. The Apollo 17 Lunar Sample Information Catalog (1973) stated that 71046 is comprised of < 1% olivine, 35% plagioclase, 45-50% pyroxene, 10-15% opaque minerals, a trace of silica, and < 5% "brown clots" of regular-shaped intergrown ilmenite and pyroxene. Although 71046 has been studied by Ma et al. (1979) and Warner et al. (1979), the mineral chemistry of this sample was not specifically presented.

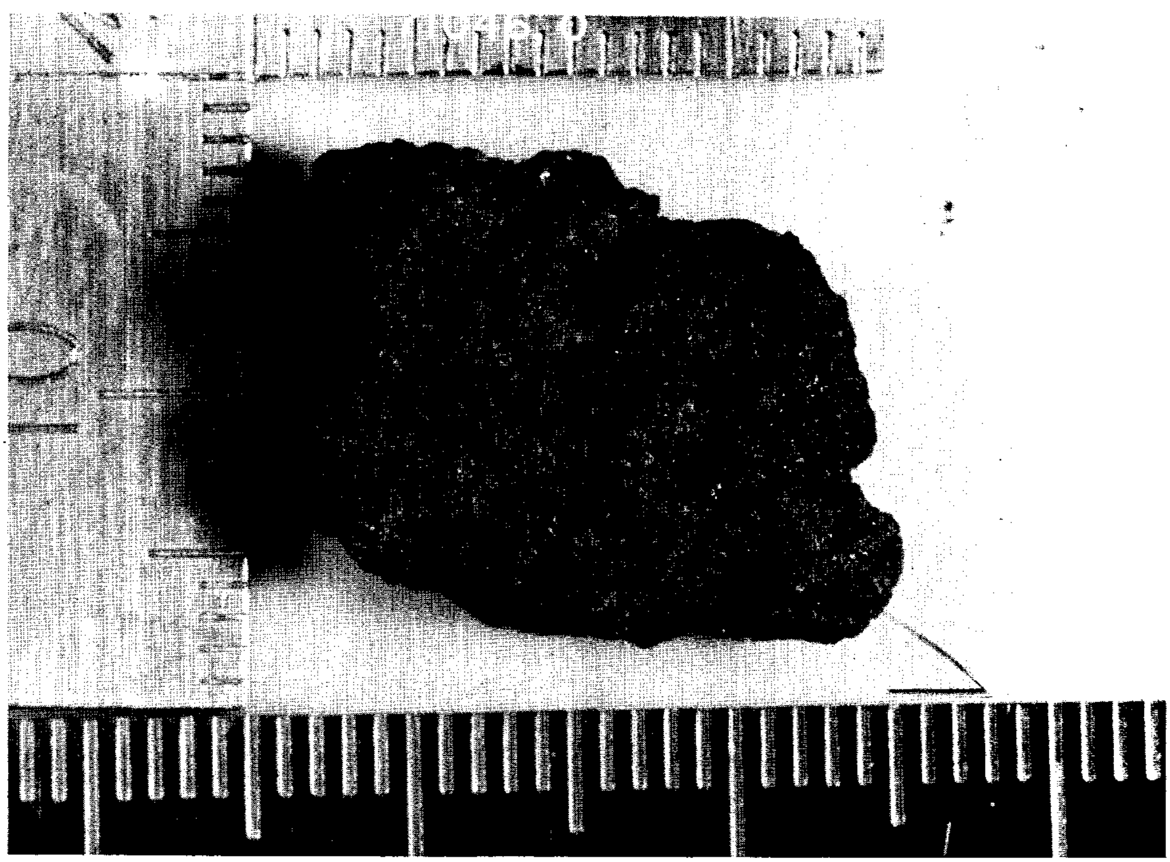


Figure 1: Hand specimen photograph of 71046,0.

Figure 2: Photomicrograph of 71046,5. Field of view is 2.5 mm.

WHOLE-ROCK CHEMISTRY

Both Ma et al. (1979) and Warner et al. (1979) report the same whole-rock analysis for 71046 (Table 1). This sample is classified as a Type B1 Apollo 17 high-Ti basalt using the whole-rock classification of Rhodes et al. (1976) and Warner et al. (1979), plus the criteria of Neal et al. (1990). 71046 contains 11.6 wt% TiO_2 with a MG# of 42.7 (Warner et al., 1979; Ma et al., 1979). The REE profile (Fig. 3) is LREE depleted with flat HREE at approximately 34 times chondritic abundances. A negative Eu anomaly is present ($[Eu/Eu^*]_N = 0.60$).

PROCESSING

Of the original 3.037g of 71046,0, 2.43g remains. 71046,1 was irradiated for INAA, and thin section 71046,5 was taken from this irradiated sample.

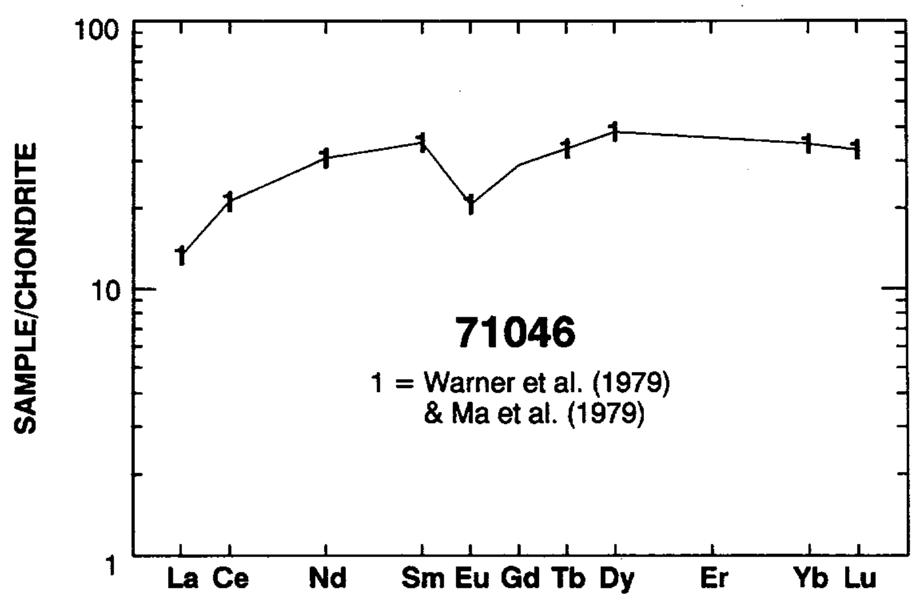


Figure 3: Chondrite-normalized rare-earth element profile of 71046.

Table 1: Whole-rock chemistry of 71046.
Data from Ma et al. (1979) and Warner et al. (1979) (same analysis).

	71046,1 I		71046,1 I
SiO_2 (wt %)		Cu	
TiO_2	11.6	Ni	
Al_2O_3	8.9	Co	19
Cr_2O_3	0.407	V	109
FeO	19.1	Sc	83
MnO	0.256	La	4.3
MgO	8	Ce	18
CaO	10.2	Nd	19
Na_2O	0.320	Sm	7.0
K_2O	0.04	Eu	1.56
P_2O_5		Gd	
S		Tb	1.9
Nb (ppm)		Dy	13
Zr		Er	
Hf	6.7	Yb	7.5
Ta	1.5	Lu	1.10
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

I = analysis by INAA.

71047

High-Ti Mare Basalt
2.78 g, 1.75 × 1 × 0.75 cm

INTRODUCTION

71047 was described as a light brownish gray, poikilitic, equigranular basalt (Apollo 17 Lunar Sample Information Catalog, 1973), containing no vugs or zap pits (Fig. 1). The surfaces are hackly and the fabric equigranular to poikilitic. 71047 has a blocky/subangular shape. This sample was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

Neal et al. (1989) described 71047 as a plagioclase poikilitic basalt, with plagioclase reaching 3.4mm and pyroxene 2.2mm. Rare inclusions of ilmenite-free armalcolite and Cr-spinel (both ~0.1mm) can be found in pyroxene. Olivine (~ 0.1mm) forms cores to pyroxene. Ilmenite is blocky and interstitial, containing exsolution lamellae (<0.005mm) of spinel chromite and rutile. Silica, native Fe, and troilite are interstitial phases. Point counting reveals that this basalt is comprised of: 48.2% pyroxene; 26.3% plagioclase; 21.7% ilmenite; 1.8% native Fe and troilite; 0.9% silica; 0.4% Cr-spinel; and 0.2% armalcolite.

Olivine exhibits little core-to-rim variation, but large compositional variations are noted between grains (Fo_{49-73}). Likewise, plagioclase exhibits a relatively large overall compositional range (An_{74-89}), but also some core-to-rim zonation (rims more sodic). Pyroxene compositions are titan-augite and pigeonite, both zoning to more Fe-rich, intermediate compositions (Fig. 2). Al/Ti ratios are constant at ~2 and Cr_2O_3 decreases with decreasing pyroxene MG#. Cr-spinels exhibit little compositional variability (Cr/(Cr+Al) = 66-68; MG# = 24-25), as does armalcolite (MG# = 43-45). Ilmenite exhibits moderate core-to-rim

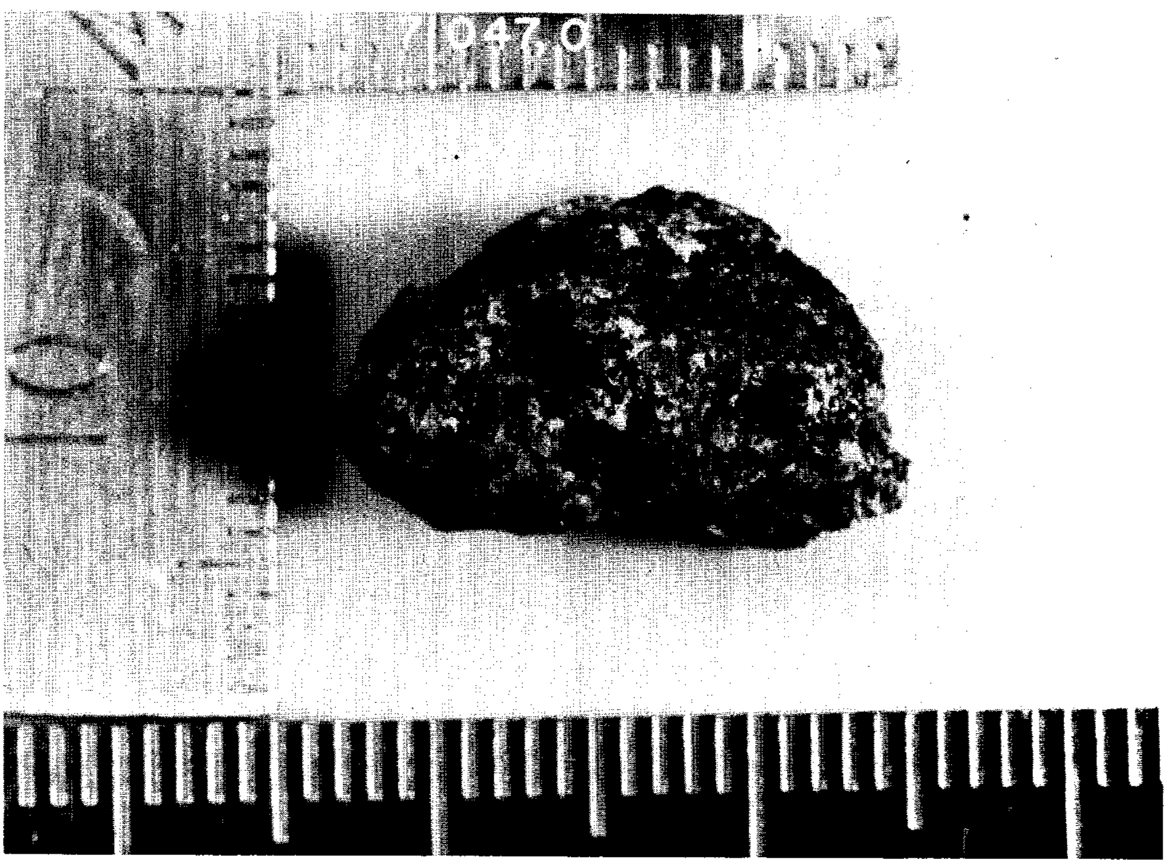


Figure 1: Hand specimen photograph of 71047,0.

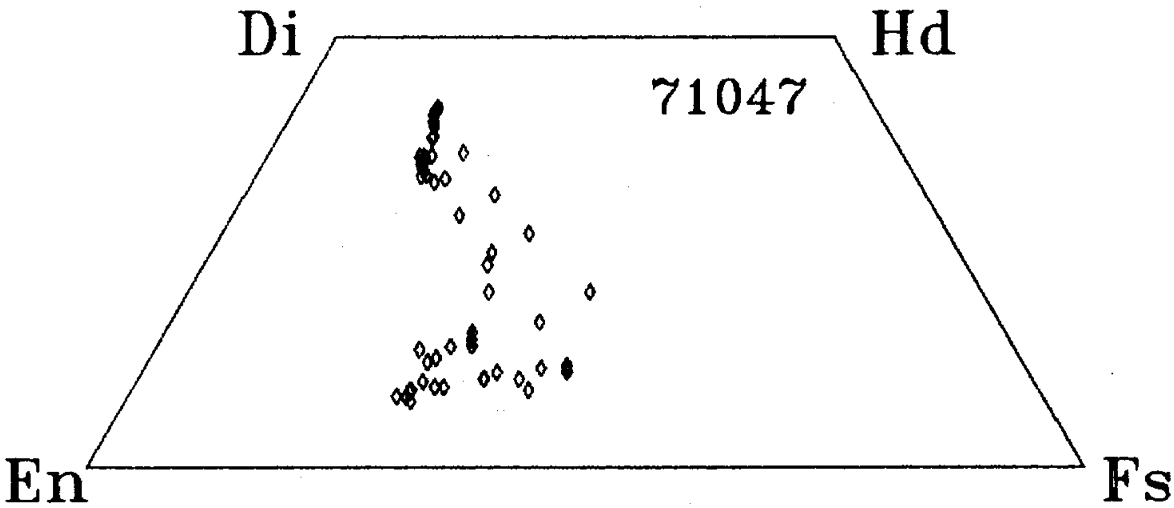


Figure 2: Pyroxene compositions of 71047 represented on a pyroxene quadrilateral.

and between-grain compositional variability (MG# = 7-29).

WHOLE-ROCK CHEMISTRY

Neal et al. (1990) classified 71047 as a Type B1 Apollo 17 high-Ti basalt. This basalt contains 12.9 wt% TiO_2 with a MG# of 46.7 (Table 1). The REE profile (Fig. 3) is LREE-depleted with a slight depletion of the HREE over the MREE. MREE attain ~ 45 times chondritic values and a negative Eu anomaly is present ($[Eu/Eu^*]_N$ = 0.60).

PROCESSING

Of the original 2.78g of 71047,0, approximately 2.01g remains. 0.69g was used for INA analysis, and 0.01g was used for thin section 71047,3.

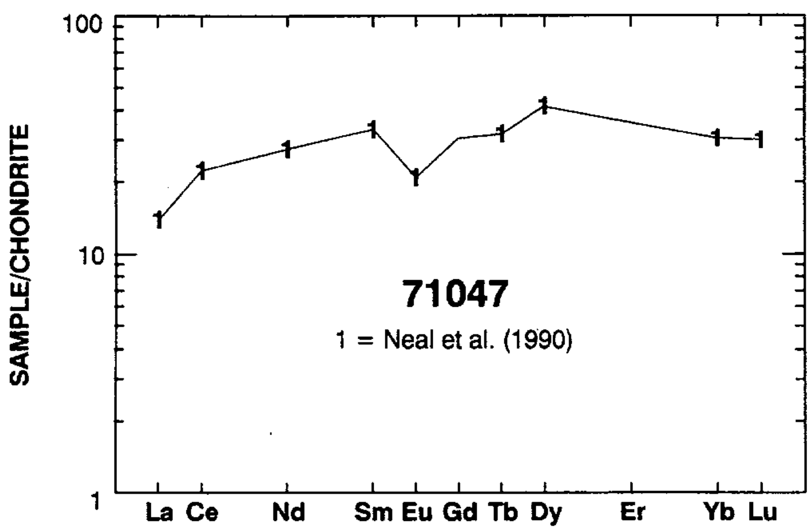


Figure 3: Chondrite-normalized rare-earth element profile of 71047.

Table 1: Whole-rock chemistry of 71047.
Data from Neal et al. (1990).

	71047,4 I		71047,4 I
SiO_2 (wt %)		Cu	
TiO_2	12.9	Ni	
Al_2O_3	8.52	Co	25
Cr_2O_3	0.258	V	132
FeO	17.8	Sc	76
MnO	0.238	La	4.46
MgO	8.8	Ce	19
CaO	9.8	Nd	17
Na_2O	0.39	Sm	6.65
K_2O	0.04	Eu	1.58
P_2O_5		Gd	
S		Tb	1.82
Nb (ppm)		Dy	14.1
Zr	136	Er	
Hf	6.64	Yb	6.61
Ta	.73	Lu	1.00
U	0.20	Ga	
Th	0.19	F	
W		Cl	
Y		C	
Sr	61	N	
Rb		H	
Li		He	
Ba	53	Ge (ppb)	
Cs	0.19	Ir	
Be		Au	
Zn		Eu	
Pb		Os	

I = Analysis by INAA.

71048
High-Ti Mare Basalt
2.457 g, 1.25 × 1 × 0.5 cm

INTRODUCTION

71048 was described as a medium dark gray, fine-grained basalt (Apollo 17 Lunar Sample Information Catalog, 1973), containing no zap pits and 1-2% of 1-2mm diameter vugs (Fig. 1) lined with ilmenite. It has an equigranular fabric and surfaces are very finely hackly. This sample was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

Neal et al. (1989) described 71048 as a fine-grained, subvariolitic, olivine porphyritic basalt containing anhedral pyroxene (< 0.2mm) and plagioclase (< 0.4mm) in the groundmass. Pyroxene and plagioclase form "bow-tie" textures. Olivine (0.4mm) and ilmenite (1.8mm) phenocrysts occur. Olivine exhibits some degree of reaction with the groundmass, although pyroxene overgrowths are not well developed. Ilmenite contains "sawtooth" margins, with no exsolved phases present. Ilmenite also forms a groundmass phase. No armalcolite is present. Cr-ulvöspinel occurs as inclusions in olivine and pyroxene. Native Fe and troilite are interstitial phases. Point counting reveals that this basalt is comprised of: 39.5% pyroxene; 20.4% plagioclase; 28.4% ilmenite; 7.5% olivine; 2.8% native Fe and troilite; 0.9% glass; and 0.4% spinel.

Olivine exhibits minor core-to-rim zonation (Fo_{66-63}), as does plagioclase (An_{86-78}). The first pyroxenes to crystallize were titan-augites which are zoned toward more Fe-rich compositions (Fig. 2). No pigeonite is present (Fig. 2). Al/Ti ratios are constant at ~2, and Cr_2O_3 abundances decrease as pyroxene MG# decreases. Spinels exhibit moderate core-to-rim zonation (Cr/(Cr + Al) = 70-78; MG# = 6-9), but ilmenite

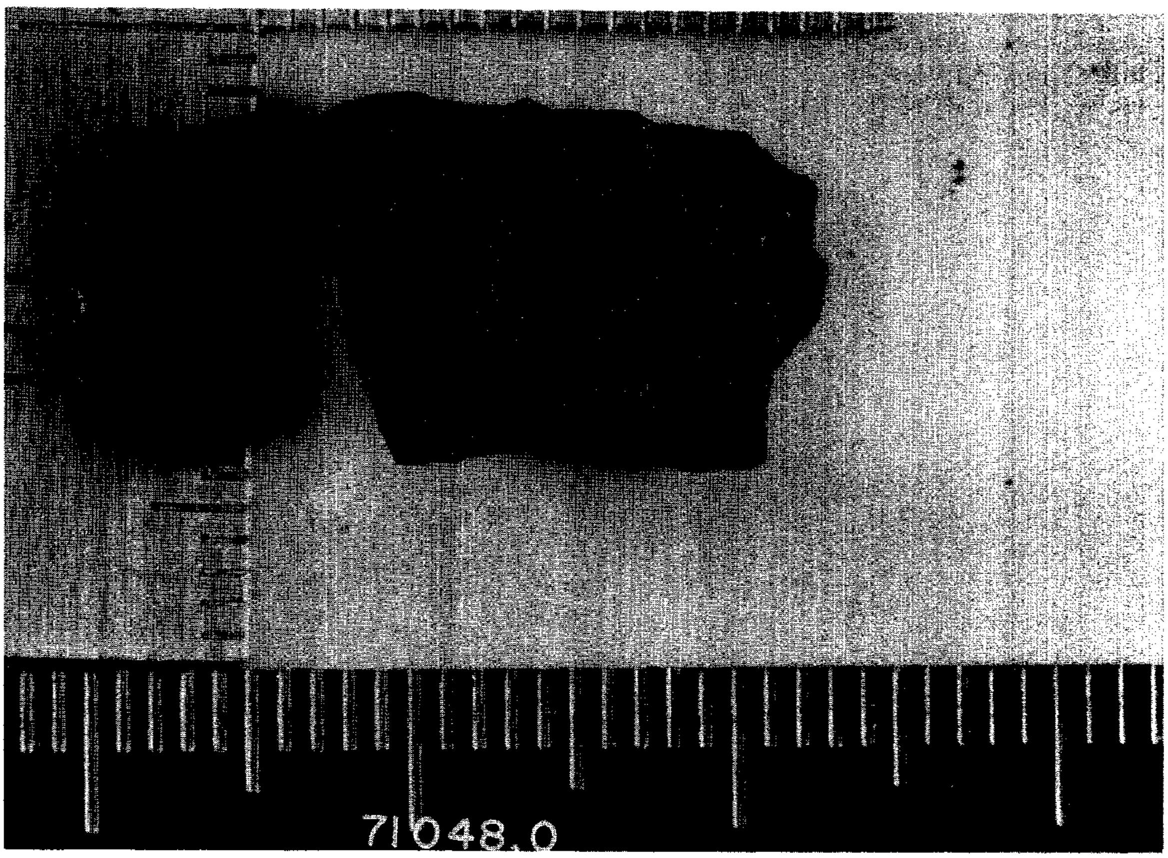


Figure 1: Hand specimen photograph of 71048,0.

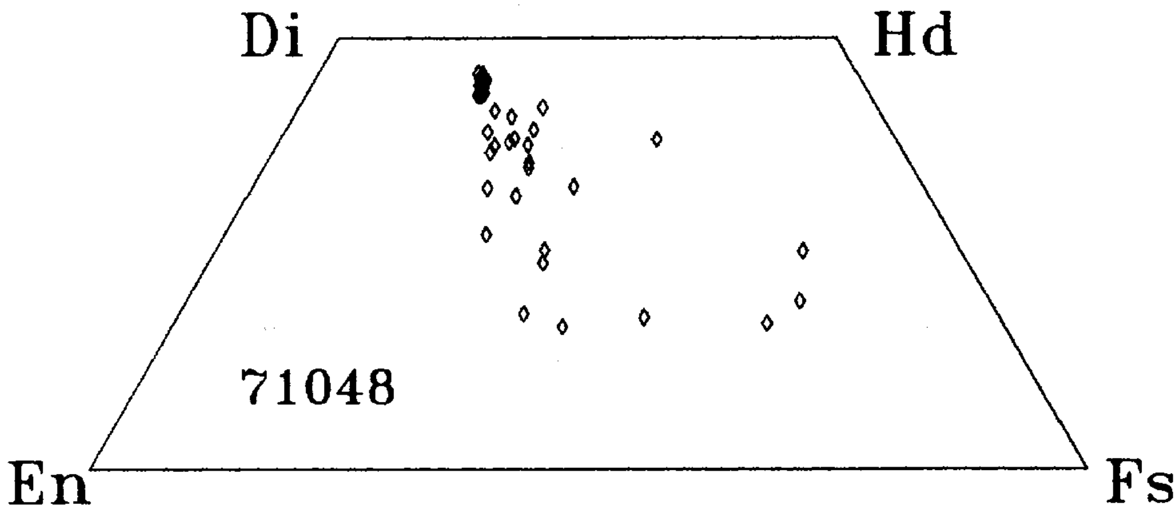


Figure 2: Pyroxene compositions of 71048 represented on a pyroxene quadrilateral.

exhibits relatively little variation either within or between grains (MG# = 7-12).

WHOLE-ROCK CHEMISTRY

Neal et al. (1990) described 71048 as a Type A Apollo 17 high-Ti basalt (Table 1) using the classification of Rhodes et al. (1976) and Warner et al. (1979).

This basalt contains 12.9 wt% TiO_2 with a MG# of 44.6. The REE profile (Fig. 3) is LREE-depleted, but convex-upward. The MREE reach > 50 times chondritic abundances. A negative Eu anomaly is present ($[Eu/Eu^*]_N = 0.53$).

PROCESSING

Of the original 2.457g of 71048,0, approximately 2.11g remains. 0.33g was used for INAA, and 0.01g was used for thin section 71048,3.

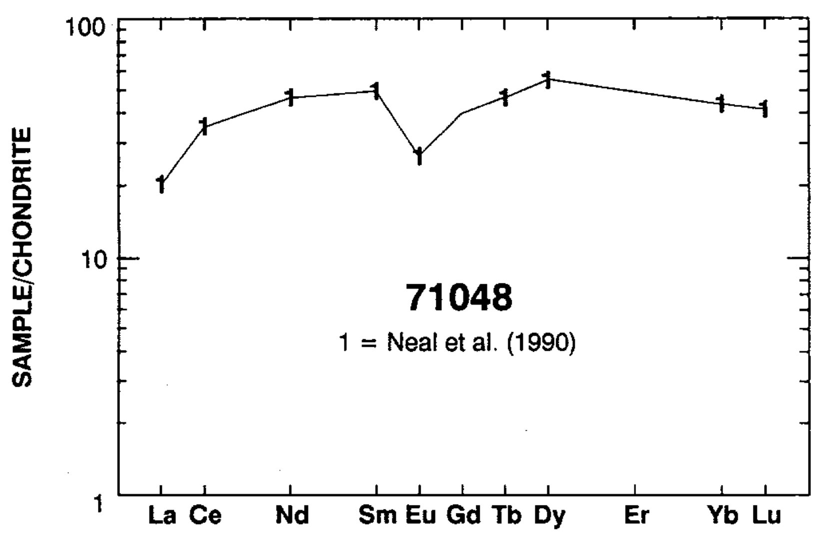


Figure 3: Chondrite-normalized rare-earth element profile of 71048.

Table 1: Whole-rock chemistry of 71048.
Data from Neal et al. (1990).

	71048,4 I		71048,4 I
SiO_2 (wt %)		Cu	
TiO_2	12.9	Ni	80
Al_2O_3	8.68	Co	19
Cr_2O_3	0.201	V	105
FeO	18.3	Sc	79
MnO	0.253	La	6.57
MgO	8.0	Ce	30
CaO	10.2	Nd	29
Na_2O	0.39	Sm	9.94
K_2O	0.07	Eu	2.01
P_2O_5		Gd	
S		Tb	2.66
Nb (ppm)		Dy	18.7
Zr	74	Er	
Hf	8.52	Yb	9.48
Ta	1.86	Lu	1.39
U	0.09	Ga	
Th	0.34	F	
W		Cl	
Y		C	
Sr	148	N	
Rb		H	
Li		He	
Ba	129	Ge (ppb)	
Cs	0.67	Ir	
Be		Au	
Zn		Eu	
Pb		Os	

I = Analysis by INAA.

71049
High-Ti Mare Basalt
1.86 g, 1 × 1 × 1 cm

INTRODUCTION

71049 was described as a medium dark gray (with brownish tint), equigranular, blocky basalt (Apollo 17 Lunar Sample Information Catalog, 1973), containing no zap pits and 1-2% irregular vugs (Fig. 1) up to 0.5mm. It has a blocky, angular shape with an equigranular fabric. This basalt was collected at Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

Neal et al. (1989) described 71049 as a plagioclase poikilitic basalt, comprised of: 41.6% pyroxene; 31.0% plagioclase; 22.5% ilmenite; 2.7% native Fe and troilite; 2.0% silica; and 0.2% olivine. Plagioclase (up to 2.2mm) poikilitically encloses pyroxene (up to 1mm) and ilmenite (up to 0.8mm). Ilmenite is blocky, occasionally interstitial, and contains chromite and rutile exsolution lamellae (<0.005mm). Olivine (~0.1mm) forms cores to pyroxene. No armalcolite or discrete spinel phases were observed. Silica, native Fe, and troilite are interstitial phases.

Olivine exhibits little core-to-rim zonation, but variation between grains is evident (Fo_{57-67}). Plagioclase exhibits little overall compositional variation (An_{79-89}), although the rims are usually more sodic. Both pigeonite and titan-augite are present, zoning toward more Fe-rich compositions (Fig. 2). Al/Ti ratios are constant at ~2, and Cr_2O_3 contents decrease with decreasing pyroxene MG#. Ilmenite exhibits little overall variation (MG# = 6-11).

WHOLE-ROCK CHEMISTRY

Neal et al. (1990) described 71049 as a Type A Apollo 17 high-Ti basalt (Table 1) using

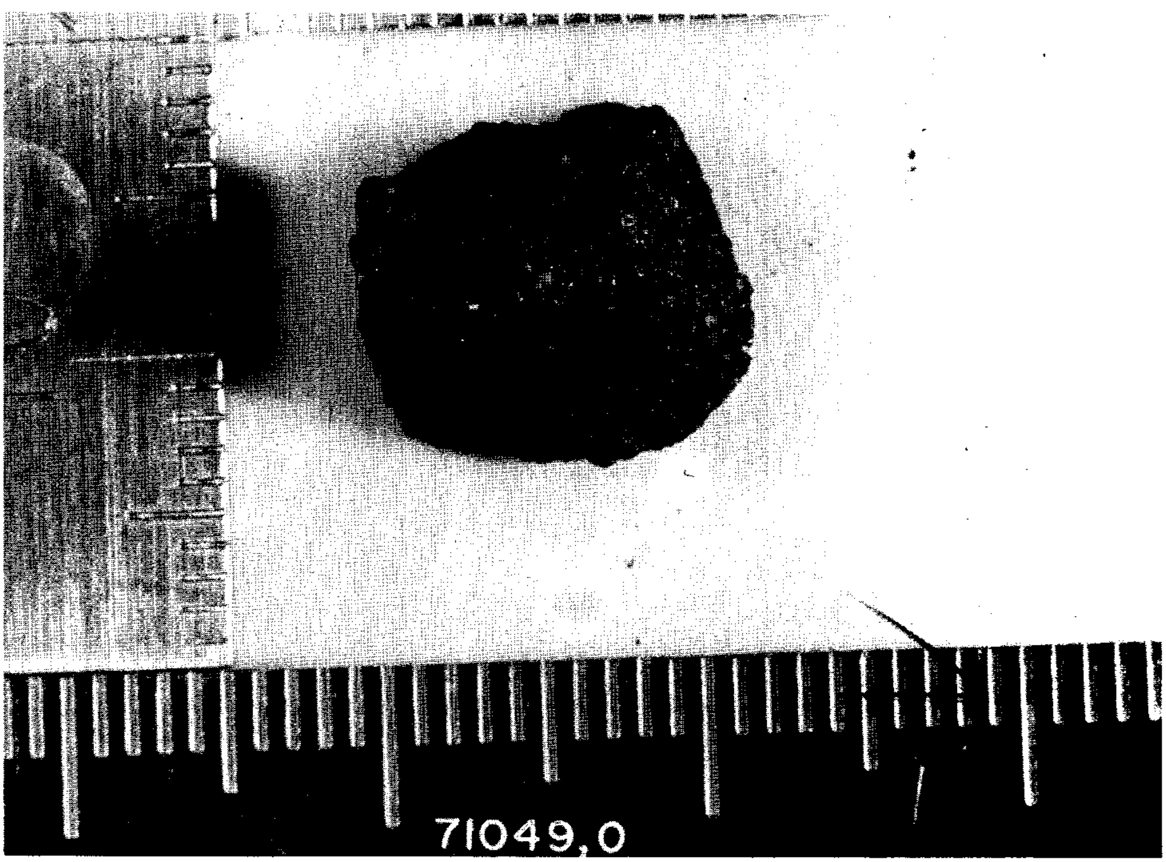


Figure 1: Hand specimen photograph of 71049,0.

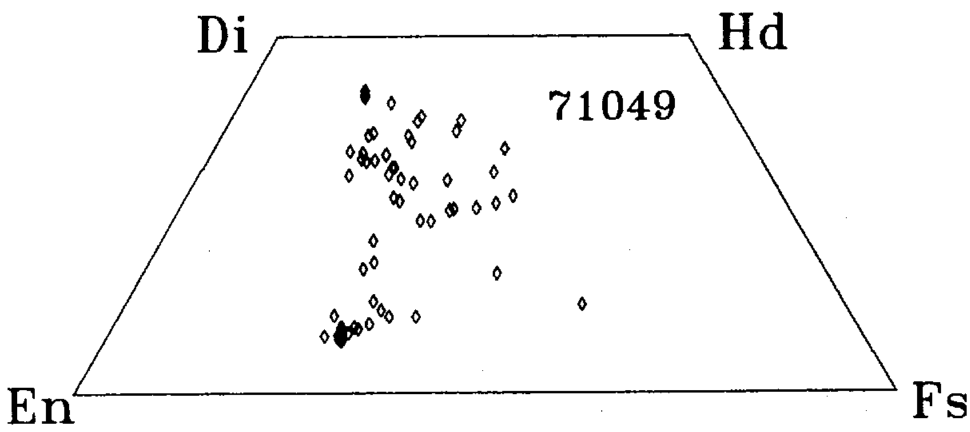


Figure 2: Pyroxene compositions of 71049 represented on a pyroxene quadrilateral.

the classification of Rhodes et al. (1976) and Warner et al. (1976). This basalt contains 12.5 wt% TiO_2 with a MG# of 44.6 (Table 1). Although the REE profile (Fig. 3) is LREE-depleted, the HREE also show a depletion relative to the MREE. The MREE reach 45-55 times chondritic levels. A negative Eu anomaly is present ($[Eu/Eu^*]_N = 0.50$).

PROCESSING

Of the original 1.86g of 71049,0, approximately 1.33g remains. 0.52g was used for INAA, and 0.01g was used for thin section 71049,3.

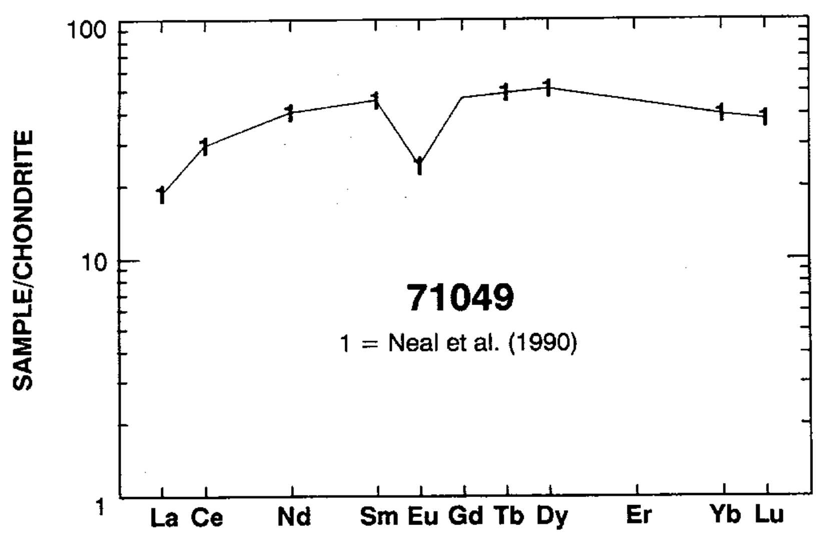


Figure 3: Chondrite-normalized rare-earth element profile of 71049.

Table 1: Whole-rock chemistry of 71049.
Data from Neal et al. (1990).

	71049,4 I		71049,4 I
SiO_2 (wt %)		Cu	
TiO_2	12.5	Ni	11
Al_2O_3	8.18	Co	19
Cr_2O_3	0.214	V	125
FeO	17.8	Sc	77
MnO	0.249	La	6.23
MgO	8.3	Ce	26
CaO	9.8	Nd	26
Na_2O	0.39	Sm	9.42
K_2O	0.07	Eu	1.90
P_2O_5		Gd	
S		Tb	2.89
Nb (ppm)		Dy	17.8
Zr	168	Er	
Hf	8.18	Yb	8.84
Ta	1.65	Lu	1.31
U	0.33	Ga	
Th	0.23	F	
W		Cl	
Y		C	
Sr	159	N	
Rb		H	
Li		He	
Ba	104	Ge (ppb)	
Cs	0.15	Ir	
Be		Au	
Zn		Ru	
Pb		Os	

I = analysis by INAA.

71055
High-Ti Mare Basalt
669.6 g, 19.5 × 9.5 × 2.5 cm

INTRODUCTION

71055 was described as a light brownish gray, angular and intergranular basalt (Apollo 17 Lunar Sample Information Catalog, 1973), containing many zap pits on S (few on other surfaces) and 20-25% vugs (<1-12mm) (Fig. 1). It has a homogeneous mineralogy, but a heterogeneous vug distribution. Vugs do not appear to be layered and pyroxene which projects into them is thin and needle-like. This basalt was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

Brown et al. (1974, 1975a,b) described 71055 as a Type IB basalt which is comprised of: 45.3% clinopyroxene; 29.0% opaque minerals; 21.2% plagioclase; 2.6% silica; and 1.9% olivine. These authors described both mineral chemistry and petrography within the general confines of their Type IB category. Dymek et al. (1975) have studied thin section 71055,75 in detail. These authors described 71055,75 as a vesicular, fine- to medium-grained, olivine-bearing ilmenite basalt with a seriate grain size distribution. The overall texture is plagioclase poikilitic. Dymek et al. (1975) also reported that 71055,75 is comprised of: 46% pyroxene; 27% plagioclase; 17% ilmenite; 3% olivine; and 2% silica. Minor amounts of Cr-ulvöspinel, troilite, native Fe, Ca-phosphate, and mesostasis are also present. Olivine (up to 0.2mm) occurs as rounded cores to pyroxene (Fig. 2), although rarely olivine

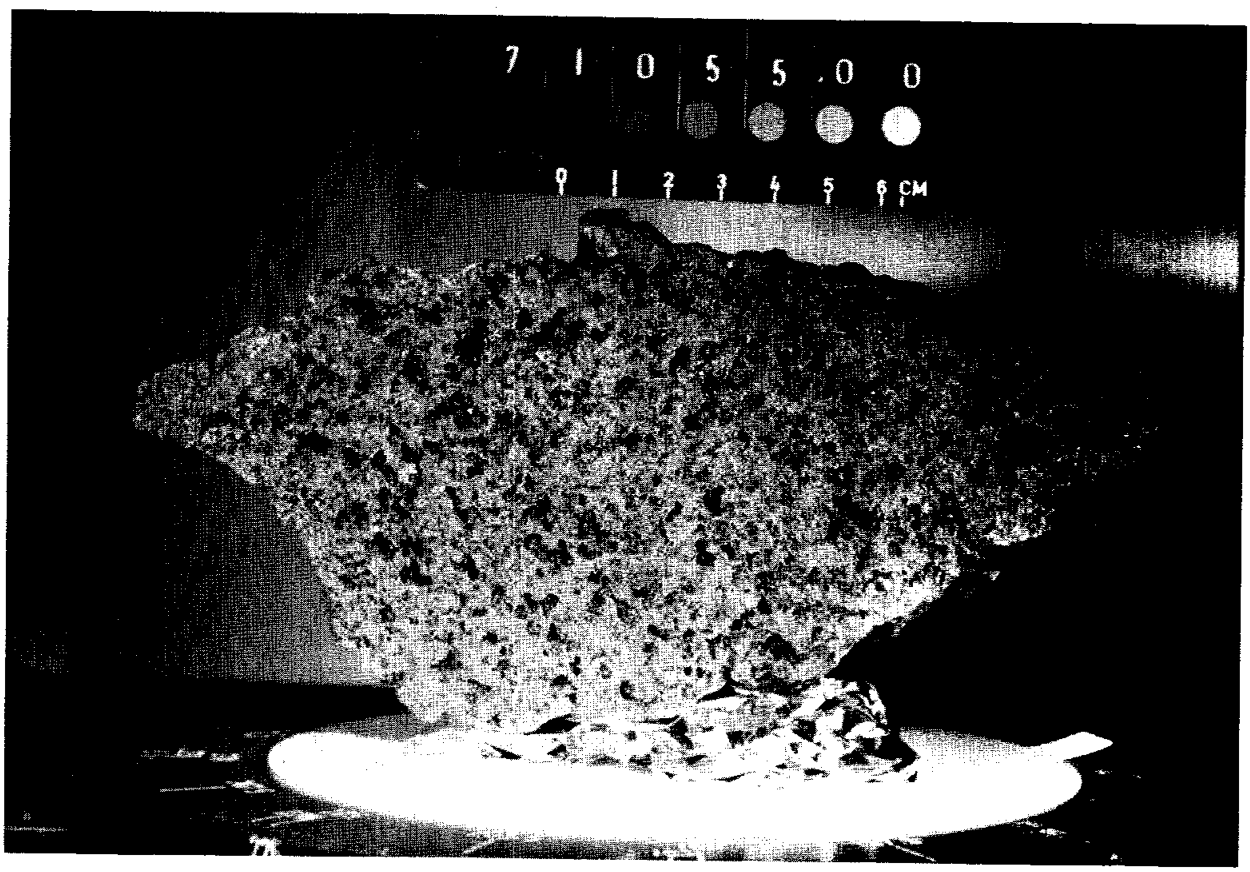


Figure 1: Hand specimen photograph of 71055,0.

Figure 2: Photomicrograph of 71055,64 depicting an olivine phenocryst rimmed with pyroxene. Field of view is 1.25 mm.

contains only a thin pyroxene rim. The range in olivine composition is $Fo_{65\text{-}75}$, although the largest variation within one grain is only 5 mole % Fo. Ilmenite occurs as dominantly subequant, skeletal grains (up to 1mm) with "sawtooth" margins. Ilmenite forms inclusions in pyroxene and is intergrown with pyroxene and plagioclase. The ilmenites exhibit a range in MG# (4-13), with the most magnesian types forming rims on Cr-ulvöspinel. Muhich et al. (1990) reported variations in ilmenite compositions in 71055 which correlated with the degree of exsolution. Ilmenites with abundant exsolution were richer in Mg relative to those without exsolution. No armalcolite was identified.

Pyroxenes are complex - the largest grains are typically composite. Pale pink (Al- and Ti-poor) to dark pink (Al- and Ti-rich) are arranged in parallel bands, in a radiating, spherulitic pattern, or forming an hourglass structure. These may have olivine cores, and contain inclusions of ilmenite, with which they occasionally form a graphic intergrowth. Smaller (up to 0.2mm) stubby pyroxene granules are enclosed poikilitically in plagioclase. Elongate pyroxenes (stubby, tabular, to acicular) form spherulitic intergrowths with plagioclase (Fig. 3). Plagioclase occurs as large, poikilitic grains (up to 1.5mm), discrete lath-like subequant grains (0.05-0.5mm), and elongate sheaves intergrown with pyroxene (Fig. 3). The measured range of plagioclase composition was $An_{77\text{-}84}$, although there is no direct correlation between petrographic type and composition. The large pyroxene grains zone towards Mg-rich, Ca-poor compositions. Al and Ti also decrease. The other petrographic types of pyroxene exhibit marked Fe enrichment relative to the larger types. Al/Ti ratios are constant at ~2. Spectral measurements suggest the presence of a substantial amount of Ti^{3+} (Sung et al., 1974a,b).

Taylor et al. (1992) report 71055,74 as being comprised of: 20% ilmenite, 42% clinopyroxene, 29% plagioclase, 5% silica, 3% olivine, and traces of native Fe, troilite, and apatite. These authors used 71055 in a study of magnetic beneficiation, and concluded that for fine-grained basalts, beneficiation requires grinding to a smaller grain size to effectively separate ilmenite from pyroxene.

Dymek et al. (1975) proposed the following crystallization sequence for 71055: Olivine, ilmenite, and Cr-ulvöspinel formed first, but their relative order is difficult to determine; olivine and ulvö-spinel ceased to crystallize, but ilmenite continued to crystallize with pyroxene

Figure 3: Photomicrograph of 71055,68 depicting a "bow-tie" or subvariolitic structure. Field of view is 2.5 mm.

and plagioclase throughout. The aluminous titan-augites formed next, in part by reaction between olivine and melt. This was followed by pigeonite, possibly due to the first appearance of plagioclase causing an abrupt decrease in Ca. However, this is not documented by the Al content of the pyroxene. Silica, native Fe, troilite and a potassic mesostasis were the last phases to crystallize.

WHOLE-ROCK CHEMISTRY

Although several whole-rock analyses have been performed on 71055 for trace elements (Philpotts et al., 1974; Brunfelt et al., 1974; Baedecker et al., 1974; Boynton et al., 1975; Dickinson et al., 1989), only one reported a complete analysis of major element oxide contents (Rose et al., 1974) of 71055,51 (Table 1). This sample contains 13.41 wt% TiO_2 with a MG# of 45.6. Miller et al. (1974) reported element wt% abundances of 71055,56. Rose et al. (1974) analyzed 71055,51 by XRF and thus did not analyse for all the REE. However, elements such as Y, Nb, Ga, Be, and Li (69, 27, 8.1, <1, and 9.6 ppm, resp.) have been analyzed. Other analyses have only included the middle and heavy REE (e.g., Baedecker et al., 1974) (Fig. 4). The three complete REE profiles which have been reported (Philpotts et al., 1974; Brunfelt et al., 1974; Boynton et al., 1975) exhibit moderate variations in overall abundance (HREE = 25-35 times chondritic abundances - Fig. 4), but the negative Eu anomaly exhibits large variations between the different analyses ($[Eu/Eu^*]_N$ = 0.50-0.69). However, all profiles are convex-upward and LREE-depleted (Fig. 4).

Garg et al. (1976a,b) determined Zr (221 and 213 ppm) and Hf (6.74 and 7.03 ppm) abundances in 71055. Dickinson et al. (1988, 1989) determined the abundance of Ge (2.7 ppb) in 71055. Carbon, nitrogen, and sulfur abundances (54, 79, and 1860 µg/g, resp. - Table 1) have been determined for 71055 by Sill et al. (1974) and Moore et al. (1974a,b).

ISOTOPES

Lead isotope studies have been undertaken by Chen et al. (1979) and Tilton and Chen (1979), the results of which are reported in Table 2. Tera et al. (1974) and Murthy and Coscio (1976) reported a crystallization age for 71055 of 3.64 ± 0.09 Ga, with an initial $^{87}Sr/^{86}Sr$ ratio of 0.69910 ± 4 (Table 3). No Sm-Nd work has been conducted upon this sample. Oxygen isotope work was conducted by Mayeda et al. (1975) on mineral separates from 71055,45 (Table 3). Arvidson et al. (1976) obtained krypton and xenon data for

Table 1: Whole-rock chemistry of 71055.

	,56	,51	,38	,36	,31	,31	,171
	I	X/O/S	ID	I	I	I	I, R
	1	2	3	4	5	6	7
SiO_2 (wt %)	37.45	38.14					
TiO_2	12.05	13.41		14.21		14.35	
Al_2O_3	8.32	8.62		8.18		10.02	
Cr_2O_3		0.41		0.407	0.192	0.181	0.41
FeO	19.48	19.20		19.09	21.16	18.58	16.0
MnO	0.258	0.26		0.258	0.163	0.153	
MgO	10.46	9.04		8.80			
CaO	9.52	10.77		11.34		10.64	12.2
Na_2O	0.45	0.31		0.31	0.42	0.41	0.34
K_2O		0.06	0.028	0.04			
P_2O_5		0.08					
S							
Nb (ppm)		27					
Zr		223					
Hf				6.6	7.0	6	5.7
Ta				1.54	1.3	1.6	1.4
U				0.132			
Th				0.32	<0.65		0.46
W				0.089			
Y		69					
Sr		170	121	104			
Rb		0.9	0.362	0.9			
Li		9.6	9.32				
Ba		315	62.4	39			63
Cs				0.07			
Be		<1					
Zn		<4		3	1.9		
Pb		<2					
Cu		31		4.4			
Ni		43		<10	2.0		
Co		51		21.6	26	22	18
V		88		129			364
Sc		87		95	94	82	80
La		<10		4.67		4.6	4.6
Ce			15.6	13.4	23	22	13
Nd			17.0				33
Sm			6.72	7.05		6.1	6.0

Table 1: (Concluded).

	,56	,51	,38	,36	,31	,31	,171
	I	X/O/S	ID	I	I	I	I, R
	1	2	3	4	5	6	7
Eu			1.36	1.49	1.5	1.8	1.3
Gd							
Tb				1.74	2.1	2.0	1.6
Dy			13.0	14.3			
Er			7.74				0.87
Yb			7.75	5.4	5.7	6.3	6.4
Lu				1.10		1.1	1.0
Ga				3.0	4.27		22
F							
Cl							
C							
N							
H							
He							
Ge (ppb)					3.3		2.4
Ir					1.1		
Au					0.082		
In					4.7		
Ru							
Os							

References: 1 = Miller et al. (1974); 2 = Rose et al. (1974); 3 = Philpotts et al. (1974); 4 = Brunfelt et al. (1974); 5 = Baedecker et al. (1974); 6 = Boynton et al. (1975); 7 = Dickinson et al. (1989).

Analysis by: I = INAA; X = XRF; O = Optical emission; S = Semimicro chemical methods; ID = Isotope Dilution; R = RNAA.

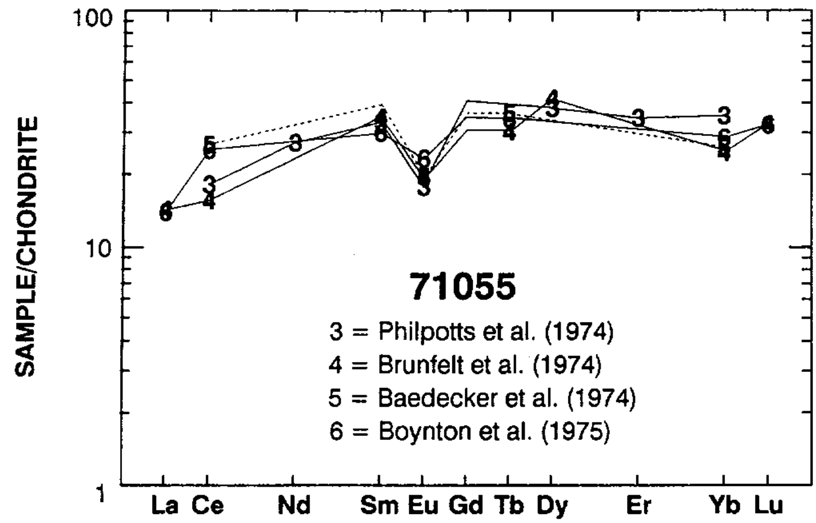


Figure 4: Chondrite-normalized rare-earth element profile of 71055.

71055 (Table 4), and reported an exposure age of 110±7 Ma for 71055.

EXPERIMENTAL

Several diverse experimental studies have been conducted upon 71055. Engelhardt (1979) used 71055 in an investigation of ilmenite in the crystallization sequence of lunar rocks. This study noted that ilmenite in 71055,68 started to crystallize before plagioclase and ended before pyroxene crystallization.

O'Hara and Humphries (1975) studied the crystallization sequence of the phenocryst assemblages in 71055 through oxygen fugacity and temperature-controlled experiments. These authors noted that spinel crystallized first, followed by armalcolite and olivine, then ilmenite. Pyroxene and plagioclase are late crystallizing phases. Usselman et al. (1975), in a study of cooling rates and textures of Apollo 17 high-Ti basalts, estimated that 71055 cooled at a rate of 103 °C/hour. Finally, Trice et al. (1974) studied the elastic properties of 71055 in order to gain insight into the near-surface structure at the Taurus-Littrow area.

MAGNETIC STUDIES

Two magnetic studies have been undertaken utilizing 71055. Brecher (1974) undertook a comparative study of the magnetic properties of a number of Taurus-Littrow basalts. Watson et al. (1974) reported the thermomagnetic properties of 71055, noting the average NRM of 71055 is 2.0×10^{-5} emu/gm.

PROCESSING

71055,0 has been entirely subdivided. The largest remaining portion of this sample is 394.6g (71055,8). Several sub-samples exist weighing between 20-40g (,7, ,10, ,14, ,26, and ,38). Fifteen thin sections have been cut from this sample (71055,64-71, and ,72-78).

Table 2a: Pb isotopic ratios and elemental abundances for 71055.
Data from Chen et al. (1979) and Tilton and Chen (1979).

Sample	Weight (mg)	Concentration (ppm)[a] Pb	U	Th	$^{232}Th/^{238}U$	$^{238}U/^{204}Pb$
71055						
Whole rock-1R[b]	99	0.2147 (+4, -14)	0.1077 (6)	0.353 (5)	3.39 (5)	636 (+64, -4)
Acid wash[c]		–	0.00460 (4)	0.0230 (2)	5.18 (6)	–
Total		–	0.1123 (6)	0.376 (5)	3.46 (5)	–
Whole rock-2R	66	0.1614 (+3, -18)	0.0828 (3)	0.277 (2)	3.46 (3)	632 (+132, -3)
Acid wash		–	0.00835 (8)	0.0425 (4)	5.26 (7)	–
Total		–	0.0912 (3)	0.320 (2)	3.62 (3)	–
Whole rock-3	101	0.2558 (+11, -9)	0.1285 (5)	0.448 (3)	3.60 (2)	760 (+34, -42)
Whole rock-4R	131	0.1524 (+5, -8)	0.0771 (3)	0.266 (9)	2.77 (2)	398 (+8, -61)
Acid wash		0.0791 (+5, -4)	0.0307 (2)	0.164 (2)	5.50 (6)	175 (+3, -4)
Total		0.2315 (+7, -9)	0.1078 (4)	0.3706 (22)	3.55 (2)	292 (+9, -6)
Whole rock-5R	176	0.1545 (+10, -12)	0.0790 (2)	0.209 (1)	2.74 (2)	418 (+4, -3)
Acid wash		0.0765 (+3, -3)	0.0294 (1)	0.161 (2)	5.67 (7)	169 (+2, -3)
Total		0.2310 (+10, -12)	0.1084 (2)	0.370 (2)	3.53 (2)	298 (+7, -4)
Pyroxene D-R	62	0.2964 (+12, -10)	0.1446 (5)	0.473 (3)	3.38 (2)	585 (+29, -36)
Acetone wash		0.00224 (1)	6.6×10^{-5} (0.5)	0.00019 (0.2)	3.07 (4)	1.98 (1)
Acid wash		–	0.0132 (1)	0.0746 (7)	5.86 (7)	–
Total		–	0.1578 (5)	0.5476 (31)	3.59 (2)	–
Pyroxene-1R	62	0.1116 (+9, -13)	0.0551 (1)	0.1546 (9)	2.90 (2)	376 (+46, -27)
Acetone wash		0.00245 (3)	–	–	–	–
Acid wash		0.0445 (+7, -2)	0.0154 (2)	0.0789 (9)	5.29 (8)	89 (+1, -5)
Total		0.1561 (+11, -13)	0.0705 (2)	0.2335 (13)	3.42 (2)	221 (+11, -13)
Pyroxene-2	51	0.1400 (+10, -16)	0.0647 (3)	0.214 (1)	3.41 (2)	284 (+26, -16)
Water wash		0.00409 (+71, -2)	0.00014 (0.1)	0.00010 (0.1)	0.75 (1)	2.41 (+2, -11)
Pyroxene-3	58	0.1631 (+4, -25)	0.0806 (3)	0.268 (1)	3.43 (1)	544 (+159, -2)

Table 2a: (Concluded).

Sample	Weight (mg)	Concentration (ppm)[a] Pb	U	Th	$^{232}Th/^{238}U$	$^{238}U/^{204}Pb$
Water wash		0.0007	0.00002	0.00005	2.5	1.5
Ilmen-ite-R	61	0.3500 (+13, -17)	0.1612 (6)	0.487 (2)	3.12 (1)	409 (+18, -11)
Acid wash		0.06055 (+2, -60)	0.0312 (4)	0.186 (1)	6.15 (8)	316 (+35, -4)
Total		0.4106 (+13, -18)	0.1924 (7)	0.673 (2)	3.61 (2)	390 (+21, -7)
Plagio-clase-1R	73	0.06645 (+65, -100)	0.01343 (8)	0.0442 (4)	3.40 (3)	37 (+16, -6)
Acid wash		0.02655 (+6, -55)	0.00423 (3)	0.0182 (1)	4.44 (4)	17 (+6, -1)
Total		0.09300 (+65, -114)	0.01766 (8)	0.0624 (4)	3.65 (3)	29 (+1, -1)
Plagio-clase-2R	31	0.0757 (+2, -14)	0.0269 (1)	0.0683 (4)	2.62 (1)	161 (+95, -1)
Acid wash		0.0400 (+4, -9)	0.0103 (6)	0.0546 (3)	5.5 (3)	41 (+5, -3)
Total		0.1157 (+44, -42)	0.0372 (6)	0.1229 (5)	3.41 (5)	90 (+19, -2)

[a]Numbers in parentheses correspond to 2δ errors for mass spectrometric ratio measurements, ±0.1% uncertainties for the concentrations of tracers, and chemical blanks.

[b]Residues from cold 1NHCl leaches.

[c]Samples contacted with cold 1NHCl for 10 minutes.

Table 2b: Observed and corrected lead isotopic ratios in 71055,21.
Data from Chen et al. (1979) and Tilton and Chen (1979).

		Observed Ratios			Corrected Ratios		
Sample	Blank (pg)	$^{208}Pb/^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{204}Pb/^{206}Pb$	$^{208}Pb/^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{204}Pb/^{206}Pb$
WR-1R	107	0.90186 (86)	0.54868 (80)	0.001825 (28)	0.8983 (+9, -40)	0.5478 (+8, -16)	0.00167 (+3, -16)
WR-2R	107	0.89425 (98)	0.54294 (68)	0.002023 (26)	0.8871 (+10, -73)	0.5412 (+7, -22)	0.00170 (+3, -30)
WR-3	158	0.91376 (40)	0.52947 (29)	0.001588 (22)	0.9095 (+20, -15)	0.5283 (+7, -6)	0.00139 (+9, -7)
WR-4R	132	0.82960 (60)	0.56287 (50)	0.002850 (36)	0.8313 (+18, -32)	0.5635 (+3, -6)	0.00263 (+9, -14)
Acid wash	60	1.2221 (15)	0.51477 (90)	0.005506 (64)	1.2286 (+35, -28)	0.5150 (+17, -14)	0.00528 (+18, -15)
Total					0.9550 (+22, -38)	0.5484 (+3, -6)	0.00345 (+12, -18)
WR-5R	132	0.8327 (40)	0.5551 (38)	0.00269 (16)	0.8358 (+48, -58)	0.5560 (+40, -42)	0.00253 (+19, -24)
Acid wash	60	1.2410 (14)	0.5196 (8)	0.005636 (40)	1.2485 (+29, -24)	0.5202 (+14, -12)	0.00545 (+25, -10)
Total					0.9594 (+55, -67)	0.5453 (+40, -42)	0.00340 (+26, -32)
PxD-R	158	0.9108 (10)	0.54867 (35)	0.002039 (22)	0.9048 (+32, -26)	0.5472 (+9, -7)	0.00177 (+12, -9)
Acetone wash	24	1.971 (10)	0.7961 (90)	0.0490 (6)	-	-	-
Px-1R	140	0.84550 (96)	0.55461 (75)	0.003305 (28)	0.8309 (+51, -73)	0.5513 (+17, -22)	0.00270 (+20, -29)
Acetone wash	24	1.982 (10)	0.8245 (80)	0.0476 (6)	-	-	-
Acid wash	59	1.3765 (40)	0.5595 (10)	0.0105 (3)	1.366 (+10, -4)	0.5553 (+35, -10)	0.00984 (+70, -30)
Total					0.9619 (+59, -84)	0.5523 (+17, -22)	0.00445 (+33, -48)
Px-2	140	0.9472 (12)	0.5566 (10)	0.00411 (4)	0.9335 (+51, -72)	0.5532 (+20, -25)	0.00350 (+22, -31)
Water wash	59	1.982 (7)	0.8100 (70)	0.0488 (13)	1.976 (+7, -17)	0.8085 (+70, -98)	0.0484 (+13, -20)
Px-3	78	0.9151 (12)	0.5353 (9)	0.00218 (2)	0.9092 (+12, -100)	0.5338 (+9, -33)	0.00192 (+2, -44)
Water wash	33	2.012 (20)	0.8240 (20)	0.0521 (4)	1.988 (+12, -87)	0.8229 (+70, -59)	0.0513 (+3, -30)
Ilm-R	137	0.91167 (80)	0.56638 (70)	0.002611 (28)	0.9071 (+20, -29)	0.5653 (+10, -12)	0.00241 (+8, -12)
Acid wash	24	1.261 (3)	0.4528 (26)	0.004042 (12)	1.2574 (+30, -78)	0.4511 (+16, -41)	0.00382 (+1, -33)
Total					0.9548 (+21, -30)	0.5498 (+10, -12)	0.00260 (+9, -13)
Pl-1R	137	1.1255 (17)	0.8643 (11)	0.01503 (10)	1.106 (+7, -11)	0.8651 (+15, -13)	0.0142 (+3, -5)
Acid wash	24	1.6176 (24)	0.71121 (86)	0.02775 (16)	1.613 (+2, -9)	0.7100 (+9, -27)	0.0275 (+4, -5)
Total					1.239 (+8, -12)	0.8244 (+14, -12)	0.0177 (+4, -6)
Pl-2R	78	0.8520 (15)	0.7301 (9)	0.00592 (4)	0.8258 (+15, -446)	0.7280 (+9, -43)	0.00488 (+4, -17)
Acid wash	33	1.535 (4)	0.6142 (30)	0.01764 (20)	1.524 (+7, -13)	0.6096 (+43, -57)	0.0169 (+4, -8)
Total					1.035 (+18, -559)	0.6925 (+9, -41)	0.00848 (+7, -29)

[a]Numbers in parentheses are 2δ errors from the mass spectrometry.

[b]Uncertainties are corrected for 0.1-0.2 ng Pb blanks and for 2δ errors in mass spectrometry. Isotopic composition of blank: ^{204}Pb:^{206}Pb:^{207}Pb:^{208}Pb = 1.00 = 18.90 = 15.60 = 38.60.

Table 3: Rb-Sr and O isotope ratios for 71055.

Rb-Sr Composition (Tera et al., 1974)				
		I(Sr)		**AGE (Ga)**
71055		0.69910+4		3.64+0.09
$\delta^{18}O$ Composition (Mayeda et al., 1975)				
	Cristobalite	**Plag**	**Pyroxene**	**Ilmenite**
71055,45	6.75	5.82	5.36	4.01

Table 4: Krypton & xenon data from 71055.
Data from Arvidson et al. (1976). Results given in units of 10^{-12} cm^3 STP/g.

Temp (°C)	**^{84}Kr**	**^{78}Kr**	**^{80}Kr**	**^{81}Kr**	**^{82}Kr**	**^{83}Kr**	**^{86}Kr**		
750	6.4	3.223 ±2.078	14.472 ±0.755		34.19 ±1.41	39.48 ±1.85	28.11 ±0.31		
1500	41.3	31.867 ±0.689	83.856 ±1.627	0.3088 ±0.0138	132.13 ±2.40	174.10 ±3.45	11.25 ±0.46		
Temp (°C)	**^{132}Xe**	**^{124}Xe**	**^{126}Xe**	**^{128}Xe**	**^{129}Xe**	**^{130}Xe**	**^{131}Xe**	**^{134}Xe**	**^{136}Xe**
750	5.1	7.115 ±0.373	6.681 ±2.511	22.36 ±1.12	107.32 ±2.69	23.91 ±0.64	110.62 ±1.96	35.44 ±1.25	28.87 ±0.77
1500	86.1	49.025 ±0.309	82.808 ±0.481	125.51 ±0.73	169.65 ±1.07	79.67 ±0.37	347.47 ±2.02	20.23 ±0.18	14.08 ±0.18

71065
High-Ti Mare Basalt
28.83 g, 4.5 × 2.5 × 2.5 cm

INTRODUCTION

71065 was described as a gray to brownish gray, fine-grained equigranular basalt (Fig. 1), which contains no zap pits and only one conspicuous vug (2mm diam.). This vug is lined with euhedral ilmenite and pyroxene crystals up to 1mm long (Apollo 17 Lunar Sample Information Catalog, 1973). Despite two dustings, all surfaces are coated with a fine dust and soil particles, except for one small chipped area next to the vug. This basalt has a rectangular to blocky shape with one penetrative fracture. It was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1979) reported the petrography and mineral chemistry of 71065, but only within the general confines of the whole-rock classification. As such 71065 was not specifically mentioned. However, during the preparation of this catalog, we examined thin section 71065,4, which is microporphyritic (Fig. 2). Olivine (up to 0.5mm), armalcolite (mantled by ilmenite - Fig. 3), and ilmenite form phenocryst phases. Ilmenites (up to 1mm long) exhibit sawtooth margins, and olivines are generally subhedral to euhedral (Fig. 2). Blocky ilmenites (~0.2mm) are also present. Pink pyroxene and plagioclase are present only as groundmass phases (< 0.3mm). Cr-ulvöspinel is present rarely as a phenocryst phase. Discrete ilmenites and those present as mantles on armalcolite contain exsolution lamellae (< 0.005mm) of chromite and rutile. Native Fe and troilite form interstitial phases. The Apollo 17 Lunar Sample Information Catalog (1973) reported that 71065 was comprised of 45-50% pyroxene, 35-40% plagioclase, 15% ilmenite, and 1% olivine.

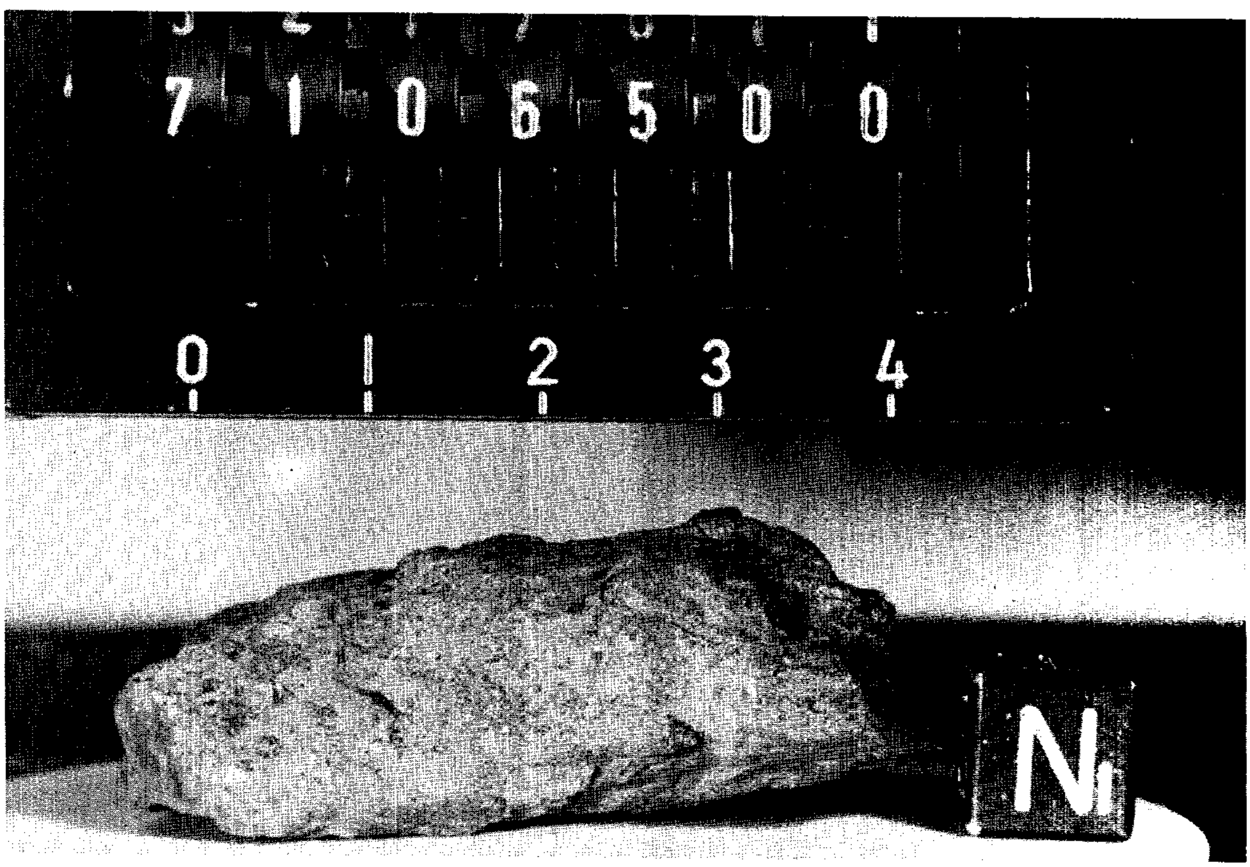


Figure 1: Hand specimen photograph of 71065,0.

Figure 2: Photomicrograph of 71065,4 depicting ilmenite and olivine phenocrysts set in a subvariolitic to interlocking groundmass. Field of view is 2.5 mm.

WHOLE-ROCK CHEMISTRY

Ma et al. (1979) and Warner et al. (1979) reported the same whole-rock analysis for 71065 (Table 1). Warner et al. (1979) classified 71065 as a Type B Apollo 17 high-Ti basalt, and it is further classified as a Type B2 basalt using the criteria of Neal et al. (1990). It contains 12.5 wt% TiO_2 with a MG# of 41.9 (Table 1). The REE profile (Fig. 4) is LREE-depleted, with constant middle and heavy REE

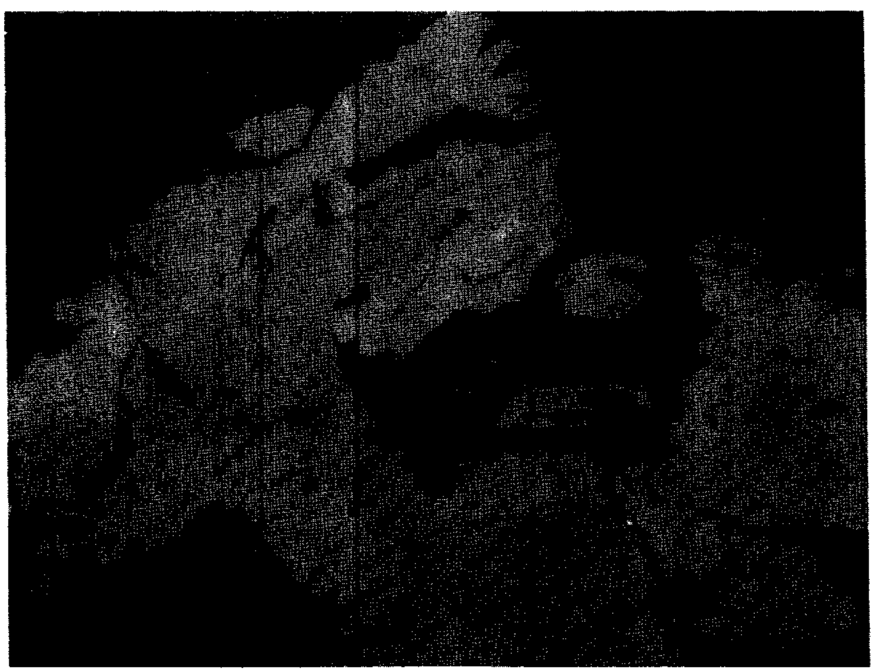


Figure 3: Photomicrograph in reflected light of 71065,4 depicting armalcolite rimmed with ilmenite. Field of view is 0.625 mm.

abundances at approximately 30 times chondritic values. A negative Eu anomaly is present ($[Eu/Eu^*]_N$ = 0.56).

PROCESSING

Of the original 28.83g of 71065,0, a total of 28.35g remains. 71065,2 was used for INAA, and thin section 71065,4 was taken from this irradiated sample.

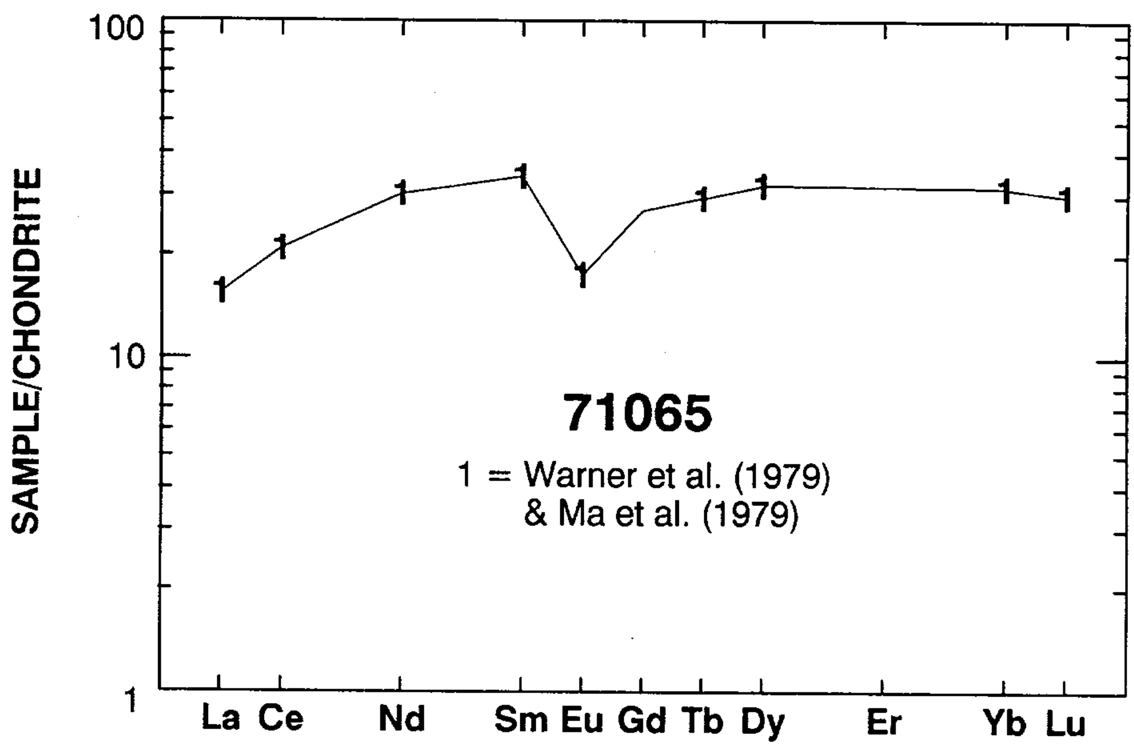


Figure 4: Chondrite-normalized rare-earth element profile of 71065.

Table 1: Whole-rock chemistry of 71065.
Data from Ma et al. (1979) and Warner et al. (1979) (same analysis).

	71065,2 I		71065,2 I
SiO_2 (wt %)		Cu	
TiO_2	12.5	Ni	
Al_2O_3	8.9	Co	22
Cr_2O_3	0.377	V	102
FeO	19.8	Sc	89
MnO	0.256	La	5.1
MgO	8	Ce	18
CaO	10.0	Nd	19
Na_2O	0.389	Sm	6.9
K_2O	0.041	Eu	1.34
P_2O_5		Gd	
S		Tb	1.7
Nb (ppm)		Dy	11
Zr		Er	
Hf	6.8	Yb	6.9
Ta	1.7	Lu	1.01
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

I = analysis by INAA.

71066
High-Ti Mare Basalt
19.96 g, 3.5 × 1.5 × 2.2 cm

INTRODUCTION

71066 was described as a medium dark gray, fine-grained, microporphyritic basalt (Apollo 17 Lunar Sample Information Catalog, 1973). This sample contains no zap pits, but does contain a line of small (0.1mm) vugs on one side and a 2mm vug on the opposite side, containing a felty intergrowth of ilmenite crystals. 71066 has an angular, wedge-shaped appearance (Fig. 1). This basalt was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1979) reported the petrography and mineral chemistry of 71065, but only within the general confines of their Type B basalts. This sample was not specifically mentioned. We examined thin section 71066,5 during the preparation of this catalog and found it to be very fine-grained (~0.1-0.3mm), with armalcolite, euhedral olivine, and ilmenite phenocrysts (0.4mm, 0.6mm, and 0.7mm, resp. - Fig. 2). Rare Cr-ulvöspinels are also present. Ilmenite contains occasional exsolution lamellae (<0.005mm) of chromite and rutile. Olivines exhibit little sign of reaction with the groundmass, but armalcolite commonly has an overgrowth of ilmenite (Fig. 3) which is usually continuous. Ilmenites exhibit "sawtooth" margins. Occasional inclusions of Cr-ulvöspinel (<0.1mm) are found in olivine phenocrysts. Groundmass phases included pink pyroxene, plagioclase,

Figure 1: Hand specimen photograph of 71066,0.

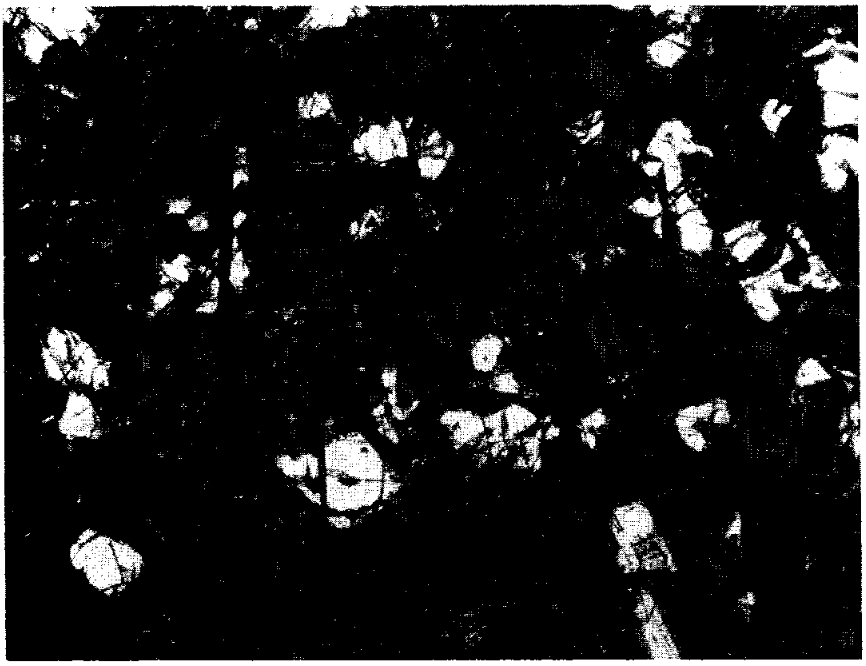


Figure 2: Photomicrograph of 71066,5 depicting ilmenite and olivine phenocrysts set in a glassy matrix. Field of view is 2.5 mm.

Figure 3: Photomicrograph in reflected light of 71066,5 depicting armalcolite rimmed with ilmenite. Field of view is 0.625 mm.

native Fe, troilite, and opaque glass.

WHOLE-ROCK CHEMISTRY

Ma et al. (1979) and Warner et al. (1979) reported the same whole-rock analysis for 71066 (Table 1). 71066 contains 14.2 wt% TiO_2 with a MG# of 43.9 and was described as a Type B Apollo 17 high-Ti basalt by Warner et al. (1979). This sample is further classified as a Type B2 basalt using the criteria of Neal et al. (1990). The REE profile is LREE-depleted, with approximately constant middle and heavy REE abundances at approximately 30 times chondritic abundances (Fig. 4). A negative Eu anomaly is present ($[Eu/Eu^*]_N = 0.56$).

PROCESSING

Of the original 19.96g of 71066,0, 19.28g remains. 71066,2 was irradiated and thin section 71066,5 taken from this irradiated sample.

