YAMATO-694 METEORITE: CHEMICAL COMPOSITION OF SILICATE MINERALS AND PETROGRAPHIC NATURE

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Abstract: Yamato-694 meteorite collected near the Yamato Mountains in Antarctica in 1969 is an ordinary chondrite belonging to a high-iron group. Major chemical composition of its silicate minerals was determined by electron probe microanalysis. Molar composition of olivine, orthopyroxene and plagioclase is Fo_{81}, En_{82} and An_{10}, respectively. In comparison with the analytical data of silicate minerals in ordinary chondrites, the chemical composition of olivine, orthopyroxene and plagioclase in Yamato-694 meteorite agrees with that of silicate grains in equilibrated high-iron chondrites. The result corresponds to the microscopic feature of this meteorite specimen showing an advanced recrystallization texture.

1. Introduction

Yamato-694 meteorite is one of the nine stone meteorites found near theYamato Mountains, Antarctica (37°E, 70°S), by the 10th Japanese Antarctic Research Expedition (YOSHIDA *et al.*, 1971). This meteorite is an ordinary chondrite of a high-iron group (SHIMA *et al.*, 1973; SHIMA, 1974), and it is composed mainly of olivine, pyroxene, plagioclase and opaque minerals, kamacite, taenite, troilite and chromite, associated with minor amounts of apatite and native copper (OKADA, 1975). Yamato-694 meteorite shows a recrystallized structure which is characteristics of equilibrated chondrites, and also has several evidences of a shock event. Optical properties of its mineral constituents and petrographic structure were investigated in the previous work (OKADA, 1975). Chemical composition of major silicate minerals, olivine, orthopyroxene and plagioclase, was determined by electron probe microanalysis in this work, and was discussed in relation to the structural feature of the meteorite.

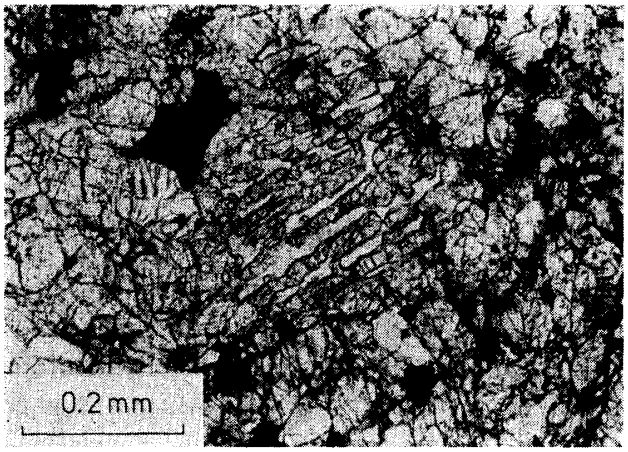
2. Experimental Method

Quantitative chemical analysis of olivine, orthopyroxene and plagioclase grains on the carbon-coated polished thin section of the meteorite specimen was carried out with JXA-5A electron probe microanalyzer. Electron beam, about 2 micrometers in diameter, accelerated by the voltage of 15 kV was bombarded

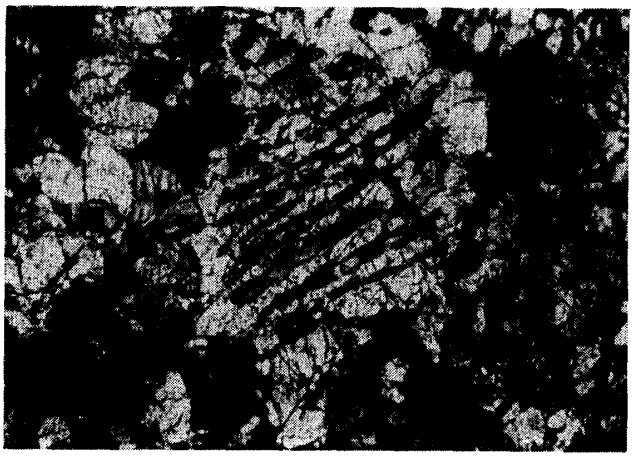
on the mineral grains, and intensities of characteristic X-ray emissions of silicon, titanium, aluminum, iron, manganese, magnesium, calcium, sodium and potassium were measured. Natural and artificial crystals of quartz, rutile, corundum, hematite, rhodonite, periclase, wollastonite, jadeite and adularia were used as standard samples for each element. Correction of the electron microprobe data was made by the procedure of SWEATMAN and LONG (1969). The thin section of the meteorite was also investigated by the polarization microscope.

3. Result and Discussion

Yamato-694 meteorite is composed of crystalline mass consisting mainly of olivine, about 40 vol.%, orthopyroxene, about 30 vol.%, plagioclase, about 10



a. Nicols not crossed.



b. Nicols crossed.

Fig. 1. A relic structure of chondrule consisting of alternate layers of olivine. The interstices between olivine layers are filled with plagioclase, and the outline of chondrule is indistinguishable in the plane polarized light.

