THE ROSEBUD METEORITE, MILAM COUNTY, TEXAS

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INTRODUCTION

The details of the history of the Rosebud meteorite are somewhat obscure. It was presented to the University of Texas by Captain J. W. Waters on May 11, 1915, and accepted by Dr. F. W. Simonds on behalf of the Department of Geology. According to a news item appearing in the *Austin Statesman* on May 11, 1915, the meteorite was seen to fall from the sky about 8 years previously and was afterwards plowed up by a field hand on Captain Waters' plantation. Its weight was given as 125 pounds. On making inquiry* in the vicinity of Rosebud it was learned that the meteorite was fairly well known in the neighborhood and at one time had been used as a hitching stone in front of a drug store in Rosebud.

Some of the older inhabitants of the neighborhood reported that the meteorite fell in the early morning "about 25 or 30 years ago." Others, however, who were living near by have no recollection of the fall whatever. The meteorite was found about 1.5 miles west of the little community of Burlington in northern Milam County. Burlington is in central Texas about 25 miles east of Temple, Texas. It might seem more appropriate to have called the meteorite the Burlington but since this name is preoccupied, the name Rosebud is applied to it, although the town of Rosebud is some six miles to the north and across the county line in Falls County. It seems doubtful whether this meteorite can be classified as an observed fall and it is therefore listed as a find dating from about 1907. Since 1915 the meteorite has been in the collections of the University of Texas and until a year or so ago in charge of Dr. F. W. Simonds, to whom the writer is indebted for the opportunity to study it.

EXTERNAL FEATURES OF THE METEORITE

The Rosebud Meteorite is a cone-shaped mass having a weight of 54.9 kilograms ($121\frac{1}{4}$ pounds). The diameter of the mass at the base is approximately 18 inches and the maximum height is 11 inches. The specific gravity as determined with a Jolly balance is 3.59.

The specimen is a rather perfect conoid-shaped mass with a smooth nose or "brustseite" from which oval shaped pittings radiate in all directions. The smooth nose is on the apex of the mass but consists of two

* The writer is indebted to Mr. Oscar Monnig of Ft. Worth, Texas, for the details of the history of the Rosebud Meteorite in the vicinity of Rosebud.

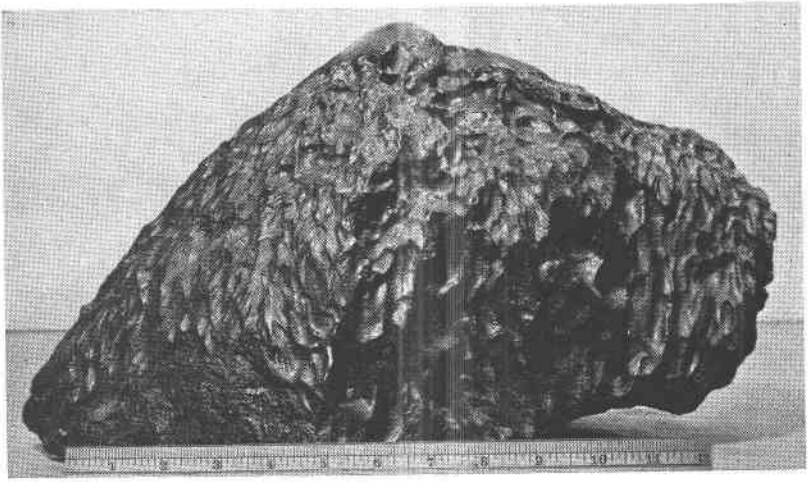

FIG. 1. Side view showing conoid shape, pitted surface, and smooth apex or "brustseite."

