THE MURRAY, CALLOWAY COUNTY, KENTUCKY, AEROLITE (CN = +0881,366)*

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ABSTRACT

The Murray, Calloway County, Kentucky, aerolite (CN = + 0881,366) exploded at a high altitude on September 20, 1950. Approximately 7 kg. of fragments, with a specific gravity of 2.82 ± 0.02, have been recovered. The history, the physical properties, and a qualitative and quantitative analysis of this carbonaceous chondrite are presented.

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1. *History.*—On Wednesday, September 20, 1950, at approximately 1:35 A. M., C.S.T., a brilliant fireball roared thru the atmosphere above the Jasper County region of southeastern Illinois. The red-orange ball of flame traveled along a path that extended approximately from north to

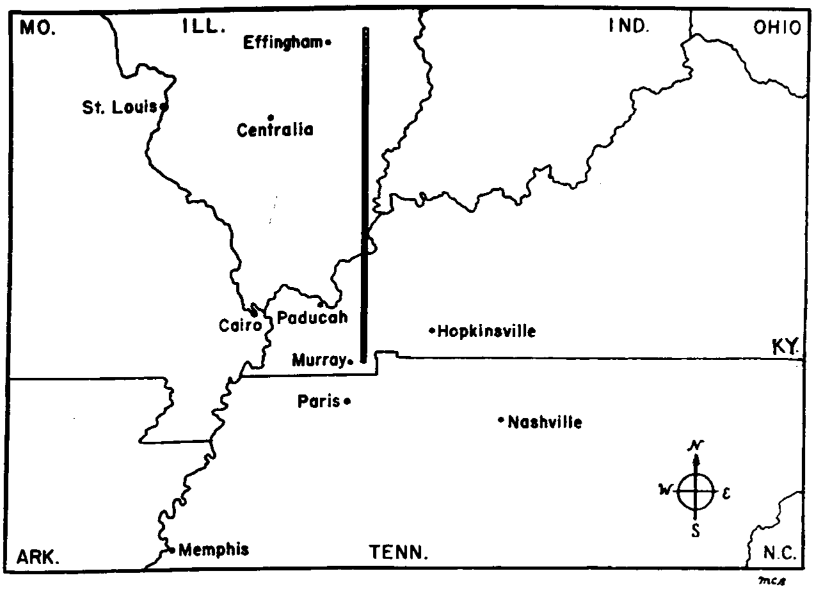

FIG. 1

THE PROJECTION OF THE PATH OF THE MURRAY, CALLOWAY COUNTY, KENTUCKY, AEROLITE

* Based upon work performed at the Oak Ridge National Laboratory under the Atomic Energy Commission Radiological Physics Fellowship Program. Read at the 15th Meeting of the Society, Albuquerque, New Mexico, 1952 September 2-4.

south, as shown in Fig. 1, leaving a luminous train visible in 5 states. The brilliant light was described by eyewitnesses as having been of such intensity that the sky was illuminated "as bright as day." About 5 seconds later, the bolide exploded with a blinding flash over western Kentucky at an altitude greater than 45 km. The force of the explosion and succeeding thundering sounds jarred windows over a thousand-square-mile area, bounded by Paducah and Madisonville, Kentucky, and Paris, Tennessee. These optical and acoustical displays were followed by a shower of meteoritic fragments that fell to Earth in Calloway County, Kentucky, at a place 9 miles east of Murray, near Wildcat Creek, on Kentucky Lake (7-digit coördinate number (CN)= +0881,366). Several observers reported hearing masses thudding into the ground approximately 30 seconds after the explosion.

One observer in Cairo, Illinois, reported that the meteor did not appear to change its course or form at the point of explosion, but left a black cloud in the clear sky while continuing its southward movement. Reports from Nashville and other middle Tennessee points seem to verify this observation, but fragments have not been recovered from any other areas.

