YAMATO-791197: A LUNAR METEORITE IN THE JAPANESE COLLECTION OF ANTARCTIC METEORITES

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Abstract: Antarctic meteorite Yamato-791197 has been identified and classified as an anorthositic regolith breccia; one of the rare meteorites that originated on the moon surface. The meteorite is remarkably similar to lunar highland regolith breccias in texture, mineralogy and chemical composition, but different from other meteorites, for instance polymict eucrites and howardites, in many respects. The specimen is almost completely covered with a thick dusty-gray fusion crust, and consists of many angular clasts and black to dark brown glassy matrix. The clasts, several mm across, are white, gray and black in color, and show a variety of textures including granulitic, gabbroic, diabasic and basaltic, and vitric (melted lithic). Most clasts have been shocked. The specimen also contains rare small glass spherules. Microprobe analyses show that feldspars range from $An_{92.0}$ to $An_{98.2}$, pyroxenes: $En_{18.0-83.1}Fs_{9.0-58.9}Wo_{1.7-44.1}$ and olivines: $Fo_{13.6-92.1}$. The FeO/MnO ratios of both pyroxenes and olivines of Yamato-791197 are lower than those of basaltic achondrites and are similar to those of lunar samples.

1. Introduction

Yamato-791197 (Y-791197), a new unique meteorite found in Antarctica, has been originally classified as a lunar anorthositic breccia (YANAI and KOJIMA, 1984). This specimen in the Yamato-79 meteorites collection, comprising over 3700 specimens, was found in November 1979 on the bare ice near the Yamato Mountains, Antarctica by the meteorites search party of the 20th Japanese Antarctic Research Expedition (JARE) (Figs. 1, 2). It contains white inclusions in black matrix and is covered with black-dusty gray fusion crust, resembling carbonaceous chondrites such as Allende (C3V). In the field, most of carbonaceous chondrites were collected with extreme care and were stored in a clean teflon bag or stainless cans which were provided by NASA. This specimen was also treated in the same way except small chips which had been removed from the main mass on the bare ice. All of the main masses of carbonaceous chondrites including specimens collected in the 1979–1980 season are being kept under frozen and clean condition at the National Institute of Polar Research (NIPR), Tokyo.

However, an examination of the thin sections from the small chips by the present authors and subsequently by K. KEIL and J.G. TAYLOR of University of New Mexico, has suggested that this specimen is an anorthositic breccia which could be of lunar origin, a unique meteorite type. The specimen shows a distinctive texture of breccia, and consists of numerous lithic and mineral fragments, glass spherules and masses of melted glass set in a dark to dark brown glassy matrix. The meteorite differs from familiar achondritic meteorites in many respects. In the present paper, the authors report some

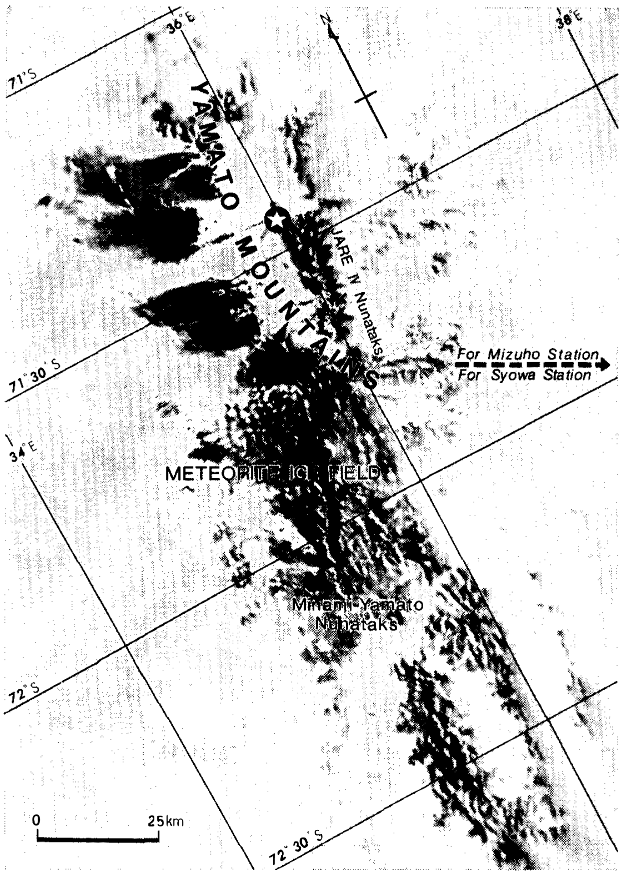

Fig. 1. Satellite image of the area around the Yamato Mountains, Queen Maud Land, East Antarctica. Darkest areas are bedrock; medium gray areas are bare ice. The Meteorite Ice Field covers an area of about 4000 km^2. The star indicates the site of discovery of Yamato-791197 on the bare ice.

important results of the preliminary examination of this anorthositic regolith breccia in the Yamato-79 collection.

On 18 January 1982, the U.S. ANSMET team recovered a lunar meteorite lying near the edge of the Middle Western Icefield near the Allan Hills region of Victoria Land, Antarctica. The meteorite was photographed *in situ* and was collected by the customary sterile procedures. It is a small meteorite, 31.4 g and $3\times2.5\times3$ cm in size, with a frosty greenish tan fusion crust, and is an unusual sample with abundant angular gray to white clasts set in black matrix. This sample was processed at the NASA Johnson Space Center in Houston and it was named Allan Hills A81005 (ALHA81005) (MARVIN, 1983).

ALHA81005 was first identified and classified as an anorthositic breccia by B. MASON (1982). He confirmed the white clasts which consist mainly of Ca-rich plagioclase. The clasts are much more feldspathic than those of eucrites and resemble the anorthositic clast described from lunar rocks (MASON, 1982).

More detail studies of this unique specimen by over twenty scientists or groups (Abstracts of Session on Meteorite from Earth's Moon, Lunar and Planetary Science Conference XIV, 1983) have strongly supported the presumption that the meteorite derived from the moon's surface.

