VIRGINIA MINERALS

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
Richmond, Virginia

Published quarterly by the DIVISION OF MINERAL RESOURCES, James L. Calver, Commissioner
Natural Resources Building, McCormick Road, Charlottesville, VA 22903

Vol. 20 August 1974 No. 3

METEORITES OF VIRGINIA

F. B. Hoffer

A *meteoroid* is any naturally occurring solid object moving in interplanetary space, smaller than an asteroid or planet, but considerably larger than an atom or molecule. The term *meteor* is used to describe the visible streak of light produced when a meteoroid passes through the atmosphere. The term *meteorite* is used for any solid object (meteoroid) that has fallen to the Earth's surface without being completely vaporized during its passage through the atmosphere. Known meteorites range in size from those having a maximum diameter of about 0.1 inch to masses weighing many tons. They consist essentially of nickel-iron alloys or silicate minerals. When composed chiefly of iron and nickel, they are called *siderites* or *irons;* when composed mostly of silicate minerals (mainly olivine, pyroxene, and plagioclase), they are called *aerolites* or *stones.* Meteorites that are a mixture of stone and iron are called *siderolites* or *stony-irons.* More than 60 minerals have been identified from meteorites and over 15 of these otherwise have not been found on Earth. No new elements have been found in meteorites.

A simple classification and description of the principal kinds of meteorites follows.

(1) Irons (siderites)—composed almost wholly of the iron-nickel minerals kamacite and taenite; may also contain the minerals plessite, troilite, schreibersite, cohenite, chromite, and graphite.

  (a) Octahedrites—6 to 16 percent nickel; polished and etched specimens show Widmanstatten figures; divided into fine, medium, and coarse.

  (b) Hexahedrites and nickel-poor ataxites—contain less than 6 percent nickel and consist of kamacite only.

  (c) Nickel-rich ataxites—contain more than 9 percent nickel and consist of pure taenite or an irregular mixture of kamacite and taenite.

(2) Stones (aerolites)—composed mostly of silicate minerals with small amounts of ferromagnesium (iron and magnesium) minerals; usually some metal in the form of grains.

  (a) Chondrites—contain generally spheroidal aggregates called chondrules; consist chiefly of olivine and/or orthopyroxene; contain from 1 to 25 percent nickel-iron and commonly up to 5 percent troilite.

  (b) Achondrites—generally do not contain chondrules and are poor in iron-nickel.

(3) Stony-irons (siderolites)—contain approximately equal amounts (by weight) of heavy, basic silicates and nickel-iron.

  (a) Pallasites—essentially olivine crystals embedded in a network of nickel-iron.

  (b) Mesosiderites—mainly pyroxene, plagioclase, and olivine, and a nickel-iron matrix.

Meteorites have been worshipped, tabooed, buried with the dead, and used as weapons and tools. They have also been studied by space engineers in the designing of spacecraft.

History's oldest records have accounts of falls, but little was known about their true identity until the early 1800's when detailed studies were begun. In early historical times, it was widely held that the fall of a meteorite was a manifestation of God's wrath.

Meteorites are named after their place of fall or find. A distinction is made between falls and finds. A *fall* is a meteorite which was picked up after it was actually seen to fall; a *find* is a meteorite which was not seen to fall but was recognized by its diagnostic features—chemical composition, mineralogical content, and structure. Irons and stony-irons are mostly finds but rarely falls. Stones, however, are mostly falls but rarely finds, because they look too much like common rocks especially after a few years of weathering. The irons and stony-irons do not look like ordinary rocks, and they also resist weathering for a long time on the earth's surface (rust slowly).

An estimated average of about 500 meteorites fall on the earth each year. Since approximately 70 percent of the surface of the earth is covered by water, probably only about 150 of them fall on land. An average of only about 4 observed falls have been recovered annually from 1800 to 1960, but if finds are included, then 7 or 8 are recovered per year. The fall of a meteorite is usually accompanied by light and sound effects, and is usually very startling. It appears as a fiery mass and passes across the sky, leaving behind a trail that appears as a luminous streak by night and a cloud of dust by day. The sound has been described as resembling cannon fire, thunder, or the passing of an express train.

With all the impressive sound and light phenomena that accompanies a meteorite, the impact of a small- or medium-sized meteorite (up to 1 ton) is amazingly slight, leaving only a hole in soft ground about the size of the meteorite. A 2,205 pound stone (largest recorded yet) that fell in Kansas in 1948 made a hole about 10 feet deep. While small meteorites tend to form *impact pits,* large meteorites form *fragmentation craters* or *impact explosion craters.* The Meteor Crater (Canyon Diablo Crater) in Arizona is the most spectacular in the United States. It is 4,260 feet across and 575 feet deep.

Throughout the world, slightly more than 2,000 meteorites (using the term meteorite for a single occurrence) have been discovered. Some occurrences may have many individual pieces. As an example, tens of thousands of fragments have been collected from Meteor Crater in Arizona. The greatest recovery from observed falls occurred between 1930 and 1940, when 79 from throughout the world were recovered.

The oldest authenticated fall from which material is still preserved is that of Ensisheim in Alsace when on November 16, 1492, a stone weighing 406 pounds fell to earth. The largest meteorite was found in 1920 near Hoba, South West Africa, and weighs 60 tons (about 9.7 x 9.3 x 3.3 feet) and is still at the place of fall; at the time it fell it probably weighed around 100 tons; the smallest meteorites, which still possess the meteoritic characteristics, are objects about 0.1 gram (0.0035 ounce) in weight.

Unlike most geological specimens needed for research, scientists cannot go to a certain area and pick up more meteoritic specimens as they are needed; they are largely dependent upon the public to help uncover new materials.

Where does one look and what does he look for in search for meteorites? They can be found almost any place. They have been found lying on top of the ground, and in the top several feet of soil. The plow has uncovered more of these than any other instrument. In 1954 a woman in Sylacaugh, Alabama was hit by a stone meteorite weighing a little over 8 pounds which broke through the roof of her house and hit her on the thigh, causing a minor bruise. A number of animals have been struck and a number of buildings have been damaged by falling meteorites.

The following points are useful in the identification of meteorites.

(1) All are heavier than common volcanic rock.

(2) All are magnetic, except that stony meteorites may be only slightly magnetic.

(3) Newly fallen specimens have a black or brown fusion coating and shallow pits resembling thumbprints.

(4) They are irregular in shape.

(5) Weathered specimens may appear very rusty in color.

(6) Certain tests can be done best in a scientific laboratory.

Meteorites are truly rare; only 11, weighing approximately 420 pounds, have been recovered from Virginia. Although about 40 percent of the world's approximately 2,000-known meteorites were observed falls, only three of the Virginia meteorites were seen falling. The other eight can be considered as finds. They were found in varying ways—four by farmers plowing and one on a frequently used path. One was found, but was too large to transport, and was not found again. Little is known of one. One was reported as an observed fall, but by testing is definitely a find.