Dr. Charles P. Olivier, the President of the American Meteor Society, has calculated the trajectory thru the atmosphere and the orbital elements,

TABLE 1

THE TRAJECTORY AND PARABOLIC ORBIT
OF THE MURRAY, CALLOWAY COUNTY, KENTUCKY, AEROLITE
(according to Dr. Charles P. Olivier of the American Meteor Society)

Date		1950 September 20
Began over	longitude (λ)	$+88^\circ$ 09′
	latitude (ϕ)	$+39^\circ$ 16′
	height (H)	197 km.
Probable end-point	longitude (λ)	$+88^\circ$ 09′
	latitude (ϕ)	$+36^\circ$ 52′
	height (H)	46 km.
Length of path		304 km.
Projected length of path		266 km.
Duration of visibility		4.3 sec.
Observed velocity		71 km./sec.*

Elements of Orbit

i (inclination)	68°
☊ (longitude of ascending node)	177°
π (longitude of perihelion)	343°
q (perihelion distance)	0.989 a. u.

* [That the heliocentric velocity of the Murray aerolite was hyperbolic is confirmed by application of the "inverse-acceleration" method of meteoritic-velocity determination as developed by Lincoln LaPaz (*v.* Chap. 19 of *Physics and Medicine of the Upper Atmosphere*, University of New Mexico Press, 1952)].—EDITORS.

under the assumption of parabolic heliocentric velocity, of the Murray fireball.[1] Table 1 contains the best possible solution compiled from data reported by many observers. The observed velocity, based upon 6 estimates, was 71 km./sec. The beginning-point altitude is rather uncertain; moreover, the explosion point has been used as the probable end-point.

A search party from Vanderbilt University entered the fall area on October 22, 1950. Intermittent rain hindered the search, which was already handicapped by the lack of information concerning the trajectory of the fireball thru the atmosphere. Altho many masses had been heard to fall in nearby woods, only a few small pieces were found, while other fragments were given to the party by farmers. Some fragments were found as far as 3 miles apart.

The largest recovered fragment (Fig. 2) of this meteorite was actually heard whistling thru the air and striking the ground. This specimen is approximately 15 cm. in diameter, weighs 3.4 kg., and embedded itself in a hard-beaten path to a depth of 15 cm., only 26 feet from the home of Mr. Ernest Barnett.

Many of the objects were fragmented upon impact with the ground. One fragment pierced the roof of a house owned by a Mr. Wilkinson, without splintering or scarring the floor onto which it fell. This fact indicates that this meteoritic fragment had decelerated from its interplanetary velocity to approximately the terminal velocity of a freely falling body, as the result of its passage thru the shock-absorbing atmosphere; moreover, its surface temperature, which had approached 2000° C., shortly after the

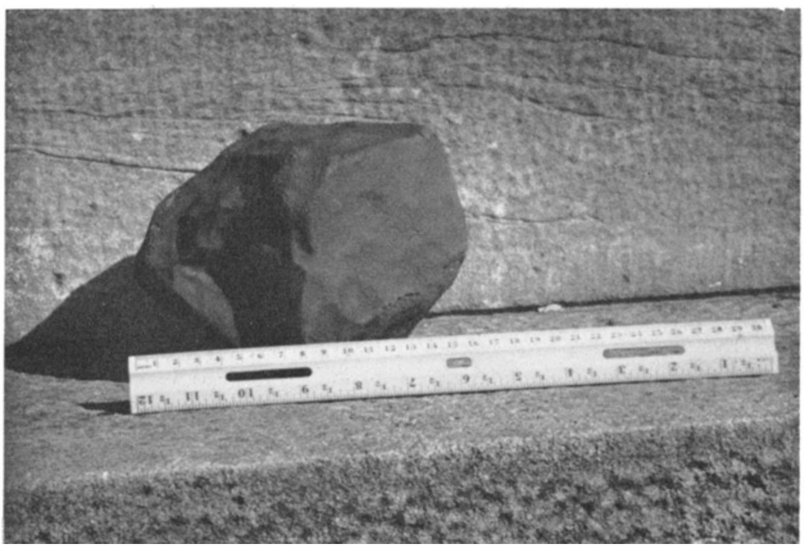

FIG. 2
THE LARGEST RECOVERED SPECIMEN OF THE AEROLITE

body entered the atmosphere, had been lowered to less than 100° C. when it reached the Earth. This result was to be expected, since the period of heat acquisition was extremely short, and the heat capacity of stony meteorites is of the order of 0.2 calory per gram.

The integrated weight of all fragments recovered is about 7 kg. This figure represents undoubtedly the weight of only a small fraction of the entire fall. Now that the necessary information on the trajectory is available, a new search south of Pottertown, Kentucky, may lead to the finding of the main mass. It is possible, however, that many large fragments fell into Kentucky Lake. Investigations of other well-observed falls have indicated a veering of meteorites to the east from the vertical planes of their trajectories during passage thru the lower portion of the atmosphere.

