THE METEORITES OF BOXIAN AND ITS MINERALS

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Received August 5, 1985.

I. THE METEORITES

Two meteorites fell on Linzimen of Boxian, Anhui Province at 2:30 p. m. on October 20, 1977 and were named Meteorites No. 1 and No. 2 (see Fig. 1). We went to the field for inspection on October 25, 1977. According to Yan Xuewen et al., about two hundred people caught the wonderful sight of Meteorite No. 1 falling to the ground. At the beginning people heard a noise humming as the plane's motor, then, it exploded like firecrackers and the dust rose up into the air as a smoke about 6 or 7 m high. About one and a half hours later the meteorite cooled down and was picked up from the ground. It weighs 5.5 kg and is 16.5 cm in length. The crater took a shape of a cone. The diameter of the base is 12 cm, while that of the apex is nearly 9 cm, depth about 50 cm. The precise locality is 33°53′ N and 115°33′ E. The dip angle is 50°—70°. Meteorite No. 2 weighs about 2 kg. It fell to the yard of a farmer's house in the Linlouzhuang village. The site is 115°34′ E, 33°54′ N. When the meteorite fell to the yard it hit the wall first, then reflected to the ground. The shape of crater was ellipsoid, its two axes are respectively 19 cm and 13 cm. The distance between Meteorites No. 2 and No. 1 is 2000 m. Their flying direction is 45° NE in the air. The sample of Meteorite No. 1 was integrated and totally recovered, while Meteorite No. 2 was broken by the collector,

Fig. 1. Meteorite No. 1 (right) and the broken pieces of Meteorite No. 2 (left).

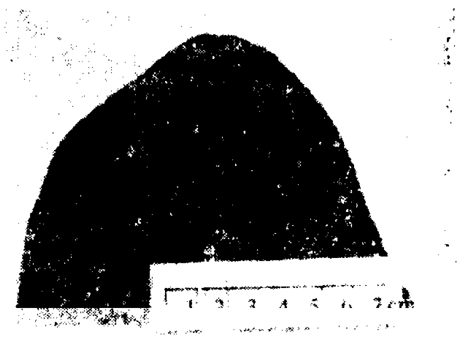

Fig. 2. The crack patterns of the ablative layer.

and only a small portion was claimed. The two meteorites are taper and ellipsoid in shape. The surface of the meteorites is ash-black, while the fresh surface is light-ashy. The surface has an ablative layer, 0.5 mm thick, obviously caused by the interaction between the meteorite and the atmosphere. On the surface ablative holes are well developed, the crack patterns of the ablative layer are also very clear (see Fig. 2). Meteorites No. 1 and No. 2 possess obvious structural spherulites with diameters from 0.5 to 1.5 mm. The biggest one found in Meteorite No. 2 is 1.2 cm. The density of Meteorite No. 1 is 3.426 g/cm^3, that of Meteorite No. 2 is 3.419 g/cm^3.

II. The Minerals in the Meteorites

Determined preliminarily with many methods the meteorites were found to contain forsterite, chrysolite, hyalosiderite, bronzite, enstatite, clinoestatite, andiopside, pigeonite, plagioclase, orthoclase, pyrophosphorite, quartz, biotite, dolomite, calcite, corundum, troilite, kamacite, taenite, chromite, magnoferrite, ilmenite, pentlandite, graphite, magnetite, wustite, copper and some indefinite minerals. The data from 75 olivine samples obtained with the electron microprobe (EM) show that Fa values vary from 2 to 17% (for 9 olivines), from 21 to 26% (for 19 olivines), and from 27 to 29% (for 47 olivines). Part of the data are listed in Table 1. The data from 59 pyroxene samples with EM show that the Fs values are in the range from 9 to 28%, most of them from 13 to 22%. Part of the data are also listed in Table 2. Plagioclase and orthoclase are of micro-crystalline aggregates. The data from plagioclase with EM are Na_2O 7.42%, MgO 3.82%, Al_2O_3 27.13%, SiO_2 51.37%, K_2O 1.85%, CaO 4.2%, TiO_2 0.85%, Cr_2O_3 0.53%, MnO 0.07%, and FeO 2.8%. The data from orthoclase with EM are MgO 0.13%, Al_2O_3 18.33%, SiO_2 64.95%,