RICHMOND METEORITE, CHESTERFIELD COUNTY

The first recorded meteorite in Virginia fell June 4, 1828 about 9 A.M. The first account was given by James Hartwell Cocke in the form of a letter written from Bremo Bluff, Fluvanna County, August 4, 1828 to the editor of the American Journal of Science (or Silliman's Journal at that time). Cocke's account follows:

"The fact that stones have fallen from the atmosphere is now universally admitted by men of science, but as there may still be some persons not acquainted with the evidence who may entertain doubts on the subject it may not be amiss to make known facts connected with an instance of this sort that occurred in Chesterfield County, Virginia about 7 miles southwest of Richmond, on the 4th of June last—this case is as well attested as any of the kind I ever recollect to have heard of.

"Being in Richmond at the time of hearing of the fall, I made some inquiry and obtained a piece of the stone about the size of a pigeon's egg. This resembled so much the only specimen of a meteoric stone I had ever seen that my anxiety to see the whole stone and to learn the facts relating to its fall was increased. It was very much like a fragment in your cabinet which was part of a stone that fell in Connecticut many years ago, an account of which is published in the American edition of Ree's Cyclopedia. After some inquiry I obtained the greater part of the stone weighing 3 pounds 3 ounces avoirdupois. Most of the exterior is of a dark-gray color, about one-third is covered with a black crust. The fracture is granular and of a light gray, interspersed with white metallic points which yield easily to the knife. For several days after the stone was taken from the earth it retained a strong scent of sulphur. The exterior exhibited several cavities from the size of a pea to that of a mustard seed; many of these are filled with earth and with fibers of the turf through which it passed on striking the earth. The whole stone, when entire, was said to have weighed 4 pounds. Its form is nearly spheroidal and its specific gravity about 4.

"The facts in relation to its fall, as I obtained them from a friend who visited the spot on the 7th of June, the day after I got possession of the stone are as follows: An overseer and several negroes were at work in a field belonging to Mr. Matthew Winfree about 9 o'clock on the morning of the 4th. An explosion was heard in the direction of Richmond toward the northeast which was at first mistaken for the report of a cannon, and in a short time after there was a noise which was thought at first to be the rumbling of a carriage on a neighboring stony road. In a few seconds, however, it was perceived to be rapidly approaching and presently after seemed to be just overhead, when it passed beyond and ended by a sound resembling the fall of a heavy body on the earth. The persons hastened toward the place from which the stroke proceeded and, after considerable search, found a hole in the turf which seemed to have been made by the entrance of a ball; they dug and got the stone described. The stone had buried itself about 12 inches; the distance of the hole from the point where persons were standing when the stroke was heard was found by measurement to be 260 paces.

"The person who gave the above account saw the hole the third day after it had been made. The bed from which the stone was taken was entire when he was there and of the size and shape of the body said to have been taken from it.

"A specimen will be submitted to the professor of chemistry at our university as soon as possible. I should have great pleasure in sending it for your inspection but for the difficulty of getting it to New Haven."

The meteorite is distributed widely—American Museum of Natural History, Amherst College, British Museum, Observatory of the Vatican, U. S. National Museum, Yale University.

Further information on the Richmond meteorite is reported in the following references.

Cocke, J. H., Jr., 1829, Virginia aerolite: Am. Jour. Sci., 1st ser., vol. 15, p. 195-196.

Shepard, C. U., 1829, A mineralogical and chemical description of a Virginia aerolite: Am. Jour. Sci., 1st ser., vol. 16, p. 191-203.

_____1843, On phosphate of lime (apatite), in the Virginia meteoric stone: Am. Jour. Sci., 1st ser., vol. 45, p. 102-103.

_____1848, Report on meteorites; 9. Richmond, Virginia: Am. Jour. Sci., 2nd ser., vol. 6, p. 411.

BOTETOURT METEORITE, BOTETOURT COUNTY

Shepard (1866) gave the following account of this meteorite:

"This iron was discovered about 1850 in a mass so ponderous that the finder, having attempted to transport it on horseback a number of miles to his house, was obliged to abandon the undertaking. He left it upon a stone wall by the side of the road, after having (with the assistance of a negro who happened along with a hammer) detached two or three small angular fragments. These were afterward given to Mr. N. S. Manross, who took them with him to Gottingen, where, in the laboratory of Professor Wohler, he analyzed one of them so far as to determine the presence of nickel in the unusually high proportion of 20 percent.

"It is whiter than most irons, extremely close and homogenous, with the exception of a few minute pyritic grains. Specific gravity, 7.64; fracture fine granular, like cast steel. It does not give the Widmanstatten figures."

There is a small fragment in the Natural History Museum in Vienna. The Indian Museum in Calcutta and Amherst College report splinters of the Botetourt meteorite.

Further information on the Botetourt meteorite is available in the following reference.

Shepard, C. U., 1866, Brief notices of several localities of meteoric iron: Am. Jour. Sci., 2nd ser., vol. 42, p. 250.

POPLAR HILL (CRANBERRY PLAINS) METEORITE, GILES COUNTY

This iron meteorite was found in 1852, but little or nothing seems to be known of its history. Its known preserved portions weigh 89 grams (approximately 3 ounces avoirdupois) of which the Harvard University Museum possesses the largest quantity (36 grams).

The only available information on the Poplar Hill meteorite is in the following references.

Cohen, E., 1905, Meteoritenkunde, Heft 3, p. 346.
Farrington, O. C., 1915, Catalogue of the meteorites of North America to January 1, 1909: Natl. Acad. Sci., Mem. 13, p. 358.

STAUNTON, AUGUSTA COUNTY

The Staunton meteorite (Figure 1) consists of six pieces with a total weight of about 270 pounds. The first three pieces of this iron were described by Mallet in 1871. The first iron weighed 56 pounds and was turned up by a plow. Mr. Mallet with the assistance of J. B. Baldwin of Staunton secured this meteorite. The second one, weighing 36 pounds, was exhibited at the Richmond Fair in 1872 by Major Hotchkiss, who said it was found in Augusta County. A little later Hotchkiss gave Mallet a third specimen weighing 3.5 pounds. All three specimens presented the same general appearance. Analyses proved all three pieces were essentially identical, and thus represented a single fall.

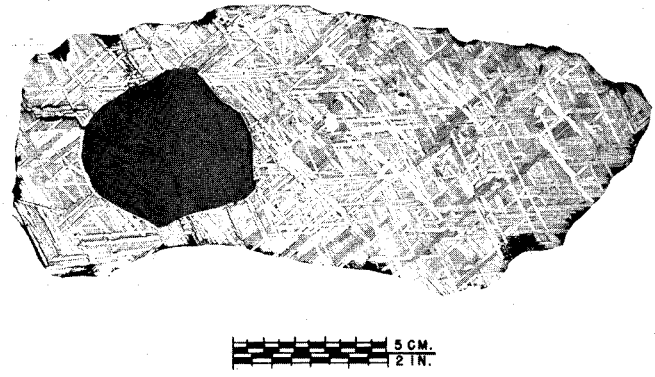


Figure 1. Etched section of Staunton octahedrite; note Widmanstatten figures. The dark inclusion is troilite. (Photograph courtesy of the Smithsonian Institution.)