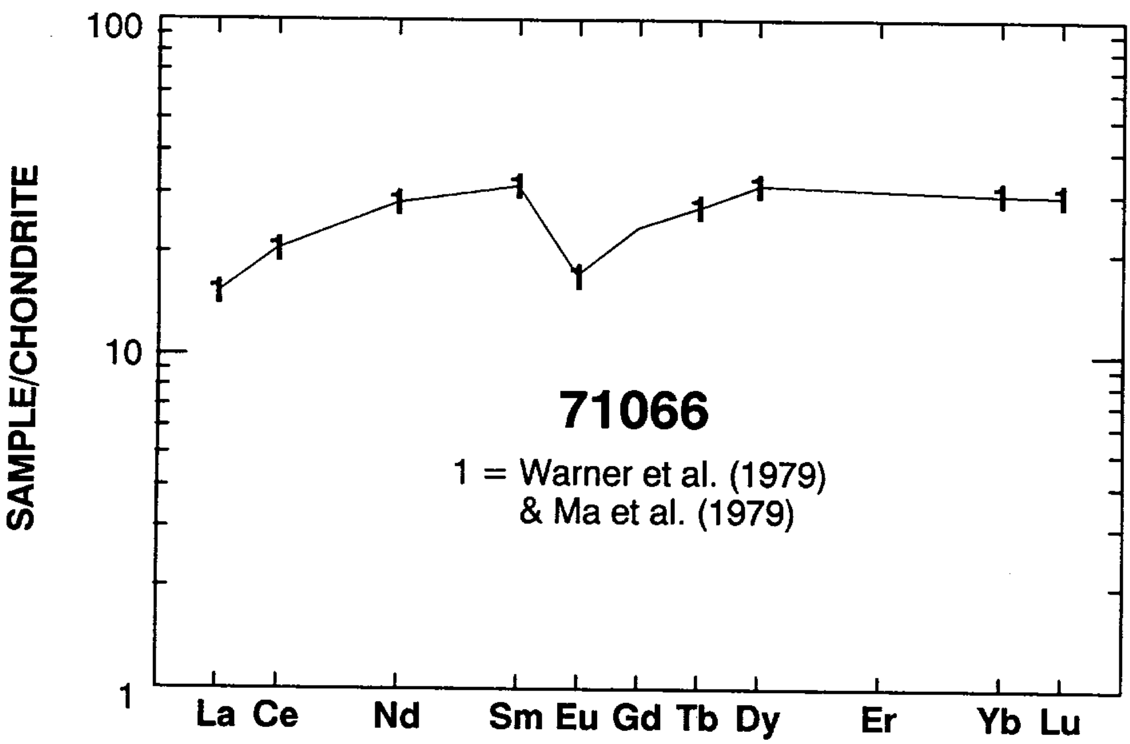


Figure 4: Chondrite-normalized rare-earth element profile of 71066.

Table 1: Whole-rock chemistry of 71066.
Data from Ma et al. (1979) and Warner et al. (1979) (same analysis).

	71066,2 I		71066,2 I
SiO_2 (wt %)		Cu	
TiO_2	14.2	Ni	
Al_2O_3	8.9	Co	27
Cr_2O_3	0.486	V	133
FeO	20.5	Sc	89
MnO	0.259	La	5.1
MgO	9	Ce	18
CaO	9.4	Nd	18
Na_2O	0.406	Sm	6.5
K_2O	0.041	Eu	1.33
P_2O_5		Gd	
S		Tb	1.6
Nb (ppm)		Dy	11
Zr		Er	
Hf	6.4	Yb	6.7
Ta	1.8	Lu	1.02
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

I = analysis by INAA.

71067
High-Ti Mare Basalt
4.245 g, 2 × 1.7 × 1 cm

INTRODUCTION

71067 was described as medium dark gray (brown tint), medium-grained, microdiabasic basalt (Apollo 17 Lunar Sample Information Catalog, 1973), containing no zap pits, but with abundant small irregular vugs (<0.5mm). These vugs are lined with euhedral needles and plates of groundmass minerals. This basalt is subrounded (Fig. 1) and intergranular. 71067 was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1979) have reported on 71067, but have only described it within the general context of their Type A Apollo 17 high-Ti basalts. This sample was not specifically mentioned. We examined thin section 71067,5 during the preparation of this catalog, noting it to be a well crystallized, medium-grained (0.2-0.6mm) high-Ti basalt. Phenocryst phases are absent, although pink pyroxene and ilmenite can reach 0.6mm. Ilmenite contains exsolution lamellae (<0.005mm) of chromite and rutile. Pale pink pyroxenes form "bow-tie" structures with plagioclase (Fig. 2). Ilmenite exhibits "sawtooth" margins and few exsolution features. Discrete spinel phases and armalcolite are rare. Occasionally, the large pink pyroxenes contain a core of relict olivine, which may in turn contain small Cr-ulvöspinel inclusions. Interstitial phases are silica, native Fe, and troilite. The Apollo 17 Lunar Sample Information Catalog (1973) reported that 71067 was comprised of 40% plagioclase, 50% pyroxene, and 10% ilmenite.

WHOLE-ROCK CHEMISTRY

Ma et al. (1979) and Warner et al. (1979) reported the same whole-rock analysis of 71067 (Table 1). Warner et al. (1979) described 71067 as a Type A Apollo 17 high-Ti basalt. It contains 12.7 wt% TiO_2 with a MG# of 45.1. The REE profile (Fig. 3) is LREE-depleted, with approximately constant middle and heavy REE abundances at 45 times chondritic values. A negative Eu anomaly is present ($[Eu/Eu^*]_N$ = 0.55).

PROCESSING

Of the original 4.245g of 71067,0, a total of 3.83g remains. 71067,2 was used for INAA, and thin section 71067,5 was taken from this irradiated sample.

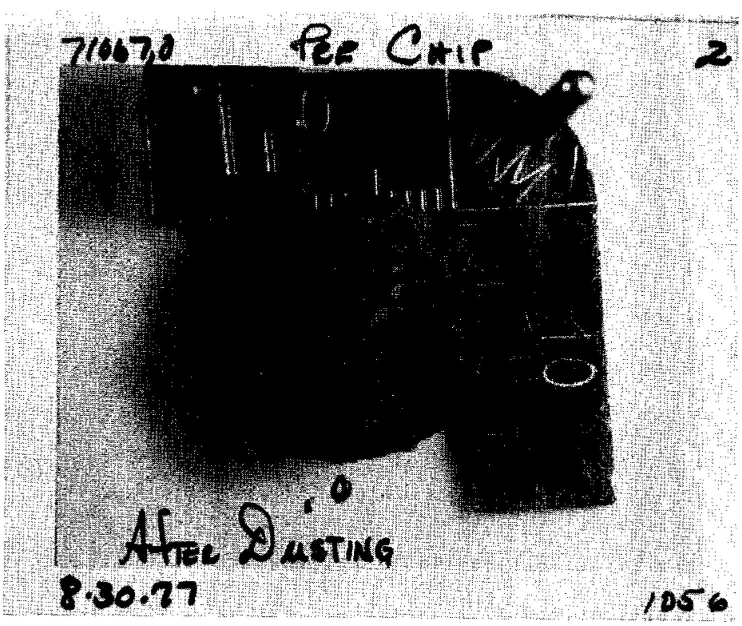


Figure 1: Hand specimen photograph of 71067,0.

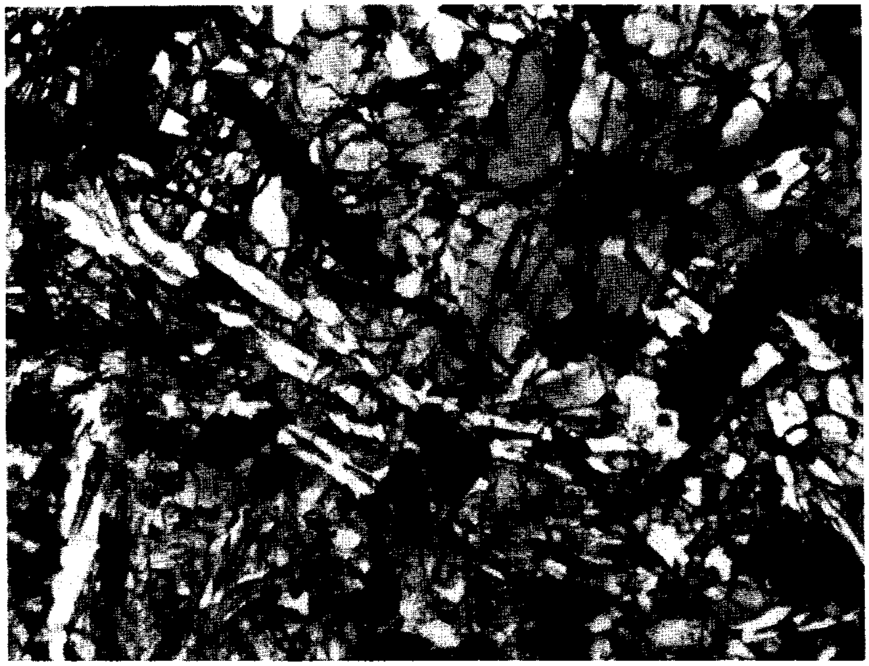


Figure 2: Photomicrograph of 71067,5. Field of view is 2.5 mm.

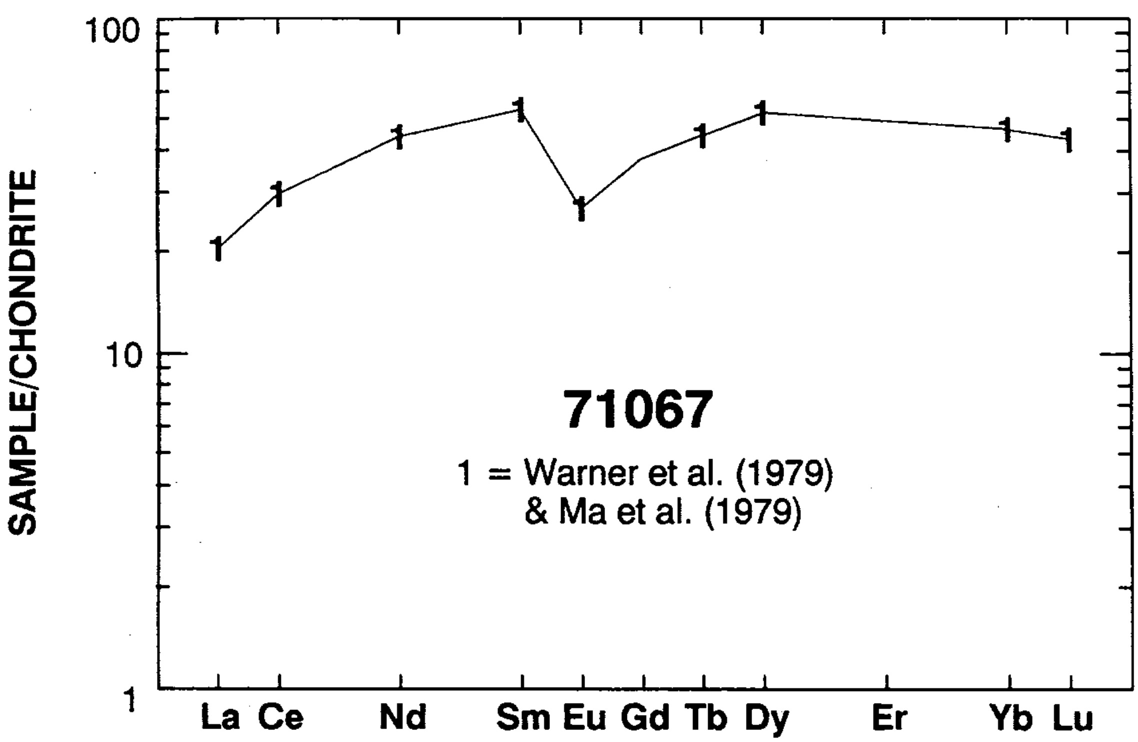


Figure 3: Chondrite-normalized rare-earth element profile of 71067.

Table 1: Whole-rock chemistry of 71067.
Data from Ma et al. (1979) and Warner et al. (1979) (same analysis).

	71067,2 I		71067,2 I
SiO_2 (wt %)		Cu	
TiO_2	12.7	Ni	
Al_2O_3	8.9	Co	20
Cr_2O_3	0.408	V	101
FeO	19.5	Sc	82
MnO	0.254	La	6.8
MgO	9	Ce	26
CaO	10.7	Nd	28
Na_2O	0.421	Sm	10.9
K_2O	0.069	Eu	2.09
P_2O_5		Gd	
S		Tb	2.6
Nb (ppm)		Dy	18
Zr		Er	
Hf	9.2	Yb	10.3
Ta	2.2	Lu	1.48
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

I = analysis by INAA.

71068

High-Ti Mare Basalt
4.208 g, 2 × 1 × 0.7 cm

INTRODUCTION

71068 was described as a medium brownish gray, medium-grained (average 0.7mm), homogeneous basalt (Apollo 17 Lunar Sample Information Catalog, 1973), containing no zap pits. This basalt is angular and blocky. The surface is coated with fine dust and soils, with some adhering glass spherules. One end of the rock is a cavity wall, broken, and lined with euhedral ilmenite crystals and coated with dust. This sample was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1979) have reported on 71068, but have described it only within the general confines of their coarse-grained basalt group. As such, 71068 was not specifically mentioned, although it does exhibit a plagioclase poikilitic texture. We examined thin section 71068,5 during the preparation of this catalog, finding it to be a coarse-grained (0.5-1mm), plagioclase poikilitic basalt. Olivine (<0.1mm) is rare, only present as cores in large, pink pyroxenes. No armalcolite is present, and ilmenite (up to 1mm) is the dominant opaque. Abundant rutile and chromite exsolution lamellae (<0.005mm) are present in the ilmenite. Native Fe, troilite, and silica form interstitial phases. The Apollo 17 Lunar Sample Information Catalog (1973) reported that 71068 is comprised of 35-40% plagioclase, 45% pyroxene, 15-20% ilmenite, and <1% olivine.

WHOLE-ROCK CHEMISTRY

Ma et al. (1979) and Warner et al. (1979) reported the same whole-rock analysis of 71068,2 (Table 1). Warner et al. (1979) described 71068 as a coarse-grained Apollo 17 high-Ti basalt (Type U of Rhodes et al., 1976). This basalt contains 13.6 wt% TiO_2 with a MG# of 45.9. The REE profile (Fig. 1) is LREE-depleted with relatively constant middle and heavy REE abundances (~30 times chondrites). A negative Eu anomaly is present ($[Eu/Eu^*]_N = 0.66$).

PROCESSING

Of the original 4.208g of 71068,0, 3.75g remains. 71068,2 was irradiated for INAA, and thin section 71068,5 was made from this irradiated sample.

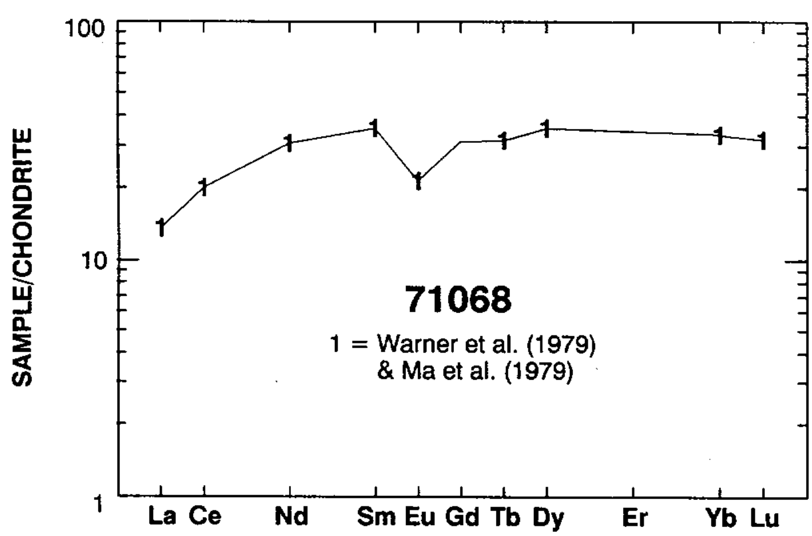


Figure 1: Chondrite-normalized rare-earth element profile of 71068.

Table 1: Whole-rock chemistry of 71068.
Data from Ma et al. (1979) and Warner et al. (1979) (same analysis).

	71068,2 I		71068,2 I
SiO_2 (wt %)		Cu	
TiO_2	13.6	Ni	
Al_2O_3	8.3	Co	25
Cr_2O_3	0.530	V	135
FeO	18.9	Sc	79
MnO	0.244	La	4.4
MgO	9	Ce	17
CaO	9.8	Nd	19
Na_2O	0.368	Sm	7.1
K_2O	0.038	Eu	1.62
P_2O_5		Gd	
S		Tb	1.8
Nb (ppm)		Dy	12
Zr		Er	
Hf	7.3	Yb	7.2
Ta	1.7	Lu	1.06
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

I = analysis by INAA.

71069
High-Ti Mare Basalt
4.058 g, 2 × 1.7 × 1 cm

INTRODUCTION

71069 was described as a fine-grained equigranular, medium dark gray, homogeneous basalt (Apollo 17 Lunar Sample Information Catalog, 1973 and Fig. 1), containing no fresh zap pits. Three small vugs (<0.15mm) are present, inside of which are minute euhedral ilmenite crystals. Dust adheres to most surfaces and ~1% olivine is present. Rock resembles 71065 and 71066. This sample was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

71069 was described by Warner et al. (1979), but only within the general confines of their Type B Apollo 17 high-Ti basalts. As such, 71069 was not specifically mentioned, although it contains microphenocrysts of olivine and ilmenite. During the preparation of this catalog, we examined thin section 71069,5. It is a fine-grained (average grain size ~0.3mm), containing large (~0.7mm) olivine and ilmenite phenocrysts. Some olivines contain a small rind of pyroxene, whereas others have been reduced to forming cores of pyroxene. Rutile and chromite exsolution lamellae (<0.005mm) are abundant in the ilmenite. Larger ilmenites

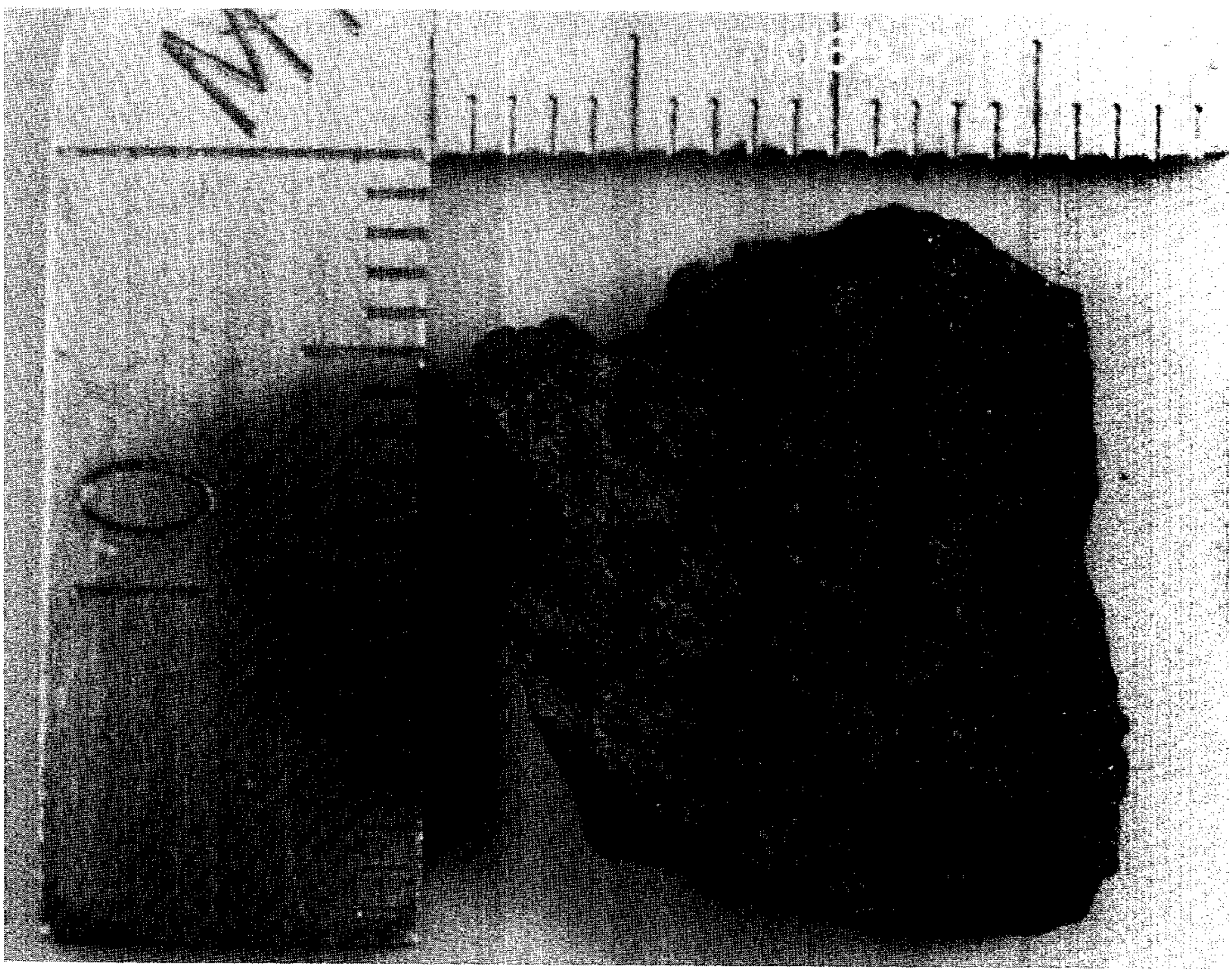


Figure 1: Hand specimen photograph of 71069,0.

contain armalcolite cores. Plagioclase, pyroxene, and ilmenite form the main groundmass phases, with pyroxene and plagioclase occasionally forming "bow-tie" structures. Native Fe and troilite form interstitial phases.

WHOLE-ROCK CHEMISTRY

Ma et al. (1979) and Warner et al. (1979) both report the analysis of 71069,2 (Table 1). Warner et al. (1979) described this basalt as a Type B Apollo 17 high-Ti basalt. This sample is further classified as a Type B1 basalt using the criteria of Neal et al. (1990). 71069 contains 12.2 wt% TiO_2 with a MG# of 48.3. The REE profile (Fig. 2) is LREE-depleted with approximately constant middle and heavy REE abundances (30-35 times chondritic values). A negative Eu anomaly is present ($[Eu/Eu^*]_N = 0.59$).

ISOTOPES

Paces et al. (1991) reported Rb-Sr (Table 2) and Sm-Nd (Table 3) data for 71069,10. These analyses were part of a larger study characterizing the basalts at the Apollo 17 site.

PROCESSING

Of the original 4.058g of 71069,0, a total of 3.76g remains. 71069,2 was irradiated for INAA, and thin section 71069,5 was taken from this irradiated sample.

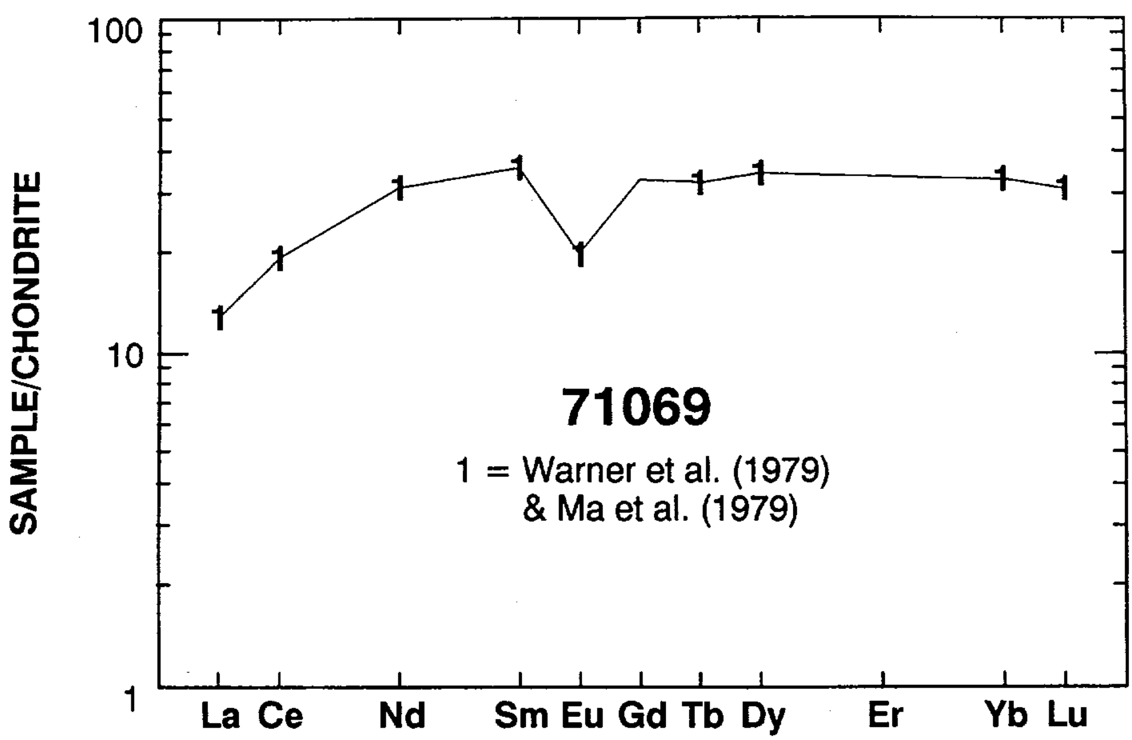


Figure 2: Chondrite-normalized rare-earth element profile of 71069.

Table 1: Whole-rock chemistry of 71069.
Data from Ma et al. (1979) and Warner et al. (1979) (same analysis).

	71069,2 I		71069,2 I
SiO_2 (wt %)		Cu	
TiO_2	12.2	Ni	
Al_2O_3	8.6	Co	21
Cr_2O_3	0.474	V	140
FeO	19.1	Sc	85
MnO	0.246	La	4.3
MgO	10	Ce	17
CaO	9.8	Nd	20
Na_2O	0.312	Sm	7.4
K_2O	0.032	Eu	1.55
P_2O_5		Gd	
S		Tb	1.9
Nb (ppm)		Dy	12
Zr		Er	
Hf	6.6	Yb	7.4
Ta	1.5	Lu	1.07
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

I = analysis by INAA.

Table 2: Rb-Sr isotopic data for 71069,10.
Data from Paces et al. (1991).

Rb (ppm)	0.315
Sr (ppm)	146
$^{87}Rb/^{86}Sr$	0.006216 ± 62
$^{87}Sr/^{86}Sr$	0.699529 ± 12
I(Sr)[a]	0.699195 ± 15
T_{LUNI}[b] (Ga)	5.5

[a]Initial Sr isotopic ratios calculated at 3.69 Ga using ^{87}Rb decay constant = 1.42×10^{-11} yr^{-1}.

[b]Model age relative to I(Sr) = LUNI = 0.69903 (Nyquist et al., 1974; Shih et al., 1986).

$T_{LUNI} = 1/\lambda * \ln[((^{87}Sr/^{86}Sr - 0.69903)/^{87}Rb/^{86}Sr) + 1]$.

Table 3: Sm-Nd isotopic data for 71069,10.
Data from Paces et al. (1991).

Sm (ppm)	7.35
Nd (ppm)	17.3
$^{147}Sm/^{144}Nd$	0.25663 ± 51
$^{143}Nd/^{144}Nd$	0.514406 ± 13
I(Nd)[a]	0.508138 ± 26
$\varepsilon_{Nd}(t)$[b]	6.0 ± 0.5
T_{CHUR}[c] (Ga)	4.4

[a]Initial Nd isotopic ratios calculated at 3.69 Ga using ^{147}Sm decay constant = $6.54 \times 10^{-12} yr^{-1}$.

[b]Initial ε_{Nd} calculated at 3.69 Ga using present-day chondritic values of $^{143}Nd/^{144}Nd = 0.512638$ and $^{147}Sm/^{144}Nd = 0.1967$.

[c]Model age relative to CHUR reservoir using present-day chondritic values listed above.

$T_{CHUR} = 1/\lambda * \ln[((^{143}Nd/^{144}Nd - 0.512638)/(^{147}Sm/^{144}Nd - 0.1967) + 1]$.

71075
High-Ti Mare Basalt
1.563 g, 1.5 × 1 × 0.5 cm

INTRODUCTION

71075 (Fig. 1) was described as a dark gray (with faint brownish tint), equigranular basalt (Apollo 17 Lunar Sample Information Catalog, 1973), containing no zap pits. Approximately 5-10% vugs are present, inside of which are euhedral ilmenite, olivine, and pyroxene crystals. These vugs are irregularly distributed and the surfaces are finely hackly. This sample was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

The mineralogy and petrography of 71075 has not been reported before, although three thin sections have been made. During the preparation of this catalog, we examined 71075,27 and ,28. This is a fine-grained (~0.1mm), well-crystallized, ilmenite-rich basalt, containing phenocrysts of olivine and ilmenite (up to 0.3mm). Little mesostasis glass is present. Ilmenite is also a groundmass phase with pyroxene and plagioclase. No armalcolite is present. Pink pyroxene masses (up to 0.3mm) exist and a pale pink pyroxene forms "bow-tie" structures with plagioclase. The pink pyroxene masses occasionally contain a core of olivine, indicating their size is due to olivine resorption. Rare Cr-ulvöspinel is present (0.15mm). Troilite and native Fe form interstitial phases.

WHOLE-ROCK CHEMISTRY

No whole-rock composition has been determined for 71075.

PROCESSING

Of the original 1.563g of 71075,0, approximately 1.38g remains. 71075,1 was used to prepare thin sections 71075,26-28.

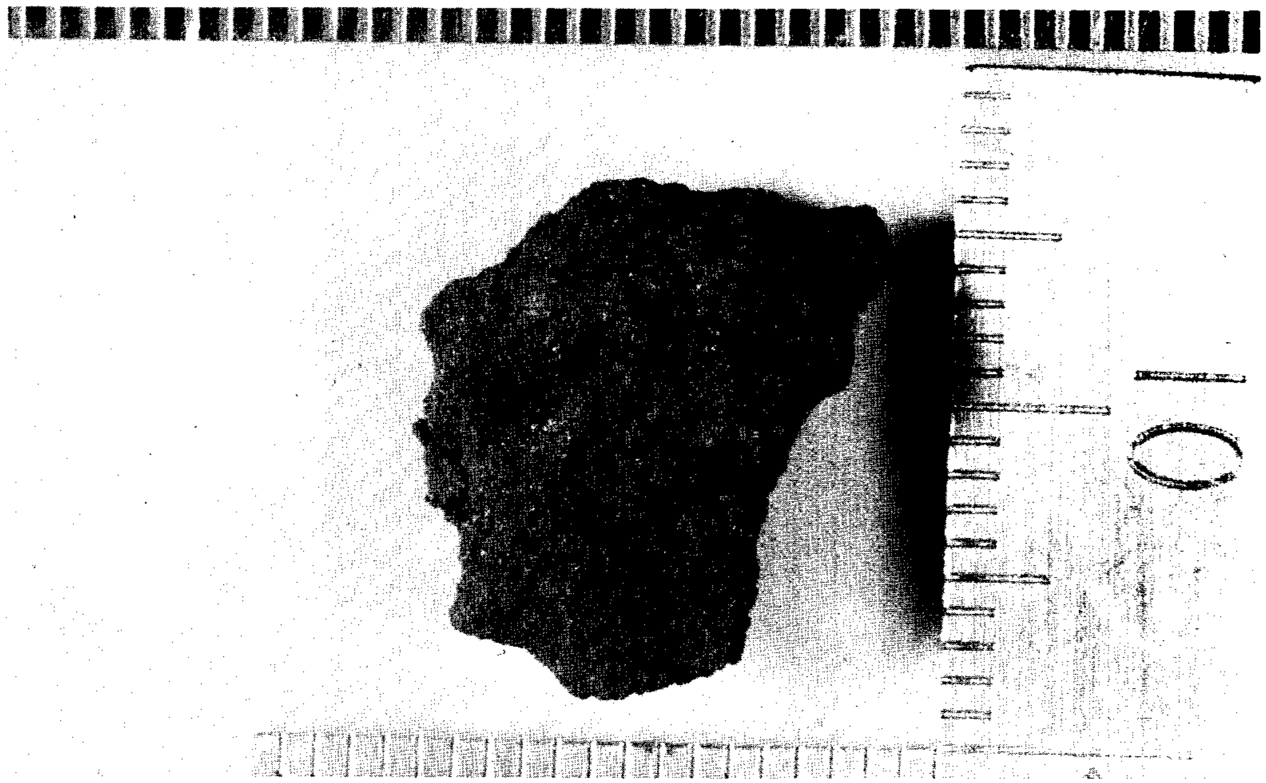


Figure 1: Hand specimen photograph of 71075,0.

71085

High-Ti Mare Basalt
3.402 g, 1.5 × 1.5 × 1 cm

INTRODUCTION

71085 (Fig. 1) was described as a medium dark gray, medium- to coarse-grained, intergranular basalt (Apollo 17 Lunar Sample Information Catalog, 1973), containing one penetrative fracture or vuggy feature where coarser crystals are found. These coarser crystals reach up to 2.5 mm. The minerals in the "vuggy vein" are: 20% euhedral plagioclase, 70% cinnamon pyroxene in large clusters and euhedral crystals, and 10% euhedral ilmenite. The surface is coated with dust after two dustings; soil grains and spherules are conspicuous on the surface. This basalt was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1979) reported the general petrographic and mineralogic features of this basalt, but only within the general confines of their coarse-grained category of Apollo 17 high-Ti basalts (Class U of Rhodes et al., 1976). As such, this sample was never specifically mentioned. One thin section, 71085,6, was taken, but was not available for our examination during the preparation of this catalog.

WHOLE-ROCK CHEMISTRY

Warner et al. (1979) and Ma et al. (1979) reported the same analysis for 71085 (Table 1). Warner et al. (1979) classified this basalt as a coarse-grained type, of which the analysis taken was probably not representative. They reported 71085,3 as containing 14.2 wt% TiO_2 with a MG# of 49.6. The REE profile (Fig. 2) is LREE-depleted, with approximately constant middle and heavy REE abundances (~25 times chondritic values). A negative Eu anomaly is present ($[Eu/Eu^*]_N = 0.65$).

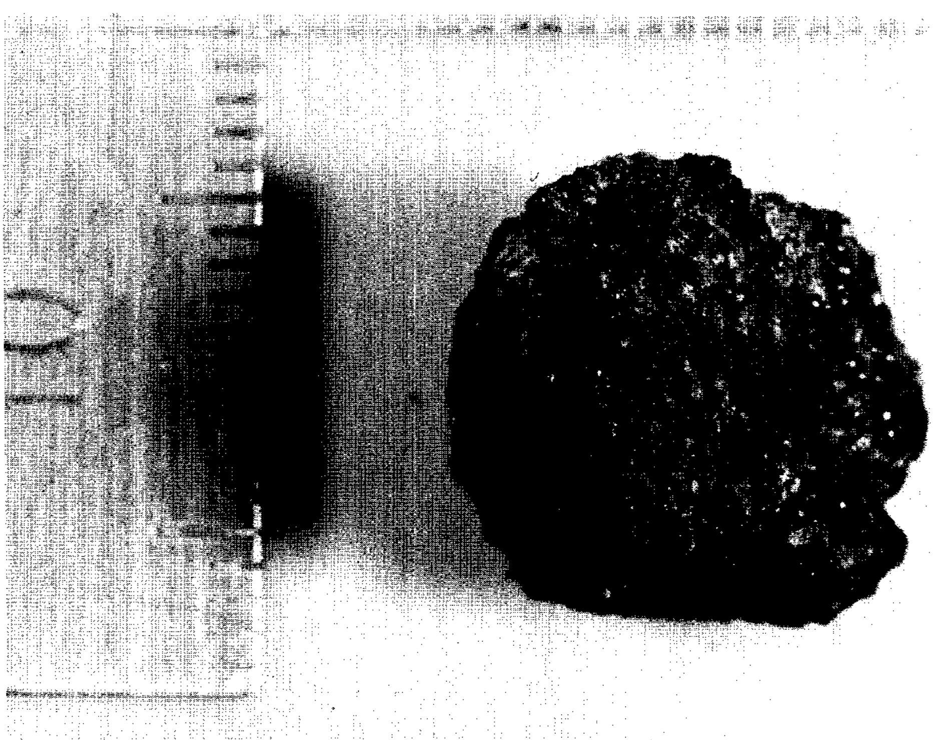


Figure 1: Hand specimen photograph of 71085,0.

Table 1: Whole-rock chemistry of 71085.
Data from Ma et al. (1979) and Warner et al. (1979) (same analysis).

	71085,3 I		71085,3 I
SiO_2 (wt %)		Cu	
TiO_2	14.2	Ni	
Al_2O_3	7.7	Co	20
Cr_2O_3	0.576	V	163
FeO	18.1	Sc	96
MnO	0.246	La	2.8
MgO	10	Ce	11
CaO	10.8	Nd	13
Na_2O	0.333	Sm	5.1
K_2O	0.032	Eu	1.21
P_2O_5		Gd	
S		Tb	1.3
Nb (ppm)		Dy	9
Zr		Er	
Hf	5.5	Yb	5.6
Ta	1.3	Lu	0.83
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

I = analysis by INAA.

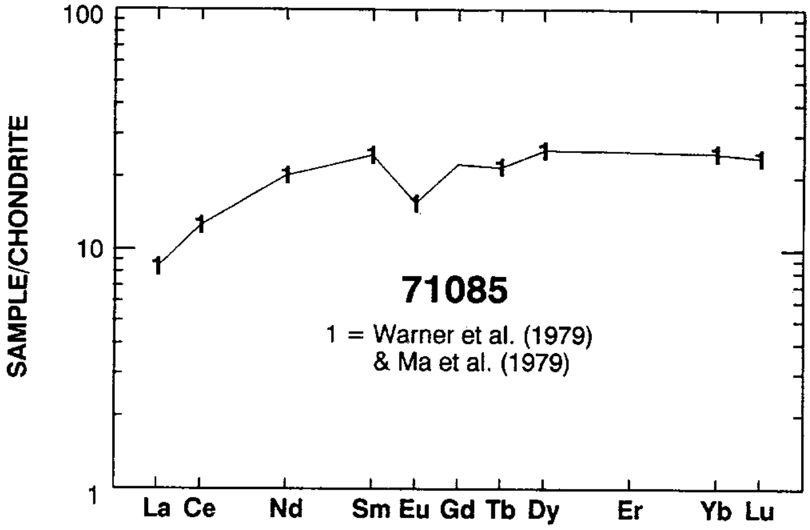


Figure 2: Chondrite-normalized rare-earth element profile of 71085.

PROCESSING

Of the original 3.402g of 71085,0, a total of 2.76g remains. 71085,3 was irradiated for INAA, and thin section 71085,6 was taken from this irradiated sample.

71086
High-Ti Mare Basalt
3.329 g, 3 × 2 × 0.7 cm

INTRODUCTION

71086 (Fig. 1) was described as a medium dark gray, fine-grained, homogeneous basalt (Apollo 17 Lunar Sample Information Catalog, 1973). This basalt contains no glass-lined zap pits, but one or two possible relict pits. Up to 50% of the surface is covered with cavities (Fig. 1) containing ilmenite crystals.

This sample was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1979) described the general petrography and mineral chemistry of 71086, but only within the confines of their Type B Apollo 17 high-Ti basalts. As such, this sample was not specifically mentioned. During the preparation of this catalog, we examined thin section 71086,5, finding it to be comprised of interlocking "bow-tie" structures of pyroxene and plagioclase. Grain size ranges from 0.1mm to 0.3mm. Corroded olivine phenocrysts occur (up to 0.6mm), but some have been reacted out to only form cores in

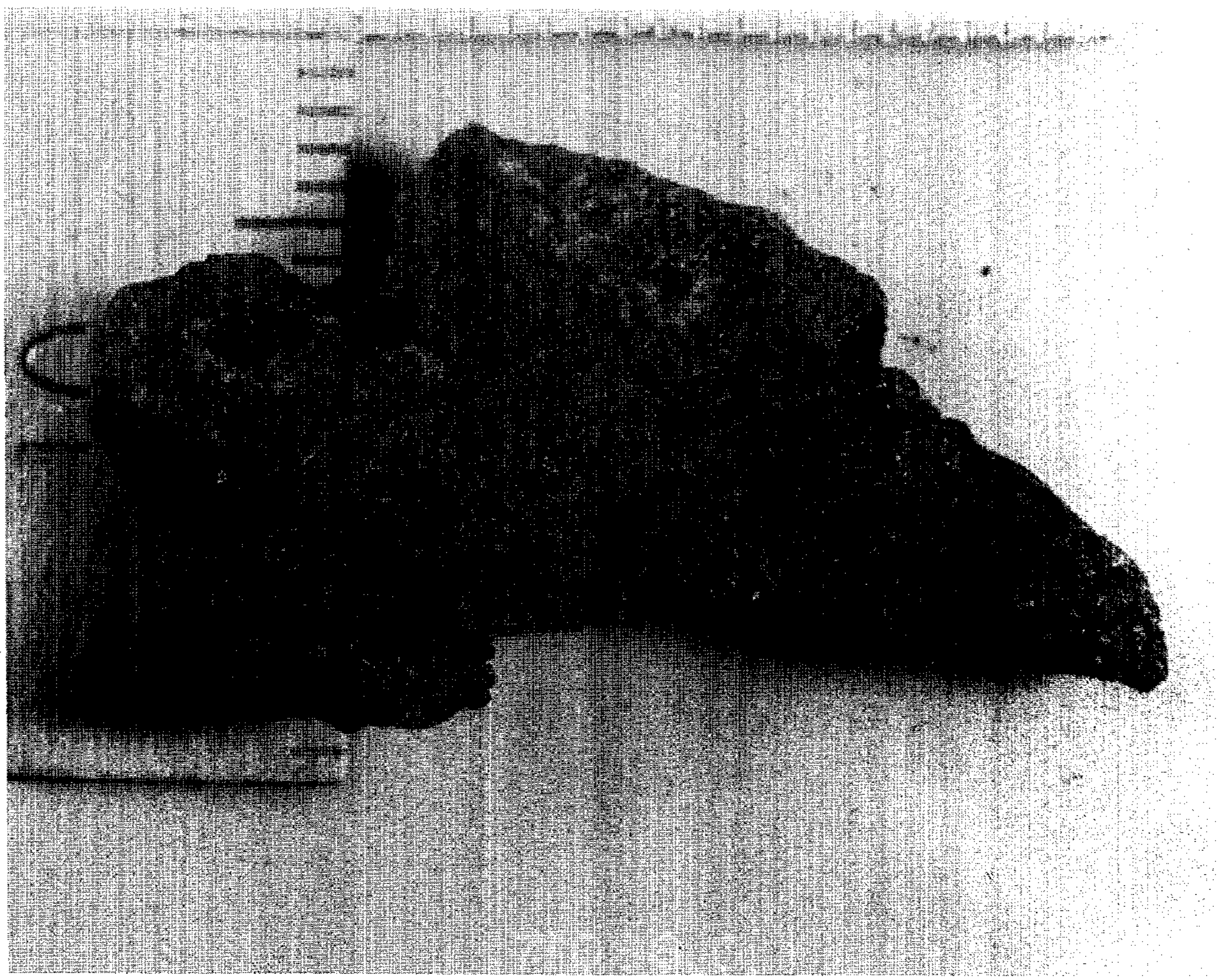


Figure 1: Hand specimen photograph of 71086,0.

pink pyroxene. Ilmenite occurs as a groundmass phase, and no armalcolite is present. Native Fe and troilite form interstitial phases.

WHOLE-ROCK CHEMISTRY

Ma et al. (1979) and Warner et al. (1979) reported the same analysis for 71086 (Table 1). Warner et al. classified 71086 as a Type B Apollo 17 high-Ti basalt, containing 11.6 wt% TiO_2 with a MG# of 42.5. 71086 is further classified as a Type B2 basalt using the criteria of Neal et al. (1990). The REE profile (Fig. 2) is LREE-depleted, with a negative Eu anomaly ($[Eu/Eu^*]_N = 0.57$). The middle and heavy REE abundances are approximately constant at 35 times chondritic values.

PROCESSING

Of the original 3.329g of 71086,0, a total of 2.93g remains. 71086,2 was irradiated for INAA, and thin section 71086,5 was taken from this irradiated sample.

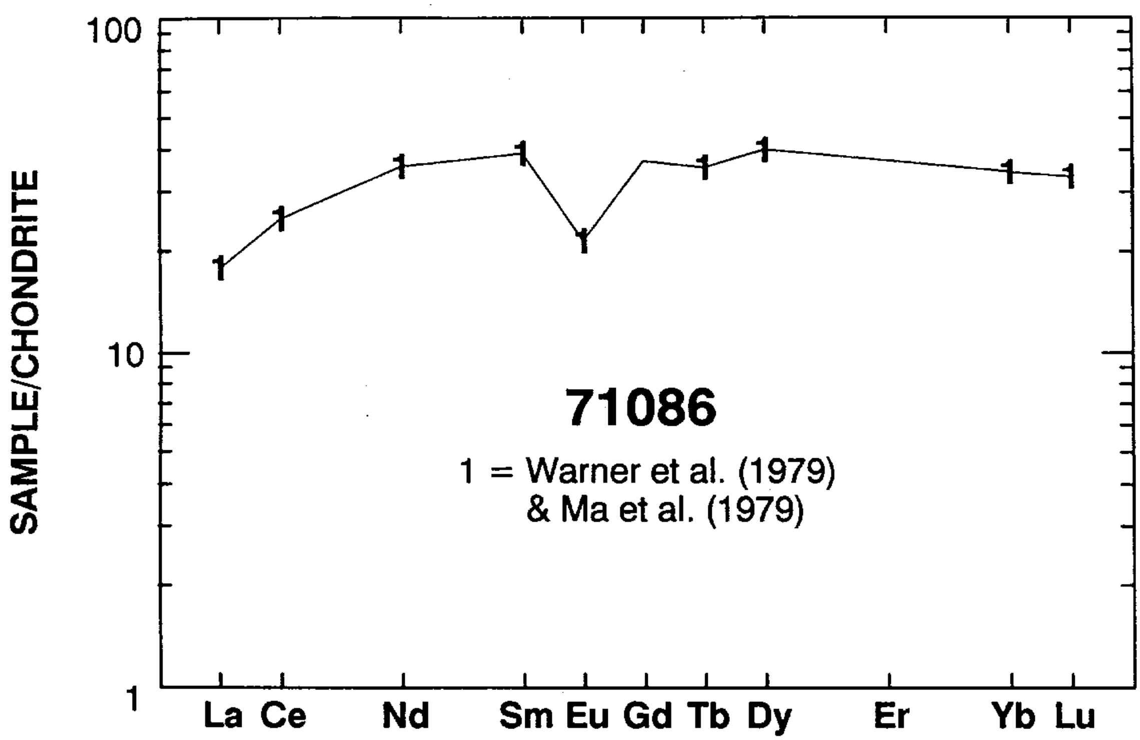


Figure 2: Chondrite-normalized rare-earth element profile of 71086.

Table 1: Whole-rock chemistry of 71086.
Data from Ma et al. (1979) and Warner et al. (1979) (same analysis).

	71086,2 I		71086,2 I
SiO_2 (wt %)		Cu	
TiO_2	11.6	Ni	
Al_2O_3	10.0	Co	18
Cr_2O_3	0.312	V	102
FeO	19.3	Sc	84
MnO	0.268	La	6.0
MgO	8	Ce	22
CaO	10.8	Nd	23
Na_2O	0.381	Sm	8.1
K_2O	0.050	Eu	1.68
P_2O_5		Gd	
S		Tb	2.1
Nb (ppm)		Dy	14
Zr		Er	
Hf	7.4	Yb	7.7
Ta	1.7	Lu	1.15
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

I = analysis by INAA.

71087
High-Ti Mare Basalt
2.20 g, 1.5 × 1.5 × 1 cm

INTRODUCTION

71087 (Fig. 1) was described as a fine-grained, equigranular, medium dark gray (with brownish tint), homogeneous basalt (Apollo 17 Lunar Sample Information Catalog, 1973). It contains only one cavity lined with ilmenite crystals and is covered with a thick dust coating. One surface is probably a broken cavity lined with ilmenite crystals. This basalt was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

Neal et al. (1990) described 71087 as a fine-grained, subvariolitic, olivine porphyritic basalt. Olivine (up to 0.7mm) and ilmenite (up to 1.2mm) phenocrysts are present, with olivine containing overgrowths of pyroxene and ilmenite "sawtooth" margins. Rutile and chromite exsolution lamellae (<0.005mm) are present in ilmenite. Plagioclase, pyroxene, and ilmenite form groundmass phases (~0.2-0.4mm). Cr-ulvöspinel (~0.1mm) occurs as inclusions in pyroxene and olivine. Silica, native Fe, and troilite form interstitial phases. Point counting reveals that this sample is comprised of: 48.1% pyroxene; 24.4% plagioclase; 21.2% ilmenite; 3.1% native Fe and troilite; 0.2% olivine; 1% silica; and 2% spinel.

Olivine exhibits only minor core-to-rim zonation (5 mole % Fo, max.), but between grains the compositional variation is more pronounced (Fo_{58-71}). Plagioclase exhibits only minor variations either core-to-rim or between grains (An_{81-87}). Pyroxene compositions (Fig. 2) range from titan-augite to pigeonite (with compositional intermediates). Fe enrichment is noted towards the rims. Al/Ti ratios are constant at ~2 and Cr_2O_3 decreases with decreasing pyroxene MG#. Cr-ulvöspinel (Cr/(Cr+Al) = 65-76; MG# = 4-18) and ilmenite (MG# = 2-12) both exhibit moderate compositional variations. Cr-ulvöspinel becomes more Al- and Fe-rich from core-to-rim, but ilmenite variation is primarily between grains. No armalcolite is present.

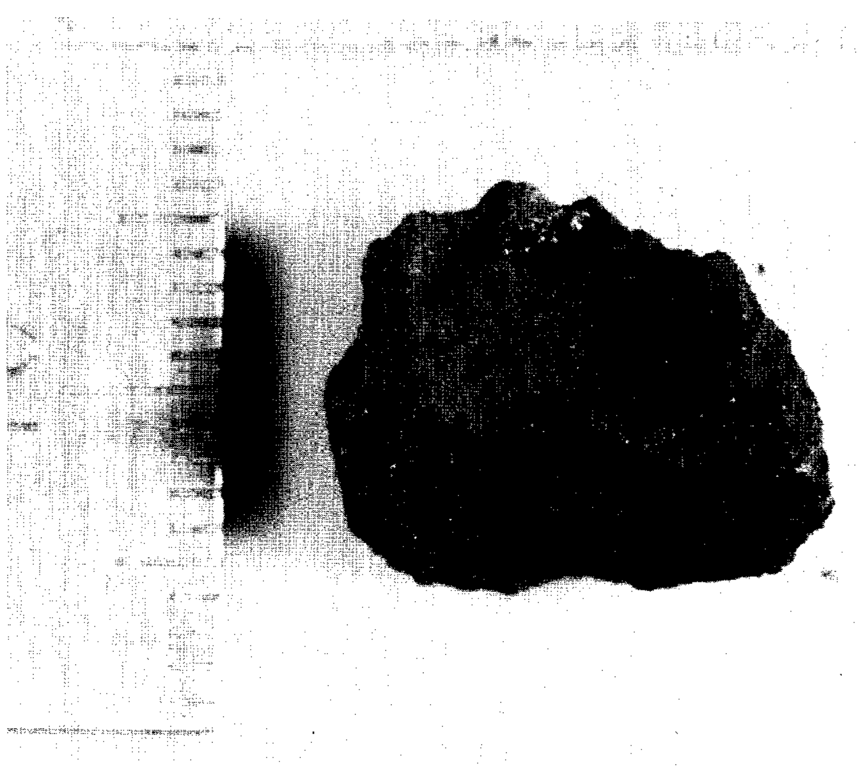


Figure 1: Hand specimen photograph of 71087,0.

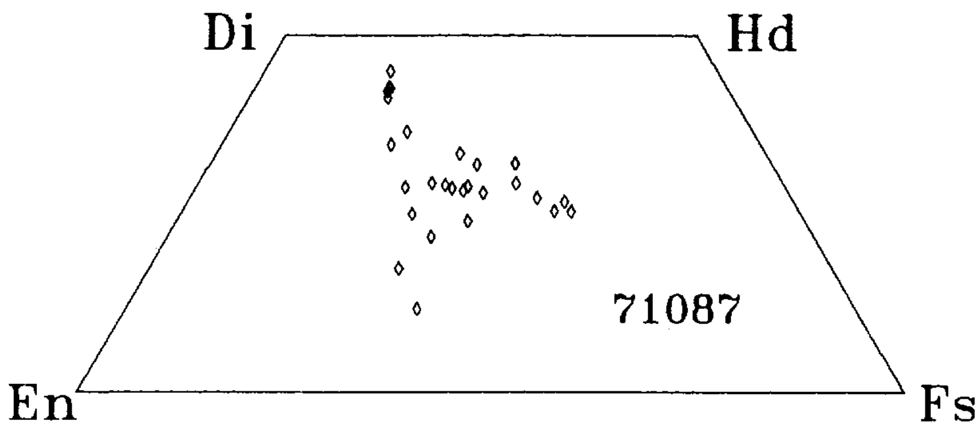


Figure 2: Pyroxene compositions of 71087 represented on a pyroxene quadrilateral.

WHOLE-ROCK CHEMISTRY

Neal et al. (1990) reported the whole-rock chemistry of 71087 (Table 1). They described 71087 as a Type A Apollo 17 high-Ti basalt (using the classification of Rhodes et al., 1976 and Warner et al., 1979) containing 12.9 wt% TiO_2 with a MG# of 43.1. The REE profile (Fig. 3) is LREE-depleted, but with an overall slight convex-upward appearance. A negative Eu anomaly is present ($[Eu/Eu^*]_N = 0.54$).

PROCESSING

Of the original 2.20g of 71087,0, a total of 1.63g remains. 71087,5 was used for INAA, and thin section 71087,4 was prepared from the irradiated sample.

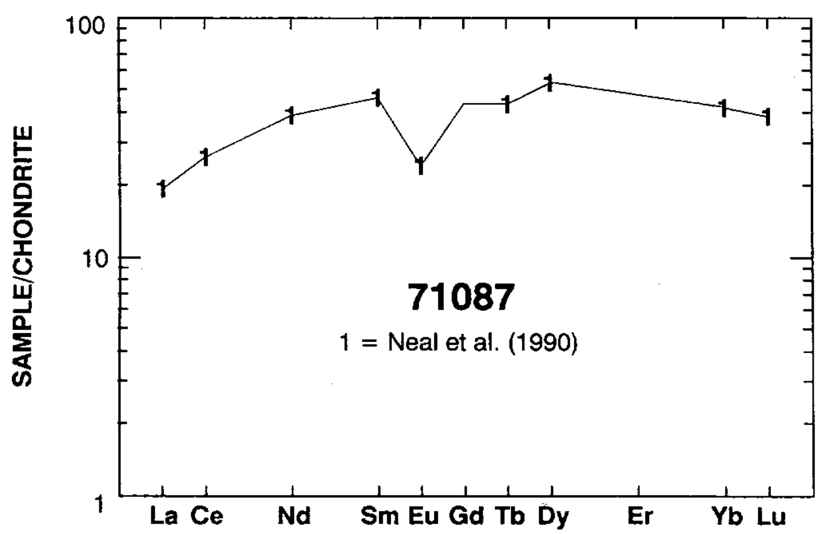


Figure 3: Chondrite-normalized rare-earth element profile of 71087.

Table 1: Whole-rock chemistry of 71087.
Data from Neal et al. (1990).

	71087,5 I		71087,5 I
SiO_2 (wt %)		Cu	
TiO_2	12.9	Ni	31
Al_2O_3	8.10	Co	19
Cr_2O_3	0.212	V	104
FeO	18.8	Sc	80
MnO	0.250	La	6.48
MgO	7.9	Ce	23
CaO	10.2	Nd	25
Na_2O	0.39	Sm	9.53
K_2O	0.08	Eu	1.89
P_2O_5		Gd	
S		Tb	2.56
Nb (ppm)		Dy	18.6
Zr	101	Er	
Hf	8.61	Yb	9.40
Ta	1.89	Lu	1.33
U		Ga	
Th	0.49	F	
W		Cl	
Y		C	
Sr	204	N	
Rb		H	
Li		He	
Ba	89	Ge (ppb)	
Cs	0.24	Ir	
Be		Au	
Zn		Ru	
Pb		Os	

I = analysis by INAA.

71088
High-Ti Mare Basalt
2.064 g, 2 × 1 × 0.5 cm

INTRODUCTION

71088 (Fig. 1) was described as a fine-grained, equigranular, medium dark gray basalt (Apollo 17 Lunar Sample Information Catalog, 1973). This basalt contains three small (1mm) vugs lined with ilmenite. It is thinly coated with dust and white patches are present on one surface. This sample was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

Neal et al. (1990) described 71088 as a fine-grained (0.2-0.4mm), subvariolitic, olivine porphyritic basalt. Olivine (up to 0.6mm) and ilmenite (up to 0.9mm) form microphenocryst phases. Olivines contain pink pyroxene overgrowths which are occasionally extensive such that olivine forms a small core. Ilmenites exhibit "sawtooth" margins, but little rutile or chromite exsolution. Cr-ulvöspinel is present as ~0.1mm inclusions in pyroxene and olivine. No armalcolite is present. Silica, native Fe, and troilite form interstitial phases. Point counting reveals that 71088 is comprised of: 36.8% pyroxene; 28.0% plagioclase; 21.7% ilmenite; 8.2% olivine; 2.3% native Fe and troilite; 2.1% spinel; and 0.9% silica.

Olivines exhibit wide compositional variations (Fo_{43-71}), usually between grains, but also from core-to-rim in the largest olivines. However, plagioclase exhibits only limited variation (An_{80-88}). The majority of pyroxenes are titan-augites (Fig. 2), although rare pigeonites are present. Fe enrichment is observed from core-to-rim. Al/Ti ratios are constant at ~2 and Cr_2O_3 decreases with decreasing MG#. Cr-ulvöspinels exhibit limited compositional variation (Cr/(Cr+Al) = 72-77;

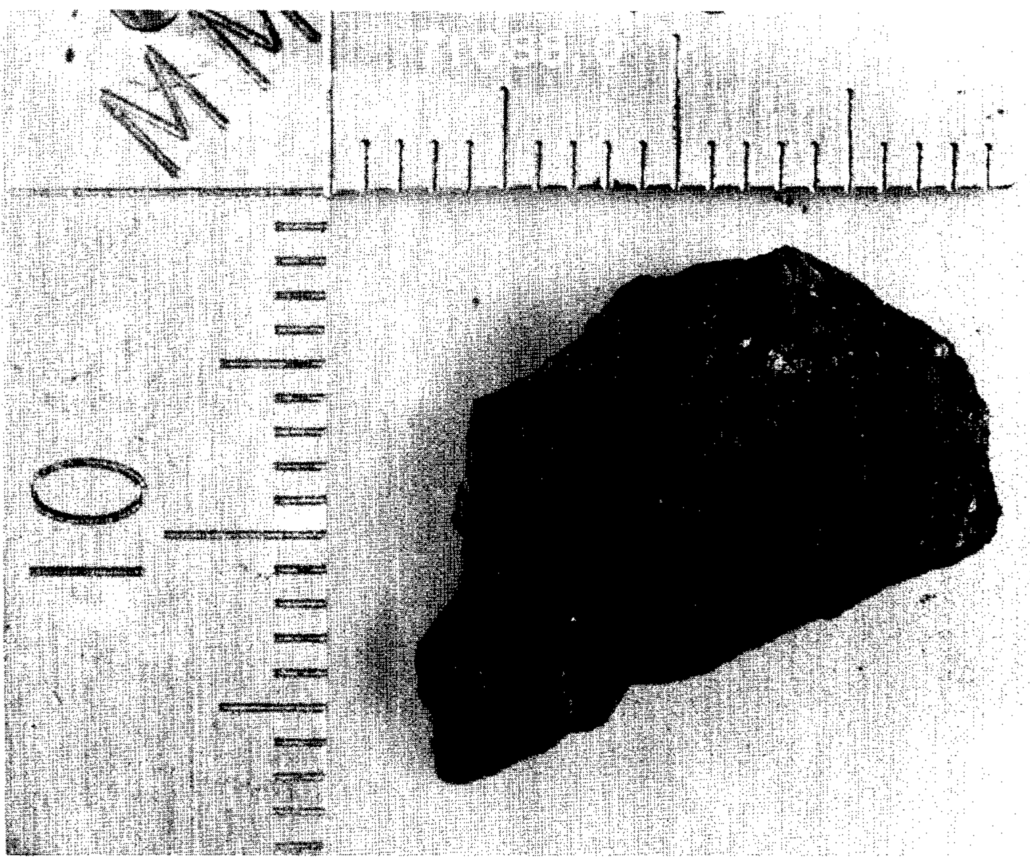


Figure 1: Hand specimen photograph of 71088,0.

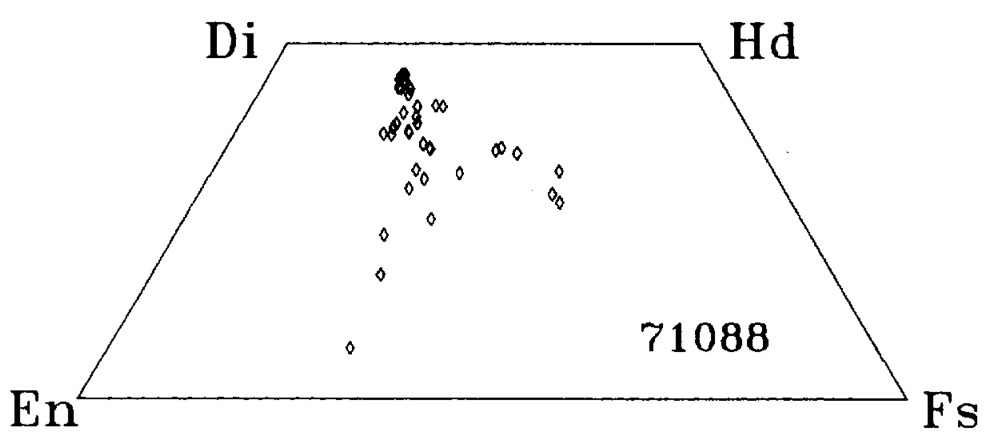


Figure 2: Pyroxene compositions of 71088 represented on a pyroxene quadrilateral.

MG# = 7-8), whereas ilmenite exhibits greater variation, mostly between individual grains (MG# = 7-18).

WHOLE-ROCK CHEMISTRY

Neal et al. (1990) described 71088 as a Type A Apollo 17 high-Ti mare basalt (using the classification of Rhodes et al., 1976 and Warner et al., 1979). 71088 contains 12.5 wt% TiO2 with a MG# of 43.4 (Table 1). The REE profile (Fig. 3) is LREE-depleted with a general convex-upward appearance. A negative Eu anomaly is present ([Eu/Eu*]N = 0.52).

PROCESSING

Of the original 2.064g of 71088,0, a total of 1.72g remains. 71088,5 was used for INAA, and thin section 71088,4 was prepared from the irradiated sample.

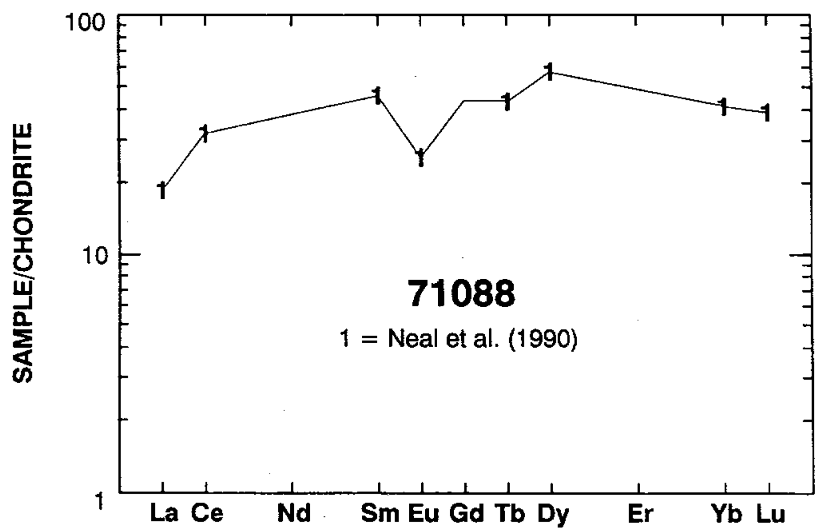


Figure 3: Chondrite-normalized rare-earth element profile of 71088.

Table 1: Whole-rock chemistry of 71088.
Data from Neal et al. (1990).

	71088,5 I		71088,5 I
SiO_2 (wt %)		Cu	
TiO_2	12.5	Ni	32
Al_2O_3	8.60	Co	20
Cr_2O_3	0.208	V	108
FeO	18.5	Sc	79
MnO	0.260	La	6.19
MgO	8.3	Ce	28
CaO	10.3	Nd	38
Na_2O	0.39	Sm	9.43
K_2O	0.06	Eu	1.99
P_2O_5		Gd	
S		Tb	2.55
Nb (ppm)		Dy	20.0
Zr	212	Er	
Hf	8.73	Yb	9.19
Ta	1.87	Lu	1.34
U		Ga	
Th	0.37	F	
W		Cl	
Y		C	
Sr	71	N	
Rb		H	
Li		He	
Ba	148	Ge (ppb)	
Cs	0.19	Ir	
Be		Au	
Zn		Ru	
Pb		Os	

I = analysis by INAA.

71089
High-Ti Mare Basalt
1.733 g, 1 × 1 × 0.5 cm

INTRODUCTION

71089 (Fig. 1) was described as a brownish-gray, medium- to coarse-grained, homogeneous basalt (Apollo 17 Lunar Sample Information Catalog, 1973). This basalt contains one vug-riddled surface. Dust adheres to one surface. This sample was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

Neal et al. (1989) described 71089 as a plagioclase poikilitic basalt, with plagioclase up to 2mm. Pyroxene (up to 1.1mm) and blocky ilmenite (up to 1.4mm) are also dominant. Chromite and rutile exsolution lamellae (<0.005mm) are abundant in the ilmenite. Occasional pyroxenes contain small (~0.06mm) olivine cores. Relatively large (up to 0.4mm) areas of silica are conspicuous. No armalcolite or discrete Cr-ulvöspinel is present. Native Fe, troilite, and silica form interstitial phases. Point counting reveals that this specimen is comprised of: 45.1% pyroxene; 24.9% ilmenite; 23.3% plagioclase; 3.9% native Fe and troilite; 2.5% silica; and 0.3% olivine.

Olivine exhibits little core-to-rim variation, the range in composition being between grains (Fo_{55-67}). Plagioclase exhibits moderate variation, both between and within grains (An_{79-91}). Two distinct pyroxene compositions are identified in Figure 2: pigeonite and titan-augite. Both of these zone towards more Fe-rich compositions. Al/Ti ratios are constant at ~2 and Cr_2O_3 decreases with decreasing pyroxene MG#. Ilmenite exhibits moderate compositional variation (MG# = 9-21), primarily between grains.

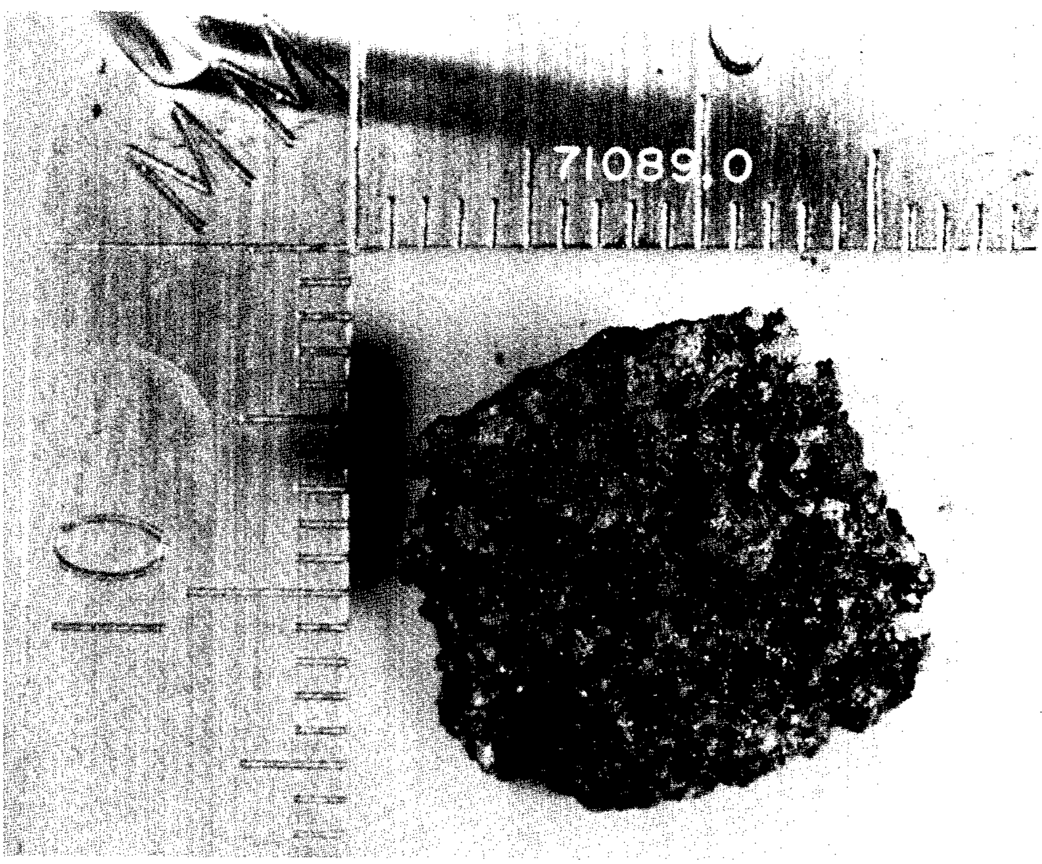


Figure 1: Hand specimen photograph of 71089,0.

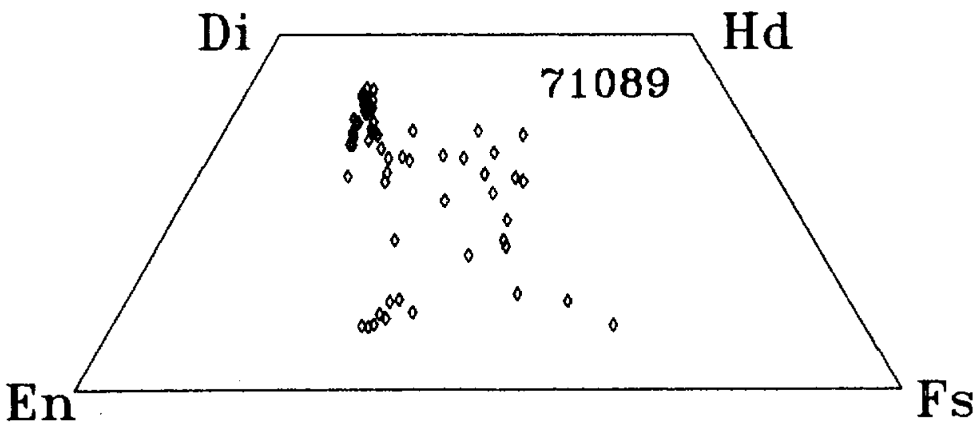


Figure 2: Pyroxene compositions of 71089 represented on a pyroxene quadrilateral.

WHOLE-ROCK CHEMISTRY

Neal et al. (1990) described 71089 as a Type B1 Apollo 17 high-Ti basalt (using the classification of Rhodes et al., 1976 and Warner et al., 1979).

71089 contains 11.3 wt% TiO_2 with a MG# of 39.4 (Table 1). The REE profile (Fig. 3) is LREE-depleted, but with an overall convex-upward appearance. A negative Eu anomaly is present ($[Eu/Eu^*]_N = 0.62$).

PROCESSING

Of the original 1.733g of 71089,0, approximately 0.8g remains. The remainder was irradiated for INAA and then used for thin section 71089,4.

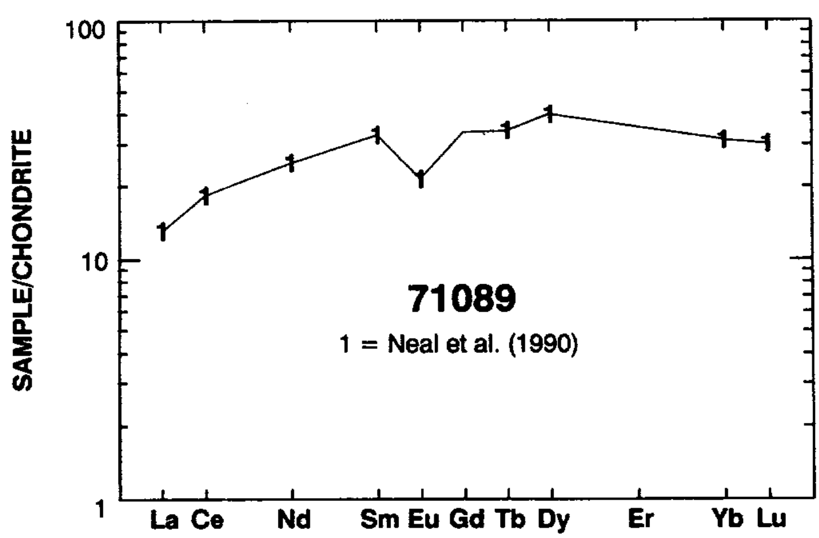


Figure 3: Chondrite-normalized rare-earth element profile of 71089.

Table 1: Whole-rock chemistry of 71089.
Data from Neal et al. (1990).

	71089,0 I		71089,0 I
SiO_2 (wt %)		Cu	
TiO_2	11.3	Ni	32
Al_2O_3	9.18	Co	18
Cr_2O_3	0.163	V	65
FeO	17.6	Sc	76
MnO	0.245	La	4.34
MgO	6.5	Ce	16
CaO	10.7	Nd	16
Na_2O	0.43	Sm	6.74
K_2O	0.06	Eu	1.67
P_2O_5		Gd	
S		Tb	2.01
Nb (ppm)		Dy	13.9
Zr	74	Er	
Hf	6.43	Yb	6.93
Ta	1.41	Lu	1.03
U	0.24	Ga	
Th	0.21	F	
W		Cl	
Y		C	
Sr	210	N	
Rb		H	
Li		He	
Ba	76	Ge (ppb)	
Cs	0.19	Ir	
Be		Au	
Zn		Ru	
Pb		Os	

I = analysis by INAA.

71095
High-Ti Mare Basalt
1.483 g, 1.5 × 1 × 1 cm

INTRODUCTION

71095 (Fig. 1) was described as a brownish gray, medium-grained, homogeneous basalt (Apollo 17 Lunar Sample Information Catalog, 1973). No vugs or zap pits are present. Three surfaces are dust coated (after two dustings). This basalt has a narrow wedge shape and was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

Neal et al. (1989) described 71095 as a subophitic basalt containing no olivine. Plagioclase grains are up to 1.1mm and pyroxene up to 0.7mm. Blocky ilmenite (up to 1.5mm) is interstitial, and exhibits no exsolution features. Silica, troilite, and native Fe form interstitial phases. Point counting reveals that 71095 is comprised of: 44.0% pyroxene; 37.6% plagioclase; 11.7% ilmenite; 3.4% native Fe and troilite; and 3.3% silica.

Plagioclase exhibits both core-to-rim and intergrain compositional variations (An_{72-88}). The cores possess higher An contents. It is the pyroxenes which are most definitive for this sample. No pigeonite is present (Fig. 2), and titan-augite zones towards pyroxferroite. This compositional range classifies 71095 as an Apollo 11 low-K type Apollo 17 high-Ti basalt (Papike et al., 1974), or Type II (Brown et al., 1975). Al/Ti ratios are constant at ~2, and Cr_2O_3 decreases with decreasing pyroxene MG#. Ilmenite is relatively depleted in MgO, and the major compositional variation is between grains (MG# = 1-10).

WHOLE-ROCK CHEMISTRY

Neal et al. (1990) described 71095 as a Type A Apollo 17

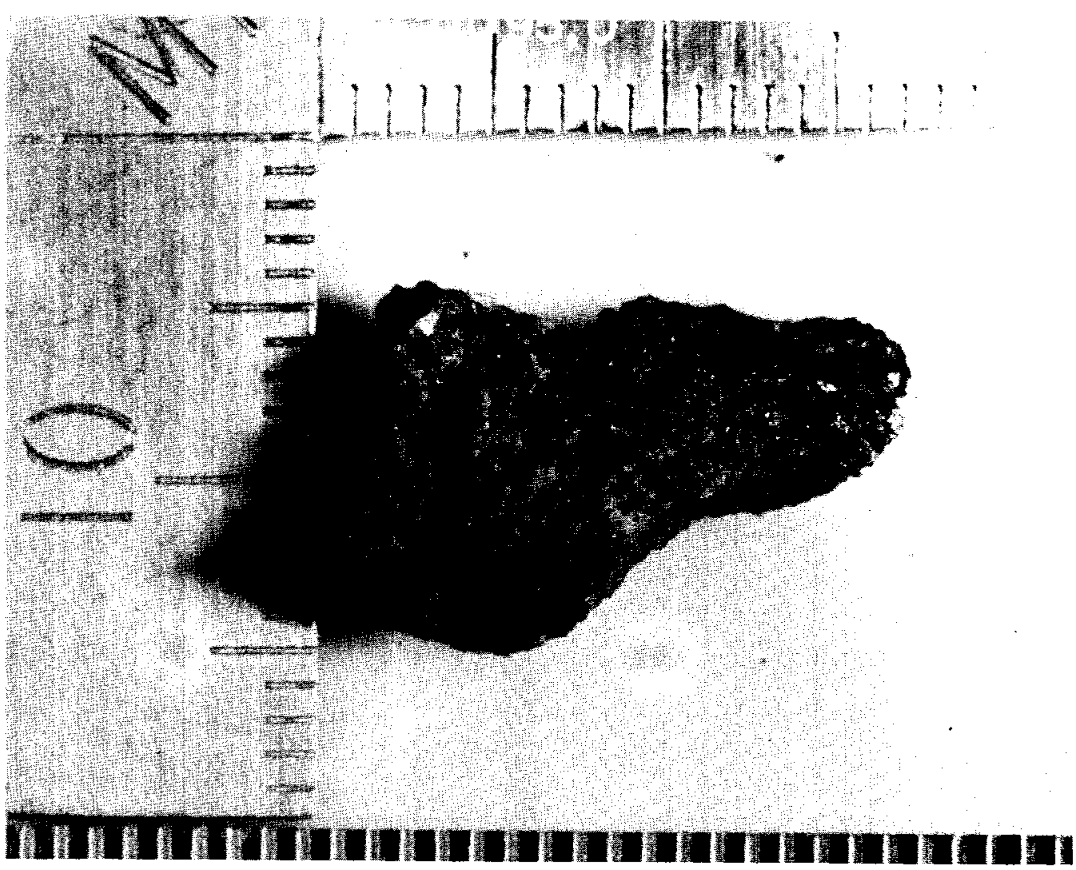


Figure 1: Hand specimen photograph of 71095,0.

Figure 2: Pyroxene compositions of 71095 represented on a pyroxene quadrilateral.

high-Ti basalt. This basalt contains only 7.7 wt% TiO_2 with a MG# of 29.7 (Table 1). The REE profile (Fig. 3) is LREE-depleted, but with an overall convex-upward shape. 71095 contains the highest abundances of the REE of any analyzed Apollo 17 high-Ti basalt. A negative Eu anomaly is present ($[Eu/Eu^*]_N = 0.50$).

ISOTOPES

Paces et al. (1991) reported Rb-Sr (Table 2) and Sm-Nd (Table 3) data for 71095,6. These analyses were part of a larger study characterizing the basalts at the Apollo 17 site.

PROCESSING

Of the original 1.483g of 71095,0, approximately 0.7g remains. 0.78g was irradiated for INAA, forming sample number 71095,0. The thin section number for this sample is 71095,4.

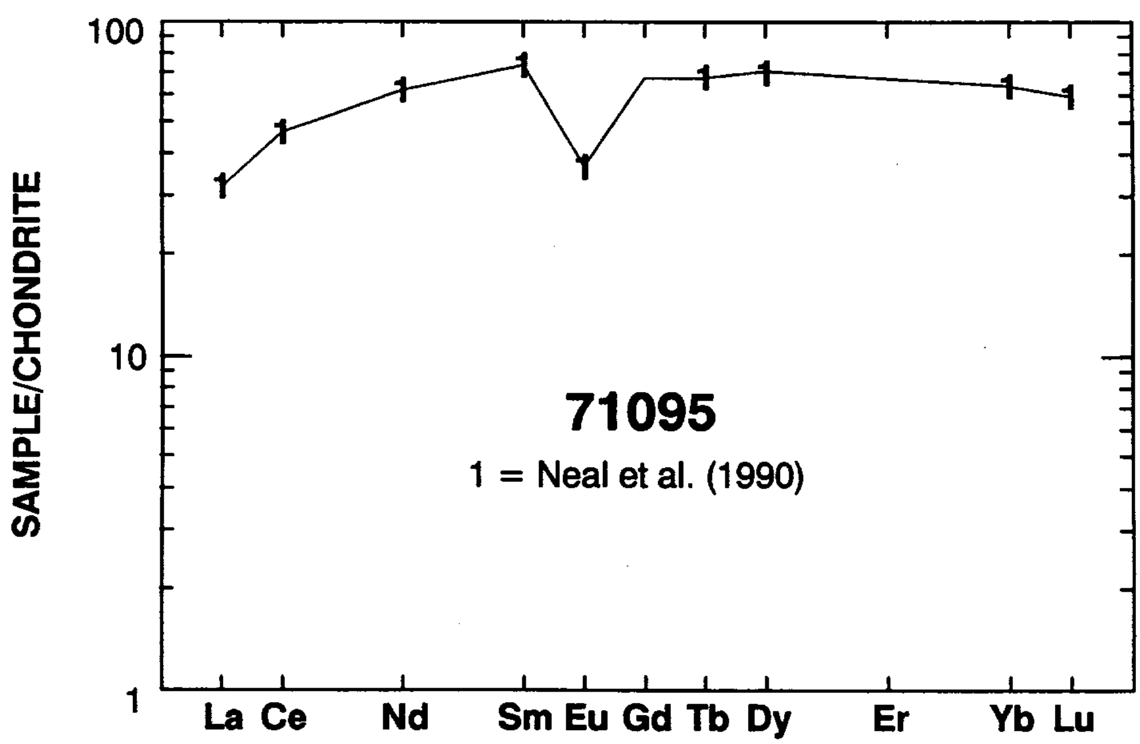


Figure 3: Chondrite-normalized rare-earth element profile of 71095.

