NOTE ON A STONE METEORITE FROM EASTERN KIANGSI

BY

C. Y. Hsieh

REPRINTED FROM THE
BULLETIN OF THE GEOLOGICAL SOCIETY OF CHINA
VOL. XI, NO. 4, 1932

NOTE ON A STONE METEORITE FROM EASTERN KIANGSI*

By C. Y. HSIEH (謝 家 榮)

(*The Geological Survey of China.*)

CONTENTS

1. INTRODUCTION

Records of meteorite fall were constantly kept among Chinese books on history or geography, but very few specimens have been actually collected and preserved for scientific study. So far as the writer is aware, only two occurrences have been until now definitely reported and the specimens microscopically examined. These are the meteoric stone of Taohohsien in Kansu province described by the writer[1] and the meteoric stone of Hsuchow in northern Kiangsu described by H. T. Lee[2]. The present report of a meteorite fall in eastern Kiangsi constitutes therefore the third known occurrence of meteoric stone of which the specimen has been actually collected.

2. NOTE ON THE FALL

The following note on the phenomenon of falling is chiefly translated from a paper written by Mr. C. E. Chen[3] (陳遵媯) published in "The Universe" Vol. 2, No. 6.

---

* Received for publication in June 1932.

1 Hsieh, C.Y., Preliminary notes on the composition and structure of the first specimen of meteorite stone received by the Geological Survey of China, Bull. Geol. Soc. China, Vol. II, Nos. 3-4, p. 95.

2 Lee, H.T., A Stone meteorite from northern Kiangsu, Bull. Geol. Soc. China, Vol. 4, Nos. 3-4, p. 273.

3 陳遵媯, 我國今年之隕星, (河南武陟縣及江西鉛山縣). The Universe, Vol. 2, No. 6, Dec. 1931, (Published monthly by the Chinese Astronomical Society). This paper contains also a preliminary note of mineralogical study of the stone by Mr. H. M. Meng of the National Research Institute of Geology, Shanghai.

"The fall took place at Liweipantsûn (禮外彭村) and Chowyuantsûn (鄒源村), about 30 li from the district city of Yükan (餘干) in eastern Kiangsi. The time of fall, according to the report of the magistrate, was at about 3 P.M., though newspaper records gave various time of 5 P.M. or still later. At first great sound was heard resembling the firing of heavy guns, and then a flash of silvery light dashed down in vertical direction from the sky and when it was still high up in the atmosphere the light separated to form a series of hyperbolic curves which fell down quickly to the earth. The sound was heard by all people in a surrounding of about 15-25 km, but the light was observed only by people close to the site. The whole phenomenon was said to last about five minutes.

More than ten pieces of stone have been afterward gathered from the region where the fall took place, the largest one weighs about 8 catties, while the smaller pieces, only several ounces. The impact of the large sized stones was so effective as to make several holes on the ground with a depth of 1-2 ft. A stream of smoke appeared from the ground after the fall of the stone and those who came immediately to the spot, have found the stone to be still hot.

It is very probable that the fall consisted originally of a single stone but was broken into pieces on its passage through the atmospnere of the earth. Some report even stated to have heard a great sound of bursting while the stone was seen still high up in the atmosphere. The cause of breaking is evidently due to the enormous resistence of the air which has exerted a powerful disruptive force in the meteorite, and has eventually dismembered it into numerous pieces.

3. PHYSICAL CHARACTERS

The meteorite is of light gray color with a thin black crust about 1/3 of a millimeter in thickness. Its specific gravity is about 3.5. It is rather compact and coherent and breaks through the grains.

The structure of the meteorite can be best seen on a polished surface. With the naked eyes, the chondritic structure of the stone becomes already very well shown. The chondri are of two different kinds: a yellowish white to grayished white chondrus and a gray to dark gray one. The former is more abundant than the latter. By microscopical study it is shown that the lighter colored chondrus is mainly composed of olivine while the darker variety is chiefly enstatite. Crossing the mass are many fine fissures filled by a dark colored material.

The metallic minerals consist of three different kinds, which on microscopical study, proved to be pyrrhotite, nickel iron, and marcasite; the first named appears to be most abundant among the three. All of these minerals occur chiefly as fine and irregular dessiminations throughout the whole mass. Very frequently the metallic element surrounds the chondrus to form a stringer-like ring a characteristic feature indicating its later crystallization.

4. Mineralogical Composition

Both thin section and polished section are used in the present investigation. For the identification of the metallic constituents of the meteorite, the study of polished section under a reflecting polarising microscope is most suitable.