The fourth piece was brought into Staunton in 1858 or 1859 by a negro man (who belonged to Mr. Van Lear, the owner of the land on which the first iron was found). He attempted to sell it for one dollar, but there were no takers. He then discarded it. Later, the meteorite was used as an anvil, and a part of two different walls. A Mr. Miller of Staunton noticed it in a wall, and had it removed. He sold the iron to Messrs. Ward and Howell of Rochester, New York, who in turn sold portions of it. Mallet (1878) concluded this iron was the same as the other irons, but a later examination showed it to have a different structure.

A fifth iron was found by Mr. Baldwin near where the other pieces were found, but he thought it had been detached from the first iron. A careful examination by Mallet showed it had not been detached from any of the other masses. An analysis shows that this iron is similar to the first three described.

A sixth iron (Figure 2) (called No. 7 by Mallet) was given to Washington and Lee University during the 1870-71 session. Analysis (Campbell and Howe, 1903) has not shown whether it is a part of the Staunton meteorite or not, but in most particulars it does resemble the fourth mass described by Mallet in 1878. Nininger (1952) points out the so-called 4 and 6 masses differ from the other masses as judged by a comparison of their Widmanstatten figures. Yet both specimens are still passing under one name in nearly all collections.

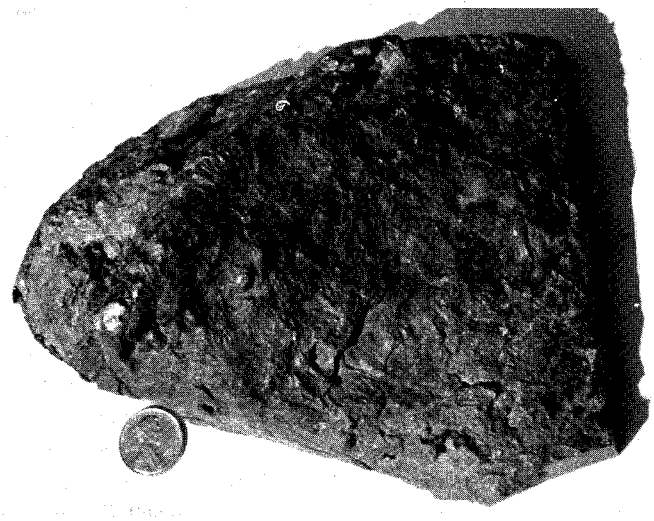


Figure 2. About half of the Staunton No. 6 meteorite; weight 3,428 grams (about 7.5 pounds avoirdupois). (Photographed with permission of Washington and Lee University.)

Fragments of the Staunton meteorite are in the following collections—Natural History Museum in Vienna, National Museum in Budapest, Harvard University, Chicago Museum of Natural History, Sydney, U. S. National Museum, Royal Scottish Museum, H. H. Nininger, Washington and Lee University. Further information on it is in the following references.

Campbell, H. D., and Howe, J. L., 1903, A new (?) meteoric iron from Augusta County, Virginia: Am. Jour. Sci., 4th ser., vol. 15, p. 469-471.

Kunz, G. F., 1887, A fifth mass of meteoric iron from Augusta County, Virginia: Am. Jour. Sci., 3rd ser., vol. 33, p. 58-59.

Mallet, J. W., 1871, On three masses of meteoric iron from Augusta County, Virginia: Am. Jour. Sci., 3rd ser., vol. 2, p. 10-15.

———1878, On a fourth mass of meteoric iron from Augusta County, Virginia: Am. Jour. Sci., 3rd ser., vol. 15, p. 337-338.

Nininger, H. H., 1952, Out of the sky—an introduction to meteoritics: Denver, Colo., Denver Univ. Press, p. 191.

HOPPER METEORITE, HENRY COUNTY

Venable (1890) gives the following description of this meteorite:

"This iron was found by Nathaniel Murphy in Henry County, Virginia, about 4 miles from the Pittsylvania County line, and 0.5 mile north of the dividing line between North Carolina and Virginia, near to Smith River. Murphy found the stone in a plowed field in the latter part of the spring of 1889. He gave it to Col. J. Turner Morehead of Leaksville, North Carolina. Together with Col. Morehead he searched over the farm, but could find nothing similar to this piece. Colonel Morehead sent the mass to Dr. H. B. Battle of Raleigh, North Carolina. It weighed 1.7 kg., and the detached pieces, mainly crust, weighed 0.22 kg. This crust broke along certain lines of cleavage, and the main mass is permeated with cracks, not irregular zigzag, but distinct and regular. This cleavage is in two directions. The laminae vary in thickness, but many are about 0.5 mm. The color of the surface is dark bluish-black, mixed with much red rust from the lawrencite. Parts of the soil apparently still cling to the mass. It measured 60 by 70 by 75 mm in its greatest dimensions. Here and there spots were to be seen with bright silvery sheen. It contains a good deal of ferric chloride and crumbles rapidly. Coarse Widmanstatten figures appear on the polished surface without etching."

Fragments of the Hopper meteorite are in the U. S. National Museum and American Museum of Natural History. Further information on it is in the following references.

Farrington, O. C., 1903, Catalogue of the collection of meteorites, May 1, 1903: Field Colombian Mus. Publ., Geol. ser., vol. 2, p. 100.

Venable, F. P., 1890, Two new meteoric irons.-2, From Henry County, Virginia: Am. Jour. Sci., 3rd ser., vol. 40, p. 162-163.

INDIAN VALLEY METEORITE, FLOYD COUNTY

While plowing a tobacco field in the western part of Floyd County in the spring of 1887, Mr. John Showalter turned up a 31-pound iron meteorite. A search in the near vicinity failed to find other pieces. Kunz and Weinschenk (1891) described the meteorite as being badly corroded and covered with a rust crust. No other details were given concerning the history of the iron. Buchwald (1965) makes the observation that the Mayodan meteorite from North Carolina (which was found about 47 miles south-southwest of the Indian Valley meteorite) and the Indian Valley may well be part of the same fall as they have the same chemical composition.

Fragments are in collections of the Chicago Museum of Natural History (more than half), Mineralogical Museum in Copenhagen, H. H. Nininger, Observatory of the Vatican, and the U. S. National Museum. The following references contain more information about this meteorite.

Buchwald, V. F., 1967, Studies of six iron meteorites—. . . Indian Valley . . .: Analecta Geol., no. 2, p. 43-47.