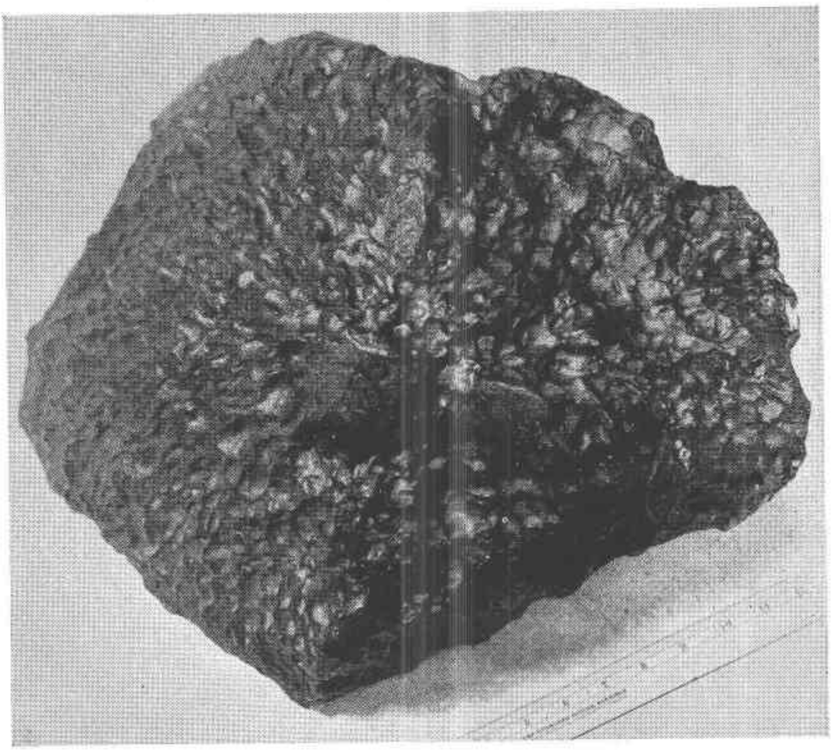

FIG. 2. Top view showing smooth apex and radial arrangement of pittings.

areas separated by a depression. It appears that the nose may have occupied a much larger area but the radial pittings encroached on the nose and destroyed all but the two areas remaining. One half of the front side is an almost perfect cone with the pittings all uniform in size and distribution. The pits are roughly oval in outline with the length about three times the width. The individual pits merge into one another. They rarely exceed one inch in length and are usually 0.15 inch or less in depth. The other half of the front side is more irregular in shape and while it

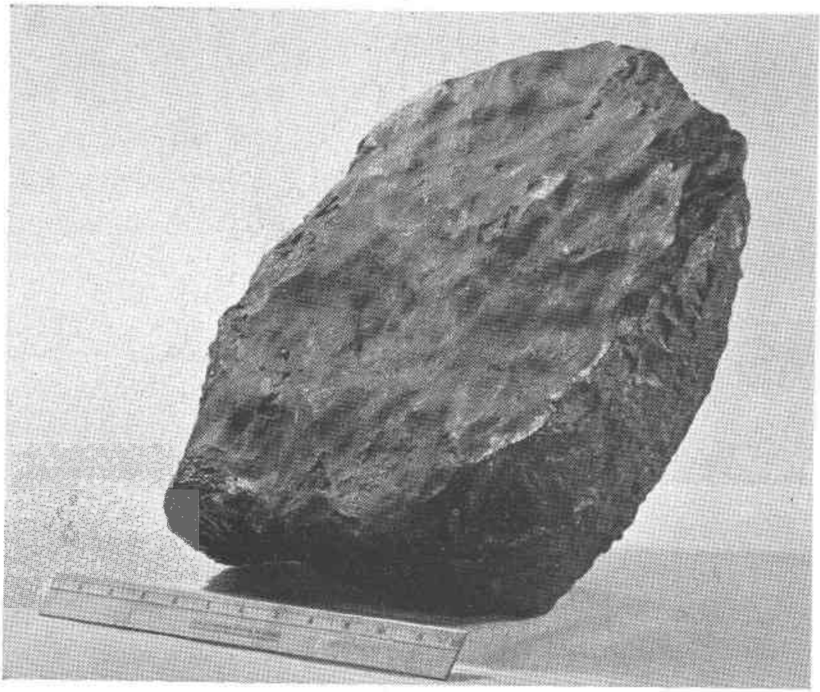

FIG. 3. Rear view showing flat surface with broad shallow pittings and blebby crust.

is completely covered with pittings, similar to those on the other half, they are not as definitely oriented, and in addition there are several deep pits, the largest of these is rudely oval in outline with a length of 2 inches and a depth of 1.5 inches (Figs. 1 and 2).