2. *Physical Properties.*—All fragments display irregular forms such as are shown by any round rock that has been shattered by a heavy blow. Most pieces have at least one surface that is coated by a thin, sooty, black fusion crust, having a maximum thickness of 0.2 mm. The thinness of the crust indicates either a compact texture or a secondary crust. A secondary crust formation, as such, could not be distinguished. Many of the surfaces were plane, almost perpendicular one to the other, with well-rounded but clearly defined edges.

Megascopic examination revealed the presence of a thread-line type of flight-marking on several specimens. These narrow ridges are about 0.3 mm. wide and 1-2 mm. long, indicating the flowage action of meteoritic matter in the process of being boiled away by atmospheric friction. Two surfaces are slightly pitted by what appears to have been the evaporation of small, rounded granules. Large elliptical and oval depressions, commonly called thumb-marks or piezoglyphs, also are present. This phenomenon has been explained by A. Daubrée[2] as the result of the evacuation of small molten areas by deflected air currents. It was not possible to establish the orientation of any fragments, nor have any accumulations of slag crust been found.

The groundmass, which has a dusty black color, is mottled as a result of its different mineral constituents. This fine-grained texture is extremely complex and heterogeneous, being composed largely of chondrules that are embedded in the fragmental base. These chondrules range in color from very light gray to dark bluish-gray, and in diameter from 0.1 to 4 mm. The interior shows a small sprinkling of metallic grains. Figs. 3 & 4 show views of a small fragment, before and after polishing, respectively. The entire mass is very brittle; it is impossible to cut it in thin sections, but it is easily broken by hammering. Numerous cracks traverse the stones and serve as fracture planes. During the crushing of small samples, it was found that concentric layers about 2 mm. thick frequently broke off. Many fractures ran across both chondrules and matrix.

The specific gravity was found to be 2.82 ± 0.02. The range of values for aerolites varies from 2.08 to 4.50. Granite has a specific gravity of 2.7, and furnishes a basis of comparison for the lightness of the Murray specimens.

FIG. 3
A SPECIMEN OF THE AEROLITIC SHOWER: UNPOLISHED SECTION; ENLARGED 4×

FIG. 4
A POLISHED SECTION SHOWING DISTINCT CHONDRULES

All fragments were examined for fluorescent minerals with a short-wave ultraviolet lamp, peaked at 2537 angstroms. The bulk of the material is inactive, but several grains radiated a weak yellow-green color. A few large gray inclusions gave off a purple fluorescence. These fluorescent areas are not radioactive. Since primary uranium minerals rarely give off an intense fluorescence, methods of intensifying this phenomenon, such as fusion of a sample with borax or sodium fluoride, or spraying the specimen with phosphoric or acetic acid, are frequently employed.[3] No additional information was obtained by using these techniques.

Magnetic separation was attempted to remove the iron from a powdered sample, which had been pulverized with a polished mullite mortar and pestle. This procedure proved impracticable because of the excessively fine division of the iron and its presence in every portion of the stony constituents. The whole mass of powder was attracted to the magnet, and thus no magnetic separation was possible.

3. *Qualitative and Quantitative Analysis.*—A combined chemical and spectrographic analysis of the meteorite is shown in Table 2. The chemical analysis was performed by J. W. Robinson at the Oak Ridge National Laboratory. All samples were taken from interior fragments, and the results were expressed in molecular proportions. A comparative spectrographic analysis also was made by using a 3-mg. sample from the crust and another from the interior. All test samples had been successively quartered from an original 25-gm. sample. No significant differences were observed in the spectrum. The following elements were sought and not found in this spectrum:

Ag	As	Be	Bi	Cb
Cd	Hg	K	P	Pb
Pt	Ta	Te	W	Zn

TABLE 2

COMBINED CHEMICAL AND SPECTROGRAPHIC ANALYSIS OF THE MURRAY, CALLOWAY COUNTY, KENTUCKY, AEROLITE

Constituent	*Percentage by Weight*
SiO_2	33.7 ± 0.34
Fe_3O_4	33.3 ± 0.33
MgO	23.5 ± 0.24
Al_2O_3	3.63 ± 0.07
NiO	2.46 ± 0.12
CaO	2.40 ± 0.05
C	1.99 ± 0.05
Mn_3O_4	0.35 ± 0.017
Cr_2O_3	0.013 ± 0.0007
Co, Na, Ti, Cu	Trace
B, Sn, V, Zr, Mo	Slight Trace
Total	101.3%