Kunz, G. F., and Weinschenk, E., 1892, On two meteoric irons; 1—Indian Valley Township, Floyd County, Virginia: Am. Jour. Sci., 3rd ser., vol. 43, p. 424-425.

NORFOLK METEORITE, FORMER NORFOLK COUNTY

The earliest published description of the Norfolk meteorite seems to be a brief note made by Reeds (1937).

"A mass of about 53 pounds fell in 1906. It was placed on exhibition at the Jamestown, Virginia Exposition, 1907, by Dr. E. A. Shubert of Virginia. He again exhibited it in Pittsburgh, Pennsylvania, 1911 and 1912, and sold it to Dr. D. J. Cable of Pittsburgh. Mr. Lloyd B. Curtie obtained the specimen from Mr. Cable in settlement of a debt, June 20, 1923 and sold it to the American Museum of Natural History, June 26, 1923."

Because of the weathered condition of this iron, it was considered probably not an observed fall. This observation was confirmed by Schaeffer and Heymann (1965) who noted that the Norfolk meteorite did not contain detectable Ar-39, so that it is definitely a find. The American Museum of Natural History has most of the meteorite (Figure 3). Further information is reported in the following references.

Reeds, C. A., 1937, Catalogue of the meteorites in The American Museum of Natural History, as of October 1, 1935: Am. Mus. Nat.

History Bull., vol. 73, p. 517-672.
Schaeffer, O. A., and Heymann, N. D., 1965, Comparison of Cl^{36}-Ar^{36} and Ar^{39}-Ar^{38} cosmic ray exposure ages of dated fall iron meteorites: Jour. Geophys. Research, vol. 70, p. 215-224.
Wiik, H. B., and Mason, Brian, 1965, Analyses of eight iron meteorites: Geochim. et Cosmochim. Acta, vol. 29, p. 1003-1005.

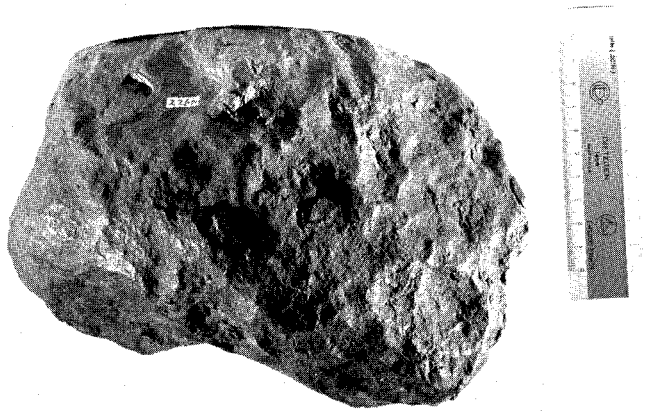


Figure 3. External appearance of the Norfolk medium octahedrite. (Photograph courtesy of the American Museum of Natural History.)

SHARPS METEORITE, RICHMOND COUNTY

On April 1, 1921, Grant Yates of Sharps was working on the farm of F. W. Motley, when he heard a noise he could not account for, and which frightened him. Upon looking up he saw an object falling that was followed by a small tail of fire. It fell about 100 yards from Yates in a plowed field, and was buried to a depth of 15 inches. When he dug it up, he reported that it "smelled strongly of brimstone."

Watson (1923) describes the stone (Figure 4) as follows:

"The total weight of the stone was 1,265 grams or about 3.4 pounds (troy). The specific gravity as determined on the entire mass was 3.53. . . . The dimensions are approximately 11.5 and 6.5 cm. It is bounded by eight irregular smooth faces of unequal size, which meet in edges that are well rounded. Three of the faces adjacent to each are concave, and each is characterized by smaller concavities or pits; the surfaces of the three faces being formed of a smooth, black, skin-like coating. The other faces are lighter in color (dark gray), several of which are only slightly concave and all are essentially free from pits or minor concavities . . . . show the stone to be a crystalline spherulite chondrite composed chiefly of olivine and enstatite and a considerable sprinkling of metallic iron."

Further information is in the following reference.

Watson, T. L., 1923, The Sharps meteorite, Richmond County, Virginia: U. S. Natl. Mus. Proc., vol. 64, art. 2, 4 p.

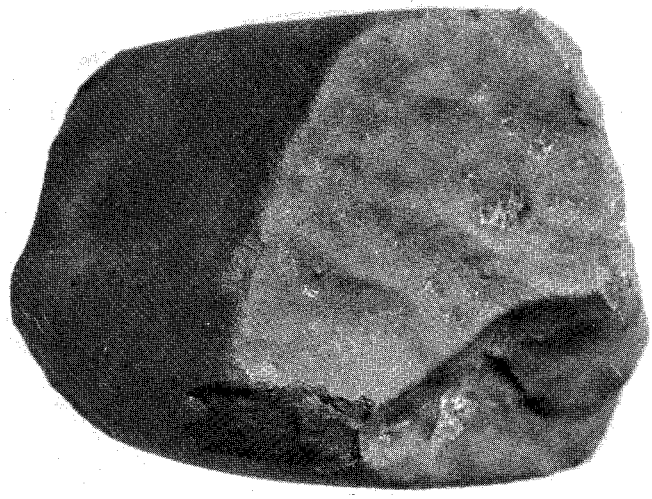


Figure 4. Sharps chondrite; its dimensions are approximately 4.5 x 3 x 2.5 inches. (Photograph courtesy of the Smithsonian Institution.)

DUNGANNON METEORITE, SCOTT COUNTY

This iron meteorite (Figure 5) was found in 1922 or 1923 in a plowed field, some 3 miles southeast of Dungannon, Scott County, by Mr. C. W. Castle of Nickelsville, Virginia. Merrill (1923) describes the meteorite as follows:

"As received, it more nearly resembled an irregular mass of terrestial limonite than a meteorite, though occasional depressions or thumb markings on the badly oxidized surface suggested its true nature. Oxidation had proceeded so far that in plowing it was broken into

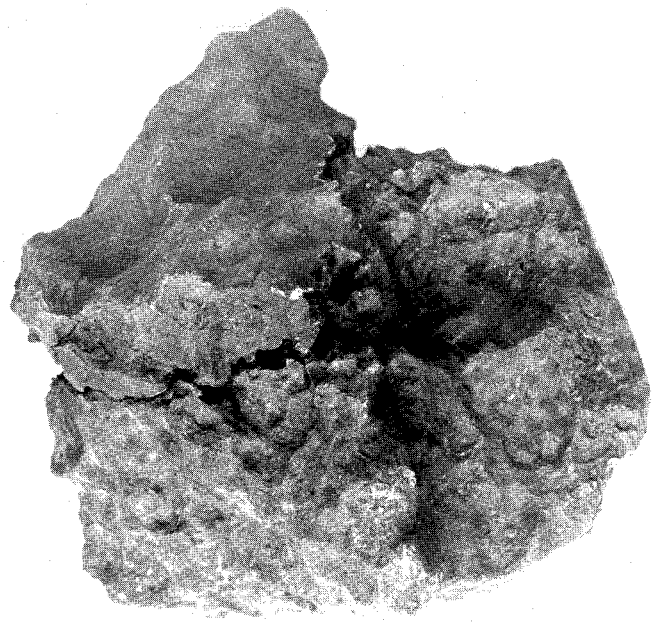


Figure 5. External appearance of the Dungannon iron showing where it was broken; the two pieces weigh about 23 pounds and 5 pounds respectively. (Photograph courtesy of the Smithsonian Institution.)

two pieces weighing respectively 5 and 23 pounds, or a total of about 13 kilograms. The fractured surface shows plainly an octahedral cleavage. The metal is soft enough to cut readily with a hand hacksaw, contains, so far as observed, no nodules of troilite or schreibersite, and is readily malleable."