Table 1: Whole-rock chemistry of 71095.
Data from Neal et al. (1990).

	71095,0 N		71095,0 N
SiO_2 (wt %)		Cu	
TiO_2	7.7	Ni	36
Al_2O_3	9.76	Co	13
Cr_2O_3	0.061	V	18
FeO	18.9	Sc	70
MnO	0.257	La	10.73
MgO	4.5	Ce	41
CaO	10.8	Nd	40
Na_2O	0.51	Sm	15.26
K_2O	0.12	Eu	2.88
P_2O_5		Gd	
S		Tb	4.01
Nb (ppm)		Dy	28.1
Zr	94	Er	
Hf	13.18	Yb	14.28
Ta	2.47	Lu	2.06
U	0.37	Ga	
Th	0.63	F	
W		Cl	
Y		C	
Sr	240	N	
Rb		H	
Li		He	
Ba	160	Ge (ppb)	
Cs	0.10	Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analyis by: N = INAA.

Table 2: Rb-Sr isotopic data for 71095,6.
Data from Paces et al. (1991).

Rb (ppm)	1.44
Sr (ppm)	319
$^{87}Rb/^{86}Sr$	0.001300 ± 13
$^{87}Sr/^{86}Sr$	0.699951 ± 13
I(Sr)[a]	0.699240 ± 20
T_{LUNI}[b] (Ga)	4.9

[a]Initial Sr isotopic ratios calculated at 3.75 Ga using ^{87}Rb decay constant = 1.42×10^{-11} yr^{-1}.

[b]Model age realtive to I(Sr) = LUNI = 0.69903 (Nyquist et al., 1974; Shih et al., 1986).
$T_{LUNI} = 1/l*ln[((^{87}Sr/^{86}Sr - 0.69903)/^{87}Rb/^{86}Sr) + 1]$.

Table 3: Sm-Nd isotopic data for 71095,6.
Data from Paces et al. (1991).

Sm (ppm)	25.2
Nd (ppm)	62.3
$^{147}Sm/^{144}Nd$	0.24471 ± 49
$^{143}Nd/^{144}Nd$	0.514164 ± 12
I(Nd)[a]	0.508088 ± 24
$\varepsilon_{Nd}(t)$[b]	6.6 ± 0.5
T_{CHUR}[c] (Ga)	4.8

[a]Initial Nd isotopic ratios calculated at 3.75 Ga using ^{147}Sm decay constant = $6.54 \times 10^{-12} yr^{-1}$.

[b]Initial ε_{Nd} calculated at 3.75 Ga using present-day chondritic values of $^{143}Nd/^{144}Nd$ = 0.512638 and $^{147}Sm/^{144}Nd$ = 0.1967.

[c]Model age relative to CHUR reservoir using present-day chondritic values listed above.
$T_{CHUR} = 1/l*ln[((^{143}Nd/^{144}Nd - 0.512638)/(^{147}Sm/^{144}Nd - 0.1967) + 1]$.

71096
High-Ti Mare Basalt
1.368 g, 1 × 1 × 1.7 cm

INTRODUCTION

71096 (Fig. 1) was described as a brownish gray, medium- to coarse-grained, homogeneous basalt (Apollo 17 Lunar Sample Information Catalog, 1973). This sample is riddled with marialitic cavities rich in euhedral crystals of ilmenite, pyroxene, and plagioclase. This basalt has an angular to blocky shape with penetrative fracturing, and was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

Neal et al. (1989) described 71096 as a fine-grained, olivine porphyritic Apollo 17 ilmenite basalt, with a well crystallized groundmass. Both olivine and ilmenite form microphenocryst phases. This is at variance with the initial description in the Apollo 17 Lunar Sample Information Catalog (1973), probably because of the difficulty in judging grain size due to the abundance of miarolitic cavities. Olivine phenocrysts (up to lmm) usually have a small pyroxene overgrowth, although occasionally these may become extensive such that olivine forms only the core. Plagioclase and pink pyroxene (rarely up to lmm), and ilmenite (up to 1.4mm) dominate the sample. Rutile and chromite exsolution lamellae (<0.005mm) are common in ilmenite. Pyroxene

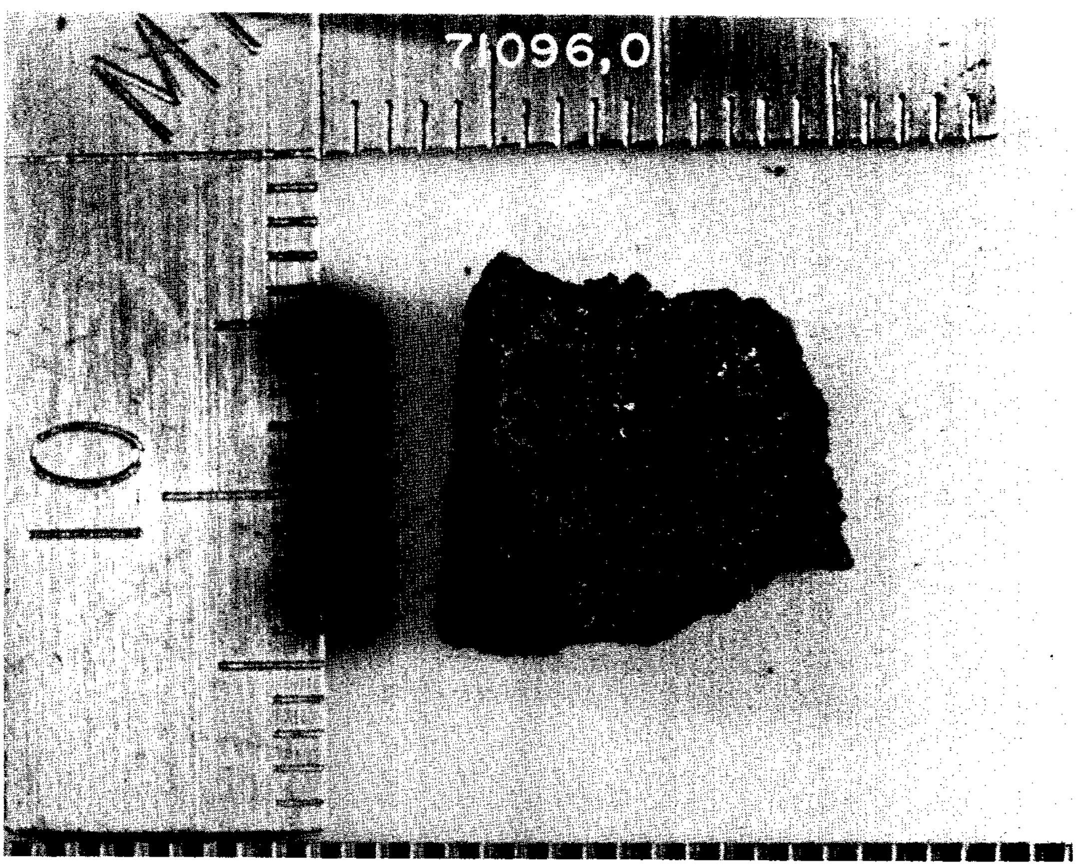


Figure 1: Hand specimen photograph of 71096,0.

and plagioclase are commonly intergrown in "bowtie" structures. Ilmenite-free armalcolite inclusions (~0.1mm) are found in pyroxene. Silica, native Fe, and troilite form interstitial phases. Point counting reveals that 71096 is comprised of: 44.0% pyroxene; 24.6% plagioclase; 21.3% ilmenite; 7.1% olivine; 1.3% native Fe and troilite; and 0.2% silica.

The larger olivine phenocrysts exhibit some core-to-rim variation, but the greatest compositional variation is between grains (Fo_{57-70}). Plagioclase exhibits a relatively large compositional range (An_{78-94}), with the most An-rich compositions being in the cores of grains. Pyroxene compositions range from pigeonite to titanaugite (Fig. 2), with zonation towards more Fe-rich compositions. Al/Ti ratios are constant at ~2, and Cr_2O_3 contents decrease with decreasing pyroxene MG#. Ilmenite exhibits a wide range in compositions (MG# = 2-18) relative to armalcolite (MG# = 36-41), with the greatest range occurring between grains in both cases, rather than core-to-rim.

WHOLE-ROCK CHEMISTRY

Neal et al. (1990) described 71096 as a Type A Apollo 17 high-Ti basalt (using the classification of Rhodes et al., 1976 and Warner et al., 1979), containing 13.0 wt% TiO_2 (Table 1) with a MG# of 41.4. The REE profile (Fig. 3) is LREE-depleted, but with an overall convex-upward shape. A negative Eu anomaly is present ($[Eu/Eu^*]_N$ = 0.51).

PROCESSING

Of the original 1.368g of 71096,0, only 0.77g remains. 0.6g was irradiated as 71096,5 for INAA; the irradiated sample was then used in the preparation of thin section 71096,4.

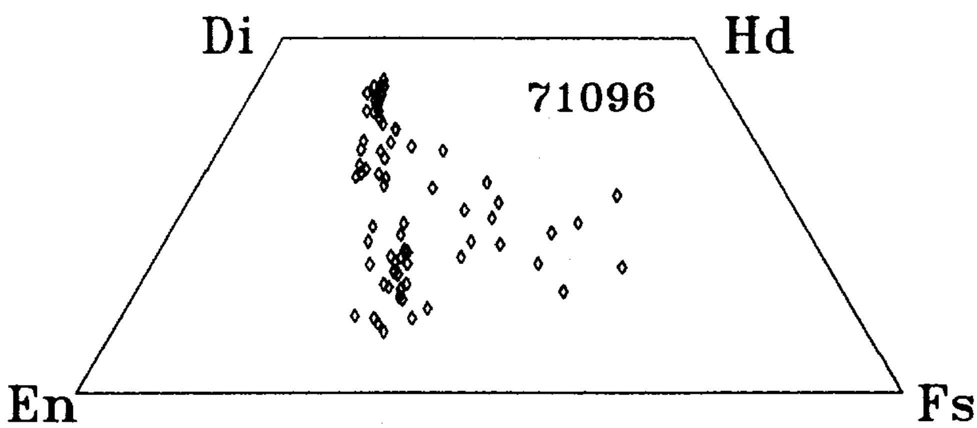


Figure 2: Pyroxene compositions of 71096 represented on a pyroxene quadrilateral.

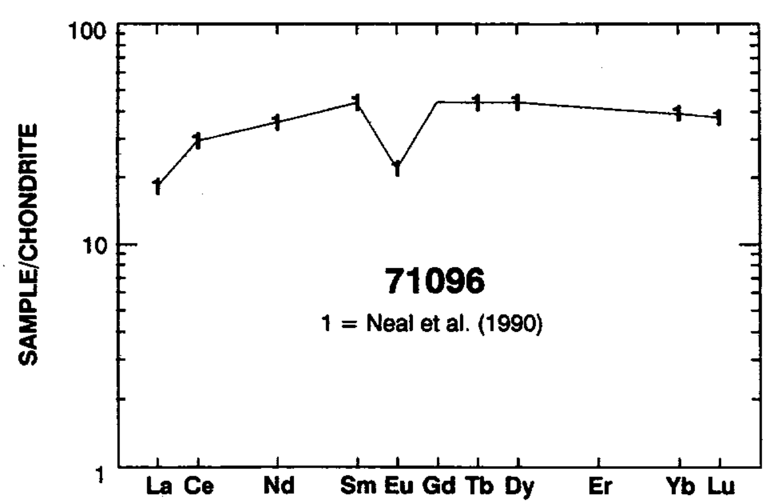


Figure 3: Chondrite-normalized rare-earth element profile of 71096.

Table 1: Whole-rock chemistry of 71096.
Data from Neal et al. (1990).

	71096,5 N		71096,5 N
SiO_2 (wt %)		Cu	
TiO_2	13.0	Ni	30
Al_2O_3	7.91	Co	22
Cr_2O_3	0.232	V	105
FeO	19.9	Sc	79
MnO	0.258	La	6.13
MgO	7.9	Ce	26
CaO	9.9	Nd	23
Na_2O	0.36	Sm	9.10
K_2O	0.06	Eu	1.73
P_2O_5		Gd	
S		Tb	2.61
Nb (ppm)		Dy	18.2
Zr	94	Er	
Hf	8.38	Yb	8.84
Ta	2.02	Lu	1.30
U	0.23	Ga	
Th	0.41	F	
W		Cl	
Y		C	
Sr	183	N	
Rb		H	
Li		He	
Ba	66	Ge (ppb)	
Cs	0.36	Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

71097
High-Ti Mare Basalt
1.355 g, 1.5 × 1 × 0.7 cm

INTRODUCTION

71097 (Fig. 1) was described as a medium dark gray, medium-grained, microporphyritic basalt (Apollo 17 Lunar Sample Information Catalog, 1973). It contains several small vugs; one end of the specimen is a large rounded cavity surface, lined with ilmenite needles and coated with a smooth, colorless glass. This basalt has an angular shape with some penetrative fracturing and was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

Neal et al. (1989) described 71097 as a fine-grained, subvariolitic, olivine porphyritic (up to 1mm) basalt, although ilmenite phenocrysts (up to 1.2mm) are also present. Plagioclase (up to 0.6mm), pyroxene (up to 0.4mm), and ilmenite form the groundmass. Chromite and rutile exsolution lamellae (<0.005mm) are present in ilmenite. Olivines occasionally contain an overgrowth of pink pyroxene. Ilmenites exhibit "sawtooth" margins. Ilmenite-free armalcolite inclusions (~0.1mm) are present in pyroxene and Cr-ulvöspinel (~0.05mm) inclusions are present in olivine. Native Fe, troilite, and silica form interstitial phases. Point counting reveals that 71097 is comprised of: 43.9% pyroxene; 23.4% ilmenite; 23.1% plagioclase; 6.8% olivine; 1.1% native Fe and troilite; 0.7% silica; 0.5% spinel; and 0.5% armalcolite.

The largest olivines display some core-to-rim zonation, but the greatest variability is between grains (Fo_{60-72}). Plagioclase exhibits moderate compositional variation (An_{78-88}), with only minor core-to-rim zonation. The majority of pyroxenes are titan-augites, although occasional pigeonites are present (Fig. 2). Compositional intermediates between these two compositions exist and limited Fe enrichment is noted. Al/Ti ratios are constant at ~2, and Cr_2O_3 contents decrease with decreasing pyroxene MG#. Armalcolite and Cr-ulvöspinel both exhibit practically no compositional variability

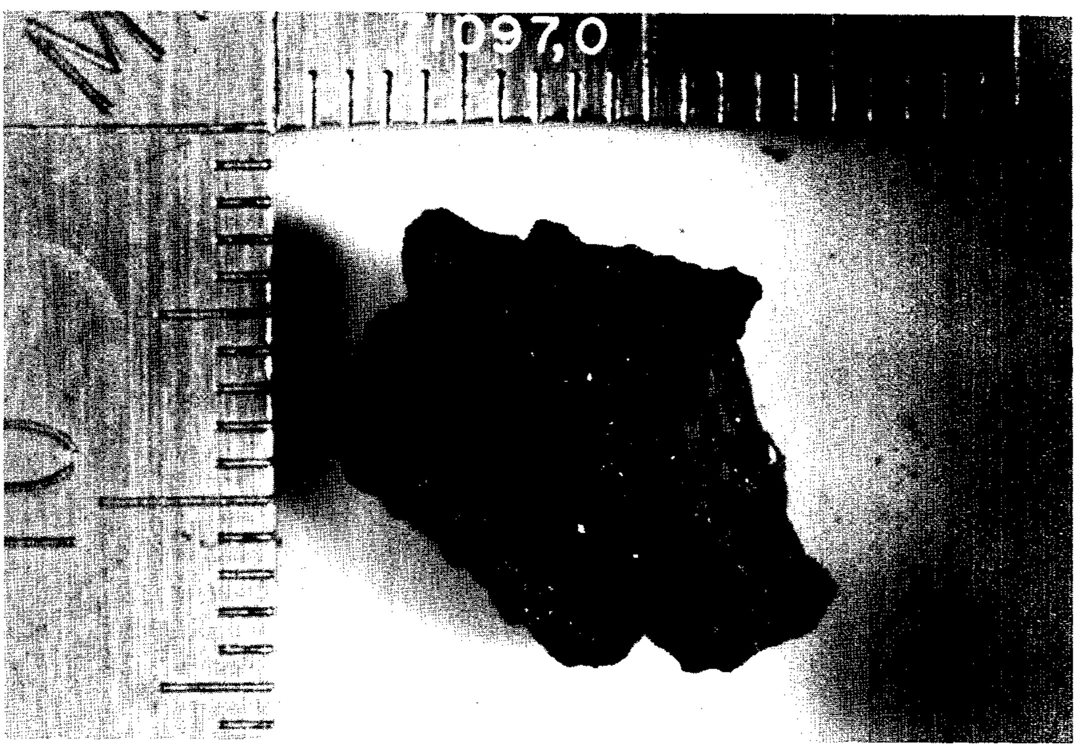


Figure 1: Hand specimen photograph of 71097,0.

(MG# = 40-42 and 7-9, resp.). Ilmenite displays a relatively large compositional variability (MG# = 2-15), usually between grains.

ISOTOPES

Paces et al. (1991) reported Rb-Sr (Table 2) and Sm-Nd (Table 3) data for 71097,5. These analyses were part of a larger study characterizing the basalts at the Apollo 17 site.

WHOLE-ROCK CHEMISTRY

Neal et al. (1990) described 71097 as a Type B2 Apollo 17 high-Ti basalt. 71097 contains 12.0 wt% TiO_2 (Table 1) with a MG# of 38.9. The REE profile (Fig. 3) is LREE-depleted, but with an overall convex-upward shape. A negative Eu anomaly is present ($[Eu/Eu^*]_N = 0.53$).

PROCESSING

Of the original 1.355g of 71097,0, approximately 1g remains. 0.35g was irradiated as 71097,4 for INAA, and 0.01g was used in the preparation of thin section 71097,3.

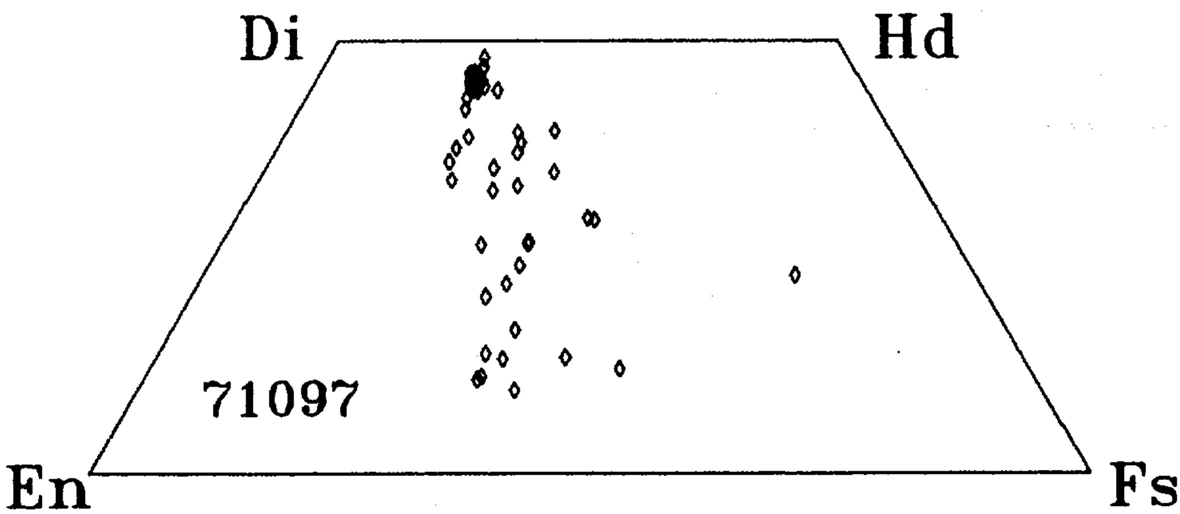


Figure 2: Pyroxene compositions of 71097 represented on a pyroxene quadrilateral.

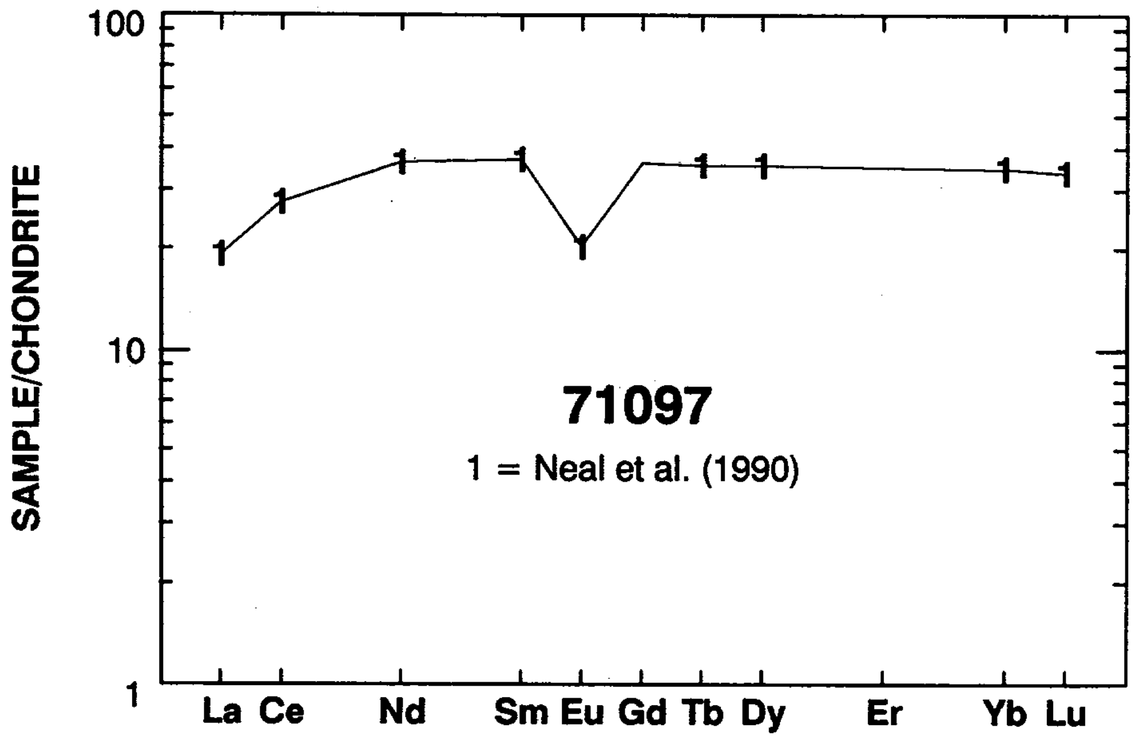


Figure 3: Chondrite-normalized rare-earth element profile of 71097.

Table 1: Whole-rock chemistry of 71097.
Data from Neal et al. (1990).

	Sample 71097,4 Method N		Sample 71097,4 Method N
SiO_2 (wt %)		Cu	
TiO_2	12.0	Ni	32
Al_2O_3	8.92	Co	21
Cr_2O_3	0.162	V	74
FeO	19.6	Sc	86
MnO	0.259	La	6.35
MgO	7.1	Ce	24
CaO	10.8	Nd	23
Na_2O	0.42	Sm	7.56
K_2O	0.06	Eu	1.56
P_2O_5		Gd	
S		Tb	2.07
Nb (ppm)		Dy	14.6
Zr	158	Er	
Hf	6.71	Yb	7.70
Ta	1.61	Lu	1.15
U	0.14	Ga	
Th	0.47	F	
W		Cl	
Y		C	
Sr	88	N	
Rb		H	
Li		He	
Ba	76	Ge (ppb)	
Cs	0.05	Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

Table 2: Rb-Sr isotopic data for 71097,5.
Data from Paces et al. (1991).

Rb (ppm)	0.293
Sr (ppm)	109
$^{87}Rb/^{86}Sr$	0.007747 ± 77
$^{87}Sr/^{86}Sr$	0.699635 ± 12
I(Sr)[a]	0.699218 ± 16
T_{LUNI}[b](Ga)	5.4

[a]Initial Sr isotopic ratios calculated at 3.69 Ga using ^{87}Rb decay constant = $1.42 \times 10^{-11} yr^{-1}$.

[b]Model age relative to I(Sr) = LUNI = 0.69903 (Nyquist et al., 1974; Shih et al., 1986).
$T_{LUNI} = 1/\lambda * \ln[((^{87}Sr/^{86}Sr - 0.69903)^{87}Rb/^{86}Sr) + 1]$.

Table 3: Sm-Nd isotopic data for 71097,5.
Data from Paces et al. (1991).

Sm (ppm)	6.61
Nd (ppm)	16.6
$^{147}Sm/^{144}Nd$	0.24141 ± 48
$^{143}Nd/^{144}Nd$	0.514028 ± 12
I(Nd)[a]	0.508131 ± 24
$\varepsilon_{Nd}(t)$[b]	5.9 ± 0.5
T_{CHUR}[c](Ga)	4.7

[a]Initial Nd isotopic ratios calculated at 3.69 Ga using ^{147}Sm decay constant = $6.54 \times 10^{-12} yr^{-1}$.

[b]Initial ε_{Nd} calculated at 3.69 Ga using present-day chondritic values of $^{143}Nd/^{144}Nd$ = 0.512638 and $^{147}Sm/^{144}Nd$ = 0.1967.

[c]Model age relative to CHUR reservoir using present-day chondritic values listed above.
$T_{CHUR} = 1/\lambda * [((^{143}Nd/^{144}Nd - 0.512638)/(^{147}Sm/^{144}Nd - 0.1967)) + 1]$.

71135
High-Ti Mare Basalt
36.85 g, 6 × 4.5 × 1.5 cm

INTRODUCTION

71135 (Fig. 1) was described as a intergranular, gray, homogeneous basalt (Apollo 17 Lunar Sample Information Catalog, 1973). This basalt contains many zap pits on T (few with glass linings), with 1% vesicles (2mm) and 5-10% vugs (up to 5mm). Some vugs are connected by vesicles and these vesicles contain glass linings. Vugs contain mainly plagioclase with rare ilmenite plates and needles. A few plagioclase crystals in some vugs are columnar with stubby-ends. This basalt has an angular shape and was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

71135 was described petrographically by Brown et al. (1975ab) as a Type IB Apollo 17 basalt, containing 24.8% opaques, 20.0% plagioclase, 49.7% pyroxene, 1.2% silica, 4.3% mesostasis, and trace olivine. Brown et al. (1975ab) described both the petrography and mineral chemistry of 71135 within the general confines of their petrographic classification, and as such, 71135 was not specifically mentioned. However, during the preparation of this catalog, we examined thin sections 71135,17 and ,25. This basalt is medium-grained (0.8-1.3mm), containing pyroxene and plagioclase intergrown into "bowtie" structures. Massive pink pyroxene (up to 0.8mm) is present, probably due to olivine resorption, especially as some of these pyroxene masses contain olivine cores. Occasionally, chromite inclusions (<0.01mm) are present in the olivine. Ilmenite laths (up to 0.8mm) are present with "sawtooth"

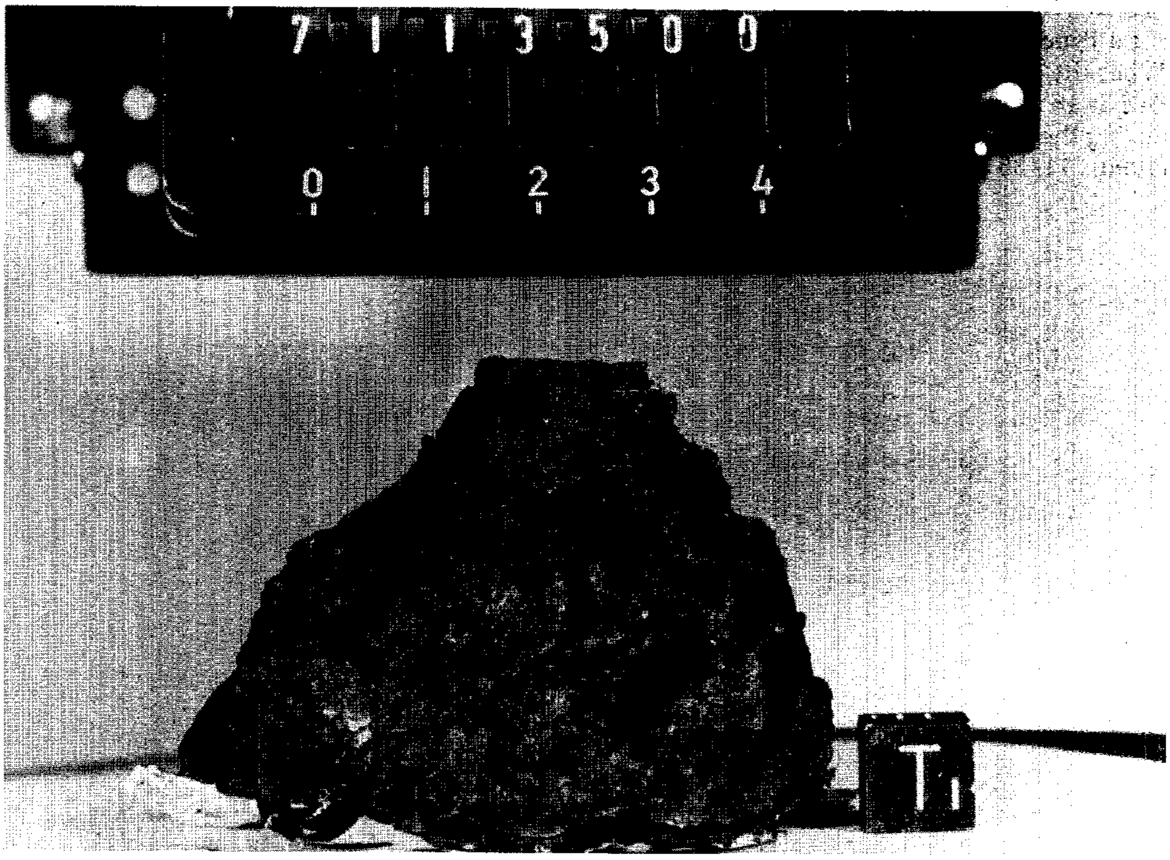


Figure 1: Hand specimen photograph of 71135,0. Cubic scale = 1cm³.

margins. Interstitial SiO_2 (~0.15mm) is conspicuous, and this, along with native Fe and troilite, form interstitial phases.

Roedder and Weiblen (1977), Weiblen and Roedder (1976), and Weiblen (1977) studied the melt inclusions in the various mineral phases of 71135. These authors concluded that the liquid line of descent of this basalt was complicated by late-stage silicate-liquid immiscibility of the residual melt. These authors also noted the presence of anomalous "low-K" melt inclusions in ilmenite.

WHOLE-ROCK CHEMISTRY

The whole-rock major and trace element chemistry of 71135 (Table 1) was reported by Rhodes et al. (1976 - majors) and Shih et al. (1975 - traces). Rhodes et al. (1976) classified 71135 as a Type B Apollo 17 high-Ti basalt; 71135 is further classified as an Apollo 17 B1 basalt using the criteria of Neal et al. (1990). 71135 contains 10.74 wt% TiO_2 with a MG# of 41.2. The REE profile (Fig. 2) is LREE-depleted, but with an overall convex-upward appearance. A negative Eu anomaly is present ($[Eu/Eu^*]_N = 0.50$). Gibson et al. (1976a,b) reported sulfur abundances for 71135 (Table 1). The sulfur abundance was determined as 1925 ± 20 μg S/g.

ISOTOPES

Nyquist et al. (1975) determined the whole-rock Rb/Sr and $^{87}Sr/^{86}Sr$ ratios for 71135 (Table 2). These authors noted that the extreme requirements on analytical precision prevented any definitive conclusions being made on the Sr isotope evolution of this sample. No Sm-Nd or U/Th-Pb work has been undertaken on 71135. All other isotope work carried out on this sample has been concerned with the cosmogenic radionuclide abundances (Eldridge et al., 1974ab; O'Kelley et al., 1974ab; Yokoyama et al., 1974 - Table 3) and exposure ages (Arvidson et al., 1976; Niemeyer, 1977ab). Arvidson et al. (1976) reported that 71135 possessed an exposure age of 102 Ma and Niemeyer (1977) reported an exposure age ranging from 58-167 Ma, depending upon the method used.

EXPERIMENTAL

Usselman et al. (1975) reported cooling rates and experimentally produced textures for Apollo 17 high-Ti mare basalts. Using these experimental studies, a cooling rate of 2-5°C/hr was deduced for 71135.

PROCESSING

71135,0 has been entirely subdivided, with the largest samples remaining being 71135,2 (13.12g) and 71135,15 (16.93g). 71135,5 was irradiated for INAA. Six thin sections have been cut from 71135, these being ,17 and ,25-,29.

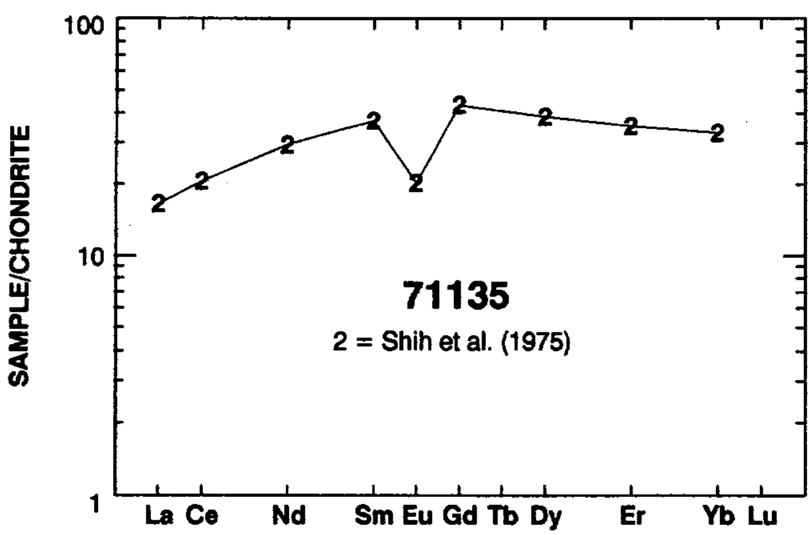


Figure 2: Chondrite-normalized rare-earth element profile of 71135. Data from Shih et al. (1975).

Table 1: Whole-rock chemistry of 71135.

	Sample 71135,5 Reference 1 Method X	Sample 71135,5 Reference 2 Method N,I		Sample 71135,5 Reference 1 Method X	Sample 71135,5 Reference 2 Method N,I
SiO_2 (wt %)	39.71		Cu		
TiO_2	10.74		Ni		
Al_2O_3	10.10		Co		17.5
Cr_2O_3	0.31		V		
FeO	18.57		Sc		82.1
MnO	0.28		La		5.43
MgO	7.31		Ce		17.8
CaO	11.62		Nd		18.6
Na_2O	0.38		Sm		7.55
K_2O	0.05	0.031	Eu		1.56
P_2O_5	0.06		Gd		12.0
S	0.11		Tb		
K (ppm)			Dy		13.3
Nb			Er		7.95
Zr		185	Yb		7.28
Hf			Lu		
Ta			Ga		
U		0.109	F		
Th			Cl		
W			C		
Y			N		
Sr		143	H		
Rb		0.354	He		
Li		8.8	Ge (ppb)		
Ba		61.4	Ir		
Cs			Au		
Be			Ru		
Zn			Os		
Pb					

Analysis by: X = XFR; I = Isotope dilution; N = INAA.

References: 1 = Rhodes et al. (1976); 2 = Shih et al. (1975).

Table 2: Rb-Sr isotope date from 71135.
Data from Nyquist et al. (1975).

	Sample 71135,5
wt (mg)	50
Rb (ppm)	0.354
Sr (ppm)	143
$^{87}Rb/^{86}Sr$	0.0072±3
$^{87}Sr/^{86}Sr^{b}$	0.69953±5
T_B	4.2±0.6
T_L	4.8±0.6

B = Model age assuming I = 0.69910 (BABI + JSC bias); C = Model age assuming I = 0.69903 (Apollo 16 anorthosites at 4.6 Ga).

Table 3: Concentrations of Primordial Radioelements (Eldridge et al., 1974) and Cosmogenic Radionuclides (O'Kelley et al., 1974) in 71135.
Cosmogenic Radionuclide Decay corrected to 2300 GMT, Dec. 14,1972.

	Sample 71135,5
K (ppm)	350±40
Th (ppm)	0.60±0.05
U (ppm)	0.14±0.03
Th/U	4.3
K/U	2214
^{26}Al (dpm/Kg)	80±6
^{22}Na	95±7
^{54}Mn	140±15
^{56}Co	290±50
^{46}Sc	70±30

71136
High-Ti Mare Basalt
25.39 g, 4 x 2 x 2 cm

INTRODUCTION

71136 (Fig. 1) was described as a gray, homogeneous, intergranular basalt (Apollo 17 Lunar Sample Information Catalog, 1973). It contains zap pits on all surfaces except B and 20% vugs (up to 20 mm) lined with crystals. 1% rounded vesicles open into vugs. These vugs are lined with crystals of plagioclase, ilmenite, pyroxene, and olivine. Plagioclase in places makes long columnar needles with their stubby ends in the vugs. Such plagioclases are 0.1mm in cross section and up to 10mm long. They are transparent and probably vapor grown. There is a small percentage of a blood-red mineral in these vugs, which is probably spinel. Basalt 71136 has an angular shape with penetrative fracturing, and was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

The petrography and mineral chemistry of 71136 has only been briefly discussed by Warner et al. (1975). During the preparation of this catalog, we examined thin section 71136,8, finding it to be a medium-grained (0.8-1.5mm) ilmenite basalt. "Bowtie" intergrowths (up to 1.5mm) of pyroxene and plagioclase dominate. No olivine is present. Ilmenite (up to 1mm long) exhibits "sawtooth" margins. No armalcolite or spinel was noted. Silica, native Fe, and troilite form interstitial phases.

WHOLE-ROCK CHEMISTRY

Rhodes et al. (1976) and Warner et al. (1975) analyzed 71136,1 and 71136,3, respectively, for major and trace elements

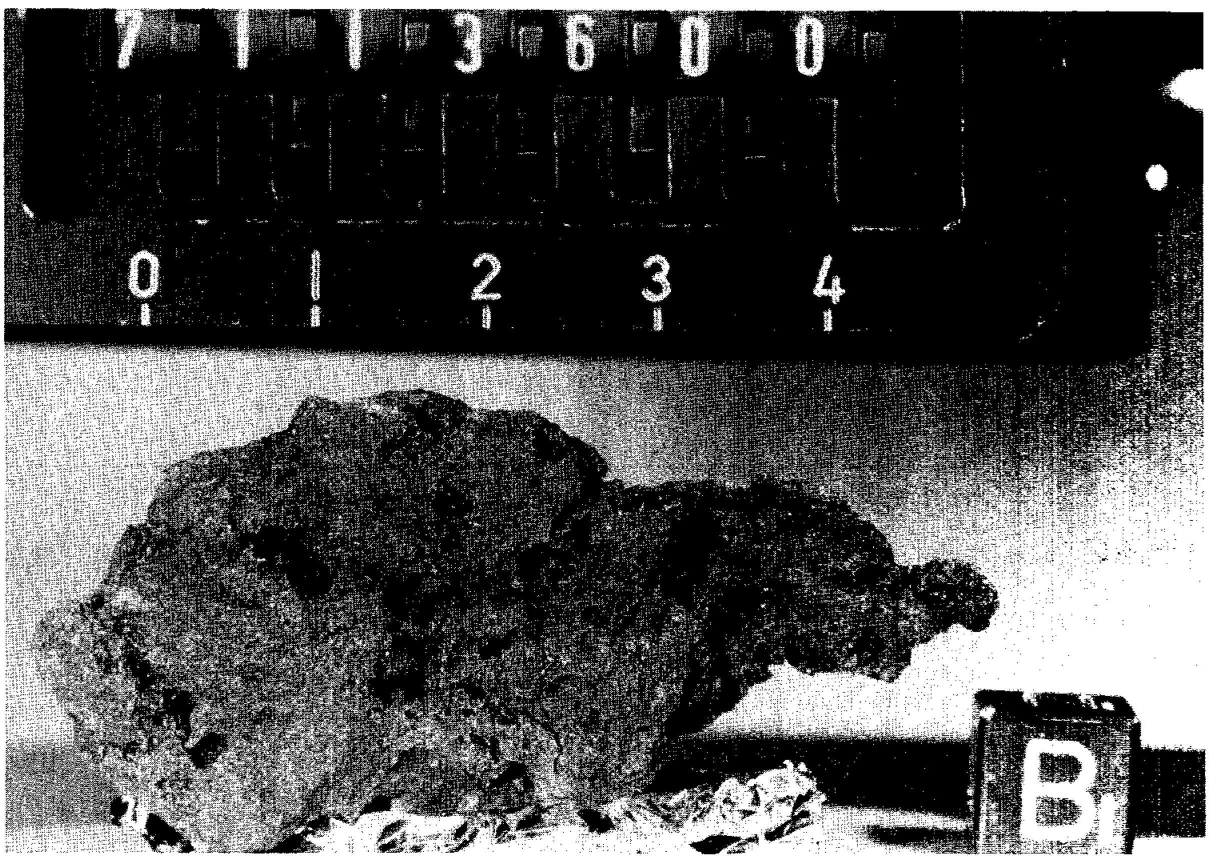


Figure 1: Hand specimen photograph of 71136,0, bottom surface. Cubic scale = 1cm³.

(Table 1). Rhodes et al. (1976) classified 71136 as a Type B Apollo 17 high-Ti basalt, containing 11.12 wt% TiO_2 (identical to the result of Warner et al., 1975 - Table 1) with a MG# of 40.5. 71136 can be further classified as a Type B2 Apollo 17 basalt using the criteria of Neal et al. (1990). The REE profile (Fig. 2) is LREE-depleted, but with an overall convex-upward appearance. Both analyses (Warner et al., 1975; Rhodes et al., 1976) are almost identical, and both give the same $(Eu/Eu^*)_N$ of 0.51 for the negative Eu anomaly. Gibson et al. (1976a,b) reported whole-rock sulfur abundances of 1720 ± 60 µg S/g with an equivalent wt% Fe^o of 0.114 for 71136.

ISOTOPES

Nyquist et al. (1976ab) reported the whole-rock Sr isotope composition of 71136 (Table 2). Other isotope work has concentrated on cosmogenic and primordial radionuclide abundances (Table 3) in 71136 (Eldridge et al., 1974a,b; O'Kelley et al., 1974a,b; Yokoyama et al., 1974).

PROCESSING

Of the original 25.39g of 71136,0, approximately 23.1g remains. 1.37g of 71136,1 is the largest subsample. Three thin sections were taken: 71136,8 and ,9 from 71136,5; 71136,11 from 71136,3.

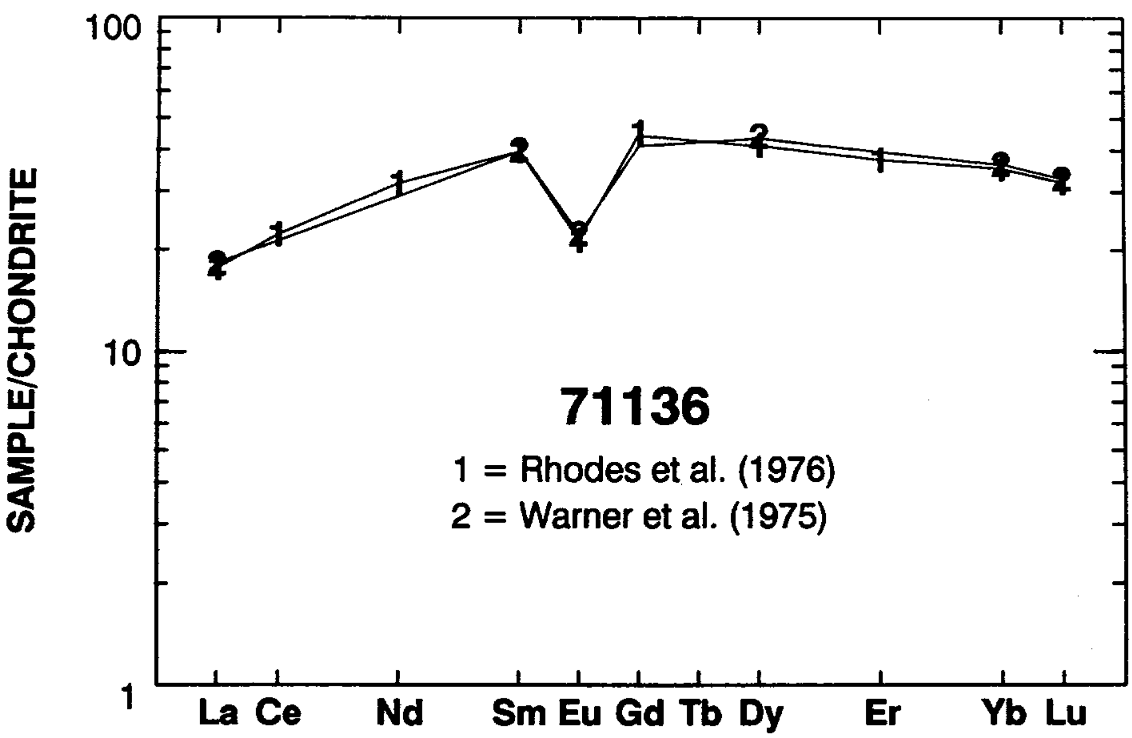


Figure 2: Chondrite-normalized rare-earth element plots for 71136. Data from Warner et al. (1975) and Rhodes et al. (1976).

Table 1: Whole-rock chemistry of 71136.

	Sample 71136,1 Reference 1 Method X,I,N	Sample 71136,3 Reference 2 Method N		Sample 71136,1 Reference 1 Method X,I,N	Sample 71136,3 Reference 2 Method N
SiO_2 (wt %)	40.30		Cu		
TiO_2	11.12	11.1	Ni		
Al_2O_3	10.21	10.9	Co	15.7	15.9
Cr_2O_3	0.28	0.296	V		89
FeO	18.44	19.3	Sc	82	87
MnO	0.28	0.224	La	5.72	5.9
MgO	7.03	7.5	Ce	19.0	
CaO	11.73	11.4	Nd	19.8	
Na_2O	0.37	0.374	Sm	7.94	8.0
K_2O	0.03	0.05	Eu	1.63	1.70
P_2O_5	0.06		Gd	12.3	
S	0.17		Tb		
K (ppm)			Dy	14.0	15
Nb			Er	8.34	
Zr			Yb	7.65	7.9
Hf	6.8		Lu	1.07	1.1
Ta			Ga		
U			F		
Th			Cl		
W			C		
Y			N		
Sr	147		H		
Rb	0.40		He		
Li	8.4		Ge (ppb)		
Ba	65.9		Ir		
Cs			Au		
Be			Ru		
Zn			Os		
Pb					

Analysis by: X = XFR; I = Isotope dilution; N = INAA.

References: 1 = Rhodes et al. (1976); 2 = Warner et al. (1975).

Table 2: Rb-Sr isotope date from 71136.
Data from Nyquist et al. (1975).

	Sample 71136,1
wt (mg)	54
Rb (ppm)	0.397
Sr (ppm)	147
$^{87}Rb/^{86}Sr$	0.0078 ± 3
$^{87}Sr/^{86}Sr^{b}$	0.69959 ± 5
T_B	4.38 ± 0.62
T_L	4.99 ± 0.64

B = Model age assuming I = 0.69910 (BABI + JSC bias); C = Model age assuming I = 0.69903 (Apollo 16 anorthosites at 4.6 Ga).

Table 3: Concentrations of Primordial Radioelements (Eldridge et al., 1974) and Cosmogenic Radionuclides (O'Kelley et al., 1974) in 71136.
Cosmogenic Radionuclide Decay corrected to 2300 GMT, Dec. 14,1972.

	Sample 71136
K (ppm)	370 ± 100
Th (ppm)	0.46 ± 0.06
U (ppm)	0.22 ± 0.05
Th/U	2.1
K/U	1680
^{26}Al (dpm/Kg)	90 ± 8
^{22}Na	93 ± 9
^{54}Mn	160 ± 60
^{56}Co	300 ± 70
^{46}Sc	70 ± 30

71155
High-Ti Mare Basalt
26.15 g, 5 x 2.5 x 2.5 cm

INTRODUCTION

71155 (Fig. 1) was described as a dark gray, intergranular basalt (Apollo 17 Lunar Sample Information Catalog, 1973). It contains a few zap pits on S, E, W, and T. Approximately 30% cavities are present, about 55% of which are vugs (up to 5mm) and 45% are vesicles (up to 3mm). Vesicles are particularly abundant on B and W. Some vesicles are lined with ilmenite and some with all minerals of this rock. Metal spherules are present in a few vesicles. About the top third of N and all of B and S display discoloration and rounding of the edges. All other surfaces are freshly broken. This sample has an irregular shape and was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

Brown et al. (1975ab) described 71155 as a Type IA Apollo 17 ilmenite basalt in their petrographic classification. Consequently, the petrography and mineral chemistry are only described within the general confines of this classification, and only the range in olivine composition has been reported (Fo_{67-74}). However, the modal mineralogy was reported, demonstrating that 71155 is comprised of 6.1% olivine, 18.4% opaques, 23.3% plagioclase, 49.3% clinopyroxene, and 2.9% silica. Also, the composition of a "new" Zr-rich mineral found in 71155 was reported by these authors (Table 1).

During the preparation of this catalog, we examined thin sections 71155,28 and ,29. 71155 is a fine-grained (0.1-0.2mm) basalt containing olivine (up to 0.4mm) and ilmenite (up to 1mm long). Ilmenite exhibits "sawtooth" margins. Cr-ulvöspinel is usually present (~0.1mm) as inclusions in olivine,

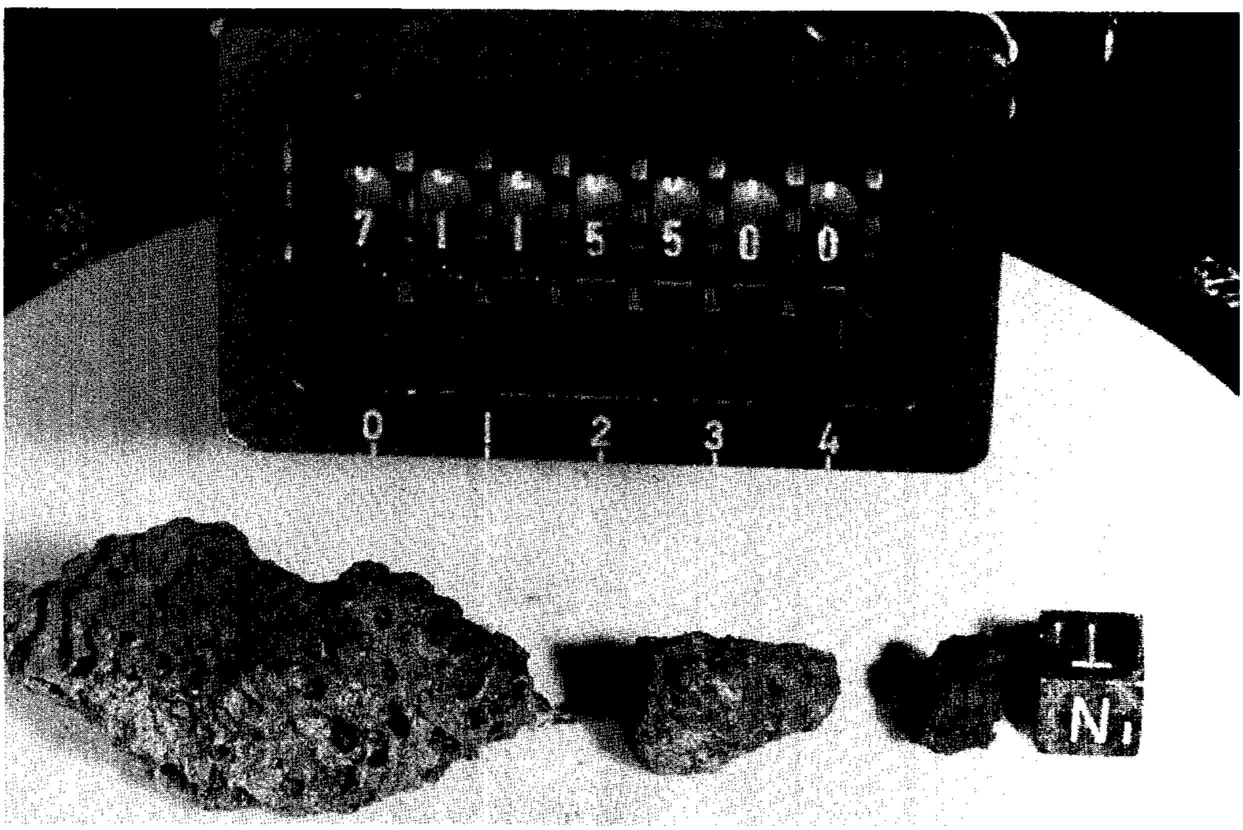


Figure 1: Hand specimen photograph of 71155,0, from which two pieces have broken off. Cubic scale = 1cm³.

occasionally rimmed by ilmenite (El Goresy et al., 1977). Discrete Cr-ulvöspinels are also present, again displaying ilmenite rims (El Goresy et al., 1977). The reverse zoning of these spinels was attributed to subsolidus equilibration with ilmenite by El Goresy et al. (1977). Pyroxene and plagioclase are intergrown into "bowtie" structures. Silica, native Fe, and troilite form interstitial phases.

WHOLE-ROCK CHEMISTRY

The major and trace element chemistry (Table 2) of the same sub-sample was reported by Ma et al. (1979) and Warner et al. (1979). Rancitelli et al. (1974) reported the major element composition of 71155. Warner et al. (1979) described 71155 as a Type B Apollo 17 high-Ti basalt, containing 10.1 wt% TiO_2 with a MG# of 42.7. However, Rancitelli et al. (1974) reported a TiO_2 content of 13.00 wt% and a MG# of 43.6. 71155 is further classified as a Type B2 Apollo 17 basalt using the criteria of Neal et al. (1990). The REE profile (Fig. 2) is LREE-depleted, with approximately constant HREE abundances at 30-35 times chondrite values. A negative Eu anomaly is present ($[Eu/Eu^*]_N$ = 0.52). Determination of other radionuclide abundances have been made by Fruchter et al. (1975) and LSPET (1973).

ISOTOPES

All isotopic studies undertaken on 71155 to date have centered on the cosmic-ray induced radionuclides (LSPET, 1973; Keith et al., 1974ab; Rancitelli et al., 1974ab; Yokoyama et al., 1974). These data are presented in Table 3.

PROCESSING

Of the original 26.15g of 71155,0, a total of 21.88g remains. 71155,31 was irradiated for INAA and thin section 71155,33 taken from this sub-sample. Other thin sections (71155,28-30) were taken from 71155,3.

Table 1: The Zr-rich mineral found in 71155,30.
Data from Brown et al. (1975).

	71155,30
SiO_2 (wt %)	0.47
TiO_2	5.86
Al_2O_3	0.39
FeO	2.78
MnO	0.34
MgO	0.12
CaO	0.79
Na_2O	0.02
ZrO_2	85.10
Cr_2O_3	0.26
Y_2O_3	1.74
Nb_2O_3	0.20
RE_2O_3	1.52
HfO_2	0.81
TOTAL	**100.10**

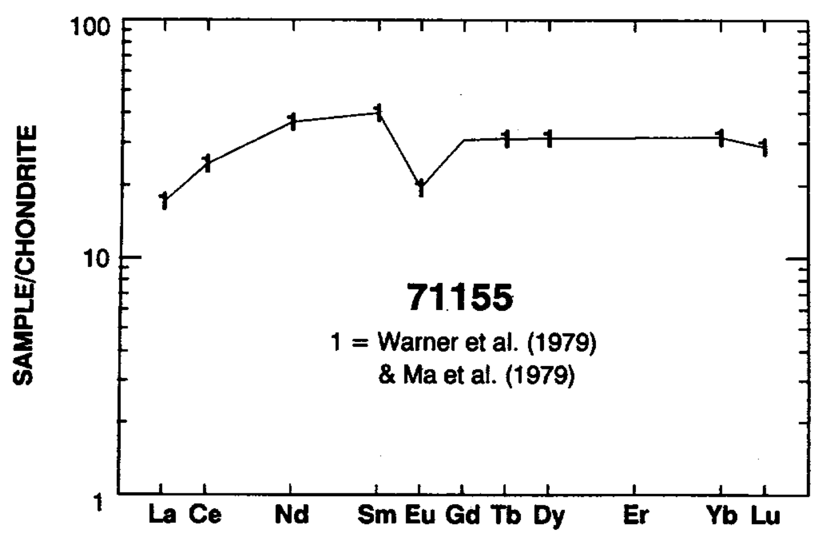


Figure 2: Chondrite-normalized rare earth element plot for 71155. The same analysis was reported by Ma et al. (1979) and Warner et al. (1979).

Table 2: Whole-rock chemistry of 71155.

	Sample 71155,31 Ref. 1 Method N	Sample 71155,0 Ref. 2 Method X
SiO_2 (wt %)		37.19
TiO_2	10.1	13.0
Al_2O_3	9.2	8.68
Cr_2O_3	0.488	
FeO	19.1	19.67
MnO	0.246	0.28
MgO	8	8.53
CaO	10.8	10.43
Na_2O	0.353	0.32
K_2O	0.048	0.036
P_2O_5		0.092
S		0.18
Nb (ppm)		
Zr		
Hf	6.3	
Ta	1.3	
U		
Th		
W		
Y		
Sr		
Rb		
Li		
Ba		
Cs		
Be		
Zn		
Pb		
Cu		
Ni		
Co	23	
V	118	
Sc	81	
La	5.6	
Ce	21	
Nd	23	

Table 2: (Concluded).

	Sample 71155,31 Ref. 1 Method N	Sample 71155,0 Ref. 2 Method X
Sm	8.1	
Eu	1.49	
Gd		
Tb	1.8	
Dy	12	
Er		
Yb	6.9	
Lu	0.97	
Ga		
F		
Cl		
C		
N		
H		
He		
Ge (ppb)		
Ir		
Au		
Ru		
Os		

References: 1 = Warner et al. (1979); 2 = Rancitelli et al. (1974).
Analysis by: N = INAA, X = XRF.

Table 3: Concentrations of Primordial Radioelements and Cosmogenic Radionuclides in 71155.
Cosmogenic Radionuclide Decay corrected to 2300 GMT, Dec. 14,1972.

Sample	**71155,0**	**71155,0**	**71155**	**71155,0**	**71155,0**
Ref.	**1**	**2**	**3**	**4**	**4**
K(ppm)		<450			
K (%)	0.045 ± 0.012		0.040 ± 0.003	<0.030	0.039 ± 0.003
Th (ppm)	0.29 ± 0.05	0.29 ± 0.05	0.31 ± 0.06	0.29 ± 0.05	0.31 ± 0.08
U (ppm)	0.13 ± 0.02	0.13 ± 0.02	0.118 ± 0.017	0.13 ± 0.02	0.109 ± 0.018
Th/U	2.20 ± 0.51	2.23	2.6	2.2 ± 0.5	2.8 ± 0.9
K/U	3460 ± 1070	<3460	3400		3600 ± 700
^{26}Al(dpm/Kg)		105 ± 4	105 ± 8	105 ± 4	93 ± 17
^{22}Na		112 ± 4	119 ± 11	112 ± 4	112 ± 24
^{54}Mn		227 ± 30	160 ± 20	227 ± 40	160 ± 80
^{56}Co		310 ± 20	310 ± 50	310 ± 20	280 ± 70
^{60}Co		<4.4		<4	
^{46}Sc		80 ± 4	81 ± 7	80 ± 4	81 ± 7
^{48}V		<60			

References: 1 = Fruchter et al. (1975); 2 = Rancitelli et al. (1974); 3 = Keith et al. (1974); 4 = Apollo 17 Preliminary Science Report (1973).

71156
High-Ti Mare Basalt
5.42 g, 2.2 × 1.5 × 1 cm

INTRODUCTION

71156 (Fig. 1) was described as medium dark gray, intergranular, homogeneous basalt (Apollo 17 Lunar Sample Information Catalog, 1973). It contains many zap pits on all surfaces, except T. Approximately 1-2% vugs are present, all 1mm in diameter. This basalt has a blocky, subrounded shape with "lumpy" surfaces except T which is smooth. 71156 was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

The petrography and mineral chemistry of 71156 was described by Warner et al. (1979), but within the general confines of their whole-rock classification. Consequently, this basalt was not specifically mentioned. No thin section of 71156 was available for our study during the preparation of this catalog.

WHOLE-ROCK CHEMISTRY

Ma et al. (1979) and Warner et al. (1979) reported the same whole-rock analysis for 71156 (Table 1). Warner et al. (1979) classified 71156 as a Type A Apollo 17 high-Ti basalt, containing 12.3 wt% TiO_2 (Table 1) with a MG# of 43.5. The REE profile is LREE-depleted, with HREE abundances approximately constant at 40-45 times chondritic values (Fig. 2). A negative Eu anomaly is present ($[Eu/Eu^*]_N = 0.53$).

PROCESSING

Of the original 5.42g of 71156,0, a total of 5.11g remains. 71156,1 was irradiated for INAA, and thin section 71156,4 was taken from this sub-sample.

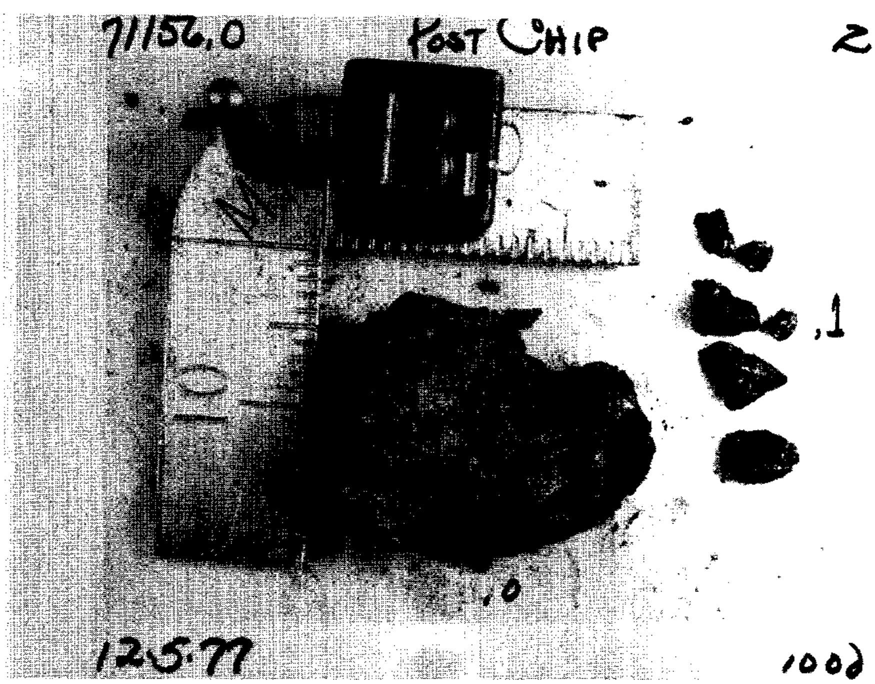


Figure 1: Hand specimen photograph of 71156,0, bottom surface, and 71156,1. Cubic scale = 1cm³.

Table 1: Whole-rock chemistry of 71156.
Data from Ma et al. (1979) and Warner et al. (1979) (same analysis).

	71156,1 N		71156,1 N
SiO_2 (wt %)		Cu	
TiO_2	12.3	Ni	
Al_2O_3	8.7	Co	18
Cr_2O_3	0.435	V	103
FeO	18.5	Sc	79
MnO	0.242	La	6.6
MgO	8	Ce	25
CaO	10.4	Nd	27
Na_2O	0.395	Sm	10.4
K_2O	0.068	Eu	2.01
P_2O_5		Gd	
S		Tb	2.7
Nb (ppm)		Dy	18
Zr		Er	
Hf	8.8	Yb	9.9
Ta	2.0	Lu	1.39
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Eu	
Pb		Os	

Analysis by: N = INAA.

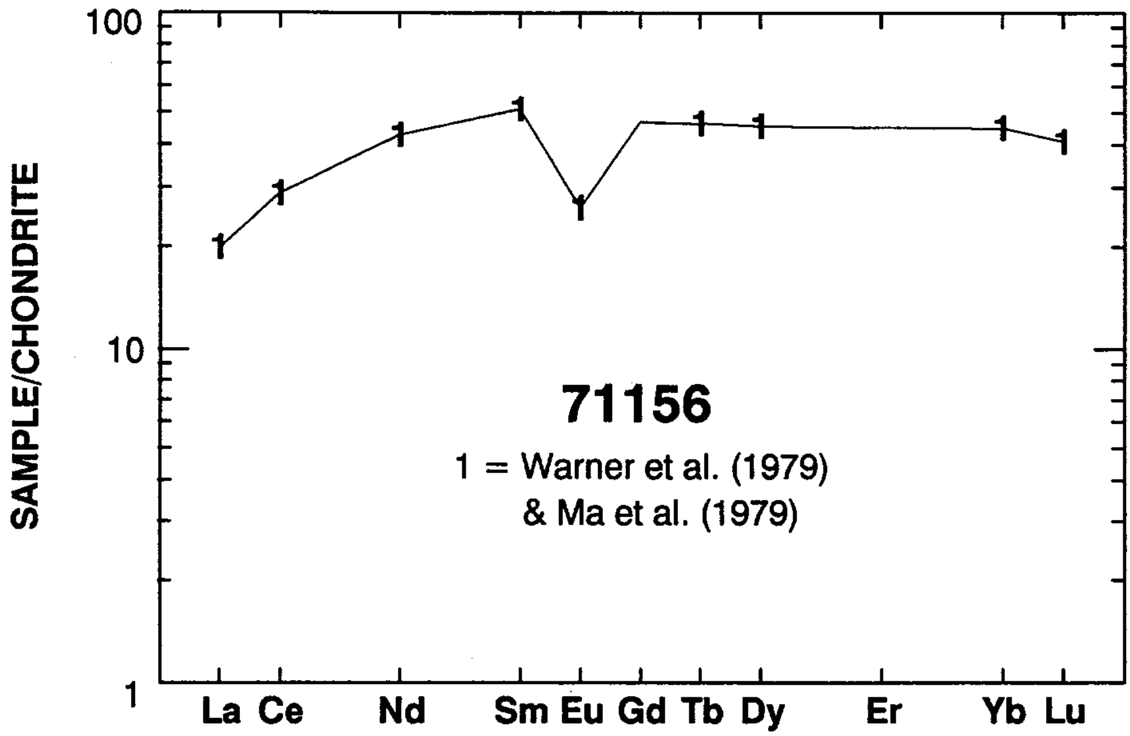


Figure 2: Chondrite-normalized rare earth element plots for 71156. The same analysis was reported by Ma et al. (1979) and Warner et al. (1979).

71157
High-Ti Mare Basalt
1.466 g, 1.2 × 1 × 0.8 cm

INTRODUCTION

71157 was described as a dark gray, blocky, aphanitic to vitrophyric basalt (Apollo 17 Lunar Sample Information Catalog, 1973). It contains a few zap pits and 2-5% vugs <1mm). This basalt has a blocky to subangular shape with a few penetrative fractures. 71157 was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

Neal et al. (1989a) described 71157 as a olivine porphyritic vitrophyre, containing 2.7% olivine, 27.9% pyroxene, 7.2% plagioclase, 13.7% ilmenite, 7.5% armalcolite, 2.5% ulvöspinel, 1.1 native Fe and troilite, and 37.4% opaque glass. Olivine exhibits minor to moderate core-to-rim zonation (up to 8 Fo units) with slight compositional differences between olivine grains (Fo_{63-75}). The plagioclase laths are too small to probe. Pyroxene compositions vary little (Fig. 1), but are distinct in that the Al/Ti ratio is not constant (> 2; Fig. 2) There is also little variation of Cr_2O_3 contents. Armalcolite exhibits the greatest compositional range of the opaque phases (MG# = 37-50). Much of this variation is between grains, although moderate core-to-rim zonation is observed. Chromite-ulvöspinel grams exhibit little zonation [100*(Cr/(Cr+Al)) = 67-69; MG# = 15-17]. Ilmenite is usually homogeneous, most of the compositional variability being between grains (MG# = 8-13).

WHOLE ROCK CHEMISTRY

Neal et al. (1989b) described 71157 as a Type B Apollo 17 high-Ti basalt, on the basis of the whole-rock classification of Rhodes et al. (1976) and Warner et al. (1979), and 71157 can be further classified as a Type B2 Apollo 17 basalt using the criteria of Neal et al. (1990). This sample contains 12.6 wt% TiO_2 with a MG# of 40.9. The REE profile (Fig. 3) is LREE depleted with a negative Eu anomaly $[(Eu/Eu^*)_N = 0.53]$. The HREE are approximately constant at 32-35 times chondritic values.

PROCESSING

Of the original 1.466g of 71157,0, approximately 1g remains. 0.41g was used for INAA and 0.01g used in the preparation of thin section 71157,4.

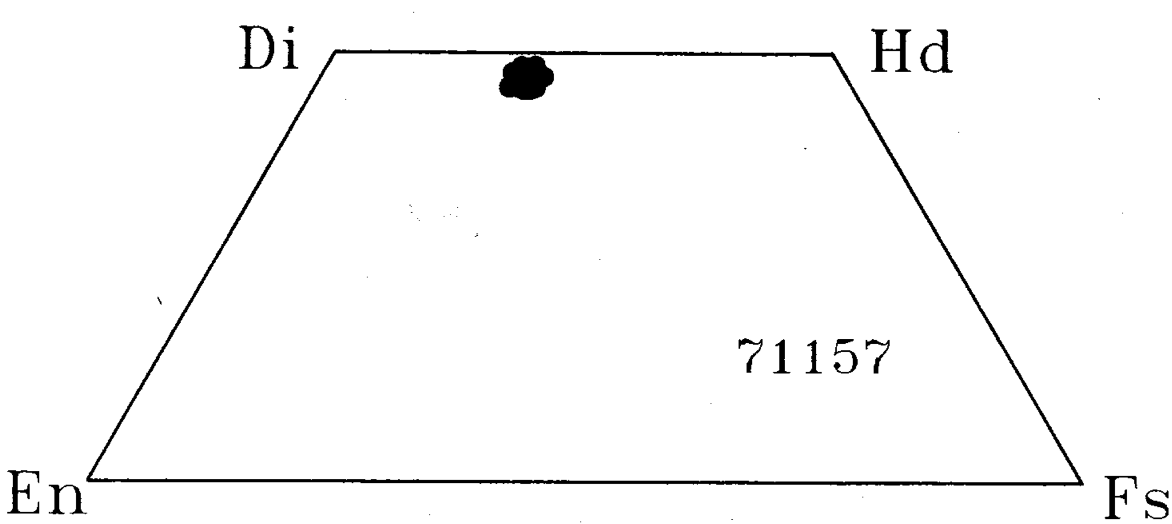


Figure 1: Pyroxene quadrilateral demonstrating the restricted compositional range of high-Ca pyroxene in thin section 71157,4.

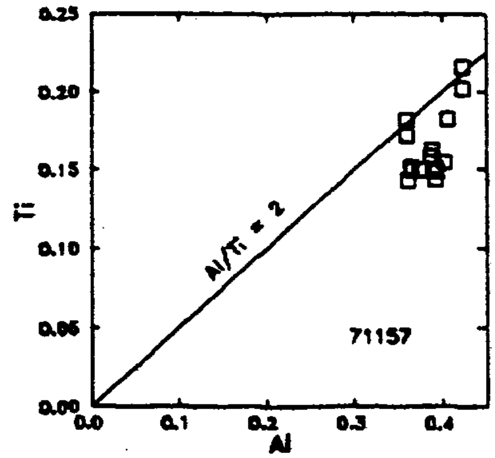


Figure 2: Al versus Ti for pyroxenes from 71157,4. Note the deviation from the typical Apollo 17 high-Ti basalt Al/Ti ratio of ~2.

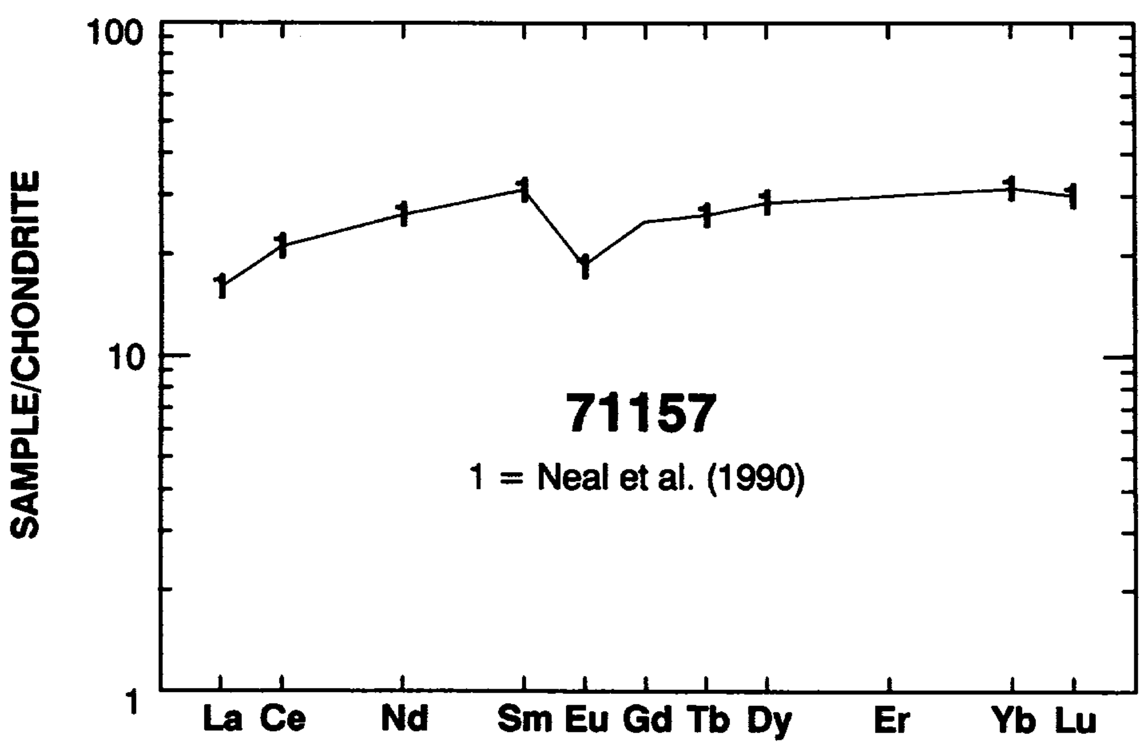


Figure 3: Chondrite-normalized rare earth element plot for 71157. Data from Neal et al. (1990).

Table 1: Whole-rock chemistry of 71157.
Data from Neal et al. (1990).

	Sample 71157,5 Method N		Sample 71157,5 Method N
SiO_2 (wt %)		Cu	
TiO_2	12.6	Ni	16
Al_2O_3	8.46	Co	22
Cr_2O_3	0.191	V	114
FeO	19.5	Sc	84
MnO	0.259	La	5.20
MgO	7.5	Ce	18
CaO	10.7	Nd	21
Na_2O	0.36	Sm	6.24
K_2O	0.03	Eu	1.40
P_2O_5		Gd	
S		Tb	1.50
Nb (ppm)		Dy	12.6
Zr	274	Er	
Hf	6.14	Yb	6.84
Ta	1.44	Lu	1.00
U		Ga	
Th	0.49	F	
W		Cl	
Y		C	
Sr	138	N	
Rb		H	
Li		He	
Ba	82	Ge (ppb)	
Cs	0.34	Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

71175
High-Ti Mare Basalt
207.8 g, 8 × 5 × 4 cm

INTRODUCTION

71175 (Fig. 1) was described as a medium gray, subangular, equigranular basalt (Apollo 17 Lunar Sample Information Catalog, 1973). All surfaces are dusty except where fragments have broken off. 71175 contains only rare zap pits (on T) and 5-10% miarolitic cavities (1-8mm diam) which have irregular distributions and shapes. These cavities rarely contain euhedral minerals. The surface of the cavities is like the surface of the rock. Some cavities are tabular. There is some suggestion of crystal growth along fractures emanating from pipe-like cavities. Two small fragments can be re-mated to the largest piece and have typical outer and fresh surfaces and mineral percentages. This basalt has a subangular shape with a few non-penetrative and penetrative

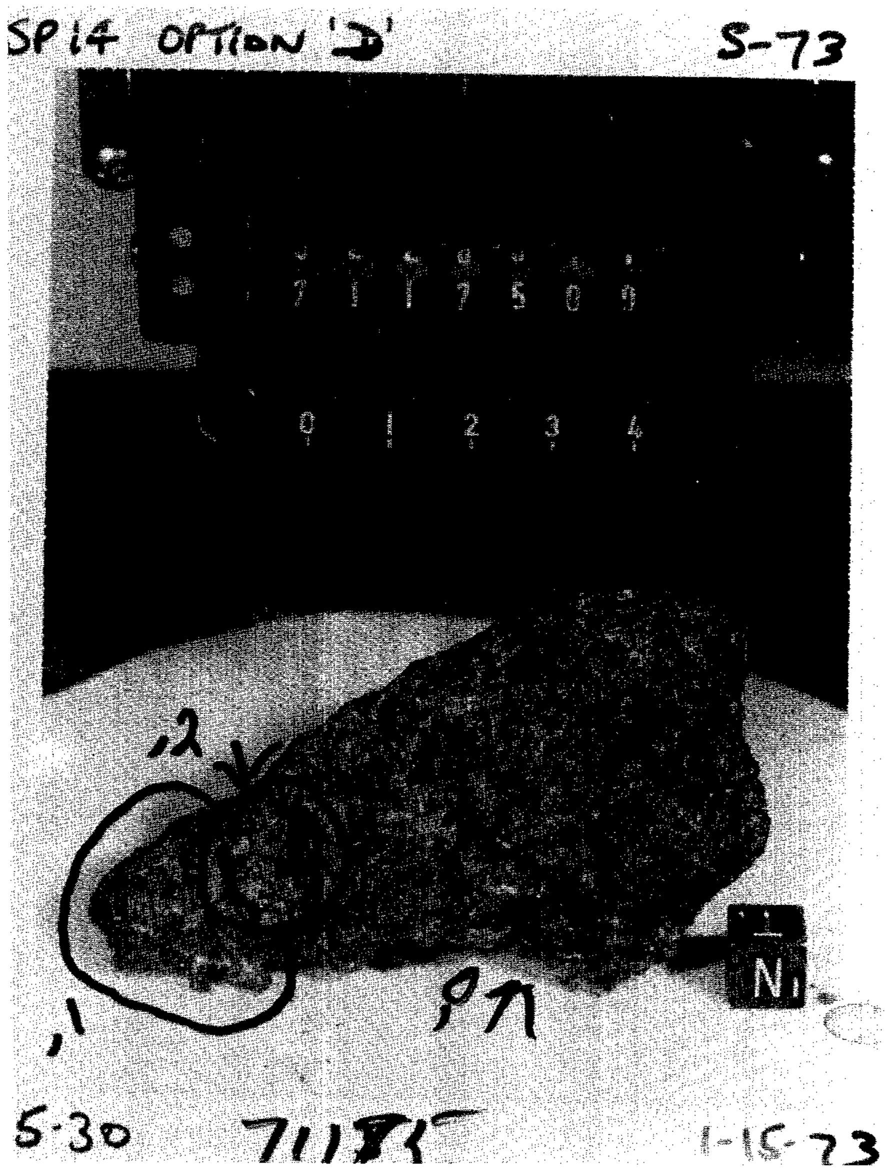


Figure 1: Hand specimen photograph of 71175,0 showing both north and top surfaces. Cubic scale = 1cm³.

fractures. 71175 was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

Brown et al. (1975) described 71175 as a Type IB Apollo 17 basalt, containing 1.7% olivine, 19.4% opaques, 27.1% plagioclase, 50.2% clinopyroxene, and 1.6% silica. Brown et al. (1975) do not specifically mention either the mineral relations or mineral chemistry of 71175 within their general petrographic descriptions. However, Roedder and Weiblen (1975) reported the compositions of anomalous "low-K" silicate melt inclusions in ilmenite from 71175.