The analysis reveals that there is nothing unusual about this meteorite with the possible exception of the 2% carbon content. The average abundance of carbon for meteorites is given in the accompanying tabulation.[4]

Irons	0.08%
Chondrites	0.16

Exceptionally high carbon contents have, however, been reported for a few other chondrites:[5]

1. Staroe Boriskino (= Boriskino)	2.65%
2. Migheï	2.5
3. Novo-Urei	2.13

Table 3 gives the average composition of the Murray aerolite for comparison with those of other meteorites and ordinary terrestrial rocks. The symbol m stands for the molecular ratio of MgO to FeO in the magnesium silicates, whereas the symbol n designates the ratio of of Fe to Ni in the nickeliferous iron.[6] The Tulia, Swisher County, Texas, chondrite[7] was found to have approximately the same composition as Murray. Inspection shows that the Murray fall differs markedly in composition from igneous

TABLE 3
AVERAGE COMPOSITION OF METEORITES AND TERRESTRIAL ROCKS

ELEMENTS	*Murray, Kentucky, Aerolite*	*Tulia, Texas, Aerolite* *	*Average Aerolite* †	*Average Meteorite* ‡	*Intermediate Plateau Basalt* †	*Igneous Rock* †
O	33.7%	31.20%	36.15%	32.70%	37.78%	46.49%
Si	21.5	22.19	18.12	16.28	18.00	27.62
Combined Fe	24.1	25.38	14.21	31.85	20.67	5.10
Combined Ni	1.93	0.57	0.33	2.08	———	0.01
Combined Co	T	0.01	0.02	0.18	———	———
Mg	14.2	12.73	13.93	12.88	11.86	2.11
S	———	2.28	1.79	1.87	———	0.05
Ca	1.72	1.12	1.74	1.18	2.16	3.63
Al	1.92	3.13	1.53	0.68	———	8.12
Na	T	3.76	0.69	0.27	———	2.85
Cr	0.0089	T	0.30	0.12	———	0.04
Mn	0.25	0.25	0.26	0.06	———	0.09
K	T	0.35	0.18	0.10	———	2.60
P	T	0.10	0.14	0.09	———	0.13
Ti	T	———	0.08	0.02	———	0.63
Cu	T	T	0.15	0.15	———	0.03
C	1.99	———	———	———	———	———
Ratio $\frac{Fe}{Ni}(= n)$	13.13%	46.78%	45.25%	16.09%	———	53.59%
Molecular Ratio $\frac{MgO}{FeO}(= m)$	1.35	1.34	2.25	0.93	1.32%	0.95

REFERENCES TO TABLE 3

* Palache, C., & Lonsdale, J. T., *Am. Jour. Sci.*, *213*, 353-9, 1927.
† Brown, H., *Sci. Mon.*, *67*, 383-9, 1948.
‡ Rankama, K., & Sahama, T. G., *Geochemistry*, 532, 1950.

rock, as one would expect. This primary terrestrial rock is considerably higher in oxygen, silicon, and alkali content and lower in combined iron and magnesium. Even tho the aerolite does not clearly resemble any large bodies of material found on the surface of the Earth, there is a similarity in its composition to that of an intermediate plateau basalt. Murray is to be classified evidently as a carbonaceous chondrite.

REFERENCES

[1] Private communication.
[2] *Cf.* E. Cohen, *Meteoritenkunde, 2,* 134-47, Stuttgart, 1903.
[3] J. J. Katz & E. Rabinowitch, *The Chemistry of Uranium,* 95-6, McGraw-Hill Book Company, New York, 1951.
[4] K. Rankama & T. G. Sahama, *Geochemistry,* 532, The University of Chicago Press, 1950.
[5] A. V. Trofimov, *Doklady Akad. Nauk. S.S.S.R., 72,* 663-6, 1950.
[6] *Cf.* G. T. Prior, *Catalogue of Meteorites, British Museum,* v, London, 1923.
[7] C. Palache & J. T. Lonsdale, *Am. Jour. Sci., 213,* 353-9, 1927.