A BRACHINA-LIKE INCLUSION IN THE YAMATO-75097 L6 CHONDRITE: A PRELIMINARY EXAMINATION

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Abstract: A Brachina-like inclusion is identified in the Yamato-75097 L6 chondrite. The inclusion has a shiny black fusion crust and is relatively large (2.5×2.5×0.8 cm) and about 15 g in weight. The fusion crust is distinguished clearly from the dull black fusion crust of the host. Microscopically, the inclusion has a fine-grained granular texture and consists mainly of olivine with minor merrillite and plagioclase, and a little chromite. Plagioclase is isotropic and presumably maskelynite. Pyroxene, nickel-iron and troilite were not identified. The texture of the inclusion appears to be similar to that of the Brachina meteorite. Compositions of the constituent minerals are olivine average Fo_{76} (range $Fo_{75.0-76.5}$, % M.D.=1.1), maskelynite $An_{15}Ab_{75}Or_{10}$ and merrillite ($MgO_{=3.62}$ $FeO_{=0.48}$ $CaO_{=44.9}$ $Na_2O_{=2.79}$ $P_2O_{5=47.4}$). Olivine is compositionally homogeneous and relatively Mg-rich compared with that of Brachina. The olivine composition is very similar to that of the host.

1. Introduction

The Yamato-75097 L6 chondrite contains some unique inclusions. One is of a relatively large size and angular shape with shiny black fusion crust and is clearly distinguished from the dull black fusion crust of the host. Megascopically, the inclusion appears light gray and consists of a fine-grained aggregate with a relatively coarser-grained aggregate in the core. Microscopically, the inclusion is a fine-grained aggregate consisting mostly of olivine with minor merrillite and plagioclase; opaques are rare. It shows a possible cumulate texture. The mineral assemblage and texture of the inclusion are similar to those of the Brachina meteorite. However, there are some extreme differences in their occurrences, and a little difference chemically and mineralogically.

2. General Features of the Y-75097 Meteorite

Yamato-75097 (Fig. 1) is a complete stone covered by a 1 to 2 mm thick, blackish brown to dull black fusion crust. Areas devoid of fusion crust are observed along edges of this angular stone, and are weathered to a yellowish brown color. The interior material is light gray with small brown oxidation haloes. Chondrules and relatively large metal grains are seen on sawed surfaces.

This stone contains some unique inclusions (Figs. 1a, 1b) which show some variety in their features. The largest of these inclusions was selected for this study.

Petrographically, Y-75097 contains a chondritic structure (Fig. 2a), but chondrules and chondrule fragments show extensive integration with the granular groundmass which consists of olivine and pyroxene with minor amounts of plagioclase, merrillite, nickel-iron and troilite. Chondrule types include granular olivine and olivine-pyroxene, barred olivine and weakly radial pyroxene. The stone is traversed by thin black veinlets probably produced by shock. The meteorite appears to be mainly unweathered.

The composition of the olivine and orthopyroxene in the chondrite host are; average $Fo_{75.8}$ (range $Fo_{74.7-77.0}$, % M.D. = 1.5) and $En_{78.1}Fs_{20.1}Wo_{1.7}$ (range $En_{76.8-79.4}$ $Fs_{19.3-21.5}Wo_{1.3-2.1}$, % M.D. = 2.2) respectively. The composition of clinopyroxene is $En_{48.7}Fs_{8.0}Wo_{43.3}$. The meteorite is classified as an L6 chondrite.

3. Materials and Methods

Three polished thin sections (Figs. 2b, 2c and 2d) which were made of the small chips of the inclusion from the Yamato-75097 were examined. All of them (NIPR section Y-75097,96–1, 96–2 and 96–3) were used for quantitative analysis and polarizing microscope measurement. Compositional analysis of the constituent minerals was carried out by an automated JEOL JCXA 733 electron microprobe, using four spectrometers. The bulk analysis of the inclusion was carried out by modal and mineral analysis.

4. Mineralogy and Texture of the Inclusion

Mode and texture: Modal data on the inclusion are tabulated in Table 1 and compared with those of Brachina. Representative mineral compositions from the inclusion are tabulated in Table 2. Textural relations are shown in Figs. 2b, 2c and 2d.

Microscopically, the inclusion is a fine to medium-grained aggregate consisting mostly of olivine with minor amounts of interstitial merrillite and plagioclase, and a trace of opaque minerals. Plagioclase is isotropic and is presumably maskelynite. Pyroxene, nickel-iron and troilite were not identified. The texture is dominated by subhedral to anhedral olivine, but there is some variety in the texture. In the relatively coarser part (Fig. 2b) the texture is dominated by subhedral olivine with interstitial merrillite and plagioclase. However, in the fine-grained part the texture is dominated by granular olivine (relatively coarse) and fine-grained olivine with a trace of merrillite, and plagioclase is found interstitially among them. Largely olivine was elongated and weakly orientated. Some veinlets in the section were recognized.