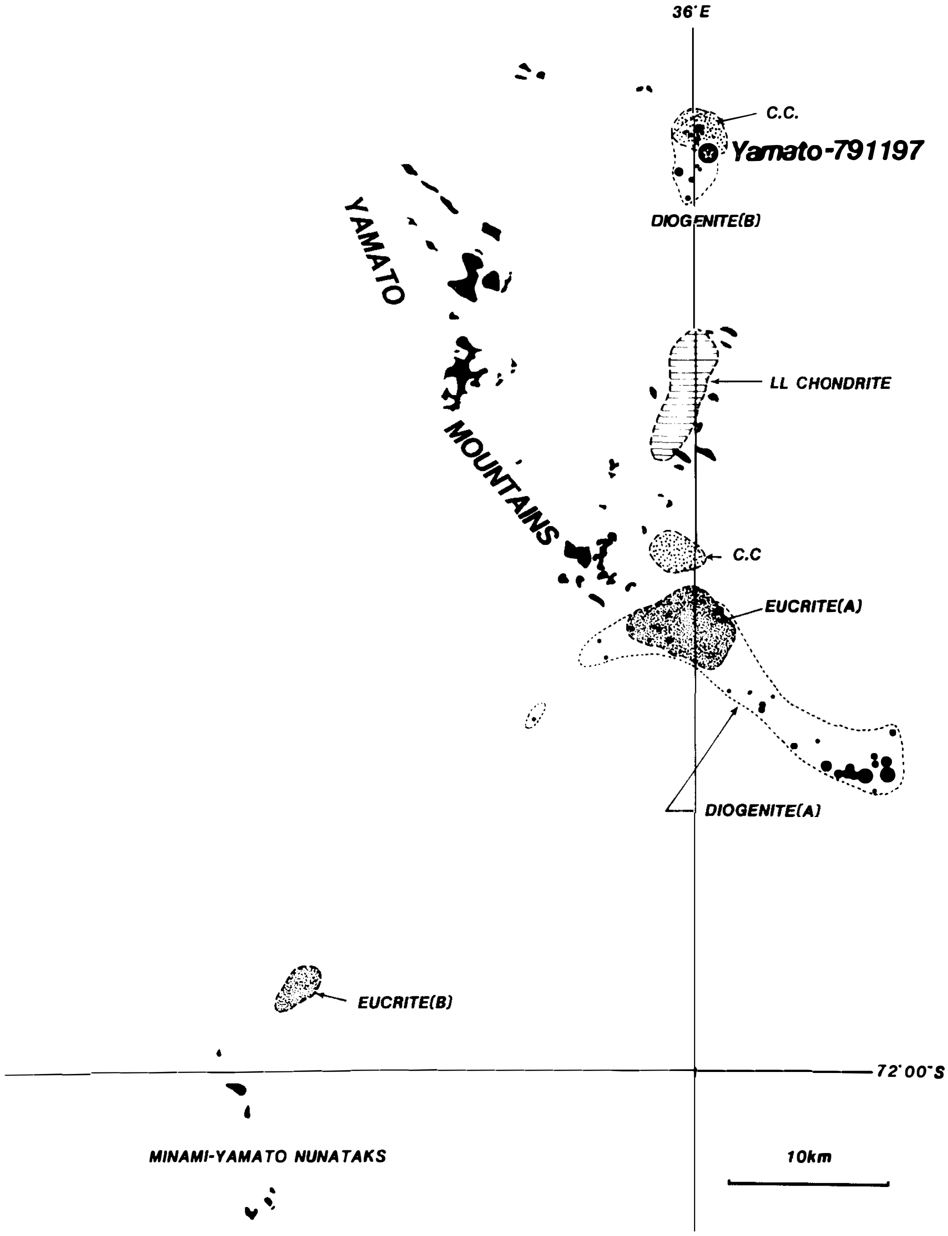

Fig. 2. The site of discovery of Yamato-791197. The meteorite was found on the bare ice near the north edge of the ice field around the JARE IV Nanataks. It was found together with many diogenites, carbonaceous chondrites, irons and chondrites in this area. Meteorites forming a group, presumably of the same fall, were found in the places marked as eucrite (A) and (B), diogenite (A) and (B), C.C. and LL chondrite.

The discovery of two lunar meteorites on the Antarctic continent within the last five years may suggest that more lunar meteorites will be recovered from Antarctica in the near future. The samples will provide us with important information on the lunar highland from where no lunar sample was brought back by the Apollo and Lunar missions.

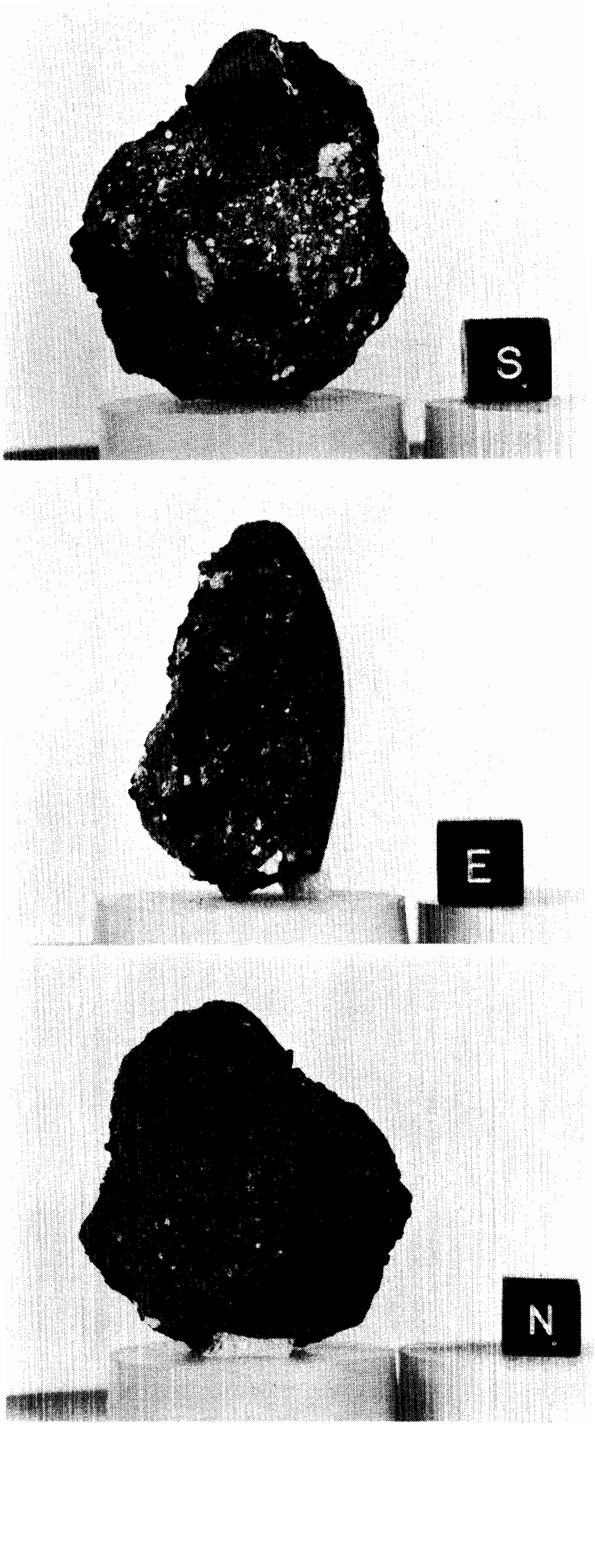

Fig. 3. Photograph of a bulk sample of Yamato-791197, which weighs 52.40 g and is covered with a thick dusty-gray colored fusion crust. Many clasts of gray-black and white, lithic and mineral fragments occur in the black to dark brown glassy matrix.