During the preparation of this catalog we examined thin section 71175,39, finding it to be a coarse-grained (0.5-2mm) sub-ophitic to plagioclase-poikilitic basalt (Fig. 2). Olivine is rare, forming the rounded cores of the larger pyroxenes. Interstitial, blocky ilmenite overlays a network of plagioclase and pyroxene (px > plag). Rutile and chromite exsolution is abundant in the ilmenites and Fe-Metal and troilite (up to 0.2mm) is occasionally associated with ilmenite. No armalcolite was found. Interstitial SiO_2 (up to 0.8mm) is conspicuous.

WHOLE-ROCK CHEMISTRY

The whole-rock chemistry of 71175 has been reported by Warner et al. (1975) and Rhodes et al. (1976) (Table 1). These authors quote a TiO_2 content of 12.7 and 13.08 wt%, respectively, with MG#'s of 46.8 and 47.0, respectively. The REE profiles are similar in that they are both LREE-depleted with linear HREE abundances (Fig. 3), with the highest normalized REE abundances being in the MREE. The analysis of Rhodes et al. (1976) contains the highest REE abundances. Both profiles contain negative Eu anomalies $[(Eu/Eu^*)_N = 0.5\text{-}0.6]$. Rhodes et al. (1976) described 71175 as a Type A Apollo 17 basalt. Gibson et al. (1976) analyzed 71175 for sulphur abundance and reported 1685 ± 30 µgS/g with an equivalent wt% Fe^o of 0.182.

Eldridge et al. (1974) reported the primordial radioelement concentrations of 71175 (Table 1). These authors also

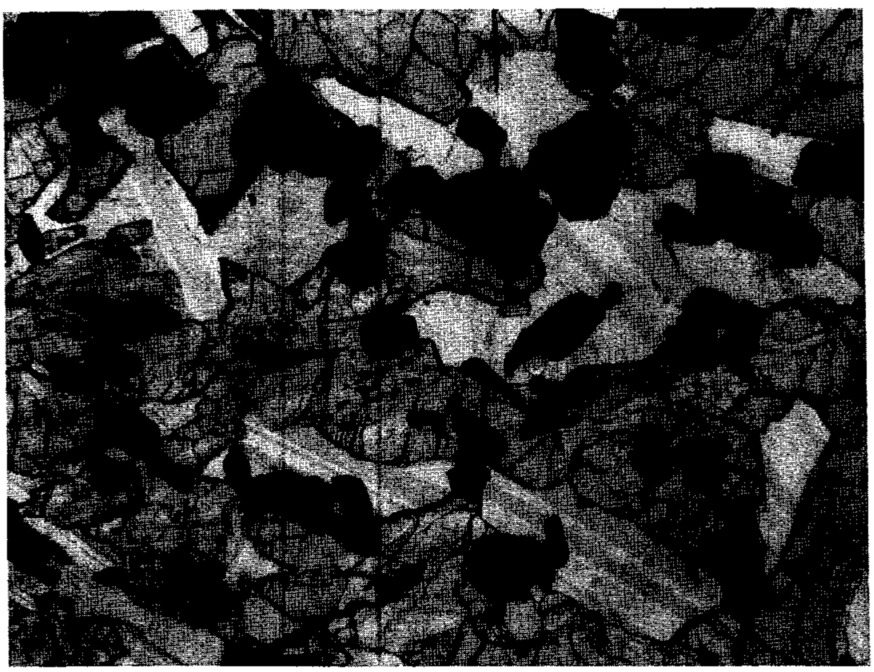


Figure 2: Photomicrograph of 71175,36 dominated by plagioclase, pyroxene, and ilmenite in a sub-ophitic to plagioclase poikilitic texture. Field of view = 2.6 mm.

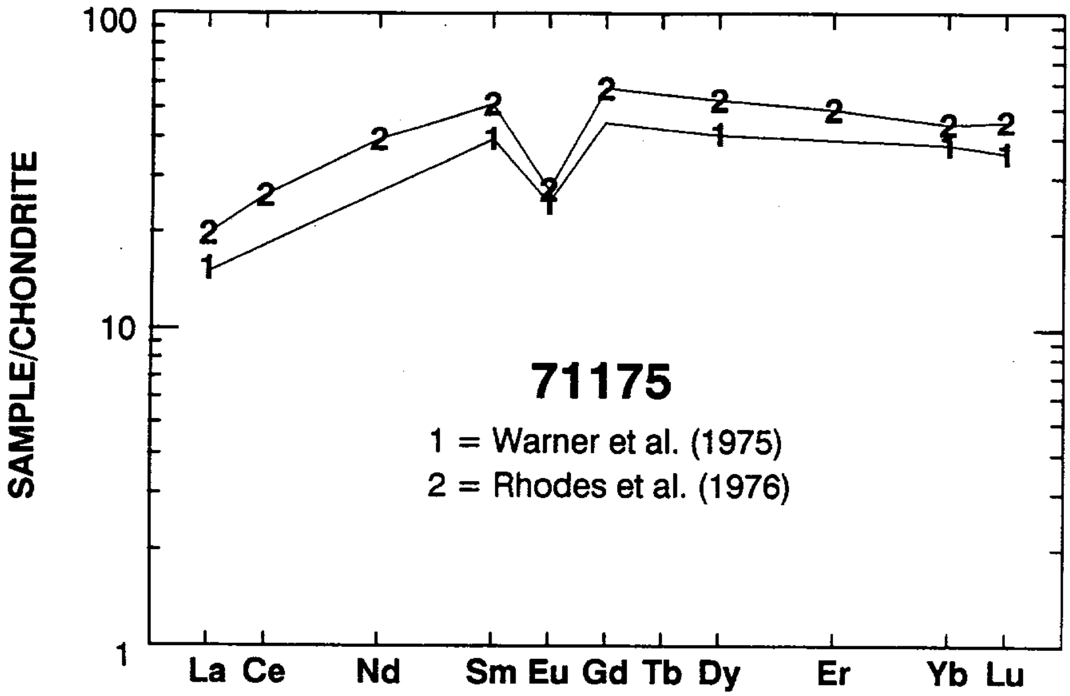


Figure 3: Chondrite-normalized rare-earth element plots for 71175. Data from Warner et al. (1975) and Rhodes et al. (1976).

reported a Th/U ratio of 3.5 and a K/U ratio of 5090 for this sample.

RADIOGENIC ISOTOPES

Nyquist et al. (1976) reported the whole-rock Rb-Sr isotopic composition of 71175 (Table 2). No age determination was conducted by these authors.

O'Kelley et al. (1974) reported the cosmogenic radionuclide concentrations of 71175 (Table 3).

PROCESSING

Of the original 207.8g of 71175,0, approximately 187.8g remains. Other large (> 1g) sub-samples are ,1 (11.93g), ,4 (2.93g), ,2 (1.53g), and ,8 (1.36g). Five thin sections have been made - ,33-36 and ,39.

Table 1: Whole-rock chemistry of 71175.

	Sample 71175,9 Ref. 1 Method N	Sample 71175,2 Ref. 2 Method X,I,N	Sample 71175 Ref. 3 Method G
SiO_2 (wt %)		37.93	
TiO_2	12.7	13.08	
Al_2O_3	9.1	8.47	
Cr_2O_3	0.506	0.54	
FeO	20.5	19.37	
MnO	0.238	0.28	
MgO	10.1	9.63	
CaO	9.2	9.79	
Na_2O	0.387	0.38	
K_2O	0.059	0.04	
P_2O_5		0.04	
S		0.16	
K(ppm)	552	560±28	
Nb			
Zr			
Hf	8.9		
Ta			
U		0.11±0.01	
Th		0.39±0.02	
W			
Y			
Sr	184		
Rb	0.59		
Li	10.0		
Ba	78.5		
Cs			
Be			
Zn			
Pb			
Cu			
Ni			
Co	21.7	17.6	
V	122		
Sc	78	77	
La	5.0	6.43	
Ce	22.3		
Nd	24.7		

Table 1: (Concluded).

	Sample 71175,9 Ref. 1 Method N	Sample 71175,2 Ref. 2 Method X,I,N	Sample 71175 Ref. 3 Method G
Sm	8.0	10.3	
Eu	1.89	2.08	
Gd	15.7		
Tb			
Dy	14	18.0	
Er		11.0	
Yb	8.3	9.69	
Lu	1.2	1.52	
Ga			
F			
Cl			
C			
N			
H			
He			
Ge (ppb)			
Ir			
Au			
Ru			
Os			

References: 1 = Warner et al. (1975); 2 = Rhodes et al. (1976); 3 = Eldridge et al. (1974).

Analysis by: X = XRF; I = Isotope dilution; N = INAA; G = Gamma-ray spectroscopy.

Table 2: Rb-Sr isotope data from 71175.
Data from Nyquist et al. (1976).

	71175,2
wt(mg)	51
Rb (ppm)	0.587
Sr (ppm)	184
$^{87}Rb/^{86}Sr$	0.0092 ± 3
$^{87}Sr/^{86}Sr$	0.69971 ± 6
T_B	4.62 ± 0.60
T_L	5.13 ± 0.60

B = Model age assuming I = 0.69910 (BABI + JSC bias); C = Model age assuming I = 0.69903 (Apollo 16 anorthosites at 4.6 Ga).

Table 3: Concentrations of Cosmogenic Radionuclides (O'Kelley et al., 1974) in 71175.
Cosmogenic Radionuclide Decay corrected to 2300 GMT, Dec. 14,1972.

	71175
^{26}Al (dpm/Kg)	60 ± 3
^{22}Na	68 ± 4
^{54}Mn	125 ± 8
^{56}Co	120 ± 30
^{46}Sc	43 ± 12

71505

High-Ti Mare Basalt
29.45 g, 3.2 × 2.5 × 2.5 cm

INTRODUCTION

71505 has been described as a dense, ilmenite-rich basalt with a very fine-grained groundmass (Fig. 1) containing acicular plagioclase. It is a dark gray, subangular-blocky, intergranular, microporphyritic basalt (Apollo 17 Lunar Sample Information Catalog, 1973). 71505 contains a few zap pits on all faces, the fewest being on B, and a few small vesicles are present. The surface is partially coated with reddish soil and small patches of dark glass. It contains a few nonpenetrative fractures and was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

The petrography and mineral chemistry of 71505 has been described only within general terms by Warner et al. (1979); compositions and textures were not specifically mentioned. Ma et al. (1979) classified 71505 as an olivine-microporphyritic ilmenite basalt. During the preparation of this catalog, we examined thin section 71505,5 and found it to be a fine-grained (0.1-0.3mm) basalt dominated by interlocking, poorly crystallized "sheaves" of plagioclase and pyroxene (Fig. 2). Corroded skeletal olivine microphenocrysts (up to 2mm) are abundant and contain small (~0.005mm) euhedral chromite inclusions. Occasional acicular plagioclase laths attain 1mm. Ilmenite is interstitial to the plagioclase and pyroxene "bow-tie" structures as well as the olivine microphenocrysts. These ilmenites reach up to 2mm long and have "sawtooth" margins (Fig. 2). Ilmenite is also

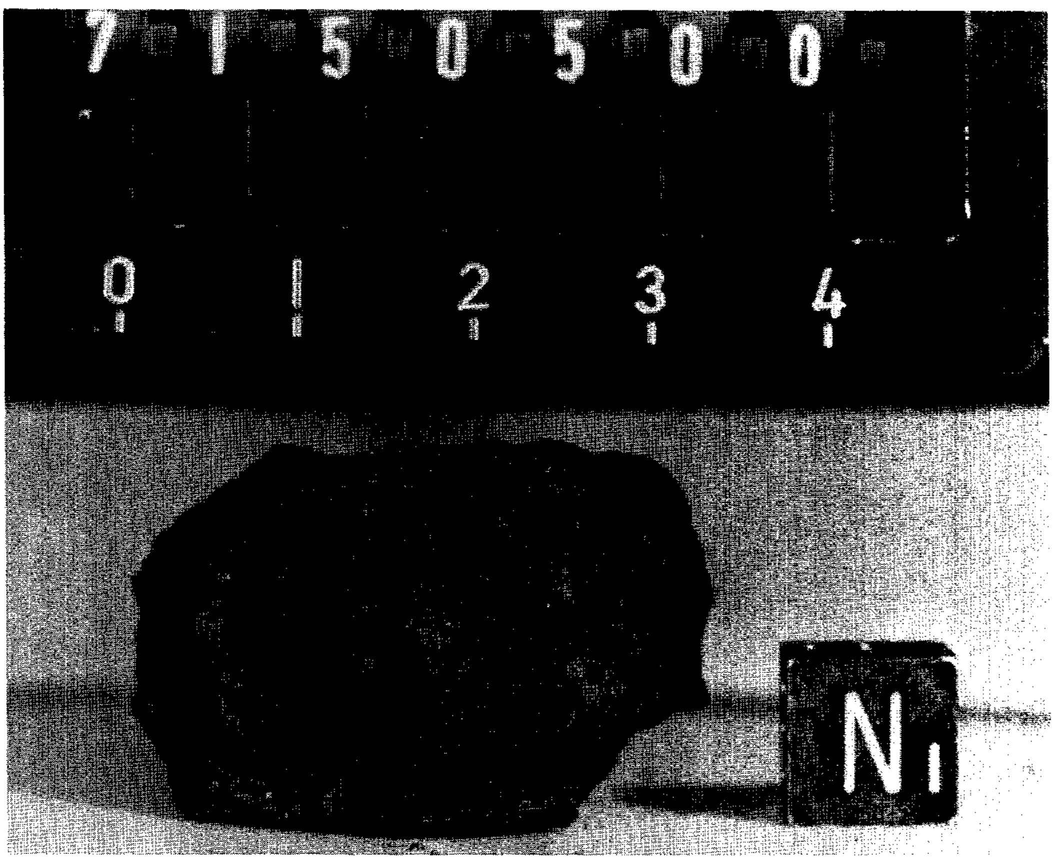


Figure 1: Hand specimen photograph of 71505,0 showing the north surface. Cubic scale = 1cm³.

a groundmass phase. No rutile or chromite exsolution is witnessed in these ilmenites and no armalcolite or interstitial SiO_2 was found. Native Fe and troilite (< 0.1mm) are either associated with ilmenite or are interstitial phases.

WHOLE-ROCK CHEMISTRY

Ma et al. (1979) and Warner et al. (1979) reported the same INA whole-rock analysis for 71505. Warner et al. (1979) classified 71505 as a Type B Apollo 17 high-Ti basalt. Using the criteria of Neal et al. (1990), 71505.is further classified as a Type B2 Apollo 17 basalt. It contains 10.5 wt% TiO_2 (Table 1) with a MG# of 39.4. 71505 is a LREE-depleted basalt containing a negative Eu anomaly [$(Eu/Eu^*)_N = 0.57$]. The HREE are constant at ~33 times chondritic abundances (Fig. 3).

PROCESSING

Of the original 29.45g of 71505,0, approximately 26.91g remains. 71505,1 weighs 2g and ,2 was irradiated for INAA and thin section 71505,5 was taken from this sample.

Figure 2: Photomicrograph of 71505,5 demonstrating a variolitic to sub-variolitic texture, with a large skeletal olivine phenocryst at the top. Field of view = 2.5 mm.

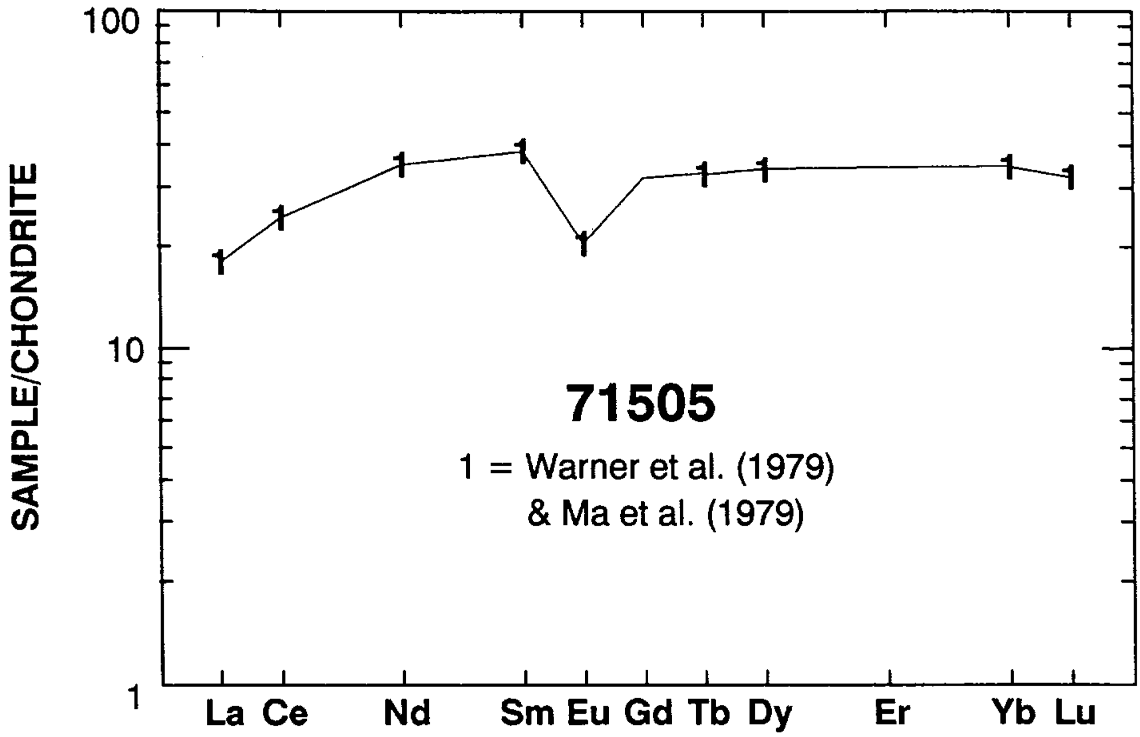


Figure 3: Chondrite-normalized rare-earth element plot for 71505. The same analysis was reported by Ma et al. (1979) and Warner et al. (1979).

Table 1: Whole-rock chemistry of 71505.
Data from Ma et al. (1979) and Warner et al. (1979) (same analysis).

	Sample 71505,2 Method N		Sample 71505,2 Method N
SiO_2 (wt %)		Cu	
TiO_2	10.5	Ni	
Al_2O_3	9.6	Co	18
Cr_2O_3	0.306	V	87
FeO	19.2	Sc	86
MnO	0.252	La	5.9
MgO	7	Ce	21
CaO	10.3	Nd	22
Na_2O	0.367	Sm	7.8
K_2O	0.048	Eu	1.57
P_2O_5		Gd	
S		Tb	1.9
Nb (ppm)		Dy	13
Zr		Er	
Hf	6.9	Yb	7.6
Ta	1.6	Lu	1.09
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

71506
High-Ti Mare Basalt
12.11 g, 3 × 2 × 1.5 cm

INTRODUCTION

71506 was described as a medium gray, intergranular, microporphyritic to porphyritic basalt (Apollo 17 Lunar Sample Information Catalog, 1973). It contains many zap pits which are glass lined on all surfaces except B which is a fresh fracture (Fig. 1a). Approximately 1% of small, irregular cavities are present, some containing small groundmass crystal terminations, but none with euhedral crystals. The fresh fracture face is in part a shallow vuggy depression. A few small, thin veinlets of light yellow to greenish glass cut across the fresh surface. 71506 has a rounded appearance (Fig. 1b) with no fractures. It was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

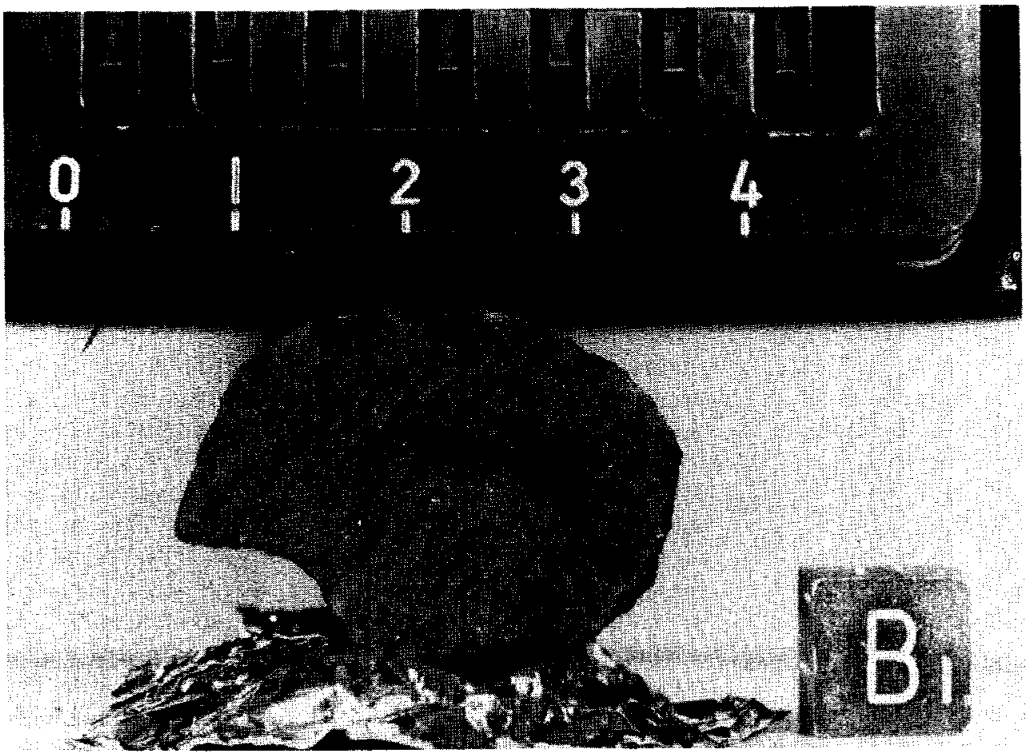
The petrography and mineral chemistry of 71506 has been described only in general terms by Warner et al. (1979); compositions and textures were not specifically mentioned. Ma et al. (1979) classified 71506 as an olivine-microporphyritic ilmenite basalt. During the preparation of this catalog, we examined thin section 71506,4. 71506 is a fine-grained (0.1-0.3mm) basalt with a groundmass dominated by poorly crystallized "bow-tie" structures of plagioclase and pyroxene (Fig. 2). Corroded olivine phenocrysts (up to 2mm) are present and contain euhedral chromite inclusions (~0.01mm). Ilmenite forms a microphenocryst/phenocryst phase (up to 2mm) as well as a groundmass phase. It is interstitial with the plagioclase-pyroxene "bow-tie" structures and olivine phenocrysts (Fig. 2). No rutile or chromite exsolution was observed in the ilmenite and no armalcolite or SiO_2 was present. Native Fe and troilite are either associated with ilmenite or form interstitial phases. 71506 is distinguished from 71505 by the presence of an opaque interstitial glass.

WHOLE-ROCK CHEMISTRY

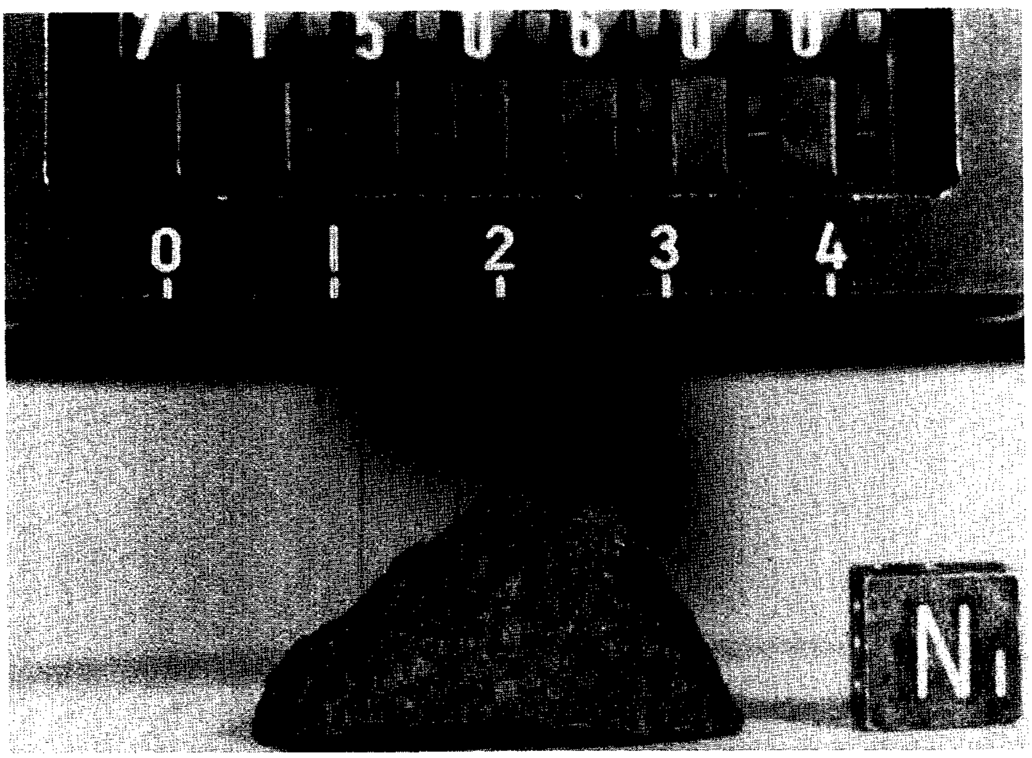
Both Ma et al. (1979) and Warner et al. (1979) reported the same INA whole-rock analysis for 71506,1. Warner et al. (1979) described 71506 as a Type B Apollo 17 basalt containing 10.7 wt% TiO_2 (Table 1) with a MG# of 39. It is further classified as a Type B2 Apollo 17 basalt using the criteria of Neal et al. (1990). The REE profile (Fig. 3) is LREE-depleted with a negative Eu anomaly [$(Eu/Eu^*)_N = 0.57$]. There is a slight decrease in the HREE abundances (relative to chondrites) compared to the MREE (Fig. 3).

PROCESSING

Of the original 12.11g of 71506,0, a total of 11.7g remains. 71506,1 was irradiated for INAA and thin section ,4 was taken from this sample.



1a: Bottom surface.



1b: Top surface.

Figure 1: Hand specimen photograph of 71506. Cubic scale = 1cm^3.

Figure 2: Photomicrograph of 71506,4 demonstrating subhedral olivine phenocrysts and ilmenite with sawtooth margins. An overall sub-variolitic texture predominates. Field of view = 2.5 mm.

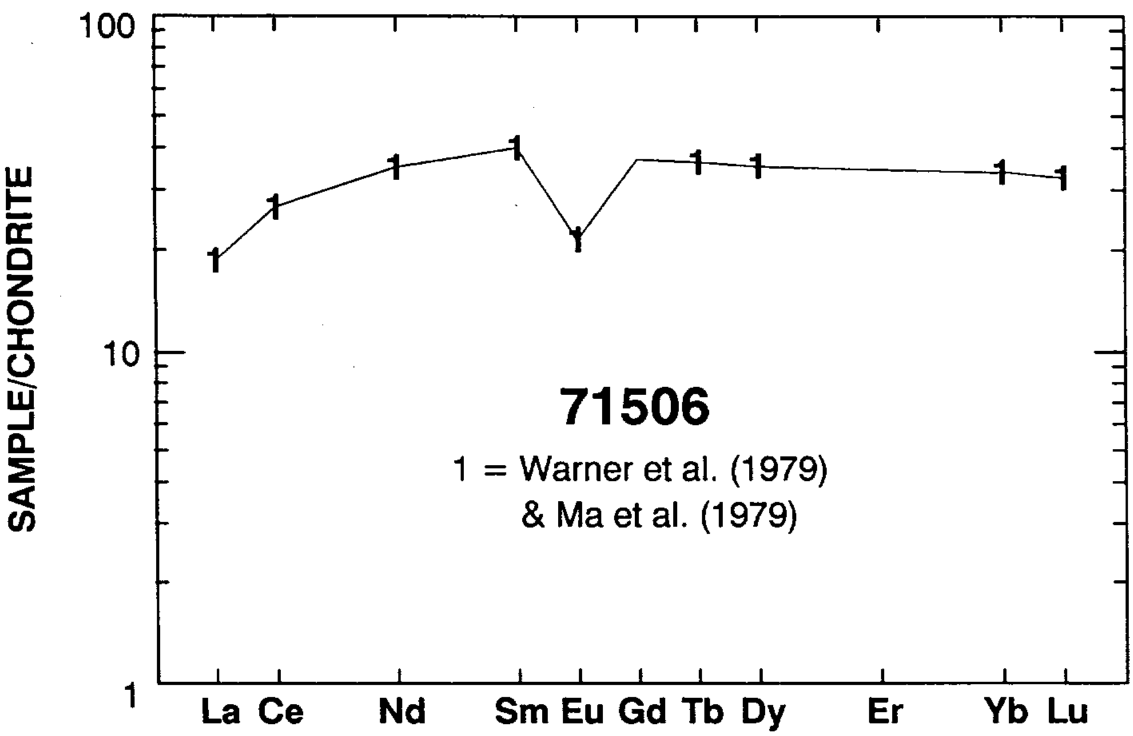


Figure 3: Chondrite-normalized rare-earth element plot for 71506. The same analysis was reported by Ma et al. (1979) and Warner et al. (1979).

Table 1: Whole-rock chemistry of 71506.
Data from Ma et al. (1979) and Warner et al. (1979) (same analysis).

	Sample 71506,1 Method N		Sample 71506,1 Method N
SiO_2 (wt %)		Cu	
TiO_2	10.7	Ni	
Al_2O_3	10.0	Co	19
Cr_2O_3	0.353	V	106
FeO	19.5	Sc	85
MnO	0.266	La	6.1
MgO	7	Ce	23
CaO	11.6	Nd	22
Na_2O	0.376	Sm	8.1
K_2O	0.052	Eu	1.64
P_2O_5		Gd	
S		Tb	2.1
Nb (ppm)		Dy	14
Zr		Er	
Hf	7.2	Yb	7.4
Ta	1.9	Lu	1.10
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

71507

High-Ti Mare Basalt
3.962 g, 3.5 × 1.7 × 1.5 cm

INTRODUCTION

71507 was described as a light reddish-gray, intergranular, medium-grained microdiabasic basalt (Apollo 17 Lunar Sample Information Catalog, 1973). It contains a few zap pits on all surfaces, and the specimen is partially dust coated on all surfaces (Fig. 1), with fresh fractures on a small area of the N face. Small, smooth vesicles and irregular vugs (1-3mm) are present throughout. This basalt has an irregular shape (Fig. 1) and contains 1 or 2 penetrative fractures. It was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

The petrography and mineral chemistry of 71507 has been described by Warner et al. (1978). During the preparation of this catalog, we examined thin section 71507,5 and found this to be a medium grained (0.2-0.8mm) basalt with blocky plagioclase and pink pyroxenes. Occasionally, plagioclase and pyroxene are intergrown into "bow-tie" structures (Fig. 2). Corroded olivines are present (~0.2mm) either forming the core to larger pyroxenes or just with a small pyroxene rim. Ilmenite (up to 1mm) overlays this texture (Fig. 2). Interstitial SiO_2 is conspicuous. Native Fe and troilite are either interstitial or associated with ilmenite. An interstitial opaque glass is also associated with ilmenite. No rutile or chromite exsolution was observed in the ilmenite, and no armalcolite was found.

WHOLE-ROCK CHEMISTRY

Murali et al. (1977) have reported the whole-rock composition of 71507,1 (Table 1). It contains 13.2 wt% TiO_2 with a

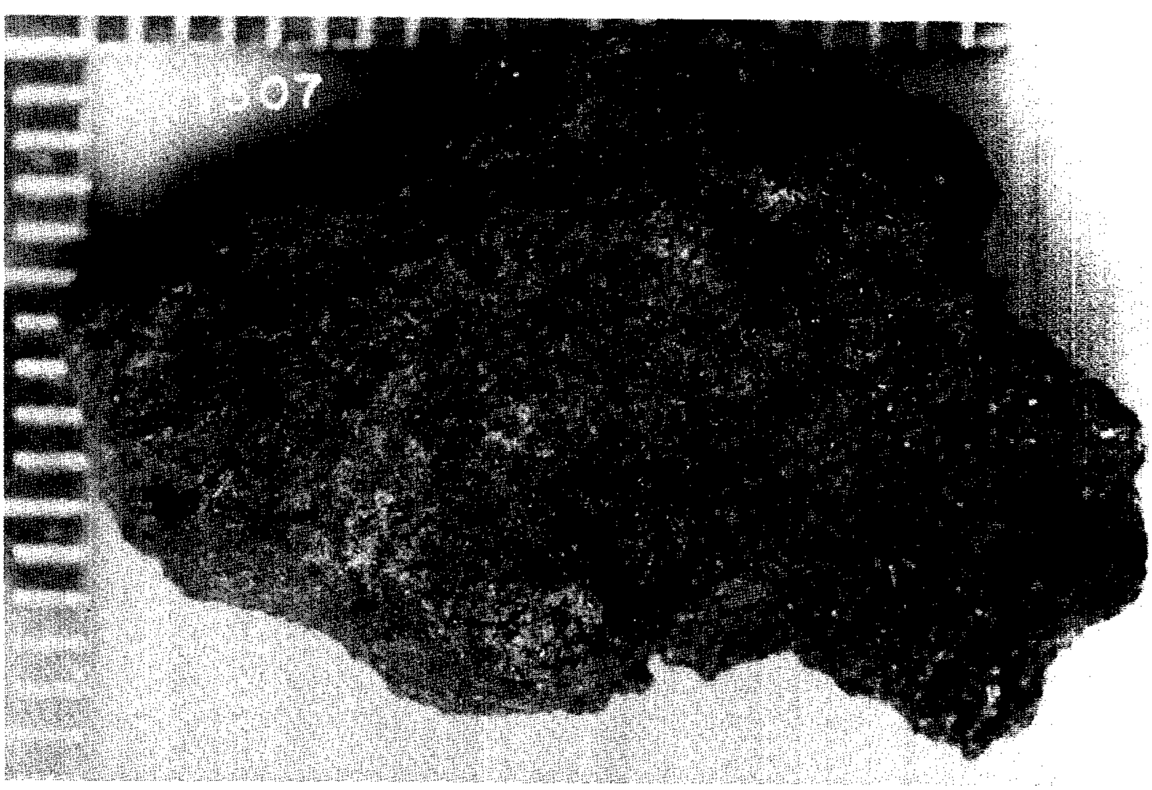


Figure 1: Hand specimen photograph of 71507,0. Small divisions on scale are in millimeters.

MG# of 44. Based on the whole-rock classification of Rhodes et al. (1976) and Warner et al. (1979), plus the criteria of Neal et al. (1990), 71507 is classified as a Type B2 Apollo 17 high-Ti basalt. The REE profile is LREE-depleted in that it exhibits a $(La/Sm)_N$ ratio < 1 the Ce analysis must be considered suspect (Fig. 3). A negative Eu anomaly is present (Fig. 3) $[(Eu/Eu^*)_N = 0.56]$. The HREE exhibit a variation between 25 and 30 times chondritic values (Fig. 3).

PROCESSING

Of the original 3.962g of 71507,0, only 3.3g remains. 71507,1 was irradiated for INAA, and thin section ,5 was taken from this sample.

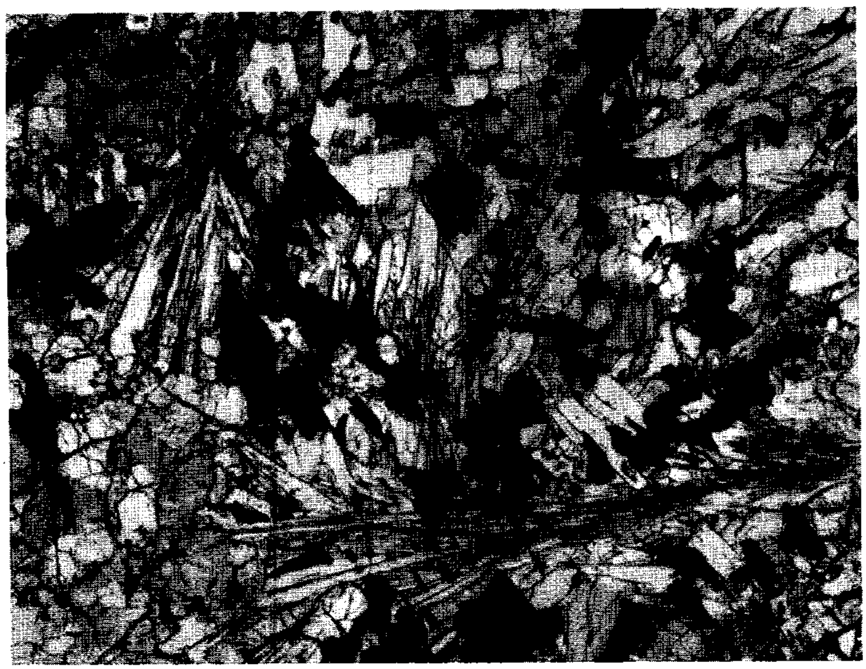


Figure 2: Photomicrograph of 71507,5 demonstrating a texture varying between blocky and well-crystallized to variolitic. Field of view = 2.5 mm.

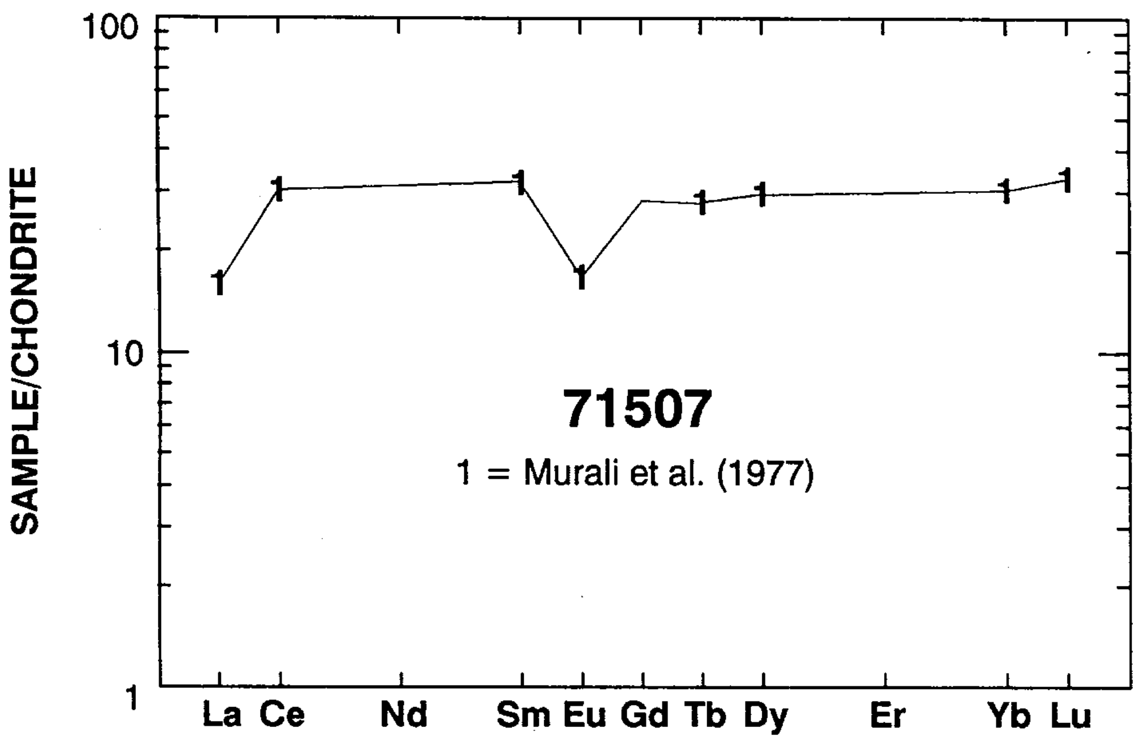


Figure 3: Chondrite-normalized rare-earth element profile of 71507. Data from Murali et al. (1977).

Table 1: Whole-rock chemistry of 71507.
Data from Murali et al. (1977).

	Sample 71507,1 Method N		Sample 71507,1 Method N
SiO_2 (wt %)		Cu	
TiO_2	13.2	Ni	
Al_2O_3	8.6	Co	17.8
Cr_2O_3	0.435	V	113
FeO	20.6	Sc	81
MnO	0.253	La	5.2
MgO	9.1	Ce	26
CaO	10.3	Nd	
Na_2O	0.39	Sm	6.4
K_2O	0.061	Eu	1.27
P_2O_5		Gd	
S		Tb	1.6
Nb (ppm)		Dy	10
Zr		Er	
Hf	6.1	Yb	6.6
Ta	1.5	Lu	1.1
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	4 ± 1
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

71508
High-Ti Mare Basalt
3.423 g, 2 × 1.5 × 1.5 cm

INTRODUCTION

71508 was described as a light reddish-gray, intergranular, medium- to coarse-grained, microdiabasic basalt (Apollo 17 Lunar Sample Information Catalog, 1973). Zap pits are present on most surfaces, but the rock is too friable to preserve many pits. 50% small irregular vugs riddle the N surface and appear to occur in the interior layers parallel to this surface. There is a partial soil coat on most surfaces (Fig. 1). No fresh exposures are present, except for broken areas around vugs.

71508 has a rhombic shape with rounded edges (Fig. 1) with fracturing which sheds a lot of grains. It was collected from Station 1A.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1978) have reported the petrography and mineral chemistry of 71508. During the preparation of this catalog we examined thin section 71508,5 and found it to be a fine- to medium- grained (0.2-0.5mm) sub-ophitic basalt. Plagioclase and pyroxene are intergrown as "bow-tie" structures, but there is also blocky, pink pyroxene present. Some of these blocky pyroxenes contain rounded olivine cores (~0.1mm) which in turn contain euhedral inclusions of chromite (<0.005mm). Ilmenite (up to 1mm) overlays the plagioclase and pyroxene. Opaque interstitial glass, native Fe, and troilite (the last two up to 0.2mm) are associated with ilmenite, although native Fe and troilite are also present as interstitial phases. Interstitial SiO_2 (up to 0.3mm) is also present.

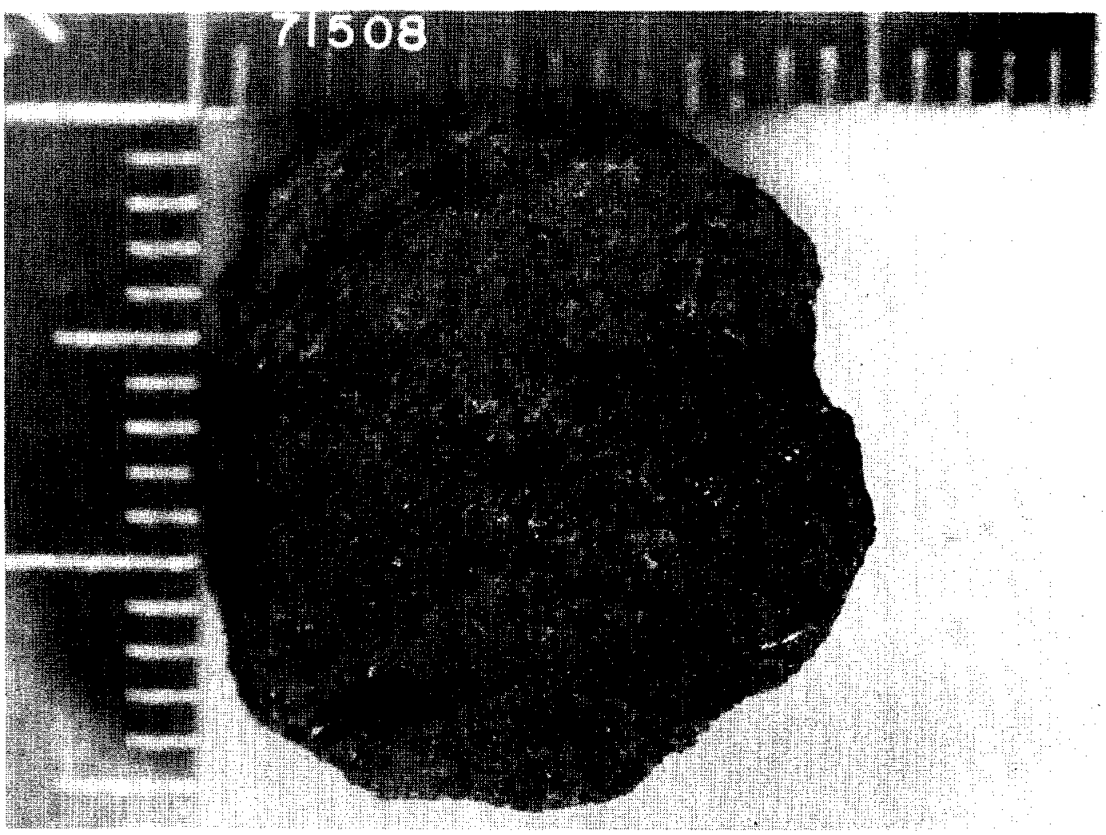


Figure 1: Hand specimen photograph of 71508,0. Small divisions on scale are in millimeters.

WHOLE-ROCK CHEMISTRY

Murali et al. (1977) have reported the whole-rock composition of 71508,1 (Table 1). Based on the whole rock classification scheme of Rhodes et al. (1976) and Warner et al. (1976), 71508 is a Type A Apollo 17 high-Ti basalt. It contains 12.1 wt% TiO_2 with a MG# of 42.5. The REE profile is LREE-depleted with a maximum abundances (relative to chondrites) in the MREE (Fig. 2). A negative Eu anomaly is present [$(Eu/Eu^*)_N = 0.54$].

PROCESSING

Of the original 3.423g of 71508,0, a total of 1.89g remains. 71508,1 was used for INAA and the thin section ,5 taken from this irradiated sample.

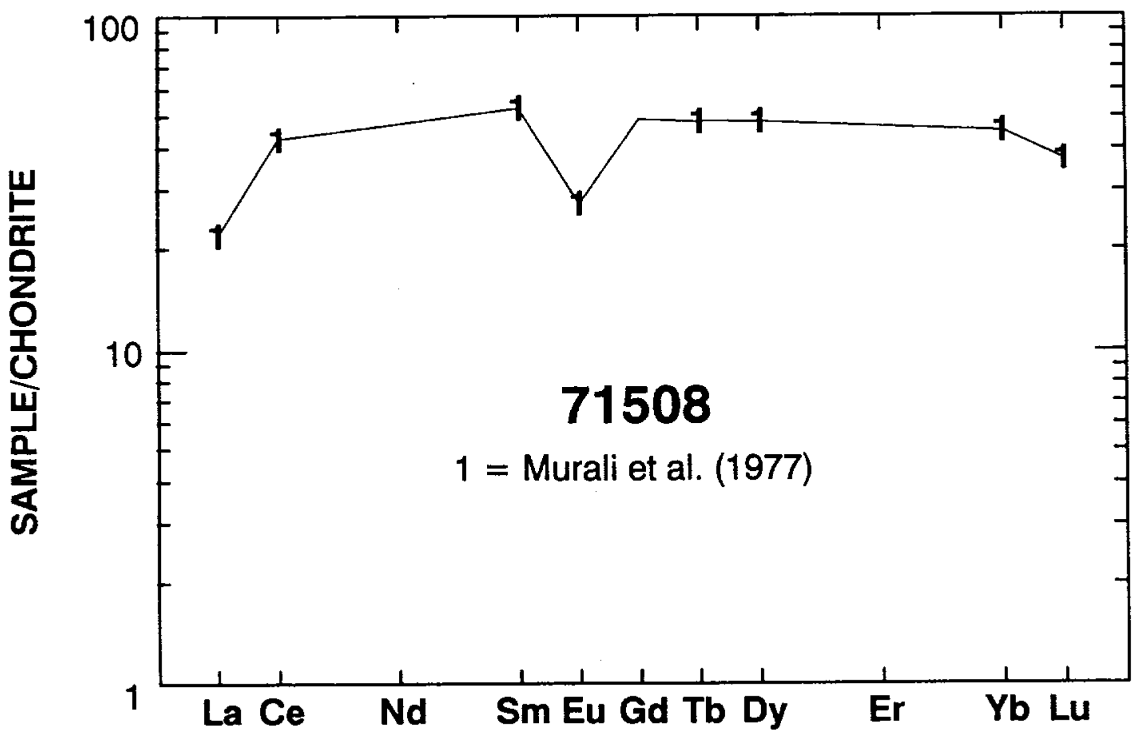


Figure 2: Chondrite-normalized rare-earth element profile of 71508. Data from Murali et al. (1977).

Table 1: Whole-rock chemistry of 71508.
Data from Murali et al. (1977).

	71508,1 N		71508,1 N
SiO_2 (wt %)		Cu	
TiO_2	12.1	Ni	
Al_2O_3	8.8	Co	17.0
Cr_2O_3	0.398	V	101
FeO	19.8	Sc	74
MnO	0.235	La	7.2
MgO	8.2	Ce	37
CaO	10.3	Nd	
Na_2O	0.40	Sm	10.8
K_2O	0.077	Eu	2.12
P_2O_5		Gd	
S		Tb	2.8
Nb (ppm)		Dy	19
Zr		Er	
Hf	9.3	Yb	10.0
Ta	1.8	Lu	1.26
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Eu	
Pb		Os	

Analysis by: N = INAA.

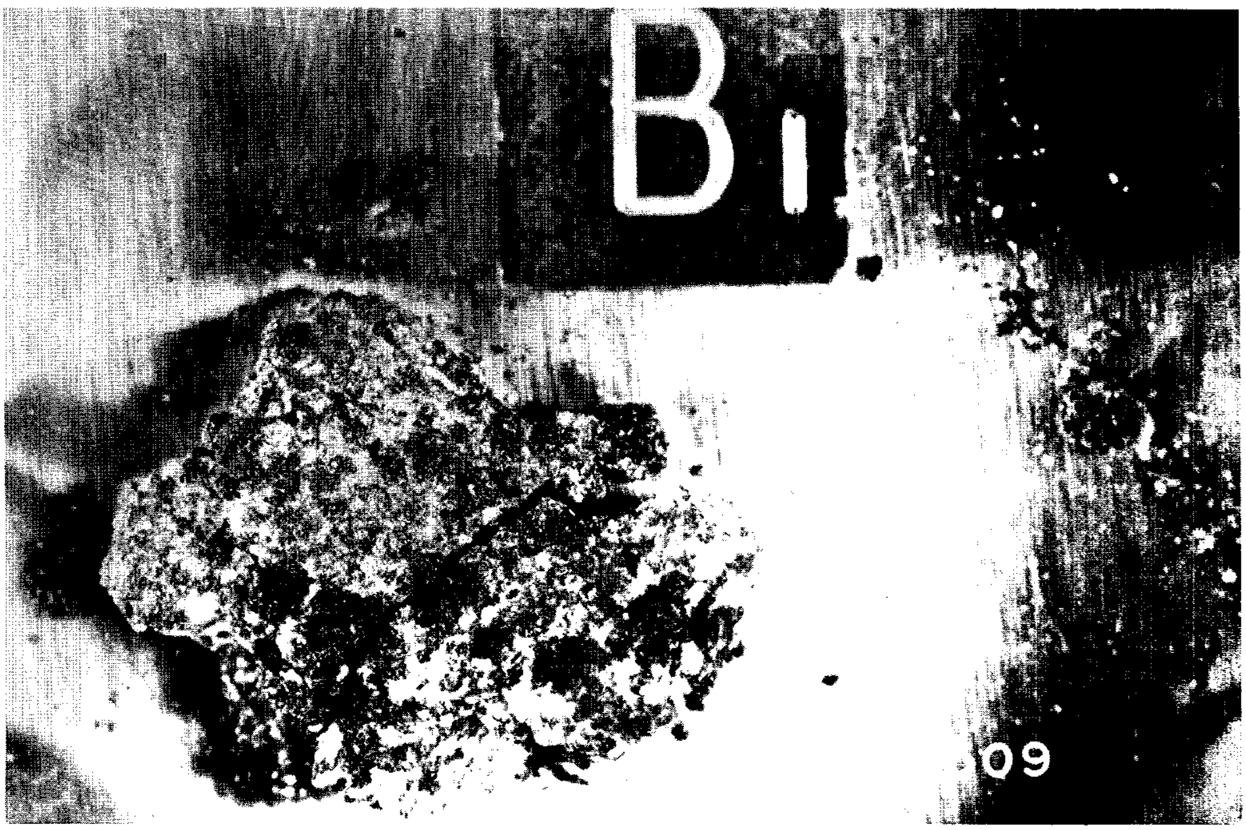
71509
High-Ti Mare Basalt
1.69 g, 2 × 1.5 × 0.5 cm

INTRODUCTION

71509 was described as a variegated white to light brown, intergranular, homogeneous, coarse-grained basalt (Apollo 17 Lunar Sample Information Catalog, 1973). It contains glomerophyric aggregates of pyroxene and ilmenite in a white plagioclase matrix (Fig. 1a,b). The rock is too friable for the preservation of zap pits and 1% vesicles are exposed on a fresh fracture surface - none are on the original top or bottom. 71509 has broken into three pieces (Fig. 1b), but was a flat fragment before handling. This basalt was collected from Station 1A.

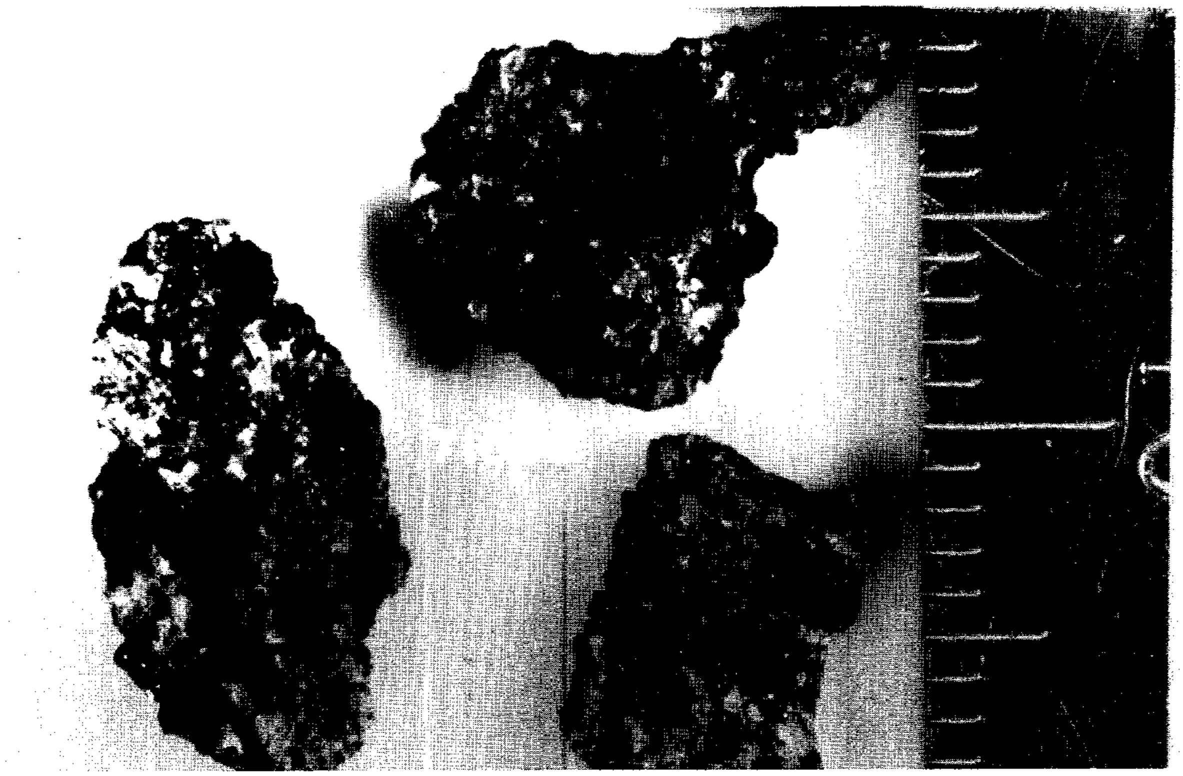
PETROGRAPHY AND MINERAL CHEMISTRY

The petrography and mineral chemistry has been reported by Warner et al. (1976ab, 1978). Warner et al. (1975) described 71509 as a plagioclase-poikilitic ilmenite basalt, but did not elaborate and did not mention mineral chemistry. During the preparation of this catalog we examined thin section 71509,5 and found it to be dominated by plagioclase and pyroxene. It is a coarse-grained (up to 2mm) plagioclase-poikilitic basalt, containing interstitial, blocky ilmenite (up to 2mm). No olivine or armalcolite are present, but interstitial SiO_2 is conspicuous. Rutile and chromite exsolution lamellae (< 0.1mm wide) are present in the ilmenite. Rare opaque glass is associated with ilmenite. Native Fe and troilite are either associated with the ilmenite or form ~0.1mm interstitial phases.



1a: Cubic scale = 1cm³.

Figure 1: Hand specimen photographs of 71509.



1b: Small divisions on scale are in millimeters.

Figure 1: Hand specimen photographs of 71509.

WHOLE-ROCK CHEMISTRY

Warner et al. (1975) reported the whole-rock composition of 71509 (given in Table 1). 71509,1 contains 13.7 wt% TiO_2 with a MG# of 47.1. 71509 is classified as a Type C Apollo 17 high-Ti basalt using the whole-rock classification of Rhodes et al. (1976). The REE profile (Fig. 2) is LREE-depleted with constant middle and heavy REE abundances at ~43 times chondritic levels. A negative Eu anomaly is present [$(Eu/Eu^*)_N = 0.5$].

PROCESSING

Of the original 1.69g of 71509,0, a total of 1.35g remains. 71509,1 was used for INAA, and thin section ,5 was taken from this irradiated sample.

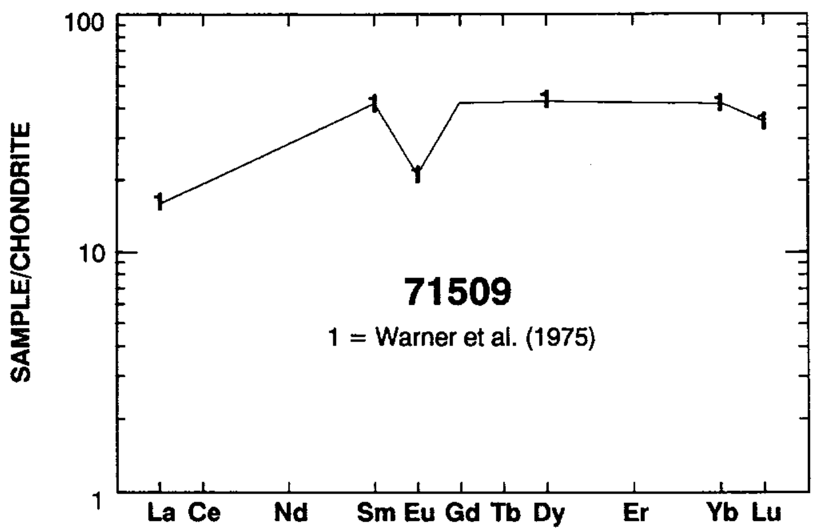


Figure 2: Chondrite-normalized rare-earth element plot of 71509. Data from Warner et al. (1975).

Table 1: Whole-rock chemistry of 71509.
Data from Warner et al. (1975).

	71509,1 Method N		71509,1 Method N
SiO_2 (wt %)		Cu	
TiO_2	13.7	Ni	
Al_2O_3	7.3	Co	24.5
Cr_2O_3	0.647	V	160
FeO	20.6	Sc	95
MnO	0.258	La	5.3
MgO	10.3	Ce	
CaO	9.6	Nd	
Na_2O	0.314	Sm	8.5
K_2O	0.054	Eu	1.62
P_2O_5		Gd	
S		Tb	
Nb (ppm)		Dy	15
Zr		Er	
Hf		Yb	9.3
Ta		Lu	1.2
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Eu	
Pb		Os	

Analysis by: N = INAA.

71515
Glass-Bonded Agglutinate
1.635 g, 2 cm at longest

INTRODUCTION

71515 was described as an irregular, intergranular and friable, glass-bonded agglutinate (Apollo 17 Lunar Sample Information Catalog, 1973) (Fig. 1). Clasts are gray-brown, whereas the glass is light brown and vitreous. About eight fragments of fine-grained, coherent, annealed breccia, with brown fine-grained matrices and small white clasts of shocked plagioclase, are welded into an aggregate by glass crusts and filaments. Fragments of basalt are also present in the aggregate. Some fragment surfaces exhibit micro-slickensides.

PETROGRAPHY AND MINERAL CHEMISTRY

The mineralogy and petrography of 71515 has been reported by Warner et al. (1978). No thin section was available during the preparation of this catalog.

WHOLE-ROCK CHEMISTRY

Warner et al. (1979b,c) included the glass composition of 71515 in their study of Apollo 17 glasses and their relationship to known lunar rock-types. However, the glass composition was not directly quoted. Laul et al. (1975b) reported the whole-rock composition of 71515,0 in their study of Apollo 17 rake samples. These authors described 71515 as a basalt-breccia. It contains 10.3 wt% TiO_2 (Table 1) with a MG# of 47.7. The REE profile is LREE-depleted with a maximum in the MREE (Fig. 2). The HREE exhibit a steady decline from the MREE, but are still present in greater abundances (relative to chondrites) than the LREE (Fig. 2). A negative Eu anomaly is present [$(Eu/Eu^*)_N$ = 0.55].

PROCESSING

Of the original 1.635g of 71515,0, a total of 1.265g remains. 71515,1 was renumbered to ,9001, and thin section ,4 was made from this sample.

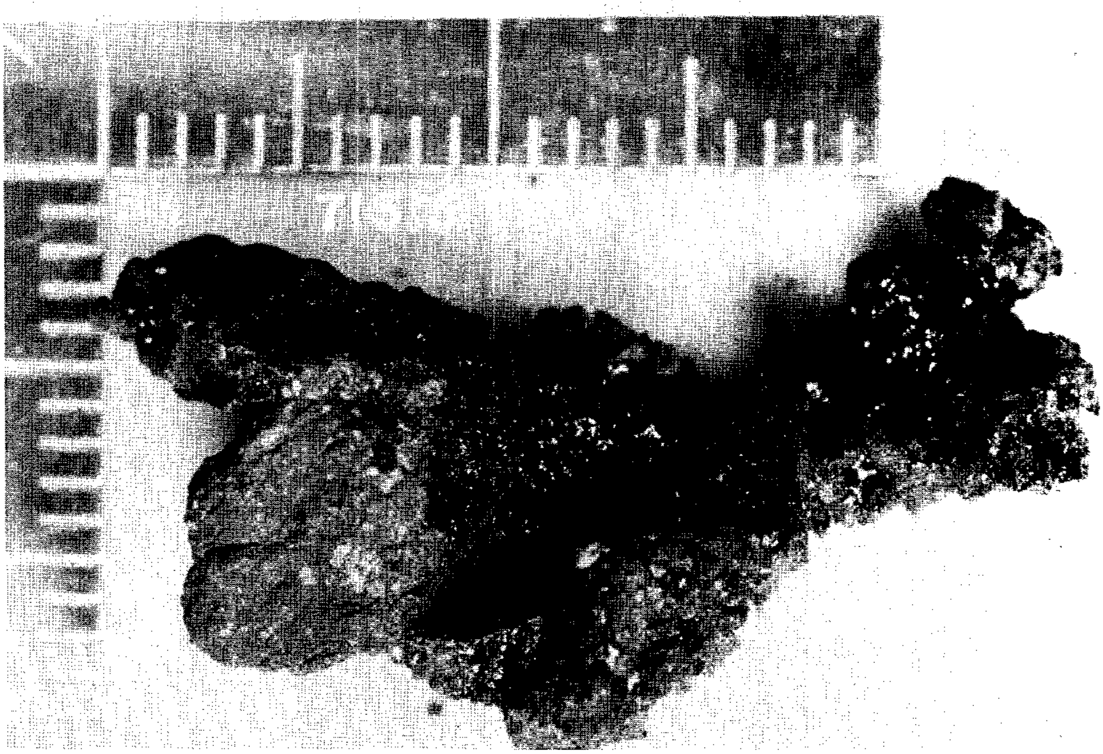


Figure 1: Hand specimen photograph of 71515,0. Note the glassy surface. Small divisions on scale are in millimeters.

Table 1: Whole-rock chemistry of 71515.
Data from Laul et al. (1975).

	Sample 71515,0 Method N		Sample 71515,0 Method N
SiO_2 (wt %)		Cu	
TiO_2	10.3	Ni	
Al_2O_3	11.2	Co	30.7
Cr_2O_3	0.458	V	100
FeO	18.2	Sc	67
MnO	0.222	La	6.9
MgO	9.3	Ce	23
CaO	10.4	Nd	
Na_2O	0.37	Sm	8.7
K_2O	0.065	Eu	1.66
P_2O_5		Gd	
S		Tb	2.1
Nb (ppm)		Dy	14
Zr		Er	
Hf	6.6	Yb	7.1
Ta	1.4	Lu	1.0
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

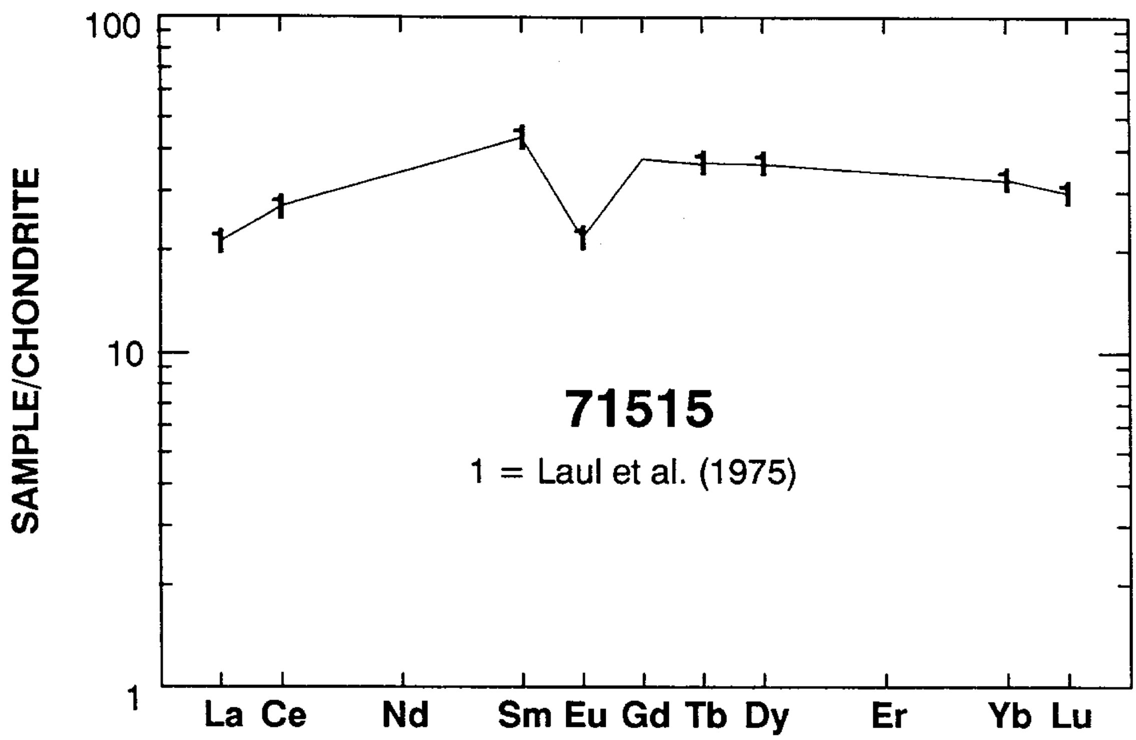


Figure 2: Chondrite-normalized rare-earth element plot of 71515. Data from Laul et al. (1975).

71525
High-Ti Mare Basalt
3.90 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples"

PETROGRAPHY AND MINERAL CHEMISTRY

The mineralogy and petrography of 71525 was described by Warner et al. (1978). During the preparation of this catalog, we examined thin section 71525,3 and found it to be a fine- to medium-grained basalt (0. 1-0.5mm - Fig. 1). It is comprised of intergrown plagioclase and pyroxene "bow-tie" structures, pink, blocky pyroxene, and corroded olivines (Fig. 1). The olivines contain euhedral chromite inclusions (< 0.05mm) (Fig. 1). Ilmenite (up to 1mm) is interstitial and is also present in the groundmass. Armalcolite forms the cores to some of the larger ilmenites. Rutile and chromite exsolution lamellae are present in the ilmenite. Opaque glass, native Fe, and troilite are associated with ilmenite, although these latter two minerals are also present as interstitial phases. Interstitial SiO_2 is conspicuous.

WHOLE-ROCK CHEMISTRY

Murali et al. (1977) reported the whole-rock composition of 71525,1 in a study of Apollo 17 rake samples (Table 1). Based on the whole-rock classification of Rhodes et al. (1976) and Warner et al. (1979), plus the criteria of Neal et al. (1990), 71525 is classified as a Type B2 Apollo 17 high-Ti basalt. This sample contains 12.9 wt% TiO_2 with a MG# of 41.3. The REE profile is LREE-depleted (Fig. 2) with a maximum in the MREE. The HREE gently decrease from the MREE, but are still present in greater abundances (relative to chondrites) than the LREE (Fig. 2). A negative Eu anomaly is present [$(Eu/Eu^*)_N = 0.51$.

PROCESSING

Of the original 3.90g of 71525,0, a total of 3.51g remains. 71525,1 was used for INAA and thin section ,3 was taken from this irradiated sample.

Figure 1: Photomicrograph of 71525,3 showing olivine and ilmenite phenocrysts set in a sub-variolitic matrix. Field of view = 2.5 mm.

Table 1: Whole-rock chemistry of 71525.
Data from Murali et al. (1977).

	Sample 71525,1 Method N		Sample 71525,1 Method N
SiO_2 (wt %)		Cu	
TiO_2	12.9	Ni	
Al_2O_3	8.8	Co	20.5
Cr_2O_3	0.392	V	106
FeO	20.8	Sc	85
MnO	0.246	La	5.8
MgO	8.2	Ce	27
CaO	11.0	Nd	
Na_2O	0.39	Sm	7.5
K_2O	0.053	Eu	1.43
P_2O_5		Gd	
S		Tb	2.1
Nb (ppm)		Dy	13
Zr		Er	
Hf	6.6	Yb	7.1
Ta	1.5	Lu	0.98
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	2 ± 1
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

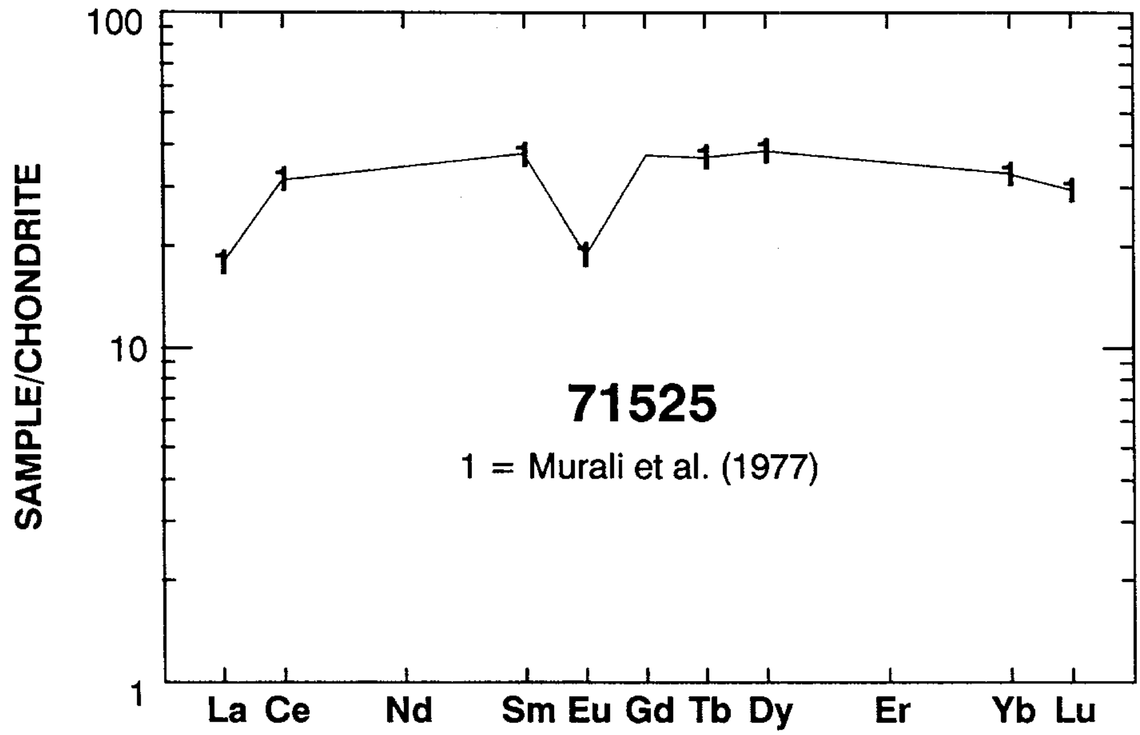


Figure 2: Chondrite-normalized rare-earth element plot of 71525. Data from Murali et al. (1975).

71526
High-Ti Mare Basalt
12.91 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1978) reported the petrography and mineral chemistry of 71526. During the preparation of this catalog we examined thin section 71526,4 and found it to be a fine- to medium-grained sub-ophitic basalt (Fig. 2). It is comprised of equigranular olivine and pyroxene (0.1-0.4mm) and the olivines exhibit no reaction rims of pyroxene. Olivines do contain euhedral chromite inclusions (< 0.05mm). Unoriented ilmenite phenocrysts (up to 0.7mm) are present (Fig. 2), exhibiting "sawtooth" margins. Ilmenite is also a groundmass mineral along with plagioclase and pink pyroxene. Plagioclase and pyroxene very rarely exhibit "bow-tie" intergrowths. Interstitial glass, native Fe, and troilite are often associated with ilmenite. No armalcolite was identified.

WHOLE-ROCK CHEMISTRY

Murali et al. (1977) reported the whole-rock composition of 71526,2 in a study of Apollo 17 rake samples (Table 1). Using the classification scheme of Rhodes et al. (1976) and Warner et al. (1979), plus the criteria of Neal et al. (1990), 71526 is classified as a Type B2 Apollo 17 high-Ti basalt. This sample contains 9.8 wt% TiO_2 with a MG# of 38.4. Murali et al. (1977) distinguished 71526 by its low V, TiO_2, MgO, and Cr_2O_3 contents and suggests that it

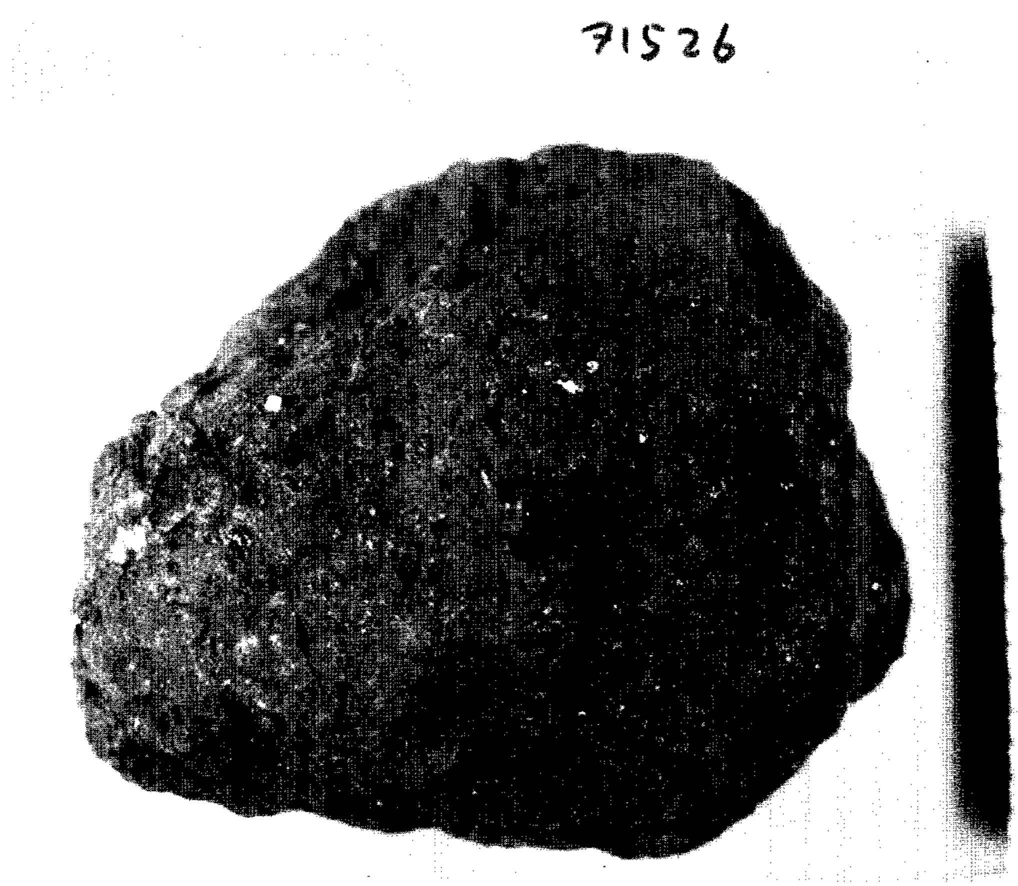


Figure 1: Hand specimen photograph of 71526,0. Small divisions on scale are in millimeters.

Figure 2: Photomicrograph of 71526,4 showing ilmenite phenocrysts with sawtooth margins and olivine microphenocrysts set in a sub-variolitic matrix. Field of view = 2.5 mm.

formed part of a distinct compositional group. The REE profile is LREE-depleted (Fig. 3) with approximately constant middle and heavy REE abundances at 35 times chondritic levels. A negative Eu anomaly is present $[(Eu/Eu^*)_N = 0.60]$.

PROCESSING

Of the original 12.91g of 71526,0, a total of 11.94g remains. 71526,2 was used for INAA, and thin section ,4 was taken from this irradiated sample.

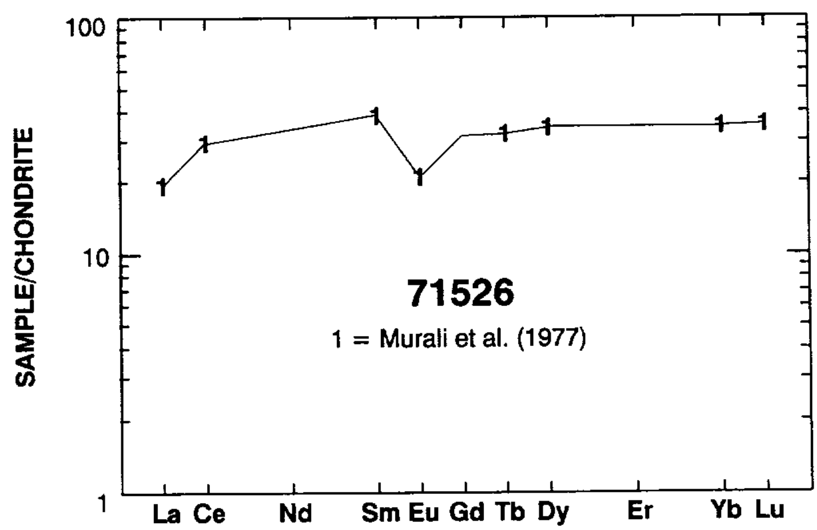


Figure 3: Chondrite-normalized rare-earth element plot of 71526. Data from Murali et al. (1977).

Table 1: Whole-rock chemistry of 71526.
Data from Murali et al. (1977).

	Sample 71526,2 Method N		Sample 71526,2 Method N
SiO_2 (wt %)		Cu	
TiO2	9.8	Ni	
Al_2O_3	9.9	Co	16.7
Cr_2O_3	0.328	V	40
FeO	19.4	Sc	77
MnO	0.263	La	6.5
MgO	6.8	Ce	26
CaO	13.3	Nd	
Na_2O	0.46	Sm	8.0
K_2O	0.055	Eu	1.65
P_2O_5		Gd	
S		Tb	1.9
Nb (ppm)		Dy	12
Zr		Er	
Hf	6.5	Yb	7.8
Ta	1.6	Lu	1.22
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

71527
High-Ti Mare Basalt
2.19 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1978) described the petrography and mineral chemistry of 71527. During the preparation of the catalog we examined thin section 71527,3 and found it to be a fine- to medium-grained basalt. It is dominated by "bow-tie" intergrowths of plagioclase and pyroxene (0.1-0.4mm). Ilmenite (up to 0.8mm) and olivine (0.7mm) phenocrysts are present. Olivine exhibits minor resorption features at the margins. No armalcolite is present and ilmenite contains only minor rutile and chromite exsolution lamellae. Native Fe and troilite (<0.1mm) are usually associated with ilmenite.