Specimens are in collections at the American Museum of Natural History, U. S. National Museum, and Chicago Museum of Natural History (main mass). For information on this meteorite see the following reference.

Merrill, G. P., 1923, A meteoric metabolite from Dungannon, Virginia: U. S. Natl. Mus. Proc., vol. 62, art. 18, 2 p.

FORKSVILLE METEORITE, MECKLENBURG COUNTY

On July 16, 1924 about 5:45 P.M., the Forksville stone meteorite was seen to fall. Four pieces of slightly more than 13 pounds were recovered in and near Forksville, Virginia. The stone was traveling in a northwest to southeast direction and was accompanied by the usual cannon-like explosions with the noise lasting 4 or 5 minutes. No light was seen. No. 1 stone (Figure 6) fell about halfway between Brodnax and Forksville on R. D. Temple's place, and was recovered in about 15 minutes. When picked up, it was cold. It weighed 2,250 grams (approximately 4.9 pounds). No. 2 stone fell in soft mud to a depth of 18 inches. A woman was within 450 feet of the impact area, and she heard the explosion directly overhead. The weight of the stone was 1,850 grams (approximately 4 pounds). No. 3 stone fell on Mrs. Trutter's place making a hole 6 to 8 inches deep; it weighed 853 grams (approximately 1.9 pounds). About 50 to 75 people near a cemetery saw No. 4 stone fall. The stones show both primary and secondary encrustations. They are classified as spherulite chondrite.

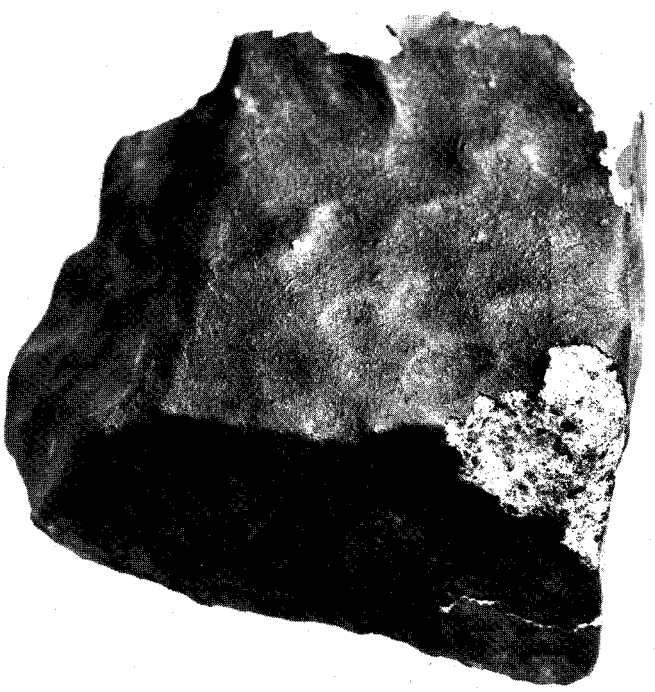


Figure 6. External appearance of the largest of the Forksville stones; size, approximately 5 x 4 x 4 inches; weight, approximately 4.9 pounds (2,250 grams); shows primary and secondary encrustation. (Photograph courtesy of the Smithsonian Institution.)

Specimens are in collections at the U. S. National Museum and University of Virginia Brooks Museum.

For further information see the following reference.

Merrill, G. P., 1927, A stony meteorite from Forksville, Mecklenburg County, Virginia: U. S. Natl. Mus. Proc., vol. 70, art. 21, 4 p.

KEEN MOUNTAIN METEORITE, BUCHANAN COUNTY

While walking along a frequently used path about 30 feet from the crest of the south face of Keen Mountain, Buchanan County in 1950, Mr. Fred Matney observed a dark-colored rock (Figure 7), entirely different from the others. Upon investigation, he discovered that it was metallic. He then sent a small piece to the U. S. Geological Survey, who in turn sent it to the Smithsonian Institution for identification. From the examination it was identified as a meteorite. Mr. Matney sold the 14.75-pound iron meteorite to Mr. Stuart H. Perry, who then presented it to the U. S. National Museum. Henderson and Perry (1958) described the meteorite as a hexahedrite (Figure 8), and from their examination concluded that it was a

Figure 7. Keen Mountain hexahedrite; it lacks the typical "thumbmark" depressions common to most iron meteorites. The shallow cavity at the lower right is surrounded with unaltered fusion crust in which flight markings are present. The file mark above the depression exposes fresh metal. The rougher surfaces represent corrosion. Weight, 14.75 pounds. (Photograph courtesy of the Smithsonian Institution.)

Table 1.—Composition of Virginia meteorites (in percent).

	Iron meteorites							
	Botetourt	Dungannon	Hopper	Indian Valley	Keen Mountain	Norfolk	Poplar Hill (Cranberry Plains)	Staunton No. 1
Iron	82.49	92.69	90.54	93.59	93.38	92.18	None	88.71
Nickel	17.51	7.069	7.70	5.56	5.65	7.51	available	10.163
Cobalt		0.090	0.094	0.53	0.73	0.65		0.396
Phosphorous		0.130	0.13	0.27	0.19			0.341
Silicon		0.015		trace				0.067
Carbon					0.06			0.172
Sulfur				0.01	none			0.019
Cerium			0.35					
Quartz			0.04					
Chlorine								0.003
Copper				trace				0.341
Manganese								trace
Tin								0.002
Total	100.00 nickel-rich atexite	99.994 medium octa-hedrite	99.70 medium octa-hedrite	99.96 hexa-hedrite	100.01 hexa-hedrite	100.34 medium octa-hedrite	fine octa-hedrite	100.214 medium octa-hedrite

	Stone meteorites		
	Sharps	Forksville	Richmond
Metallic portions	9.69	6.46	12.59
Rock materials	87.89	93.54	87.41
Troilite	2.42		
Total	100.00	100.00	100.00

recent fall, but not observed fall. Later examination has determined that it is not a recent fall, but fell about 1,300 years ago (Anders, 1963).