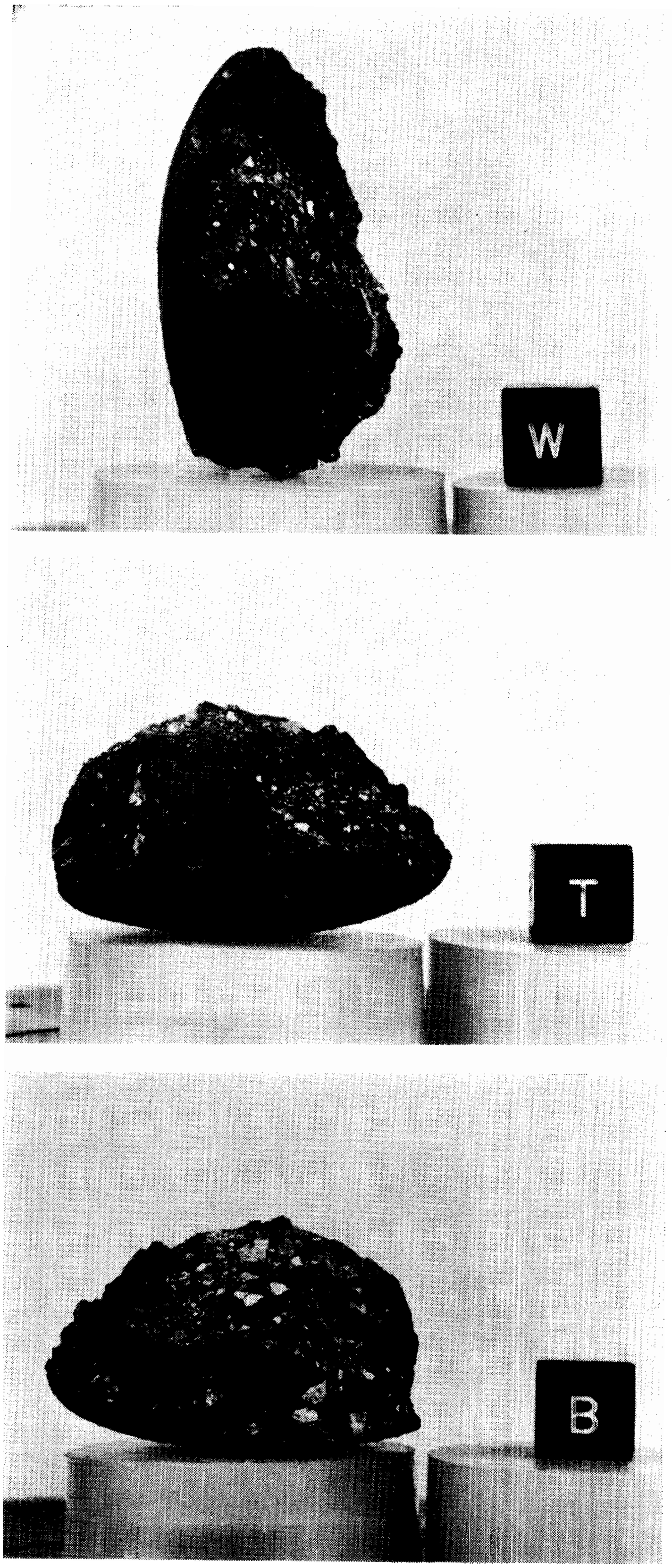

Fig. 3 (continued).

2. Initial Processing of Yamato-791197

The meteorite put in a clean teflon bag was maintained together with other carbonaceous chondrites in frozen condition under $-20°C$ at the NIPR. However, after its preliminary identification using the polished thin sections, the authors suggested that the meteorite differs from all other meteorites. Then the processing of the meteorite started. The meteorite was returned to room temperature in a dry nitrogen-filled cabinet at the NIPR. The authors placed the meteorite in a clean flow bench and described it as a breccia with many angular clasts of gray to white color, under mostly several mm in size, set in a dark to dark gray matrix. The meteorite was photographed in six directions (Fig. 3). It weighed 52.40 g and measured $4.5 \times 4.2 \times 2.8$ cm. The original volume of the meteorite is 18.45 cubic cm and the specific gravity is 2.84 (g/cm^3). The specimen was named Yamato-791197 (Y-791197). A polished thin section was already made from a small chip, 0.225 g, at NIPR. The specimen differs from all carbonaceous chondrites including the Allende (CV3) and known polymict eucrites. After examining the whole sample and the thin section, the authors preliminarily classified the specimen as an anorthositic breccia because it shows a brecciated texture containing many feldspathic clasts. Some clasts of Yamato-791197, especially plagioclase, resemble those in the thin section of ALHA81005 (regolith breccia), which was examined briefly by one of the authors (K.Y.) in October 1982.

3. Material and Methods

A small fragment of Y-791197, chipped from the exterior of the breccia was made into polished thin sections. All polished thin sections (NIPR section Y-791197,91-1 and 91-2) were studied under the microscope in both transmitted and reflected light. The quantitative chemical analyses of the constituent minerals were carried out by an automated electron microprobe analyzer JEOL JCXA 733 with five spectrometers at the NIPR. The method is the same as that of KUSHIRO and NAKAMURA (1970). Bulk wet chemical analysis of the 0.84 g exterior chip was done by H. HARAMURA.

4. Physical Description of the Yamato-791197 Anorthositic Regolith Breccia

Yamato-791197 is an almost complete rounded stone, covered with a thick dusty-gray fusion crust. The interior consists mainly of angular clasts, dark gray to white in color, set in a black to dark brown glassy matrix (Fig. 3). The size of the most of clasts is smaller than 1 mm, but some clasts reached up 4 mm in diameter are observed.

Petrographically Yamato-791197 is a polymict microbreccia containing clasts in a dark brown glassy matrix (Fig. 4). Two or more types of clasts are observed in thin section, such as polymineralic, monomineralic and melt clasts. Most of larger clasts are polymineralic, frequently composed of calcic plagioclase, olivine, and pyroxene; less commonly plagioclases and pyroxenes, or plagioclases alone. Smaller clasts are mineral fragments dominantly plagioclases, with some pyroxenes and olivines, and melted lithic fragments. The clasts also show a variety of textures (Fig. 3), including troctolitic, gabbroic, diabasic, basaltic and shock-melted glassy clasts. Some of the

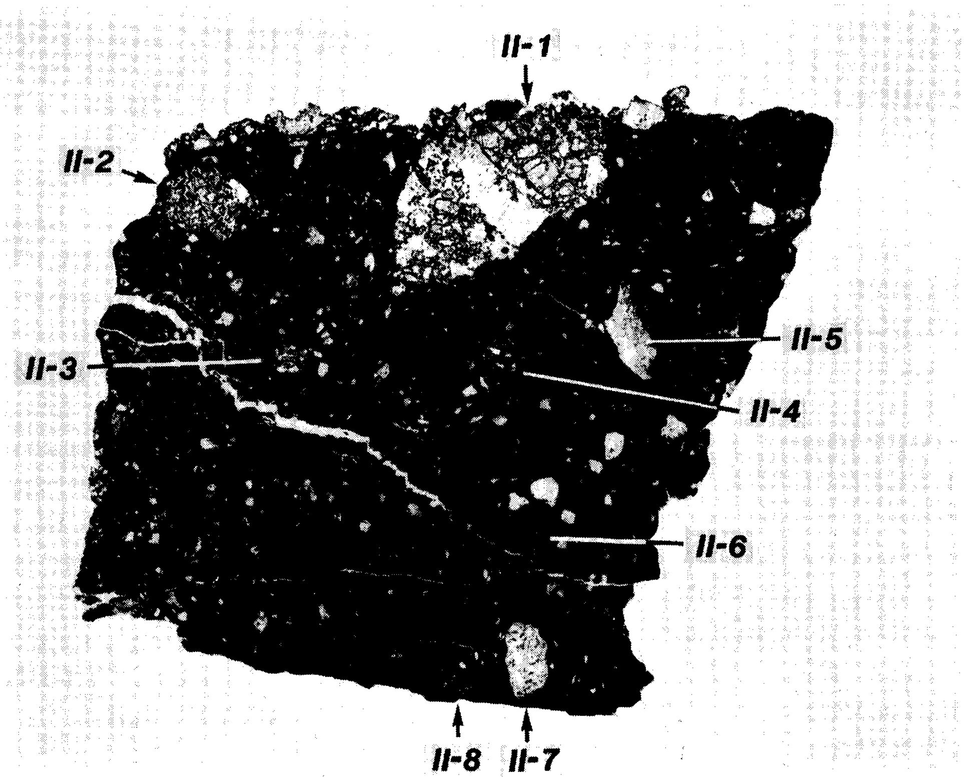

Fig. 4. Photomicrograph of a thin section Yamato-791197,91 showing the heterogeneous appearances of clasts, spherule and glass in the dark matrix (plane-polarized light). Width 8 mm. Clast II-1 to II-8 and glass spherule are further magnified in Figs. 5 to 8 and Fig. 10.

clasts are similar to those of eucrites and howardites, but most of them are more feldspathic.