Olivine: Olivine is compositionally homogeneous and relatively Mg-rich, $Fo_{75.8}$ (Table 2; Fig. 3), compared with Brachina. The range is $Fo_{75.0-76.5}$, % M. D. = 1.1 (Table 2). The olivine composition is very similar to that of the host chondrite (average $Fo_{75.8}$, range $Fo_{74.7-77.0}$).

Plagioclase: Plagioclase is anhedral, and appears as interstitial grains between olivine grains. In the core, plagioclase is less abundant than merrillite, but in the mantle part plagioclase is more abundant attaining to about 10%. It occurs between olivine grains, and some plagioclase encloses olivine grains poikiliticaly. Most plagioclase

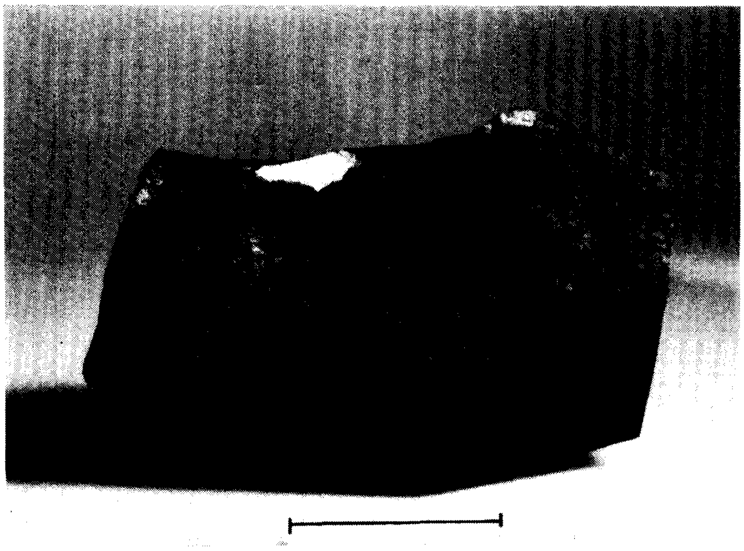

Fig. 1a. The Yamato-75097, L6 chondrite (2570.2 g). This specimen is a nearly complete, subangular stone with a 1–2 mm thick blackish-brown fusion crust. The stone contains some angular inclusions with shiny black fusion crust. A relatively large one, 2.5×2.5 cm in diameter, is seen at the top of the specimen. Scale is 5 cm.

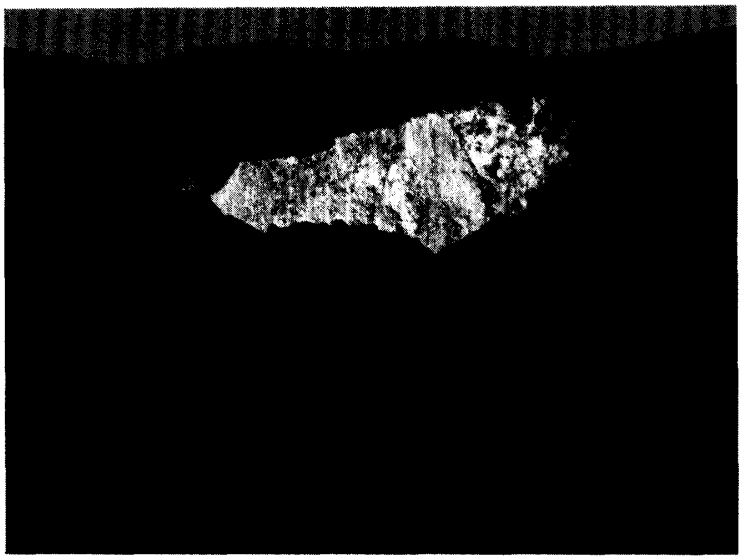

Fig. 1b. An enlarged photograph of the inclusion of Fig. 1a. The inclusion consists of a core with relatively coarse-grained aggregates (white to light gray) and a finer-grained mantle, gray to pale gray. Area of field is 5.7×4.3 cm.