The rear side is, in general, flat with broad shallow pittings roughly round in outline with a diameter of about 5 inches and a depth of one inch. The depressions merge into one another and superimposed on the larger depressions are many smaller ones which give the surface a pebbly appearance. The crust on the rear surface is distinctly blebby (Fig. 3).

The color of the outer surface is brownish black, the brownish color evidently resulting from the oxidation of the crust. The interior of the specimen is a dull black to grayish black in color. The crust is quite thin although it appears to be somewhat thicker on the rear surface than on the front surface. In breaking off chips of the specimen many fracture lines are evident and along these fractures is a coating of reddish brown iron oxide, probably the result of weathering.

Structure

From a study of thin sections the specimen is observed to be crystalline, with only a minor amount of glass. The structure consists of many chondrules in a matrix of silicate minerals, metal and troilite. The chondrules are relatively larger than the matrix and in this respect the structure of the whole is somewhat porphyritic. Most of the chondrules are broken (fragments of larger chondrules) and the specimen as a whole might well be considered a chondrule breccia. The various types of chondrules are cemented together in a matrix of silicate minerals but definite movement after consolidation is indicated by faulted chondrules and many chondrules and crystals are abruptly terminated by fracture lines. Only a few chondrules are perfect, most of them being irregular in shape and fragmental. A rather large variety of chondrules is present for a single meteorite. The various types of chondrules are as follows:

1. Olivine chondrules of the monosomatic barred type consisting of laminae of olivine, roughly parallel but not in continuous bands. Some are almost perfectly round, or are partly round, but the majority are irregular-shaped fragments. In most cases the optical orientation of the various laminae are not all the same in a single chondrule. The chondrules range in diameter from 0.3 mm. to 1.5 mm. (Fig. 4, No. 4). Many of the chondrules are apparently fragments of much larger masses.

2. Polysomatic chondrules of euhedral olivine with fragments of different optical orientation and orthorhombic pyroxene. There is a tendency for the crystals to be oriented with their long axes parallel to the circumference of the chondrule. The space between the olivine crystals is filled with fibrous orthorhombic pyroxene and a small amount of glass (Fig. 4, No. 3). In some of the chondrules small grains of chromite (?) are quite abundant. In general metal is rare in the chondrules but is abundant in the matrix surrounding the chondrules.

3. Monosomatic chondrules of barred olivine with a rim of olivine forming a border. The rim is usually optically continuous with the olivine of the interior. Metal encroaches slightly on the chondrule but in general is far more abundant in the matrix. One chondrule of this type is faulted