Yamato-791197 appears to be a regolith breccia with glass spherules and an abundance of clasts, especially feldspathic clasts, set in a dark brown glassy matrix. In texture, Y-791197 resembles the lunar regolith breccia of 64505 and 65787 (J. TAYLOR, personal communication). But the authors have not recognized yet any swirly brown glass in this meteorite.

Microprobe analyses indicate that feldspar compositions range from $An_{92.0}$ to $An_{98.2}$ mostly between $An_{95.5}$ and $An_{97.5}$. Pyroxenes and olivines are also variable in the composition. The compositional range of pyroxenes is $En_{18.0-83.1}Fs_{9.0-58.9}Wo_{1.7-44.1}$. Most olivines are Fo_{55-80}, but several grains with $Fo_{92.1}$ and $Fo_{13.3}$ are found.

5. Texture, Composition and Mineralogy of Lithic Clasts

As mentioned above, Yamato-791197 shows a brecciated texture consisting of microbreccia clasts and mineral fragments set in a translucent to dark brown glassy matrix. The texture is similar to those of howardites and most eucrites, but many clasts are more feldspathic than those in howardites and most polymict eucrites. Some of the larger clasts are described below.

Clast II-1: This is a troctolitic clast, 3.2×2.1 mm in size, with a granular texture. It

consists of olivines and plagioclases with minor pyroxenes, and rare opaques (Fig. 5). Most olivines occur as euhedral to subhedral grains with numerous fractures, and range from 0.01 to 0.3 mm in size. Plagioclase occurs interstitially between olivine and pyroxene, and is partially granulated with undulatory extinction. Chemical compositions of olivines, plagioclases, pyroxenes and an opaque are shown in Table 1.
Clast II-2: This doleritic clast, about 1 mm in diameter, has an ophitic texture and

Table 1. Chemical compositions of olivines, pyroxenes, plagioclases, opaque and glass spherule in clasts and matrix of the Yamato-791197 anorthositic regolith breccia.

Clast	II-1 Ol	II-2 Ol	II-3 Ol	in matrix Ol	in matrix Ol	II-1 Px	II-1 CaPx	II-2 Px	II-2 Px
SiO_2	35.77	37.19	39.57	40.13	30.76	53.22	53.21	53.34	51.34
TiO_2	0.05	0.07	0.05	0.02	0.09	0.43	0.50	0.76	0.59
Al_2O_3	0.05	0.09	0.16	0.23	0.17	0.72	1.45	1.85	2.18
FeO	36.87	26.49	17.54	8.06	62.23	21.74	7.07	12.44	16.79
MnO	0.37	0.27	0.24	0.13	0.75	0.34	0.09	0.25	0.16
MgO	27.19	34.28	44.21	50.60	5.70	22.38	16.65	27.62	20.64
CaO	0.12	0.26	0.06	0.27	0.51	1.93	20.49	1.97	6.05
Na_2O	0.01	0.02	0.0	0.01	0.0	0.0	0.05	0.01	0.01
K_2O	0.0	0.01	0.02	0.20	0.0	0.01	0.0	0.0	0.0
Cr_2O_3	0.02	0.17	0.09	0.18	0.01	0.30	0.25	0.45	0.33
NiO	0.0	0.03	0.0	0.04	0.0	0.0	0.0	0.05	0.0
Total	100.46	98.83	101.94	99.88	100.22	101.07	99.76	98.74	98.09
End member (mol %)									
Fo	56.6	69.8	81.8	91.8	14.0				
Fa	43.4	30.2	18.2	8.2	86.0				
						En 62.2	47.1	76.7	60.0
Range	$Fo_{55.3-57.3}$				$Fo_{13.5-15.7}$	Fs 33.9	11.2	19.4	27.4
						Wo 3.9	41.7	3.9	12.6

Clast	II-2 Px	II-3 Px	II-4 Px	II-4 CaPx	II-4 CaPx	II-4 CaPx	II-8 Px	II-1 Pl	II-2 Pl
SiO_2	50.66	53.28	52.50	46.75	49.43	49.96	51.21	44.31	43.22
TiO_2	1.04	0.68	0.21	1.47	0.78	0.79	0.32	0.02	0.03
Al_2O_3	2.34	1.77	2.88	1.52	1.88	1.98	1.36	36.01	35.37
FeO	15.07	10.84	11.72	30.58	17.16	19.53	20.16	0.14	0.24
MnO	0.16	0.29	0.23	0.47	0.35	0.30	0.37	0.03	0.01
MgO	19.21	28.51	26.65	5.62	12.47	14.84	19.32	0.07	0.16
CaO	9.05	2.92	3.24	11.72	15.22	11.51	6.26	19.24	19.64
Na_2O	0.0	0.01	0.0	0.03	0.02	0.04	0.01	0.33	0.30
K_2O	0.0	0.01	0.0	0.03	0.0	0.02	0.02	0.01	0.02
Cr_2O_3	0.45	0.54	0.85	0.18	0.72	0.69	0.68	0.02	0.01
NiO	0.06	0.0	0.08	0.0	0.0	0.04	0.04	0.0	0.02
Total	98.04	98.85	98.36	98.37	98.02	99.70	99.75	100.17	99.02
End member (mol %)									
En	56.2	77.7	75.0	18.0	37.7	43.6	55.0	An 96.9	97.2
Fs	24.7	16.6	18.5	55.0	29.1	32.2	32.2	Ab 3.0	2.7
Wo	19.0	5.7	6.5	27.0	33.1	24.3	12.8	Or 0.1	0.1
Range								$An_{96.2-97.7}$	$An_{96.9-97.4}$
								$Ab_{2.3-3.7}$	$Ab_{1.9-3.0}$
								$Or_{0-0.1}$	$Or_{0-0.2}$

Table 1 (continued).

Clast	II-3 Pl	II-4 Pl	II-5 Pl	II-6 Pl	II-7 Pl	II-8 Pl	III-2 Pl	II-1 opaque	in matrix spherule
SiO_2	43.28	46.90	43.65	43.38	43.30	43.54	42.75	0.04	38.83
TiO_2	0.02	0.02	0.01	0.07	0.02	0.03	0.01	19.16	0.33
Al_2O_3	35.11	33.00	35.49	35.68	35.17	35.17	35.67	5.73	29.77
FeO	0.16	0.52	0.20	0.22	0.34	0.27	0.16	46.66	5.79
MnO	0.02	0.04	0.03	0.0	0.03	0.07	0.0	0.40	0.02
MgO	0.19	0.49	0.11	0.04	0.30	0.21	0.10	3.71	6.98
CaO	19.31	18.03	19.56	19.37	19.21	19.23	19.38	0.10	17.55
Na_2O	0.40	0.76	0.38	0.36	0.36	0.34	0.17	0.0	0.02
K_2O	0.02	0.01	0.01	0.03	0.04	0.02	0.01	0.04	0.01
Cr_2O_3	0.01	0.02	0.0	0.0	0.02	0.01	0.0	25.11	0.07
NiO	0.01	0.03	0.03	0.05	0.0	0.05	n.d.	0.0	0.01
Total	98.53	99.88	99.46	99.20	98.79	98.94	98.25	100.95	99.38
End member (mol %)									
An	96.3	92.8	96.6	96.6	96.7	96.8	98.4		
Ab	3.6	7.1	3.4	3.3	3.2	3.1	1.6		
Or	0.1	0.1	0.0	0.2	0.1	0.1	0.1		
Range	$An_{97.4-94.3}$ $Ab_{5.5-2.6}$ $Or_{0-0.2}$	$An_{92.2-93.4}$ $Ab_{6.6-7.7}$ $Or_{0-0.1}$	$An_{96.3-96.8}$ $Ab_{3.2-3.4}$ $Or_{0-0.1}$		$An_{96.4-96.9}$ $Ab_{3.0-3.6}$ $Or_{0.1}$				

consists mainly of euhedral plagioclases and interstitial pyroxenes, with rare olivine (Fig. 6). Chemical compositions of these phases are shown in Table 1.