WHOLE-ROCK CHEMISTRY

Murali et al. (1977) reported the whole-rock composition of 71527,1 in a study of Apollo 17 rake samples (Table 1). 71527 is classified as a Type A Apollo 17 high-Ti basalt using the classification scheme of Rhodes et al. (1976) and Warner et al. (1979). This sample contains 12.8 wt% TiO_2 with a MG# of 48.0. The REE profile (Fig. 2) is LREE-depleted with a maximum in the MREE. The HREE are more abundant (relative to chondrites) than the LREE. A negative Eu anomaly is present [(Eu/Eu*) = 0.52].

PROCESSING

Of the original 2.19g of 71527,0, approximately 2.04g remains. 71527,1 was used for INAA and thin section ,3 was taken from this irradiated sample.

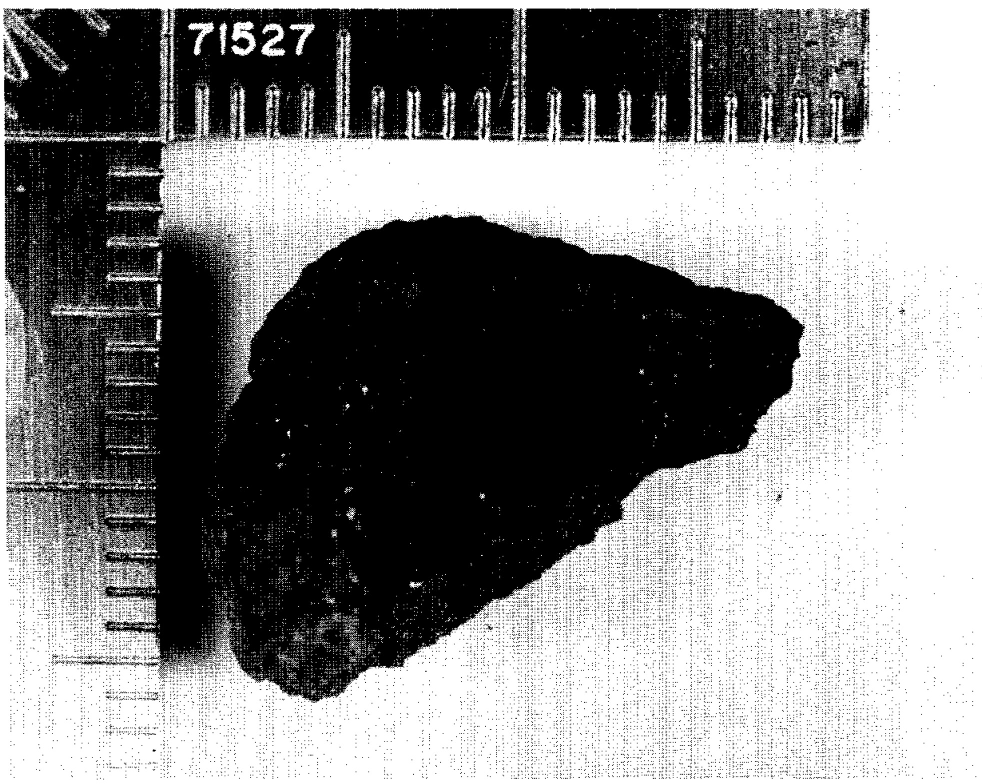


Figure 1: Hand specimen photograph of 71527. Small divisions on scale are in millimeters.

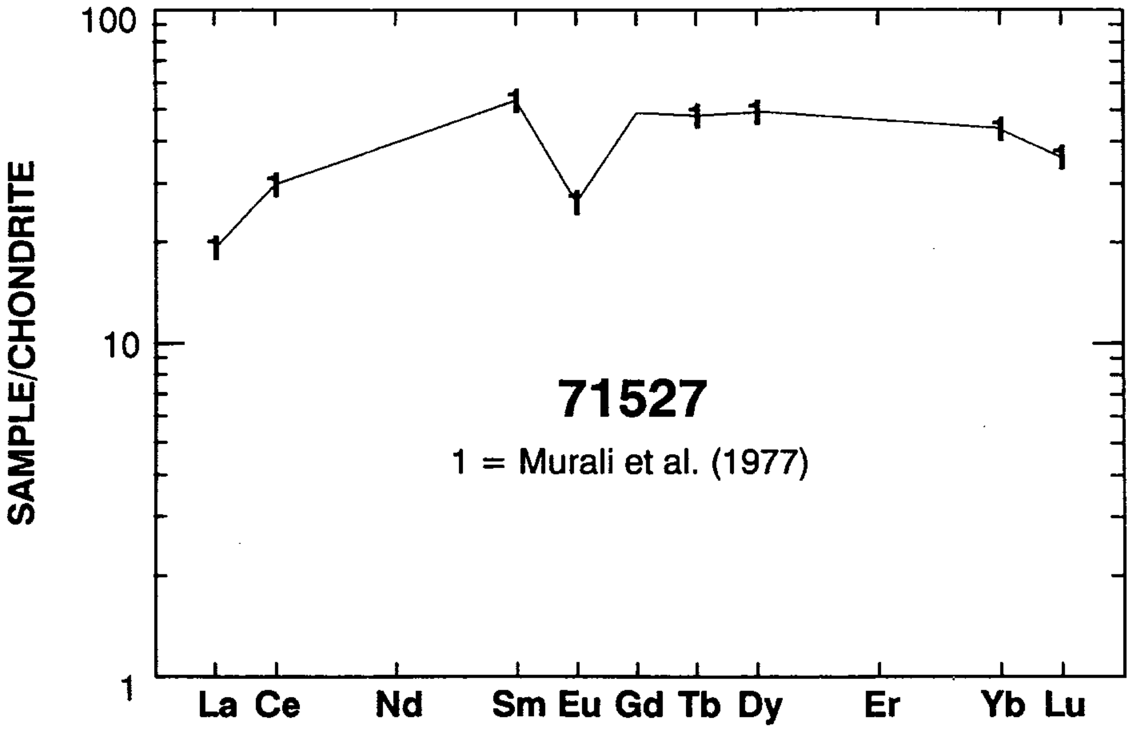


Figure 2: Chondrite-normalized rare-earth element plot of 71527. Data from Murali et al. (1977).

Table 1: Whole-rock chemistry of 71527.
Data from Murali et al. (1977).

	Sample 71527,1 Method N		Sample 71527,1 Method N
SiO_2 (wt %)		Cu	
TiO_2	12.8	Ni	
Al_2O_3	9.1	Co	17.0
Cr_2O_3	0.408	V	100
FeO	19.3	Sc	77
MnO	0.255	La	6.4
MgO	10.0	Ce	26
CaO	10.1	Nd	
Na_2O	0.42	Sm	10.9
K_2O	0.066	Eu	2.05
P_2O_5		Gd	
S		Tb	2.8
Nb (ppm)		Dy	17
Zr		Er	
Hf	9.1	Yb	9.7
Ta	1.8	Lu	1.23
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

71528
High-Ti Mare Basalt
11.25 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1978) reported the petrography and mineral chemistry of 71528. During the preparation of this catalog, we examined thin section 71528,4 and found it to be a fine- to medium-grained (0.1-0.5mm) basalt. It is comprised of blocky, pink pyroxene and plagioclase (occasionally intergrown to form "bow-tie" structures). Corroded olivine phenocrysts (up to 0.6mm) are conspicuous (Fig. 2) and rimmed by pink pyroxene. These olivines contain euhedral chromite inclusions <0.005mm. Ilmenite phenocrysts are present (up to 1mm) with "sawtooth" margins and blocky ilmenite forms an interstitial groundmass phase (Fig. 2). Opaque glass, native Fe, and troilite are associated with ilmenite, although the latter two also form discrete interstitial phases (< 0.05mm). No armalcolite is present, but there is minor interstitial SiO_2.

WHOLE-ROCK CHEMISTRY

Murali et al. (1977) reported the whole-rock composition of 71528,2 in a study of Apollo 17 rake samples (Table 1). 71528 is classified as a Type A Apollo 17 high-Ti basalt, based on the whole-rock classification of Rhodes et al. (1976) and Warner et al. (1979). This sample contains 10.9 wt% TiO_2 with a MG# of 43.5. The REE profile (Fig. 3) is LREE-depleted with a

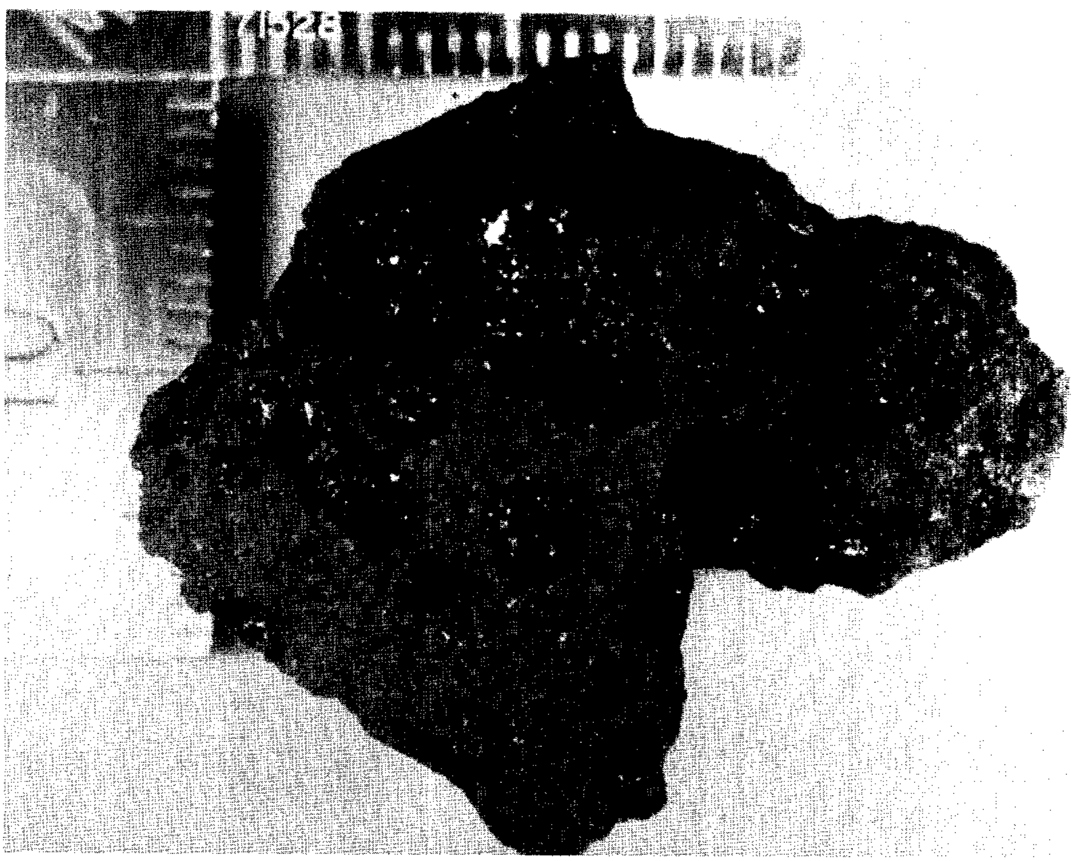


Figure 1: Hand specimen photograph of 71528. Small divisions on scale are in millimeters.

Figure 2: Photomicrograph of 71528,4. Olivine and ilmenite microphenocrysts are set in a sub-variolitic to blocky groundmass. Field of view = 2.5 mm.

maximum in the MREE. The HREE are more abundant (relative to chondrites) than the LREE. A negative Eu anomaly is present [$(Eu/Eu^*)_N = 0.50$].

PROCESSING

Of the original 11.25g of 71528,0, a total of 9.46g remains. 71528,1 weighs 1.46g, and ,2 was used for INAA. The thin section 71528,4 was taken from the irradiated sample.

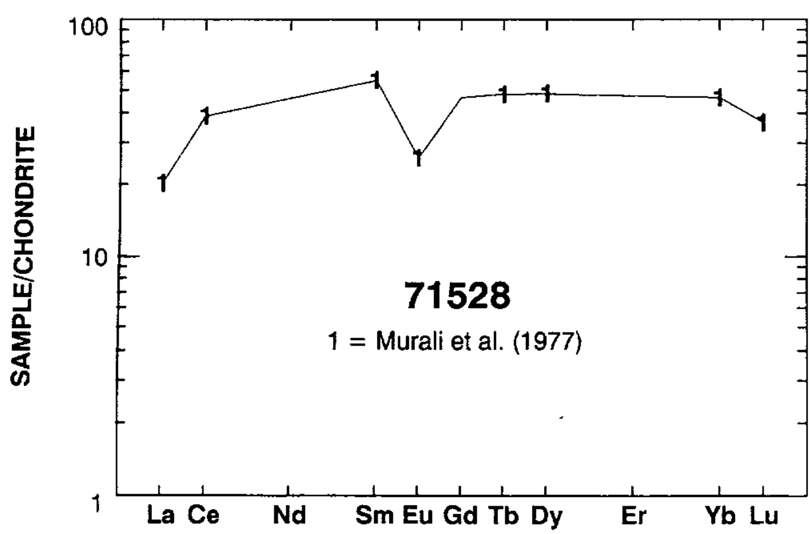


Figure 3: Chondrite-normalized rare-earth element plot of 71528. Date from Murali et al. (1977).

Table 1: Whole-rock chemistry of 71528.
Data from Murali et al. (1977).

	Sample 71528,2 Method N		Sample 71528,2 Method N
SiO_2 (wt %)		Cu	
TiO_2	10.9	Ni	
Al_2O_3	9.2	Co	16.3
Cr_2O_3	0.330	V	71
FeO	19.2	Sc	76
MnO	0.248	La	6.7
MgO	8.3	Ce	34
CaO	11.0	Nd	
Na_2O	0.43	Sm	11.3
K_2O	0.062	Eu	2.01
P_2O_5		Gd	
S		Tb	2.8
Nb (ppm)		Dy	18
Zr		Er	
Hf	9.0	Yb	10.3
Ta	1.7	Lu	1.25
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	1.6 ± 0.5
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

71529
High-Ti Mare Basalt
6.025 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1978) reported the petrography and mineral chemistry of 71529. During the preparation of this catalog we examined thin section 71529,4 and found it to be a fine- to medium-grained (0.2-0.5mm) basalt. It is comprised of plagioclase-pyroxene "bow-tie" intergrowths (unevenly distributed) and blocky, pink/brown pyroxenes (up to 0.5mm). Corroded olivines, containing euhedral chromite inclusions (< 0.05mm) and with a mantle of pink pyroxene, are present. Ilmenite phenocrysts reach up to 1mm long with "sawtooth" margins and also form an interstitial groundmass phase. Minor rutile and chromite exsolution in the ilmenite was observed, but no armalcolite was found. Opaque glass, native Fe, and troilite are associated with the ilmenite, although the latter two minerals also form <0.05mm interstitial phases. Minor interstitial SiO_2 is also present.

WHOLE-ROCK CHEMISTRY

Murali et al. (1977) reported the whole-rock composition of 71529,1 in a study of Apollo 17 rake samples (Table 1). Based on the classifications of Rhodes et al. (1976) and Warner et al. (1979), 71529 is classified as a Type A Apollo 17 high-Ti basalt. This sample contains 11.9 wt% TiO_2 with a MG# of 43.1. The REE profile (Fig. 2) is LREE-depleted with a maximum in the MREE. The HREE are more abundant (relative to chondrites) than the LREE. A negative Eu anomaly is present $[(Eu/Eu^*)_N = 0.53]$.

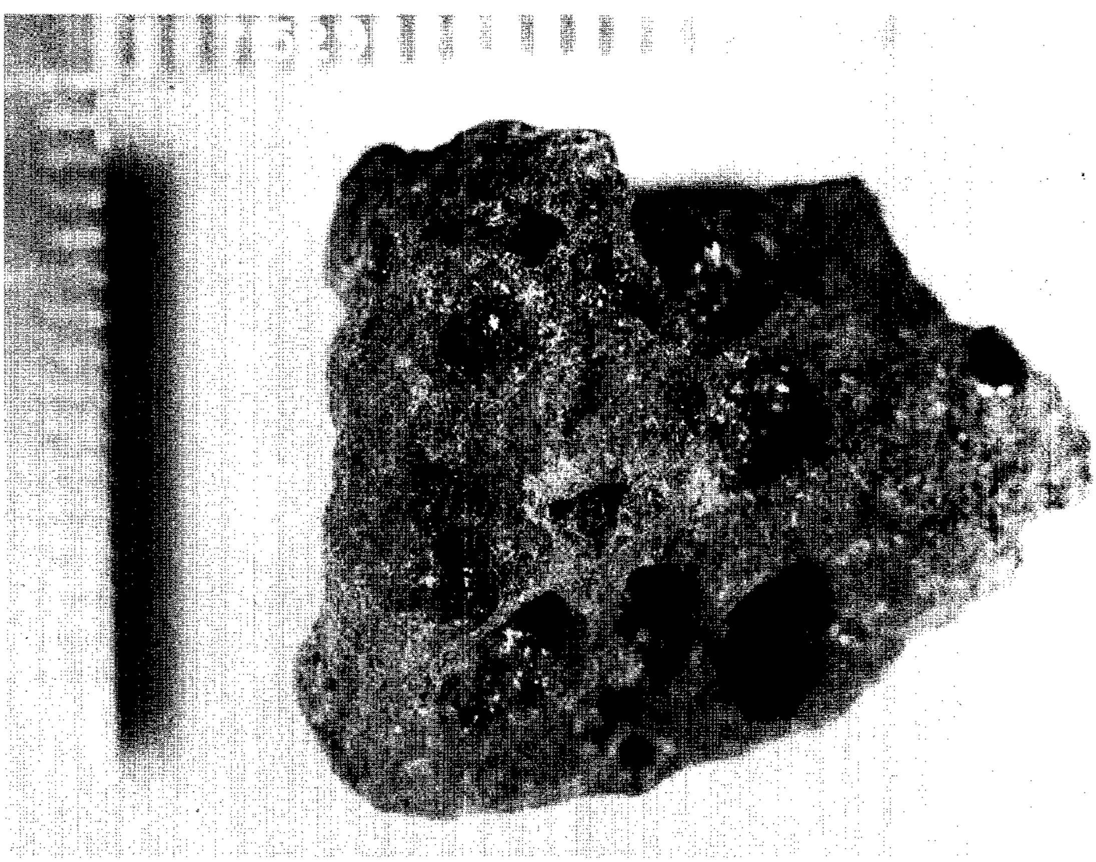


Figure 1: Hand specimen photograph of 71529,0. Small divisions on scale are in millimeters.

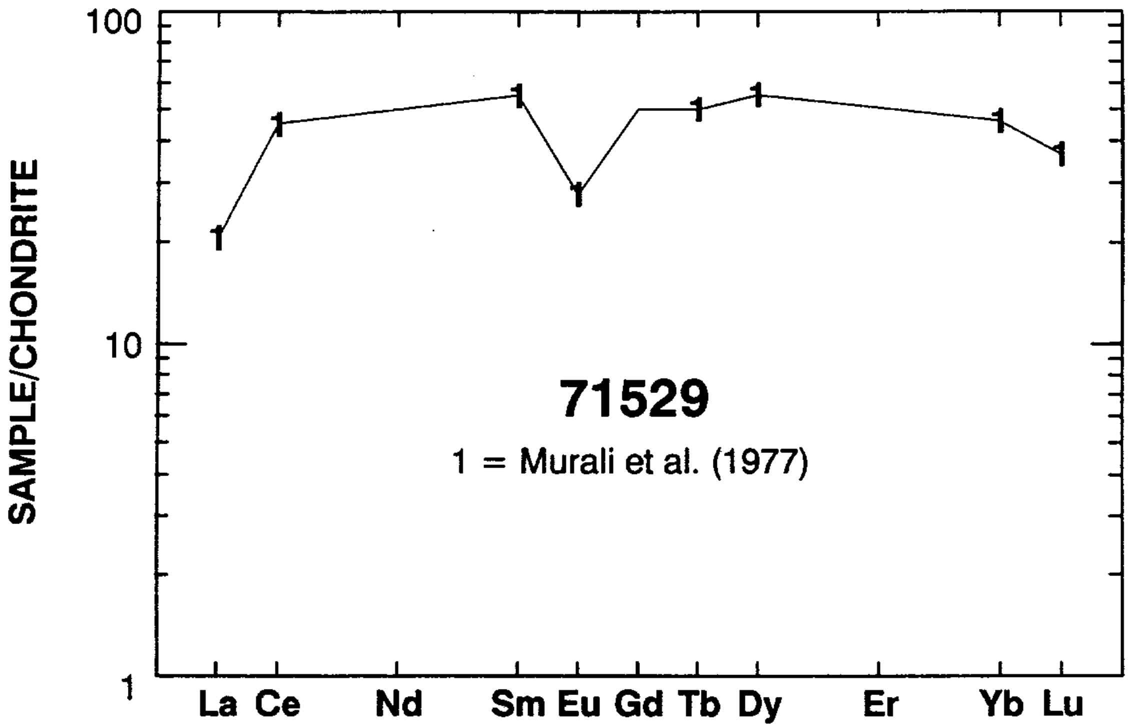


Figure 2: Chondrite-normalized rare-earth element plot of 71529. Data from Murali et al. (1977).

PROCESSING

Of the original 6.025g of 71529,0, a total of approximately 5.36g remains. 71529,1 was used for INAA and the thin section ,4 was taken from this irradiated sample.

Table 1: Whole-rock chemistry of 71529.
Data from Murali et al. (1977).

	Sample 71529,1 Method N		Sample 71529,1 Method N
SiO_2 (wt %)		Cu	
TiO_2	11.9	Ni	
Al_2O_3	8.7	Co	17.3
Cr_2O_3	0.400	V	94
FeO	19.8	Sc	79
MnO	0.242	La	6.8
MgO	8.4	Ce	39
CaO	11.2	Nd	
Na_2O	0.42	Sm	11.2
K_2O	0.081	Eu	2.14
P_2O_5		Gd	
S		Tb	2.9
Nb (ppm)		Dy	19
Zr		Er	
Hf	9.2	Yb	10.1
Ta	1.8	Lu	1.24
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	1.9 ± 0.6
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

71535
High-Ti Mare Basalt
17.71 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1978) reported the petrography and mineral chemistry of 71535. During the preparation of this catalog, we examined thin section 71535,4 and found it to be a medium-grained (0.3-0.7mm) basalt. It is comprised of interlocking pink/brown pyroxene and plagioclase bordering upon sub-ophitic. Pyroxene is more abundant, and some pyroxenes exhibit undulose extinction. No olivine or armalcolite is present. Ilmenite can reach up to 1.2mm but is also an interstitial groundmass phase. Ilmenite phenocrysts possess "sawtooth" margins. Occasional exsolution lamellae of rutile and chromite can be seen in the ilmenite. Minor opaque glass, native Fe ($<$ 0.1mm), and troilite ($<$ 0.1mm) are associated with ilmenite, although the latter two also occur as interstitial phases. Interstitial SiO_2 is conspicuous.

WHOLE-ROCK CHEMISTRY

Murali et al. (1977) reported the whole-rock composition of 71535,1 in a study of Apollo 17 rake samples (Table 1). Sample 71535 is classified as a Type B2 Apollo 17 high-Ti basalt, based on the whole-rock classification of Rhodes et al. (1976) and Warner et al. (1979), plus the criteria of Neal et al. (1990). This sample contains 11.7 wt% TiO_2, with a MG# of 40.4. The REE profile (Fig. 2) is LREE-depleted, specifically it has $(La/Sm)_N < 1$. The elevated Ce abundance is suspect considering the generally smooth LREE depletion typical of Apollo 17 basalts. The HREE are generally constant at ~30 times chondritic abundances (Fig. 2). A negative Eu anomaly is present [$(Eu/Eu^*)_N = 0.56$].

PROCESSING

Of the original 17.71g of 71535,0, a total of 17.13g remains. 71535,1 was used for INAA, and the thin section ,4 was taken from this irradiated sample.

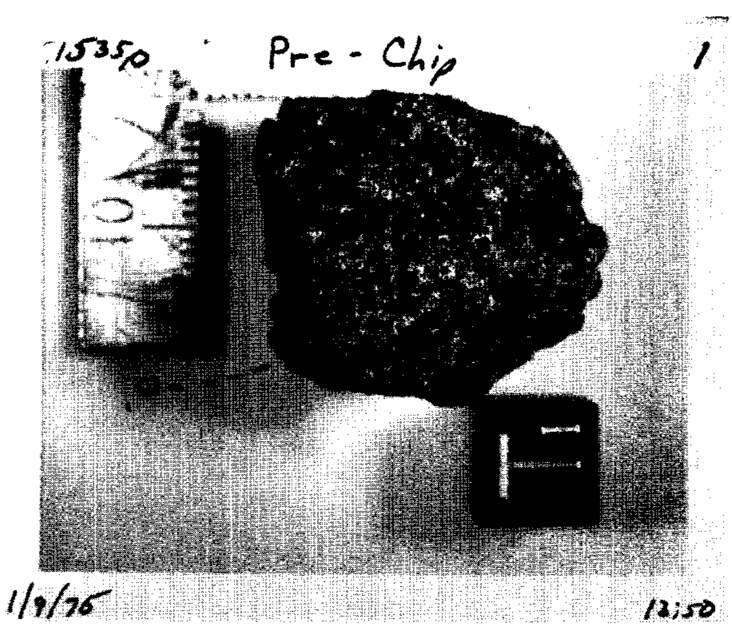


Figure 1: Hand specimen photograph of 71535,0. Small divisions on scale are in millimeters.

Table 1: Whole-rock chemistry of 71535.
Data from Murali et al. (1977).

	Sample 71535,1 Method N		Sample 71535,1 Method N
SiO_2 (wt %)		Cu	
TiO_2	11.7	Ni	
Al_2O_3	8.6	Co	19.5
Cr_2O_3	0.350	V	90
FeO	19.7	Sc	80
MnO	0.417	La	5.2
MgO	7.5	Ce	28
CaO	10.5	Nd	
Na_2O	0.42	Sm	6.8
K_2O	0.054	Eu	1.37
P_2O_5		Gd	
S		Tb	1.7
Nb (ppm)		Dy	11
Zr		Er	
Hf	5.8	Yb	6.7
Ta	1.0	Lu	0.92
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

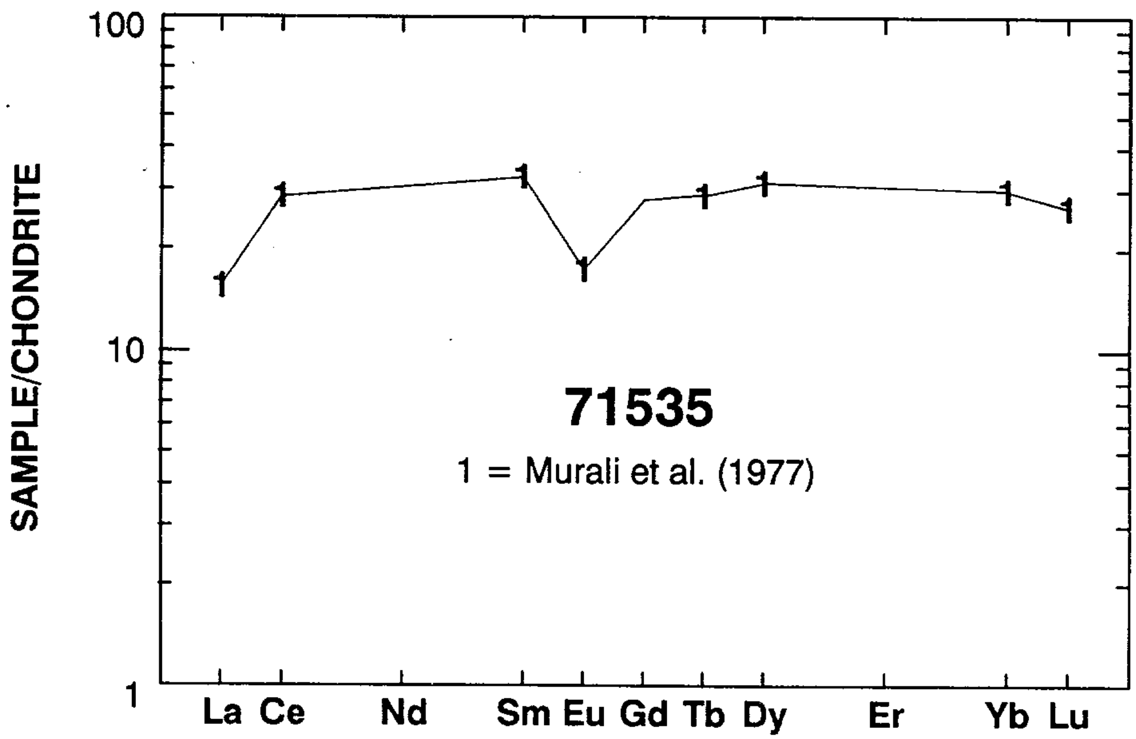


Figure 2: Chondrite-normalized rare-earth element plot of 71535. Data from Murali et al. (1977).

71536
High-Ti Mare Basalt
5.32 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1978) reported the petrography and mineral chemistry of 71536. During the preparation of this catalog, we examined thin section 71536,4 and found it to be a coarse-grained (0.6-1.5mm), sub-ophitic to plagioclase-poikilitic basalt (Fig. 2). Blocky ilmenite of the same size overlays the plagioclase and pyroxene (Fig. 2). No rutile or chromite exsolution was found in the ilmenite. Olivine and armalcolite were not observed. Native Fe and troilite (up to 0.3mm) are either associated with ilmenite or form interstitial phases. Conspicuous interstitial SiO_2 is also present.

WHOLE-ROCK CHEMISTRY

Murali et al. (1977) reported the whole-rock composition of 71536,1 in a study of Apollo 17 rake samples (Table 1). 71536 is classified as a Type A Apollo 17 high-Ti basalt using the classification of Rhodes et al. (1976) and Warner et al. (1979). This sample contains 7.8 wt% TiO_2, with a MG# of 44.7. Murali et al. (1977) distinguished 71536 by its low V, TiO_2, MgO, and Cr_2O_3 contents and suggested that it formed part of a distinct compositional group. The REE profile (Fig. 3) is LREE-depleted with a maximum at Sm and the HREE constant at ~40 times chondritic values. A negative Eu anomaly is present [$(Eu/Eu^*)_N$ = 0.63].

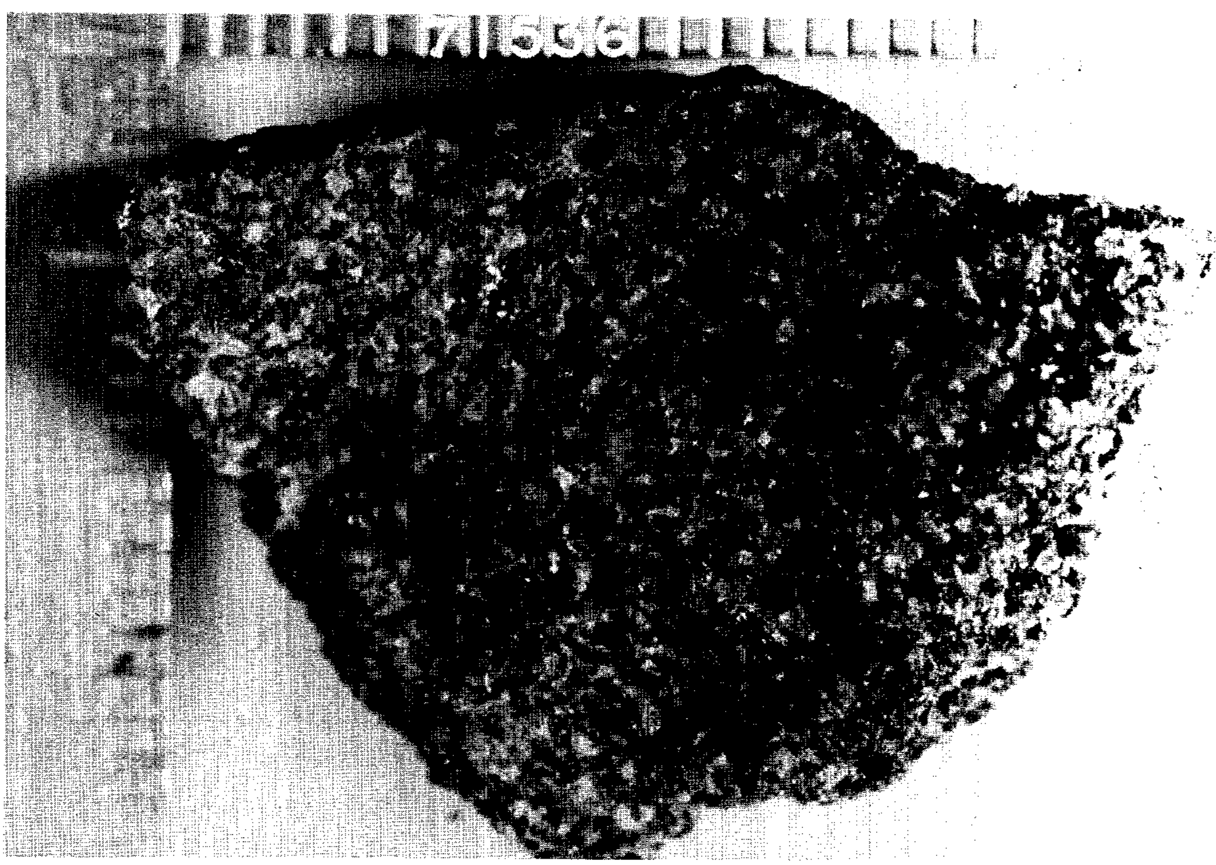


Figure 1: Hand specimen photograph of 71536,0. Small divisions on scale are in millimeters.

PROCESSING

Of the original 5.32g of 71536,0, approximately 4.46g remains. 71536,1 was used for INAA, and the thin section 71536,5 was taken from this irradiated sample.

Figure 2: Photomicrograph of 71536,4 demonstrating a sub-ophitic texture. Field of view = 2.5 mm.

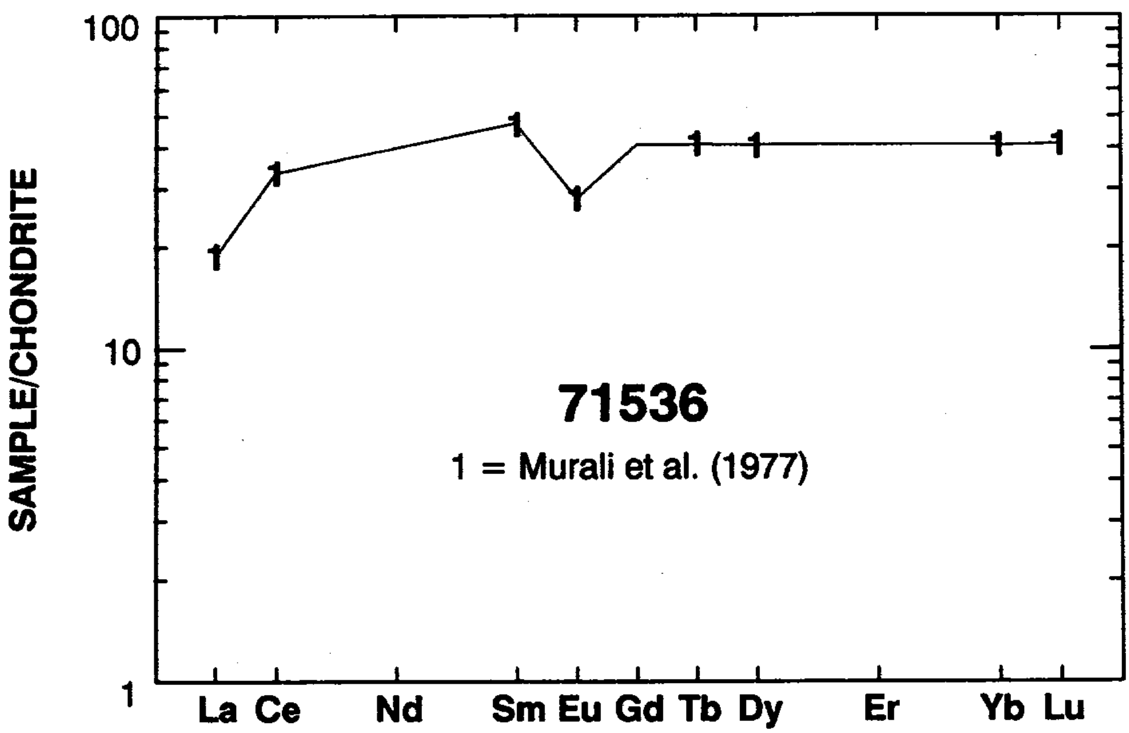


Figure 3: Chondrite-normalized rare-earth element plot of 71536. Data from Murali et al. (1977).

Table 1: Whole-rock chemistry of 71536.
Data from Murali et al. (1977).

	Sample 71536,1 Method N		Sample 71536,1 Method N
SiO_2 (wt %)		Cu	
TiO_2	7.8	Ni	
Al_2O_3	11.7	Co	12.7
Cr_2O_3	0.338	V	39
FeO	16.1	Sc	73
MnO	0.223	La	6.2
MgO	7.3	Ce	29
CaO	13.6	Nd	
Na_2O	0.50	Sm	9.6
K_2O	0.071	Eu	2.17
P_2O_5		Gd	
S		Tb	2.4
Nb (ppm)		Dy	14
Zr		Er	
Hf	7.2	Yb	9.0
Ta	1.4	Lu	1.4
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	1.4 ± 0.4
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

71537
High-Ti Mare Basalt
12.25 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1978) reported the petrography and mineral chemistry of 71537. During the preparation of this catalog, we examined thin section 71537,5 and found it to be a fine- to medium-grained (0.05-0.4mm) basalt. It is comprised of interlocking "bow-tie" intergrowths of plagioclase and pyroxene (Fig. 2). Opaque glass is associated with these "bow-tie" structures. Ilmenite (up to 0.8mm) and corroded olivine (up to 0.7mm) are present. Ilmenite has "sawtooth" margins (Fig. 2) and is also a groundmass phase. Rutile and chromite exsolution is observed in these ilmenites. Olivine contains small (~0.005mm) euhedral chromite inclusions. There is minor interstitial SiO_2 present. Native Fe and troilite (< 0.1mm) are either associated with ilmenite or are interstitial phases. No armalcolite was observed.

WHOLE-ROCK CHEMISTRY

Murali et al. (1977) reported the whole-rock composition of 71537,1 in a study of Apollo 17 rake samples (Table 1). 71537 is classified as a Type A Apollo 17 high-Ti basalt, based on the classification of Rhodes et al. (1976) and Warner et al. (1979). This sample contains 10.9 wt% TiO_2, with a MG# of 43.1. The REE profile (Fig. 3) is LREE-depleted with a maximum at Sm. The HREE exhibit a decrease from Dy to Lu, but are still more abundant (relative to chondrites) than the LREE. A negative Eu anomaly is present [$(Eu/Eu^*)_N = 0.52$].

PROCESSING

Of the original 12.25g of 71537,0, a total of 10.41g remains. 71537,2 weighs 1.37g, and ,1 was used for INAA. Thin section 71537,5 was taken from the irradiated sample.

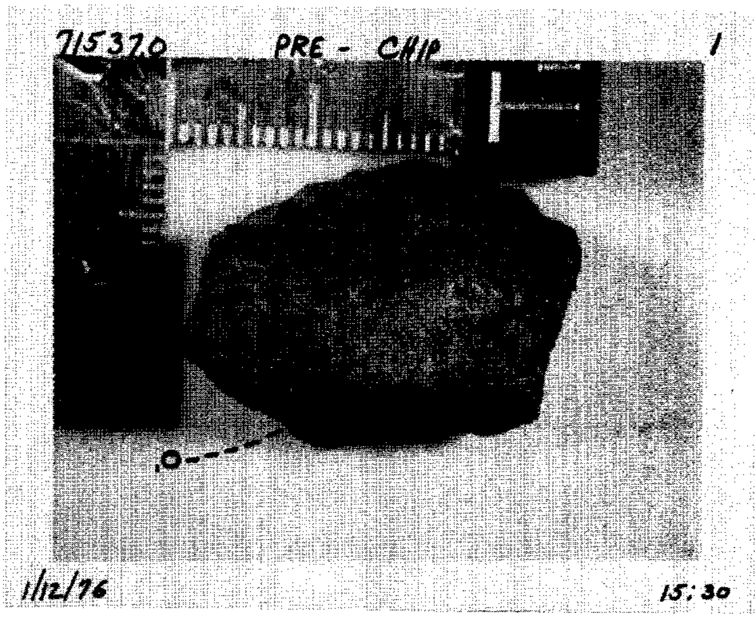


Figure 1: Hand specimen photograph of 71537. Small divisions on scale are in millimeters.

Table 1: Whole-rock chemistry of 71537.
Data from Murali et al. (1977).

	Sample 71537,1 Method N		Sample 71537,1 Method N
SiO_2 (wt %)		Cu	
TiO_2	10.9	Ni	
Al_2O_3	9.7	Co	17.0
Cr_2O_3	0.341	V	99
FeO	19.3	Sc	78
MnO	0.257	La	5.8
MgO	8.2	Ce	25
CaO	11.2	Nd	
Na_2O	0.37	Sm	7.9
K_2O	0.050	Eu	1.47
P_2O_5		Gd	
S		Tb	2.0
Nb (ppm)		Dy	13
Zr		Er	
Hf	6.8	Yb	7.4
Ta	1.4	Lu	0.94
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by: N = INAA

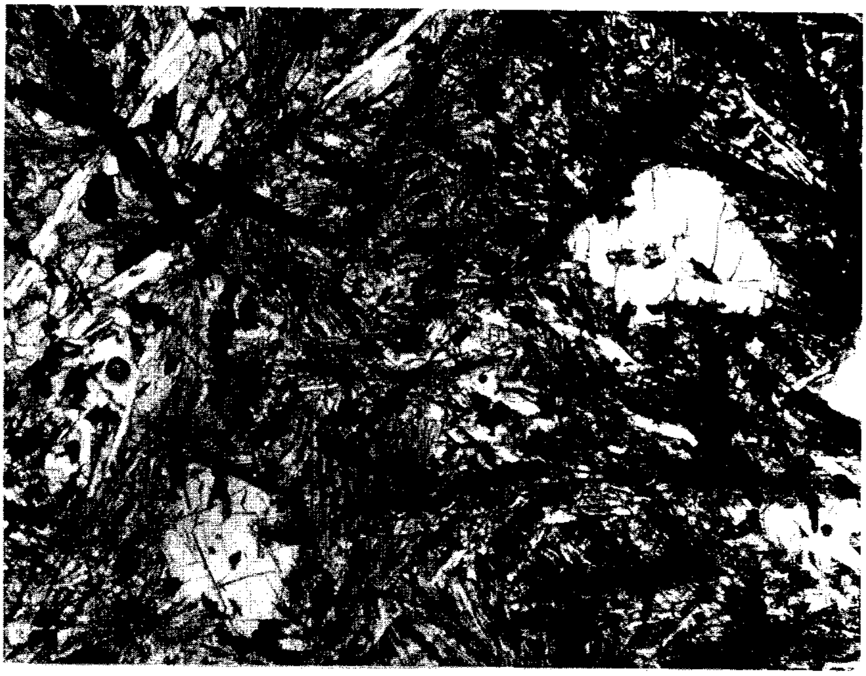


Figure 2: Photomicrograph of 71537,5 showing olivine and ilmenite phenocrysts set in a variolitic, glassy matrix. Field of view = 2.5 mm.

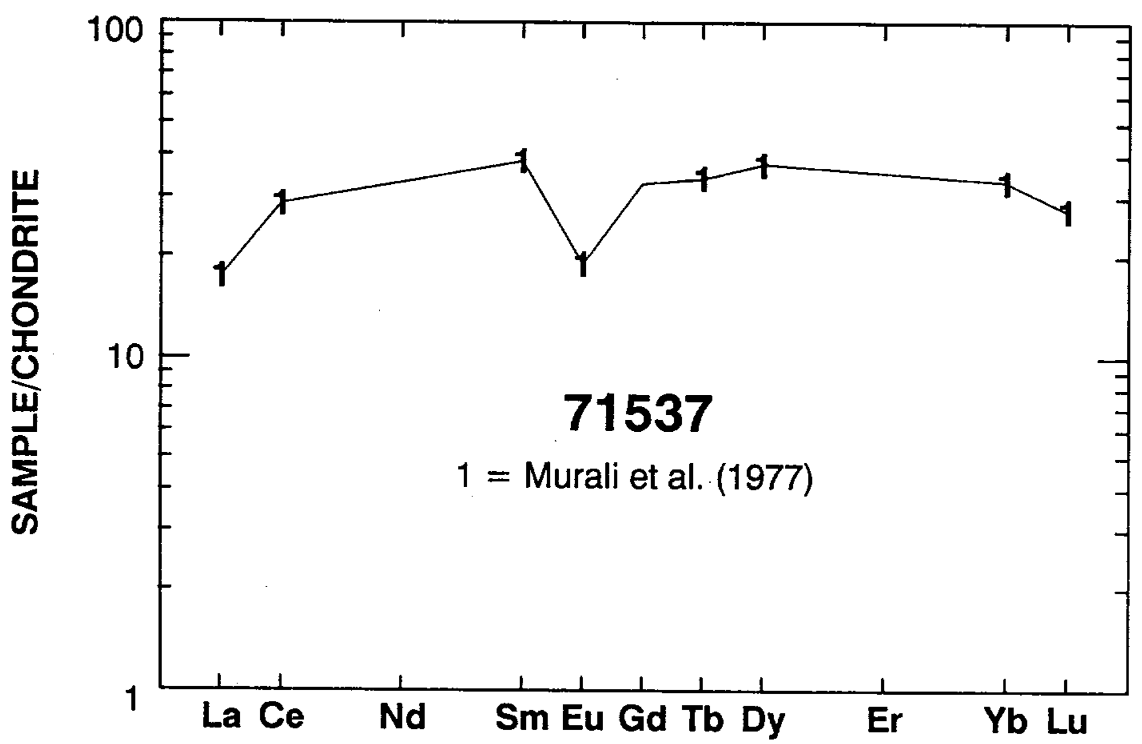


Figure 3: Chondrite-normalized rare-earth element plot of 71537. Data from Murali et al. (1977).

71538
High-Ti Mare Basalt
8.04 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1978) reported the petrography and mineral chemistry of 71538. During the preparation of this catalog, we examined thin section 71538,4 and found it to be a medium-grained basalt (0.2-0.4mm). It is comprised of interlocking "bow-tie" intergrowths of pyroxene and plagioclase (Fig. 2), as well as blocky plagioclase and pyroxene. Opaque interstitial glass is unevenly distributed. Phenocrysts of ilmenite (up to 1mm) and corroded olivine (up to 0.5mm) are present (Fig. 2), with euhedral chromite inclusions (~0.005mm) present in the olivines (Fig. 2b). Pink pyroxene usually mantles these oiivines (Fig. 2b). Ilmenites exhibit "sawtooth" margins (Fig. 2a) and contain minor rutile and chromite exsolution features. Native Fe and troilite (<< 0.1mm) are disseminated throughout. No armalcolite is present.

WHOLE-ROCK CHEMISTRY

Murali et al. (1977) reported the whole-rock composition of 71538,2 in a study of Apollo 17 rake samples (Table 1). Based on the classification of Rhodes et al. (1976) and Warner et al. (1979), 71538 is classified as a Type A Apollo 17 high-Ti basalt. This sample contains 12.8 wt% TiO_2, with a MG# of 43.8. The REE prolile (Fig. 3) is LREE-depleted with a maximum at Sm. The HREE exhibit a decrease from Dy to Lu, but are in approximately the same abundance (relative to chondrites) as the LREE. A negative Eu anomaly is present [$(Eu/Eu^*)_N = 0.54$].

PROCESSING

Of the original 8.04g of 71538,0, a total of 6.86g remains. 71538,1 was used for INAA, and thin section 71538,5 was taken from the irradiated sample.

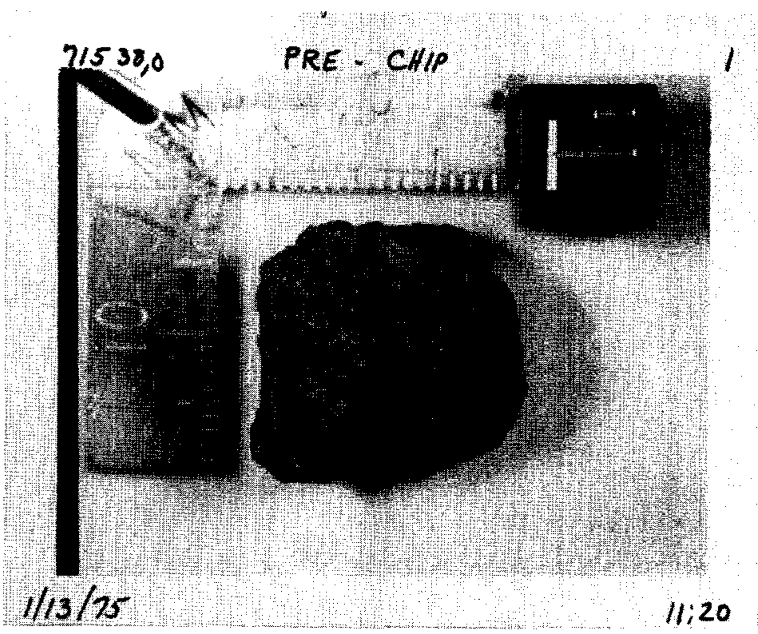


Figure 1: Hand specimen photograph of 71538,0. Small divisions on scale are in millimeters.

2a: Olivine and ilmenite microphenocrysts set in a glassy, variolitic matrix - field of view = 2.5 mm.

2b: Gradation from variolitic to blocky texture - field of view = 1.25 mm.

Figure 2: Photomicrographs of 71538,4.

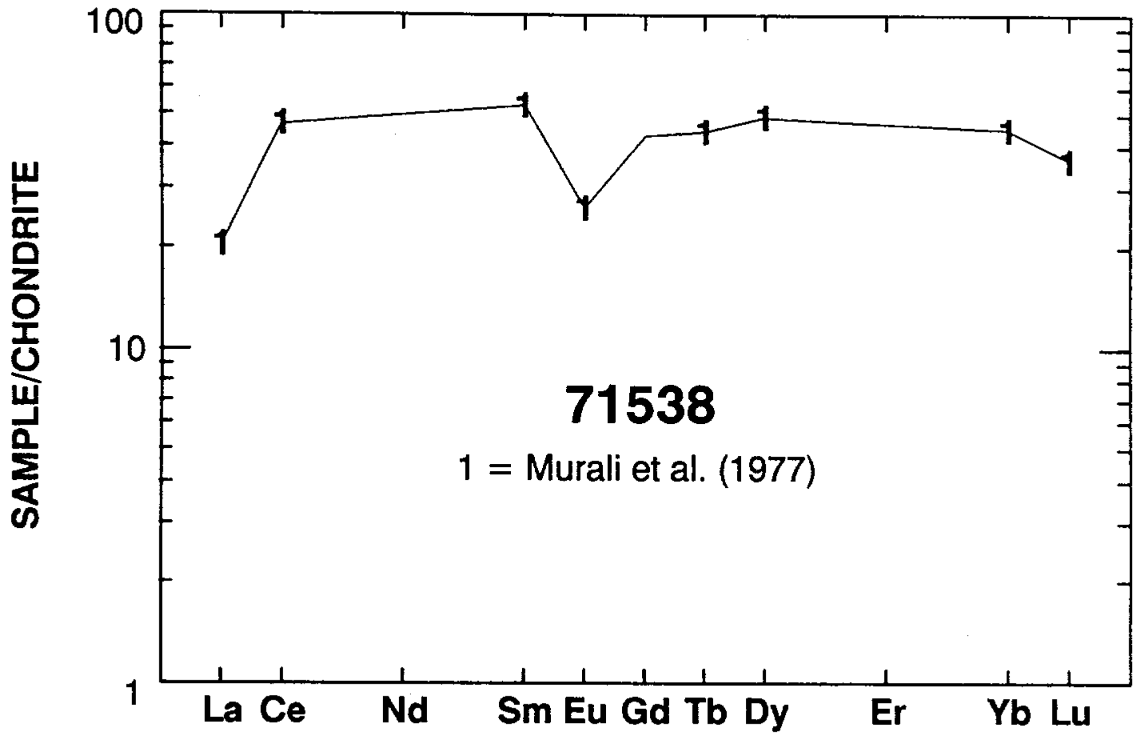


Figure 3: Chondrite-normalized rare-earth element plot of 71538. Data from Murali et al. (1977).

Table 1: Whole-rock chemistry of 71538.
Data from Murali et al. (1977).

	Sample 71538,2 Method N		Sample 71538,2 Method N
SiO_2 (wt %)		Cu	
TiO_2	12.8	Ni	
Al_2O_3	8.4	Co	17.7
Cr_2O_3	0.430	V	109
FeO	19.7	Sc	79
MnO	0.251	La	6.8
MgO	8.6	Ce	41
CaO	10.1	Nd	
Na_2O	0.40	Sm	10.9
K_2O	0.064	Eu	2.03
P_2O_5		Gd	
S		Tb	2.6
Nb (ppm)		Dy	17
Zr		Er	
Hf	9.0	Yb	10.0
Ta	1.7	Lu	1.25
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	4 ± 1
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

71539
High-Ti Mare Basalt
10.90 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1978) reported the petrography and mineral chemistry of 71539. During the preparation of this catalog we examined thin section 71539,5 and found it to be a well crystallized, sub-ophitic, medium-grained (0.3-0.7mm) basalt (Fig. 2). The sample is dominated by plagioclase and pink pyroxene which is overlain by ilmenite (Fig. 2). Ilmenite phenocrysts often exceed 1mm in length and exhibit "sawtooth" margins; blocky ilmenite is a groundmass phase. No rutile and chromite exsolution lamellae were observed in the ilmenites. No olivine or armalcolite was observed. Native Fe and troilite (both < 0.1mm) are disseminated throughout and interstitial SiO_2 is present.

WHOLE-ROCK CHEMISTRY

Murali et al. (1977) reported the whole-rock composition of 71539,1 in a study of Apollo 17 rake samples (Table 1). 71539 is classified as a Type A Apollo 17 high-Ti basalt, based on the classification of Rhodes et al. (1976) and Warner et al. (1979). This sample contains 8.6 wt% TiO_2 with a MG# of 33.5. Murali et al. (1977) distinguished 71539 by its low V, TiO_2, MgO, and Cr_2O_3 contents and suggested that it formed part of a distinct compositional group. The REE profile (Fig. 3) is LREE-depleted with the HREE exhibiting a slight depletion relative to the MREE. However, the $(La/Yb)_N$ ratio is < 1. A negative Eu anomaly is present [$(Eu/Eu^*)_N = 0.55$].

ISOTOPE CHEMISTRY

Paces et al. (1991) reported whole-rock Rb-Sr and Sm-Nd data for 71539,6 (Tables 2 and 3). In addition, these same authors reported Rb-Sr and Sm-Nd data for mineral separates from 71539,6 (Tables 4 and 5). Paces et al. (1991) report an internal isochron age of 3.75 ± 0.07 Ga for this sample. 71539

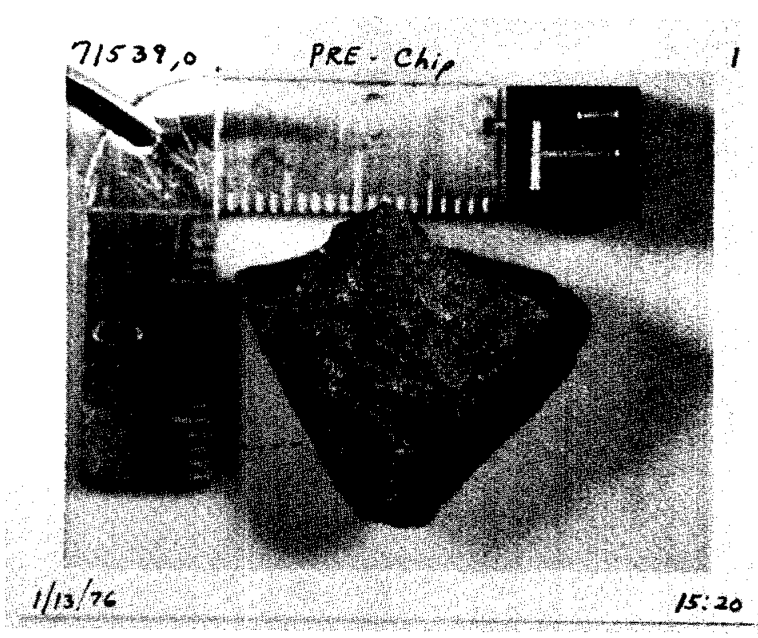


Figure 1: Hand specimen photograph of 71539,0. Small divisions on scale are in millimeters.

Figure 2: Photomicrograph of 71539,5 showing ilmenite phenocrysts set in a sub-ophitic matrix. Field of view = 2.5 mm.

was studied as part of a larger isotopic investigation of the Apollo 17 high-Ti basalts.

PROCESSING

Of the original 10.90g of 71539,0, a total of ~10.14g remains. 71539,1 was used for INAA and the thin section ,5 was taken from this irradiated sample.

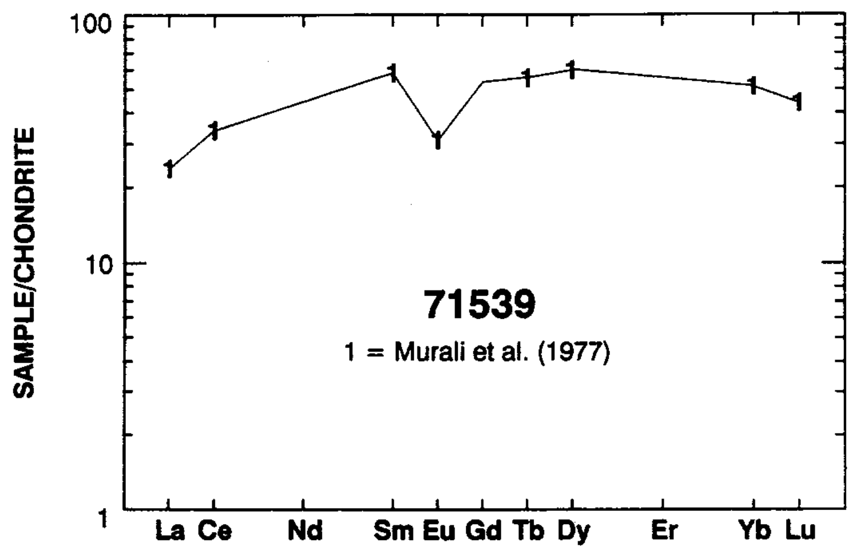


Figure 3: Chondrite-normalized rare-earth element plot of 71539. Data from Murali et al. (1977).

Table 1: Whole-rock chemistry of 71539.
Data from Murali et al. (1977).

	Sample 71539,1 Method N		Sample 71539,1 Method N
SiO_2 (wt %)		Cu	
TiO_2	8.6	Ni	
Al_2O_3	9.8	Co	13.5
Cr_2O_3	0.186	V	36
FeO	19.1	Sc	73
MnO	0.258	La	8.0
MgO	5.4	Ce	30
CaO	12.1	Nd	
Na_2O	0.47	Sm	12.1
K_2O	0.081	Eu	2.44
P_2O_5		Gd	
S		Tb	3.3
Nb (ppm)		Dy	21
Zr		Er	
Hf	9.9	Yb	11.5
Ta	1.8	Lu	1.52
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

Table 2: Rb-Sr data for 71539,6.
Data from Paces et al. (1991).

Rb (ppm)	0.787
Sr (ppm)	229
$^{87}Rb/^{86}Sr$	0.009892 ± 98
$^{87}Sr/^{86}Sr$	0.699776 ± 14
I(Sr)[a]	0.699235 ± 19
T_{LUNI}[b](Ga)	5.2

[a]Initial Sr isotopic ratios calculated at 3.75 Ga using ^{87}Rb decay constant = $1.42 \times 10^{-11} yr^{-1}$.

[b]Model age relative to I(Sr) = LUNI = 0.69903 (Nyquist et al., 1974; Shih et al., 1986).
$T_{LUNI} = 1/\lambda * 1n[((^{87}Sr/^{86}Sr - 0.69903)^{87}Rb/^{86}Sr) + 1]$.

Table 3: Sm-Nd data for 71539,6.
Data from Paces et al. (1991).

Sm (ppm)	13.4
Nd (ppm)	32.5
$^{147}Sm/^{144}Nd$	0.25018 ± 50
$^{143}Nd/^{144}Nd$	0.514306 ± 11
I(Nd)[a]	0.508094 ± 23
ε_{Nd}[b]	6.7 ± 0.6
T_{CHUR}[c](Ga)	4.7

[a]Initial Nd isotopic ratios calculated at 3.75 Ga using ^{147}Sm decay constant = $6.54 \times 10^{-12} yr^{-1}$.

[b]Initial ε_{Nd} calculated at 3.75 Ga using present-day chondritic values of $^{143}Nd/^{144}Nd$ = 0.512638 and $^{147}Sm/^{144}Nd$ = 0.1967.

[c]Model age relative to CHUR reservoir using present-day chondritic values listed above.
$T_{CHUR} = 1/\lambda * [((^{143}Nd/^{144}Nd - 0.512638)/(^{147}Sm/^{144}Nd - 0.1967)) + 1]$.

Table 4: Rb-Sr results for 71539,6 whole rock and mineral separates used for internal isochrons.
Data from Paces et al. (1991).

	Rb (ppm)	Sr (ppm)	$^{87}Rb/^{86}Sr^{a}$	$^{87}Sr/^{86}Sr^{b}$
WR	0.787	229	0.009893 ± 98	0.699776 ± 14
Plg1	0.260	623	0.001199 ± 11	0.699336 ± 22
Plg2	0.594	536	0.003192 ± 31	0.699382 ± 20
NMag1[c]	0.188	253	0.002139 ± 21	0.699360 ± 21
Px1	0.121	58.7	0.005917 ± 59	0.699564 ± 22
Mag1[c]	0.573	103	0.01602 ± 32	0.700119 ± 20
Ilm1	1.23	104	0.03395 ± 98	0.701188 ± 20
Ilm2	0.642	128	0.01444 ± 98	0.700033 ± 20

[a]Uncertainties (corresponding to last decimal places) reported for parent/daughter ratios reflect the magnitude of the blank correction, mass spectrometer precision and corrections for the quality of spiking.

[b]Normalized to $^{86}Sr/^{88}Sr$ = 0.1194. Quoted errors include 2-sigma run precision for whole rock analyses plus an additional uncertainty of 0.00001(2-sigma) reflecting corrections for fractionation and spike contributions in total-spiked mineral separates. Nd was measured as the metal ion.

[c]Non-pure mineral separates consisting of predominantly "nonmagnetic" plagioclase and pyroxene in NMag and "magnetic" pyroxene and ilmenite in Mag.

Table 5: Sm-Nd results for 71539,6 whole rock and mineral separates used for internal isochrons.
Data from Paces et al. (1991).

	Sm (ppm)	Nd (ppm)	^{147}SM/^{144}Nd[a]	^{143}Nd/^{144}Nd[b]
WR	13.4	32.5	0.25018 ± 50	0.514306 ± 11
Plg1	2.08	5.70	0.2204 ± 22	0.513565 ± 19
Plg2	5.91	15.2	0.2352 ± 24	0.513899 ± 20
NMag1[c]		9.20		0.513868 ± 20
Px1	5.12	9.22	0.3362 ± 17	0.516428 ± 18
Mag1[c]				0.514780 ± 16
Ilm1	18.4	38.3	0.2900 ± 14	0.515283 ± 22
Ilm2		22.4		0.514350 ± 19

[a]Uncertainties (corresponding to last decimal places) reported for parent/daughter ratios reflect the magnitude of the blank correction, mass spectrometer precision and corrections for the quality of spiking.

[b]Normalized to ^{146}Nd/^{144}Nd = 0.7219. Quoted errors include 2-sigma run precision for whole rock analyses plus an additional uncertainty of 0.00001(2-sigma) reflecting corrections for fractionation and spike contributions in total-spiked mineral separates. Nd was measured as the metal ion.

[c]Non-pure mineral separates consisting of predominantly "nonmagnetic" plagioclase and pyroxene in NMag and "magnetic" pyroxene and ilmenite in Mag.

71545
High-Ti Mare Basalt
17.26 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1978) reported the petrography and mineral chemistry of 71545. During the preparation of this catalog we examined thin section 71545,3 and found it to be a fine- to medium-grained basalt (Fig. 2). It is comprised of blocky areas of pink pyroxene (~0.4mm) as well as interlocking "bow-tie" intergrowths of pyroxene and plagioclase (up to 0.6mm). Olivine is present as corroded phenocrysts (up to 0.6mm - Fig. 2), as well as cores to larger, pink pyroxenes. Rarely does olivine contain euhedral inclusions of chromite. Ilmenite phenocrysts are also present (> 1mm - Fig. 2) and these often exhibit "sawtooth" margins. Minor rutile and chromite exsolution features are present in the ilmenite. There is little ilmenite in the groundmass which is dominated by plagioclase, pyroxene, and an opaque glass. Native Fe and troilite (<0.05mm) are disseminated throughout as interstitial phases.

WHOLE-ROCK CHEMISTRY

Murali et al. (1977) reported the whole-rock composition of 71545,1 in a study of Apollo 17 rake samples (Table 1). 71545 is classified as a Type B2 Apollo 17 high-Ti basalt, based on the whole-rock classification of Rhodes et al. (1976) and Warner et al. (1979), plus the criteria of Neal et al. (1990). This sample contains 13.0 wt% TiO_2 with a MG# of 43.2. The REE profile (Fig. 3) is LREE-depleted with a maximum at Sm. The Ce analysis suggests that the pattern is flat except for La. However, consideration of the REE patterns of other Apollo 17 basalts suggests that the Ce abundance reported by Murali et al. (1977) is probably imprecise, due to the errors inherent in analyzing Ce by INA. The HREE form a flat pattern at ~31 times chondritic abundances. A negative Eu anomaly is present [$(Eu/Eu^*)_N = 0.54$].

ISOTOPE CHEMISTRY

Paces et al. (1991) reported whole-rock Rb-Sr and Sm-Nd data for 71545,4 (Tables 2 and 3). 71545 was studied as part of a larger isotopic investigation of the Apollo 17 high-Ti basalts.

PROCESSING

Of the original 17.26g of 71545,0, approximately 16.95g remains. 71545,1 was used for INAA and the thin section ,3 was taken from this irradiated sample.

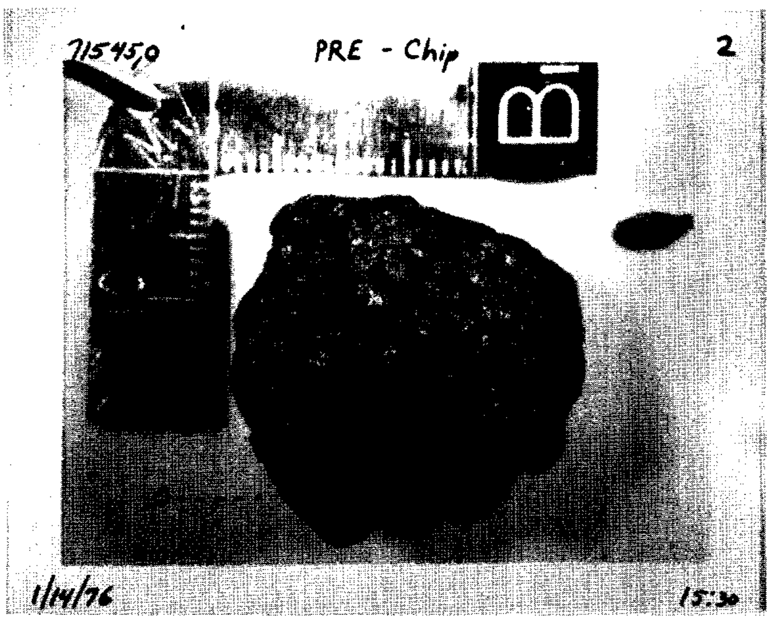


Figure 1: Hand specimen photograph of 71545,0. Small divisions on scale are in millimeters.

Table 1: Whole-rock chemistry of 71545.
Data from Murali et al. (1977).

	71545,1 N		71545,1 N
SiO_2 (wt %)		Cu	
TiO_2	13.0	Ni	
Al_2O_3	8.9	Co	19.6
Cr_2O_3	0.350	V	99
FeO	20.6	Sc	79
MnO	0.260	La	6.4
MgO	8.8	Ce	29
CaO	10.9	Nd	
Na_2O	0.41	Sm	6.9
K_2O	0.055	Eu	1.36
P_2O_5		Gd	
S		Tb	1.8
Nb (ppm)		Dy	11
Zr		Er	
Hf	6.2	Yb	6.9
Ta	1.5	Lu	1.08
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	1.3 ± 0.6
Zn		Eu	
Pb		Os	

Analysis by: N = INAA.

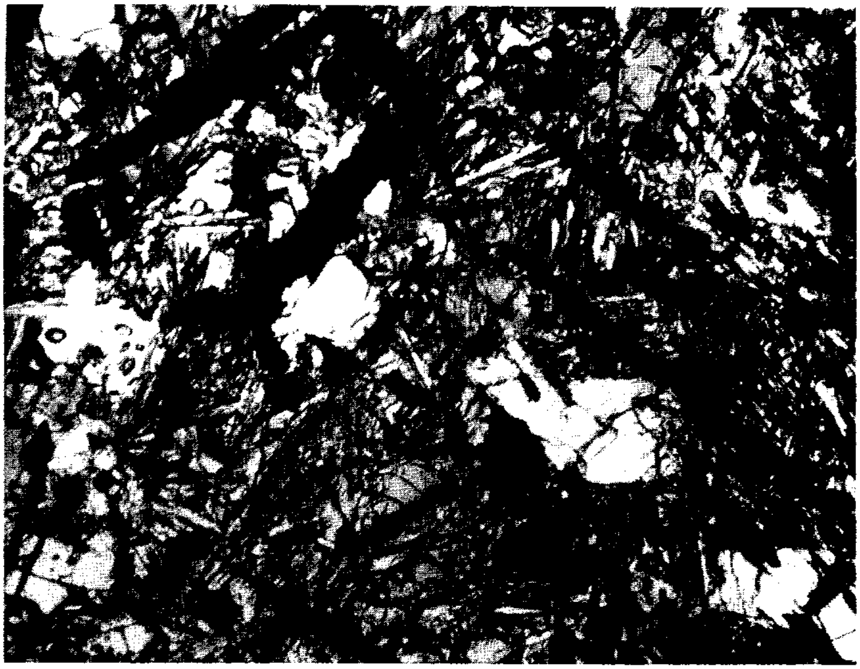


Figure 2: Photomicrograph of 71545,3. Ilmenite and olivine phenocrysts are set in a variolitic and glassy matrix. Field of view = 2.5 mm.

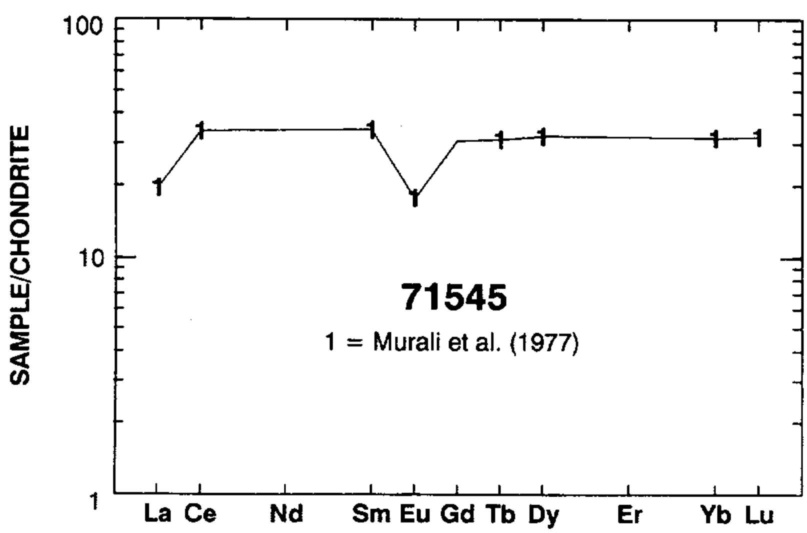


Figure 3: Chondrite-normalized rare-earth element plot of 71545. Data from Murali et al. (1977).

Table 2: Rb-Sr data for 71545,4.
Data from Paces et al. (1991).

Rb (ppm)	0.354
Sr (ppm)	120
$^{87}Rb/^{86}Sr$	0.008497 ± 84
$^{87}Sr/^{86}Sr$	0.699676 ± 12
I(Sr)[a]	0.699219 ± 17
T_{LUNI}[b](Ga)	5.2

[a]Initial Sr isotopic ratios calculated at 3.69 Ga using ^{87}Rb decay constant = 1.42×10^{-11} yr^{-1}.

[b]Model age relative to I(Sr) = LUNI = 0.69903 (Nyquist et al., 1974; Shih et al., 1986). $T_{LUNI} = 1/\lambda * \ln[((^{87}Sr/^{86}Sr - 0.69903)/^{87}Rb/^{86}Sr) + 1]$.

Table 3: Rb-Sr data for 71545,4.
Data from Paces et al. (1991).

Sm (ppm)	6.67
Nd (ppm)	16.5
$^{147}Sm/^{144}Nd$	0.24519 ± 49
$^{143}Nd/^{144}Nd$	0.514057 ± 11
I(Nd)[a]	0.508068 ± 23
ε_{Nd}[b]	4.6 ± 0.4
T_{CHUR}[c](Ga)	4.4

[a]Initial Nd isotopic ratios calculated at 3.69 Ga using ^{147}Sm decay constant = 6.54×10^{-12} yr^{-1}.

[b]Initial ε_{Nd} calculated at 3.69 Ga using present-day chondritic values of $^{143}Nd/^{144}Nd = 0.512638$ and $^{147}Sm/^{144}Nd = 0.1967$.

[c]Model age relative to CHUR reservoir using present-day chondritic values listed above. $T_{CHUR} = 1/\lambda*[((^{143}Nd/^{144}Nd - 0.512638)/(^{147}Sm/^{144}Nd - 0.1967)) + 1]$.

71546
High-Ti Mare Basalt
150.70 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1975,1976,1978) reported the petrography and mineral chemistry of 71546. These authors classified 71546 as an olivine microporphyritic ilmenite basalt, but did not specifically mention this sample during their descriptions of Apollo 17 rake samples. During the preparation of this catalog, we examined thin section 71546,13 and found it to be a medium-grained (0.2-0.7mm) basalt. It is comprised of interlocking "bow-tie" intergrowths of plagioclase and pyroxene, as well as more blocky plagioclase and pyroxene, as well as ilmenite (Fig. 2). The grain size is not consistent throughout: some areas are comprised of plagioclase-pyroxene intergrowths, while other areas are made up of more blocky and coarser-grained examples of these minerals. Corroded olivine phenocrysts (0.5-0.7mm) are present, often with pink pyroxene overgrowths. Ilmenite phenocrysts can exceed 1mm in length and contain minor amounts of rutile and chromite exsolution. Native Fe ($<$ 0.05mm), troilite ($<$ 0.05mm), and opaque glass are disseminated throughout. Minor interstitial SiO_2 is conspicuous. No armalcolite was observed.

WHOLE-ROCK CHEMISTRY

The whole-rock composition of 71546 was reported by Warner et al. (1975) and Rhodes et al. (1976) (see Table 1). These authors reported a TiO_2 content of 12.1 and 12.33 wt% and a MG# of 43.0 and 43.8, respectively. Rhodes et al. (1976) defined 71546 as a Type A Apollo 17 high-Ti basalt. The REE profiles are presented in Fig. 3, and demonstrate reasonable agreement for La and Ce between the two analyses. For the other REE, the analysis of 71546 by Warner et al. (1975) has lower REE abundances than that of Rhodes et al. (1976) (Fig. 3). The REE analysis reported by Rhodes et al. (1976) is probably the more accurate as it was performed by isotope dilution (Table 1). Both REE profiles are LREE depleted with a maximum at Sm (Warner et al., 1975) and Gd (Rhodes et al, 1976). The HREE show a gentle decrease from the MREE but are still more abundant (relative to chondrites) than the LREE (Fig. 3). Both profiles

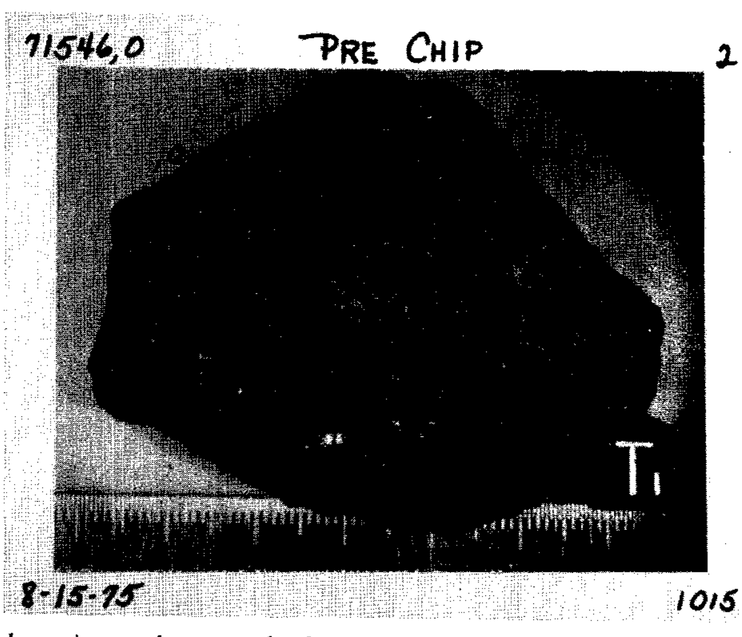


Figure 1: Hand specimen photograph of 71546,0. Small divisions on scale are in millimeters.

Table 1: Whole-rock chemistry of 71546.

	Sample 71546,1 Ref. 1 Method N	Sample 71546,5 Ref. 2 Method X,I,N	Sample 71546 Ref. 3 Method G
SiO_2 (wt %)		39.14	
TiO_2	12.1	12.33	
Al_2O_3	9.2	8.91	
Cr_2O_3	0.405	0.41	
FeO	17.7	19.11	
MnO	0.235	0.28	
MgO	7.5	8.34	
CaO	11.0	10.79	
Na_2O	0.38	0.40	
K_2O	0.072	0.05	
P_2O_5		0.05	
S		0.19	
K(ppm)		580	500 ± 25
Nb			
Zr			
Hf	9.0	9.4	
Ta	2.1		
U			0.15 ± 0.02
Th			0.40 ± 0.03
W			
Y			
Sr		191	
Rb		0.63	
Li		10.2	
Ba		83.2	
Cs			
Be			
Zn			
Pb			
Cu			
Ni			
Co	18.0	18.4	
V	120		
Sc	77	80	
La	6.5	6.69	
Ce	24	23.8	

Table 1: (Concluded).

	Sample 71546,1 Ref. 1 Method N	Sample 71546,5 Ref. 2 Method X,I,N	Sample 71546 Ref. 3 Method G
Nd		25.9	
Sm	9.5	10.7	
Eu	1.89	2.14	
Gd		16.7	
Tb	2.3		
Dy	15	19.1	
Er		11.2	
Yb	7.8	10.3	
Lu	1.3	1.47	
Ga			
F			
Cl			
C			
N			
H			
He			
Ge(ppb)			
Ir			
Au			
Ru			
Os			

References: 1 = Warner et al. (1975); 2 = Rhodes et al. (1976); 3 = Eldridge et al. (1975).

Analysis by: X = XRF; I = Isotope dilution; N = INAA, G = Gamma-ray spectroscopy.

Figure 2: Photomicrograph of 71546,13. A sub-variolitic to interlocking texture predominates. Field of view = 2.5 mm.