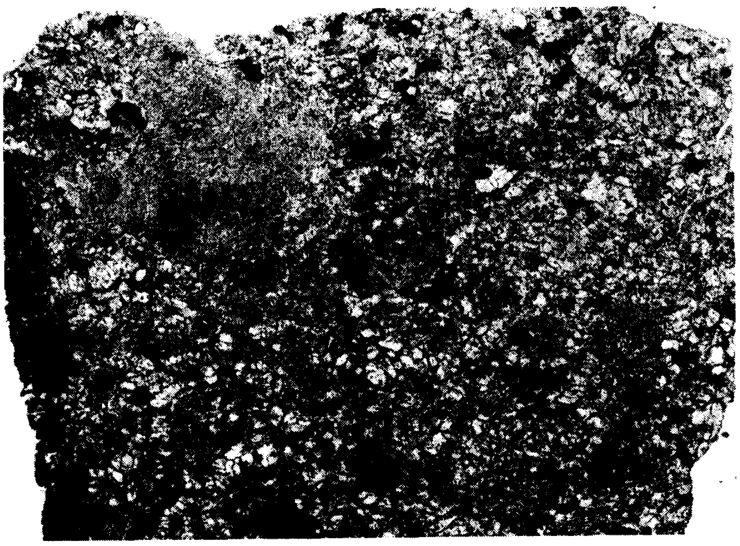

Fig. 2a. A photomicrograph of thin section (area of field is 11.3×8.6 mm) of Yamato-75097. Chondritic structure is present, but chondrules and chondrule fragments show extensive integration with the groundmass. At the upper left of the section, the relatively large inclusion, a fine-grained aggregate mainly of olivine is recognized.

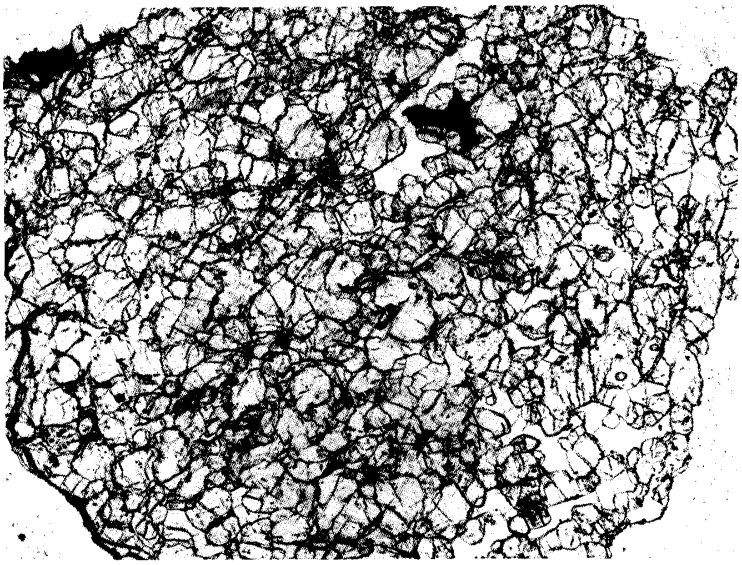

Fig. 2b. A photomicrograph of the section (area of field is 2.9×2.2 mm) of the inclusion (Y-75097, 96–1). The photo shows a possible cumulate texture of the core, which consists mostly of olivine and a trace of chromite with minor interstitial merrillite and plagioclase.

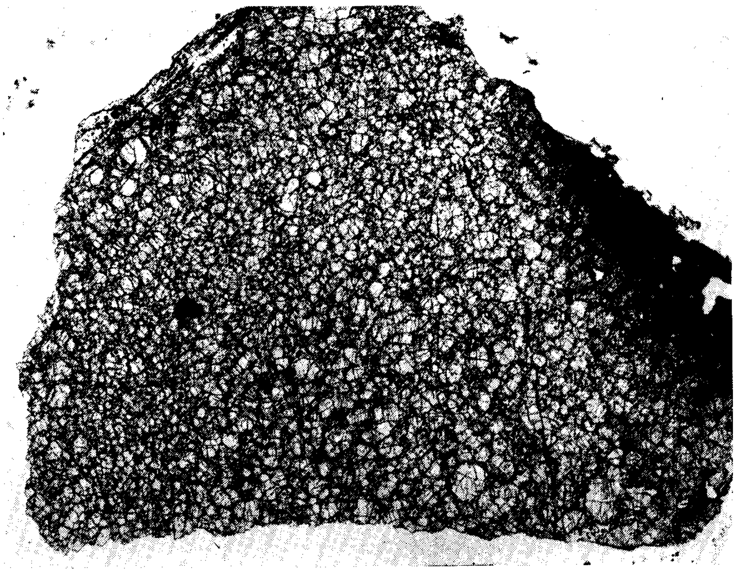

Fig. 2c. A photomicrograph of the section (area of field is 6.1×4.4 mm) of the inclusion (Y-75097,96–3). The photo shows the granular texture of the mantle which consists of relatively large olivine and fine-grained olivine with minor interstitial plagioclase. A veinlet through the section is also seen.

