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% armaicolite, 0.2% ulvospinel, 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 $F0_{73-75}$ cores and zone outwards to more Fe-rich compositions adjacent to mantling pyroxene ($Fo_{64.66}$). 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% $A1_2O_3$) 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_{85-90} (Fig. 3). A few smaller plagioclase crystals are present, associated with late-stage cristobaiite and are of composition ~An_8o.

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

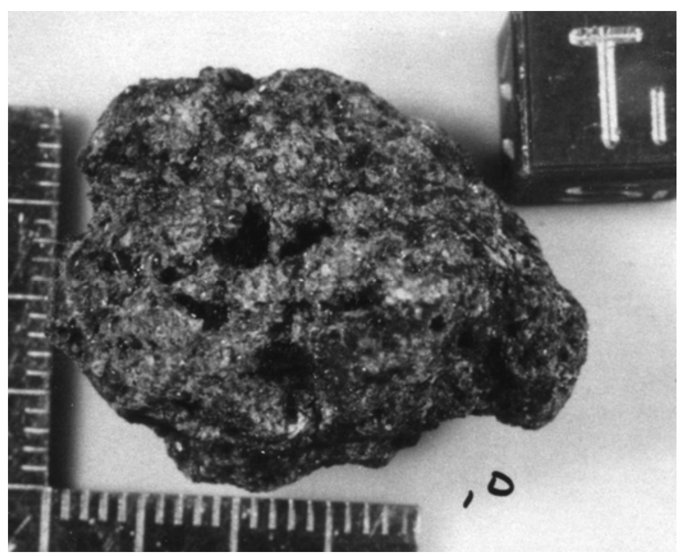

Figure 1: Hand specimen photograph of 71597,0. Small divisions on scale are in millimeters.

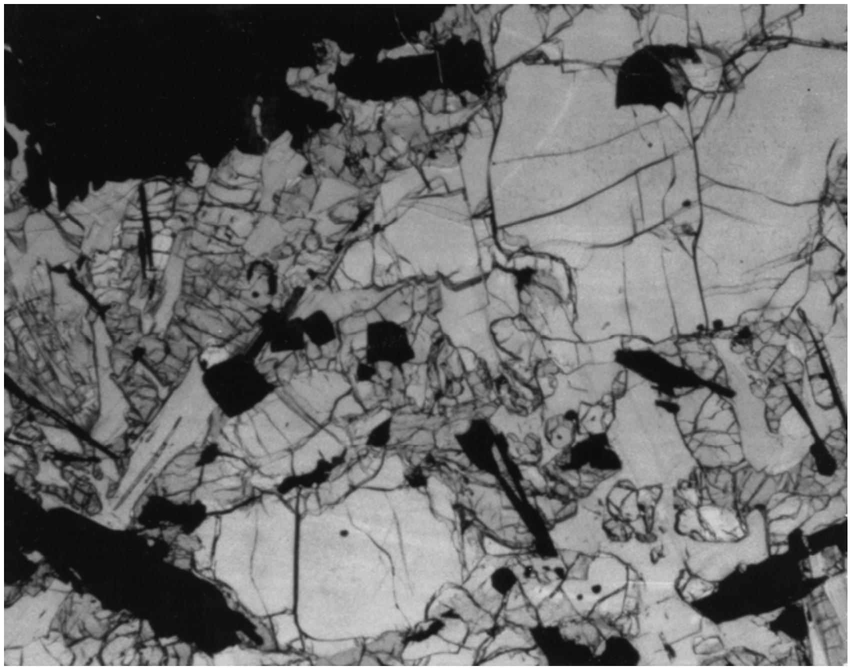

Figure 2: Photomicrograph of 71597,5 showing the large olivine phenocrysts. Field of view = 2.5 mm.

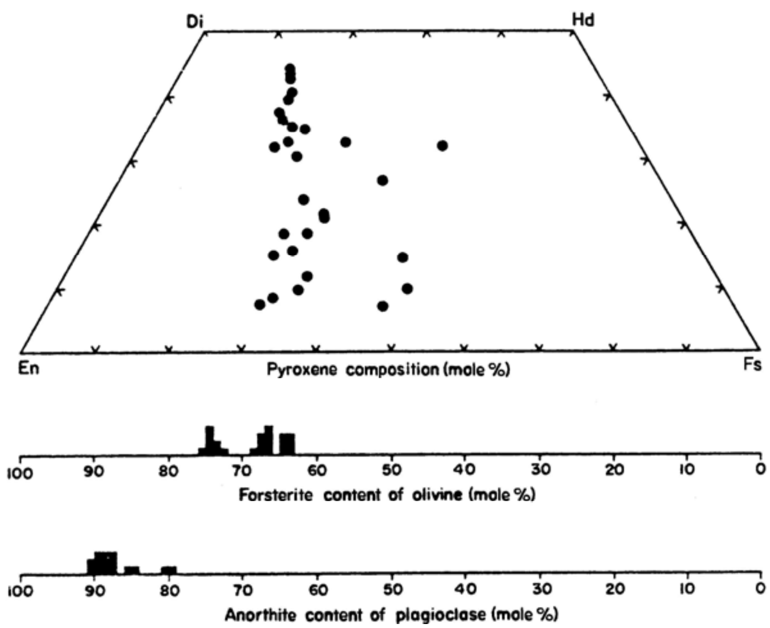

Figure 3: Composition of pyroxenes (projected onto pyroxene quadrilateral), olivines and plagioclases in 71597. Olivine compositions >Fo_{70} are from cores of large skeletal olivine grains; those <Fo_{90} are from small "matrix" olivine crystals.