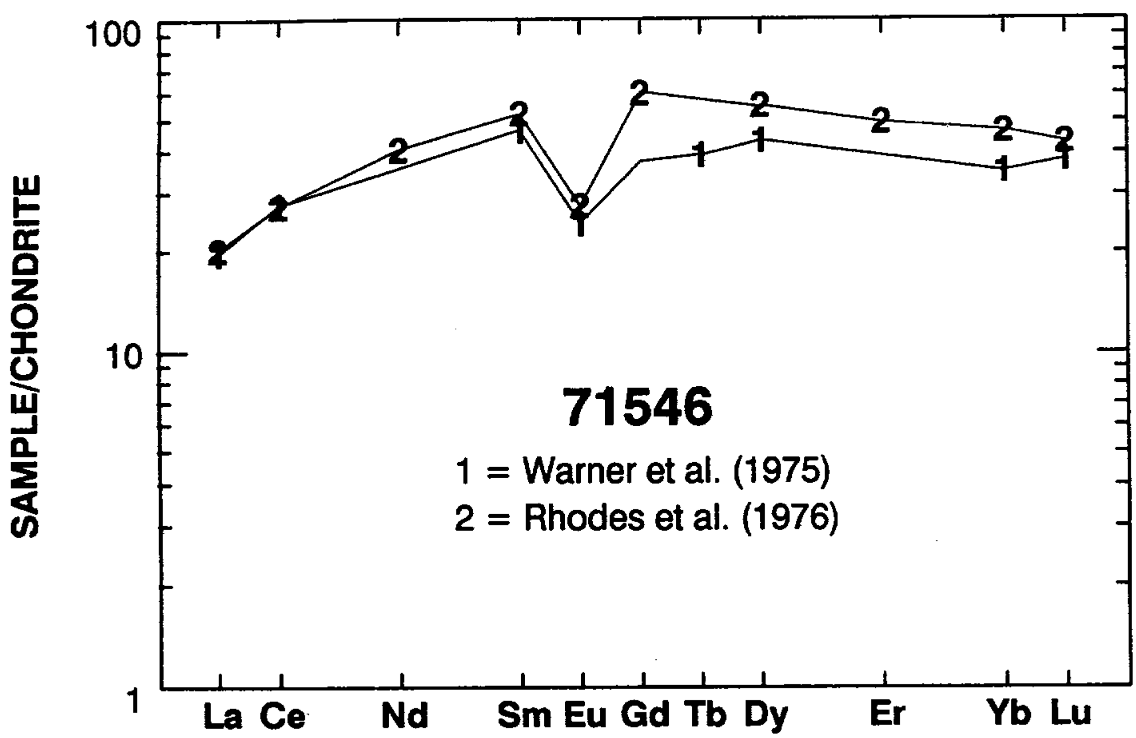


Figure 3: Chondrite-normalized REE profiles of 71546. Data from Warner et al. (1975) and Rhodes et al. (1976).

contain a negative Eu anomaly, with the analysis of Warner et al. (1975) containing an anomaly more pronounced [$(Eu/Eu^*)_N$ = 0.57] than that of Rhodes et al. (1976) E$(Eu/Eu^*)_N$ = 0.49].

Eldridge et al. (1975) reported the concentration of the primordial radioelements of 71546 (Table 1). These authors also quoted a Th/U ratio of 2.67 ± 0.41 and a K/U ratio of 3333 ± 475 for 71546. Gibson et al. (1976) reported a total sulphur content of 1810 ± 10 µgS/g with an equivalent wt% Fe^o of 0.122.

RADIOGENIC ISOTOPES

Nyquist et al. (1976) reported the whole-rock Rb-Sr composition of 71546,5 (Table 2). No age dating was undertaken on this sample.

Eldridge et al. (1975) reported the concentration of cosmogenic radionuclides in 71546,0 (Table 3). Concentrations of ^{22}Na and ^{54}Mn were corrected for decay to 14 December, 1972.

PROCESSING

Of the 150.70g of 71546,0, a total of 136.7g remains. Significant sub-samples are ,5 which has a mass of 1.5g and ,8 with a mass of 10.07g. 71546,9001 was irradiated for INAA. Four thin sections have been made of this basalt: 71546,9, ,10, ,11, and ,13.

Table 2: Rb-Sr isotope data from 71546.
Data from Nyquist et al. (1976).

	71546,5
wt(mg)	50
Rb (ppm)	0.632
Sr (ppm)	191
$^{87}Rb/^{86}Sr$	0.0096 ± 3
$^{87}Sr/^{86}Sr$	0.69966 ± 4
T_B	4.08 ± 0.42
T_L	4.57 ± 0.42

B = Model age assuming I = 0.69910 (BABI + JSC bias); L = Model age assuming I = 0.69903 (Apollo 16 anorthosites at 4.6 Ga).

Table 3: Concentrations of Cosmogenic Radionuclides (O'Kelley et al., 1975) in 71546.
Cosmogenic Radionuclide Decay corrected to 2300 GMT, Dec. 14, 1972.

	71546
^{26}Al (dpm/kg)	70 ± 3
^{22}Na	94 ± 7
^{54}Mn	165 ± 30

71547
High-Ti Mare Basalt
12.54 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1978) reported the petrography and mineral chemistry of 71547. During the preparation of this catalog, we examined thin section 71547,4 and found it to be a well crystallized, medium-grained (0.2-0.6mm) basalt. It is comprised of minor intergrowths of plagioclase-pyroxene "bow-tie" structures. The groundmass is comprised primarily of blocky plagioclase and pink pyroxene, as well as minor ilmenite (Fig. 2). Corroded olivine phenocrysts (up to 0.6mm) are present, containing euhedral chromite inclusions (< 0.005mm) (Fig. 2). Occasionally these olivine phenocrysts possess pink pyroxene overgrowths. Ilmenite phenocrysts reach up to > 1mm in length; these contain "sawtooth" margins (Fig. 2). Blocky ilmenite is also present (Fig. 2). These ilmenites contain minor rutile and chromite exsolution features. Native Fe and troilite (< 0.1mm) are disseminated throughout. No armalcolite was observed.

WHOLE-ROCK CHEMISTRY

Murali et al. (1977) reported the whole-rock composition of 71547,1 in a study of Apollo 17 rake samples (Table 1). 71547 is classified as a Type B2 Apollo 17 high-Ti basalt, based on the classification of Rhodes et al. (1976) and Warner et al. (1979), plus the criteria of Neal et al. (1990). This sample contains 10.9 wt% TiO_2, with a MG# of 44.8. The REE profile (Fig. 3) is LREE-depleted with a maximum at Sm. Murali et al. (1977) reported a Ce abundance of 35 ppm, but suggested that this was spurious. As such, the Ce abundance has not been plotted in Figure 3. The HREE form a flat pattern at ~32 times chondritic abundances. A negative Eu anomaly is present [$(Eu/Eu^*)_N = 0.52$].

PROCESSING

Of the original 12.54g of 71547,0, a total of 12.02g remains. 71547,1 was used for INAA, and thin section ,4 was taken from this irradiated sample.

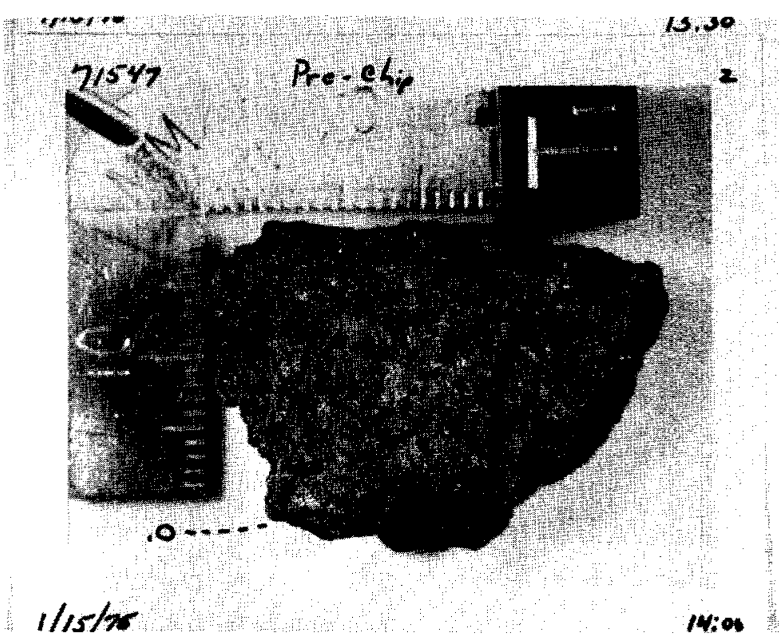


Figure 1: Hand specimen photograph of 71547,0. Small divisions on scale are in millimeters.

Table 1: Whole-rock chemistry of 71547.
Data from Murali et al. (1977).

	71547,1 N		71547,1 N
SiO_2 (wt %)		Cu	
TiO_2	10.9	Ni	
Al_2O_3	9.4	Co	20.0
Cr_2O_3	0.440	V	116
FeO	19.7	Sc	79
MnO	0.256	La	5.6
MgO	9.0	Ce	(35)
CaO	10.2	Nd	
Na_2O	0.36	Sm	7.8
K_2O	0.069	Eu	1.41
P_2O_5		Gd	
S		Tb	1.9
Nb (ppm)		Dy	12
Zr		Er	
Hf	6.3	Yb	7.0
Ta	1.3	Lu	1.09
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Eu	
Pb		Os	

Analysis by: N = INAA.

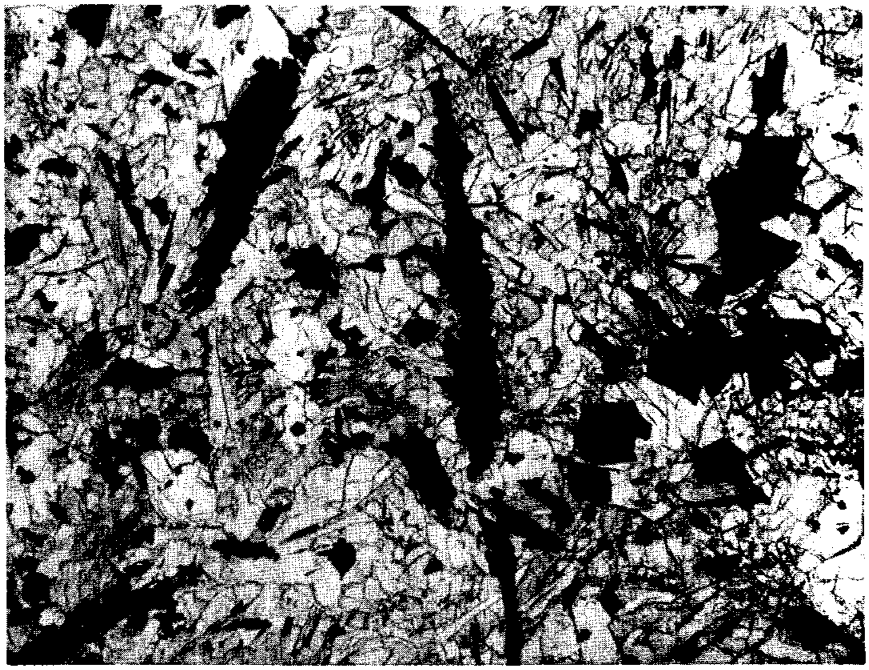


Figure 2: Photomicrograph of 71547,4. Ilmenite phenocrysts with sawtooth margins are set in a sub-variolitic to interlocking texture. Field of view = 2.5 mm.

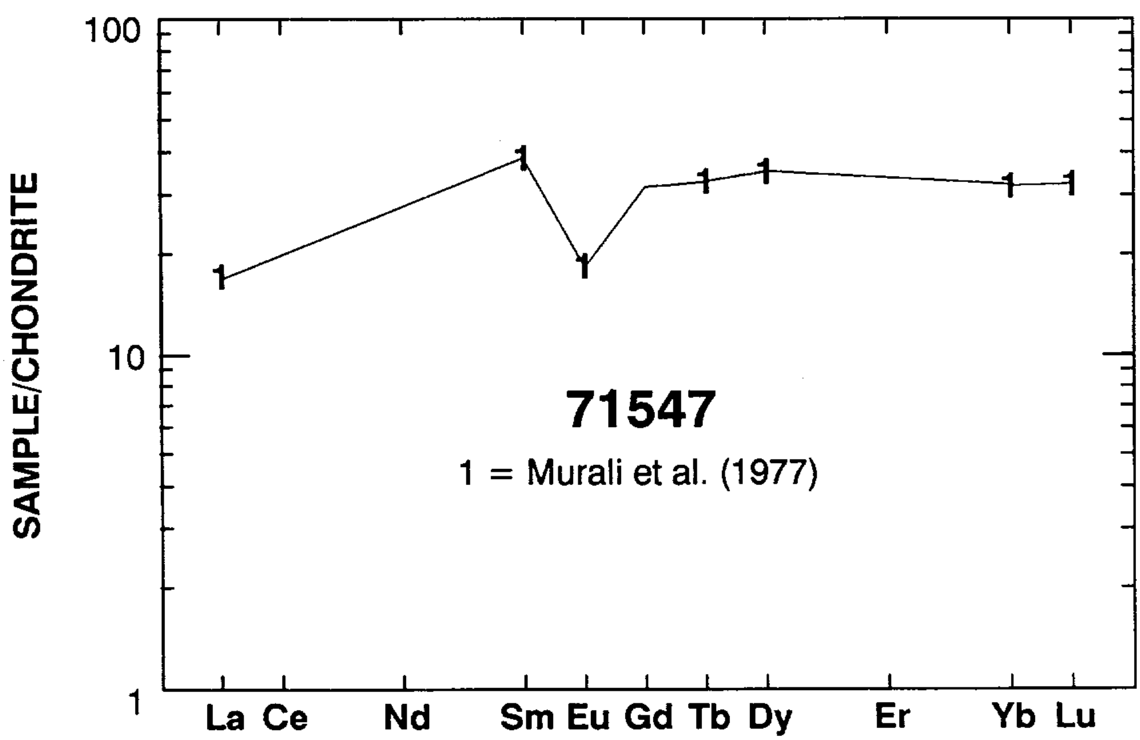


Figure 3: Chondrite-normalized rare-earth element plot of 71547. Data from Murali et al. (1977).

71548
High-Ti Mare Basalt
25.46 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1978) reported the petrography and mineral chemistry of 71548. During the preparation of this catalog, we examined thin section 71548,4 and found it to be a medium-grained (0.2-0.6mm), sub-ophitic basalt. It is comprised of blocky, pink pyroxene (some with olivine cores ~0.1mm) and plagioclase. Blocky ilmenite (up to 1mm) overlays the plagioclase, and pyroxene and minor interstitial, opaque glass is associated with this ilmenite. Rutile and chromite exsolution features are present in the ilmenites. SiO_2 (0.2-0.5mm) is conspicuous, and native Fe and troilite (< 0. 1mm) are disseminated throughout. No armalcolite was observed.

WHOLE-ROCK CHEMISTRY

Murali et al. (1977) reported the whole-rock composition of 71548,1 in a study of Apollo 17 rake samples (Table 1). Based on the whole-rock classification of Rhodes et al. (1976) and Warner et al. (1979), this sample is classified as a Type A Apollo 17 high-Ti basalt. This sample contains 12.4 wt% TiO_2 with a MG# of 43.6. The REE profile (Fig. 2) is LREE-depleted with a maximum at Sm. The HREE exhibit a slight decrease from the MREE, but are still more abundant (relative to chondrites) than the LREE (Fig. 2) A negative Eu anomaly is present [$(Eu/Eu^*)_N = 0.56$].

PROCESSING

Of the original 25.46g of 71548,0, approximately 22.82g remains. 71548,2 weighs 2.22g. 71547,1 was used for INAA, and thin section ,4 was taken from this irradiated sample.

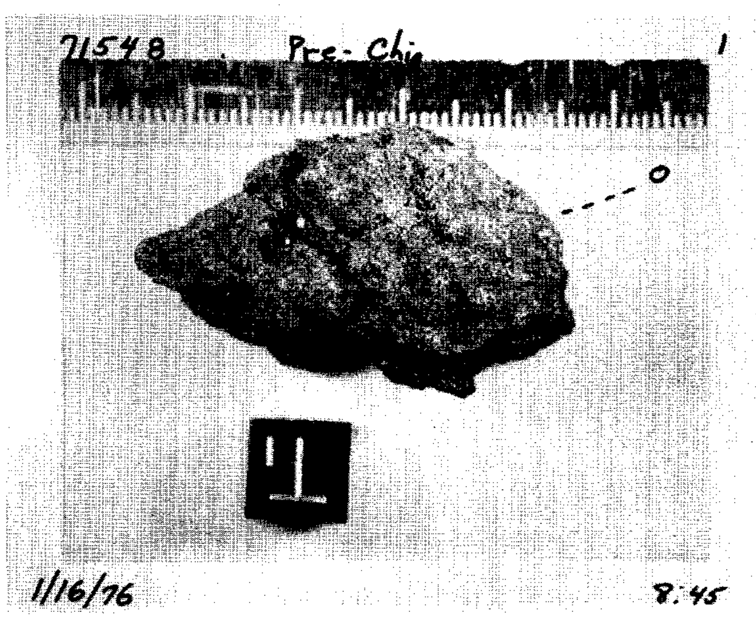


Figure 1: Hand specimen photograph of 71548,0. Small divisions on scale are in millimeters.

Table 1: Whole-rock chemistry of 71548.
Data from Murali et al. (1977).

	Sample 71548,1 Method N		Sample 71548,1 Method N
SiO_2 (wt %)		Cu	
TiO_2	12.4	Ni	
Al_2O_3	8.7	Co	17.4
Cr_2O_3	0.455	V	110
FeO	19.6	Sc	77
MnO	0.238	La	6.5
MgO	8.5	Ce	38
CaO	9.3	Nd	
Na_2O	0.41	Sm	9.9
K_2O	0.057	Eu	2.01
P_2O_5		Gd	
S		Tb	2.6
Nb (ppm)		Dy	17
Zr		Er	
Hf	9.8	Yb	9.4
Ta	1.0	Lu	1.43
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

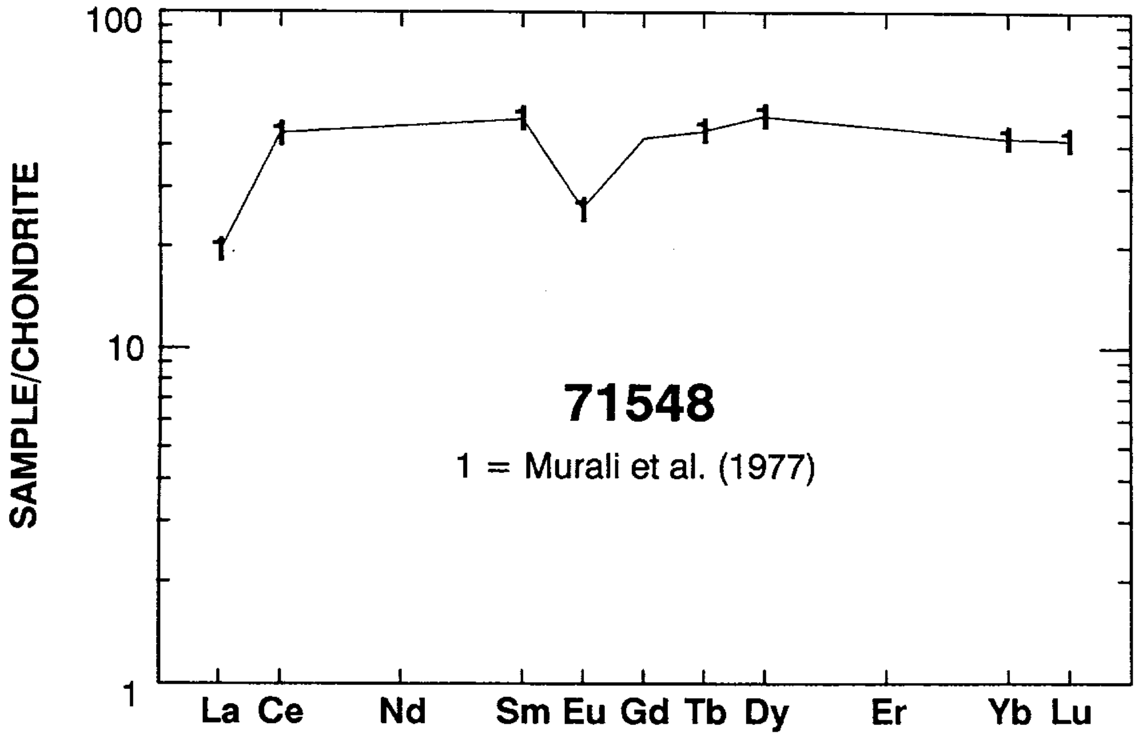


Figure 2: Chondrite-normalized rare-earth element plot of 71548. Data from Murali et al. (1977).

71549
High-Ti Mare Basalt
7.90 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1978) reported the petrography and mineral chemistry of 71549. During the preparation of this catalog, we examined thin section 71549,5 and found it to be a coarse-grained (0.4-1mm), sub-ophitic/intersertal to plagioclase-poikilitic basalt. It is comprised of pink, blocky pyroxene (larger grains have ~0.1mm rounded olivine cores) and plagioclase (Fig. 2). Ilmenite up to 1mm overlays this network, and these rarely contain "sawtooth" margins. Rutile and chromite exsolution are common in the ilmenite and minor opaque glass is associated with this mineral. Native Fe and troilite (<0.1mm) are disseminated throughout. Conspicuous interstitial SiO_2 is present (up to 0.3mm). No armalcolite was observed.

WHOLE-ROCK CHEMISTRY

Murali et al. (1977) reported the whole-rock composition of 71549,2 in a study of Apollo 17 rake samples (Table 1). Using the classification of Rhodes et al. (1976) and Warner et al. (1979), 71549 is classified as a Type A Apollo 17 high-Ti basalt. This sample contains 12.2 wt% TiO_2, with a MG# of 41.7. The REE profile (Fig. 3) is LREE-depleted with a maximum at Sm. Murali et al. (1977) reported a Ce abundance of 40 ppm, but

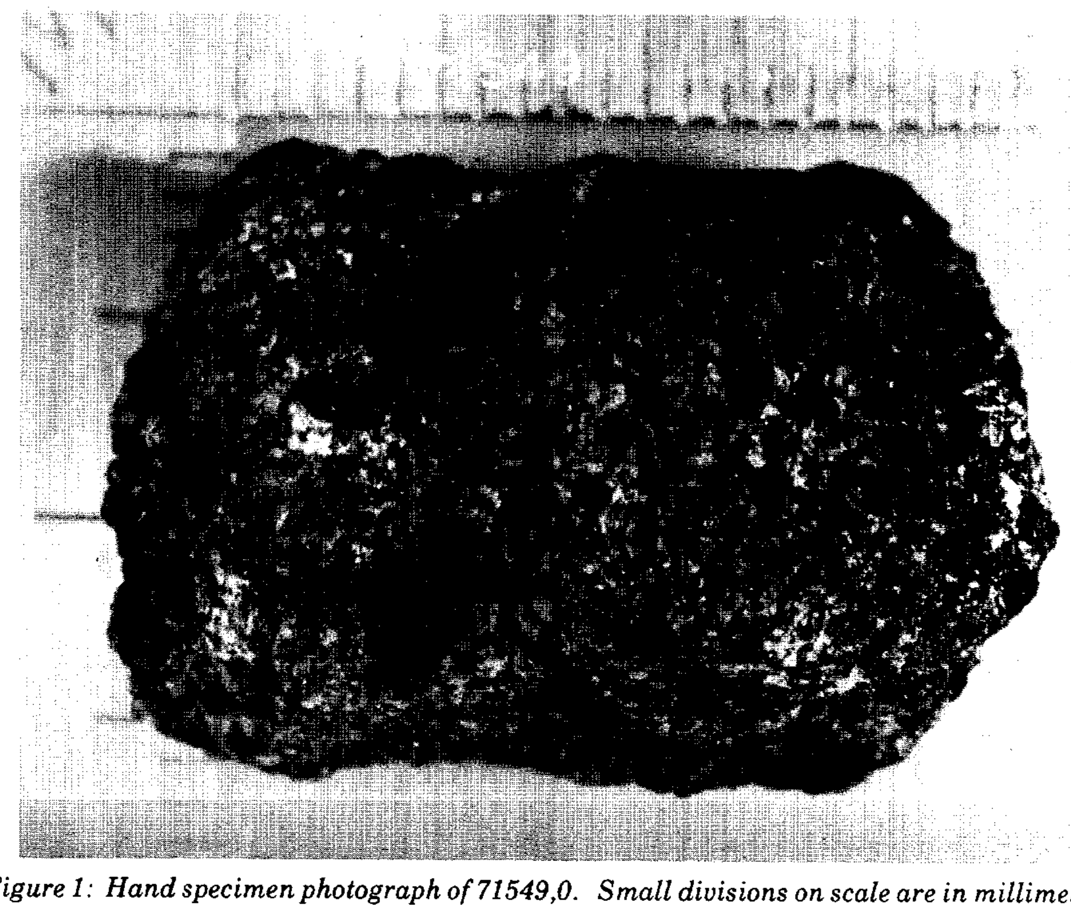


Figure 1: Hand specimen photograph of 71549,0. Small divisions on scale are in millimeters.

Table 1: Whole-rock chemistry of 71549.
Data from Murali et al. (1977).

	71549,2 N		71549,2 N
SiO_2 (wt %)		Cu	
TiO_2	12.2	Ni	
Al_2O_3	8.3	Co	19.2
Cr_2O_3	0.473	V	108
FeO	20.2	Sc	81
MnO	0.239	La	5.5
MgO	8.1	Ce	(40)
CaO	10.0	Nd	
Na_2O	0.40	Sm	8.2
K_2O	0.061	Eu	1.95
P_2O_5		Gd	
S		Tb	2.2
Nb (ppm)		Dy	14
Zr		Er	
Hf	9.0	Yb	8.0
Ta	0.92	Lu	1.23
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Eu	
Pb		Os	

Analysis by: N = INAA.

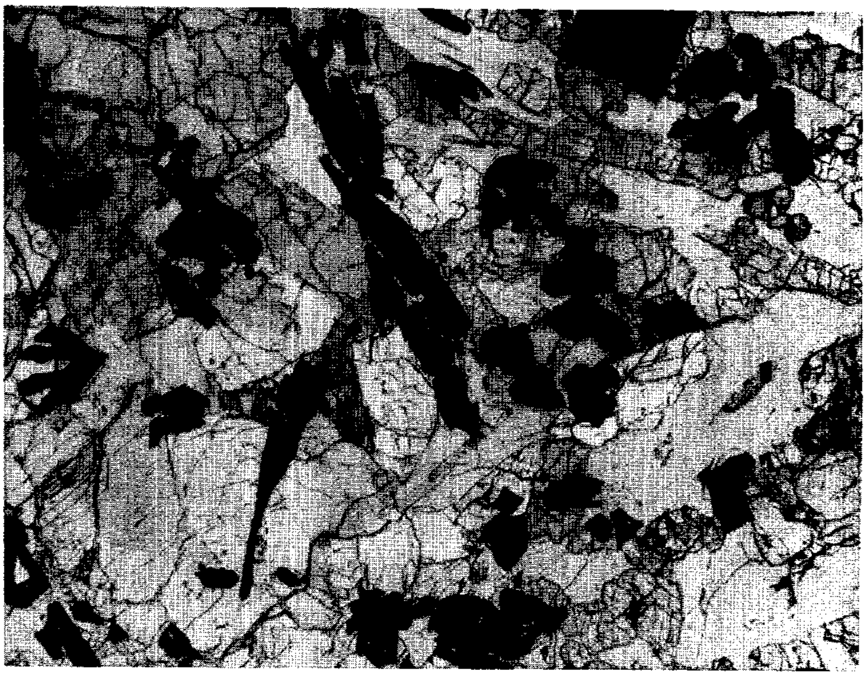


Figure 2: Photomicrograph of 71549,5. An ophitic texture predominates and interstitial SiO_2 is present. Field of view = 2.5 mm.

suggested this was spurious. As such, we have not included Ce in the REE profile of Figure 3. The HREE exhibit a slight decrease from the MREE, but are all more abundant (relative to chondrites) than the LREE (Fig. 3) A negative Eu anomaly is present [$(Eu/Eu^*)_N = 0.65$].

PROCESSING

Of the original 7.90g of 71549,0, a total of 5.23g remains. 71549,1 weighs 1.16g. 71549,2 was used for INAA, and thin section ,5 was taken from this irradiated sample.

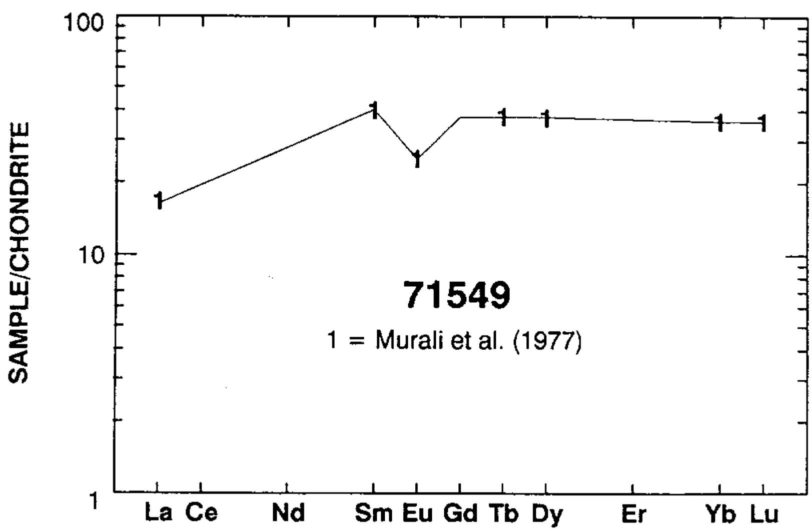


Figure 3: Chondrite-normalized rare-earth element plot of 71549. Data from Murali et al. (1977).

71555
High-Ti Mare Basalt
4.55 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1978) reported the petrography and mineral chemistry of 71555. During the preparation of this catalog, we examined thin section 71555,4 and found it to be a medium-grained (0.2-0.6mm) basalt. It is comprised of areas of pink, blocky pyroxene and swirling "bow-tie" intergrowths of plagioclase and pyroxene (Fig. 2). Minor rounded olivine (~0.1-0.2mm) is present at the center of the larger pyroxenes (Fig. 2) and rarely at the center of the "bow-tie" intergrowths. Ilmenite phenocrysts reach up to 1mm long with "sawtooth" margins. Blocky ilmenite is an interstitial groundmass phase. Opaque glass is associated with ilmenite. Ilmenite also contains rutile and chromite exsolution features. Native Fe and troilite (<0.1mm) is disseminated throughout. Interstitial SiO_2 is conspicuous. No armalcolite was observed.

WHOLE-ROCK CHEMISTRY

Murali et al. (1977) reported the whole-rock composition of 71555,1 in a study of Apollo 17 rake samples (Table 1). 71555 is classified as a Type A Apollo 17 high-Ti basalt, based on the whole-rock classification of Rhodes et al. (1976) and Warner et al. (1979). This sample contains 13.0 wt% TiO_2, with a MG# of 46.3. The REE profile (Fig. 3) is relatively flat, except

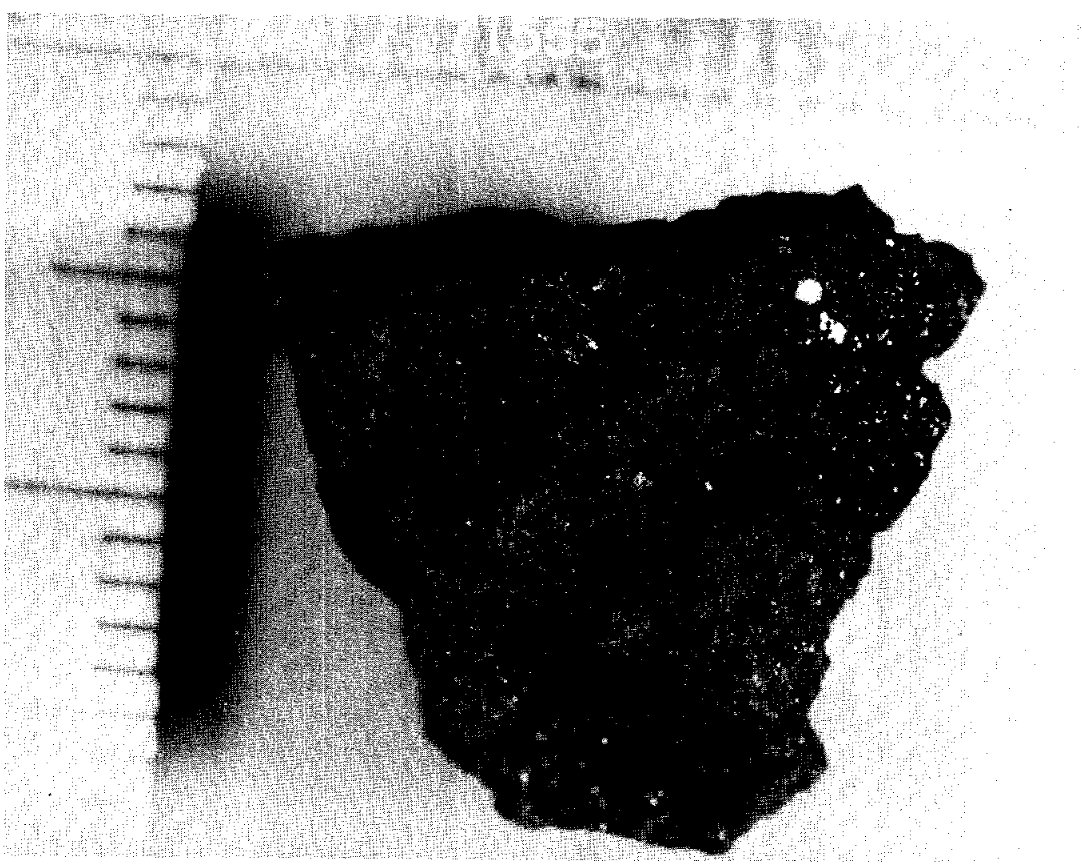


Figure 1: Hand specimen photograph of 71555,0. Small divisions on scale are in millimeters.

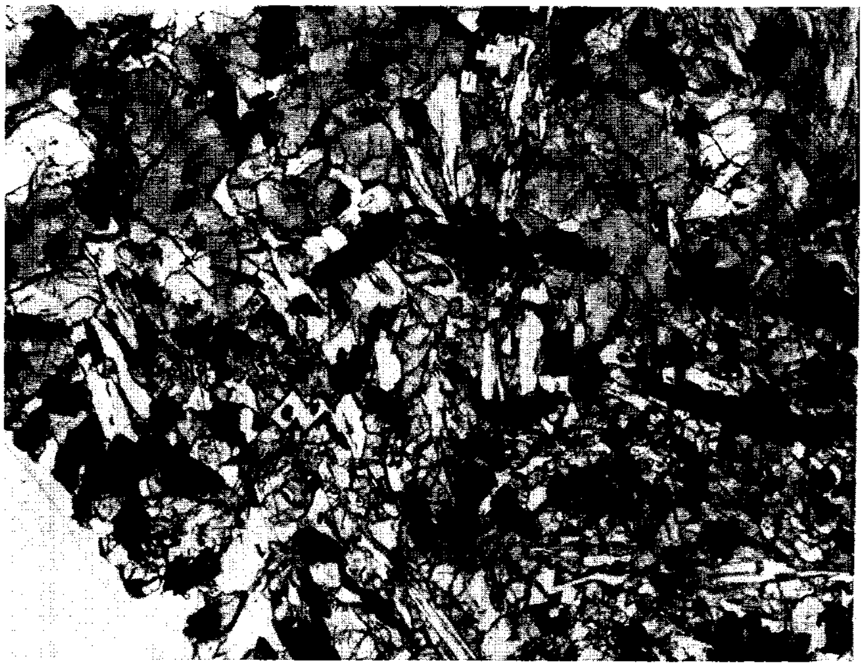


Figure 2: Photomicrograph of 71555,4. A fine-grained, blocky, interlocking texture predominates, with olivine forming cores to pyroxenes. Field of view is 2.5 mm.

for La. However, the Ce analyses of Murali et al. (1977) tend to be higher than expected, probably due to the large uncertainties associated with the analysis of Ce by INA. The LREE-depleted nature of Apollo 17 basalts indicates that the quoted Ce abundance in Table 1 is a maximum and that in reality, Ce is probably present in lower quantities than 40 ppm. The HREE are flat at an abundance of ~45 times chondritic abundances (Fig. 3) A negative Eu anomaly is present [$(Eu/Eu^*)_N$ = 0.59].

PROCESSING

Of the original 4.55g of 71555,0, a total of 4.11g remains. 71555,1 was used for INAA, and thin section ,4 was taken from this irradiated sample.

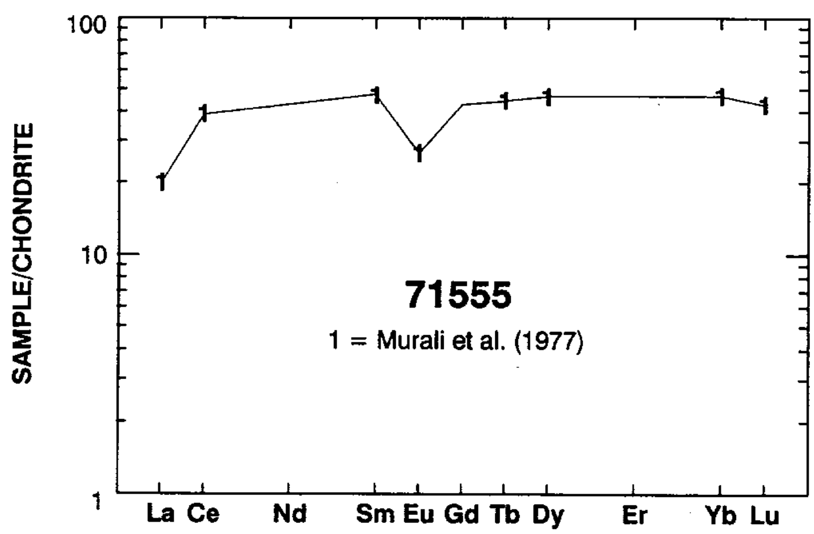


Figure 3: Chondrite-normalized rare-earth element plot of 71555. Data from Murali et al. (1977).

Table 1: Whole-rock chemistry of 71555.
Data from Murali et al. (1977).

	Sample 71555,1 Method N		Sample 71555,1 Method N
SiO_2 (wt %)		Cu	
TiO_2	13.0	Ni	
Al_2O_3	8.9	Co	18.0
Cr_2O_3	0.440	V	119
FeO	19.6	Sc	78
MnO	0.243	La	6.6
MgO	9.5	Ce	40
CaO	10.0	Nd	
Na_2O	0.42	Sm	9.6
K_2O	0.066	Eu	2.06
P_2O_5		Gd	
S		Tb	2.6
Nb (ppm)		Dy	16
Zr		Er	
Hf	9.4	Yb	10.3
Ta	1.8	Lu	1.46
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

71556
High-Ti Mare Basalt
29.14 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1978) reported the petrography and mineral chemistry of 71556. During the preparation of this catalog, we examined thin section 71556,4 and found it to be a well-crystallized, coarse-grained (0.4-1mm), sub-ophitic to plagioclase-poikilitic basalt (Fig. 2). It is comprised of pink pyroxene and plagioclase, with olivine forming rounded cores to the larger pyroxenes. Blocky ilmenites (0.4-1mm) form an intersertal texture with plagioclase and pyroxene, and contain rutile and chromite exsolution features. Interstitial SiO_2 (0.2-0.5mm) is present. Native Fe and troilite (up to 0.2mm) are disseminated throughout. No armalcolite was observed.

WHOLE-ROCK CHEMISTRY

Murali et al. (1977) reported the whole-rock composition of 71556,1, in a study of Apollo 17 rake samples (Table 1). Sample 71556 is classified as a Type A Apollo 17 high-Ti basalt, based on the whole-rock classification of Rhodes et al. (1976) and Warner et al. (1979). This sample contains 11.7 wt% TiO_2, with a MG# of 40.2. The REE profile (Fig. 3) is relatively flat, except for La. However, the Ce analyses of Murali et al. (1977) tend to be higher than expected, due to the large uncertainties associated with the analysis of Ce by INA. The LREE-depleted nature of Apollo 17 basalts indicates that the quoted Ce abundance in Table 1 is a maximum

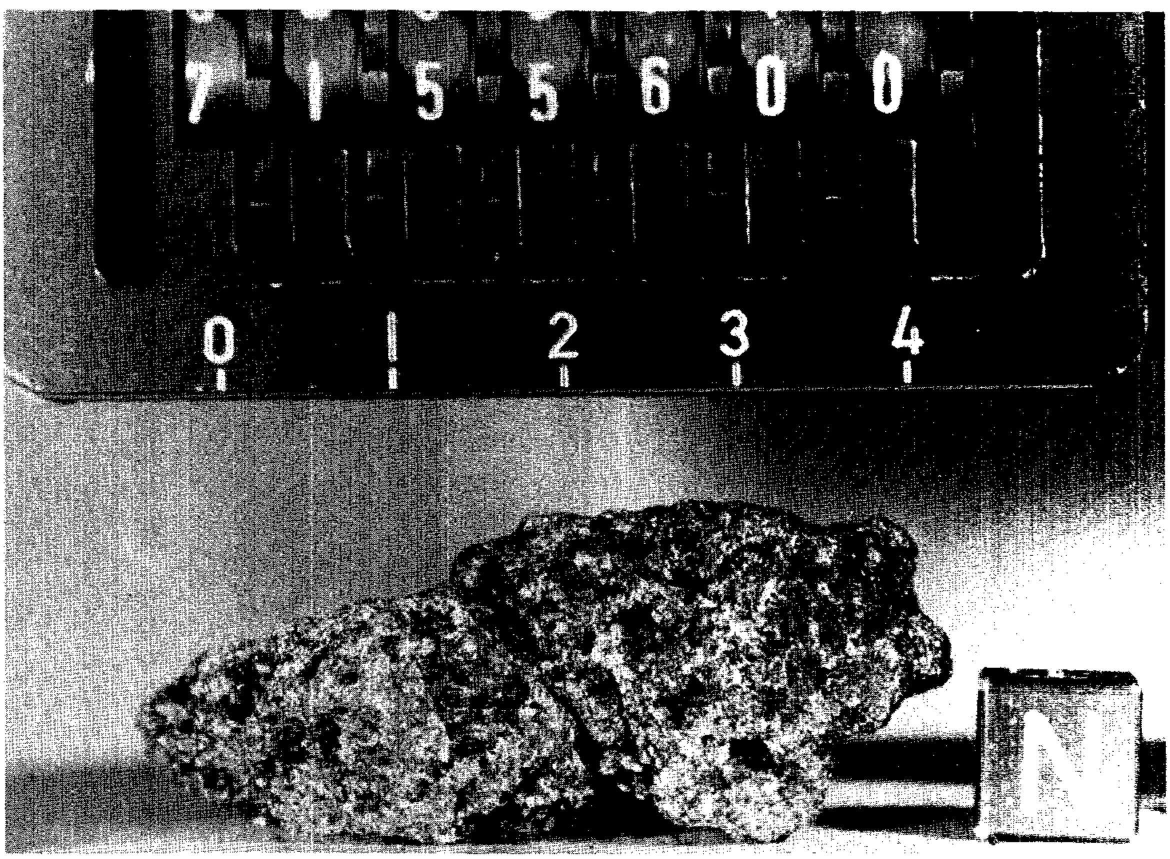


Figure 1: Hand specimen photograph of 71556,0. Cubic scale = 1 cm^3.

Figure 2: Photomicrograph of 71556,4. A sub-ophitic to plagioclase poikilitic texture is evident.

and that in reality, Ce is probably present in lower quantities than 35 ppm. The HREE are flat at an abundance of ~43 times chondritic abundances (Fig. 3) A negative Eu anomaly is present [$(Eu/Eu^*)_N = 0.68$].

PROCESSING

Of the original 29.14g of 71556,0, approximately 28.33g remains. 71556,1 was used for INAA, and thin section ,4 was taken from this irradiated sample.

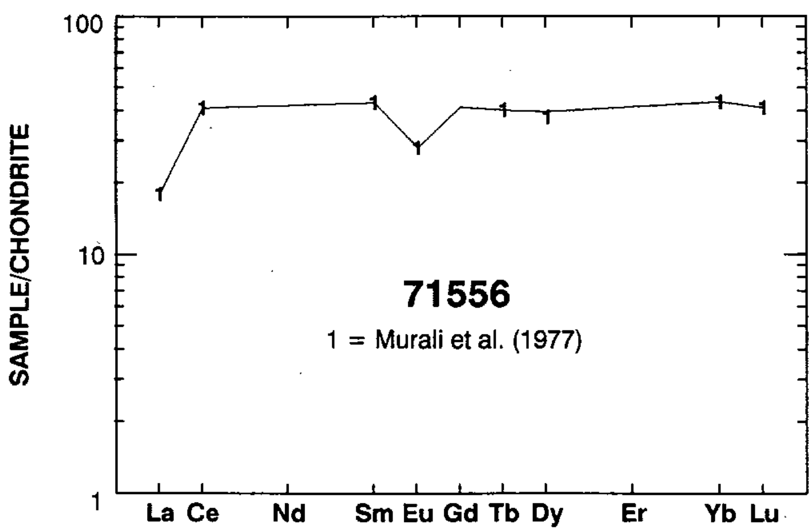


Figure 3: Chondrite-normalized rare-earth element plot of 71556. Data from Murali et al. (1977).

Table 1: Whole-rock chemistry of 71556.
Data from Murali et al. (1977).

	Sample 71556,1 Method N		Sample 71556,1 Method N
SiO_2 (wt %)		Cu	
TiO_2	11.7	Ni	
Al_2O_3	10.0	Co	17.2
Cr_2O_3	0.355	V	74
FeO	19.9	Sc	70
MnO	0.236	La	5.8
MgO	7.5	Ce	35
CaO	10.5	Nd	
Na_2O	0.45	Sm	8.6
K_2O	0.056	Eu	2.11
P_2O_5		Gd	
S		Tb	2.3
Nb (ppm)		Dy	15
Zr		Er	
Hf	8.3	Yb	9.4
Ta	1.7	Lu	1.37
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

71557
High-Ti Mare Basalt
40.35 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1975b,c, 1976a,b, 1978) reported the petrography and mineral chemistry of 71557. However, the mineral chemistry is reported only within the general context of petrographic type and not specifically mentioned. During the preparation of this catalog, we examined thin section 71557,6 and found it to be a well-crystallized, coarse-grained (0.4-1mm), sub-ophitic to plagioclase-poikilitic basalt. It is comprised of pink pyroxene and plagioclase, with olivine forming rounded cores to the larger pyroxenes. Blocky ilmenites (0.4-1mm) form an intersertal texture with plagioclase and pyroxene and contain rutile and chromite exsolution features. Interstitial SiO_2 (0.2-0.5mm) is present. Native Fe and troilite (up to 0.2mm) are disseminated throughout. No armalcolite was observed.

WHOLE-ROCK CHEMISTRY

Warner et al. (1975) reported the whole-rock composition of 71557,1 in a study of Apollo 17 rake samples (Table 1). 71557 is classified as a Type B1 Apollo 17 high-Ti basalt, based on the classification of Rhodes et al. (1976) and Warner et al. (1979), plus the criteria of Neal et al. (1990). This sample contains 13.0 wt% TiO_2, with a MG# of 44.2. The REE profile (Fig. 2) is LREE-depleted with a maximum at Dy, although the uncertainties associated with

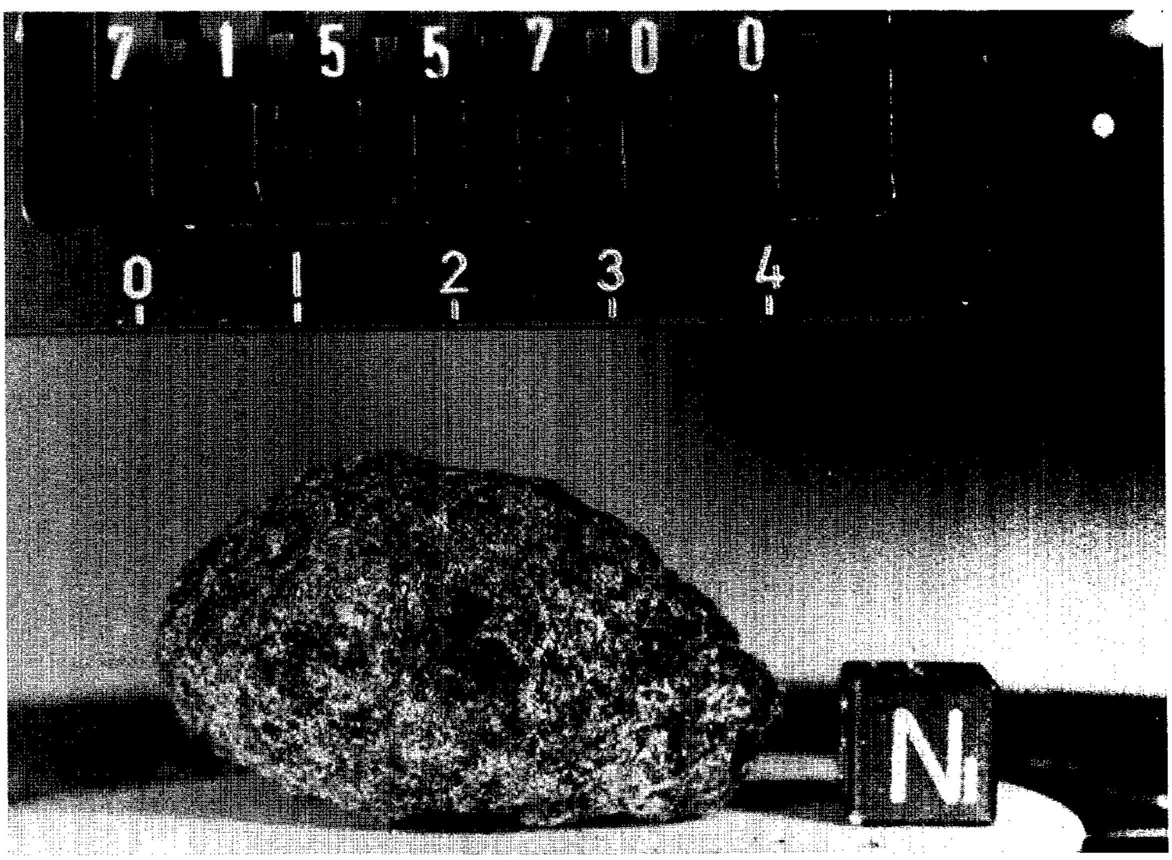


Figure 1: Hand specimen photomicrograph of 71557,0. Cubic scale = 1 cm^3.

Table 1: Whole-rock chemistry of 71557.
Data from Warner et al. (1975).

	Sample 71557,9001 Method N		Sample 71557,9001 Method N
SiO_2 (wt %)		Cu	
TiO_2	13.0	Ni	
Al_2O_3	9.3	Co	19.3
Cr_2O_3	0.508	V	120
FeO	19.1	Sc	80
MnO	0.235	La	4.8
MgO	8.5	Ce	24
CaO	10.5	Nd	
Na_2O	0.41	Sm	7.5
K_2O	0.057	Eu	1.72
P_2O_5		Gd	
S		Tb	1.8
Nb (ppm)		Dy	13
Zr		Er	
Hf	6.8	Yb	7.2
Ta	1.7	Lu	1.1
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

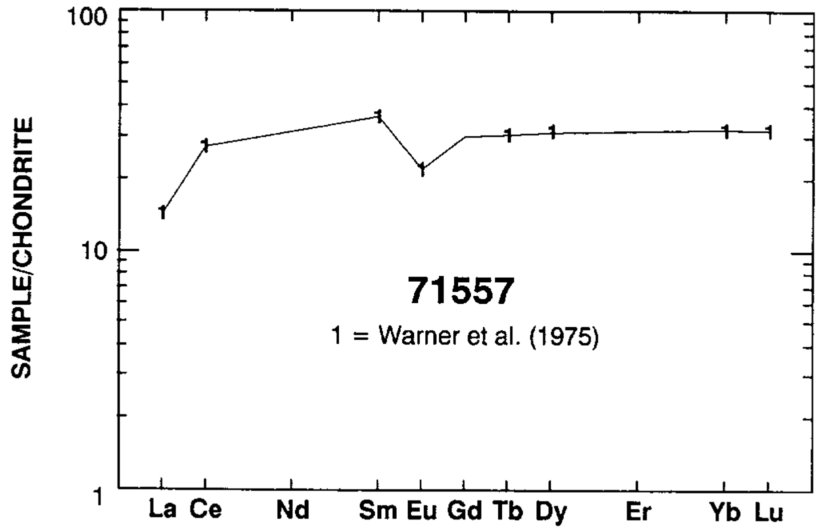


Figure 2: Chondrite-normalized rare-earth element plot of 71557. Data from Warner et al. (1975).

the analysis of Dy by INA may be responsible for this. The HREE have a generally flat profile at 30-35 times chondrite levels. A negative Eu anomaly is present [$(Eu/Eu^*)_N = 0.66$].

PROCESSING

Of the original 40.35g of 71557,0, a total of 38.9g remains. 71557,1 was split into ,9001 for INAA and ,6 for a thin section.

71558
High-Ti Mare Basalt
15.81 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1975b,c, 1976a,b, 1978) reported the petrography and mineral chemistry of 71558. However, the mineral chemistry is reported only within the general context of petrographic type and not specifically mentioned. During the preparation of this catalog, we examined thin section 71558,6 and found it to be a medium-grained (0.2-0.6mm) basalt. It is dominated by an interlocking network of pink pyroxene and plagioclase (bordering upon "plagioclase-poikilitic"), but occasional "bow-tie" intergrowths of plagioclase and pyroxene are present. Olivine is present as rounded cores (<0.1mm) to the larger pyroxenes. Occasionally these olivine cores contain euhedral chromite inclusions (~0.005mm). Ilmenite occurs as phenocrysts (up to 1.5mm) which form an intersertal texture with plagioclase and pyroxene, as well as a groundmass phase. The larger ilmenites exhibit "sawtooth" margins. Rutile and chromite exsolution lamellae were observed in, and minor opaque glass is associated with, these ilmenites. Native Fe and troilite (<0.1mm) is found both associated with ilmenite and as an interstitial phase. Interstitial SiO_2 (<0.2mm) is also present, but no armalcolite was observed.

WHOLE-ROCK CHEMISTRY

Warner et al. (1975) reported the whole-rock composition of 71558,1 in a study of Apollo 17 rake samples (Table 1). 71558 is classified as a Type B2 Apollo 17 high-Ti basalt using the whole-2

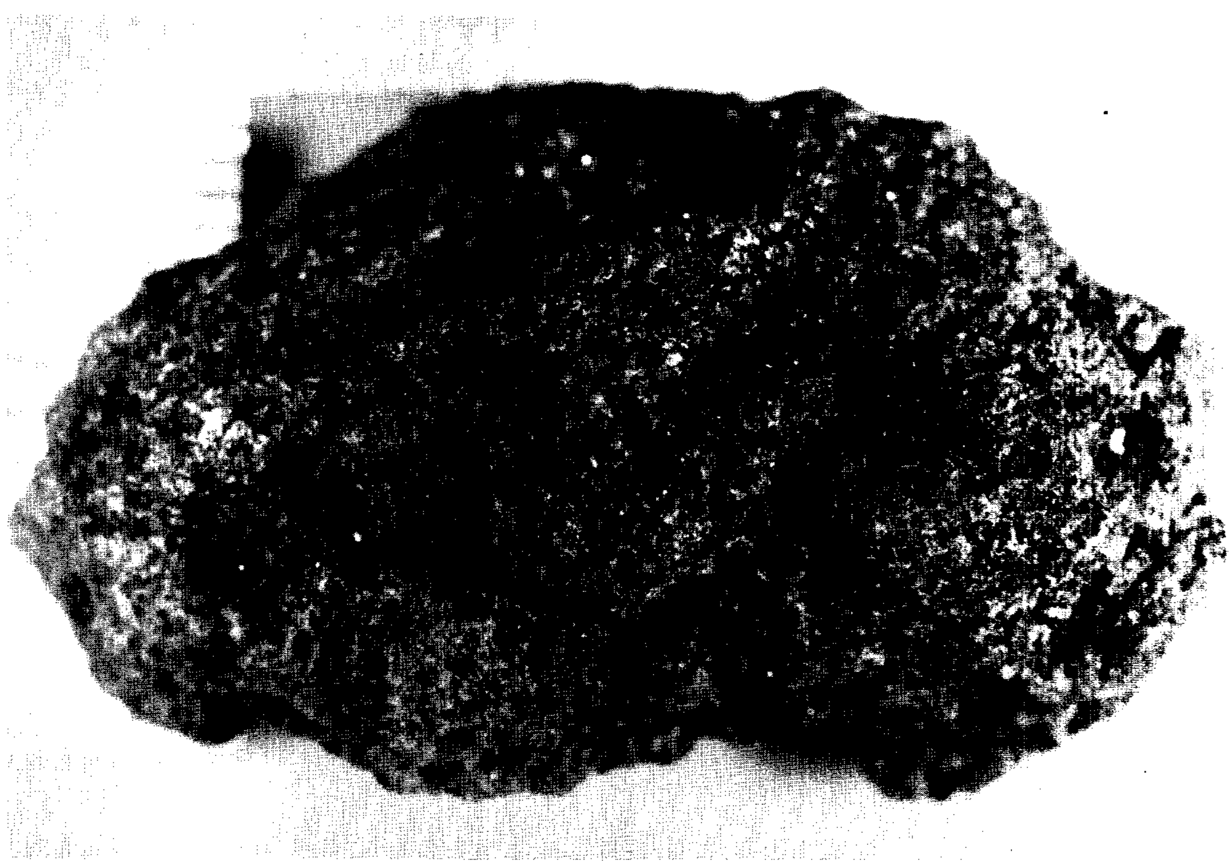


Figure 1: Hand specimen photograph of 71558,0. Small divisions on scale are in millimeters.

Table 1: Whole-rock chemistry of 71558.
Data from Warner et al. (1975).

	Sample 71558,1 Method N		Sample 71558,1 Method N
SiO_2 (wt %)		Cu	
TiO_2	13.6	Ni	
Al_2O_3	9.1	Co	21.4
Cr_2O_3	0.430	V	120
FeO	20.2	Sc	83
MnO	0.257	La	5.4
MgO	8.4	Ce	18
CaO	10.8	Nd	
Na_2O	0.37	Sm	6.5
K_2O	0.044	Eu	1.41
P_2O_5		Gd	
S		Tb	1.7
Nb (ppm)		Dy	11
Zr		Er	
Hf	6.6	Yb	6.4
Ta	1.8	Lu	1.0
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

rock classification of Rhodes et al. (1976) and Warner et al. (1979), plus the criteria of Neal et al. (1990). This sample contains 13.6 wt% TiO_2, with a MG# of 42.6. The REE profile (Fig. 2) is LREE-depleted with a maximum at Sm. The HREE are approximately constant at 30 times chondritic abundances. A negative Eu anomaly is present [$(Eu/Eu^*)_N = 0.59$].

PROCESSING

Of the original 15.81g of 71558,0, a total of ~14.47g remains. 71558,1 was subdivided into ,9001 which was irradiated for INAA, and ,6 for a thin section.

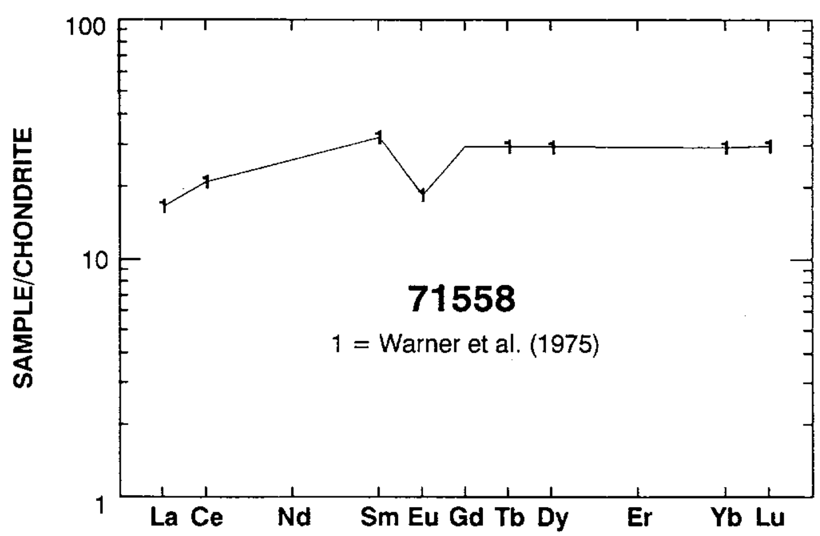


Figure 2: Chondrite-normalized rare-earth element plot of 71558. Data from Warner et al. (1975).

71559
High-Ti Mare Basalt
82.16 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1975b,c, 1976a,b, 1978) reported the petrography and mineral chemistry of 71559. Warner et al. (1975c) described 71559 as a medium grained, sub-ophitic basalt similar to the Apollo 11 ophitic basalts. Pyroxenes zone from titanaugite ($\sim En_{44}Wo_{40}Fs_{16}$; ~3.5 wt% Al_2O_3; ~5 wt% TiO_2) to pyroxferroite, but not toward pigeonite, which is absent (Fig. 2). Ilmenite is much less modally abundant (as seen from Fig. 3), and there is no olivine or Cr-ulvöspinel.

During the preparation of this catalog, we examined thin section 71559,7 and found it to be a medium-grained, sub-ophitic basalt (Fig. 3). It is dominated by pink pyroxene and plagioclase, with occasional ilmenite phenocrysts reaching up to 1.5mm (Fig. 3). Rutile and chromite exsolution lamellae were observed in the ilmenite. Native Fe and troilite (up to 0.2mm) may or may not be associated with ilmenite. Interstitial SiO_2 (up to 0.4mm) is conspicuous, forming "crinkled" patches as seen in Fig. 3. No armalcolite, olivine, or Cr-ulvöspinel was observed.

WHOLE-ROCK CHEMISTRY

Laul et al. (1975) and Warner et al. (1975) reported the same whole-rock analysis of 71559,1 in a study of Apollo 17 rake samples (Table 1). Based on the whole-rock classification of Rhodes et al. (1976) and Warner et al. (1979), 71559 is classified as a Type A Apollo 17 high-Ti basalt. This sample contains

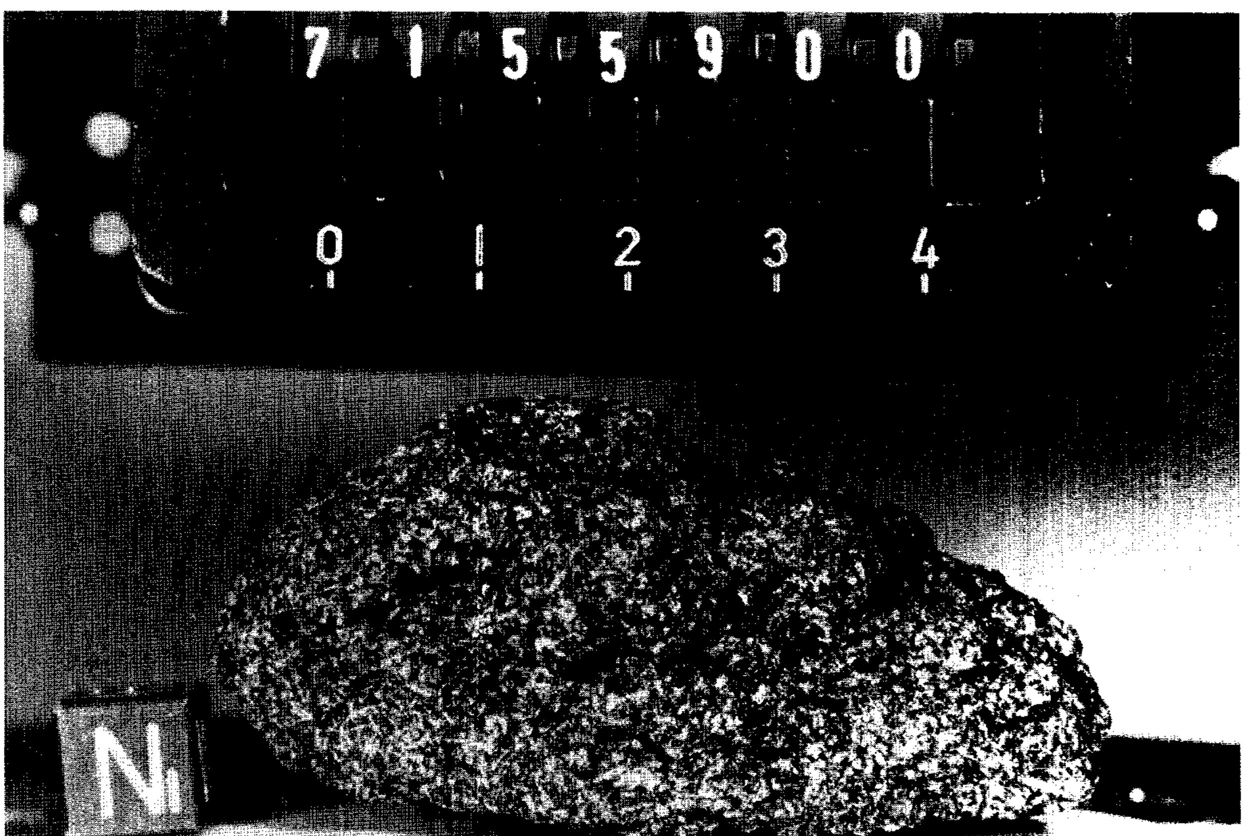


Figure 1: Hand specimen photograph of 71559,0. Cubic scale = 1 cm^3.

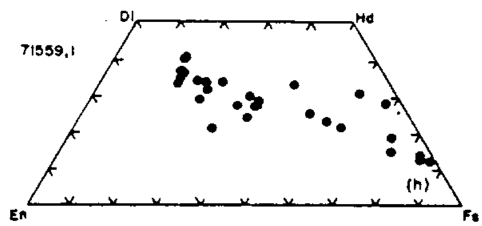


Figure 2: Quadrilateral of pyroxene compositions from 71559,1.

8.3 wt% TiO_2, with a MG# of 38.7. The REE profile (Fig. 4) is LREE-depleted with a maximum at Sm. The HREE exhibit a slight depletion compared to the MREE, but are still enriched (relative to chondrites) over the LREE. A negative Eu anomaly is present [$(Eu/Eu^*)_N = 0.60$].

PROCESSING

Of the original 82.16g of 71559,0, a total of 71.1g remains. 71559,1 was also assigned the number ,9001 and was used for INAA. Thin section ,7 was taken from this irradiated sample.

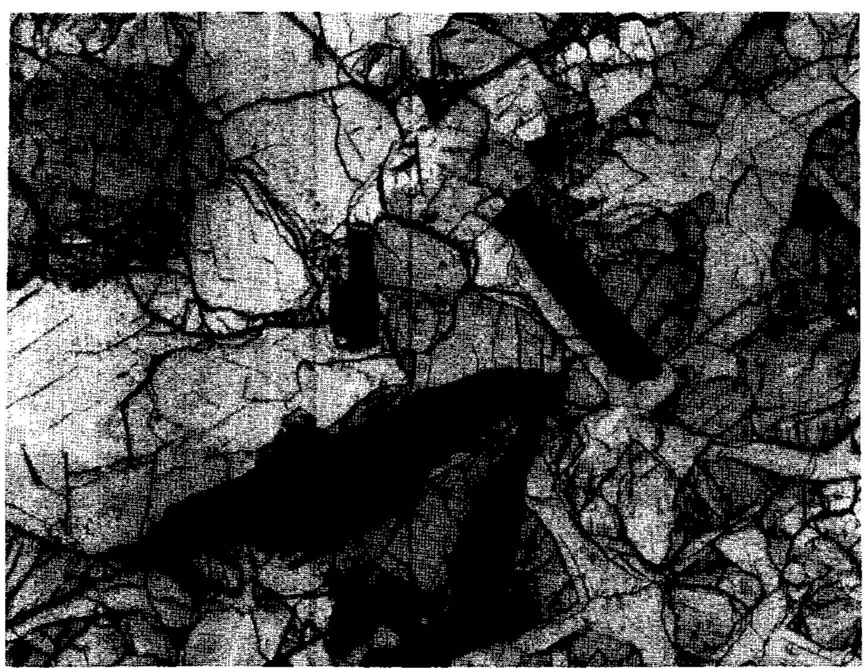


Figure 3: Photomicrograph of 71559,7. A sub-ophitic texture predominates. Field of view = 2.5 mm.

Table 1: Whole-rock chemistry of 71559.
Data from Laul et al. (1975) and Warner et al. (1975) (same analysis).

	Sample 71559,1 Method N		Sample 71559,1 Method N
SiO_2 (wt %)		Cu	
TiO_2	8.3	Ni	
Al_2O_3	10.3	Co	14.4
Cr_2O_3	0.228	V	30
FeO	17.8	Sc	72
MnO	0.226	La	6.6
MgO	6.3	Ce	26
CaO	12.2	Nd	24
Na_2O	0.48	Sm	10.4
K_2O	0.068	Eu	2.20
P_2O_5		Gd	
S		Tb	2.6
Nb (ppm)		Dy	17
Zr		Er	
Hf	8.8	Yb	9.2
Ta	1.5	Lu	1.4
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

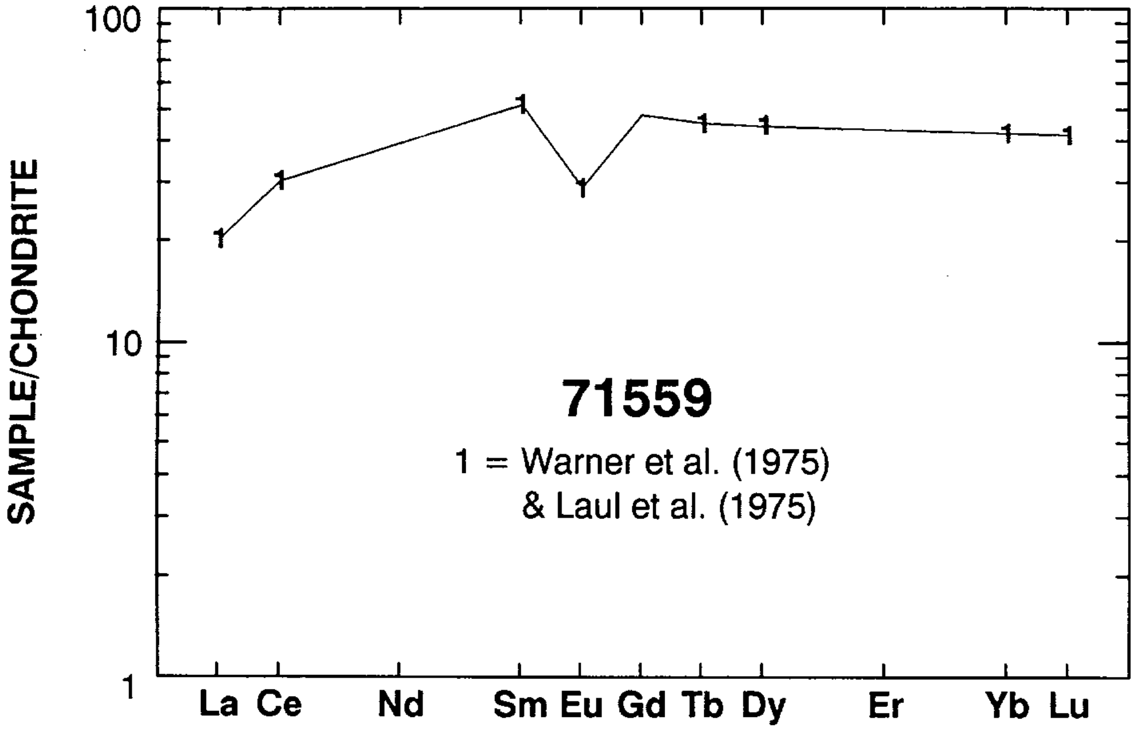


Figure 4: Chondrite-normalized rare-earth element plot of 71559. The same analysis was reported by Warner et al. (1975) and Laul et al. (1975).

71565
High-Ti Mare Basalt
24.09 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1975bc, 1976ab, 1978) reported the petrography and mineral chemistry of 71565. Warner et al. (1975c) described 71565 as a poikilitic ilmenite basalt, but did not specifically mention the petrography or mineral chemistry in their study of Apollo 17 rake samples. During the preparation of this catalog, we examined thin section 71565,6 and found it to be a coarse-grained (0.5-2.0mm) plagioclase-poikilitic basalt. It is dominated by plagioclase and pink/brown pyroxene. Olivine forms rounded cores (~ 0.1mm) in the larger pyroxenes, and these olivines contain euhedral chromite inclusions (~ 0.005mm). Blocky ilmenite overlays the plagioclase-pyroxene network, which contains rutile and chromite exsolution features. Minor opaque glass is associated with this ilmenite. Native Fe and troilite (0.1-0.2mm) is disseminated throughout. Interstitial SiO_2 is conspicuous and can reach up to 0.6mm. No armalcolite was observed.

WHOLE-ROCK CHEMISTRY

Warner et al. (1975) reported the whole-rock composition of 71565,1 in a study of Apollo 17 rake samples (Table 1). 71565 is classified as a Type A Apollo 17 high-Ti basalt, based on the whole-rock classification of Rhodes et al. (1976) and Warner et al. (1979). This sample

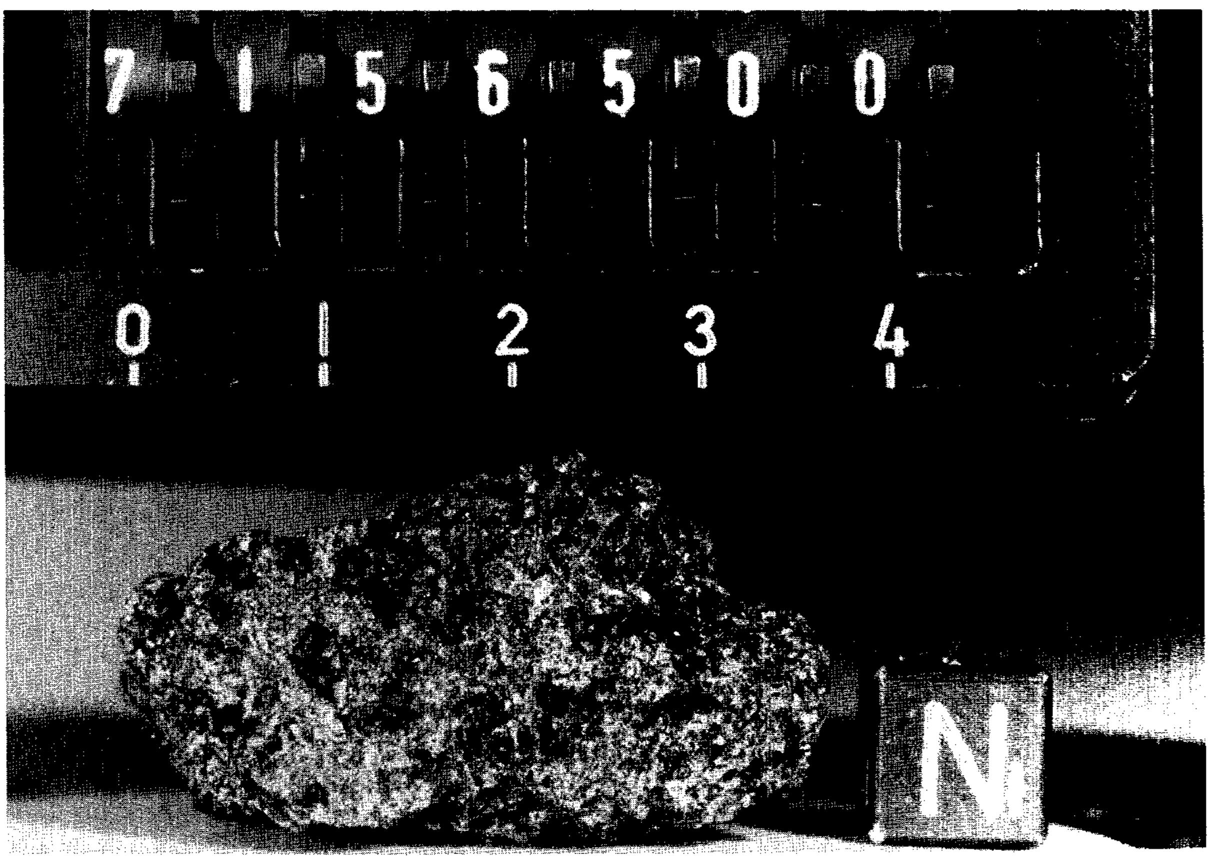


Figure 1: Hand specimen photograph of 71565,0. Cubic scale = 1cm^3.

contains 10.8 wt% TiO_2, with a MG# of 43.2. The REE profile (Fig. 2) is LREE-depleted with a maximum at Sm. The HREE are approximately constant at 40 times chondritic abundances. A negative Eu anomaly is present [$(Eu/Eu^*)_N = 0.64$].

PROCESSING

Of the original 24.09g of 71565,0, approximately 22.53g remains. 71565,1 was subdivided into ,9001, which was irradiated for INAA, and ,6 was made into a thin section.

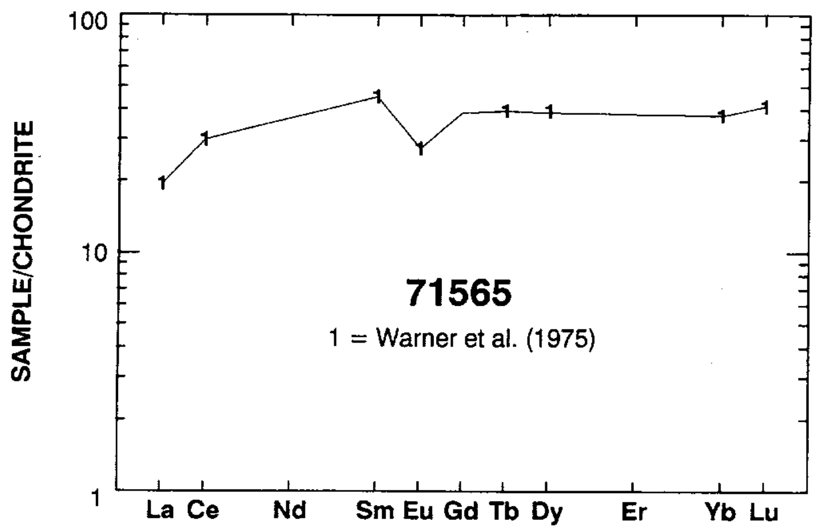


Figure 2: Chondrite-normalized rare-earth element profile of 71565. Data from Warner et al. (1975).

Table 1: Whole-rock chemistry of 71565.
Data from Warner et al. (1975).

	Sample 71565,1 Method N		Sample 71565,1 Method N
SiO_2 (wt %)		Cu	
TiO_2	10.8	Ni	
Al_2O_3	10.1	Co	16.1
Cr_2O_3	0.357	V	90
FeO	17.6	Sc	76
MnO	0.225	La	6.4
MgO	7.5	Ce	26
CaO	11.7	Nd	
Na_2O	0.43	Sm	9.2
K_2O	0.071	Eu	2.11
P_2O_5		Gd	
S		Tb	2.3
Nb (ppm)		Dy	15
Zr		Er	
Hf	8.0	Yb	8.3
Ta	1.9	Lu	1.4
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Eu	
Pb		Os	

Analysis by: N = INAA.

71566
High-Ti Mare Basalt
414.4 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1975bc, 1976ab, 1978) reported the petrography and mineral chemistry of 71566. Warner et al. (1975c) described 71566 as a poikilitic ilmenite basalt. However, they did not specifically mention the petrography or mineral chemistry of this sample in their study of Apollo 17 rake samples, except for the zonation observed in the pyroxenes (Fig. 2). These exhibit core-to-rim zonations from titanaugite, through pigeonite toward pyroxferroite (Fig. 2).

During the preparation of this catalog, we examined thin sections 71566,16 and ,18. 71566 is a coarse-grained (0.5-1.5mm), plagioclase-poikilitic basalt which contains pyroxene aggregates up to 2mm. Ilmenite usually forms an intersertal texture with pyroxene and can reach up to 1.5mm. Rutile and chromite exsolution is present in the ilmenites. Olivine is only found as rounded cores (~ 0.1-0.2mm) in the pyroxenes. These olivines contain 0.005mm euhedral chromite inclusions. Discrete Cr-ulvöspinel is rare. Troilite and native Fe form 0.1mm interstital phases, and occasionally troilite contains small grains of native Fe. Troilite is occasionally found as 0.1mm inclusions in ilmenite. Interstitial SiO_2 (~ 0.1-0.2mm) is usually associated with ilmenite.

