FERROPSEUDOBROOKITE-SILICA MINERAL-ALBITE-CHONDRULE IN THE ALH-77015 CHONDRITE (L3)

Hirokazu FUJIMAKI, Mikio MATSU-URA, Ken-ichiro AOKI and Ichiro SUNAGAWA

Institute of Mineralogy, Petrology and Economic Geology, Faculty of Science, Tohoku University, Sendai 980

***Abstract*:** Ferropseudobrookite-silica mineral-albite-chondrule was found in an unequilibraed (L3) chondrite (ALH-77015). This is the first finding of ferropseudobrookite in chondrite. The ferropseudobrookite exhibits a weakly zonal structure. The stability field of ferropseudobrookite suggests that the chondrule should have been quenched at a temperature near $1140 \pm 10°C$.

1. Introduction

We found a unique chondrule in the ALH-77015 chondrite. It consists of albite, silica mineral, ferropseudobrookite and glass. Such a chondrule has not been reported so far in L3-type chondrites. Therefore, it is worthwhile to report the petrographic description and the results of analyses of the constituent phases of the chondrule.

2. Experimental Procedure

The constituent minerals and glass were analyzed by a HITACHI X-560S electron probe microanalyzer using an energy-dispersive analytical system. The technique and the accuracy of this method will be reported shortly by FUJIMAKI and AOKI (1981 in preparation). The conventional ZAF correction was applied to obtain weight percentage of each oxide.

3. Petrographic Description of the Chondrule

The chondrule is ellipsoidal in shape. The microphotographs are shown in Figs. 1 and 2.

Albite crystals are abundant in the chondrule followed by a silica mineral. The boundaries between the albite and the silica mineral are not straight. The albite and the silica mineral appear to have a myrmekite-like texture. In Fig. 2, the light gray minerals are albite and the dark gray minerals are silica mineral. All the albite crystals and silica mineral show simultaneous extinction, respectively, which is clearly seen in Fig. 2. Only two grains of ferropseudobrookite were found; one being an elongated

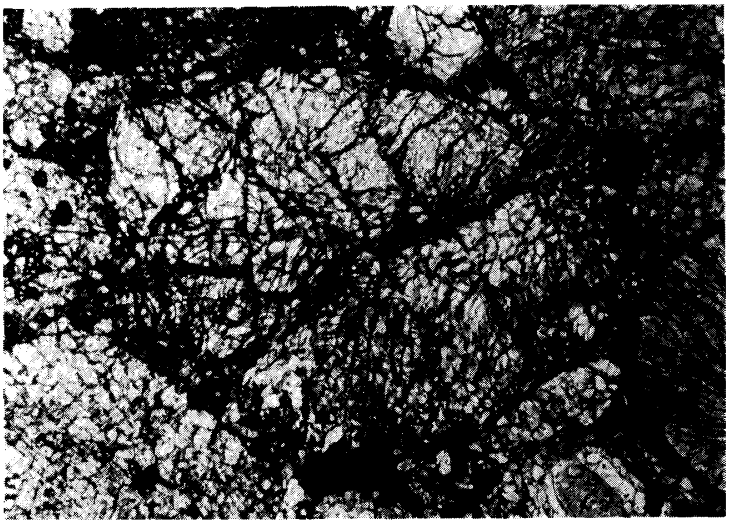

Fig. 1. Ferropseudobrookite-silica mineral-albite-chondrule in the ALH-77015 chondrite; Plane light. Long dimension of photograph = 1.6 mm.

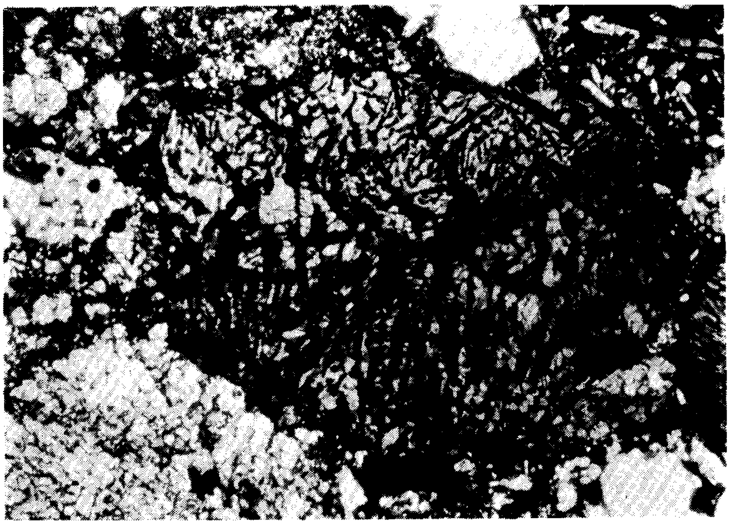

Fig. 2. The same as Fig. 1. Crossed nicols. See text.