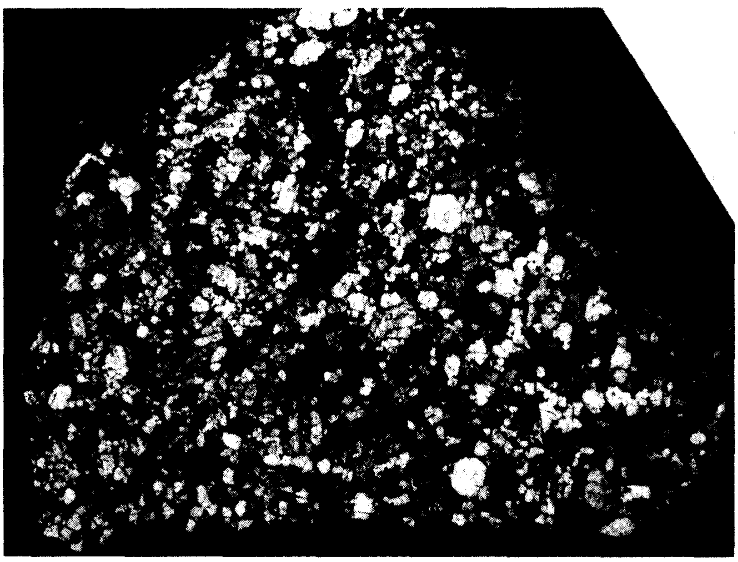

Fig. 2d. A photomicrograph of the same section as in Fig. 2c. This photo is shown in cross-polarized light.

Table 1. Modal compositions of the inclusion in the Yamato-75097 L6 chondrite (in vol %), Brachina meteorite (in wt %).

Sample	Y-75097 Inclusion: Inclusion core	Y-75097 Inclusion: Inclusion mantle	Brachina* (wt %)
Olivine	86.8 (Fo_{76})	90.3 (Fo_{76})	80.4 (Fo_{70})
Pyroxene	—	—	5.5
Plagioclase	2.5 (An_{15})	7.2 (An_{15})	9.9 (An_{22})
Merrillite	9.9	0.5	—
Chromite	0.8	1.9	0.5
Chlorapatite	—	—	0.5
Troilite	—	—	2.9
Pentlandite	—	—	0.3
Fe-Ni	—	—	trace

* NEHRU *et al.* (1983)

Table 2. Representative microprobe analyses of silicates, phosphates and oxides in the inclusion in the Yamato-75097 L6 chondrite and the Brachina meteorite (in wt %).

Sample	Inclusion Ol	Inclusion Plag	Inclusion Merri	Inclusion Chr	Brachina* Ol	Brachina* Plag	Brachina* Chr
SiO_2	38.1	68.9	—	0.05	37.2	62.5	0.03
TiO_2	—	0.04	0.04	3.28	—	—	2.48
Al_2O_3	0.03	22.7	0.01	5.31	—	23.2	7.3
FeO	22.5	0.43	0.48	29.9	26.8	0.48	28.9
MnO	0.53	0.03	0.03	0.73	0.42	—	0.53
MgO	39.0	0.03	3.62	2.35	34.9	—	6.8
CaO	0.01	2.03	44.9	0.01	0.27	4.6	—
Na_2O	0.02	5.86	2.79	0.01	—	9.0	—
K_2O	—	1.15	0.65	—	—	0.26	—
P_2O_5	—	—	47.4	—	—	—	—
Cr_2O_3	0.07	0.01	0.05	52.4	—	—	
NiO	—	0.02	0.05	0.03			
Total	100.26	101.20	100.02	94.07	99.59	100.04	99.24
End member (mole %)							
	$Fo_{75.8}$	An_{15}			$Fo_{69.8}$	$An_{21.6}$	
	$Fa_{24.4}$	Ab_{75}			$Fa_{30.2}$	$Ab_{76.9}$	
		Or_{10}				$Or_{1.0}$	

Ol: olivine, Plag: plagioclase, Merri: merrillite, Chr: chromite.
*: From NEHRU *et al.* (1983)

is isotropic and is maskelynite. The plagioclase is albite-rich, $An_{15}Ab_{75}Or_{10}$ (Table 2).
Merrillite: Merrillite is anhedral and occurs as interstitial grains (0.2–0.3 mm) among olivine grains similar to plagioclase; some encloses olivine poikiliticaly. The composition is given in Table 2.
Chromite: Chromite is a trace mineral in the inclusion and appears as subhedral grains; it is 0.2–0.3 mm in diameter. The composition of the chromite is given in Table 2.