Henderson and Perry (1958) described the meteorite in the following way:

"On its surface there are sizable patches of unaltered black fusion crust that contain flight markings. In a few places the silver color of Ni-iron alloy can be seen through the fusion crust. However, on the surface of this iron, patches of loosely attached oxide as well as some small corrosion pits occur."

The other known hexahedrite from Virginia was found 100 miles east of Keen Mountain, at Indian Valley, Floyd County. Although both hexahedrites were found on the southern face of mountains, Henderson and Perry (1958) believe this is only a coincidence.

Most of this meteorite is in the U. S. National Museum. Further information is available in the following references:

Anders, Edward, 1963, Meteorite ages, *in* The moon, meteorites, and comets: Chicago, Ill., Univ. Chicago Press, p. 402-495.

Henderson, E. P., and Perry, S. H., 1958, Studies of seven siderites: U. S. Natl. Mus. Proc., vol. 107, no. 3388, p. 393-399.

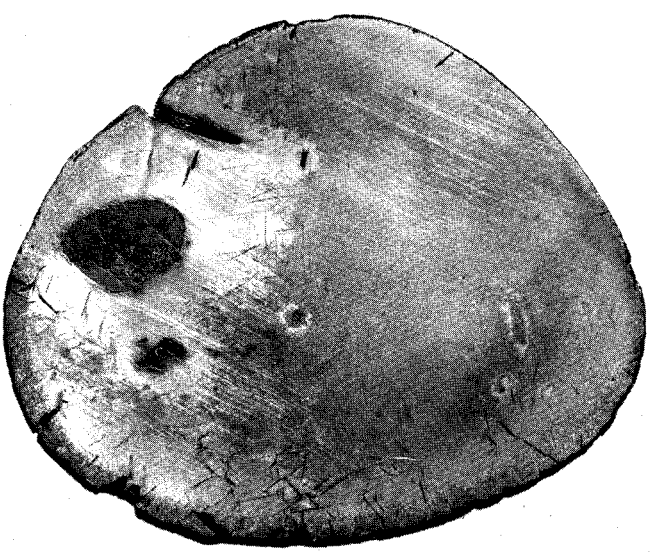


Figure 8. Keen Mountain hexahedrite; a thin slice showing the Neumann lines in the center being slightly deformed. (Photograph courtesy of the Smithsonian Institution.)

GENERAL REFERENCES AND SUGGESTED READINGS

Heide, Fritz, 1964, Meteorites (translation of *Kleine Meteoritenkunde* by Edward Anders and Eugene R. DuFresne): Chicago, Ill., Univ. Chicago Press, 144 p.

Hey, M. H., 1966, Catalogue of meteorites: London, British Museum (Nat. Hist.), HMSO, 637 p.

McCall, G. J. H., 1973, Meteorites and their origins: New York, John Wiley and Sons, 352 p.

Mason, Brian, 1962, Meteorites: New York, John Wiley and Sons, 274 p.

Nininger, H. H., 1952, Out of the sky—an introduction to meteoritics: Denver, Colo., Denver Univ. Press, 336 p.; *reprinted* by Dover Publications, New York, 1959.

GLOSSARY

chromite—A brownish- to iron-black mineral of the spinel group: $(Fe,Mg)(Cr,Al)_2O_4$. It is common in stones (stony meteorites).

cohenite—A tin-white meteorite mineral: Fe_3C or $(Fe,Ni,Co)_3C$.

fusion crust—A thin, glassy outer covering on a meteorite, usually black and generally a fraction of a mm thick, which was formed by ablation on its surface as it passed through the atmosphere.

kamacite—A meteorite mineral (native metal) consisting of the alpha-phase of a nickel-iron alloy, with a fairly constant composition of about 5-7 percent nickel.

lawrencite—A green or brown meteorite mineral: $FeCl_2$.

Neumann lines—Fine, straight lines on the etched surfaces of hexahedrites and caused by mechanical twinning on planes in kamacite.

olivine—An olive-green, grayish-green, or brown silicate mineral: $(Mg,Fe)_2SiO_4$. It is probably the most abundant silicate in meteorites.

plagioclase—A series of feldspars of general formula: $(Na,Ca)Al(Si,Al)Si_2O_8$. Present in mesosiderites, chondrites, and achondrites. (Feldspars are the most widespread group of minerals in the Earth's crust and constitute about 80 percent of it.)

plessite—A meteorite mineral consisting of a fine-grained intergrowth of the meteorite minerals kamacite and taenite.

schreibersite—A silver-white to tin-white, highly magnetic, meteorite mineral: $(Fe,Ni)_3P$. Also known as rhabdite.

taenite—A meteorite mineral (native metal) consisting of the gamma-phase of a nickel-iron alloy, with the nickel content ranging from about 27 percent to 65 percent.

troilite—A mineral that occurs in small amounts in most meteorites: FeS. It is a variety of pyrrhotite.

Widmanstatten figures—A triangular pattern on polished or etched surfaces of octahedrites, composed of parallel bands of the mineral kamacite bordered by the mineral taenite.

HISTORICAL BRIEFS ABOUT METEORITES

A "thunderstone" fell on the Island at Crete about 1478 B. C.

The blackstone in the Kaaba at Mecca is believed to be a meteorite.

The "image" which was once in the temple of Diana in Ephesus may have been a meteorite (Acts 19:35).

The treasury of an early Hittite king listed gold from a certain city; silver, copper and bronze from mines; and "black iron of heaven from the sky."

On November 16, 1492 about 11:30 a.m., a meteorite fell at Ensisheim, Alsace. Most of it is still preserved at the town hall in Ensisheim. This is the oldest meteorite in existence which was observed to fall. The Emperor Maximilian referred to this meteorite fall as a sign of God directed against the Turks.

In 1794, E. F. F. Chladni wrote a scientific treatise maintaining that meteorites do, indeed, fall from the sky. He followed this with a book published in 1819, removing all doubt of the reality of meteorite fall.

On April 26, 1803, a shower of several thousand stones fell at L'Aigle, France. This event convinced the French Academy at Paris, and thus the scientific world, of the reality of meteorite fall. This date is often said to mark the beginning of the science of meteoritics.

Several stones fell at Weston, Connecticut on December 14, 1807. This event was studied and reported by Silliman and Kingsley of Yale. Thomas Jefferson said of this event, "I would more easily believe that two Yankee professors would lie than that stones would fall from heaven."

The meteorite crater known as Meteor Crater or Canyon Diablo Crater in Arizona was known to white men as early as 1871, but was not clearly recognized as a meteorite crater until about 40 years ago. It is also called Barringer Meteorite Crater in honor of Daniel Moreau Barringer who provided the evidence of its meteorite origin.