Clast II-3: This granulitic clast, less than 0.5 mm in diameter, consists largely of plagioclase and pyroxene with minor olivine. It has a granular to mosaic texture. Chemical compositions of these phases are shown in Table 1.

Clast II-4: This is a pyroxene-plagioclase clast, about 0.6 mm in diameter, containing large radial pyroxene fragments and plagioclases (Fig. 7). Chemical compositions of pyroxenes and plagioclases are shown in Table 1. The range of pyroxene composition is from $Wo_{4.4}En_{79.7}Fs_{15.9}$ to $Wo_{33.3}En_{41.5}Fs_{25.2}$ and $Wo_{27.0}En_{18.0}Fs_{55.0}$. Plagioclases have lower An_{4-6} (mol %) than in other clasts.

Clasts II-5 and 7: These plagioclase clasts are relatively large single plagioclase grains, 1.3×1.3 mm and 0.8×0.5 mm in size, and show cataclastic to mosaic texture (Fig. 8). Plagioclases are fairly homogeneous in composition ($An_{96.3-96.9}Ab_{3.0-3.6}Or_{0.1}$) (Table 1). These might be remnants of shocked anorthosites.

Clasts II-6 and 8: Plagioclase-maskelynite clasts, consisting mainly of plagioclase maskelynite and minor pyroxene. The clasts are dark gray due to shock effects, and have a weak mosaic recrystallization texture. Chemical compositions of plagioclases and pyroxenes are shown in Table 1.

Clast III-2: This cataclastic plagioclase fragment is 0.4×0.2 mm in size. It has albite twins (Fig. 9), but plagioclase crystal has been partially crushed and randomized optically. This clast has the most Ca-rich plagioclase ($An_{98.4}Ab_{1.6}Or_{0.1}$) compared with other clasts, and may be a pristine clast.

Mg-rich and Fe-rich olivine: Mg-rich olivine and extremely Fe-rich olivine occur as individual mineral grains in the matrix. The most Mg-rich olivine is $Fo_{92.1}$ and the most Mg-poor olivine is $Fo_{13.5}$, in the range of $Fo_{13.5}$ to $Fo_{15.7}$ (Table 1).

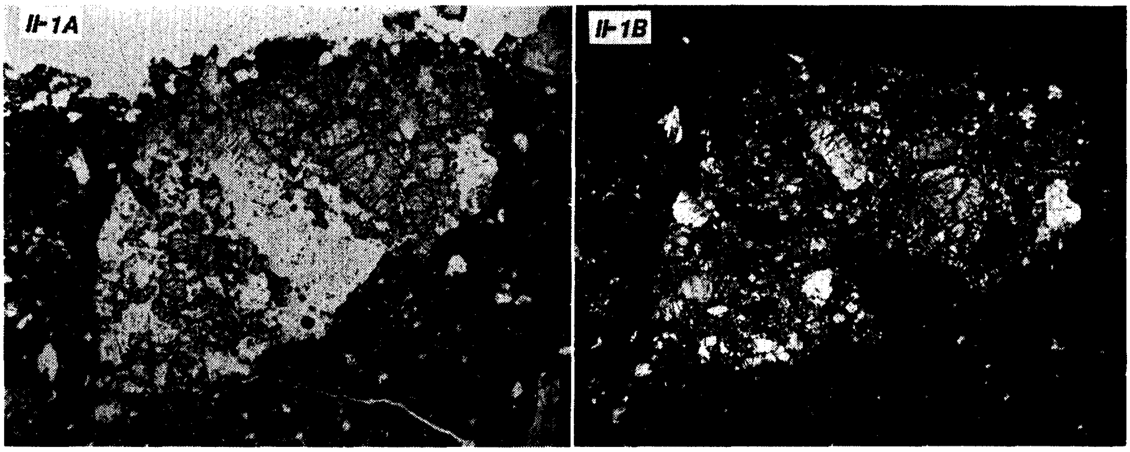

Fig. 5. Troctolitic clast (II-1) has a granulitic texture. Granulitic olivines and pyroxenes (rare) occur in plagioclases. Larger plagioclases with undulatory extinction, and finer-grained plagiolaases are also present indicating that the clast is recrystallized. (II-1A: plane-polarized light, II-1B: cross-polarized light). With 3.6 mm.

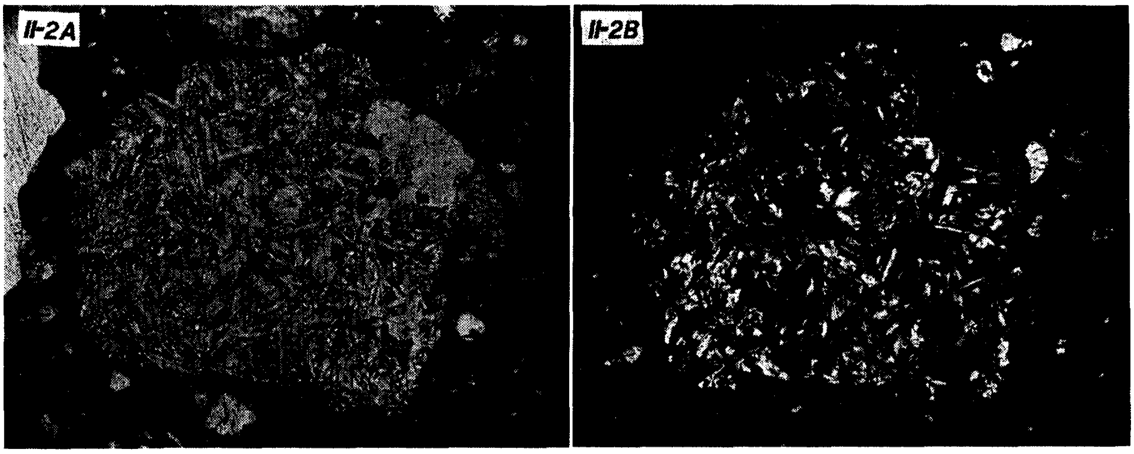

Fig. 6. Doleritic clast (II-2) has a subophitic texture, consisting of euhedral plagioclase laths, fine-grained pyroxenes, and rare olivine. (II-2A: plane-polarized light, II-2B: cross-polarized light). Width 1.2 mm.