Table 1

Part of the Data From the Olivines of Boxian Meteorite With Electron Microprobe

Content (wt%) / Sample No.	SiO_2	MgO	FeO	Al_2O_3	Na_2O	K_2O	CaO	TiO_2	MnO	Cr_2O_3	P_2O_5	Sum	Fa(%)
Matrix 1—30	38.63	35.38	25.08	0.00	0.01	0.00	0.06	0.02	0.46	0.02	0.00	99.66	28.46
Matrix 4—36	38.54	35.81	24.98	0.00	0.00	0.00	0.03	0.00	0.40	0.06	0.06	99.88	28.14
Matrix 5—37	38.58	35.80	24.32	0.00	0.00	00.0	0.02	0.02	0.37	0.01	0.04	99.16	27.60
Matrix 6—39	38.63	35.54	25.25	0.00	0.00	0.00	0.01	0.03	0.33	0.03	0.02	99.84	28.50
Matrix 7—41	38.22	35.44	25.85	0.03	0.07	0.00	0.05	0.09	0.29	0.04	0.00	100.08	29.05
Matrix 8—43	38.01	35.76	25.64	0.00	0.01	0.00	0.02	0.04	0.32	0.08	0.09	99.97	28.69
No. 12-1	38.83	36.35	24.69	0.00	0.01	0.00	0.04	0.00	0.35	0.03	0.04	100.34	27.60
12-4-1-5	39.23	35.46	24.60	0.00	0.00	0.00	0.04	0.02	0.35	0.00	0.02	99.72	28.02
12-4-2-7	39.01	36.29	23.41	0.05	0.01	0.00	0.00	0.00	0.30	0.10	0.00	99.17	26.58
12-4-3-9	38.91	36.23	23.55	0.00	0.01	0.00	0.05	0.04	0.38	0.01	0.00	99.18	26.72
6-6	41.44	48.96	8.46	0.09	0.03	0.01	0.01	0.00	0.32	0.24	0.03	99.59	8.83
12-4-5-14	38.85	35.34	24.44	0.02	0.00	0.00	0.03	0.02	0.42	0.00	0.00	99.86	27.96
No. 5-2-4	41.52	46.02	11.81	0.07	0.04	0.00	0.02	0.01	0.04	0.30	0.02	99.85	12.59
Optic-1-1	38.21	36.41	24.33	0.00	0.06	0.00	0.04	0.01	0.51	0.01	0.05	99.62	27.27
No. 12-16	39.73	40.90	18.87	0.01	0.00	0.00	0.03	0.00	0.29	0.03	0.00	99.85	20.56
No. 12-4-1	38.94	36.67	24.49	0.00	0.01	0.00	0.06	0.00	0.39	0.00	0.01	100.57	27.25

Table 2

Part of the Data From the Pyroxenes of Boxian Meteorite (With Electron Microprobe)

Content (wt%) / Sample No.	SiO_2	MgO	FeO	Al_2O_3	Na_2O	K_2O	CaO	TiO_2	MnO	Cr_2O_3	P_2O_5	Sum	Fs(%)	En(%)	Wo(%)	Minerals
No. 3-6	56.78	31.99	9.83	0.60	0.06	0.00	0.57	0.04	0.08	0.49	0.00	100.44	14.54	84.37	1.09	Clinoenstatite
No. 2-4	54.49	29.54	11.24	2.52	0.12	0.00	1.18	0.11	0.39	0.80	0.00	100.39	17.19	80.50	2.31	Clinoenstatite
No. 1-2	54.13	29.69	13.77	0.27	0.17	0.00	0.42	0.03	0.63	0.33	0.00	99.49	20.48	78.72	0.80	Broncite
No. 5-1	53.80	27.70	14.71	1.85	0.18	0.00	1.33	0.13	0.12	0.45	0.00	100.27	22.36	75.05	2.59	Broncite
16-9	55.71	14.83	4.56	8.79	1.18	0.05	11.81	0.45	0.17	1.57	0.06	99.18	9.89	57.30	32.81	Endiopside
14-2-6	57.84	28.62	11.45	0.25	0.09	0.00	0.47	0.04	0.45	0.27	0.00	99.48	18.16	80.88	0.95	Broncite
14-1-4	55.96	26.61	15.57	0.12	0.04	0.00	0.22	0.00	0.37	0.45	0.00	99.34	24.61	74.95	0.44	Broncite
No. 4-8	56.23	31.88	10.68	0.43	0.04	0.00	0.56	0.01	0.09	0.41	0.05	100.38	15.65	83.30	1.05	Clinoenstatite
No. 1	53.45	25.10	13.99	1.76	0.54	0.00	3.80	0.14	0.61	0.36	0.03	99.78	22.00	70.34	7.06	Pigeonite
13-3-2-23	56.11	28.75	11.18	0.33	0.12	0.00	1.86	0.09	0.53	0.46	0.04	99.47	17.25	79.07	3.68	Broncite
12-1-4	56.28	31.36	11.95	0.20	0.08	0.00	0.18	0.01	0.34	0.48	0.00	100.88	17.55	82.11	0.34	Broncite
12-3-3-26	59.03	20.22	11.95	3.01	0.77	0.00	3.36	0.15	0.32	0.48	0.00	99.29	22.85	68.92	8.23	Pigeonite
No. 12-20	59.02	34.34	6.38	0.36	0.07	0.00	0.27	0.00	0.09	0.40	0.20	100.86	9.39	90.10	0.56	Enstatite
No. 12-5	51.14	17.24	5.60	7.99	0.05	0.00	15.87	0.73	0.09	0.90	0.00	99.61	9.88	54.23	35.89	Endiopside
No. 13-3	50.19	16.11	5.70	10.68	0.14	0.00	15.84	0.56	0.19	0.24	0.07	99.72	10.41	52.48	37.10	Endiopside
No. 12-18	57.37	30.44	8.29	1.43	0.02	0.00	1.49	0.12	0.21	0.86	0.03	100.26	12.86	84.17	2.97	Clinoenstatite

