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Features

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Better Know A Meteorite Collection: Natural History Museum in London, United Kingdom



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PSRD highlights places and people around the world who play central roles in caring for and analyzing meteorites. Join us as we visit the U. K. national meteorite collection at the Natural History Museum in London and talk with the people who help make history and new discoveries come alive. ☀

The Natural History Museum in London, with its combined collections of over 70 million specimens of minerals, fossils, plants and animals and its brilliant public galleries, is also home to first-class scientific research departments. The Mineralogy Department's meteorite collection is one of the world's finest and a focus for scientific discoveries by researchers based at the museum and around the globe. The collection has about 5000 individually registered specimens, collected from every continent, representing just under 2000 distinct meteorites. In the jargon of meteoritics, there are falls and finds. Falls are meteorites that are recovered after eye witness accounts of fireballs and thunderous noises lead to their collection. Finds are meteorites that are found later. The U. K. collection has a significantly large number of meteorite falls, 673, which is 62% of all accredited falls and perhaps the most of any collection.

PSRD had the golden opportunity to visit the U. K. national collection of meteorites in April 2009 in the company of the Curator, Dr. Caroline Smith. We went behind the scenes to see the specimens, including key meteorite falls that we highlight in this article. Dr. Smith also introduced **PSRD** to some of the scientists working in the museum's state-of-the-art laboratories who are helping to *define* the cutting-edge of meteoritics and we are pleased to share how their work is advancing our understanding of our Solar System.

Curator, Dr. Caroline Smith, NHM London



Photo by L. Martel, www.psr.d.hawaii.edu with permission of Natural History Museum, London.

*Display of Meteorites,
Natural History Museum of London*



L. Martel, www.psr.d.hawaii.edu

[LEFT] Dr. Caroline Smith stands at the meteorite sample drawers in the research offices. The open drawer contains specimens of the Barwell meteorite, the largest meteorite fall in the U. K. The wooden cabinets and drawers help to buffer the meteorites from London's seasonal temperature fluctuations. [RIGHT] This is a photograph of one of the several educational displays of meteorites in the museum's galleries. Exciting plans are also underway to soon create a brilliant new gallery showcasing eight or nine "hero specimens" so-called because of their significance to the science of meteoritics.

Barwell

We begin our meteorite tour with Barwell, the largest meteorite fall in the U. K., with a mass of about 44 kilograms. Its shower of stones fell in Leicestershire, north of London, after a fireball was seen on Christmas Eve 1965. About 18 kilograms were recovered, which when assembled together were described as about the size of a turkey. Barwell is a L6 [chondrite](#). [[Data link](#) from the Meteoritical Bulletin.] A dark clast in this meteorite, indicated by an arrow in the photo below, caused a stir when it was recognized in the 1970s to be [basalt](#). This discovery was a surprise because chondrites are considered [primitive meteorites](#) that come from asteroids that did not melt or [differentiate](#). The piece of basalt, an igneous rock created through melting and differentiation, is therefore out of place in a chondrite. The basalt clast must have come from another asteroid where heating was high enough to cause melting and differentiation. The fact that the piece of basalt is incorporated into the Barwell chondrite is clear evidence that the process of differentiation took place prior to or simultaneously to the accretion of the chondrite parent body. This challenged the idea that chondrites formed first, before any other process, and led to new ideas about the timing of events in the early Solar System.

Basaltic Pebble in the Barwell Meteorite



Photo by L. Martel, www.psr.d.hawaii.edu with permission of Natural History Museum, London.

The pebble-sized (~1.5 cm across) basalt clast in the Barwell meteorite tells the story of differentiation and igneous activity on an asteroid that was subsequently shattered by collisions sending this fragment out on a crash course into the parent body of the L6 chondrite.

Murchison

The Murchison meteorite was an observed fall in Victoria, Australia on September 28, 1969. The date is significant because laboratory facilities had just been prepared to receive the first lunar samples that arrived two months earlier from the U. S. [Apollo 11](#) mission to the Moon. Murchison meteorite fragments (more than 100 kilograms were collected), and samples of the Allende meteorite that also fell in 1969 in Mexico, were studied immediately by enthusiastic cosmochemists who were keen to use their state-of-the-art instruments on any extraterrestrial materials. Murchison is a CM2 carbonaceous chondrite and is one of the most studied meteorites in the world. [[Data link](#) from the Meteoritical Bulletin.]