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 ulvospinel 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, 15-201im wide, and contain > 29 wt% Cr_2O_3. Euhedral, 15-201am wide spinels occur as inclusions in the small (0.1-0.5mm) olivines; they contain less Cr_2O_3 (~25 wt%). Euhedral to subhedral ulvospinels 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 cristobaliterich 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

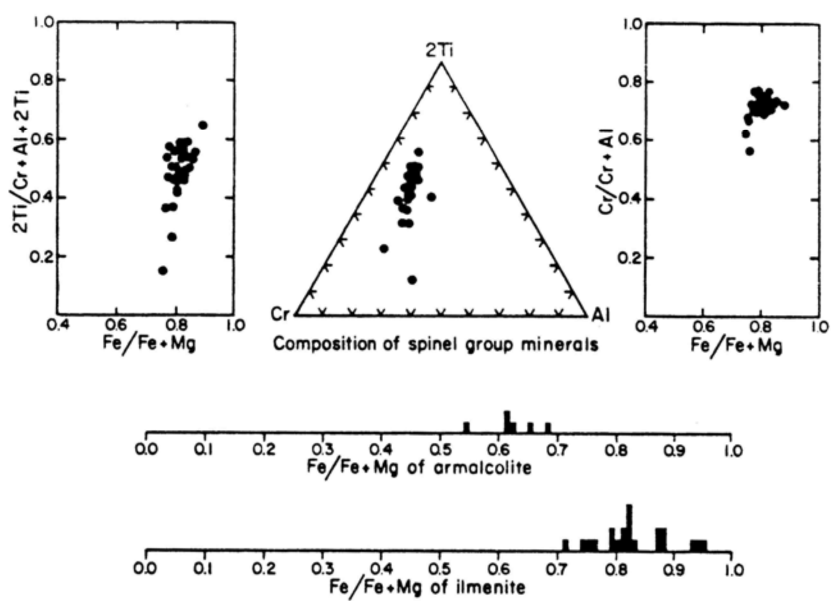

Figure 4: Compositions of spinels (projected onto lunar spinel prism), armalcolites and ilmenites in 71597.

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.

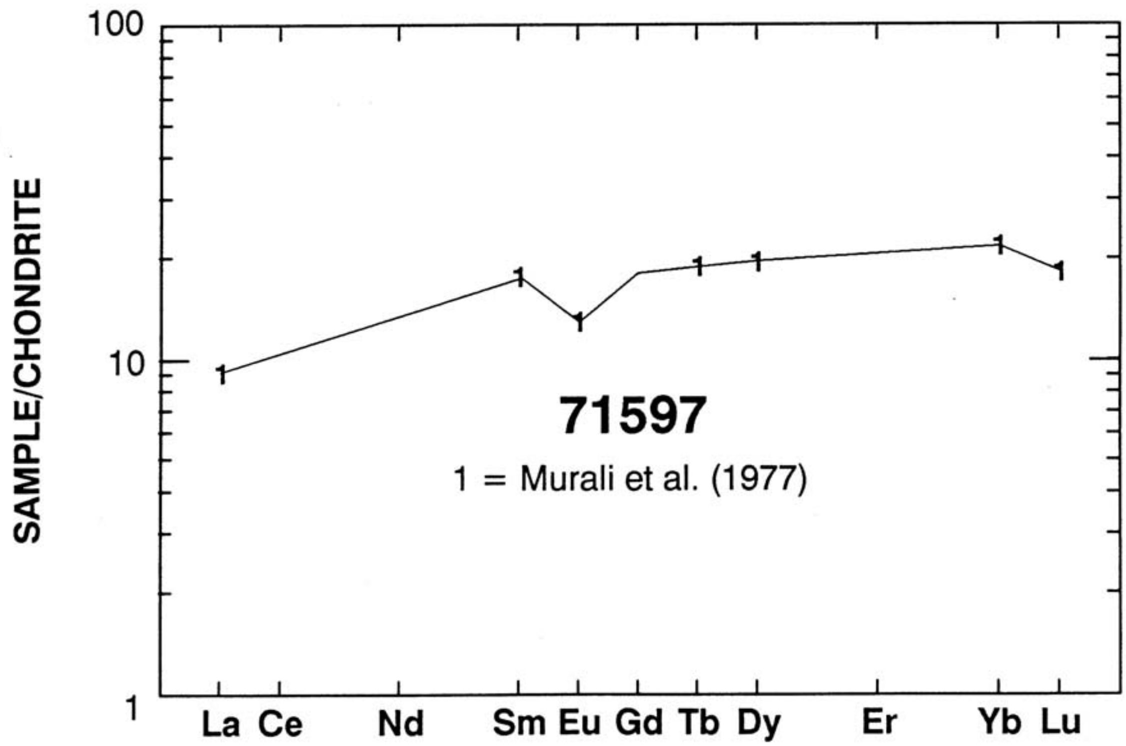

Figure 5: Chrondrite -normalized rare-earth element profile of 71597. Data from Murali et al. (1977).

Table 1: Whole-rock chemistry of 71596.
Data from Laul et al. (1975) and Warner et al. (1975) (same analysis).

	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.