K_2O 16.14%, CaO 0.3% ,TiO_2 0.02%, MnO 0.1%, FeO 0.17%. The contents of quartz, corundum, dolomite, calcite, pyrophosphorite, and biotite are very little. Troilite is idiomorphic, hypoautomorphic, being aggregates of crystal combination. Twins of troilite are well developed. Troilite appears in several kinds. The data from troilite with EM are Fe 64.53—66.74%, S 32.75—35.42%, Ni 0—0.02% and Co 0.02—0.05%. Kamacite and taenite are intimate intergrowth. The occurrence of them is the same as troilite. The data from kamacite with EM are Ni 3.87—14.88%, Co 0—1.69%, while those from taenite are Ni 25.88—53.47% and a little amount of cobalt. Chromite is idiomorphic and hypantomorphic, being of a few kinds. The data from chromite with EM are FeO 31.09—39.33%, Cr_2O_3 55.39—61.22%, TiO_2 0.76—2.9%, MnO 0.43—0.55%, MgO 1.09—2.07%, Al_2O_3 1.70—4.02%, Na_2O 0—0.1% and CaO 0.02—0.11%. Ilmenite is idiomorphic and hypantomorphic.

The data from ilmenite with EM are FeO 42.79—45.63%, TiO_2 50.88—53.22, MnO 0.48—0.86%, Cr_2O_3 0—0.2%, MgO 2.32—3.04%, Al_2O_3 0—0.02%, Na_2O 0—0.04%, CaO 0—0.07%. Magnoferrite appears idiomorphic and is distributed in olivines. The data from magnoferrite with EM are FeO 16.49%, Cr_2O_3 6.87%, Al_2O_3 54.93%, MgO 17.27%, SiO_2 0.25%, CaO 0.12% and MnO 0.07%. Wustite occurs as grains, veins and network veins, located on the margin of kamacite and taenite. With EM it contains 98% of FeO. Pentlandite appears in vein in troilite. The data from pentlandites are Ni 20.78—21.12%, Fe 45.56—46.99%, S 30.99—31.91%, Co 0.32—0.40%, and Cu 0.01%. Copper is in grains, or irregular grains, lathshaped or saw-toothed shaped, mainly located in kamacite and taenite. The data from copper with EM are Cu 95.75%—98.81%, Fe 3.00—4.66%, Ni 1.26—2.40%, Co 0.03%, As 0.02%, S 0.08—0.16%.

III. Discussion

(1) The chemical-rock type of the meteorites of Boxian is assigned to LL_4 for the reasons: (i) The Fa value of olivine is 27—29%; (ii) the density of Meteorites No. 1 is 3.426, while that of No. 2 is 3.419, and (iii) the principal parameters of the meteorite are $Fe/SiO_2 = 0.50$, $Fe^\circ/Fe = 0.21$, $SiO_2/MgO = 1.57$ (analysed by Li Binxian et al.). The reasons for the rock type 4 are: (i) The composition of the major olivine is uniform; (ii) there is more clino-pyroxene in the meteorite; (iii) plagioclase presents in microcrystalline aggregates; (iv) the highest content of Ni is 53.7%, and (v) the outline of spherulites is clear.

(2) Based on repeated X-ray analyses of whole rocks, the d_{130} value of olivine is constant (2.784 Å). The Fa value calculated from the d_{130} value is consistent with the value (27—29%), which we obtained from olivine with EM. Therefore, in order to classify the chemical group of the chondrites we suggest that only to do the X-ray analyses of whole rocks and calculate the Fa values from the d_{130} values. The procedure is of great advantage in time saving and cost.

(3) We summarized the chemical composition of ilmenite in various groups, and discovered that FeO contents of ilmenite might reflect the difference among the chemical groups. From H $\rightarrow$ L $\rightarrow$ LL (groups) the content of FeO in ilmenite increases gradually. Therefore, we propose to use the FeO content of ilmenite as a parameter for classifying the chondrites into the chemical groups. However, most chondrites are lack of data in

ilmenite with EM. In order to get the reliable parameters, further study is necessary.

(4) Thermal metamorphism in the meteorites are affirmed because: (i) The composition of olivine is uniform; (ii) clinoaugite has been changed into orthopyroxene; (iii) troilite appears in euhedral crystals and twins; (iv) there are apospherulites in the meteorite; (v) in overlapping spherulites, there is a group of augites, which have the same optic orientation and cut all on overlapping spherulites, and (vi) the augite with radiated structure has been changed into lathshaped augite.

5. There is percussion metamorphism in the meteorite. The reasons are: (i) Olivine, augite and troilite have obvious breaks; (ii) augite has obvious wavy extinction; (iii) clino-augite appears in polysynthetic twins; (iv) troilite and ilmenite have a few polysynthetic twins; (v) there are metallic spherulite groups in the meteorite; and (vi) some spherulites are with faulted appearance.

We thank the coworkers of the Institute of Ore Deposits, Chinese Academy of Geological Sciences and the Institute of Maanshan Mine for assistance in the EM analyses.

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