What makes Murchison so special are the authentic, extraterrestrial organic molecules it contains. These materials are organic but non-biological or, in other words, created in the absence of life. *They are, more accurately, the building blocks of life.* The piece of the Murchison meteorite in the U. K. collection was kept in a sealed container and only recently opened. It has a distinctive odor due to its organic molecules that some people describe as reminiscent of asphalt. Though discovered previously in other carbonaceous chondrite meteorites, it was often difficult to prove the organic compounds came from within the meteorite instead of being terrestrial contamination from the fall site or accidental contamination acquired during curation or laboratory handling.

The Murchison meteorite changed that thinking when scientists found 92 different amino acids in the meteorite of which only 19 are also found on Earth (they confirmed this by measuring carbon isotopic ratios). In 2001 researchers also found sugars in Murchison. And recently, in the summer of 2008, scientists at Imperial College in the U. K. found inside Murchison two substances, uracil and xanthine, that are precursors of the building-blocks, known as nucleobases, of DNA and RNA. The discovery of nucleobases in Murchison, in addition to its amino acids and sugars, supports the hypothesis that life's raw materials were already present in the early Solar System and delivered to the early Earth and other planets from space by impacting bodies, including carbonaceous meteorites. Scientists also regard comet impacts as another source of the basic chemical building blocks of life onto the early Earth. The Murchison meteorite continues to be a hot research specimen for studies of Solar System formation and chemical seeding of the early Earth.

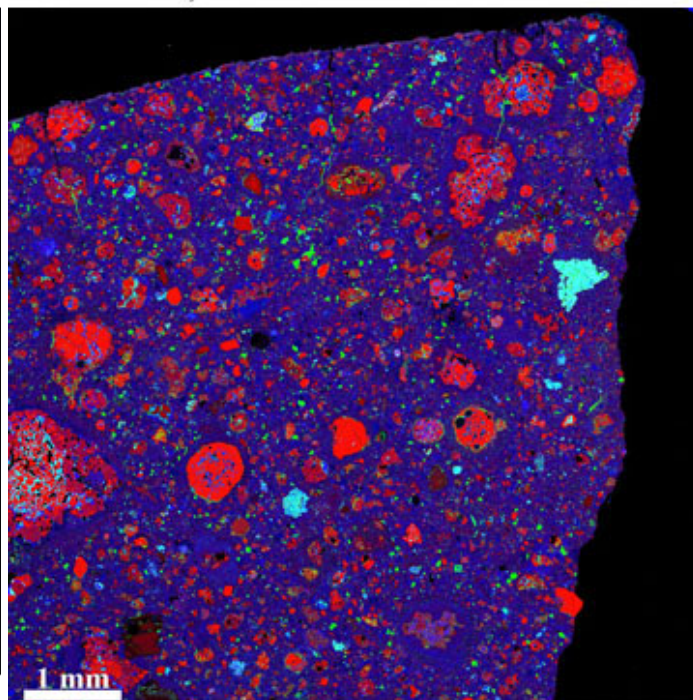
Murchison, CM2 Carbonaceous Chondrite



© Natural History Museum, London.

(Image courtesy of Natural History Museum, London.)

Murchison, CM2 Carbonaceous Chondrite



(Image courtesy of Alexander Krot, University of Hawaii.)

The picture on the [LEFT] shows a large piece of the Murchison meteorite courtesy of the Natural History Museum, London. [RIGHT] This image is known as a 'combined X-ray elemental map.' It was created by combining X-ray intensities due to magnesium (red), calcium (green) and aluminum (blue) from a thin slice of the Murchison meteorite,

courtesy of Alexander Krot, a meteorite researcher at the University of Hawai'i. The x-rays were made by bombarding the sample with a beam of electrons in an electron microprobe.

I is for Ivuna

The Ivuna meteorite was an observed fall in Tanzania in 1938. This extremely rare meteorite is one of only nine classified as CI carbonaceous chondrites. Ivuna is the type specimen, the I in CI. [[Data link](#) from the Meteoritical Bulletin.] These meteorites, primordial building blocks of our Solar System and the most primitive chemically, have elemental abundances nearly the same as those of the Sun (except for the most volatile elements). Some scientists have suggested Ivuna is a remnant of a comet instead of an asteroid, but that is still under discussion. What we know is that Ivuna, like the other rare carbonaceous chondrites, contains such things as carbonates, clay-like minerals, water-bearing minerals, organic compounds, amino acids, iron oxides, and many more substances -- all a rich record of the chemical evolution of our Solar System. This particular specimen is the largest piece of Ivuna in existence and has been stored in a nitrogen atmosphere for preservation. It was purchased by the Natural History Museum in 2008 and is a distinguished specimen of the research collection. Read more about the museum's acquisition of Ivuna [note that all these links will open in a new window] in this Museum News Item: [Meteorite Flies into Museum](#) and this report from The Geological Society of London: [NHM Buys New Meteorite](#). You can also watch a short interview with Curator Smith on the [BBC news](#). Scientists study Ivuna to better understand the starting materials and chemical evolution of all the bodies in our Solar System. The museum will allocate samples of Ivuna to scientists for laboratory studies and will put a portion of Ivuna on public display in a purpose-built, atmosphere-controlled case.