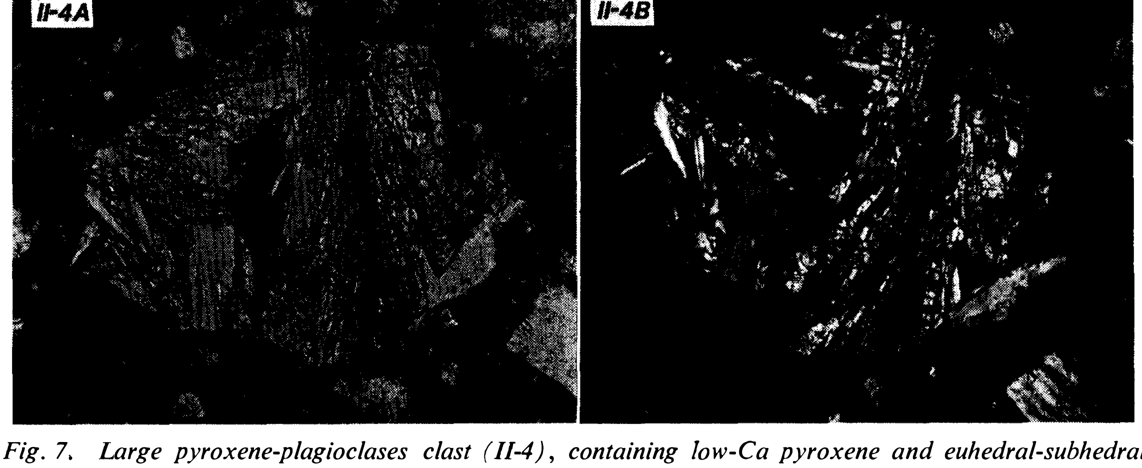

Fig. 7. Large pyroxene-plagioclases clast (II-4), containing low-Ca pyroxene and euhedral-subhedral plagioclases. (II-4A: plane-polarized light, II-4B: cross-polarized light). Width 0.85 mm.

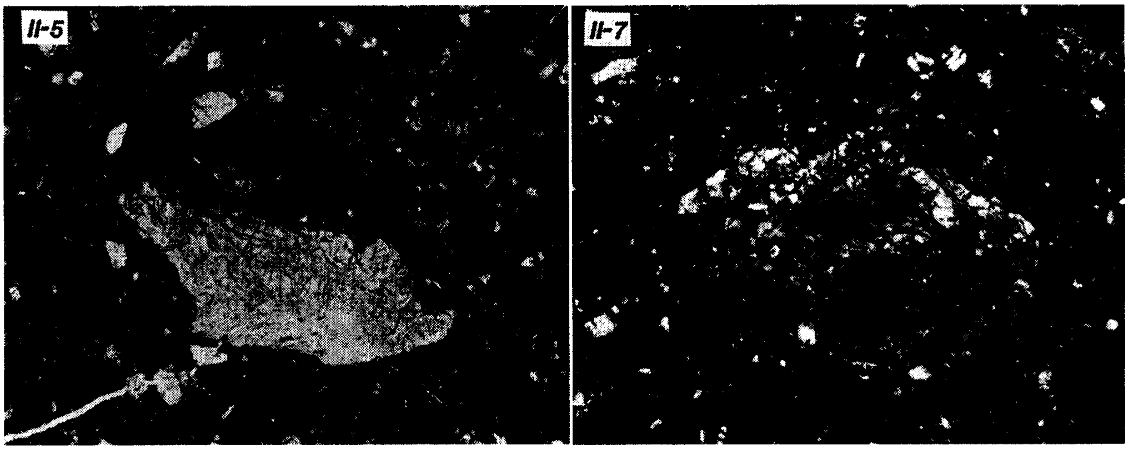

Fig. 8. Granulated and partially melted plagioclase clasts. (II-5: width 1.5 mm, plane-polarized light; II-7: width 1 mm, cross-polarized light).

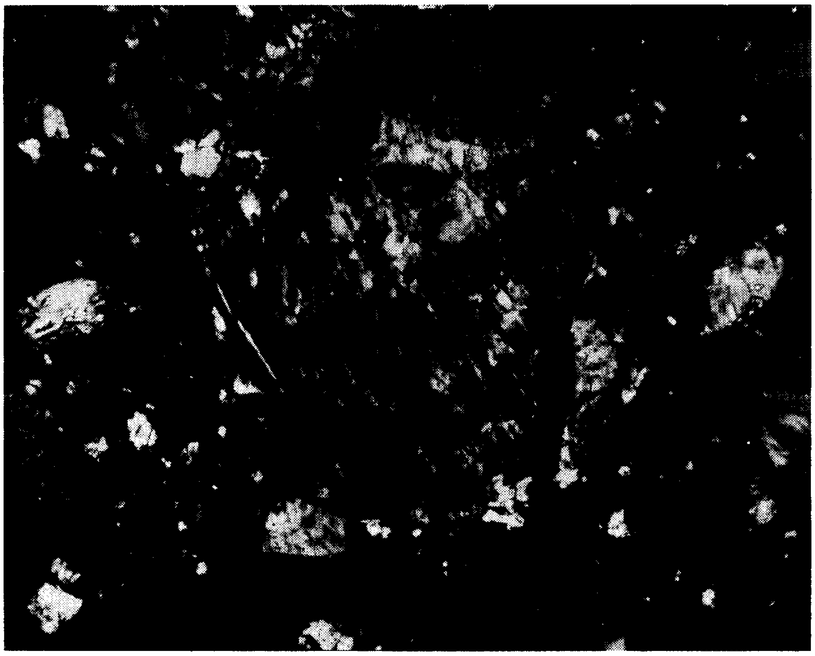

Fig. 9. Plagioclase fragment (III-2) showing well-developed albite twinning and partial granulation. This plagioclase is the most Ca-richest one in Yamato-791197 (cross-polarized light). Width 0.5 mm.

Glass spherule: Only one glass spherule, about 0.2 mm in diameter, was recognized in section 91-2. It has a few fractures and occurs in the brown matrix (Fig. 10). The glass spherule is heterogeneous in composition, with most analyses rich in Al_2O_3, FeO, MgO and Ca, but poor in alkali (Table 1).

There are an abundance of olivines, pyroxenes and plagioclase as individual minerals fragments in brown glassy matrix. Most olivine grains have compsition Fo_{80-55}. Pyroxene compositions range from $Wo_{1.7}En_{53.1}Fs_{45.1}$ to $Wo_{44.1}En_{38.3}Fs_{17.6}$, $Wo_{30.8}En_{25.2}Fs_{43.9}$ to $Wo_{2.8}En_{83.1}Fs_{14.1}$ and $Wo_{42.7}En_{48.3}Fs_{9.0}$ to $Wo_{2.1}En_{39.0}Fs_{58.9}$. Plagioclases have composition $An_{92.0-98.0}$.

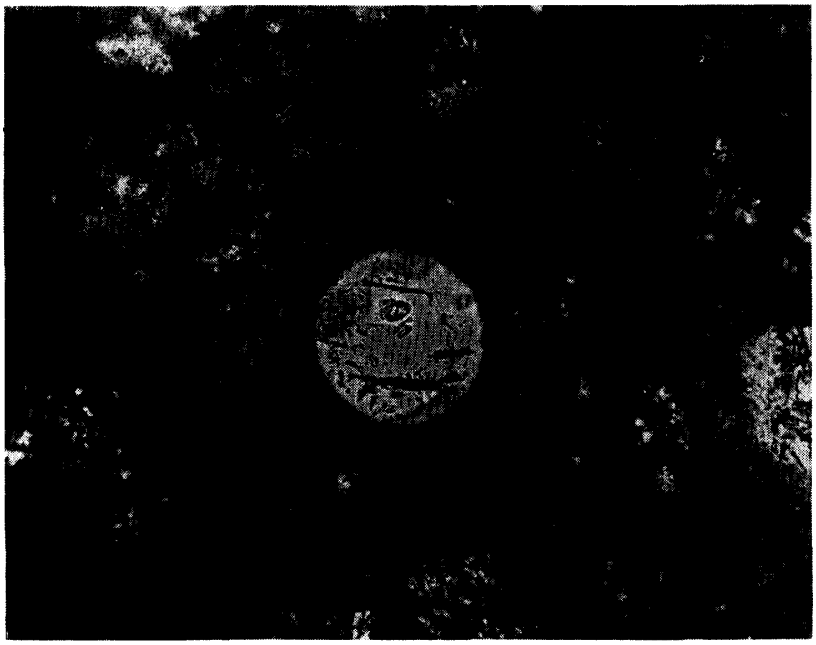

Fig. 10. Well-rounded glass spherule, about 0.2 mm in diameter.

