The Tomhannock Creek, New York, chondrite.

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Summary.—The Tomhannock Creek chondrite has been analysed, with the following results: Fe 11·36, Ni 1·69, Co 0·07, FeS 5·26, SiO_2 36·88, TiO_2 0·135, Al_2O_3 1·80, Cr_2O_3 0·30, FeO 14·94, MnO 0·31, MgO 23·81, CaO 1·39, Na_2O 0·73, K_2O 0·095, P_2O_5 0·36, H_2O+ 0·34, C 0·10; total 99·57. The mineralogical composition is olivine (Fo_{81}), hypersthene (En_{83}), plagioclase (An_{22}), nickel-iron, troilite, chromite, and probably apatite. The density of the meteorite is 3·65.

Tomhannock Creek is not identical with Homestead, nor with Yorktown. Yorktown is a chondrite that appears to have fallen near Yorktown, Westchester County, New York (41° 17′ N., 73° 49′ W.), in September 1869.

THE history of the Tomhannock Creek meteorite is given by Bailey (1887), as follows: 'About the year 1863, Mr. H. Bancker, of Schaghticoke, New York, found, near the base of a large tree on the bank of the Tomhannock Creek in Rensselaer County, a stone of unusual appearance which he took home with him. After breaking off from it a fragment, the stone was laid aside and little further attention given to it until May 1884, when it was sent to the writer who recognized it as an aerolite.'

Curiously enough, the first mention of this meteorite in the literature is not this description by Bailey, but a brief mention by Brezina (1885), under the name 'Ironhannock Creek'. A piece weighing 22 g. was received by Brezina in 1885 (presumably from Bailey) and he describes it as follows: 'Iron hannock Creek dunkel graugrün, ähnlich dem dunkelgrünen Homestead; im Bruch etwas schimmernd, an die Ck erinnernd. Rinde kaum von der Grundmasse zu unterscheiden.' He gave the date of the finding of the meteorite as 1863–64.

In 1895 Brezina was more specific regarding its similarity to Homestead: 'Tom Hannock Creek dürfte vielleicht aus der Reihe der Fallorte zu streichen sein. Ich habe schon seinerzeit die Aehnlichkeit mit den dunkelgrünen Homestead hervorgehoben; dieselbe ist im Dünnschliffe (den ich seither auch von Tom Hannock machen ließ) ungewöhnlich groß; ebenso stimmt die ganz eigenartige Beschaffenheit der Rinde, welche kaum von der Grundmasse zu underscheiden ist, bei beiden Steinen völlig überein. Auch in Amerika bezweifelt man die Existenz eines Falles in jener Gegend. Hierher gehört wahrscheinlich auch Yorktown, New York 1869, wovon Siemaschko einen Splitter durch Gregory erhielt; ziemlich dunkles Cg, das den mittleren Partien von Homestead oder den helleren von Tom Hannock entspricht.'

The suggested identity of Tomhannock Creek with Homestead was accepted as proven by LaPaz (1944). He gives no grounds for this statement, and it is presumably based on the work of Brezina.

The original specimen described by Bailey is now in the collection of The American Museum of Natural History (catalogue no. 1034), and can be recognized as such from the drawing and description given by Bailey. On comparing it with specimens of Homestead we cannot agree with Brezina's statements. The two meteorites are quite distinct. A cut surface of Tomhannock Creek is dark chocolate brown; that of Homestead is light grey. These differences are more clearly seen in thin sections; much of the thin section of Tomhannock Creek is almost opaque from finely divided pigment and limonitic alteration products, whereas Homestead is quite unaltered. The composition of the olivine in Tomhannock Creek is Fo_{81}; that in Homestead Fo_{76}. Thanks to the courtesy of Dr. A. Schiener, of the Naturhistorisches Museum in Vienna, we have been able to examine the specimen and thin section on which Brezina based his description of Tomhannock Creek, and we are at a loss to account for his correlation of this meteorite with Homestead.

The resolution of the confusion between Tomhannock Creek and Homestead does not solve the problem of Yorktown. The identity of Yorktown with Tomhannock Creek has been accepted by later authorities, evidently on the basis of Brezina's statement. The American Museum of Natural History has a specimen labelled Yorktown (catalogue no. 380). This specimen came to the museum with the Bement Collection in 1900, and the accompanying label reads as follows: 'Grey chondrite, Westchester County, New York; fell 1869.' Mr. L. P. Gratacap, who was curator of the collection at that time, commented in the manuscript catalogue: 'Half of a pellet-like mass, grey-white color, chondritic, nickel-iron in flakes and strings; if Tomhannock certainly not the same as the Bement specimen of that fall. . . . This meteorite referred to Rensselsaer County fall, but apparently an Iowa stone. Some mistake.'