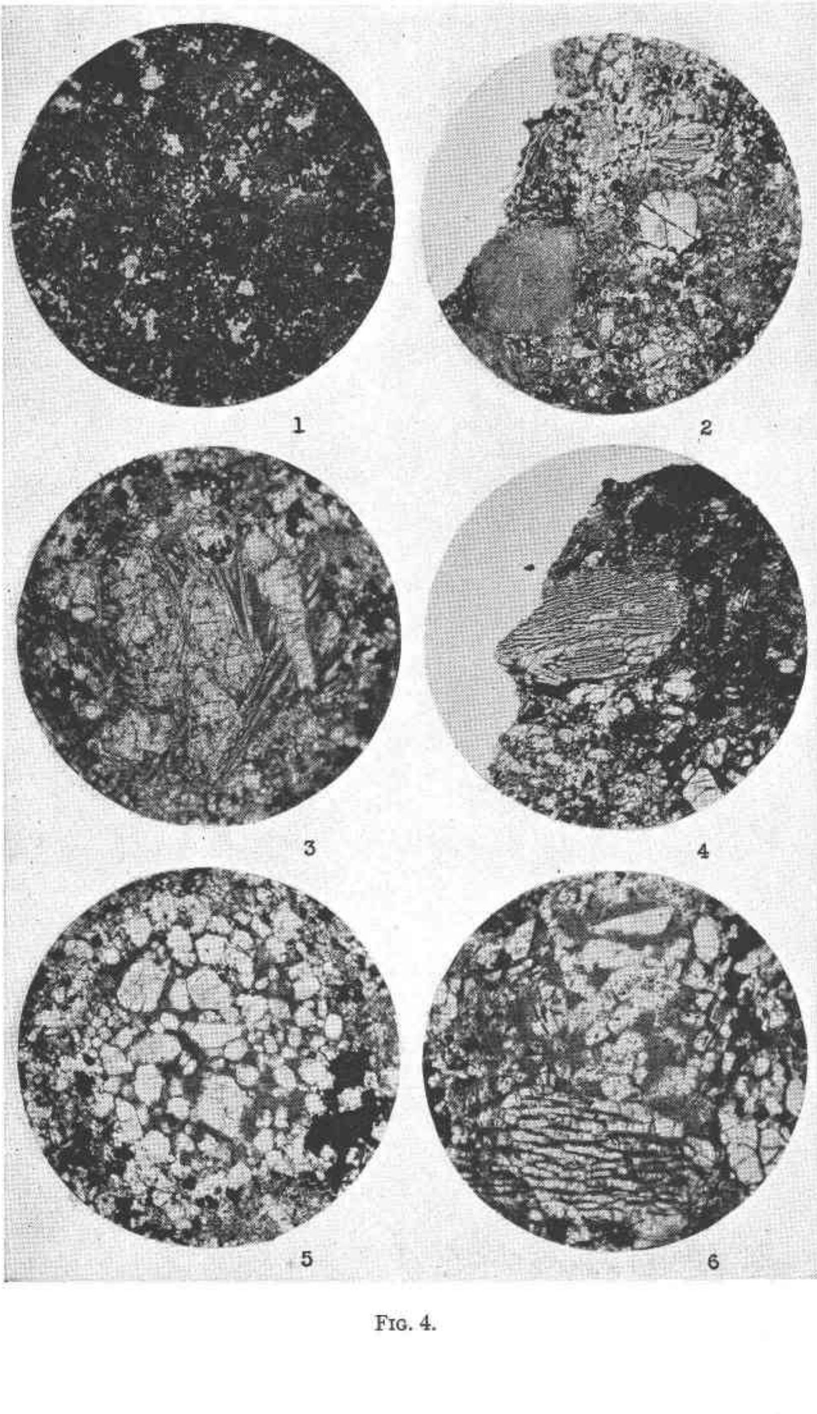

Fig. 4.

Explanation of Figure 4.

1. Photomicrograph by reflected light showing distribution of metal. The larger metallic fragments (light areas) have a diameter of 0.2 to 0.3 mm. ×10.

2. Photomicrograph showing general relation of chondrules and matrix. In the lower left is an irregular chondrule of enstatite. In the upper right is a chondrule composed of fragments of barred olivine. The dark material filling the interspaces is fibrous enstatite. Near the center of the field is a large, somewhat fractured, olivine crystal. Portions of porphyritic olivine chondrules are visible in the lower center and upper center of the field. The dark areas in the field are metal. ×12.

3. Long prismatic, orthorhombic pyroxene enclosing euhedral olivine. The dark areas between the pyroxene fibers consist of a structureless, very faintly double refractive substance. The dark color seems to be due to minute dust-like particles of an opaque material. ×25.

4. Monosomatic chondrule of barred olivine. The interspaces are filled with granular particles of olivine intermixed with a dark, practically isotropic material. The portion below the wide band is of different optic orientation. The light crystals in the lower part of the field are olivine. ×20.

5. Chondrule of porphyritic olivine with interspaces filled with enstatite mixed with unidentified dark opaque specks. A tendency for the crystals on the margin to be oriented with the long axes parallel to the circumference of the chondrule is noticeable. The chondrule grades rather imperceptibly into the matrix. The dark areas are metal. ×45.

6. Chondrule composed of fragments of two chondrules. The lower part is barred olivine while the upper part is porphyritic olivine. The dark material filling the spaces between the olivine, in both cases, is fibrous enstatite. ×35.