On June 30, 1908, the most dramatic meteorite fall of historic times took place near the Tunguska River in central Siberia. It was observed over an area more than 900 miles in diameter and produced detonations heard 600 miles from the place of fall. The shock wave killed reindeer and devastated a forest of about 700 to 800 square miles in area. Only minute meteorite fragments have been recovered.

The second greatest meteorite fall of recorded times took place February 12, 1947 in the Sikhote-Alin Mountains in Siberia. Many small craters and impact holes were produced and more than twenty-five tons of meteoritic iron has been recovered.

INFORMATION CIRCULAR 20

The Division has received many inquiries concerning the contents of Information Circular 20, "Geographic and place names in Virginia." In addition to the information that appears in the May 1974 issue of *Virginia Minerals,* a page of the publication is reproduced below.

The 30,000-name index is aimed at locating a particular feature on a map, and will be of great value to the many users of the standard 7.5-minute (1:24,000 scale; 1 inch equals 2,000 feet) topographic maps of the U. S. Geological Survey.

INFORMATION CIRCULAR 20

WATER FEATURES

NAME	CITY/COUNTY	QUADRANGLE
PHILLIPPI BRANCH	SMYTH COUNTY	55-A, 55-D
PHILLIPS CREEK	NORTHAMPTON COUNTY	93-A
	WISE COUNTY	90-C
PHILLIPS LICK	AUGUSTA COUNTY	177-B
PHILLIPS POND	CAROLINE COUNTY	149-A
PHILLIPS SPRING	HIGHLAND COUNTY	177-B
	WASHINGTON COUNTY	26-B
PHILPOTT RESERVOIR	FRANKLIN COUNTY	50-D
	HENRY COUNTY	50-D
	PATRICK COUNTY	50-C, 50-D
PHILS ARM RUN	WARREN COUNTY	208-C
PHILS CREEK	FLUVANNA COUNTY	152-B,152-C
PHOEBE BRANCH	APPOMATTOX COUNTY	105-C
PHOEBE LAKE	APPOMATTOX COUNTY	105-C
PIANKATANK RIVER	GLOUCESTER COUNTY	122-C,123-D
	MATHEWS COUNTY	122-C,122-D
	MIDDLESEX COUNTY	122-C,122-D,123-D
PICKLES BRANCH	CRAIG COUNTY	110-B
	ROANOKE COUNTY	110-B
PICTURE BRANCH	DINWIDDIE COUNTY	70-A
PIE CREEK	PITTSYLVANIA COUNTY	48-A
PIERCE BRANCH	SMYTH COUNTY	55-C
PIERCE CREEK	SURRY COUNTY	66-C
PIFER RUN	FREDERICK COUNTY	218-A,218-B
PIG CREEK	PATRICK COUNTY	19-B, 19-C
PIG RUN	BATH COUNTY	178-D
PIG SWAMP	SOUTHAMPTON COUNTY	37-A
PIGEON BRANCH	BUCHANAN COUNTY	88-A
	GILES COUNTY	113-C
PIGEON CREEK	WISE COUNTY	61-A, 61-D
	LYNCHBURG CITY	106-B
PIGEON ROOST BRANCH	DICKENSON COUNTY	88-B
PIGEON RUN	SPOTSYLVANIA COUNTY	171-A,171-D
PIGEON SWAMP	SUSSEX COUNTY	68-C
PIGEONROOST CREEK	BRUNSWICK COUNTY	9-C
PIGEONROOST SWAMP	SURRY COUNTY	67-C
PIGG RIVER	FRANKLIN COUNTY	48-A, 48-B, 49-A, 49-B
		50-A, 79-D
	PITTSYLVANIA COUNTY	47-B, 48-A, 77-C
PIKE BRANCH	FAIRFAX COUNTY	204-D
	SCOTT COUNTY	28-A
PIKE POND	ALLEGHANY COUNTY	159-D
PILTZER CREEK	SPOTSYLVANIA COUNTY	170-B,183-C
PIMMIT RUN	ARLINGTON COUNTY	204-A
	FAIRFAX COUNTY	204-A,204-B
PINE BRANCH	CARROLL COUNTY	21-A
	DICKENSON COUNTY	89-B
	FAUQUIER COUNTY	183-B,195-C
	FLOYD COUNTY	80-C
	SCOTT COUNTY	28-A
	WISE COUNTY	60-B, 90-C
PINE CAMP CREEK	WISE COUNTY	59-B, 60-A
PINE CREEK	APPOMATTOX COUNTY	104-C
	CARROLL COUNTY	20-A, 52-C
	DICKENSON COUNTY	90-A
	FLOYD COUNTY	51-A
	PITTSYLVANIA COUNTY	15-A, 46-C, 47-D
	RUSSELL COUNTY	87-C
PINE FORK	FLOYD COUNTY	80-C
PINE HILL CREEK	KING GEORGE COUNTY	168-A,168-B,181-C,181-D
PINE LAKE	CAMPBELL COUNTY	106-C
	PITTSYLVANIA COUNTY	16-D
PINE ORCHARD BRANCH	WISE COUNTY	59-B
PINE RUN	AUGUSTA COUNTY	156-B,176-C,176-D
	PULASKI COUNTY	53-A
	WYTHE COUNTY	54-B
PINE SWAMP	ISLE OF WIGHT COUNTY	37-D
	NANSEMOND COUNTY	4-C, 4-D
PINE SWAMP BRANCH	GILES COUNTY	112-A
PINE WOODS POND	JAMES CITY COUNTY	97-D
PINETREE BRANCH	VIRGINIA BEACH CITY	34-D
PINEY BRANCH	ALLEGHANY COUNTY	159-C,159-D

The index is an important complement to the maps, and provides additional necessary knowledge of the geographic and cultural features of Virginia. By using the index, the location of towns and villages, the course of streams and drainage basins, major mountains, and natural scenic features as well as historic homes, forts, and churches, can be more easily determined.

Aside from its practical use in conjunction with topographic maps, the index should be of great interest to other groups, such as historians and genealogists. Many of the place names reflect the cultural background of early inhabitants of Virginia, and their desire to bring some heritage of the old home to the new.

Names like Tobaccoville, Slate, Iron Gate, Timberville, and Saltville, give an indication of the natural resources of various areas, while others such as Troy, Treasure Island, Tenth Legion, and Ivanhoe, show a romanticist side of the early Virginians. Local color shows in the names people gave to their surroundings: Hanging Rock, Bellyache Swamp, Cursing Hollow, Dr. Jack Gut, Ghost Knob, Pleasure House Creek, Purgatory Creek, Lovers Leap, True Blue, and Youbedamn Landing.