Under a polarising microscope, the thin section of the meteorite shows the presence of the following minerals:

1) *Olivine*—This is the most abundant mineral found in this meteorite. It occurs both in the chondrus and in the groundmass; in the latter, the mineral forms usually rounded grains or platy crystals of variable sizes. The chondri forms of olivine are also of various structures; the mineral may occur as granular aggregate together with some enstatite or as small grains mixed with fibrous enstatite. Monosomatic chondrus of olivine is also observed, but it is rather rare. Spherulitic to eccentric chondri of lamella-olivine is also of frequent occurrence in this meteorite.

The mineral exhibits a rather high refringence very near to enstatite, but it can be easily distinguished from the latter from its higher and bright interference color. The optical sign is positive.

2) *Enstatite*—This mineral is not so abundant as the one just described. It occurs also in the chondri as well as in the groundmass. Among the enstatite chondri, the eccentrically arranged fibrous forms are most abundant.

The mineral is characterized by a rather high refringence and a distinctly weak birefringence, which character distinguishes it from the other mineral olivine. The extinction is parallel and positive and its optical sign is also positive.

3) *Plagioclase of unknown composition*—In the thin section of the meteorite there is occasionally observed a fibrous and weakly birefringent mineral (Fig. 1, Pl. II) forming usually interstatial or small cavity filling and among which is embedded sometimes, small, tabular crystals of olivine or enstatite. Under the convergent light, this mineral shows a distinct biaxial and positive interference figure. Its indices of refraction are nearly equal to the Canada balsam. The elongation of the fiber is negative.

The above optical determination seems to show that the mineral in question is a plagioclase of the acid variety. The only unusual character is the fibrous form which in plagioclase is rather rarely observed.

From the occurrence and the weakly birefringent character, the mineral may also be compared with maskelynite, a mineral frequently found in meteorite, but its exact nature and especially the optical characters have not yet been determined. According to Lacroix,[4] maskelynite gives no optical effect under polarized light, but our mineral shows a distinct isogyre of biaxial and positive character. In the text book of Dana, maskelynite is also stated as isometric.[5] Whether the mineral in question is really a maskelynite is yet to be studied.

4) *Pyrrhotite, nickel iron, & marcasite*—These three minerals form the metallic constituents of the meteorite. Pyrrhotite is the most abundant mineral among the three and is already distinguishable even to the naked eyes; its bronze-like color is characteristic enough to be differentiated from all other metallic minerals. Nickel iron shows a bright metallic luster of steel gray color.

The optical character of the metallic constituents can be better studied on polished section under a reflecting polarizing microscope. By this way the

4 Lacroix, A., Mineralogie de la France et de ces Colonies, Tome IV, 1910, pp. 821.

5 Dana, E. S., The System of Mineralogy, 1909. pp. 335.

contrast in color between the pyrrhotite and the nickel iron becomes distinctly shown. When examining under the crossed nicols, the pyrrhotite is further characterized by its strong anisotropic effect while the nickel iron is essentially isotropic. By the effect of the anisotropism, the internal structure of the pyrrhotite in the form of interlocking plates or laminaes becomes very well displayed.

Both pyrrhotite and nickel iron occur as fine dessiminations, irregular flakes or grains and not infrequently also as thin periphery bordering on the chondri of both olivine and enstatite. A small amount of the metallic constituent occurs also as filling in the fine veins of the meteorite. In the crust, some metallic constituents are also found.

Microscopic study shows that pyrrhotite forms frequently small grains included in nickel iron or to form layers around the latter; in the latter structure, pyrrhotite often sends small projections into the main mass of the nickel iron. These relationships seem to point a later formation of the pyrrhotite.

On closer microscopic examination there is observed a third kind of metallic constituent which is more yellow in color and harder than pyrrhotite. Only a very small amount of this mineral is present and it occurs frequently as small flakes or patches on the border of pyrrhotite. The color difference between these two minerals is distinct enough, though such a difference may be overlooked if not observed very carefully. It shows also a marked anisotropic effect in crossed nicols. Because of its minute size and limited distribution, its exact identification is not possible. Provisionally I shall call it a marcasite, because of its anisotropic effect, the real yellow color as well as its rather higher hardness.

With the aid of a Wentworth's improved recording micrometer, the mineralogical composition of this meteorite has been quantitatively determined as follows:

Minerals	% in terms of volume.	% in terms of weight.
Olivine	52%	47%
Enstatite	37%	35%

Pyrrhotite, Nickel iron, marcasite?	10%	16%
Fused glass forming veins, crust etc.	1% ±	
Plagioclase	< 1%	

5 THE STRUCTURES

The stone meteorite from eastern Kiangsi is a typical chondrite in which chondri of different size and color are the most characteristic structure. To the naked eye, the chondri may be divided roughly into two kinds, namely, a gray chondrus chiefly made up by enstatite and a white one composed essentially of olivine.