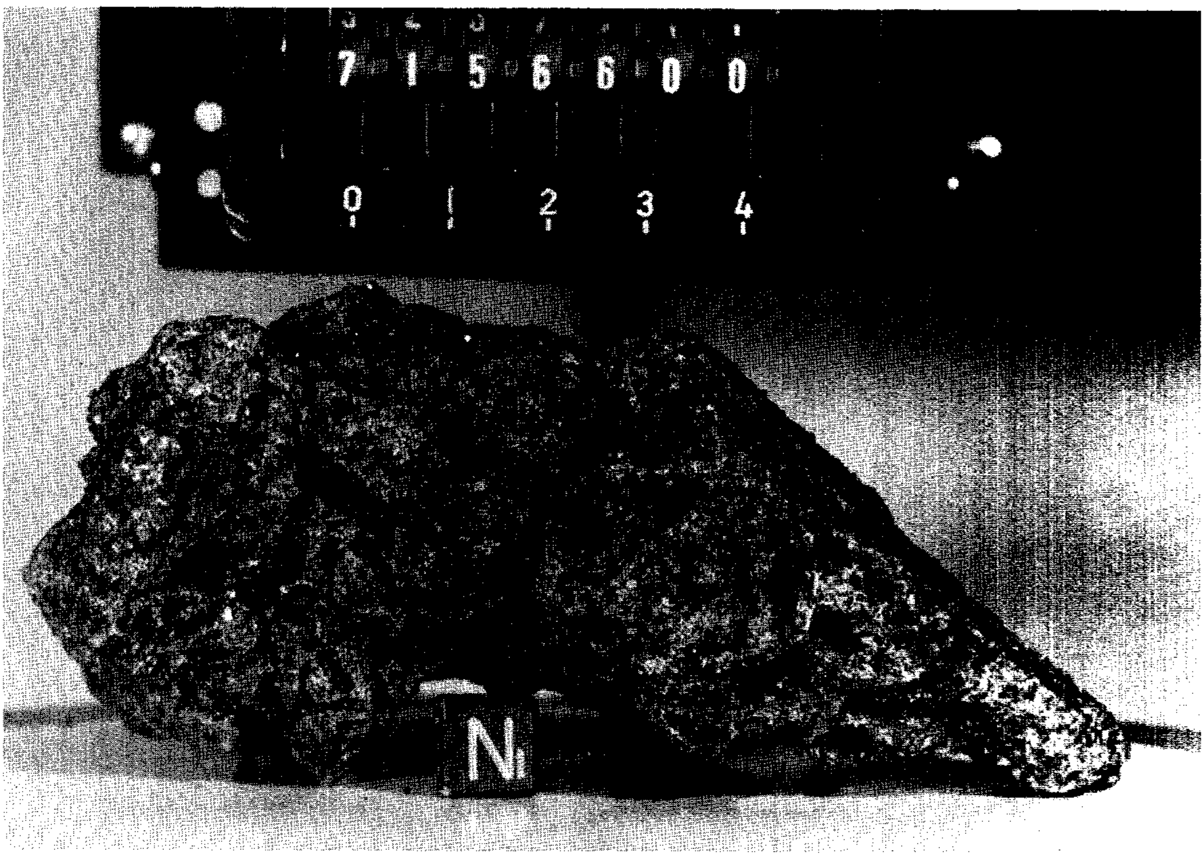


Figure 1: Hand specimen photograph of 71566,0. Cubic scale = 1cm³.

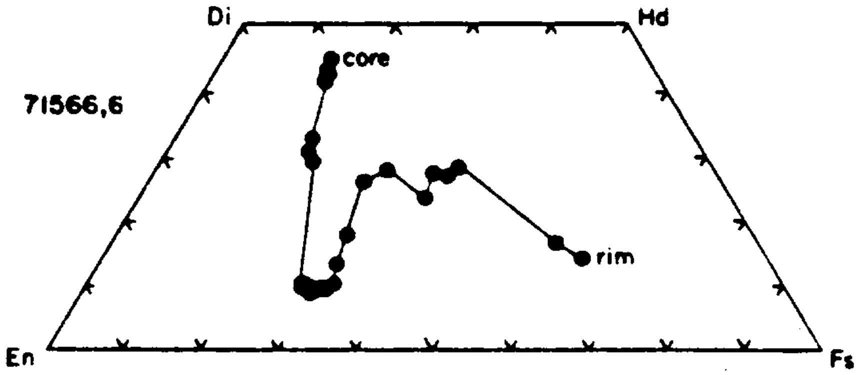


Figure 2: Pyroxene quadrilateral demonstrating compositional zonation in a pyroxene from 71566,6.

WHOLE-ROCK CHEMISTRY

Laul et al. (1975) and Warner et al. (1975) reported the same whole-rock analysis of 71566,6 in a study of Apollo 17 rake samples (Table 1). These authors reported a TiO_2 content of 11.5 wt%, with a MG# of 44.3. Rhodes et al. (1976) classified 71566 as a Class U Apollo 17 high-Ti basalt and reported a TiO_2 content of 12.01 wt% for 71566,10, with a MG# of 44.4. REE patterns are LREE depleted with a maximum in the MREE (Fig. 3). The analysis of Rhodes et al. (1976) only reports abundances of La, Ce, Sm, Eu, Yb, and Lu, but by extrapolation, an $(Eu/Eu^*)_N$ = 0.61 is defined, compared to a value of 0.67 defined by the analysis of Laul et al. (1975) and Warner et al. (1975). Both analyses are in reasonable agreement for the LREE, but the profile of Rhodes et al. (1976) contains greater HREE abundances (Fig. 3).

Gibson et al. (1976) reported a sulfur content of 1760 ± 40, µgS/g for 71566 with an equivalent of 0.147 wt% Fe^o. Eldridge et al. (1974) reported the primordial radioelement concentrations of 71566 (Table 1). These authors calculated a Th/U ratio of 3.4 and a K/U ratio of 4890.

COSMOGENIC RADIONUCLIDES

O'Kelley et al. (1974) reported the cosmogenic radionuclide abundances of 71566 (Table 2). All decays were corrected to 2300 GMT, 14 December 1972.

PROCESSING

71566,0 has been entirely subdivided. The largest subsamples remaining are: ,4 (west end = 230.7g); ,5 (east end = 178.8g); ,10 (1.30g). Four thin sections have been made of this sample - 71566,14-16, and ,18. 71566,6 has been renumbered to ,9001.

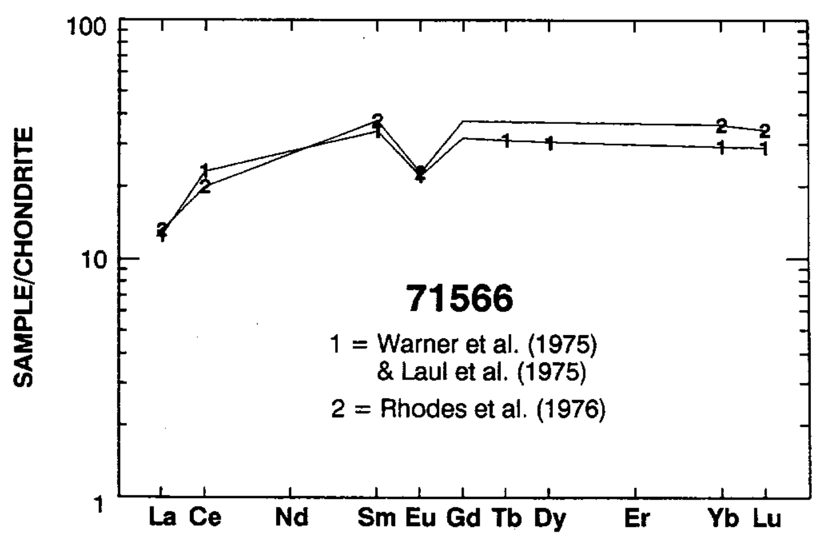


Figure 3: Chondrite-normalized rare-earth element profile of 71566. The same analysis was reported by Warner et al. (1975) and Laul et al. (1975). A second analysis is from Rhodes et al. (1976).

Table 1: Whole-rock chemistry of 71566.

	Sample ,6 Method N Reference 1	Sample ,10 Method X,N Reference 2	Method G Reference 3
SiO_2 (wt %)		39.27	
TiO_2	11.5	12.01	
Al_2O_3	9.4	9.22	
Cr_2O_3	0.390	0.38	
FeO	18.4	18.73	
MnO	0.232	0.27	
MgO	8.2	8.4	
CaO	11.0	10.89	
Na_2O	0.44	0.40	
K_2O	0.046	0.03	
P_2O_5		0.03	
S		0.16	
K (ppm)			450 ± 20
Nb			
Zr			
Hf	6.6	7.8	
Ta	1.3		
U			0.092 ± 0.008
Th			0.31 ± 0.01
W			
Y			
Sr			
Rb			
Li			
Ba			
Cs			
Be			
Zn			
Pb			
Cu			
Ni			
Co	20.0	18.1	
V	90		
Sc	73	78	
La	4.1	4.29	
Ce	20	17.2	

Table 1: (Concluded).

	Sample ,6 Method N Reference 1	Sample ,10 Method X,N Reference 2	Method G Reference 3
Nd	18		
Sm	6.9	7.62	
Eu	1.70	1.75	
Gd			
Tb	1.8		
Dy	12		
Er			
Yb	6.4	7.9	
Lu	0.98	1.16	
Ga			
F			
Cl			
C			
N			
H			
He			
Ge (ppb)			
Ir			
Au			
Ru			
Os			

Analysis by: N = INAA; X = XRF; G + Gamma-ray Spectroscopy.

References: 1 = Warner et al. (1975) and Laul et al. (1975) (same analysis); 2 = Rhodes et al. (1976); 3 = Eldridge et al. (1974).

Table 2: Cosmogenic Radionuclide abundances of 71566.
Data from O'Kelley et al. (1974).

	Sample 71566
^{26}Al (dpm/kg)	50 ± 2
^{22}Na	49 ± 3
^{54}Mn	95 ± 8

71567
High-Ti Mare Basalt
146.0 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1975b,c, 1976a,b, 1978) reported the petrography and mineral chemistry of 71567. Warner et al. (1975c) described 71567 as a poikilitic ilmenite basalt, but only described it in general terms within the context of this petrographic group. During the preparation of this catalog, we examined thin sections 71567,14 and ,15. 71567 is a coarse-grained (0.5-2mm), plagioclase-poikilitic basalt containing pyroxene grains up to 2mm. Olivine forms rounded cores (<0.1mm) in the larger pyroxenes and contains euhdral chromite inclusions (~0.05mm). Ilmenite (up to 1.5mm) usually forms an intersertal texture with pyroxene and contains rutile and chromite exsolution lamellae. Native Fe and troilite (up to 0.2mm) form interstitial phases, and troilite occasionally contains rounded grains of native Fe. Intertstitial SiO_2 is present (up to 0.2mm), but armalcolite was not observed.

WHOLE-ROCK CHEMISTRY

Laul et al. (1975) and Warner et al. (1975) reported the same whole-rock analysis of 71567,1 in a study of Apollo 17 rake samples (Table 1). These authors reported a TiO_2 content of 11.4 wt%, with a MG# of 42.6. Rhodes et al. (1976) classified 71567,9 as a Class U Apollo 17 high-Ti basalt and reported a

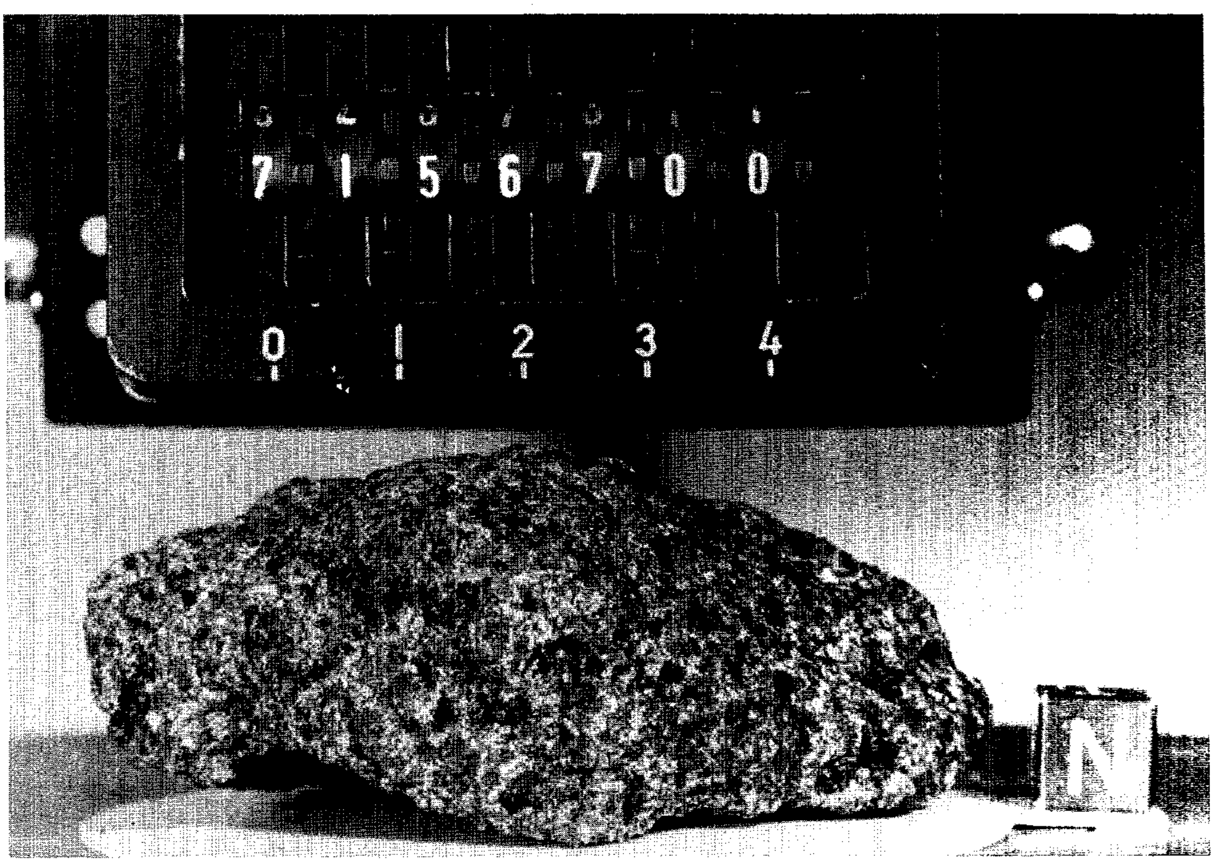


Figure 1: Hand specimen photograph of 71567,0. Cubic scale = 1 cm^3.

Table 1: Whole-rock chemistry of 71567.

	Sample ,1 Method N Reference 1	Sample ,9 Methods X, N, I Reference 2
SiO_2 (wt %)		38.06
TiO_2	11.4	12.98
Al_2O_3	9.3	8.59
Cr_2O_3	0.380	0.43
FeO	18.0	19.40
MnO	0.230	0.28
MgO	7.5	8.83
CaO	10.3	10.57
Na_2O	0.40	0.38
K_2O	0.065	0.03
P_2O_5		0.02
S	0.16	
K (ppm)		386
Nb		
Zr		
Hf	8.4	7.6
Ta	1.7	
U		
Th		
W		
Y		
Sr		161
Rb		0.39
Li		9.2
Ba		54.4
Cs		
Be		
Zn		
Pb		
Cu		
Ni		
Co	16.7	19.9
V	100	
Sc	73	79
La	6.0	4.15
Ce	24	14.4
Nd		16.3

Table 1: (Concluded).

	Sample ,1 Method N Reference 1	Sample ,9 Methods X, N, I Reference 2
Sm	10.9	6.91
Eu	2.00	1.66
Gd		11.4
Tb	2.6	
Dy	15	12.7
Er		8.28
Yb	9.4	7.35
Lu	1.3	1.08
Ga		
F		
Cl		
C		
N		
H		
He		
Ge (ppb)		
Ir		
Au		
Ru		
Os		

Analysis by: N = INAA; X = XRF; I = Isotope dilution.

References: 1 = Warner et al. (1975) and Laul et al. (1975) (same analysis); 2 = Rhodes et al. (1976).

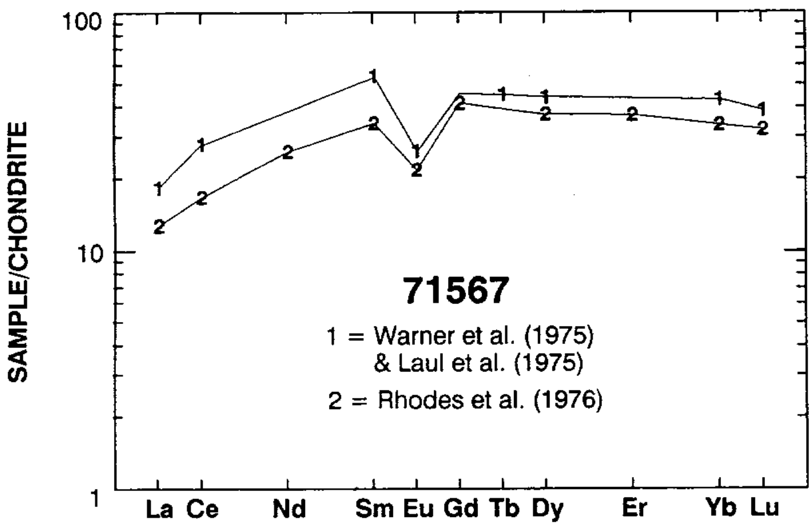


Figure 2: Chondrite-normalized rare-earth element profiles for 71567. The same analysis was reported by Warner et al. (1975) and Laul et al. (1975). A second analysis is from Rhodes et al. (1976).

TiO_2 content of 12.98 wt% for 71567,9, with a MG# of 44.8. REE patterns are LREE depleted with a maximum in the MREE (Fig. 2). The analysis of Rhodes et al. (1976) is more complete and reported lower REE abundances than that of Warner et al. (1975) and Laul et al. (1975) (Table 1; Fig. 2). Both profiles define a negative Eu anomaly (Fig. 2). The profile of Warner et al. (1975) and Laul et al. (1975) exhibits an $(Eu/Eu^*)_N = 0.53$, compared to a value of 0.57 defined by the analysis of Rhodes et al. (1976). Gibson et al. (1976) reported a sulfur content of 1625 ± 30 µgS/g for 71567 with an equivalent of 0.142 wt% Fe^o.

RADIOGENIC ISOTOPES

Nyquist et al. (1976) reported the whole-rock Rb-Sr composition of 71567,9 (Table 2). This analysis was undertaken as part of a large study of the Rb-Sr compositions of Apollo 17 high-Ti basalts.

PROCESSING

Of the original 146.0g of 71567,0, a total of 107.26g remains. Several sub-samples exceed 1g - ,6 (17.7g), ,7 (6.83g), ,9 (1.30g), ,10 (9.58g). Five thin sections have been prepared and are ,12-,16.

Table 2: Rb-Sr composition of 71567.
Data from Nyquist et al. (1976).

	Sample 71567,9
wt (mg)	50
Rb (ppm)	0.388
Sr (ppm)	161
$^{87}Rb/^{86}Sr$	0.0070 ± 3
$^{87}Sr/^{86}Sr^{b}$	0.69959 ± 9
T_B	4.87 ± 0.90
T_L	5.54 ± 0.90

b = Uncertainties correspond to last two figures and are 2 sigma - normalized to $^{88}Sr/^{86}Sr = 8.37521$; B = Model age assuming I = 0.69910 (BABI + JSC bias); L = Model age assuming I = 0.69903 (Apollo 16 anorthosites for T = 4.6 Ga).

71568
High-Ti Mare Basalt
10.02 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1978) reported the petrography and mineral chemistry of 71568. During the preparation of this catalog, we examined thin section 71568,5 and found it to be a coarse-grained (up to 1.5mm), plagioclase-poikilitic basalt. It is comprised of plagioclase and pyroxene and interstitial, blocky ilmenite. Cr-ulvöspinel is present (~0.1mm). Rare rutile and chromite exsolution was observed in the ilmenite. Native Fe and troilite (up to 0.2mm) form interstitial phases. Large areas (up to 0.5mm) of interstitial SiO_2 are conspicuous. No armalcolite or olivine was found.

WHOLE-ROCK CHEMISTRY

Murali et al. (1977) reported the whole-rock composition of 71568,1 in a study of Apollo 17 rake samples (Table 1). 71568 is classified as a Type A Apollo 17 high-Ti basalt, based on the whole-rock classification of Rhodes et al. (1976) and Warner et al. (1979). This sample contains 9.8 wt% TiO_2, with a MG# of 42.1. The REE profile (Fig. 2) is LREE-depleted with a maximum in the MREE. The HREE are flat at ~40 times chondritic abundances (Fig. 2). A negative Eu anomaly is present [$(Eu/Eu^*)_N = 0.60$].

PROCESSING

Of the original 10.02g of 71568,0, approximately 8.96g remains. 71568,1 was used for INAA, and thin section ,5 was taken from this irradiated sample.

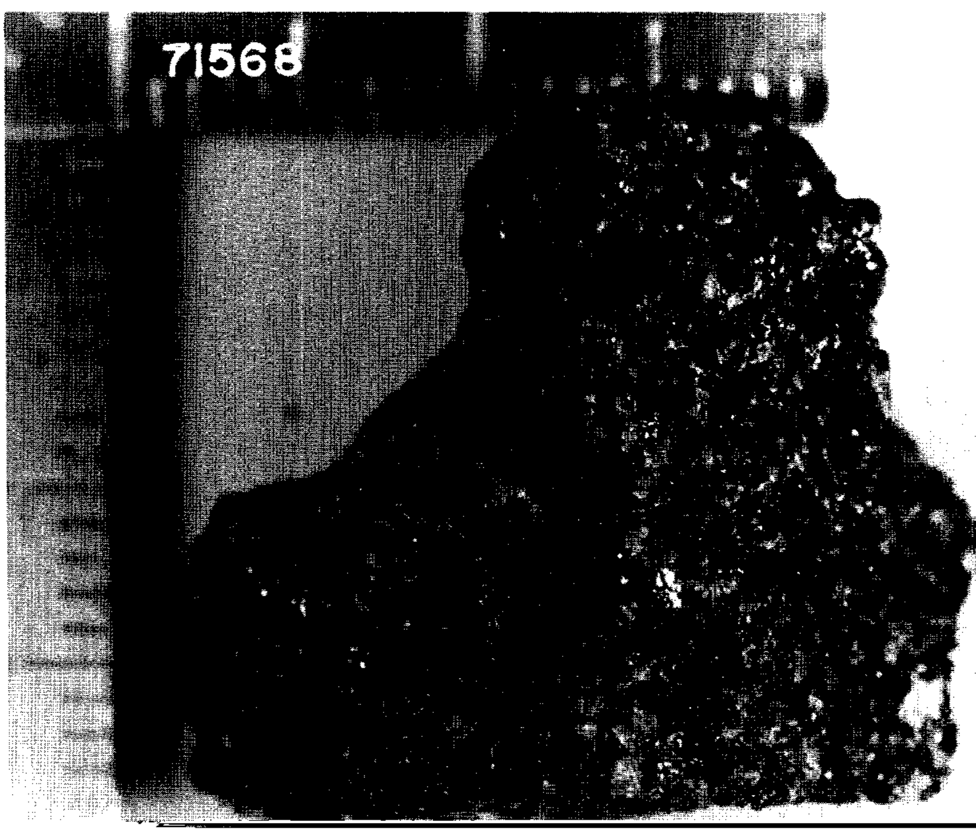


Table 1: Whole-rock chemistry of 71568.
Data from Murali et al. (1977).

	Sample 71568,1 Method N		Sample 71568,1 Method N
SiO_2 (wt %)		Cu	
TiO_2	9.8	Ni	
Al_2O_3	10.1	Co	14.7
Cr_2O_3	0.247	V	27
FeO	19.4	Sc	79
MnO	0.249	La	5.3
MgO	7.9	Ce	29
CaO	13.4	Nd	
Na_2O	0.46	Sm	8.5
K_2O	0.058	Eu	1.91
P_2O_5		Gd	
S		Tb	2.4
Nb (ppm)		Dy	14
Zr		Er	
Hf	8.6	Yb	8.1
Ta	1.6	Lu	1.36
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

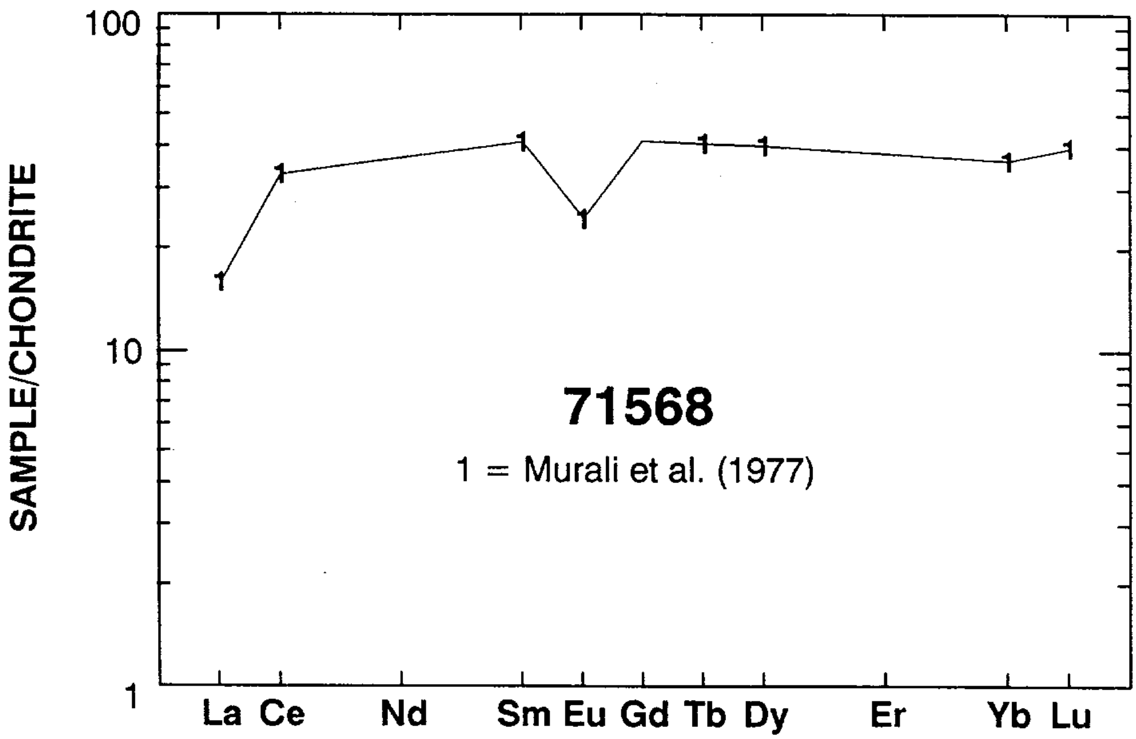


Figure 2: Chondrite-normalized rare-earth element plot of 71568. Data from Murali et al. (1977).

71569
High-Ti Mare Basalt
289.6 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Longhi et al. (1974), and Warner et al. (1975, 1978a,b,f) reported the petrography and mineral chemistry of 71569. Longhi et al. (1974) only briefly mentioned 71569, stating that it is similar to 70215. Warner et al. (1975) described 71569 as a micro-porphyritic ilmenite basalt, but did not specifically mention the petrography and mineral chemistry of this basalt during their study of Apollo 17 rake samples.

During the preparation of this catalog, we examined thin sections 71569,46, ,53, ,57, and ,60. 71569 is a medium-grained (0.1-0.4mm), porphyritic basalt. Olivine occurs as phenocrysts (up to 1mm), as well as rounded cores (~0.05-0.10mm) in larger pyroxenes (up to 0.4mm - Fig. 2). Olivine contains euhedral chromite inclusions (<0.005mm). Ilmenite occurs as phenocrysts (with "sawtooth" margins) up to 1.5mm, as well as a groundmass phase (Fig. 2). Rare rutile and chromite exsolution features were observed in the phenocrystic ilmenite. Pyroxene, plagioclase, and ilmenite form the groundmass. Pyroxene occurs either as feathery or blocky masses. Blocky pyroxene masses usually possess an olivine core. Occasionally plagioclase and pyroxene are intergrown into "bow-tie" structures. Native Fe and troilite (<0.1mm) form interstitial phases. No armalcolite or interstitial SiO_2 was observed.

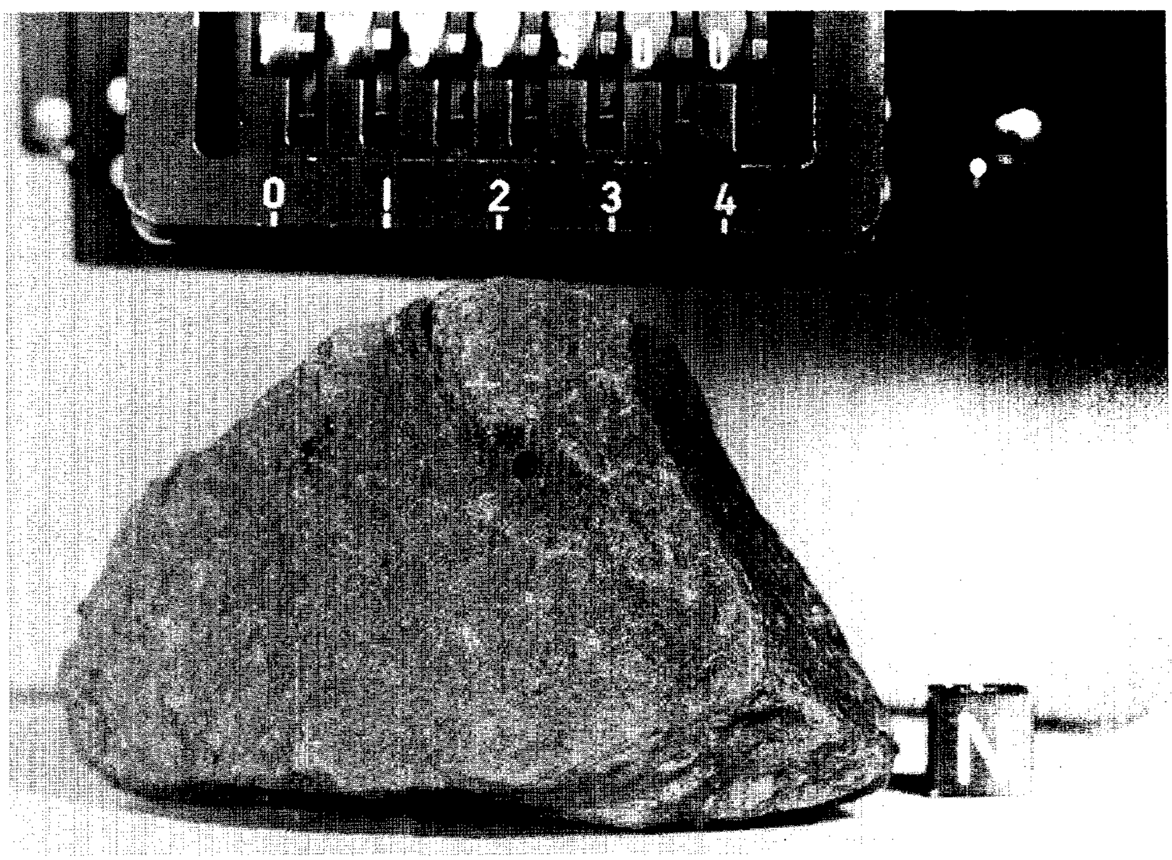


Figure 1: Hand specimen photograph of 71569,0. Cubic scale = 1cm^3.

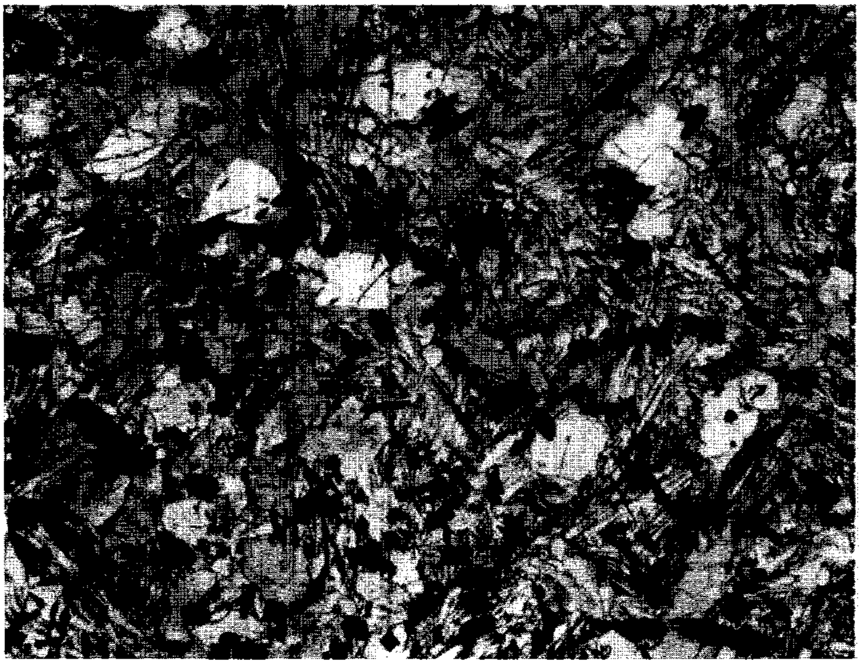


Figure 2: Photomicrograph of 71569,60 showing pyroxene reaction rims around olivine phenocrysts and ilmenite phenocrysts with sawtooth margins. These are set in a sub-variolitic matrix.

WHOLE-ROCK CHEMISTRY

Detailed whole-rock determinations of 71569 have been conducted by Warner et al. (1975) (the same analysis was also reported by Laul et al., 1975), Wänke et al. (1975), and Rhodes et al. (1976) (Table 1). Warner et al. (1975) reported a TiO_2 content in 71569,20 of 13.2 wt%, with a MG# of 47.8. Wänke et al. (1975) analyzed 71569,24 and reported a TiO_2 content of 12.04 wt%, with a MG# of 44.4. Rhodes et al. (1976) defined 71569,11 as a Type A Apollo 17 high-Ti basalt with 11.57 wt% TiO_2 and a MG# of 42.0.

The REE profiles determined by Wänke et al. (1975), Warner et al. (1975), and Rhodes et al. (1976) show good agreement in the LREE (Fig. 3 and Table 1), but exhibit more discrepancy in the middle and heavy REE (Fig. 3). The profile of Rhodes et al. (1976) exhibits a decrease from Gd to Lu, whereas the other two are relatively flat. The analysis of Warner et al. (1975) contains the lowest abundances of the middle and heavy REE (Fig. 3). All are LREE-depleted and contain a negative Eu anomaly. All three

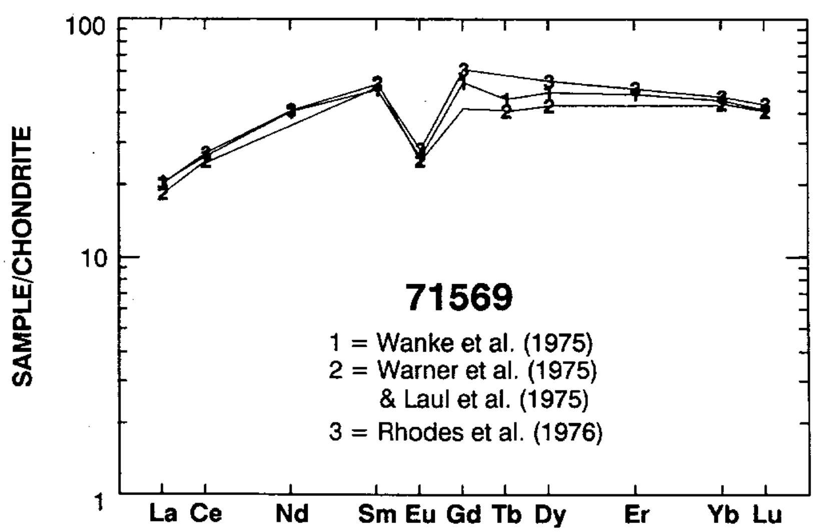


Figure 3: Chondrite-normalized rare-earth element profiles for 71569. The first analysis is from Wänke et al. (1975). The second analysis was reported both by Warner et al. (1975) and Laul et al. (1975). The third analysis was reported by Rhodes et al. (1976).

studies yield $(Eu/Eu^*)_N$ values between 0.50 and 0.53.

Two specialized whole-rock analyses of 71569 have been published. Gibson et al. (1976) reported the sulphur abundance as 2005 ± 40 μgS/g with an equivalent wt% Fe^o of 0.076. Jovanovic et al. (1977) reported the Ru and Os abundances in 71569,37 (Table 1).

RADIOGENIC ISOTOPES

Nyquist et al. (1976) reported the whole-rock Rb-Sr composition of 71569,11 (Table 2). This formed part of a much larger study of Apollo 17 basalt petrogenesis. Nunes et al. (1974) reported the U-Th-Pb systematics for 71569 (Table 3).

COSMOGENIC RADIONUCLIDES & EXPOSURE AGES

Arvidson et al. (1976) reported a Kr-Kr exposure age for 71569 of 134 Ma. Niemeyer et al. (1977) went into more detail with 71569. These authors reported the rare gas isotope composition of 71569,15 (Table 4), as well as exposure ages for this sample using a variety of techniques (Table 5).

EXPERIMENTAL

71569 has been used in a variety of experimental studies. Walker et al. (1975) and O'Hara and Humphries (1975) used 71569 in a crystallization study concerned with the origins of high-Ti basalts. Simmons et al. (1975) used 71569 in a study of microcracks in lunar samples. Finally, Longhi et al. (1978) used 71569 to determine the partitioning of Fe and Mg between olivine and lunar basaltic liquids.

PROCESSING

71569 has been studied extensively and as such, 71569,0 has been entirely subdivided. Numerous sub-samples remain which are of reasonable size (i.e., >1g). These, along with thin section numbers, are reported in Table 6.

Table 1: Whole-rock chemistry of 71569.

	Sample ,24 Method X,N Reference 1	Sample ,29 Method N Reference 2	Sample ,11 Method X,N,I Reference 3	Sample ,37 Method N Reference 4
SiO_2 (wt %)	39.38		39.97	
TiO_2	12.04	13.2	11.57	
Al_2O_3	8.58	8.5	9.08	
Cr_2O_3	0.218	0.420	0.36	
FeO	18.96	17.9	18.85	
MnO	0.147	0.220	0.28	
MgO	8.48	9.2	7.66	
CaO	10.58	9.6	11.27	
Na_2O	0.21	0.37	0.41	
K_2O	0.052	0.065	0.06	
P_2O_5	0.013		0.06	
S	0.16		0.19	
K (ppm)			585	
Nb	24			
Zr	258			
Hf	8.70	8.4	9.7	
Ta	1.75	1.7		
U	0.147			
Th				
W	0.079			
Y	91			
Sr	170		195	
Rb	0.74		0.64	
Li	8.1		10.1	
Ba	88		84.4	
Cs	0.041			
Be				
Zn				
Pb				
Cu	4.00			
Ni				
Co	18.6	17.5	18.0	
V		100		
Sc	82.4	73	81	
La	6.82	6.1	6.74	
Ce	23.0	22	23.8	

Table 1: (Concluded).

	Sample ,24 Method X,N Reference 1	Sample ,29 Method N Reference 2	Sample ,11 Method X,N,I Reference 3	Sample ,37 Method N Reference 4
Nd	26.0		26.3	
Sm	10.4	11.1	10.9	
Eu	2.03	1.97	2.19	
Gd	15.1		17.1	
Tb	2.7	2.4		
Dy	17.1	15	19.0	
Er	11.0		11.6	
Yb	10.1	9.8	10.5	
Lu	1.42	1.4	1.50	
Ga	2.15			
F	78.0			
Cl	4.9			
C				
N				
H				
He				
Ge (ppb)				
Ir	4.8			
Au	0.25			
Ru				0.08 ± 0.57
Os				0.4 ± 0.2

Analysis by: N = INAA; X = XRF; I = Isotope dilution.

References: 1 = Wänke et al. (1975); 2 = Warner et al. (1975) and Laul et al. (1975) (same analysis); 3 = Rhodes et al. (1976); 4 = Jovanovic et al. (1977).

Table 2: Rb-Sr composition of 71569.
Data from Nyquist et al. (1976).

	Sample 71569,9
wt (mg)	57
Rb (ppm)	0.638
Sr (ppm)	195
$^{87}Rb/^{86}Sr$	0.0095 ± 2
$^{87}Sr/^{86}Sr^{b}$	0.69979 ± 5
T_B	5.04 ± 0.54
T_L	5.54 ± 0.54

b = Uncertainties correspond to last two figures and are 2 sigma - normalized to $^{88}Sr/^{86}Sr = 8.37521$; B = Model age assuming I = 0.69910 (BABI + JSC bias); L = Model age assuming I = 0.69903 (Apollo 16 anorthosites for T = 4.6 Ga).

Table 3: U-Th-Pb systematics of 71569.
Data from Nunes et al. (1974).

	1	2	3	4	5
wt(mg)	158.6	213.7	158.6		
U (ppm)	0.1176				
Th (ppm)	0.3881				
Pb (ppm)	0.2663				
$^{232}Th/^{238}U$	3.41				
$^{238}U/^{204}Pb$	370				
$^{206}Pb/^{204}Pb$		180.4@	249.6@		
$^{207}Pb/^{204}Pb$		109.8@	149.9@		
$^{208}Pb/^{204}Pb$		176.2@	–		
$^{206}Pb/^{204}Pb$		220.3*	380.2*		
$^{207}Pb/^{204}Pb$		133.7*	225.7*		
$^{208}Pb/^{204}Pb$		210.7*	–		
$^{207}Pb/^{206}Pb$		0.6042*	0.5936*		
$^{208}Pb/^{206}Pb$		0.9564*	–		
$^{206}Pb/^{238}U$				0.9844[a]	1.003[a]
$^{207}Pb/^{235}U$				78.95[a]	80.24[a]
$^{207}Pb/^{206}Pb$				0.5820[a]	0.5808[a]
$^{208}Pb/^{232}Th$				0.2479[a]	–
$^{206}Pb/^{238}U$				4459[b]	4519[b]
$^{207}Pb/^{235}U$				4506[b]	4523[b]
$^{207}Pb/^{206}Pb$				4529[b]	4525[b]
$^{208}Pb/^{232}Th$				4538[b]	–

1 = Elemental concentrations; 2,3 = @ - Observed ratios, * - corrected for analytical blank; 4,5 = a - corrected for blank and primordial Pb, b - single stage ages in Ma.

Table 4: Rare gas and cosmogenic rare gas abundances in 71569.
Data from Niemeyer et al. (1977).

Rare Gases

	^{3}He	^{4}He	^{22}Ne	^{36}Ar	$^{20}Ne/^{22}Ne$	$^{21}Ne/^{22}Ne$	$^{38}Ar/^{36}Ar$	$^{40}Ar/^{36}Ar$
	(x 10^{-12} cm^3 STP/g)							
71569:	78.5±2.5	6100±350	19.18±0.87	10.16±0.51	0.841±0.004	0.8791±0.0038	1.559±0.016	186±1

	^{84}Kr	^{78}Kr	^{80}Kr	^{81}Kr	^{82}Kr	^{83}Kr	^{86}Kr
	(x 10^{-12} cm^3 STP/g)	(^{84}Kr = 100)					
71569:	149.1±7.2	42.50±0.55	109.95±0.79	0.3071±0.0152	169.05±0.85	223.76±1.00	4.14±0.12

	^{132}Xe	^{124}Xe	^{126}Xe	^{128}Xe	^{129}Xe	^{130}Xe	^{131}Xe	^{134}Xe	^{136}Xe
	(x 10^{-12} cm^3 STP/g)	(^{132}Xe = 100)							
71569:	23.8±1.0	49.79±1.26	86.65±1.73	123.5±2.4	171.6±1.9	76.60±0.98	325.8±4.3	21.49±0.39	15.34±0.35

Cosmogenic Rare Gases*

	^{22}Ne	^{38}Ar	^{83}Kr	^{126}Xe	^{78}Kr	^{80}Kr	^{81}Kr	^{82}Kr	^{84}Kr
	(x 10^{-8} cm^3 STP/g)		(x 10^{-12} cm^3 STP/g)		(^{83}Kr = 100)				
71569:	18.9	15.7	333	19.9	19.0±0.3	49.2±0.5	0.134±0.007	75.4±0.5	43.7±4.5

	^{124}Xe	^{128}Xe	^{129}Xe	^{130}Xe	^{131}Xe	^{132}Xe	^{134}Xe
	(^{126}Xe = 100)						
71569:	59±2	144±3	157±3	84±2	351±7	69±2	5±1

* Cosmogenic Ne and Ar abundances are calculated from the total gas amounts assuming trapped Ne and Ar of solar composition and cosmic ratios of $^{20}Ne/^{22}Ne \sim 0.8$, $^{21}Ne/^{22}Ne \sim 0.9$, and $^{36}Ar/^{38}Ar \sim 0.6$. Both Kr and Xe isotopic compositions are derived from the 1650°C data which was blank corrected only for hydrocarbon contamination. The cosmogenic Kr spectra are calculated assuming ($^{86}Kr/^{83}Kr$) = 0.15±0.15 and trapped Kr of terrestrial composition. The cosmogenic Xe spectra are deduced assuming ($^{136}Xe/^{126}Xe$) = 0.0032±0.0016, a terrestrial composition for the trapped Xe, and fissiogenic Xe from in situ spontaneous fission of U for 3.8 Ga.

Table 5: Cosmic ray exposure ages (Ma).
Data from Niemeyer et al. (1977).

Method	Sample 71569
^{81}Kr-Kr	134 ± 7
^{3}He	79
^{21}Ne	151
^{38}Ar	125
^{83}Kr	174
^{126}Xe	198

Table 6: Sample numbers of 71569 sub-samples > 1g and thin section numbers.
Note that thin section numbers on the same line do not necessarily mean that this thin section was taken from the sub-sample weighing > 1g. This lay-out is purely for presenting the information.

Sample	Weight (g)	Thin Section
,1	173.4	,46
,2	36.5	,53
,3	3.70	,54
,4	12.7	,55
,6	6.00	,56
,7	2.75	,58
,8	2.23	,59
,9	2.10	,60
,10	7.00	,61
,11	1.40	,62
,12	7.10	,63
,15	1.30	,64
,16	4.90	,65
,17	2.32	
,24	1.00	
,24	2.27	
,26	2.40	
,28	10.5	

71575
High-Ti Mare Basalt
2.113 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1978) reported the petrography and mineral chemistry of 71575. During the preparation of this catalog, we examined thin section 71575,6 and found it to be a fine- to medium-grained basalt (0.1-0.4mm). It is dominated by "bow-tie" intergrowths of plagioclase and pyroxene. Blocky pyroxene with a striking pink/brown color is also present. Corroded olivine phenocrysts (up to 0.7mm) with pyroxene overgrowths are occasionally seen. Only rare euhedral chromite inclusions (~0.005mm) are found in the olivines. Ilmenite phenocrysts (up to 1mm with "sawtooth" margins) overlay the plagioclase and pyroxene groundmass, but blocky ilmenite is also a groundmass phase. Rutile and chromite exsolution is found in both phenocryst and groundmass ilmenite. Native Fe and troilite (up to 0.1mm) are disseminated throughout, but interstitial SiO_2 (up to 0.1mm) is usually associated with ilmenite.

WHOLE-ROCK CHEMISTRY

Murali et al. (1977) reported the whole-rock composition of 71575,3 in a study of Apollo 17 rake samples (Table 1). 71575 is classified as a Type A Apollo 17 high-Ti basalt using the classification of Rhodes et al. (1976) and Wraner et al. (1979). This sample contains 12.4 wt% TiO_2, with a MG# of 39.9. The REE profile (Fig. 2) is relatively flat, except for La. The uncertainties associated with analyzing Ce by INA, coupled with the overall LREE-depleted nature of Apollo 17 high-Ti basalts, suggests that the 46 ppm Ce quoted by Murali et al.

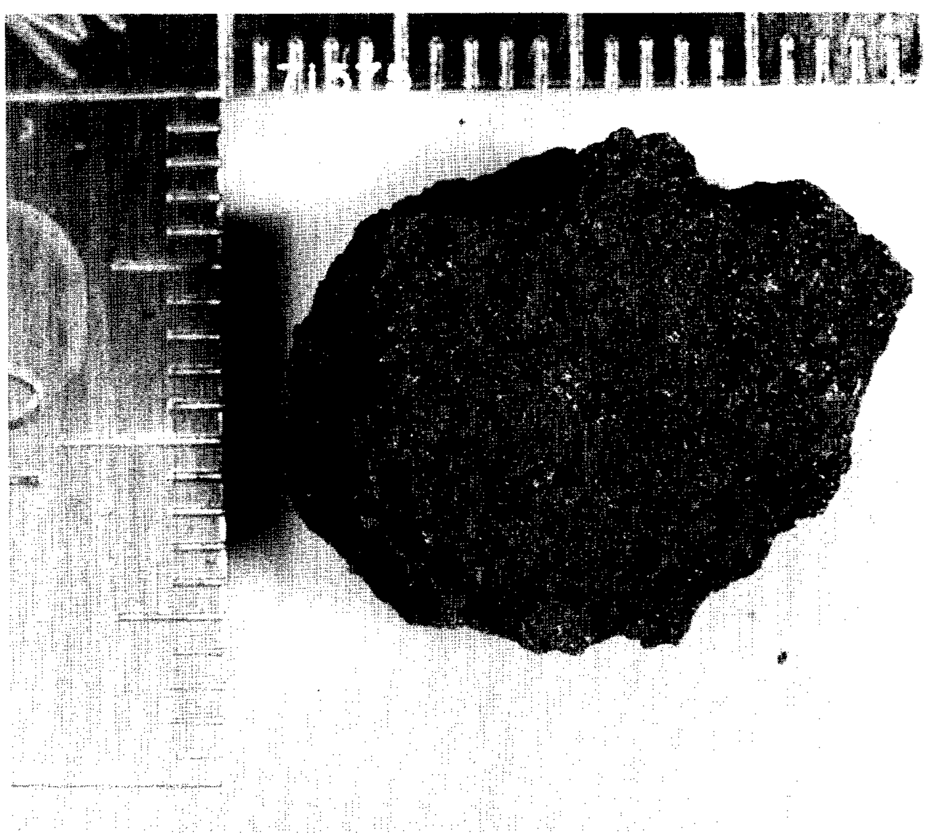


Figure 1: Hand specimen photograph of 71575,0. Small divisions on scale are in millimeters.

(1977) is probably a maximum. In reality, this value is probably lower, and Ce has not been plotted in Fig. 2. The HREE exhibit a steady decrease from Dy to Lu (Fig. 2), but are still more abundant (relative to chondrites) than La. A negative Eu anomaly is present [$(Eu/Eu^*)_N = 0.55$].

PROCESSING

Of the original 2.113g of 71575,0, a total of 1.22g remains. 71575,3 was used for INAA, and thin section ,6 was taken from this irradiated sample.

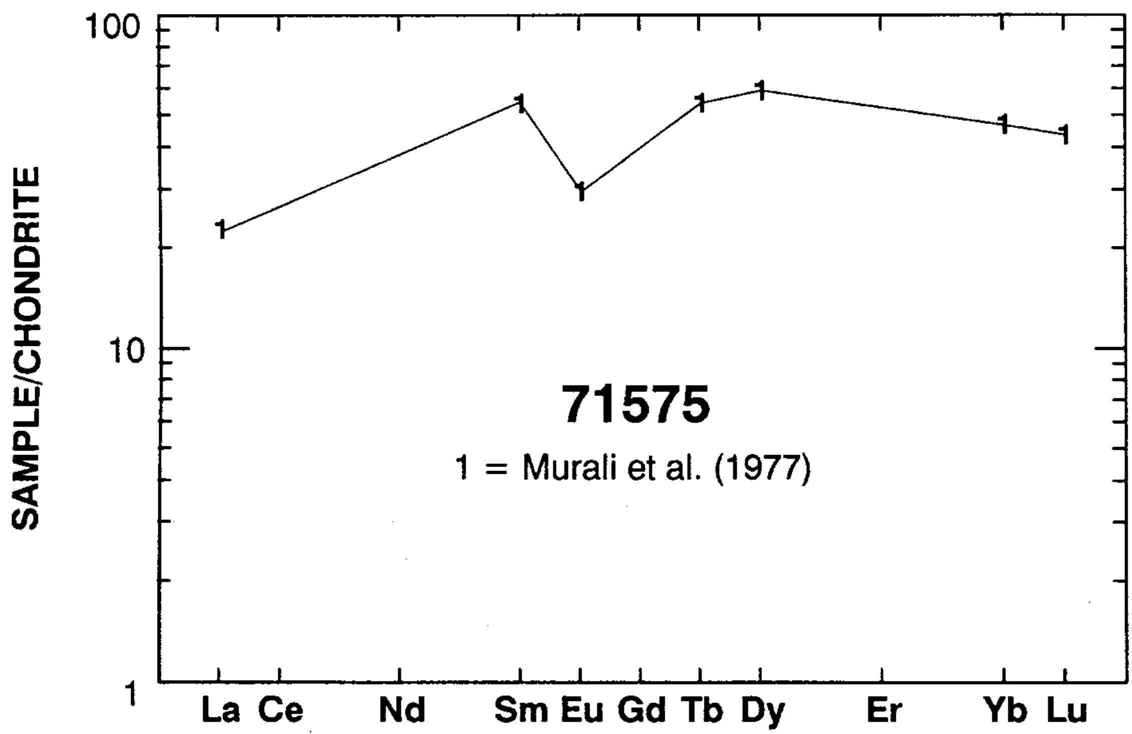


Figure 2: Chondrite-normalized rare-earth element profile of 71575. Data from Murali et al. (1977).

Table 1: Whole-rock chemistry of 71575.
Data from Murali et al. (1977).

	71575,3		71575,3
SiO_2 (wt %)		Cu	
TiO_2	12.4	Ni	
Al_2O_3	9.0	Co	18.2
Cr_2O_3	0.439	V	111
FeO	20.4	Sc	73
MnO	0.221	La	7.4
MgO	7.6	Ce	(46)
CaO	10.0	Nd	
Na_2O	0.40	Sm	10.8
K_2O	0.068	Eu	2.24
P_2O_5		Gd	
S		Tb	3.1
Nb (ppm)		Dy	20
Zr		Er	
Hf	10.9	Yb	10.1
Ta	1.9	Lu	1.45
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

71576
High-Ti Mare Basalt
23.54 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1978) reported the petrography and mineral chemistry of 71576. During the preparation of this catalog, we examined thin section 71576,3 and found it to be a fine- to medium-grained (average grain size ~ 0.2-0.3mm) basalt. It is dominated by "bow-tie" intergrowths of plagioclase and pyroxene. Some areas contain much opaque interstitial glass. Better-crystallized areas contain pink-brown, blocky pyroxene. Subhedral olivine phenocrysts (up to 0.6mm) are present, along with ilmenites up to 1.5mm long. The ilmenite phenocrysts contain armalcolite cores. Ilmenite generally exhibits rutile and chromite exsolution lamellae. These are not present in the armalcolite. Native Fe and troilite (<0.1mm) form interstitial phases and are disseminated throughout.

WHOLE-ROCK CHEMISTRY

Murali et al. (1977) reported the whole-rock composition of 71576,1 in a study of Apollo 17 rake samples (Table 1). 71576 is classified as a Type B2 Apollo 17 high-Ti basalt based on the whole-rock classification of Rhodes et al. (1976) and Warner et al. (1979), plus the criteria of Neal et al. (1990). This sample contains 11.8 wt% TiO_2 with a MG# of 37.7. The REE profile (Fig. 2) flat, except for La. However, the uncertainties associated with analyzing Ce by

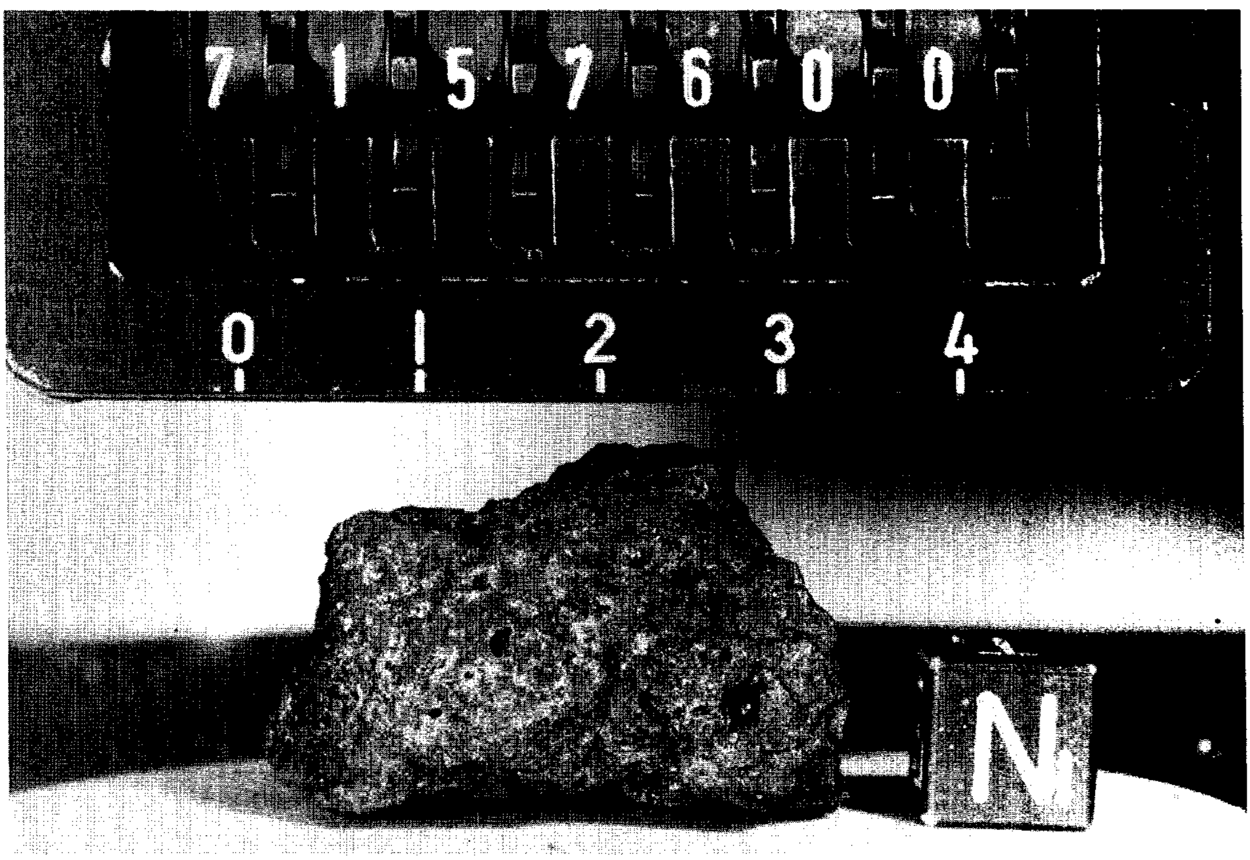


Figure 1: Hand specimen photograph of 71576,0. Cubic scale = 1cm³.

INA, coupled with the overall LREE-depleted nature of Apollo 17 high-Ti basalts, suggests that the 31 ppm Ce quoted by Murali et al. (1977) is probably a maximum. In reality, this value is probably lower. The HREE are relatively flat at approximately 35 times chondritic levels (Fig. 2). A negative Eu anomaly is present [$(Eu/Eu^*)_N = 0.59$].

ISOTOPE CHEMISTRY

Paces et al. (1991) reported whole-rock Rb-Sr and Sm-Nd data for 71576,4 (Tables 2 and 3). 71576 was studied as part of a larger isotopic investigation of the Apollo 17 high-Ti basalts.

PROCESSING

Of the original 23.54g of 71575,0, a total of ~23.19g remains. 71575,1 was used for INAA and the thin section ,3 was taken from this irradiated sample.

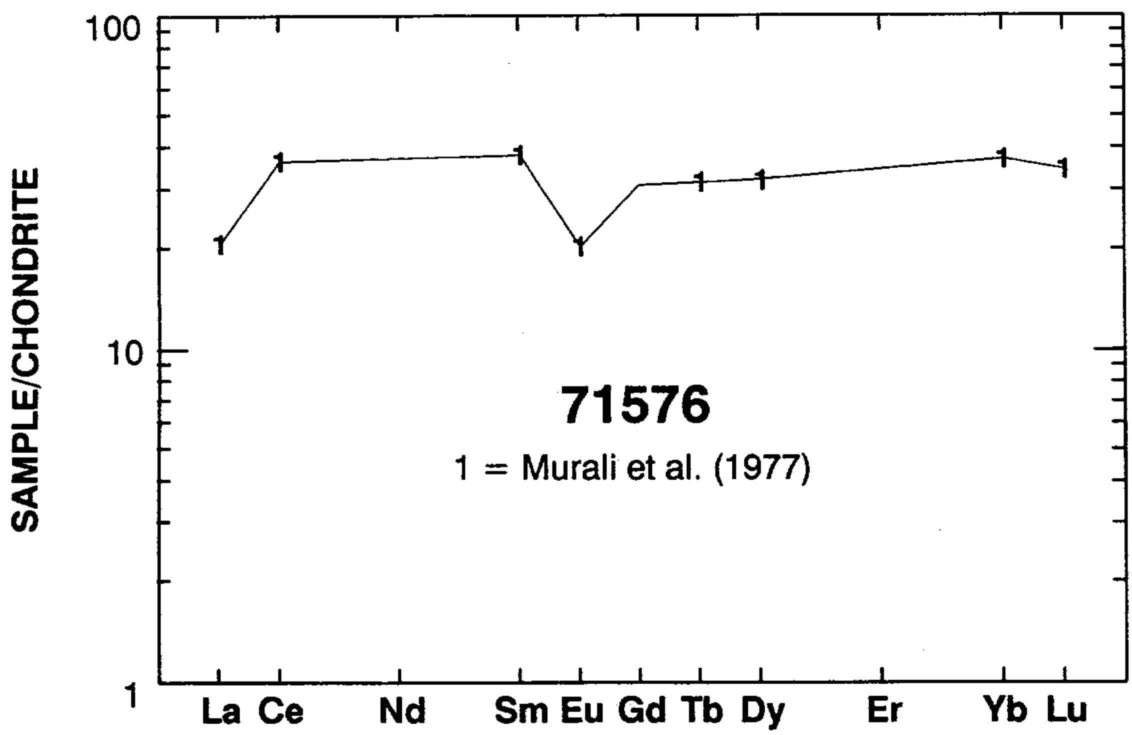


Figure 2: Chondrite-normalized rare-earth element profile of 71576. Data from Murali et al. (1977).

Table 1: Whole-rock chemistry of 71576.
Data from Murali et al. (1977).

	Sample 71576,1 Method N		Sample 71576,1 Method N
SiO_2 (wt %)		Cu	
TiO_2	11.8	Ni	
Al_2O_3	8.9	Co	19.2
Cr_2O_3	0.335	V	85
FeO	20.0	Sc	80
MnO	0.242	La	6.7
MgO	6.8	Ce	31
CaO	10.6	Nd	
Na_2O	0.39	Sm	7.6
K_2O	0.053	Eu	1.54
P_2O_5		Gd	
S		Tb	1.8
Nb (ppm)		Dy	12
Zr		Er	
Hf	7.0	Yb	8.0
Ta	1.5	Lu	1.15
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

Table 2: Rb-Sr data for 71576,4.
Data from Paces et al. (1991).

Rb (ppm)	0.382
Sr (ppm)	127
$^{87}Rb/^{86}Sr$	0.008658 ± 86
$^{87}Sr/^{86}Sr$	0.699669 ± 13
I(Sr)[a]	0.699203 ± 18
T_{LUNI}[b](Ga)	5.1

[a]Initial Sr isotopic ratios calculated at 3.69 Ga using ^{87}Rb decay constant = $1.42 \times 10^{-11} yr^{-1}$.

[b]Model age relative to I(Sr) = LUNI = 0.69903 (Nyquist et al., 1974; Shih et al., 1986).
$T_{LUNI} = 1/\lambda * \ln[((^{87}Sr/^{86}Sr - 0.69903)^{87}Rb/^{86}Sr) + 1]$.

Table 3: Sm-Nd data for 71576,4.
Data from Paces et al. (1991).

Sm (ppm)	7.25
Nd (ppm)	18.2
$^{147}Sm/^{144}Nd$	0.24154 ± 48
$^{143}Nd/^{144}Nd$	0.513996 ± 9
I(Nd)[a]	0.508096 ± 21
ε_{Nd}[b]	5.2 ± 0.4
T_{CHUR}[c](Ga)	4.6

[a]Initial Nd isotopic ratios calculated at 3.69 Ga using ^{147}Sm decay constant = $6.54 \times 10^{-12} yr^{-1}$.

[b]Initial ε_{Nd} calculated at 3.69 Ga using present-day chondritic values of $^{143}Nd/^{144}Nd$ = 0.512638 and $^{147}Sm/^{144}Nd$ = 0.1967.

[c]Model age relative to CHUR reservoir using present-day chondritic values listed above.
$T_{CHUR} = 1/\lambda*[((^{143}Nd/^{144}Nd - 0.512638)/(^{147}Sm/^{144}Nd - 0.1967)) + 1]$.

71577
High-Ti Mare Basalt
234.7 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1975bc, 1976ab, 1978) reported the petrography and mineral chemistry of 71577. Warner et al. (1975c) described 71577 as a microporphyritic ilmenite basalt, but only described it in general terms within the context of this petrographic group. During the preparation of this catalog, we examined thin section 71577,12 and found it to be a fine- to medium-grained (0.05-0.35mm) basalt. Olivine phenocrysts (up to 0.7mm) are reasonably euhedral with occasional embayments. Euhedral chromite inclusions (~0.005mm) are found in the olivines. Plagioclase-pyroxene "bow-tie" intergrowths are occasionally present (Fig. 2). Ilmenite also forms a phenocryst phase (Fig. 2), but is generally smaller than olivine (maximum = 0.5mm). However, ilmenite is more commonly a groundmass phase. Rare rutile and chromite exsolution is seen in the ilmenite. Minor opaque glass is associated with ilmenite. Native Fe and troilite (<0.1mm) are usually, but not exclusively, associated with ilmenite. Small (~0.05mm) areas of interstitial glass are conspicuous. No armalcolite was observed.

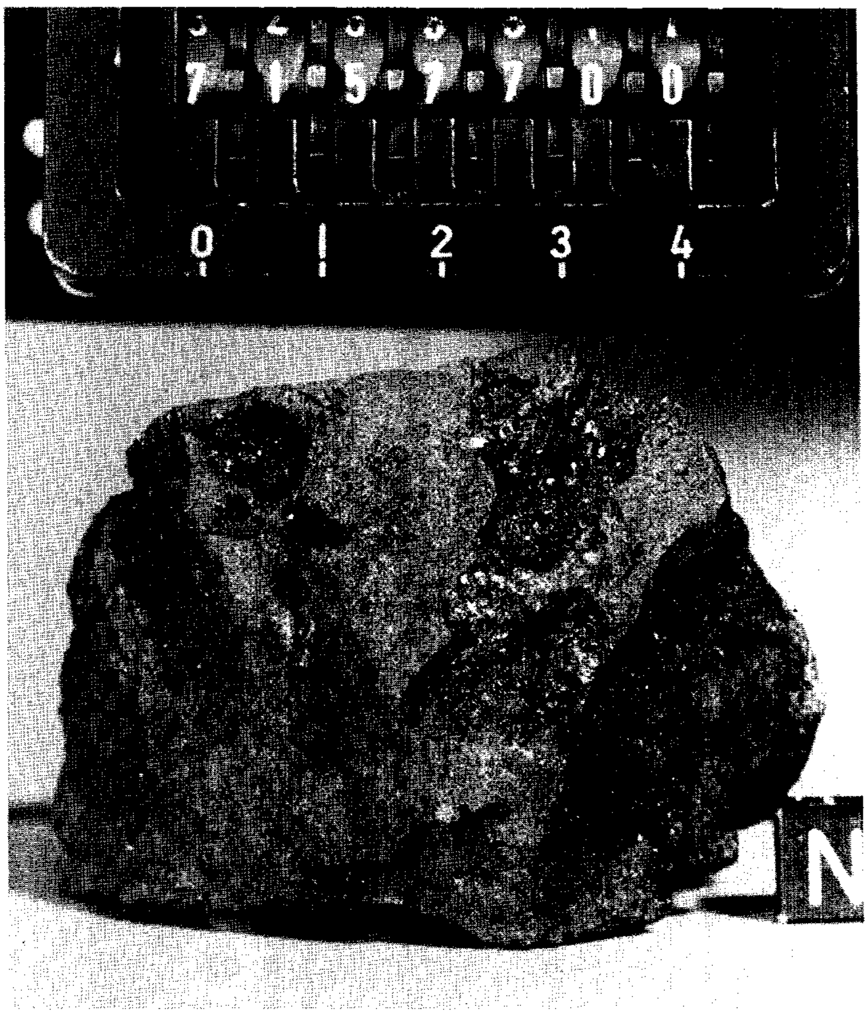


Figure 1: Hand specimen photograph of 71577,0. Cubic scale = 1cm³.

WHOLE-ROCK CHEMISTRY

Laul et al. (1975) and Warner et al. (1975) reported the same whole-rock analysis of 71577,1 in a study of Apollo 17 rake samples (Table 1). These authors reported a TiO_2 content of 12.8 wt%, with a MG# of 41.9. Rhodes et al. (1976) classified 71577,4 as a Type A Apollo 17 high-Ti basalt and reported a TiO_2 content of 12.04 wt% for 71577,4, with a MG# of 43.5. Both REE patterns are LREE depleted with a maximum in the MREE (Fig. 3). The analysis of Rhodes et al. (1976) is more complete and reported lower LREE but higher middle and heavy REE abundances than that of Warner et al. (1975) and Laul et al. (1975) (Table 1; Fig. 3). Both profiles exhibit a decrease in HREE over the MREE and have negative Eu anomalies (Fig. 3). The profile of Warner et al. (1975) and Laul et al. (1975) exhibits $(Eu/Eu^*)_N$ = 0.57, compared to a value of 0.49 defined by the analysis of Rhodes et al. (1976). Gibson et al. (1976) reported a sulfur content of 1880 $\pm$ 20 μgS/g for 71577 with an equivalent of 0.121 wt% Fe^o.

RADIOGENIC ISOTOPES

Nyquist et al. (1976) reported the whole-rock Rb-Sr composition of 71577,4 (Table 2). This analysis was undertaken as part of a large study of the Rb-Sr compositions of Apollo 17 high-Ti basalts.

PROCESSING

Of the original 234.7g of 71577,0, a total of 230.8g remains. 71577,4 weighs 1.34g and ,1 was used for INAA. 71577,1 has been renumbered to ,9001, and thin section ,12 has been taken from this irradiated sample. Three other thin sections have been made - ,8, ,9, ,10.

Figure 2: Photomicrograph of 71577,8. Olivine and ilmenite phenocrysts (sawtooth margins are present). Phenocrysts are set in a sub-variolitic to variolitic groundmass. Field of view = 2.5 mm.

Table 1: Whole-rock chemistry of 71577.

	Sample ,1 Method N Reference 1	Sample ,4 Method X,N,I Reference 2		Sample ,1 Method N Reference 1	Sample ,4 Method X,N,I Reference 2
SiO_2 (wt %)		39.18	Cu		
TiO_2	12.8	12.04	Ni		
Al_2O_3	8.8	8.92	Co	20.6	18.4
Cr_2O_3	0.460	0.41	V	110	
FeO	20.5	18.90	Sc	79	81
MnO	0.256	0.28	La	6.8	6.9
MgO	8.3	8.15	Ce	28	23.8
CaO	10.4	10.95	Nd	28	26.5
Na_2O	0.44	0.39	Sm	10.4	11.0
K_2O	0.070	0.06	Eu	2.14	2.17
P_2O_5		0.05	Gd		16.8
S		0.17	Tb	2.6	
K (ppm)		583	Dy	18	19.5
Nb			Er		11.4
Zr			Yb	9.3	10.4
Hf	9.2	10.4	Lu	1.4	1.43
Ta	1.7		Ga		
U			F		
Th			Cl		
W			C		
Y			N		
Sr			H		
Rb		0.64	He		
Li		10.4	Ge (ppb)		
Ba		83.9	Ir		
Cs			Au		
Be			Ru		
Zn			Os		
Pb					

Analysis by: N = INAA; X = XRF; I = Isotope dilution.

References: 1 = Warner et al. (1975) and Laul et al. (1975) (same analysis); 2 = Rhodes et al. (1976).

Table 2: Rb-Sr composition of 71577.
Data from Nyquist et al. (1976).

Sample	71577,9
wt (mg)	59
Rb (ppm)	0.637
Sr (ppm)	191
$^{87}Rb/^{86}Sr$	0.0096 ± 2
$^{87}Sr/^{86}Sr^{b}$	0.69967 ± 5
T_B	4.15 ± 0.45
T_L	4.64 ± 0.46

b = Uncertainties correspond to last two figures and are 2 sigma - normalized to $^{88}Sr/^{86}Sr$ = 8.37521; B = Model age assuming I = 0.69910 (BABI + JSC bias); L = Model age assuming I = 0.69903 (Apollo 16 anorthosites for T = 4.6 Ga).

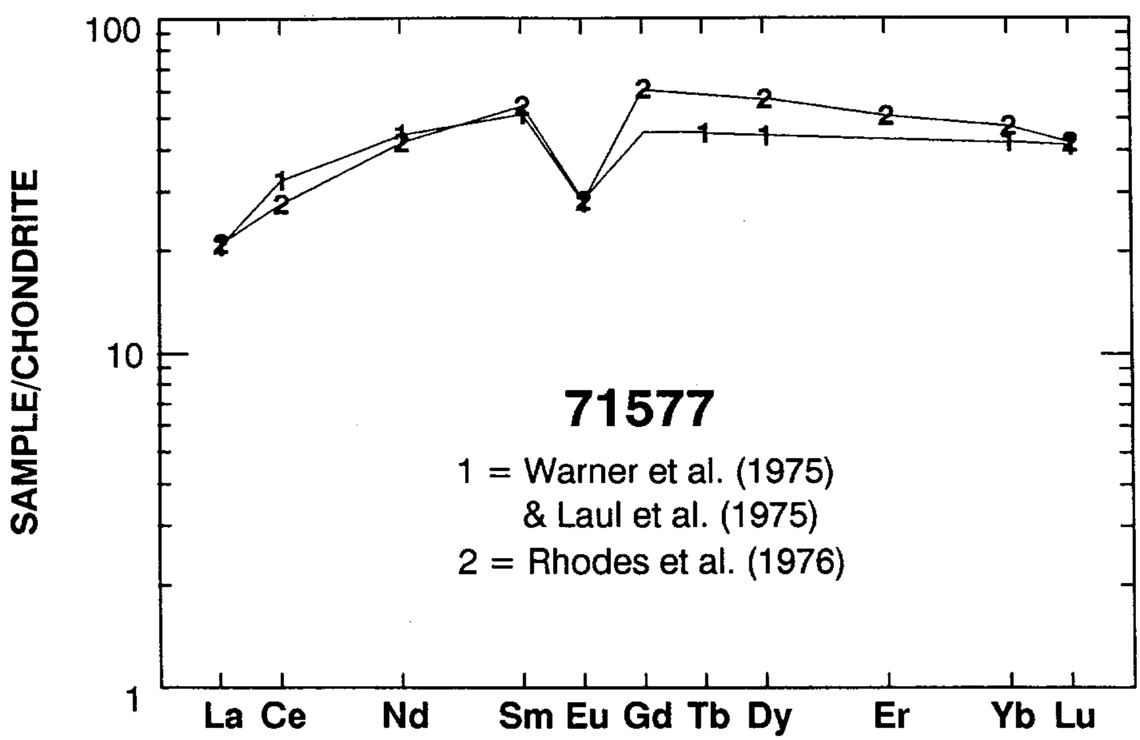


Figure 3: Chondrite-normalized rare-earth element profile of 71577. The same analysis was reported by Warner et al. (1975) and Laul et al. (1975). A second analysis is from Rhodes et al. (1976).

71578
High-Ti Mare Basalt
353.9 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1975bc, 1976ab, 1978) reported the petrography and mineral chemistry of 71578. Warner et al. (1975c) described 71578 as a microporphyritic ilmenite basalt, but only described it in general terms within the context of this petrographic group. During the preparation of this catalog, we examined thin section 71578,5 and found it to be a medium-grained (0.2-0.5mm) basalt (Fig. 2). 71578,5 contains two textural domains: 1) "bow-tie" intergrowths of plagioclase and pyroxene and 2) blocky areas dominated by pink pyroxene (up to 0.5mm), some containing rounded olivine cores (<0.1mm). Olivine is also present as microphenocrysts (up to 0.7mm) (Fig. 2). Ilmenite is present in the groundmass, but phenocrysts reach up to 1mm with "sawtooth" margins (Fig. 2). Minor exsolution of rutile and chromite was observed. Native Fe and troilite (<0.05mm) are disseminated throughout. No armalcolite was observed.

WHOLE-ROCK CHEMISTRY

Laul et al. (1975) and Warner et al. (1975) reported the same whole-rock analysis of 71578,1 in a study of Apollo 17 rake samples (Table 1). Based on the whole-rock classification of Rhodes et al. (1976) and Warner et al. (1979), 71578 is classified as a Type A Apollo 17 high-Ti basalt. These authors reported a TiO_2 content of 11.7 wt%, with a MG# of 43.7. The REE profile (Fig. 3) is LREE depleted with a maximum in the MREE. A

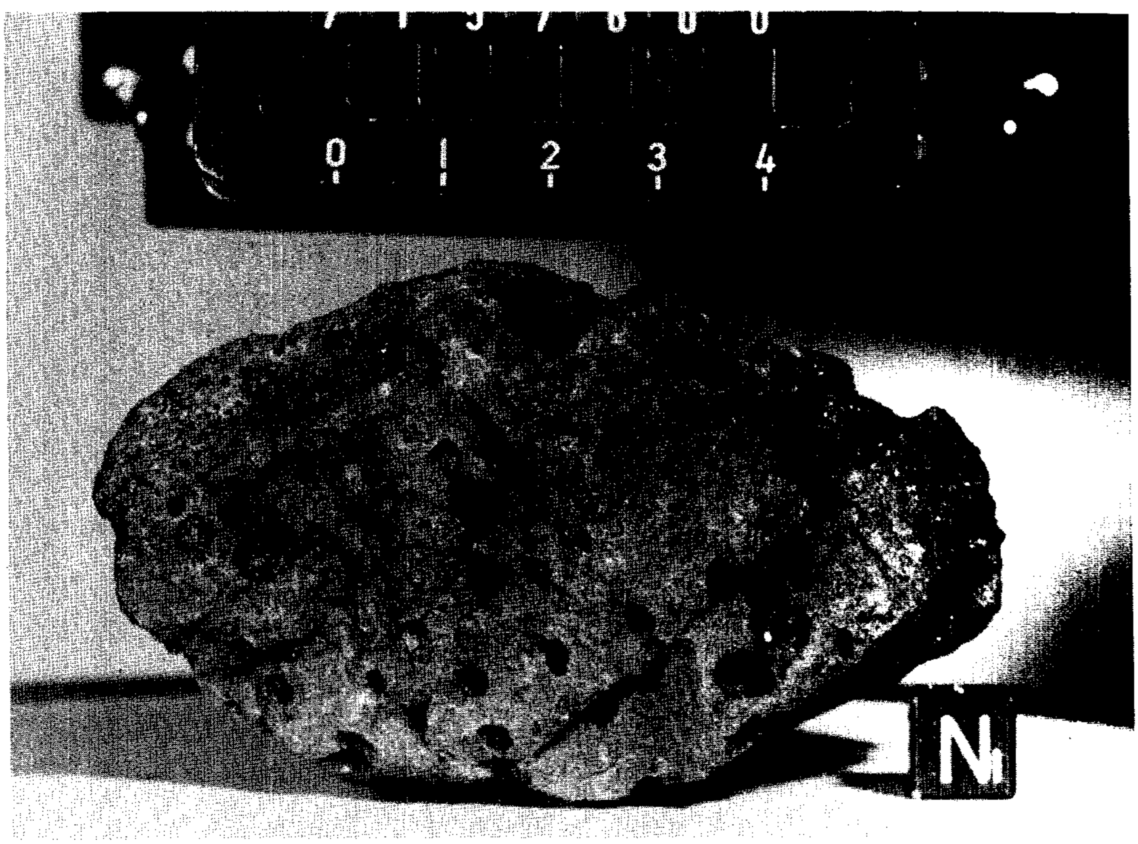


Figure 1: Hand specimen photograph of 71578,0. Cubic scale = 1cm³.