6. Chemical Compositions of Bulk Rock and Individual Minerals

The bulk chemical composition of the Yamato-791197 anorthositic regolith breccia is given in Table 2. Both the bulk composition and mineral compositions are plotted

Table 2. Bulk chemical composition of two lunar meteorites and lunar rocks (wt %).

	Lunar meteorite		Appollo 15[2]	Luna 16[3]
	Y-791197	ALHA81005[1]	15418	21013
SiO_2	43.14	46.46		
TiO_2	0.35	0.23	0.30	0.2
Al_2O_3	26.01	25.32	26.4	27.0
Fe_2O_3	0.04	—		
FeO	7.02	5.40	7.0	5.2
MnO	0.08	587(Mn ppm)	0.084	0.066
MgO	6.22	7.98	6.0	7.8
CaO	15.33	15.11	15.7	15.0
Na_2O	0.33	0.31	0.29	0.31
K_2O	0.02	0.029	0.011	0.021
$H_2O(-)$	0.10			
$H_2O(+)$	0.48			
P_2O_5	0.31			
Cr_2O_3	0.13	0.12	(0.28)	0.11
Ni	0.018	186(ppm)		
Co	0.003	20.2(ppm)		
S	0.41			
Total	99.99	100.9		

Analyst: H. HARAMURA. 1) PALME *et al.* (1983), 2) LAUL and SCHMITT (1973), 3) SMITH *et al.* (1983).

in the MnO *vs.* FeO diagram (Fig. 11) along with those of ALHA81005 (PALME *et al.*, 1983), some lunar highland rocks (LAUL and SCHMITT, 1973), and numerous Yamato achondrites (diogenites, howardites and eucrites) (authors' data). This diagram indicates that the Yamato-791197 anorthositic regolith breccia is positioned near the field for lunar pyroxenes and moon whole rocks. The bulk composition of Yamato-791197 is very similar to that of ALHA81005 and lunar breccia 15418 and 21013 (LAUL and SCHMITT, 1973; SMITH *et al.*, 1983). However, the ratio of MnO *vs.* FeO in pyroxene in Yamato-791197 differs from those in Yamato achondrites (authors' data). The pyroxenes of Yamato-791197 plotted in the lunar field provide a strong evidence for its lunar origin. Another piece of evidence for the lunar origin of Yamato-791197 is its oxygen isotope ratios (CLAYTON *et al.*, 1984).

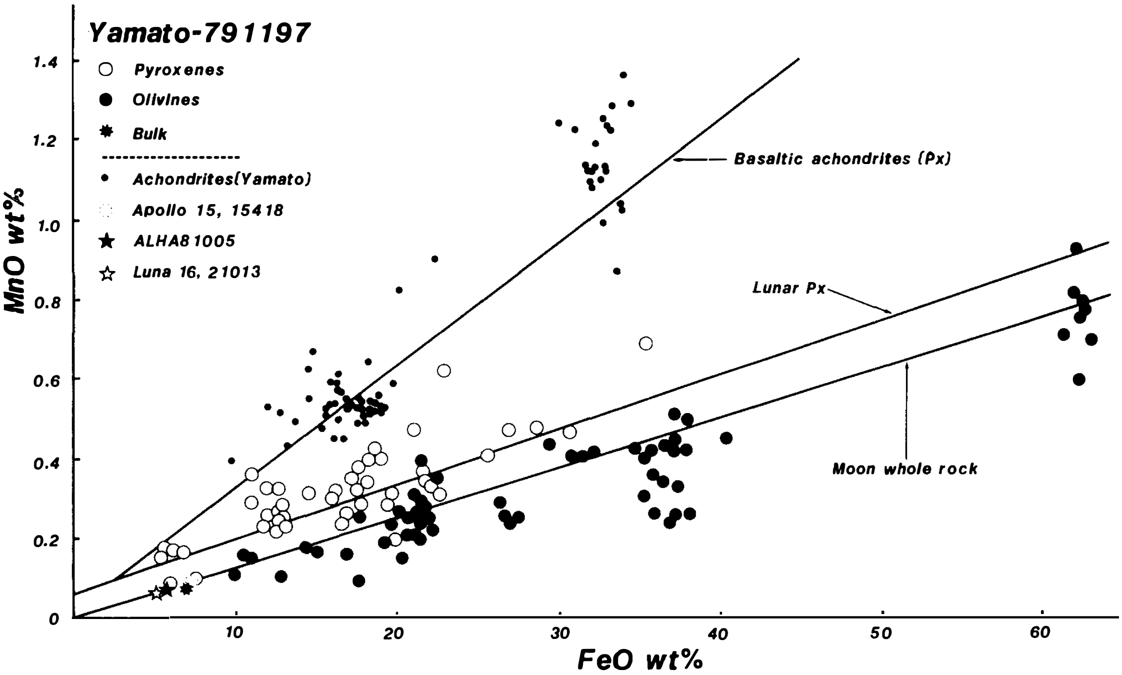

Fig. 11. The FeO/MnO ratio of the Yamato-791197 meteorite, lunar rocks and Yamato achondrites. The large open circles represent pyroxenes of Yamato-791197 plotted in the lunar field. Some of them extend to the achondrite field. The pyroxene compositions are plotted near the lunar whole rock and the olivine compositions (large solid) are on or below it.

The range of the chemical composition of olivines is shown in Fig. 12. Most olivines range from Fo_{55} to Fo_{80}, although some Mg-rich ($Fo_{92.1}$) and Fe-rich ($Fo_{14.0}$) ones are observed. Olivines in clast II-1 are Mg-poorer than those in the other clasts. Most of olivines in the clasts are Mg-rich and similar in composition to those in the matrix. The composition of pyroxenes ranges from $En_{18.0}$ to $En_{83.1}$, $Fs_{9.0}$ to $Fs_{58.9}$ and $Wo_{1.7}$ to $Wo_{44.1}$ (Fig. 12).

Plagioclases are compositionally homogeneous and are Ca-rich ranging from An_{95} to An_{97}, compared with most eucrites. Plagioclases in doleritic-gabbroic clasts are more Na-rich ($An_{92.0}$) that those in the matrix, granular and anorthositic clasts. The

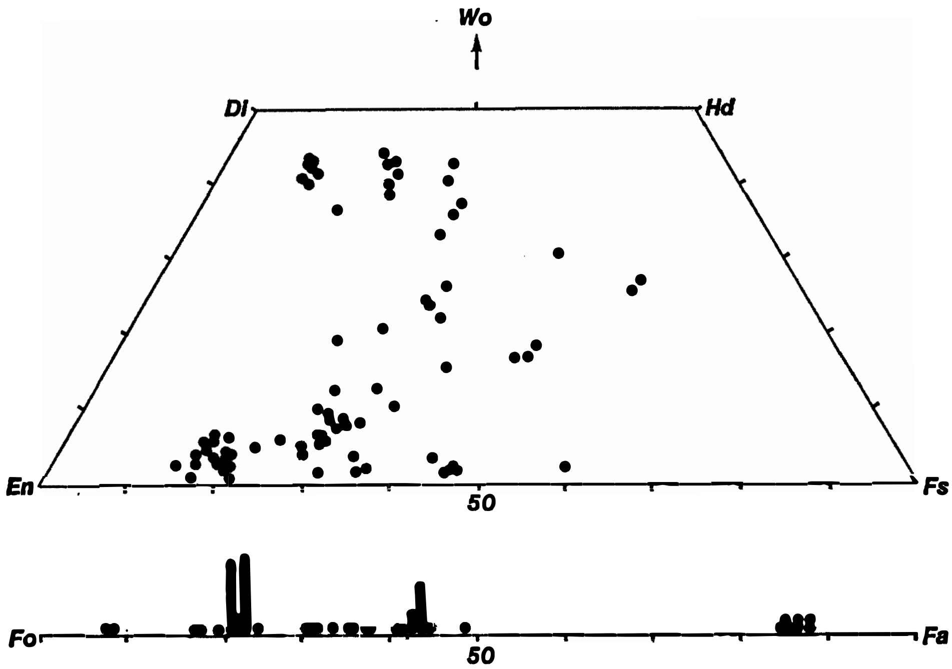

Fig. 12. Pyroxene quadrilateral and olivine compositions in Yamato-791197.