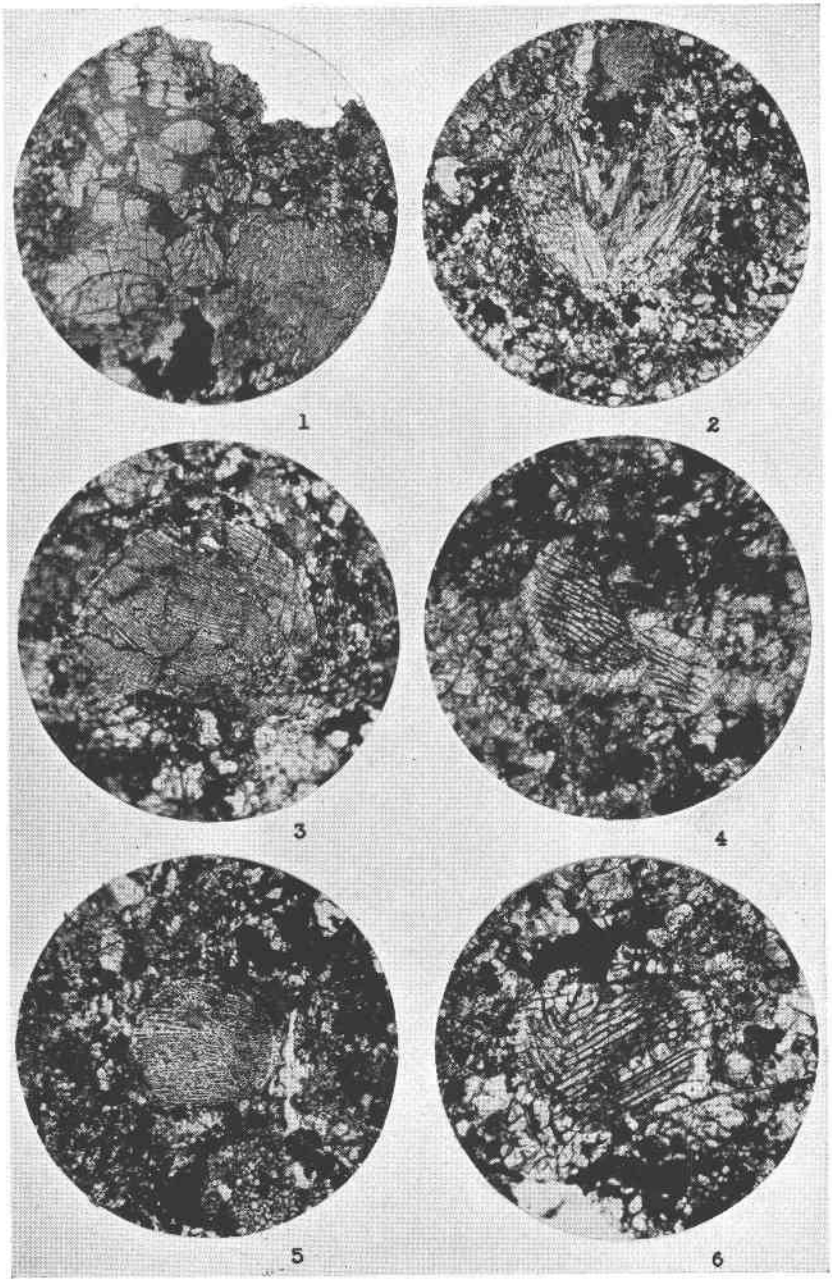

Fig. 5.

EXPLANATION OF FIGURE 5.

1. Photomicrograph showing two chondrules in contact. The one on the left consists of subhedral fragments of orthorhombic pyroxene enclosed in faintly greenish, fibrous orthorhombic pyroxene. The one in the lower right of the field is enstatite radiating from several centers. ×38.

2. Chondrule of orthorhombic pyroxene (hypersthene). The small round mass at the top is radiating enstatite. The light areas in the ground mass are chiefly olivine. ×20.

3. Broken chondrule of radiating orthorhombic pyroxene. ×24.

4. Faulted chondrule of barred olivine. The rim is in optical continuity with the interior. ×47.

5. Round chondrule of orthorhombic pyroxene. The bands are slightly diverging and with the exception of one area the material is all of the same optical orientation. The rim is optically continuous with the adjoining portion of the interior. ×28.