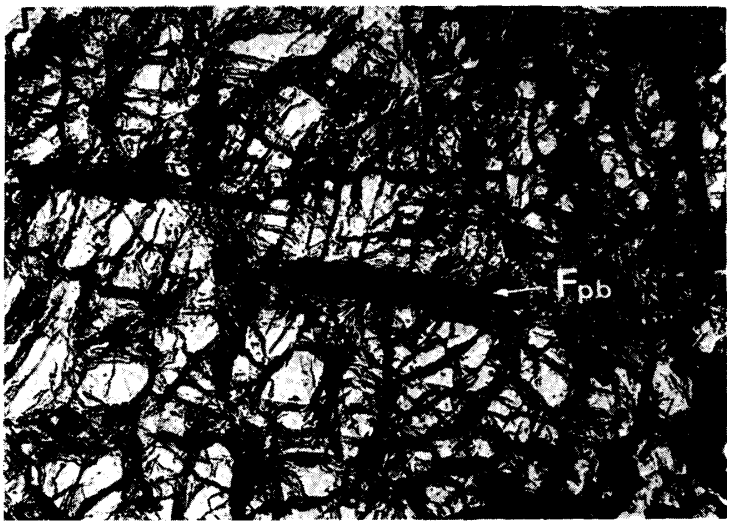

Fig. 3. Ferropseudobrookite in albite-silica mineral myrmekite-like texture. Plane light. Long dimension of photograph = 0.3 mm. Fpb: Ferropseudobrookite.

ellopsoidal form (Fig. 3), the other rounded. Glass is clear and fills the interstices between albite and silica mineral. There is no glass between ferropseudobrookite and albite, as well as silica mineral. In addition to glass, cryptocrystalline materials are observed filling the grain boundaries. Fe-rich olivine is rarely found in the grain boundaries. Metals and sulfides cannot be found.

Chondrules composed of albite, silica mineral and ferropseudobrookite have not been reported so far in L3-type chondrite, and this is the first finding of ferropseudobrookite in chondrite.

4. Results and Discussion

The representative analytical results of albite, silica mineral, glass and olivine are presented in Table 1.

The albite crystals are relatively homogeneous in chemical composition. They scarcely contain CaO and K_2O, whereas some albite crystals involve TiO_2. The formulae calculated on the basis of eight oxygen atoms are not good enough to fit the ideal stoichiometric formula of albite.

Table 1. Analyses of albite, silica mineral, glass and olivine.

	Albite			Silica mineral		Glass	Olivine
Na_2O	13.25	12.83	13.30	0.54	0.40	9.96	
MgO						1.75	19.32
Al_2O_3	19.10	18.68	19.76	1.97	1.90	16.51	
SiO_2	66.38	67.59	67.09	96.58	95.99	61.77	34.10
K_2O	0.24	0.19	0.34			0.16	
CaO	0.21	0.15				0.30	
TiO_2		0.11	0.17	0.34	0.31	0.18	
MnO						0.26	
FeO		0.27		0.10	1.02	9.13	46.56
Total	99.18	99.82	100.66	99.52	99.61	100.02	99.98
	Cation (O=8)					Cation (O=4)	
Na	1.143	1.098	1.132			Mg	0.847
Al	1.002	0.972	1.022			Si	1.003
Si	2.955	2.984	2.944			Fe	1.146
K	0.013	0.011	0.019			Σ	2.996
Ca	0.010	0.007					
Ti		0.006	0.008				
Fe		0.010					
Σ	5.123	5.088	5.125				

The silica mineral contains minor amounts of Al_2O_3, Na_2O, TiO_2 and FeO. Its SiO_2 content ranges from 95 wt% to 97 wt%. This mineral is most probably either tridymite or crystobalite.

Clear glass filling the interstices is variable in composition. One example of the composition is presented in Table 1. The glass usually contains Na_2O and FeO in major amounts and MgO and K_2O in minor amounts.