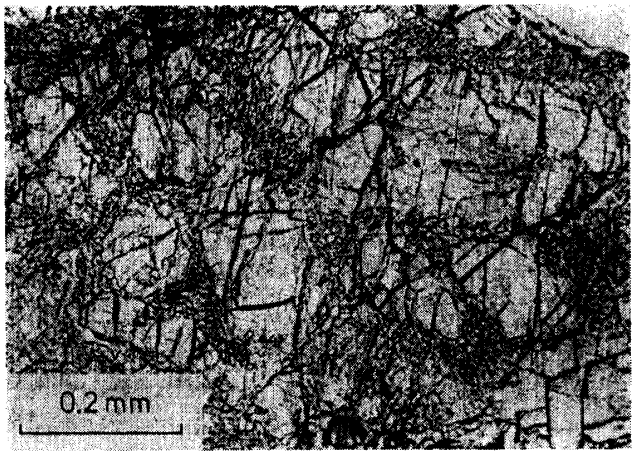


Fig. 2. Fine-grained and recrystallized material consisting of pyroxene and plogioclase, filling the interstices among olivine crystals.

vol.%, and opaque minerals. Chondritic structure is apparent by microscopic observation of the thin section. Chondules consisting of alternate layers of olivine and intersistially filling plagioclase are commonly present, but the chondrule-matrix boundary is indistinguishable in the plane polarized light because of the advanced recrystallization (Fig. 1). The interstitial material among olivine and orthopyroxene crystals in chondrules is completely recrystallized into plagioclase or a mixture of plagioclase and pyroxene (Figs. 1 and 2). The analytical result of olivine and orthopyroxene is shown in Table 1 and Table 2. The average molar composition of olivine and orthopyroxene is Fo_{81} and En_{82}, respectively, and their chemical composition is nearly homogeneous from grain to grain. KEIL and

Table 1. Electron microprobe analysis of olivine (wt.%).

	1	2	3	4
SiO_2	39.8	39.7	39.5	39.5
TiO_2	0.02	0.00	0.00	0.02
Al_2O_3	0.01	0.03	0.02	0.08
FeO	17.7	18.1	17.7	17.8
MnO	0.39	0.41	0.51	0.48
MgO	42.9	42.6	42.3	42.4
CaO	0.03	0.01	0.04	0.03
Na_2O	0.02	0.03	0.03	0.03
Total	100.87	100.88	100.10	100.34
Fo	81.2	80.8	81.0	80.9
Fa	18.8	19.2	19.0	19.1

Table 2. Electron microprobe analysis of orthopyroxene (wt.%).

	1	2	3	4	5
SiO_2	57.2	56.4	57.2	56.8	56.8
TiO_2	0.22	0.24	0.12	0.24	0.22
Al_2O_3	0.45	0.19	0.20	0.18	0.18
FeO	11.3	11.1	11.1	11.1	11.3
MnO	0.49	0.49	0.49	0.45	0.45
MgO	30.1	30.4	30.7	31.0	30.7
CaO	0.90	0.67	0.81	0.57	0.91
Na_2O	0.01	0.05	0.01	0.02	0.03
Total	100.67	99.44	100.63	100.36	100.59
Wo	1.7	1.3	1.5	1.1	1.7
En	81.2	82.0	81.9	82.4	81.5
Fs	17.1	16.7	16.6	16.5	16.8

Table 3. Electron microprobe analysis of plagioclase (wt.%).

	1	2	3
SiO_2	64.8	64.8	64.4
TiO_2	0.04	0.00	0.00
Al_2O_3	21.2	21.2	20.6
FeO	0.32	0.31	0.27
MnO	0.03	0.03	0.01
MgO	0.03	0.06	0.06
CaO	2.51	2.45	2.38
Na_2O	11.0	10.7	11.3
K_2O	0.96	1.19	1.10
Total	100.89	100.74	100.12
Or	4.8	6.1	5.4
Ab	84.5	83.3	84.7
An	10.7	10.6	9.9

FREDRIKSSON (1964) found by a large number of electron microporobe analyses that the chemical composition of olivine and orthopyroxene in the equilibrated ordinary chondrites varies corresponding to each chondrite group, H-, L- and LL-group, and that variation of Fe/(Fe+Mg) mole ratios of olivine and orthopyroxene is 16.1–19.4 and 14.7–17.2 in H-chondrites, 21.6–24.5 and 17.9–21.7 in L-chondrites and 26.3–29.0 and 22.2–24.6 in LL-chondrites. The average Fe/(Fe+Mg) mole ratios of olivine and orthopyroxene of Yamato-694 meteorite, 19.0 and 17.0,

respectively, indicate that this meteorite is a H-group chondrite, as was confirmed from bulk chemical analysis (SHIMA, 1974). Calcium content of olivine is an indicator of recrystallization of ordinary chondrites (DODD, 1969). In unequilibrated chondrites the content is high, and becomes less than 0.1 wt.% in equilibrated chondrites owing to the depletion of calcium from the lattice of olivine (KEIL and FREDRIKSSON, 1964). The fact that the CaO content is low in Table 1 is in agreement with the rather highly recrystallized texture of Yamato-694 meteorite. Table 3 shows the chemical composition of plagioclase. Plagioclase is commonly present both in the matrix and in chondrules of this meteorite, and contains about 10 mole % of anorthite component. The result agrees with the fact that anorthite component reaches 10–20 mole % with the advance of recrystallization (MASON, 1965). Both chemical composition of silicate minerals and textural appearance show that Yamato-694 meteorite is an equilibrated high-iron chondrite.

Acknowledgments

The authors would like to express their profound thanks to Prof. K. YAGI of Hokkaido University, for his guidance and discussion through this work, and to Prof. M. GORAI of Tokyo University of Education, for his courtesy to put the specimen at the authors' disposal for this work. Drs. S. IGI, T. SOYA and K. OKUMURA of the Geological Survey of Japan kindly permitted the use of the electron probe microanalyzer. The authors are indebted to all these persons.

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(Received May 6, 1978)