Gratacap's statement is correct in so far as the specimen labelled Yorktown is certainly not part of the Tomhannock Creek stone. The only published statement regarding Yorktown seems to be that of Brezina in 1895. Wülfing (1897) records six specimens of Yorktown totalling 216 g. in collections. A search of the files of the U.S. National Museum and of the New York State Museum has failed to yield any information regarding Yorktown. However, Dr. M. H. Hey has kindly examined the files of the British Museum and sent me photostat copies of correspondence between Bailey and J. R. Gregory, and between Bailey and Sir Lazarus Fletcher. This correspondence shows that Bailey obtained the Yorktown material and distributed it. He describes the fall and the finding of the meteorite in a letter to Gregory dated 6 March 1884, as follows: 'The first mentioned (Yorktown) fell in September 1869 (the day I can probably get soon) at Yorktown 7 or 8 miles East of this place [Cortlandt on Hudson, Westchester Co.]. A considerable number of persons in carriages were returning from a Temperance meeting or lecture about 10 p.m. when a brilliant meteor was seen passing from the westward in the same direction (east) and parallel with the road they were travelling, at so low an altitude as to be seen to be between them and a hill or ridge on the other side of a little valley (less than half a mile distant) when it exploded, and the larger portion of the fragment seemed to fall almost directly downward. The detonation was much like a musket shot, but louder, and my informant believes that it burst by striking a large oak tree—of which I have little doubt, from his description of the sound produced by the explosion. The stone I sent was picked up some 10 or 12 years ago, tho the finder cannot locate the exact spot, further than as a little gravelly spot near the foot of a ledge of rock.'

On the basis of Bailey's statement it seems therefore that Yorktown is a genuine fall. Yorktown is a small village in Westchester County, New York, 41° 17′ N., 73° 49′ W. Of the 216 g. recorded by Wülfing the major part (177 g.) was in Bailey's collection; we do not know the present location of this material.

General description. The appearance of the Tomhannock Creek stone is shown in the photograph (fig. 1). It was originally oblately spheroidal in form, with a diameter approximately 10 cm. The original weight was about 1·5 kg., but pieces have been cut off and distributed, and the present weight of the main mass is 1 082 g. The upper surface of the stone shown in fig. 1 is marked with prominent 'thumb-prints'. The stone is fine-grained, compact, and hard; a cut surface polishes well, has a dark brown to almost black colour, and shows numerous bright particles of nickel-iron. Contrary to the statement of Brezina, there is

FIG. 1. The Tomhannock Creek meteorite (diameter of stone is 10 cm.).

little if any trace of an original glassy crust; it appears that the stone had lain in the ground and been subjected to weathering for many years before it was found.

The density was determined by placing a weighed piece of the stone in a beaker under a bell jar and evacuating by means of an oil pump. After evacuation carbon tetrachloride was run in, and the apparent loss of weight on suspension in this liquid measured. The density so determined was 3·65.

Mineralogical composition.

The minerals identified in the meteorite are olivine, hypersthene, plagioclase, nickel-iron, troilite, and chromite; a phosphate mineral (apatite or merrillite) is probably present in small amount.

Olivine. The refractive indices are: α 1·674, γ 1·709, indicating a composition of Fo_{81}, according to the determinative curve of Poldervaart (1950). Using the X-ray method of Yoder and Sahama (1957) the composition was found to be Fo_{82}.

Hypersthene. The refractive indices are: α 1·670, γ 1·682, indicating a composition of En_{83}, according to the determinative curve of Kuno (1954).

Plagioclase is present in small amount, and was separated by digesting a sample of the meteorite powder in 1:1 HCl (thereby dissolving nickel-iron, troilite, and olivine), and centrifuging the residue in an acetone–methylene-iodide mixture of density 2·9. The light fraction was a concentrate of plagioclase. Its indices are: α' 1·540, γ' 1·547, indicating a composition of An_{22}.

Nickel-iron. An X-ray powder photograph of nickel-iron separated magnetically from the crushed meteorite shows lines of kamacite and taenite.

A thin section of the meteorite is very dark in colour on account of a great deal of limonitic staining and possibly some fine-grained carbonaceous pigment. It shows numerous chondrules 0·5 to 1 mm. in diameter, of granular olivine or finely prismatic, often radiating hypersthene, set in a finely granular groundmass of olivine, hypersthene, and opaque material. Microscopic examination of a polished surface shows that the grains of nickel-iron are coated with crusts of limonitic material, whereas the sulphide grains appear to be unaffected by weathering.