6. Twinned chondrule of orthorhombic pyroxene. The rim is optically continuous with the interior. ×80.

with a displacement equal to about half the diameter of the chondrule. The faulted chondrule has a diameter of 0.45 mm. (Fig. 5, No. 4).

4. Porphyritic chondrules of euhedral to subrounded crystals of olivine. The olivine is optically negative indicating a rather high percentage of FeO. The individual crystals have a maximum diameter of 0.15 mm. The chondrules, as a whole, are rounded but are not sharply separated from the matrix. The maximum diameter of the chondrules is about 0.5 mm. There is a definite tendency for the olivine crystals to be oriented with their long axes parallel to the circumference of the chondrule, especially along the outer edge of the chondrule. The space between the olivine crystals is filled with fibrous enstatite and glass (Fig. 4, No. 5). Other chondrules consist of a mosaic of variously oriented crystals of olivine fitting close together without any filling of other material between the crystals.

5. Radiate orthorhombic pyroxene chondrules in which the fibers diverge from an eccentric point. Others show a mass of confused fibers or the fibers may form a network due to crossing or interlacing. Some of these chondrules, especially the smaller ones, are almost perfectly round (Fig. 5, Nos. 2, 3, and 5).

6. Chondrules of porphyritic orthorhombic pyroxene in a fibrous matrix of the same material (Fig. 5, No. 1, left side).

Individual crystals of olivine of about the same size as the chondrules also occur. The largest olivine crystal noted has a diameter of 0.6 mm.

In the Rose-Tschermak-Brezina system of classification the Rosebud meteorite would be classified as a Black Chondrite (Csa).

Mineralogy

There is some variation in the relative abundance of the various minerals in different sections so that it is difficult to give a mode for the meteorite with any degree of accuracy. However, in all sections olivine is by far the most abundant mineral making up more than half of the specimen. Metal is next in abundance, followed closely by the pyroxenes (enstatite-hypersthene) with troilite, glass and chromite in relatively small amounts. The actual composition seems to correspond rather closely with the norm given below and the percentages given for the various minerals in the calculated norm is perhaps as close an estimate of the relative abundance as it is possible to make.

Olivine.—This mineral occurs as rounded grains, irregular-shaped fragments, and in fairly well developed euhedral crystals. The grains generally occur in the matrix while the fragments and euhedral crystals occur either as phenocrysts or in the chondrules. The olivine is colorless to slightly yellowish and is similar to that found in terrestrial rocks. It is optically negative with a large axial angle indicating a relatively high FeO content.

Pyroxenes.—The pyroxenes are orthorhombic and both enstatite and hypersthene are represented. No monoclinic pyroxenes were identified in thin section. In general the enstatite in chondrules occurs as fibers which radiate from eccentric points. It also occurs in chondrules, usually associated with olivine, in which the enstatite is a mass of confused fibers which have a somewhat netted appearance due to the crossing of the fibers, filling in the space between the olivine. The material is slightly greenish, with low interference colors, parallel extinction, and a very faint pleochroism. The axial angle is quite large and in many cases is so close to 90° that the determination of the sign is impossible. Some fragments occur as isolated masses not associated with chondrules and in many of these a marked polysynthetic twinning is observed. Polysynthetic twinning is also observed on some of the material filling the spaces between olivine bands in olivine-enstatite chondrules. On some of the larger fragments showing polysynthetic twinning, good bisectrix interference figures were obtained which gave a negative sign, indicating hypersthene. It appears, therefore, that both enstatite and hypersthene are present, although an intermediate form with some variation in optical properties might account for the two types observed.

Metal.—The metal is rather uniformly distributed throughout the mass, in general, occurring, in irregularly shaped masses ranging from small specks up to 0.5 mm. in diameter. In a few instances the metal is concentrated along veins. In general, the metal is more abundant in the matrix than in the chondrules. In reflected light the metal is of two distinct types, one with a rather dull iron black color and another, in a smaller amount, showing a bright tin white luster.

Troilite.—Occurs as bronze-yellow grains irregularly scattered through the mass.