One of Fe-rich olivines found in the grain boundaries is presented in Table 1. There are a few olivines in the chondrule. All of them are enriched in FeO.

The representative analytical results of the ferropseudobrookite are given in Table 2. This mineral is not armalcolite because of the defficiency of karooite ($MgTi_2O_5$) molecules (ANDERSON *et al.*, 1970). The TiO_2 content ranges from 66 wt% (center) to 79 wt% (margin). The mineral contains minor amounts of CaO, Cr_2O_3 and MnO. The atomic formulae are calculated on the basis of five oxygen atoms. The ferropseudobrookite is weakly zoned with major elements, although the minor elements are relatively homogeneous. The central portion of the ferropseudobrookite is more enriched in iron oxide than the marginal portion. The totals of cations of the analytical results, excluding No. 4 in Table 2, are less than 3.000. These data imply that Ti^{3+} and/or Cr^{2+} may be involved in the analyzed portions. On the contrary, one of the totals of cations of the central portion (No. 4 in Table 2) is more than 3.000. This portion may not involve Ti^{3+} and Cr^{2+}.

The analytical results of the ferropseudobrookite present an interesting problem. It is inferred from the results that the marginal portion of the mineral had crystallized

Table 2. Chemical compositions of ferropseudobrookite.

No.	Margin			........Center........				........Margin
	1	2	3	4	5	6	7	8
CaO	3.12	3.07	2.48	2.65	2.97	3.13	3.06	3.21
TiO_2	78.79	77.63	72.41	65.83	72.02	79.18	77.85	77.67
Cr_2O_3	3.23	3.20	2.81	2.51	2.96	3.27	3.41	3.24
MnO	0.84	0.43	n.d.	n.d.	0.40	0.44	0.46	0.92
FeO	16.02	16.32	22.42	28.55	21.86	16.36	16.20	15.92
Total	102.00	100.65	100.12	99.54	100.21	102.38	100.98	100.96
Cation (O=5)								
Ca	0.120	0.120	0.099	0.110	0.119	0.119	0.118	0.124
Ti	2.119	2.117	2.037	1.923	2.026	2.121	2.116	2.113
Cr	0.091	0.092	0.083	0.077	0.088	0.092	0.097	0.093
Mn	0.025	0.013			0.013	0.013	0.014	0.028
Fe	0.479	0.495	0.701	0.928	0.684	0.487	0.490	0.482
Σ	2.834	2.837	2.920	3.038	2.930	2.832	2.835	2.840

n.d.: not detected.

under an extremely reducing condition, whereas the central portion of the mineral had crystallized under a relatively oxidizing condition.

Ferropseudobrookite is easily decomposed to ilmenite solid solution and rutile below 1140±10°C (AKIMOTO *et al.*, 1957; HAGGARTY and LINDSLEY, 1970). The stability field of ferropseudobrookite, however, would be affected by the minor elements such as CaO and Cr_2O_3 included in the mineral. Consequently, though the exact temperature of quenching of the chondrule cannot be determined, the existence of the ferropseudobrookite implies that the chondrule has been quenched at a high temperature at which ferropseudobrookite was stable.

Acknowledgments

We are grateful to Prof. T. NAGATA and Dr. K. YANAI of the National Institute of Polar Research for providing us with the sample. We thank Prof. I. KUSHIRO for useful suggestions. Our thanks are also due to Mr. I. HINO who prepared the thin section.

References

AKIMOTO, S., NAGATA, T. and KATSURA, T. (1957): The $TiFe_2O_5$-Ti_2FeO_5 solid solution series. Nature, **179**, 37–38.

ANDERSON, A. T., BUNCH, T. E., CAMERON, E. N., HAGGERTY, S. E., BOYD, F. R., FINGER, L. W., JAMES, O. B., KEIL, K., PRINZ, M., RAMDOHR, P. and EL GORESY, A. (1970): Armalcolite: A new mineral from the Apollo 11 samples. Proc. Apollo 11 Lunar Sci. Conf., 55–63.

HAGGERTY, S. E. and LINDSLEY, D. H. (1970): Stability of the pseudobrookite (Fe_2TiO_5)-ferropseudobrookite ($FeTi_2O_5$) series. Carnegie Inst. Washington, Yearb., **68**, 247–249.

(Received May 8, 1981; Revised manuscript received July 24, 1981)