Chemical composition.

The chemical analysis is given in table I, in the conventional form expressed as oxides, FeS, and metal; in terms of the individual elements; and recalculated on a volatile-free basis. The normative mineral composition, expressed as weight percentages, is also given; this has been calculated as suggested by Wahl (1950), except that we prefer to calculate P_2O_5 as apatite, not merrillite; the composition of merrillite is not well established, being based on a single analysis of a small amount of impure material, and this mineral may well be a variety of apatite.

It should be emphasized that the normative mineral composition

TABLE I. Chemical analysis and normative composition of the Tomhannock Creek meteorite.

	A		B	C		D
Fe	11·36	H	0·038	—	Nickel-iron	13·12 %
Ni	1·69	C	0·10	—	Troilite	5·26 %
Co	0·07	O	34·612	—	Olivine	44·53 %
FeS	5·26	Na	0·54	0·86	Hypersthene	23·88 %
SiO_2	36·88	Mg	14·35	22·81	Diopside	2·63 %
TiO_2	0·135	Al	0·95	1·51	Albite	6·18 %
Al_2O_3	1·80	Si	17·23	27·39	Anorthite	1·33 %
Cr_2O_3	0·30	P	0·16	0·25	Orthoclase	0·56 %
FeO	14·94	S	1·92	—	Apatite	0·84 %
MnO	0·31	K	0·08	0·13	Chromite	0·45 %
MgO	23·81	Ca	0·99	1·57	Ilmenite	0·26 %
CaO	1·39	Ti	0·08	0·13		
Na_2O	0·73	Cr	0·21	0·33		
K_2O	0·095	Mn	0·24	0·38		
P_2O_5	0·36	Fe	26·31	41·83		
H_2O+	0·34	Co	0·07	0·11		
C	0·10	Ni	1·69	2·69		
	99·57		99·57	99·99		

A. Chemical analysis expressed as nickel-iron, troilite, and oxides (all H as H_2O, all C as C (both free and combined)).
B. Chemical analysis expressed as elements, with calculated figure for oxygen.
C. Chemical analysis recalculated on a volatile-free (O, C, S, H) basis.
D. Normative composition calculated according to Wahl's method.

calculated from the chemical analysis can only approximate to the actual mineralogy of the meteorite. The calculation involves several arbitrary procedures: Alumina is calculated entirely as feldspar, although it is known that small amounts are present in pyroxene (an analysis of orthorhombic pyroxene from the Miller, Arkansas, chondrite shows 1·22 % Al_2O_3 (Mason and Wiik, 1960)). The TiO_2 is calculated as ilmenite, but the titanium is present wholly or in large part in the ferromagnesian minerals, pyroxene and olivine (the analysis of orthopyroxene from the Miller meteorite shows 0·21 % TiO_2). Nevertheless, when interpreted with care and discrimination, the normative mineral composition provides a useful guide to the actual mineral composition, and conversely the actual mineral composition can be mostly readily correlated with the chemical composition through the calculated norm.

The normative composition correlates well with the observed mineral composition. No diopside was seen, but the small amount of this component is probably in solid solution in the hypersthene. Normative pyroxene is 26·51 %, normative olivine 44·53 %, giving a ratio of pyroxene to olivine of 3:5, which agrees with estimates from thin sections and X-ray powder photographs. Normative feldspar is 8·07 %, which is probably more than the actual amount of plagioclase, since some of the Al_2O_3 calculated as feldspar will be in the pyroxene. The 0·45 % normative chromite corresponds to the amount seen in polished surfaces. Although neither apatite nor merrillite were observed in thin section, the 0·84 % apatite in the norm could well be present; it would be extremely difficult to recognize in a thin section, since it probably occurs in small grains intimately mixed with pyroxene and olivine.

The proportions of FeO to MgO in the normative pyroxene and olivine are somewhat higher than in the minerals themselves. This is due to the fact that in the analysis all iron not as troilite or as nickel-iron is calculated as FeO, although the stone contains some Fe_2O_3 as limonitic alteration of the metal. Thus some of the oxide iron is present as limonite, not combined in the silicates; the result is that the olivine and pyroxene are poorer in iron than indicated by the norm.

The chemical analysis shows that the Tomhannock Creek stone, in Prior's classification, falls into his group of hypersthene–olivine chondrites of the Baroti and Soko-Banja types. According to the classification of Urey and Craig (1953), it belongs to their H group, since it contains high total iron (26·31 %), the average for the H group being 28·58 %, and for the L group 22·33 %).

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