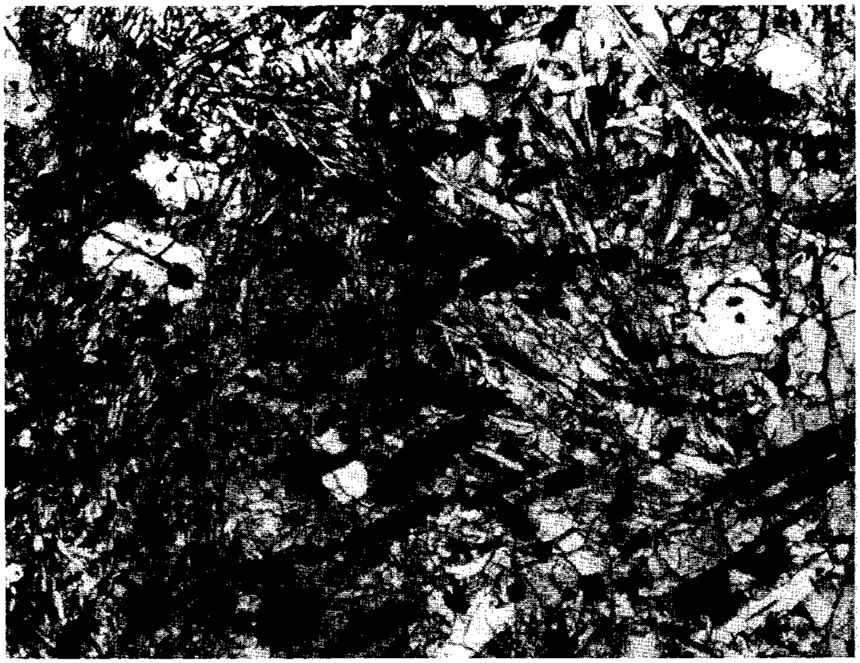


Figure 2: Photomicrograph of 71578,5. Olivine and ilmenite microphenocrysts are set in a sub-variolitic to variolitic groundmass. Blocky areas are dominated by pyroxene. Field of view = 2.5 mm.

negative Eu anomaly is present [$(Eu/Eu^*)_N = 0.56$].

PROCESSING

Of the original 353.9g of 71578,0, a total of 352.7g remains. 71578,1 was used for INAA and has since been renumbered to ,9001. Thin section ,5 was taken from this irradiated sample.

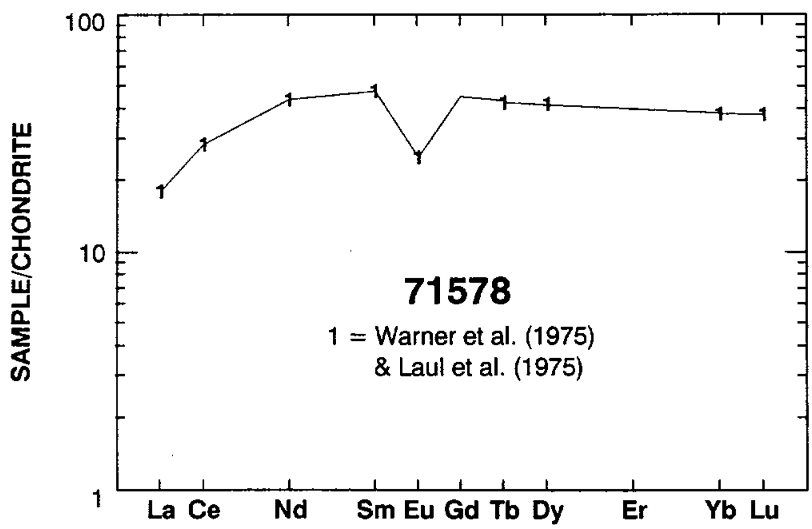


Figure 3: Chondrite-normalized rare-earth element profile of 71578. The same analysis was reported by Warner et al. (1975) and Laul et al. (1975).

Table 1: Whole-rock chemistry of 71578.
Data from Laul et al. (1975) and Warner et al. (1975) (same analysis).

	Sample ,1 Method N		Sample ,1 Method N
SiO_2 (wt %)		Cu	
TiO_2	11.7	Ni	
Al_2O_3	8.4	Co	18.5
Cr_2O_3	0.420	V	100
FeO	18.6	Sc	74
MnO	0.240	La	6.0
MgO	8.1	Ce	25
CaO	9.5	Nd	28
Na_2O	0.42	Sm	9.8
K_2O	0.070	Eu	1.96
P_2O_5		Gd	
S		Tb	2.5
K (ppm)		Dy	17
Nb		Er	
Zr		Yb	8.5
Hf	8.9	Lu	1.3
Ta	1.6	Ga	
U		F	
Th		Cl	
W		C	
Y		N	
Sr		H	
Rb		He	
Li		Ge (ppb)	
Ba		Ir	
Cs		Au	
Be		Ru	
Zn		Os	
Pb			

Analysis by: N = INAA.

71579
High-Ti Mare Basalt
7.94 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1978) reported the petrography and mineral chemistry of 71579. During the preparation of this catalog, we examined thin section 71579,3 and found it to be a fine- to medium-grained (0.1-0.4mm) basalt (Fig. 2). It is dominated by "bow-tie" intergrowths of plagioclase and pyroxene. Pyroxene also occurs as blocky masses. Corroded olivine phenocrysts (0.7mm) with pyroxene rims are present (Fig. 2). The olivines contain subhedral chromite inclusions (~0.005mm). Ilmenite phenocrysts (up to 1mm) contain "sawtooth" margins (Fig. 2) and also form a groundmass phase. Rutile and chromite exsolution is present in the ilmenites. Native Fe and troilite (<0.1mm) are disseminated throughout. Minor interstitial SiO_2 (~0.1mm) is associated with ilmenite.

WHOLE-ROCK CHEMISTRY

Murali et al. (1977) reported the whole-rock composition of 71579,1 in a study of Apollo 17 rake samples (Table 1). 71579 is classified as a Type B2 Apollo 17 high-Ti basalt, based on the classification of Rhodes et al. (1976) and Warner et al. (1979), plus the criteria of Neal et al. (1990). This sample contains 12.1 wt% TiO_2, with a MG# of 39.7. The REE profile (Fig. 3) is LREE-depleted. However, Murali et al. (1977) reported 33 ppm Ce, but in parentheses - inclusion of Ce in the profile would give 71579 a positive Ce anomaly. We have not included Ce in Fig. 3, as the uncertainties associated with analyzing Ce by INA, coupled with the overall LREE-depleted nature of Apollo 17 high-Ti basalts, suggests that the 33 ppm Ce quoted by Murali et al. (1977) is probably a maximum. In reality, this value must be lower. The HREE are generally flat at 32-34 times chondritic levels. A negative Eu anomaly is present [$(Eu/Eu^*)_N$ = 0.57].

Figure 1: Hand specimen photograph of 71579,0. Small divisions on scale are in millimeters.

Figure 2: Photomicrograph of 71579,3. Ilmenite and olivine phenocrysts are set in a variolitic groundmass. Field of view = 2.5 mm.

PROCESSING

Of the original 7.94g of 71579,0, approximately 7.52g remains. 71579,1 was used for INAA and the thin section ,3 was taken from this irradiated sample.

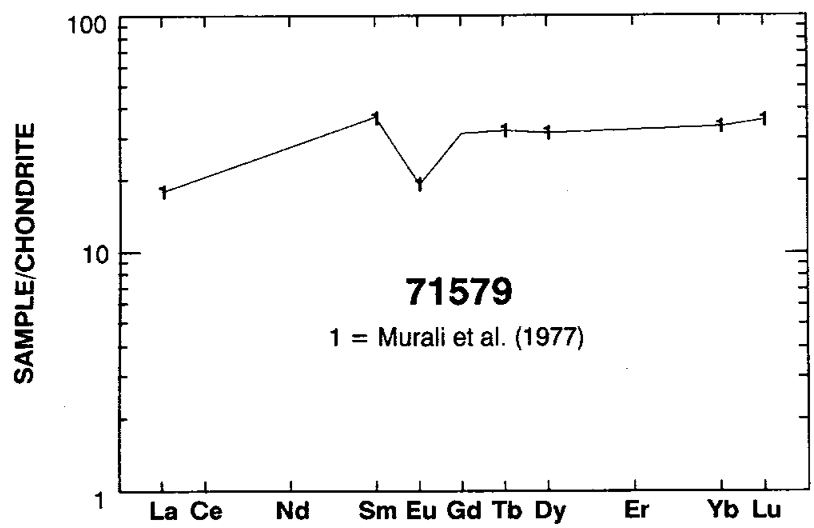


Figure 3: Chondrite-normalized rare-earth element profile of 71579. Data from Murali et al. (1977).

Table 1: Whole-rock chemistry of 71579.
Data from Murali et al. (1977).

	Sample 71579,1 Method N		Sample 71579,1 Method N
SiO_2 (wt %)		Cu	
TiO_2	12.1	Ni	
Al_2O_3	8.9	Co	20.1
Cr_2O_3	0.358	V	88
FeO	20.6	Sc	82
MnO	0.245	La	6.0
MgO	7.6	Ce	(33)
CaO	9.3	Nd	
Na_2O	0.40	Sm	7.5
K_2O	0.053	Eu	1.50
P_2O_5		Gd	
S		Tb	1.9
Nb (ppm)		Dy	11
Zr		Er	
Hf	7.1	Yb	7.5
Ta	1.5	Lu	1.23
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

71585
High-Ti Mare Basalt
13.86 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1975bc, 1976ab, 1978) reported the petrography and mineral chemistry of 71585. Warner et al. (1975c) described 71585 as a microporphyritic ilmenite basalt, but only described it in general terms within the context of this petrographic group. During the preparation of this catalog, we examined thin section 71585,6 and found it to be a fine- to medium-grained (0.1-0.4mm), sub-ophitic basalt. It is comprised of "bow-tie" intergrowths of plagioclase and pyroxene as well as areas of blocky, pink/brown pyroxene. Rare plagioclase laths extend up to 0.6mm. Ilmenite (up to 1mm) and olivine (up to 0.8mm) phenocrysts are present, olivine containing euhedral chromite inclusions (~0.005mm). Olivines are corroded and usually have a pyroxene reaction rim. Minor interstitial, opaque glass is associated with ilmenite and ilmenite contains very fine (~0.002mm) chromite and rutile exsolution lamellae. Native Fe (0.05-0.1mm) is usually associated with ilmenite, but troilite (up to 0.2mm) is disseminated throughout. Minor interstitial SiO_2 is conspicuous (~0.1mm). No armalcolite was identified.

WHOLE-ROCK CHEMISTRY

Warner et al. (1975) reported the whole-rock composition of 71585,4 in a study of Apollo 17 rake samples (Table 1). 71585 is classified as a Type B2 Apollo 17 high-Ti basalt, based on the classification of Rhodes et al. (1976) and Warner et al. (1979),

Figure 1: Hand specimen photograph of 71585,0. Small divisions on scale are in millimeters.

Table 1: Whole-rock chemistry of 71585.
Data from Warner et al. (1975).

	Sample 71585,4 Method N		Sample 71585,4 Method N
SiO_2 (wt %)		Cu	
TiO_2	11.1	Ni	
Al_2O_3	9.4	Co	22.0
Cr_2O_3	0.478	V	120
FeO	20.2	Sc	81
MnO	0.243	La	5.9
MgO	7.2	Ce	24
CaO	10.6	Nd	
Na_2O	0.33	Sm	7.1
K_2O	0.045	Eu	1.55
P_2O_5		Gd	
S		Tb	1.9
Nb (ppm)		Dy	11
Zr		Er	
Hf	7.2	Yb	7.0
Ta	1.7	Lu	1.1
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Eu	
Pb		Os	

Analysis by: N = INAA.

plus the criteria of Neal et al. (1990). This sample contains 11.1 wt% TiO_2, with a MG# of 44.8. The REE profile (Fig. 2) is LREE-depleted with a maximum at Sm. The HREE are approximately constant at 32 times chondritic abundances. A negative Eu anomaly is present $[(Eu/Eu^*)_N = 0.60]$.

PROCESSING

Of the original 13.86g of 71585,0, a total of 12.29g remains. 71585,4 was subdivided into ,9001 which was irradiated for INAA, and ,6 for a thin section.

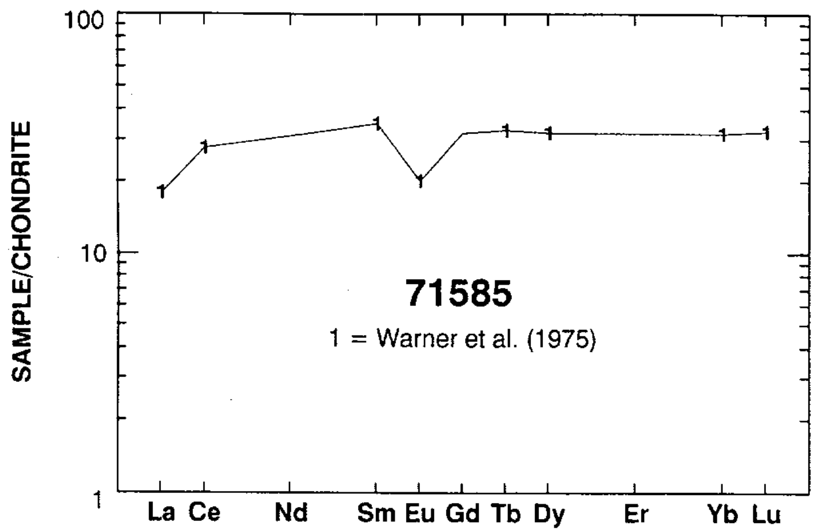


Figure 2: Chondrite-normalized rare-earth element profile of 71585. Data from Warner et al. (1975).

71586
High-Ti Mare Basalt
26.92 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1978) reported the petrography and mineral chemistry of 71586. During the preparation of this catalog, we examined thin section 71586,4 and found it to be a fine- to medium-grained (0.1-0.35mm) basalt. 71586 is comprised of plagioclase-pyroxene "bow-tie" intergrowths (Fig. 2). It contains olivine microphenocrysts (up to 0.6mm - Fig. 2) all of which exhibit resorption features and minor pink pyroxene overgrowths. The olivines contain euhedral chromite inclusions (~0.005mm). Ilmenite phenocrysts reach up to 1.5mm and overlay the plagioclase-pyroxene groundmass, but not the olivine phenocrysts (Fig. 2). These ilmenite phenocrysts have "sawtooth" margins. Ilmenite also forms a minor groundmass phase. Both groundmass and phenocryst ilmenite contain minor rutile and chromite exsolution. No armalcolite was observed.

WHOLE-ROCK CHEMISTRY

Murali et al. (1977) reported the whole-rock composition of 71586,1 in a study of Apollo 17 rake samples (Table 1). Based on the classification of Rhodes et al. (1976) and Warner et al. (1979), as well as the criteria of Neal et al. (1990), 71586 is classified as a Type B2 Apollo17 high-Ti basalt. This sample contains 10.5 wt% TiO_2 with a MG# of 42.9. The REE profile (Fig. 3) is LREE-depleted, but Ce has not been included. Murali et al. (1977) reported 38 ppm Ce, but in parentheses, and inclusion of it in this profile would produce a positive Ce anomaly. The high uncertainties associated with analyzing Ce by INA, coupled with the overall LREE-depleted nature of Apollo 17 high-Ti basalts, suggests that the 38 ppm Ce quoted by Murali et al. (1977) is probably spurious. In reality, this value is probably lower. The HREE are flat at approximately 33 times chondritic abundances (Fig. 3). A negative Eu anomaly is present $[(Eu/Eu^*)_N = 0.56]$.

PROCESSING

Of the original 26.92g of 71586,0, a total of 26.53g remains. 71586,1 was used for INAA, and thin section ,4 was taken from this irradiated sample.

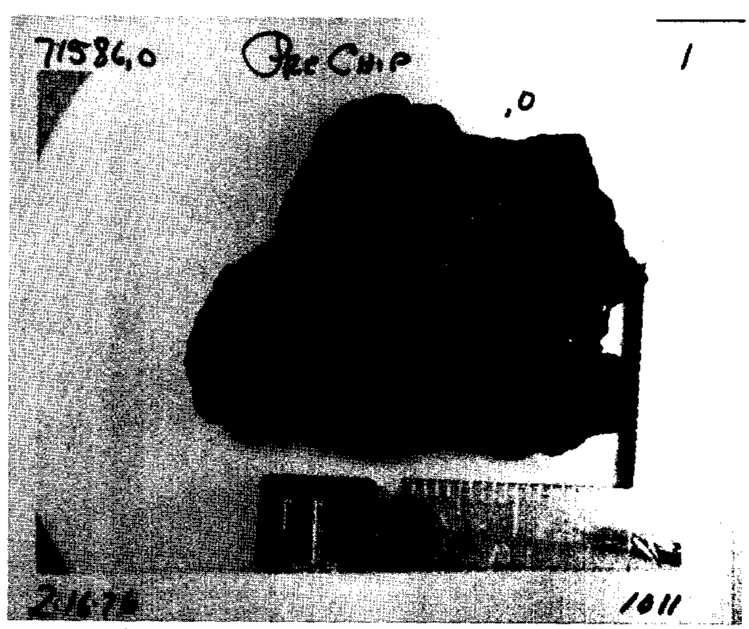


Figure 1: Hand specimen photograph of 71586,0. Small divisions on scale are in millimeters.

Figure 2: Photomicrographs of 71586,4. Olivine microphenocrysts have a reaction rim of pyroxene. Ilmenite phenocrysts have sawtooth margins. These are set in a variolitic groundmass. Field of view is 2.5 mm.

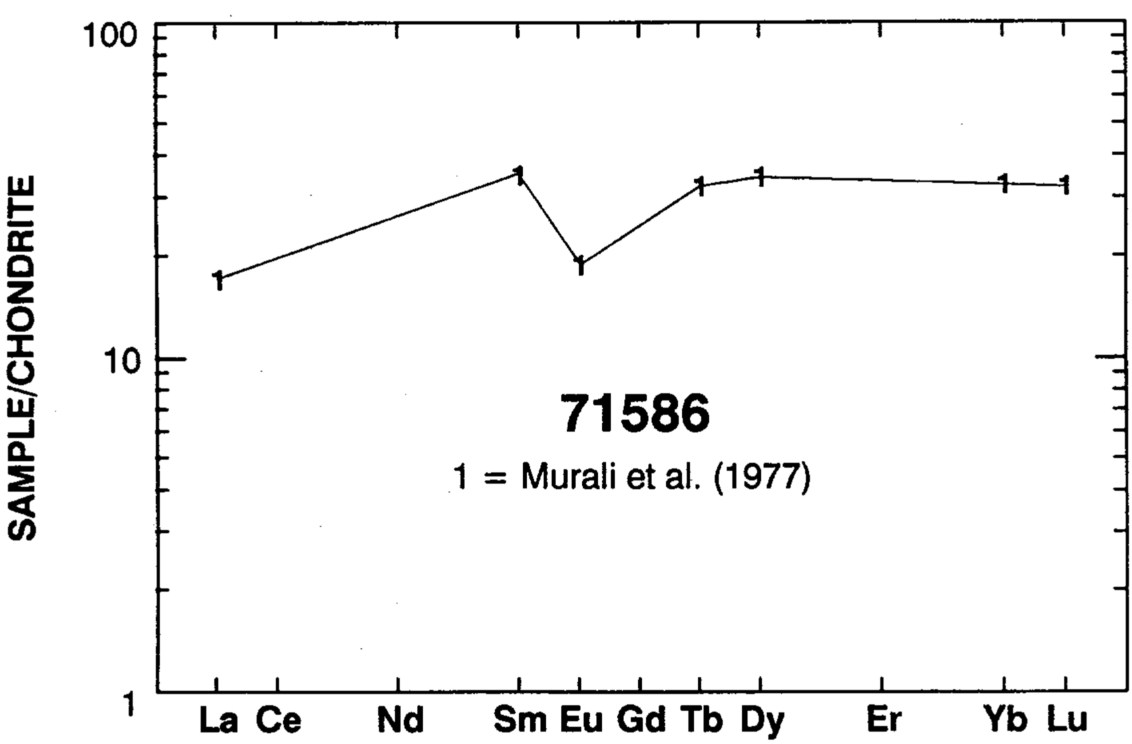


Figure 3: Chondrite-normalized rare-earth element profile of 71586. Data from Murali et al. (1977).

Table 1: Whole-rock chemistry of 71586.
Data from Murali et al. (1977).

	Sample 71586,1 Method N		Sample 71586,1 Method N
SiO_2 (wt %)		Cu	
TiO_2	10.5	Ni	
Al_2O_3	9.2	Co	22.3
Cr_2O_3	0.486	V	131
FeO	19.7	Sc	75
MnO	0.248	La	5.7
MgO	8.3	Ce	(38)
CaO	9.3	Nd	
Na_2O	0.33	Sm	7.2
K_2O	0.044	Eu	1.47
P_2O_5		Gd	
S		Tb	1.9
Nb (ppm)		Dy	12
Zr		Er	
Hf	7.0	Yb	7.3
Ta	1.3	Lu	1.11
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Eu	
Pb		Os	

Analysis by: N = INAA.

71587
High-Ti Mare Basalt
41.27 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

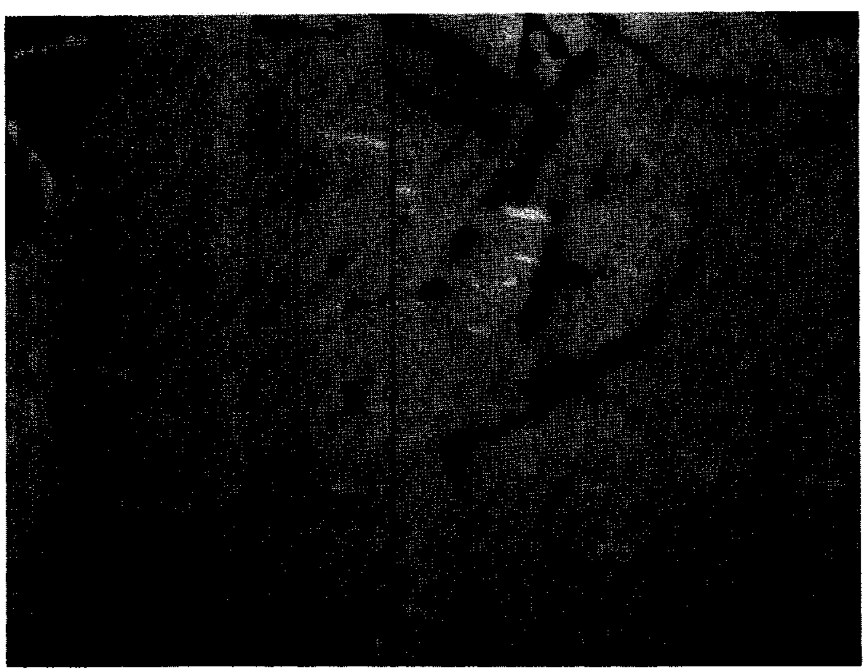
Warner et al. (1975bc, 1976ab, 1978) reported the petrography and mineral chemistry of 71587. Warner et al. (1975c) described 71587 as a microporphyritic ilmenite basalt, but only described it in general terms within the context of this petrographic group. During the preparation of this catalog, we examined thin section 71587,6 and found it to be a fine- to medium-grained (0.1-0.4mm), microporphyritic basalt. It contains olivine and ilmenite microphenocrysts (both up to 0.7mm). Olivines are corroded, and some have minor pink pyroxene overgrowths. Rare euhedral chromite inclusions (~0.005mm) are seen in these olivines. Commonly, the ilmenites contain armalcolite cores (Fig. 2a), as well as rutile and chromite exsolution features. "Bow-tie" intergrowths of plagioclase and pyroxene form the groundmass of this basalt, along with minor ilmenite. Discrete Cr-ulvöspinels are also present (up to 0.3mm) in the groundmass. These contain exsolution blebs of ilmenite (Fig. 2b) and native Fe. Very little native Fe and troilite was observed.

WHOLE-ROCK CHEMISTRY

Laul et al. (1975) and Warner et al. (1975) reported the same whole-rock analysis of 71587,1 in a study of Apollo 17 rake samples (Table 1). This sample is classified as a Type B2 Apollo 17 high-Ti basalt, based on the whole-rock classification of Rhodes et al. (1976) and Warner et al. (1979), plus the

Figure 1: Hand specimen photograph of 71587,0. Small divisions on scale are in millimeters.

2a: Armalcolite core rimmed by ilmenite exhibiting rutile exsolution – field of view = 0.625 mm.



2b: Ilmenite exsolution in ulvöspinel – field of view = 0.625 mm.

Figure 2: Photomicrographs of 71587,6.

criteria of Neal et al. (1990). Laul et al. (1975) and Warner et al. (1975) reported a TiO_2 content of 12.7 wt%, with a MG# of 41.4. The REE profile (Fig. 3) is LREE depleted with a maximum at Sm. The HREE are approximately constant at 33 times chondritic abundances. A negative Eu anomaly is present [$(Eu/Eu^*)_N = 0.52$].

PROCESSING

Of the original 41.27g of 71587,0, approximately 39.72g remains. 71587,1 was used for INAA, and has since been renumbered to ,9001. Thin section ,6 was taken from this irradiated sample.

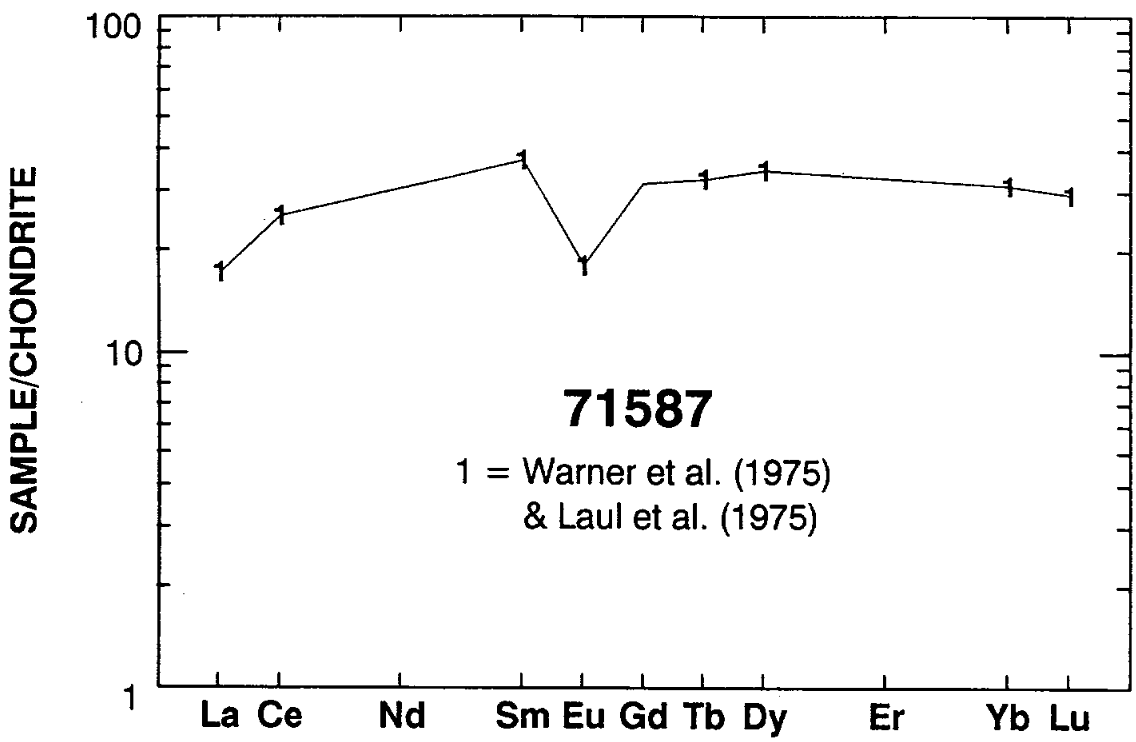


Figure 3: Chondrite-normalized rare-earth element profile of 71587. The same analysis was reported by Warner et al. (1975) and Laul et al. (1975).

Table 1: Whole-rock chemistry of 71587.
Data from Laul et al. (1975) and Warner et al. (1975) (same analysis).

	Sample 71587,1 Method N		Sample 71587,1 Method N
SiO_2 (wt %)		Cu	
TiO_2	12.7	Ni	
Al_2O_3	8.7	Co	20.8
Cr_2O_3	0.405	V	100
FeO	19.2	Sc	80
MnO	0.240	La	5.7
MgO	7.6	Ce	22
CaO	10.3	Nd	
Na_2O	0.39	Sm	7.6
K_2O	0.050	Eu	1.40
P_2O_5		Gd	
S		Tb	1.9
K (ppm)		Dy	12
Nb		Er	
Zr		Yb	6.9
Hf	6.2	Lu	1.0
Ta	5.4	Ga	
U		F	
Th		Cl	
W		C	
Y		N	
Sr		H	
Rb		He	
Li		Ge (ppb)	
Ba		Ir	
Cs		Au	
Be		Ru	
Zn		Os	
Pb			

Analysis by: N = INAA.

71588
High-Ti Mare Basalt
48.98 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1975bc, 1976ab, 1978) reported the petrography and mineral chemistry of 71588. Warner et al. (1975c) described 71588 as a microporphyritic ilmenite basalt, but only described it in general terms within the context of this petrographic group. However, Warner et al. (1975) did report pyroxene compositions (Fig. 2). These range from titanaugite, to pigeonite, toward pyroxferroite. During the preparation of this catalog, we examined thin section 71588,6 and found it to be a medium-grained (0.2-0.4mm), equigranular basalt. It is comprised of blocky, pink pyroxene and plagioclase, although rare "bow-tie" intergrowths of these two minerals are also present. Olivine (0.8-1mm) and ilmenite (up to 1mm) phenocrysts are also present, and ilmenite is also present in the groundmass. One ilmenite reaches ~3mm, but this is unusual. Ilmenite phenocrysts exhibit "sawtooth" margins. Rutile and chromite exsolution lamellae (<0.002mm wide) are present in both phenocryst and groundmass ilmenite. Euhedral chromite inclusions (~0.005mm) are seen in the olivine phenocrysts. Interstitial SiO_2 is conspicuous, forming masses up to 0.15mm. Native Fe and troilite (~0.005mm) are disseminated throughout. No armalcolite was identified.

WHOLE-ROCK CHEMISTRY

Laul et al. (1975) and Warner et al. (1975) reported the same whole-rock analysis of 71588,2 in a study of Apollo 17 rake samples (Table 1). 71588 is classified as a Type B2 Apollo 17 high-Ti basalt, based on the classification of Rhodes et al. (1976) and Warner et al. (1979), plus the criteria of Neal et al. (1990). Laul et al. (1975) and Warner et al. (1975) reported a TiO_2 content of 12.0 wt%, with a MG# of 41.7. The REE profile (Fig. 3) is LREE depleted. The HREE show a decrease from Dy at ~26-28 times chondritic levels. A negative Eu anomaly is present [$(Eu/Eu^*)_N = 0.56$].

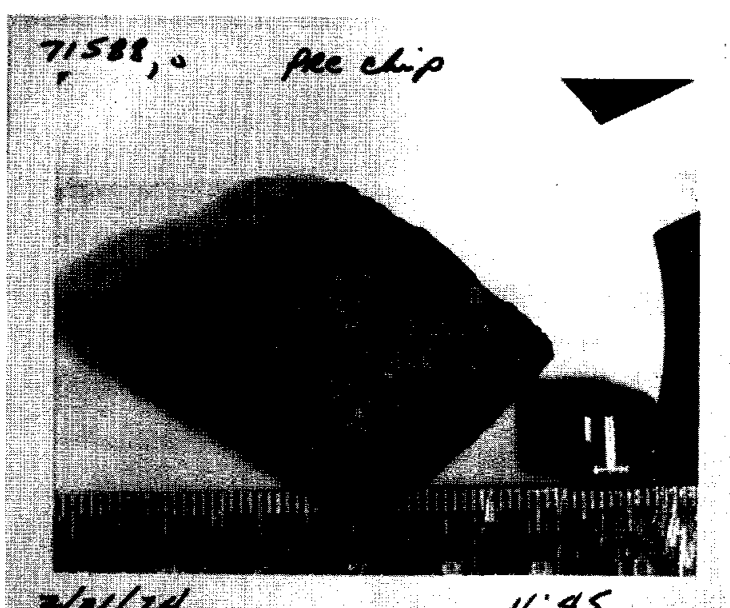


Figure 1: Hand specimen photograph of 71588,0. Small divisions on scale are in millimeters.

PROCESSING

Of the original 48.98g of 71588,0, a total of 47.92g remains. 71588,2 was used for INAA and has since been renumbered to ,9001. Thin section ,6 was taken from this irradiated sample.

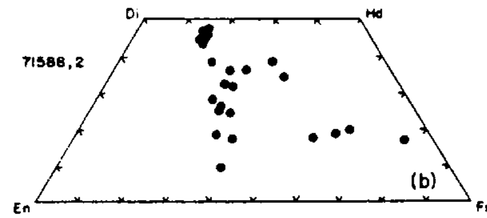


Figure 2: Pyroxene compositions from 71588,2 represented on a pyroxene quadrilateral.

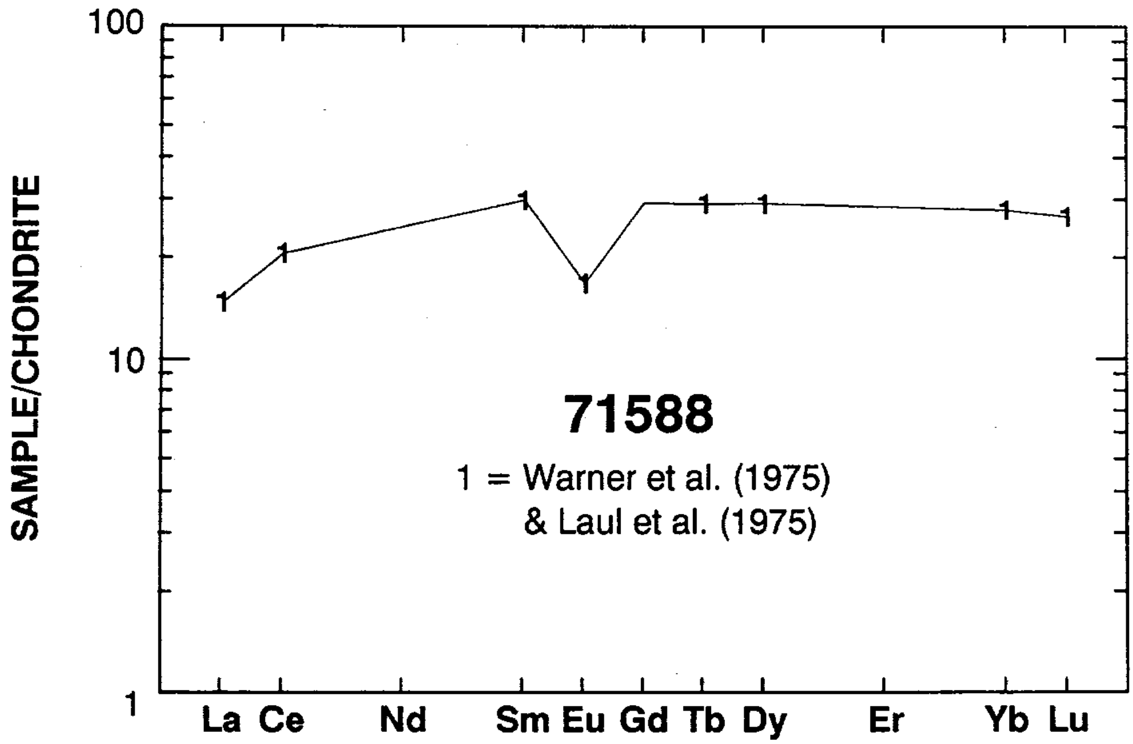


Figure 3: Chondrite-normalized rare-earth element profile of 71588. The same analysis was reported by Warner et al. (1975) and Laul et al. (1975).

Table 1: Whole-rock chemistry of 71588.
Data from Laul et al. (1975) and Warner et al. (1975) (same analysis).

	Sample 71588,2 Method N		Sample 71588,2 Method N
SiO_2 (wt %)		Cu	
TiO_2	12.0	Ni	
Al_2O_3	8.4	Co	23.1
Cr_2O_3	0.419	V	110
FeO	19.9	Sc	79
MnO	0.244	La	4.9
MgO	8.0	Ce	18
CaO	10.1	Nd	
Na_2O	0.35	Sm	6.1
K_2O	0.040	Eu	1.30
P_2O_5		Gd	
S		Tb	1.7
K (ppm)		Dy	11
Nb		Er	
Zr		Yb	6.2
Hf	6.0	Lu	0.91
Ta	1.4	Ga	
U		F	
Th		Cl	
W		C	
Y		N	
Sr		H	
Rb		He	
Li		Ge (ppb)	
Ba		Ir	
Cs		Au	
Be		Ru	
Zn		Os	
Pb			

Analysis by: N = INAA.

71589
High-Ti Mare Basalt
6.86 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1978) reported the petrography and mineral chemistry of 71589. During the preparation of this catalog, we examined thin section 71589,4 and found it to be a fine-grained (0.05-0.25mm) basalt. It is comprised of interwoven "bow-tie" plagioclase-pyroxene intergrowths (Fig. 2). Ilmenite is also present in this groundmass material (Fig. 2), as well as a phenocryst phase (up to 1mm with "sawtooth" margins). Rutile and chromite exsolution lamellae (<0.001mm wide) are present in both groundmass and phenocrystic ilmenite. Corroded olivine microphenocrysts (up to 0.6mm) are mantled by reaction rims of pink pyroxene. These olivines contain euhedral chromite inclusions (~0.005mm) (Fig. 2). Native Fe and troilite (<0.05mm) are disseminated throughout the thin section as interstitial phases. No armalcolite was observed.

WHOLE-ROCK CHEMISTRY

Murali et al. (1977) reported the whole-rock composition of 71589,1 in a study of Apollo 17 rake samples (Table 1). 71589 is classified as a Type B2 Apollo 17 high-Ti basalt, based on the whole-rock classification of Rhodes et al. (1976) and Warner et al. (1979), plus the criteria of Neal et al. (1990). This sample contains 10.7 wt% TiO_2, with a MG# of 41.6. The REE profile (Fig. 3) is LREE-depleted, but Ce has not been included. Murali et al. (1977) reported 37 ppm Ce, but in parentheses, and inclusion of it in this profile would produce a positive Ce anomaly. The high uncertainties associated with analyzing Ce by INA, coupled with the overall LREE-depleted nature of Apollo 17 high-Ti basalts, suggests that the

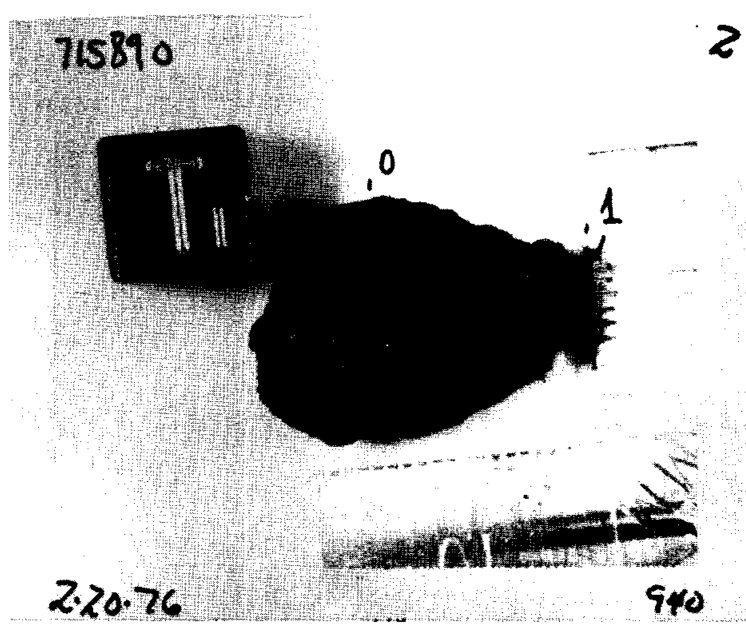


Figure 1: Hand specimen photograph of 71589,0. Small divisions on scale are in millimeters.

Figure 2: Photomicrograph of 71589,4. Olivine and ilmenite phenocrysts set in a sub-variolitic to variolitic ground mass. Field of view = 2.5 mm.

37 ppm Ce quoted by Murali et al. (1977) is probably spurious. In reality, this value is probably lower. The HREE exhibit a slight decrease from Tb and Dy (Fig. 3). A negative Eu anomaly is present [$(Eu/Eu^*)_N = 0.57$].

PROCESSING

Of the original 6.86g of 71589,0, a total of 6.64g remains. 71589,1 was used for INAA, and thin section ,4 was taken from this irradiated sample.

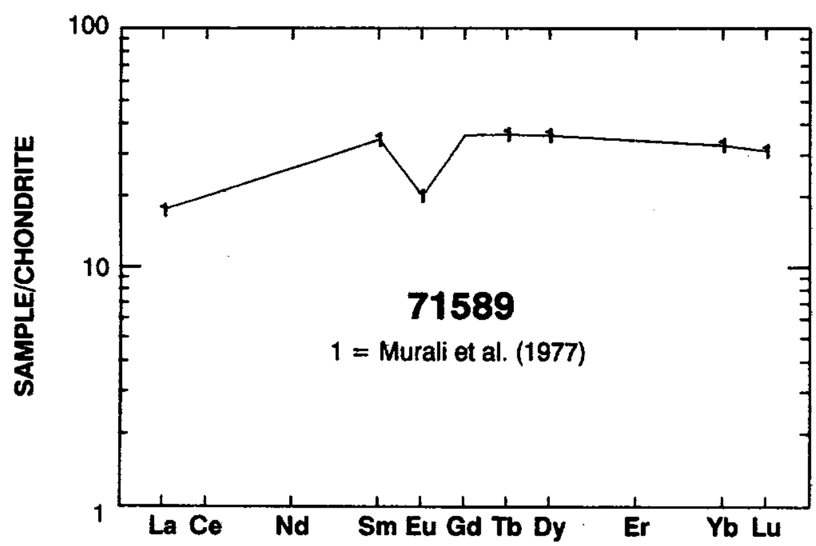


Figure 3: Chondrite-normalized rare-earth element profile of 71589. Data from Murali et al. (1977).

Table 1: Whole-rock chemistry of 71589.
Data from Murali et al. (1977).

	Sample 71589,1 Method N		Sample 71589,1 Method N
SiO_2 (wt %)		Cu	
TiO_2	10.7	Ni	
Al_2O_3	9.2	Co	19.5
Cr_2O_3	0.428	V	114
FeO	20.0	Sc	79
MnO	0.247	La	5.7
MgO	8.0	Ce	(37)
CaO	10.5	Nd	
Na_2O	0.34	Sm	7.0
K_2O	0.050	Eu	1.54
P_2O_5		Gd	
S		Tb	2.1
Nb (ppm)		Dy	13
Zr		Er	
Hf	7.4	Yb	7.2
Ta	1.4	Lu	1.05
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

71595
High-Ti Mare Basalt
25.21 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1978) reported the petrography and mineral chemistry of 71595. During the preparation of this catalog, we examined thin section 71595,5 and found it to be a fine- to medium-grained (0.1-0.3mm) basalt. It is comprised of interlocking plagioclase-pyroxene "bow-tie" intergrowths. Areas of blocky, pink pyroxene and plagioclase are present. There is much opaque, quench glass present (Fig. 2a). Ilmenite is also present in the groundmass, overlayng the plagioclase-pyroxene "bow-tie" structures (Fig. 2a). Ilmenite (up to 1mm) and olivine (up to 1mm) phenocrysts are present (Fig. 2a). Olivine contains small (~0.005mm) euhedral chromite inclusions and is often corroded with reaction rims of pink pyroxene. Embayed armalcolites commonly form the cores of larger ilmenite phenocrysts (Fig. 2b). Both groundmass and phenocrystic ilmenite contain rutile and chromite exsolution lamellae (<0.005mm wide). Native Fe and troilite (<0.05mm) are disseminated throughout the thin section as interstitial phases.

WHOLE-ROCK CHEMISTRY

Murali et al. (1977) reported the whole-rock composition of 71595,1 in a study of Apollo 17 rake samples (Table 1). 71595 is classified as a Type B2 Apollo 17 high-Ti basalt using the classification of Rhodes et al. (1976) and Warner et al. (1979), plus the criteria of Neal et al. (1990).

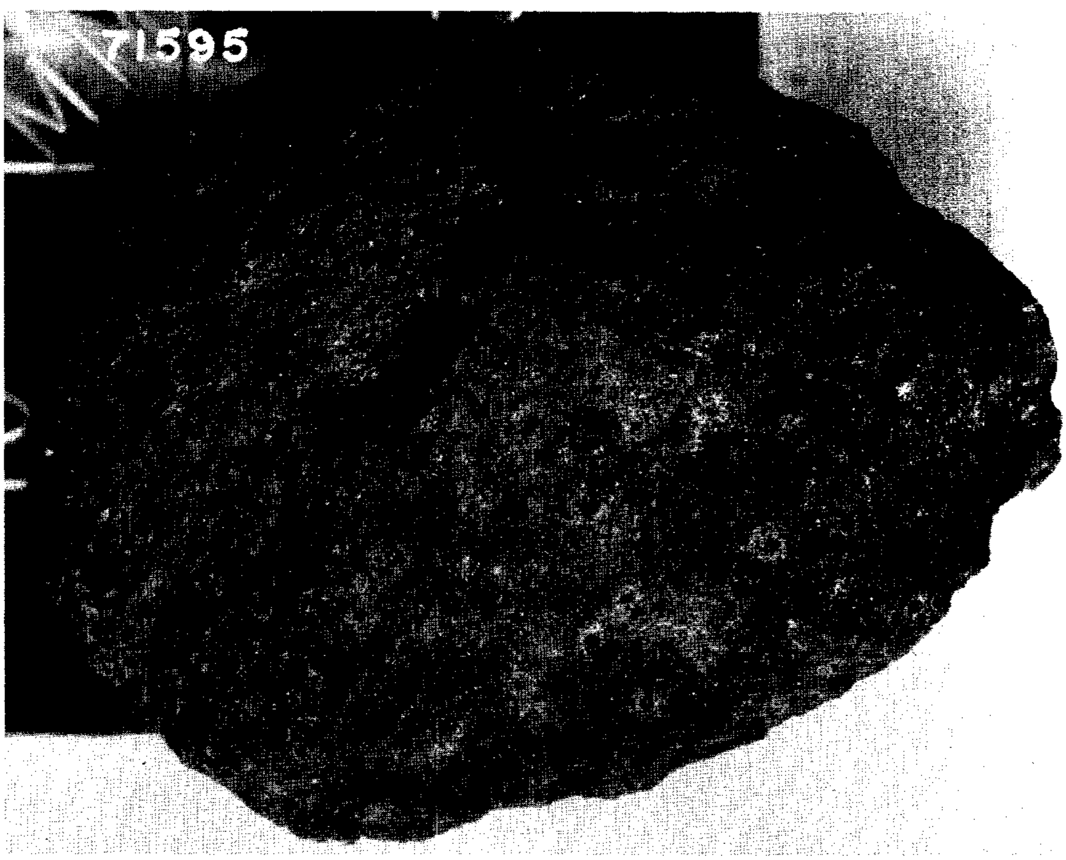


Figure 1: Hand specimen photograph of 71595,0.

2a: Illustration of the glassy/variolitic and blocky/interlocking portions of the basalt – field of view = 2.5 mm.

2b: Armalcolite core in ilmenite phenocryst – field of view = 0.625 mm.

Figure 2: Photomicrographs of 71595,0.

Table 1: Whole-rock chemistry of 71595.
Data from Murali et al. (1977).

	Sample 71595,1 Method N		Sample 71595,1 Method N
SiO_2 (wt %)		Cu	
TiO_2	10.4	Ni	
Al_2O_3	9.3	Co	18.4
Cr_2O_3	0.416	V	100
FeO	19.6	Sc	78
MnO	0.247	La	6.4
MgO	7.4	Ce	29
CaO	10.6	Nd	
Na_2O	0.39	Sm	6.9
K_2O	0.044	Eu	1.43
P_2O_5		Gd	
S		Tb	1.8
Nb (ppm)		Dy	12
Zr		Er	
Hf	6.5	Yb	7.5
Ta	1.5	Lu	1.11
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

This sample contains 10.4 wt% TiO_2, with a MG# of 40.2. The REE profile (Fig. 3) is flat, except for La. As in the other INA analyses of Apollo 17 high-Ti basalts reported by Murali et al. (1977), we consider Ce to be spurious, or at best the reported 29 ppm Ce in 71595,1 is a maximum. The high uncertainties associated with analyzing Ce by INA, coupled with the overall LREE-depleted nature of Apollo 17 high-Ti basalts, suggests that 71595 is probably LREE-depleted. The HREE are generally flat at 32-35 times chondritic levels (Fig. 3). A negative Eu anomaly is present [$(Eu/Eu^*)_N = 0.56$].

PROCESSING

Of the original 25.21g of 71595,0, approximately 24.33g remains. 71595,1 was used for INAA, and thin section ,5 was taken from this irradiated sample.

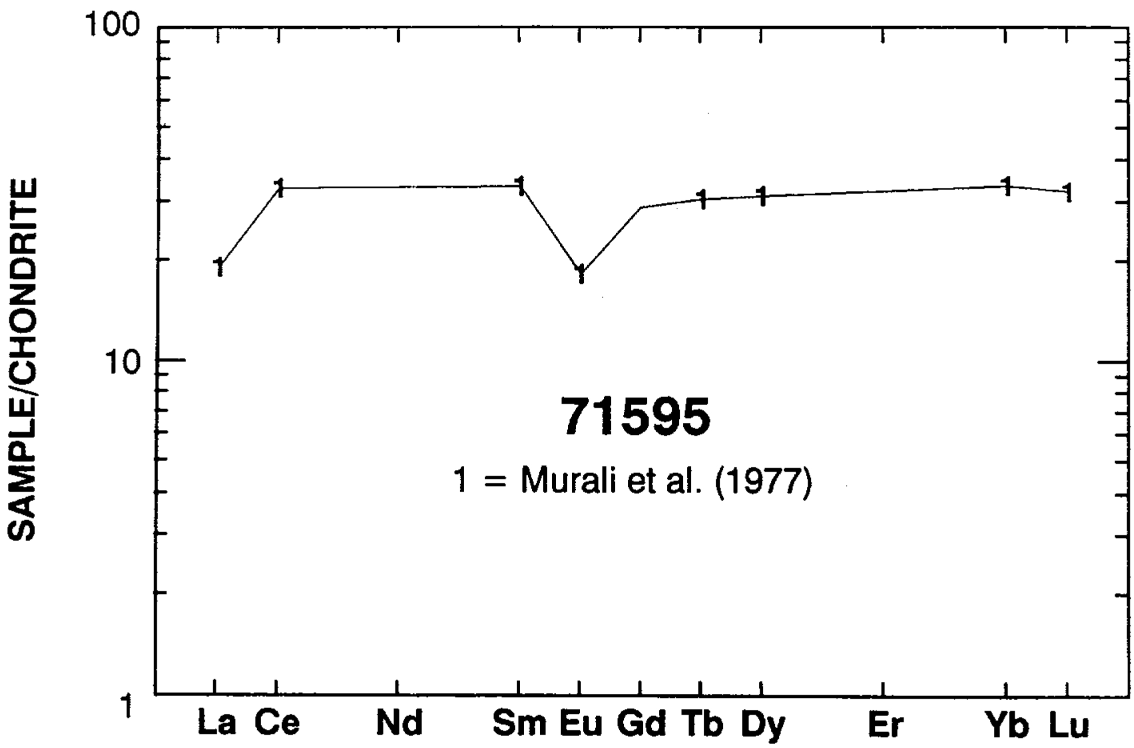


Figure 3: Chondrite-normalized rare-earth element profile of 71595. Data from Murali et al. (1977).

71596
High-Ti Mare Basalt
61.05 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1975bc, 1976ab, 1978) reported the petrography and mineral chemistry of 71596. Warner et al. (1975c) described 71596 as a microporphyritic ilmenite basalt. However, the petrography and mineral chemistry of this sample was not specifically mentioned, only being discussed in the general description of this basalt group. During the preparation of this catalog, we examined thin section 71596,5 and found it to be a medium-grained (0.2-0.4mm) basalt (Fig. 2). It is comprised of two textural domains: 1) plagioclase-pyroxene "bow-tie" intergrowths; and 2) blocky, pink pyroxene and plagioclase in an almost sub-ophitic relationship. Blocky ilmenite is found in both domains, but ilmenite also occurs as phenocrysts (up to 1mm) with "sawtooth" margins (Fig. 2). Both groundmass and phenocrystic ilmenite contain rutile and chromite exsolution lamellae (~0.001mm wide). Olivine microphenocrysts are also present (up to 0.6mm) (Fig. 2), and these contain inclusions of euhedral chromite (~0.005mm). The olivines have corroded margins and occasionally have reaction rims of pink pyroxene. Native Fe and troilite (<0.05mm) are disseminated throughout the sample as interstitial phases. No armalcolite or SiO_2 was observed.

WHOLE-ROCK CHEMISTRY

Laul et al. (1975) and Warner et al. (1975) reported the same

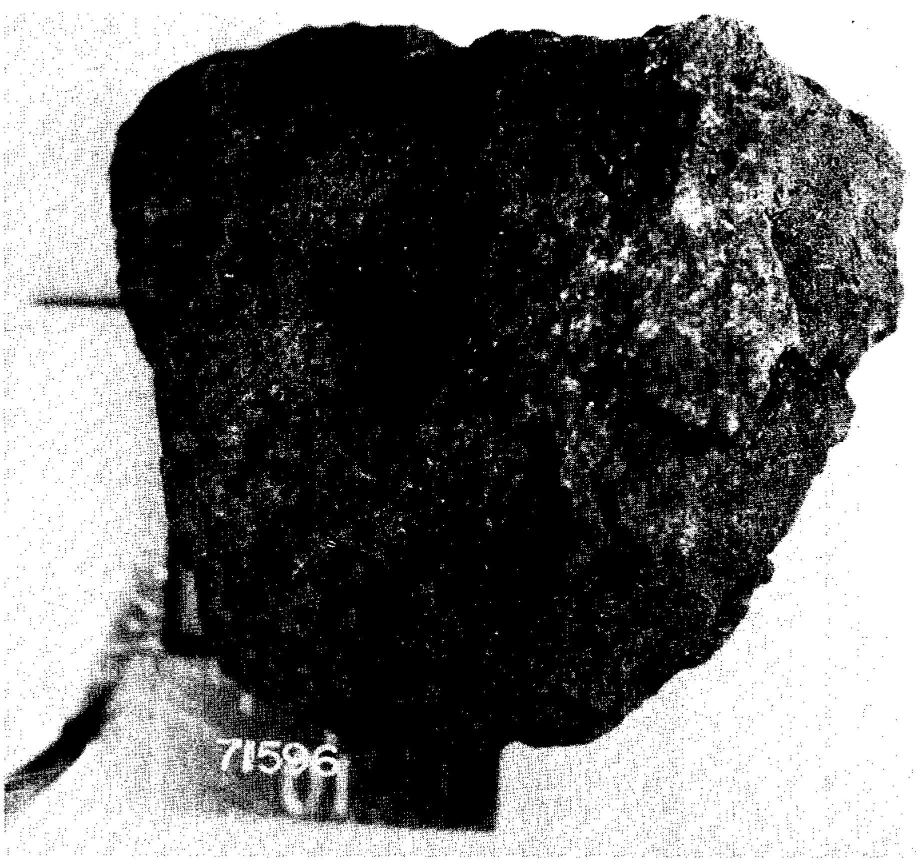


Figure 1: Hand specimen photograph of 71596,0. Small divisions on scale are in millimeters.

Figure 2: Photomicrograph of 71596,5. Olivine microphenocrysts and ilmenite phenocrysts with sawtooth margins are seen set in a sub-variolitic to variolitic groundmass.

whole-rock analysis of 71596,1 in a study of Apollo 17 rake samples (Table 1). 71596 is classified as a Type B2 Apollo 17 high-Ti basalt, based on the whole-rock classification of Rhodes et al. (1976) and Warner et al. (1979), plus the criteria of Neal et al. (1990). This sample contains 11.0 wt% TiO_2, with a MG# of 42.5. The REE profile (Fig. 3) is LREE-depleted with a maximum at Sm. The HREE exhibit a slight depletion compared to the MREE, but are still enriched (relative to chondrites) over the LREE (Fig. 3). A negative Eu anomaly is present [$(Eu/Eu^*)_N = 0.58$].

PROCESSING

Of the original 61.05g of 71596,0, a total of 59.88g remains. 71596,1 was used for INAA and renumbered to ,9001. Two thin sections (,4 and ,5) were taken from this irradiated sample.

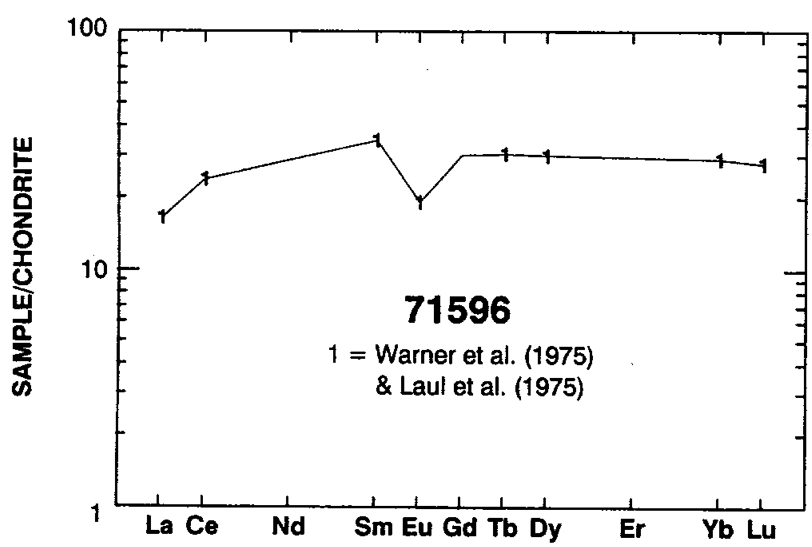


Figure 3: Chondrite-normalized rare-earth element profile of 71596. The same analysis was reported by Warner et al. (1975) and Laul et al. (1975).

Table 1: Whole-rock chemistry of 71596.
Data from Laul et al. (1975) and Warner et al. (1975) (same analysis).

	Sample 71596,1 Method N		Sample 71596,1 Method N
SiO_2 (wt %)		Cu	
TiO_2	11.0	Ni	
Al_2O_3	9.2	Co	20.2
Cr_2O_3	0.400	V	120
FeO	18.8	Sc	75
MnO	0.246	La	5.5
MgO	7.8	Ce	21
CaO	10.3	Nd	20
Na_2O	0.38	Sm	7.2
K_2O	0.044	Eu	1.50
P_2O_5		Gd	
S		Tb	1.8
Nb (ppm)		Dy	11
Zr		Er	
Hf	6.3	Yb	6.5
Ta	1.3	Lu	0.96
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

71597
High-Ti Mare Basalt
12.35 g

INTRODUCTION

See "Rake Sample Descriptions" and "Table of Rake Samples", as well as Fig. 1.

PETROGRAPHY AND MINERAL CHEMISTRY

Warner et al. (1977, 1978) reported in great detail the petrography and mineral chemistry of 71597. The following is the description presented by Warner et al. (1977). These authors described 71597 as a coarse-grained basalt, but our examination of thin section 71597,4 showed it to be gabbroic (grain size up to 5mm). It contains 19.3% olivine, 39.4% pyroxene, 28.3% plagioclase, 11.8% ilmenite, 0.1% armalcolite, 0.2% ulvöspinel, 0.2% metal and troilite, 0.4% cristobalite, and 0.2% glassy mesostasis. All but 1-2% of the modal olivine is present as a small number of very large (2-5+ mm) crystals (Fig. 2), most of which are skeletal. The large skeletal olivines contain sparse melt inclusions as well as euhedral chromites (<0.03 mm). Margins of the olivines are often corroded and are mantled by pyroxene. There is some tendency for these large olivines to cluster. Compositionally, these large skeletal olivines have $Fo_{73\text{-}75}$ cores and zone outwards to more Fe-rich compositions adjacent to mantling pyroxene ($Fo_{64\text{-}66}$). The remainder of the olivine in 71597 consists of numerous small crystals 0.1-0.5mm long. The majority occur as euhedral, prismatic crystals poikilitically enclosed by plagioclase; a few occur as rounded grains surrounded by pyroxene. The small olivines are unzoned and have compositions ranging from Fo_{63} to Fo_{69}.

Pyroxene grains exhibit sector zonation of titan-augite which range up to 2mm across, but are most commonly 0.5-1mm wide. The majority of the pyroxene occurs as anhedral, subequant to bladed crystals 0.2-0.3mm wide. Compositions range from titan-augite (max. 4.5 wt% TiO_2; 6.5 wt% Al_2O_3) to pigeonite (Fig. 3). The extreme Fe-enrichment typical of late-stage pyroxene crystallization in other Apollo 17 basalts is not present.

Plagioclase occurs as large platy crystals (up to 6mm long and 2.5mm wide) that poikilitically enclose crystals of olivine, pyroxene, and ilmenite; compositions are $An_{85\text{-}90}$ (Fig. 3). A few smaller plagioclase crystals are present, associated with late-stage cristobalite and are of composition $\sim An_{80}$.

Ilmenite is the most abundant opaque mineral. It exhibits a two-fold grain-size distribution similar to (but less pronounced than) olivine in that there are a small number of very large (up to 5mm) crystals which are an order of magnitude larger than the majority of the ilmenites (Fig. 2). The large ilmenites (~2 modal %) are elongate (equant in cross section) skeletal crystals

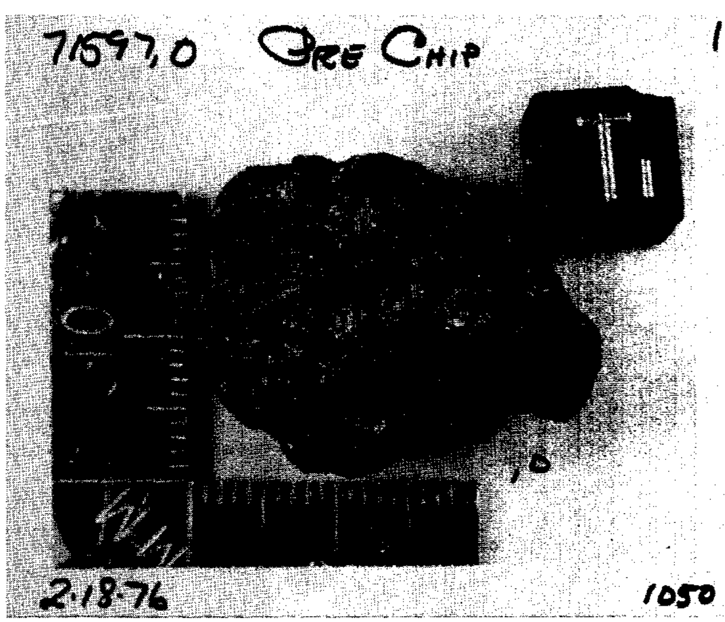


Figure 1: Hand specimen photograph of 71597,0. Small divisions on scale are in millimeters.

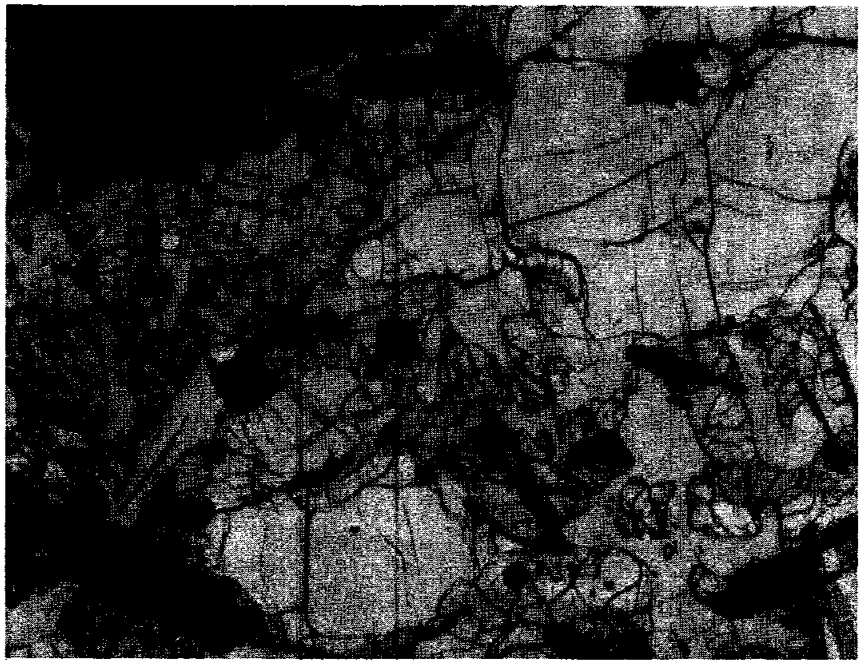


Figure 2: Photomicrograph of 71597,5 showing the large olivine phenocrysts. Field of view = 2.5 mm.

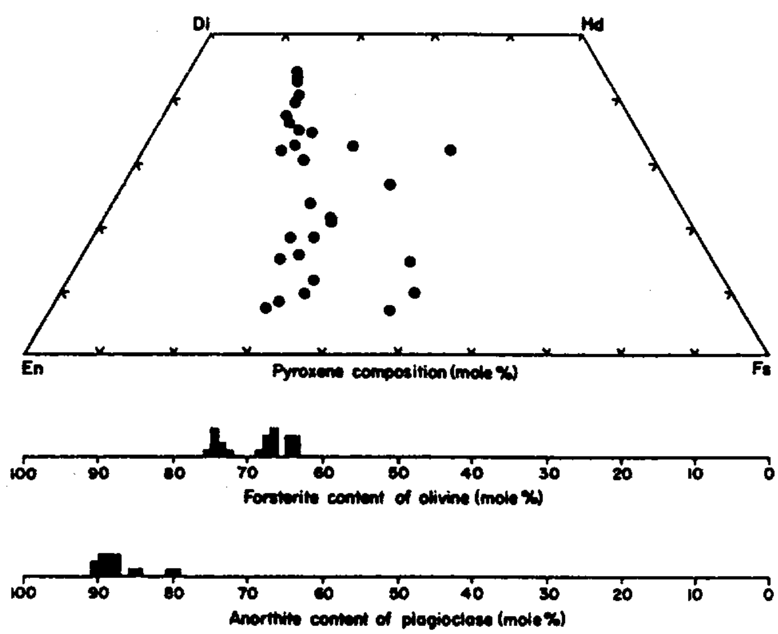


Figure 3: Composition of pyroxenes (projected onto pyroxene quadrilateral), olivines and plagioclases in 71597. Olivine compositions $>Fo_{70}$ are from cores of large skeletal olivine grains; those $<Fo_{70}$ are from small "matrix" olivine crystals.

with "sawtooth" bladed margins. They contain 4.8-5.1 wt% MgO. The remainder of the ilmenite occurs as subequant crystals 0.1-0.2mm wide or as laths generally <0.5mm long. They show a considerable range in MgO (1-8 wt%) depending upon their textural setting: ilmenite crystals inside olivine melt inclusions or inside titan-augite crystals often contain > 7 wt% MgO, whereas ilmenite crystals associated with plagioclase and/or cristobalite often contain <2 wt% MgO. Overall, ilmenite ranges in Fe/(Fe + Mg) from 0.71-0.96 (Fig. 4). Blebs and lamellae of rutile and chromite are commonly present.

Armalcolite is rare, but where present, it is usually partly or wholly mantled by ilmenite. The composite grains are usually large (> 0.5mm across). Cores of armalcolite grains vary in Fe/(Fe + Mg) from 0.55 to 0.69 (Fig. 4); the most magnesian grains are zoned, with Fe/(Fe + Mg) increasing outwards, coupled with decreasing Cr_2O_3. Ilmenite mantling armalcolite contains nearly 6 wt% MgO.

Spinel of intermediate chromian ulvöspinel composition (Fig. 4) is widely disseminated throughout 71597. A few crystals occur at the outer margins of some of the large skeletal olivines; these are generally euhedral, 15-20µm wide, and contain > 29 wt% Cr_2O_3. Euhedral, 15-20µm wide spinels occur as inclusions in the small (0.1-0.5mm) olivines; they contain less Cr_2O_3 (~25 wt%). Euhedral to subhedral ulvöspinels occur inside pyroxene grains and are also abundantly scattered throughout the rest of the rock, where they overlap pyroxene-plagioclase grain boundaries. A number of these latter crystals exceed 0.1mm in width. These "matrix" spinels are the least Cr_2O_3-rich.

Cristobalite is inhomogeneously distributed in 71597. It is most abundant in areas of least olivine. Native Fe and troilite (often intergrown) are widely disseminated in a cristobalite-rich mesostasis and in ilmenite. A few tiny crystals of zirconolite are also present.

WHOLE-ROCK CHEMISTRY

Murali et al. (1977) reported the major- and trace-element composition of 71597 and Warner et al. (1977) reproduced the major-element analysis. These authors reported a TiO_2 content of 8.4 wt% for 71597, with a high MG# of 58.7. This high MG#, coupled with the

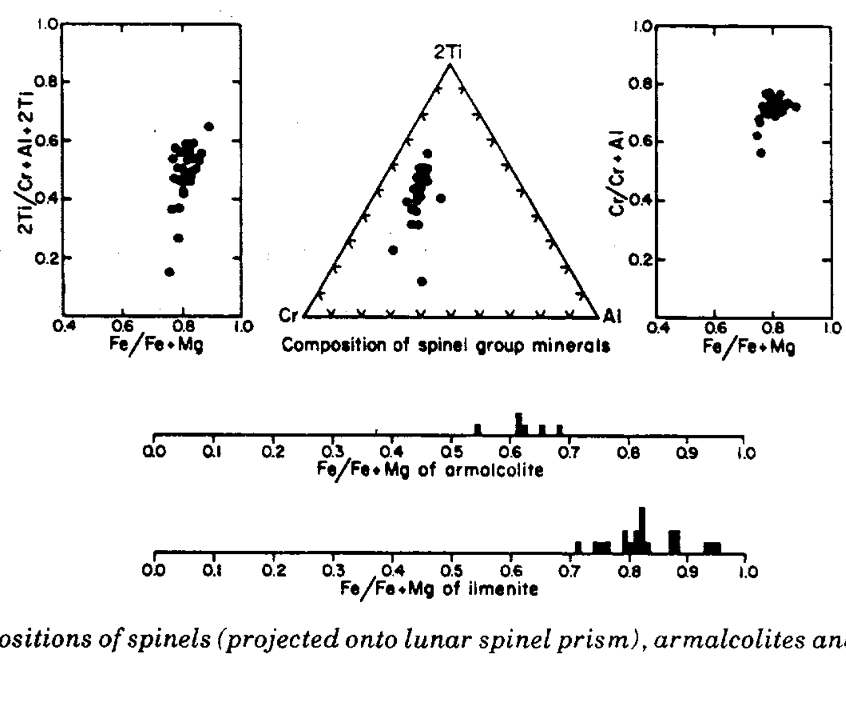


Figure 4: Compositions of spinels (projected onto lunar spinel prism), armalcolites and ilmenites in 71597.

trace-element abundances and olivine compositions, was used to propose a cumulate origin for 71597. The REE (Fig. 5) are present in much lower abundances than in other Apollo 17 high-Ti basalts, although the shape of the REE profile is similar. Murali et al. (1977) and Warner et al. (1977) concluded that this was due to olivine and minor opaque oxide accumulation resulting in the dilution of the trace-elements. The REE profile is LREE-depleted (Fig. 5) with a maximum at Yb. There is a slight positive slope between Tb and Yb. A negative Eu anomaly is present [$(Eu/Eu^*)_N = 0.70$].

PROCESSING

Of the original 12.35g of 71597,0, a total of 11.63g remains. 71597,1 was used for INAA, and two thin sections (,4 and ,5) were taken from this irradiated sample.

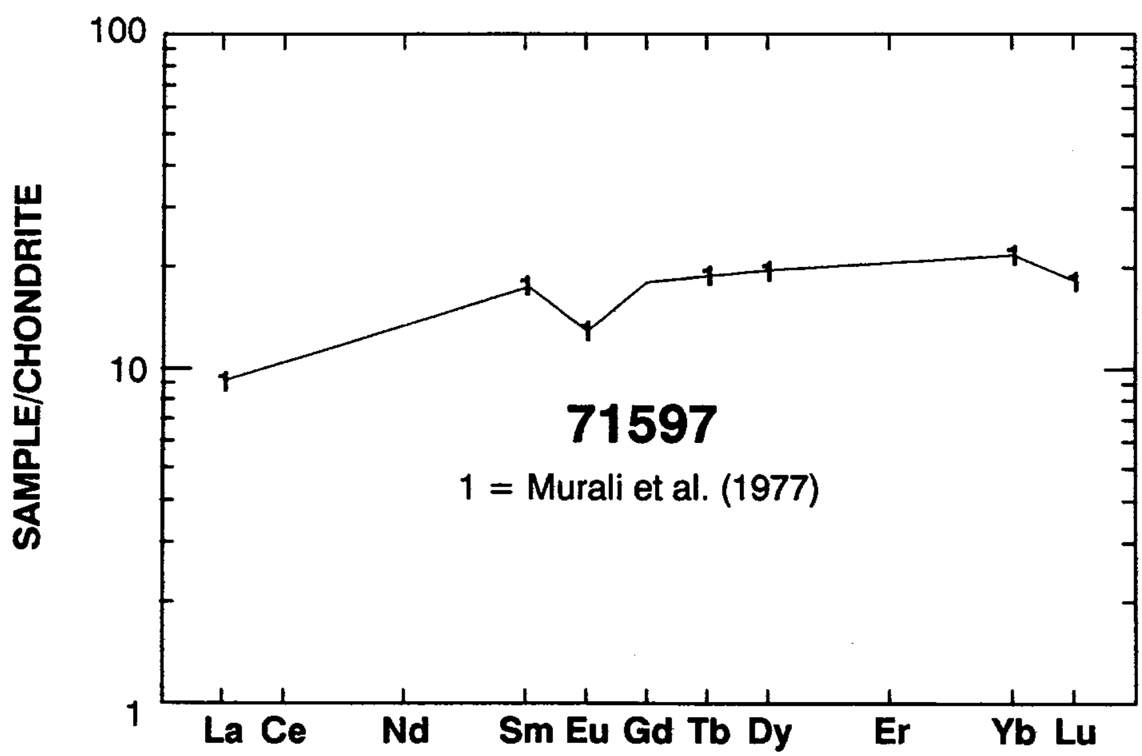


Figure 5: Chrondrite-normalized rare-earth element profile of 71597. Data from Murali et al. (1977).

Table 1: Whole-rock chemistry of 71597.
Data from Murali et al. (1977).

	Sample 71597,1 Method N		Sample 71597,1 Method N
SiO_2 (wt %)		Cu	
TiO_2	8.4	Ni	
Al_2O_3	7.9	Co	43
Cr_2O_3	0.470	V	126
FeO	19.8	Sc	71
MnO	0.237	La	3.0
MgO	15.8	Ce	
CaO	7.9	Nd	
Na_2O	0.29	Sm	3.9
K_2O	0.027	Eu	1.0
P_2O_5		Gd	
S		Tb	1.1
Nb (ppm)		Dy	7
Zr		Er	
Hf	4.2	Yb	4.8
Ta	0.86	Lu	0.62
U		Ga	
Th		F	
W		Cl	
Y		C	
Sr		N	
Rb		H	
Li		He	
Ba		Ge (ppb)	
Cs		Ir	
Be		Au	
Zn		Ru	
Pb		Os	

Analysis by: N = INAA.

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APPENDIX A

RAKE SAMPLE DESCRIPTIONS

71505–71509, 71515, 71525–71597
(exclusive of numbers ending in digits 0-4)

SAMPLE TYPE: Rocks (fragments > 1 cm from the Station 1 rake (38 fragments) and associated soil (6 fragments) samples).

BINOCULAR DESCRIPTION

Individual characteristics of the fragments are given in the following table. All but one of the 44 fragments are basalts, which consist of colorless calcic plagioclase, cinnamon-brown augite, black ilmenite, and, in most fragments, yellow-green olivine. The olivine content ranges from zero to two percent for most samples, two samples contain more olivine (about 7 and 25 percent). Modes of plagioclase, pyroxene, and ilmenite were not estimated for the samples. The samples range from 1 × 1 × 1 cm to 4 × 7 × 12 cm. The size of the fragments may be estimated from the accompanying photos. The single non-basalt fragment (sample 71515 from the rake soil), is a glass bonded agglutinate.

Pyroxene occurs in prismatic crystals. Plagioclase occurs in lath-shaped crystals. Ilmenite occurs in blocky crystals. Olivine occurs in subhedral to euhedral 1 to 2 mm crystals. Thus, in the fine and medium grained basalts, the olivine crystals are phenocrysts. In those rocks that contain less than 1 percent olivine, the olivine phenocrysts tend to occur in groups of two or three crystals. In the olivine-poor rocks, it is common for the olivine to be scattered (i.e., in a sample with a 10 cm^2 surface area, there will be less than 10 olivine phenocrysts). Therefore, every thin section will not have an olivine crystal (as is the case with sample 10022). In addition, the olivine phenocrysts tend to define "layers" that are about 1 cm long and contain three to five olivine crystals or groups of crystals.

Most of the basalts have pores which are present as spherical vesicles, equant vugs, and/or irregular vugs. Most vesicles are lined with tangential ilmenite laths. Most vugs contain projecting, columnar crystals of pyroxene and plagioclase. Olivine is not common in vugs. The finer-grained basalts tend to contain more spherical or equant pores. The volume of pore-space ranges from zero to about 50 percent. This space is not uniformly distributed and many rocks show pore-rich and pore-poor regions. Where the boundary between regions is well defined, layers of pore-rich rock intercalated with layers of pore-poor rock is suggested, as described by Schmitt on the lunar surface. These layers are greater than 1 cm in thickness.

For the purpose of numbering them, the rake fragments were grouped by olivine content, and arranged in order of increasing grain size within these groups. The five basalt fragments (71505 - 71509) from the rake soil are arranged in the following table of descriptions in the appropriate places according to the same sorting scheme. Also in the table, grain size is used as a relative term between the extremes: coarse-grained samples contain crystals 1 - 2 mm across and very fine-grained samples contain crystals less than 0.02 mm across. (71515, a glass bonded agglutinate, is omitted from the table, which is devoted to characteristics of the basalt samples.)

APPENDIX B

TABLE OF RAKE SAMPLES

71505–71509, 71515, 71525–71597
(Continued)

Sample Number	Olivine Content	Grain Size	Nature of Pore Space (Comments)
71525	None	Dust covered	Spherical vesicles
71526	None	Very fine	Filled vugs (ilm rich rock)
71527	None	Fine	Spherical vesicles
71528	None	Fine	1-2 mm, ilm lined, spherical vesicles
71529	None	Med	1-2 mm, ilm lined, spherical vesicles
71508	None	Med coarse	1-2 mm vugs
71535	None	Med coarse	1-5 mm vugs
71536	None	Coarse	None
71537	<1%	Very fine	Few, 3-4 mm,spherical vesicals
71538	<1%	Fine	Few, 2 mm, ilm lined, spherical vesicles
71539	<1%	Fine	One 3 mm irregular vug
71545	<1%	Fine	None
71505	<1%	Fine	None (ilm rich rock)
71506	<1%	Fine	1-2 mm vugs (ilm rich rock)
71546	<1%	Med fine	Few, 3-10 mm, spherical vesicles plus 1 mm vugs
71547	<1%	Med	2-4 mm vugs
71548	<1%	Med	Layers of 3-4 mm vugs
71549	<1%	Med	Few 1 mm vugs
71555	<1%	Med	Layers of 2-8 mm, ilm lined, spherical vesicles
71507	<1%	Med	1-3 mm spherical vesicles
71556	<1%	Med coarse	Layers of 1-4 mm vugs
71557	<1%	Med coarse	Few 2 mm vugs
71558	<1%	Med coarse	Layers of 1-3 mm vugs
71559	<1%	Coarse	Few 2 mm vugs
71565	<1%	Coarse	Few 1-4 mm vugs
71566	<1%	Coarse	Layers of 1-20 mm vugs
71567	<1%	Coarse	Layers of 1-8 mm vugs
71568	<1%	Coarse	None
71509	<1%	Coarse	None

Sample Number	Olivine Content	Grain Size	Nature of Pore Space (Comments)
71569	1-2%	Very fine	Few, 1-8 mm, ilm lined, spherical vesicles (ilm rich rock)
71575	1-2%	Fine	Small, ilm lined, spherical vesicles
71576	1-2%	Fine	1-4 mm spherical vugs
71577	1-2%	Fine	2-15 mm, ilm lined, spherical vesicles
71578	1-2%	Med	Layers of 2-6 mm, ilm lined, spherical vugs
71579	1-2%	Med	1-3 mm spherical vugs
71585	1-2%	Med	Layers of 1 mm vugs
71586	1-2%	Med	1-15 mm, ilm lined, vesicles
71587	1-2%	Med	Layers of abundant 2-4 mm vugs
71588	1-2%	Med	None
71589	1-2%	Med	Few, 4 mm, ilm lined, vugs
71595	1-2%	Med	None
71596	5-10%	Med	One, 12 mm, ilm lined, vesicle
71597	20-30%	Coarse	2 mm spherical vesicles, plus abundant 5 mm vugs