Glass.—From the chemical analysis it is apparent that either feldspar (see norm) or glass is present to account for the alumina and alkalies present. Some material, tentatively identified as partially devitrified glass, can be observed in the chondrules and also filling spaces between the silicate minerals in the matrix. An attempt to isolate some of the material with heavy liquids was without success since it is so finely divided and apparently included in other minerals so that no separation was possible. A careful search of a number of thin sections failed to reveal any material which could be identified as feldspar. However, the matrix is rather obscure and in many cases stained with iron oxide so that the positive identification of all the constituents is not possible.

Chromite.—In the chondrules are some small black opaque grains which in concentrated light show a reddish border. These are tentatively identified as chromite.

Schreibersite.—The analysis of the soluble silicate portion contains the elements present in schreibersite and it is apparent that this mineral is present. It was not identified in thin section.

Iron oxide.—The outer edge of the meteorite and extending some distance in from the edge of veins and cracks is a reddish stain which is apparently iron oxide. Its concentration along cracks and veins and on the outer edge of the specimen suggests a secondary origin for the material.

Chemistry

A chemical analysis of the specimen was made by F. A. Gonyer and is given below:

Metallic portion	13.35%
Iron sulphide	3.42
Soluble silicate portion	44.86
Insoluble silicate portion	38.37

	Insoluble Silicates	Soluble Silicates	Metallic Portion	Composite
SiO_2	54.31	29.98		34.28
TiO_2	None	None		—
Al_2O_3	6.70	2.16		3.53
Fe_2O_3	None	Present*		—
Cr_2O_3	0.32	0.04		0.14
FeO	9.86	33.46		18.79
MnO	0.23	0.14		0.15
CaO	3.42	1.09		1.80
MgO	23.72	32.70		23.77
NiO	None	0.32		0.14
CoO	None	Trace		Trace
Na_2O	1.09	—		0.41
K_2O	0.17	—		0.06
P_2O_5	None	0.20		0.09
H_2O	—	0.17		0.07
FeS	—	—		3.42
Fe	—	—	91.04	12.15
Ni	—	—	8.61	1.15
Co	—	—	0.39	0.05
P	—	—	0.02	0.003
Cu	—	—	Trace	Trace
Mn	—	—	None	—
Sum	99.82	100.26	100.06	100.003

* From examination of specimen it is quite evident that ferric oxide is present.

The soluble silicate portion of the analysis consists mainly of the olivine of the specimen. The elements contained in schreibersite are present in this portion and in determining this mineral the phosphorus of the analysis was allotted to an appropriate amount of nickel, cobalt and iron to form schreibersite. The ferric oxide, not determined but obviously present, is included with the ferrous iron. The insoluble silicate portion includes the pyroxenes, and the potash, soda, lime and alumina, which on first glance appears to suggest a feldspar, but presumably is present as glass.

A norm calculated from the analysis, according to standard methods, is as follows:

Norm for Rosebud Meteorite

Schreibersite	0.28
Chromite	0.14
Albite	0.33
Anorthite	7.70
Diopside	0.93
Hypersthene	9.66
Olivine	60.97
Troilite	3.42
Metal	13.35
	99.92

The above norm seems to check quite closely with the composition as observed from a study of thin sections, except in the amount of feldspar shown. As previously stated the feldspar indicated in the norm is probably present as glass but from the amount indicated in the norm it should be far more prominent in the thin sections than is actually the case. Also the small amount of diopside shown was not identified in thin section.

A spectrographic analysis of the three portions of the meteorite made by Dr. H. A. Wilhelm, showed the presence of germanium (trace), barium (faint trace), and vanadium (trace), in addition to the constituents reported in the chemical analysis. The complete spectrographic analysis is given below.

	Na	Cu	Mg	Ca	Al	Si	Ge	Co	Cr	Mn	Ni	Fe	Ba	K	Ti	Si	V
Metallic	3	4	3	4	4	3	4	3	4	4	3	1	—	—	—	—	—
Soluble	4	—	2	4	4	2	—	4	5	4	4	3	5	—	—	—	—
Insoluble	2	—	3	4	4	—	—	5	3	4	4	3	—	3	5	2	4

Intensities: 1 strong, 2 present, 3 weak, 4 trace, 5 faint trace.

Acknowledgments

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