Under the microscope the detailed structure of different chondri is beautifully shown (Plate 1). According to form and composition, the following types may be distinguished:

a) Monosomatic chondrus—This is rather rarely represented in this meteorite. At certain place, a rounded chondrus made up of one single crystal of olivine is observed.

b) Polysomatic chondrus of granular aggregates of both olivine and enstatite—This is common and in which olivine is generally more abundant than enstatite (Fig. 2, Pl. II). All the grains are rather rounded, being aggregated together at different orientations.

c) Polysomatic chondrus of different individuals of the same variety—Both olivine and enstatite are seen to form such structure, and their different individuality is best shown under crossed nicols (Fig. 3, Pl. II).

d) Eccentrically arranged fan-like chondrus of fibrous form—This form seems to be more frequent in enstatite (Fig. 2, 3, Pl. III) than in olivine, although example of the latter is also not rare. In some cases, the chondrus is composed of only one mineral, but very frequently there shows also the occurrence of two minerals either as alternating layers in which case a marked lamelliform appearance is produced or with one fibrous mineral (general enstatite) forming the groundmass and in which the other granular mineral olivine is developed porphyritically. In still another case, a layer of olivine may form as thin periphery on the fibrous chondrus of enstatite.

e) Fibrous chondrus with fibers arranged in two or more directions— This form is most frequent in enstatite. The different orientation of the fibers often results in most anastomising and complicating structure which could hardly be exactly described. Intergrown with the fibers are often found also fibers or grains of another mineral as olivine.

The meteorite is characterized by a superficial coating of black color, known as crust. It is extremly thin, being about 1/3 of a mm in thickness. When examined under the microscope, the crust is seen to be composed essentially of a black and opaque material of fused glass, and in which flakes or grains of pyrrhotite and nickel iron are also frequently observed. The zoning relation of the crust as described by Tschernak[6] was not observed.

Crossing the mass in different directions, there occurs a fairly abundant amount of thread-like veinlets of black color (Fig. 4 Pl. III. The veinlets varying from very fine to about one mm in width, follow usually the groundmass or between the groundmass and the chondrus. When examined under the microscope, the vein is composed essentially of a fused mass of black color in which is sometimes mixed up with flakes or grains of pyrrhotite; nickel iron is very rare, if it is not absent. On both sides of the veins, there occurs the same mineralogical constituents as the meteorite itself.

Sometimes many fine veinlets are grouped together to form a complicated brecciated zone of 2 or 3 mm in width. Under microscopic examination it is seen that in these veinlets both the black glassy matter and pyrrhotite are present and that they follow a course either between the chondrus and the groundmass or to fill up the intergranular spaces in the chondrus, if the latter is made up of polysomatic granules. All these evidences indicating that the vein materials were formed by filling of fissures or cracks by fused material of the meteorite itself and that this fusion was caused by heat generated from friction with the atmosphere during its falling.

6 Described in O. C., Farrington's "Meteorite", published in 1915, pp. 82.

In other words, they were formed under the same condition as the formation of crust.

6. CONCLUSION

In following the classification of Brezina, the present meteorite may be called an intermediate chondrite veined (Cia), and is characterized by an abundance of olivine and enstatite and with metallic constituents of pyrrhotite, nickel iron and possibly also a little marcasite. A maskylenite-like mineral is also present, but in view of its definite optical property, it is here provisionally identified as a plagioclase of acid variety. The structure is typically chondritic with somewhat development of fine and thread-like veins.

The present meteoric stone differs from the previously described stone of Kansu and Kiangsu by the following features:

1) Light gray in color, while the meteoric stones from Kansu and Kiangsu are all yellowish or greenish.

2) Marked development of chondritic structure. For the other meteorites this structure is not so conspicuous.

3) Presence of vein. In other meteorite, vein is practically absent.

4) Instead of hypersthene, the present stone contains an abundant amount of enstatite.

5) Lesser abundance of metallic constituent and especially the nickel iron possibly a little marcasite is present.

Explanation of

Plate I

PLATE I.

General view of the chondritic structure in a stone meteorite from eastern Kiangsi. E_1, eccentrically arranged chondrus of enstatite with a thin border of mixture of enstatite and olivine. E_2, fibrous chondrus of enstatite arranged in different directions. E_3, fibrous chondrus of enstatite eccentrically arranged. E_4, chondrus composed of granular aggregates of olivine and enstatite.