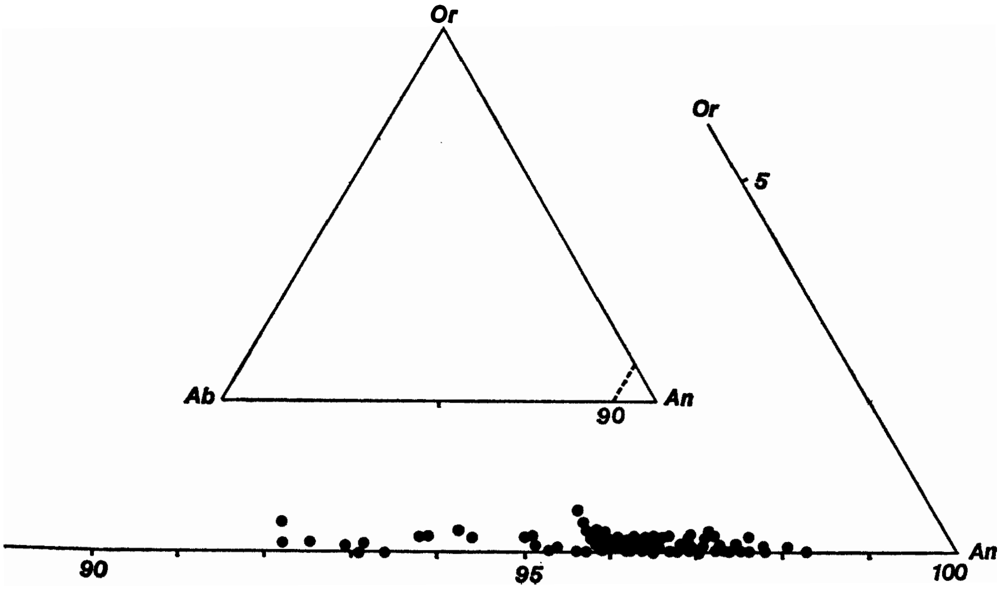

Fig. 13. Chemical compositions of plagioclases in Yamato-791197 plotted in the Ab-An-Or diagram.

Ca-richest plagioclase ($An_{98.2}$) occurs in the anorthositic clast which may be pristine (Fig. 13).

7. Discussion and Summary

The Yamato-791197 meteorite has been classified as a lunar regolith breccia, one of two lunar meteorites, because it has appearances of a regolith breccia with an abundance of lithic clasts and dark brown glassy matrix. This is the first lunar meteorite recovered from the Yamato Mountains, Antarctica.

a. The MnO/FeO ratio in pyroxenes of Yamato-791197 are plotted in the lunar field, differing from those of achondrites. This strongly indicates a lunar origin of the meteorite

b. The bulk chemical composition of Yamato-791197 is very similar to that of ALHA81005 (lunar meteorite) and some lunar rocks, such as lunar breccia 15418 and 21013.

c. Yamato-791197 is a brecciated meteorite and contains several kinds of clasts in a dark brown glassy matrix.

d. Clasts have a variety of textures, including anorthositic, troctolitic, gabbroic, diabasic, basaltic and melted lithic glass, most of which were strongly shocked and partly granulated, in a dark brown glassy matrix.

e. The textures resemble those of howardites and polymict eucrites, but Yamato-791197 appears to be more feldspathic than them. In texture this meteorite is very similar to the lunar regolith breccia of 64505, 65787 and the ALHA81005 lunar meteorite (regolith breccia), especially with the presence of the dark brown glassy matrix and the feldspathic clasts which frequently show mosaic textures due to shock effects. But the swirly brown glass noticed in ALHA81005 is not yet recognized in Yamato-791197.

f. Plagioclases are very Ca-rich, ranging from $An_{92.0}$ to $An_{8.2}$. Pyroxenes are variable in composition, $En_{18.0}Fs_{9.0}Wo_{1.7}$ to $En_{83.1}Fs_{58.9}Wo_{44.1}$. Some low-Ca pyroxenes are more Mg-rich than in most eucrites. Most olivines range from Fo_{55} to Fo_{80}, but some Mg-rich grains ($Fo_{92.1}$) and Fe-rich grains ($Fo_{13-15.7}$) are observed.

g. Discovery of the second lunar meteorite from a different location in Antarctica suggested that more lunar meteorites may be recovered from Antarctica.

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Postscript: Yamato-82192 anorthositic regolith breccia: Preliminary description of the third lunar meteorites;

Then the third lunar meteorites, Yamato-82192 has been identified as an anorthositic regolith breccia by the present authors (YANAI *et al.*, 1984). Yamato-82192 meteorite specimen was collected on the southern bare ice of the Minami-Yamato Nunataks, Antarctica by Mr. T. KATSUSHIMA, University of Hokkaido, geologist of the Japanese Antarctic Research Expedition in 1982–1983 field season. This specimen is nearly half stone, 36.67 g and covered with less fusion crust, but it has some smooth surface which is corted with yellowish-tan colored. Fresh surface and interior show gray to light gray color. This specimen consists of aboundant clasts which range from mm to one cm, and they show dark to black and white in color in a light gray matrix.

The section of the specimen shows numerous clasts which made of melted lithic fragments, crystalline fragments and brecciated lithic fragments in matrix. There are two type clasts of polymineral and monomineral in the section. The pyroxene and olivine, and plagioclase-pyroxene. The smaller clasts are individual mineral fragments of most plagioclase and with some pyroxenes and minor of olivine. Most of melted fragments showing brown color are divitrified and contain fine plagioclases and minor pyroxenes. In the rare case the specimen contains small glass spherules. The clasts of the crystalline rock fragments show a variety of texture including diabasic, basaltic and granulitic, and most of them have been shocked more or less. Matrices of the specimen consist of two part of brown color area and light area which shows a divitrified and recrystallized textures.

Microprobe analyses show that feldspar ranges from $An_{83.0\ to\ 98.2}$ with most analysis following between An_{93} and An_{98}, and they are containing 1.3% (maximum) of Or component; pyroxene and olivine is variable in composition, pyroxene: $Wo_{1.8-43.2}$, $En_{13.8-79.4}$, $Fs_{8.1-57.6}$ and olivine, $Fo_{6.8-89.1}$ were analyzed. MnO content of the both pyroxene and olivine are lower than theirs of the all achondrites, but they are very similar to the some of lunar rocks, especially anorthositic regolith breccia.

This specimen shows a brecciated texture of numerous lithic fragments, which is common occurrences in the most polymict eucrites and howardites, but it is different from eucrites and howardites in most respects of mineralogically, chemically and others.