Presented alphabetically, the index lists more than 30,000 names taken from the 7.5-minute quadrangle maps, broken down into four categories. The first section, *place names,* comprises 26 percent of the index, and includes most man-made features such as cities, towns, forts, landings, and military bases. The second section lists all *water features* of Virginia, representing 32 percent of the total entries. It includes rivers, lakes, swamps, and channels. A third category, *landforms,* lists natural topographic forms within the State, and includes the mountains, valleys, hills, and shoals, as well as the more unusual features such as natural tunnels, natural bridges, and caves. The landform section comprises 24 percent of the index. The final section, *religious institutions,* is the smallest of the categories (18 percent), and includes all religion-oriented entries — mainly churches, chapels, temples, and tabernacles.

The compilation of the index began in the mid-1960's when a joint Virginia-U. S. Geological Survey topographic program was accelerated. It represents a supplemental product to the over-all joint mapping program.

In commenting on the new index, Donald J. Orth, head of the U. S. Geological Survey's Geographic Names Section, Topographic Division, Reston, Virginia, praised it as a "most welcome addition to the geographic literature," adding that "it will not only serve official needs, but will become an important reference tool for schools, libraries, and places of business."

Information Circular 20, by Thomas H. Biggs, is available from the Division for $2.75 (plus 4 percent State sales tax for Virginia residents). The topographic maps on which this index is based are available for 75 cents each plus tax; a listing of such is obtainable free on request.

NEW PUBLICATIONS

DIRECTORY OF THE MINERAL INDUSTRY IN VIRGINIA—1974, by D. C. Le Van; 56 p. Price: $0.50 (plus 4 percent State sales tax).

LIST OF PUBLICATIONS (1974), 55 p. No charge.

VIRGINIA GEOLOGY FIELD CONFERENCE

The sixth annual Virginia Geology Field Conference will be held in the Richmond area on Friday and Saturday, October 25-26, 1974. The Atlantic Coastal Plain Geological Association has accepted an invitation to join the field trip. Emil Onuschak, Jr., and Paul A. Daniels, Jr., will be the field trip leaders. Richmond is located on the James River at the Fall Line, with sediments of the Coastal Plain to the east and rocks of the Piedmont to the west. The purpose of the trip will be to examine the sediments and rocks of the Richmond area, both at the surface and by means of drilling information from the subsurface; to derive an interpretation of the geology; and to observe the influence of geology upon the urban development of Richmond. Nongeologists including planners, contractors, engineers, and other public and private individuals are specifically invited and encouraged to attend. To be placed on the mailing list to receive later information about this trip, contact Emil Onuschak, Jr., Virginia Division of Mineral Resources, Box 3667, Charlottesville, Virginia 22903.

ADDITION TO STAFF

Mr. Stephen C. Bell joined the Division staff on June 3, 1974 and will assist in various phases of economic geology activities. He received his B.S. degree in geology from West Virginia University in 1969. He was previously employed by a geophysical surveying firm in Oklahoma. Mr. Bell is married.

Virginia Division of Mineral Resources
Box 3667
Charlottesville, VA 22903

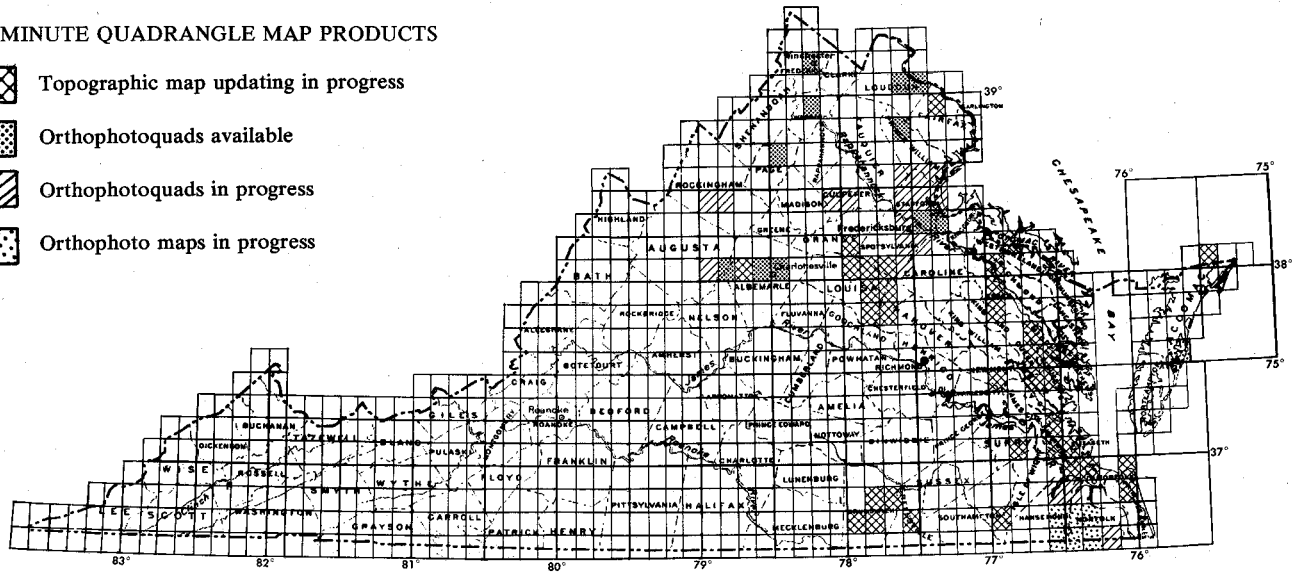
Second-class postage paid at
Charlottesville, Virginia.

Return Postage Guaranteed

TOPOGRAPHIC MAPS, ORTHOPHOTOQUADS, AND ORTHOPHOTO MAPS

7.5-MINUTE QUADRANGLE MAP PRODUCTS

- Topographic map updating in progress
- Orthophotoquads available
- Orthophotoquads in progress
- Orthophoto maps in progress



Quadrangle map products published from April 1, 1974 to June 15, 1974

Orthophotoquads:
- Charlottesville East
- Charlottesville West
- Fredericksburg
- Front Royal
- Gainesville
- Leesburg
- Luray
- Passapatanzy
- Sterling
- Waynesboro East
- Winchester

Updated photorevised topographic map: Belmont

Advance print of topographic map for updating:
- Chancellorsville
- Charlottesville East
- Charlottesville West
- Crozet
- Culpeper East
- Vienna
- Waynesboro East
- Waynesboro West

ADVANCE PRINTS

Advance prints are available at 75 cents each from the Eastern Mapping Center, Topographic Division, U. S. Geological Survey, Reston, Virginia 22092.

PUBLISHED TOPOGRAPHIC MAPS

State index is available free. Updated photorevised maps, on which recent cultural changes are indicated, are now available for certain areas of industrial, residential, or commercial growth. Published maps for all of Virginia are available at 75 cents each (plus 4 percent State sales tax for Virginia residents) from the Virginia Division of Mineral Resources, Box 3667, Charlottesville, Virginia 22903.