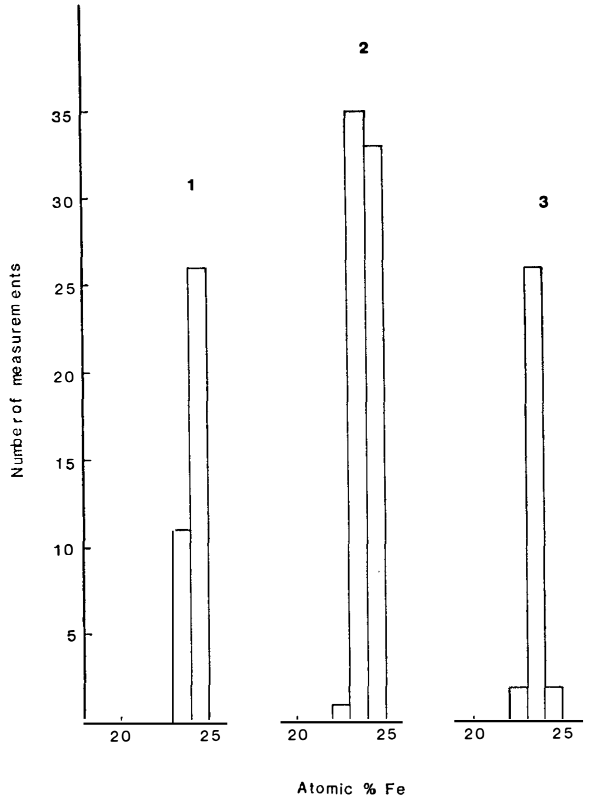

Fig. 3. Histograms of olivine compositions in the olivine-rich inclusion of the Yamato-75097 L6 chondrite. 1: Y-75097, 96–1 (inclusion core), 2: Y-75097, 96–2 (inclusion core-mantle), 3: Y-75097, 96–3 (inclusion mantle).

Table 3. Bulk chemistry of the inclusion, Y-75097 and Brachina meteorite (in wt %).

Sample	1 Y-75097 A	1 Y-75097 B	2 Inclusion core	3 Inclusion mantle	4 Brachina
SiO_2	39.71	44.7	34.8	39.4	40.0
TiO_2	0.21	0.24	0.03	0.06	0.13
Al_2O_3	2.60	2.92	0.64	1.77	2.23
FeO	15.77	17.7	19.3	20.9	24.9
MnO	0.34	0.38	0.47	0.49	0.36
MgO	26.03	29.3	34.2	35.3	28.6
CaO	1.82	2.05	4.51	0.38	2.20
Na_2O	0.95	1.07	0.45	0.45	0.66
K_2O	0.08	0.09	0.09	0.08	0.08
P_2O_5	0.26	0.29	4.70	0.24	0.28
Cr_2O_3	0.58	0.65	0.40	1.06	0.61
NiO	0.59	0.66	—	—	—
FeS	5.94				
Fe	4.88				
Ni	0.73				
Co	0.008				
Total	100.51				

1. A: Bulk meteorite (Analyst: H. HARAMURA).
   B: Iron-free compositions; recalculated to 100%.
2, 3. Calculated by modal and mineral analysis.
4. Brachina (JOHNSON *et al.*, 1977) recalculated to 100%.

5. Bulk Chemistry

The bulk chemical compositions of the inclusion are tabulated in Table 3 for comparison with those of the host Y-75097 L6 chondrite and Brachina. There are some significant differences in composition of the inclusion, particularly in the mantle portion. SiO_2, Al_2O_3 and Na_2O are more abundant than in the core portion, but CaO and P_2O_5 are enriched in the core. This plagioclase is abundant in the mantle, but a large amount of merrillite is found in the core. The inclusion contains larger quantities of Al_2O_3, Na_2O, CaO and P_2O_5 than Brachina meteorites, because of the abundance of plagioclase and merrillite.

6. Disscussion

Basically, the core and mantle of the inclusion have the same mineralogy and bulk chemistry (except for the phosphate-rich core), and similar texture, but the texture is quite different from that of the whole chondrite (host). The inclusion has similar texture, mineralogy and bulk chemistry to Brachina, although the inclusion does not have any pyroxenes and liquid inclusions. Nevertheless, the implication is that the similarity of the inclusion and Brachina might be driven by some slight differentiation process from L or LL group chondrites.

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