O_1, chondrus of fibrous olivine; O_2, polysomatic chondrus of granular olivine. Py, pyrrhotite with small amount of nickel iron; V, vein of fused material, black and opaque.

The groundmass consists essentially of olivine with some amount of enstatite. ×30.

1

Explanation of

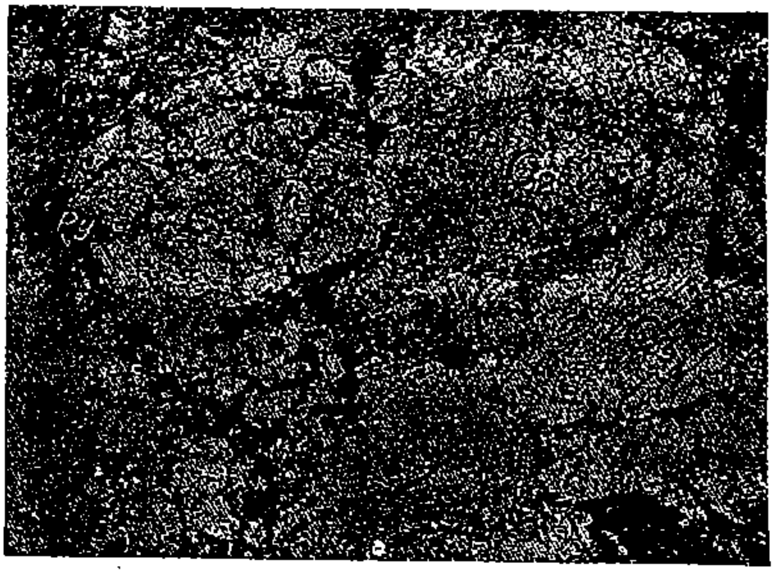
Plate II

PLATE II.

Fig. 1. Another view of the chondritic structure showing C_1, a polysomatic chondrus composed chiefly of enstatite with only one plate (o) and a few grains of olivine. C_2, a polysomatic chondrus composed chiefly of granular olivine with a small amount of enstatite. C_3, a fibrous chondrus of enstatite and olivine in alternating intergrowth. C_4, a monosomatic chondrus of olivine. Py, pyrrhotite and a little nickel iron. ×42.

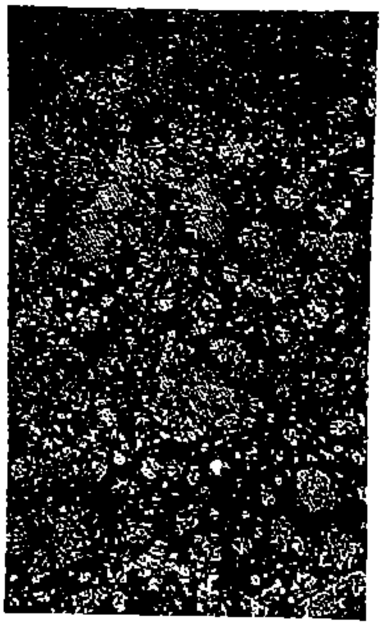
Fig. 2. Two chondri, the upper one is a monosomatic chondrus of olivine traversed by a network of brown colored probably fused material of glassy character; its monosomatic nature is proved by the simultaneous extinction under the crossed nicols. The other chondrus is a mixture of olivine and enstatite. the former occurs as prismatic crystals either cut across or to form border on the fibrous enstatite. ×42.

Fig. 3. Part of a big polysomatic chondrus (about 3 mm in diameter) composed of granular aggregates of olivine crossed by a network of fused materials. ×38.



1

2



3

Explanation of Plate III

PLATE III.

Fig. 1. Part of a big polysomatic chondrus about 3 mm in diameter consisting chiefly of platy crystals of enstatite with also some plates or granules of olivine. × 63.

Fig. 2. An eccentrically arranged fan-like chondrus of fibrous enstatite. In the outer skirt of the fan, some olivine occurs as interlamination with the enstatite. Whole length of the fan measures about 1.6 mm. × 68.

Fig. 3. Another form of the fan-shaped chondrus of fibrous enstatite. Under crossed nicols one can see, scattered among the fibers, small grains of olivine which are, however, not shown in this figure. The black area to the right is nickel iron and pyrrhotite. × 42.

Fig. 4. A fine veinlet of fused material cut across the meteorite. Black patches on both sides of the veinlet are chiefly pyrrhotite with a small amount of nickel iron. × 39.

1

3

2

4