Meteorite Experts with Ivuna specimen at NHM, London Ivuna, CI Carbonaceous Chondrite



© Natural History Museum, London. (Image courtesy of Natural History Museum, London.)



© Natural History Museum, London.

(Image courtesy of the Natural History Museum, London.)

The scientifically priceless specimen of the Ivuna meteorite merely looks like a common piece of coal or dried mud ball. The photo on the [LEFT] shows from left to right, Professor Sara Russell the Head of Meteoritics and Cosmic Mineralogy, Dr. Gretchen Benedix, meteorite researcher, and Dr. Caroline Smith, Curator, examining the specimen upon its acquisition by the Natural History Museum in London. This piece is now encased in temporary packaging that keeps it preserved in an oxygen-free, dry atmosphere otherwise the minerals in the rock would react with the atmosphere. The picture on the [RIGHT] is a closer view of Ivuna courtesy of the Natural History Museum, London. (Click either image to link to NHM news release.) Scientists will be working with the Ivuna sample to better understand the starting materials and chemical evolution of all the bodies in our Solar System.

Orgueil

We move on to another interesting CI carbonaceous chondrite in the collection called Orgueil. This was an observed fall in France in 1864. [[Data link](#) from the Meteoritical Bulletin.] Pieces of Orgueil are known not just for their scientific importance but also for triggering an argument as well as a famous hoax, both concerning the possibility of it containing extraterrestrial life versus contamination.

The case of supposed spores in Orgueil is well-described by Jeff Taylor in the [PSRD](#) article: [Organic Globules from the Cold Far Reaches of the Proto-Solar Disk](#): "One of the greatest arguments in meteoritics erupted in the early 1960s with the announcement of the discovery of tiny fossils in carbonaceous chondrites. The research had been done by microbiologist George Claus (New York University Medical Center) and organic chemist Bartholomew Nagy (Fordham University). They thought they had found spores in the carbonaceous chondrites they studied. Botanists and biologists were mystified by the structures, which Claus and Nagy called "organized elements," but all agreed that they were probably biological in origin. Edward Anders and colleagues at the University of Chicago were instrumental in debunking the claim. They showed that the unusual structures were probably ragweed pollen that had been altered by a dye Nagy had used to make them easier to see. They were biological all right, but not extraterrestrial."

Heads turned again in 1962 when scientists looked at a piece of Orgueil that had been stored in a sealed glass jar since 1864 and found, to their surprise, a plant fragment and piece of coal embedded in it. Edward Anders and colleagues, summarizing the incident in their 1964 article in *Science*, wrote that contamination from the fall site was ruled out as was accidental contamination "since coal was not used as a household fuel in southern France during the 1860s, but was found mainly in blacksmiths' forges." If someone contaminated the meteorite deliberately in 1864, was there a motive for the hoax? Anders and colleagues wrote, "Perhaps. In April 1864, only a few weeks before the fall of Orgueil, [French chemist and microbiologist Louis] Pasteur delivered before the French Academy his famous lecture discrediting spontaneous generation of life [the notion that life could originate from inanimate matter]." They go on to say that perhaps a person of the "proper disposition" was inspired to play a practical joke on the scientists or otherwise stimulate debate on spontaneous generation. "Somehow the plot failed, and the contaminated stone went unrecognized for 98 years." So, it turns out that a seed from a European rush or woody shrub was glued into a piece of the meteorite.

Pretending to have a space plant stuck in a meteorite seems like a B movie plot today now that we have meteorites with authentic, extraterrestrial amino acids and building blocks of genes. Little did the people from the 1800s know the truth would be more fantastic than their hoax. New analytical instruments and analysis techniques are now available, and the Natural History Museum in London is well-equipped with them, as highlighted in the next section.

Orgueil, CI Carbonaceous Chondrite

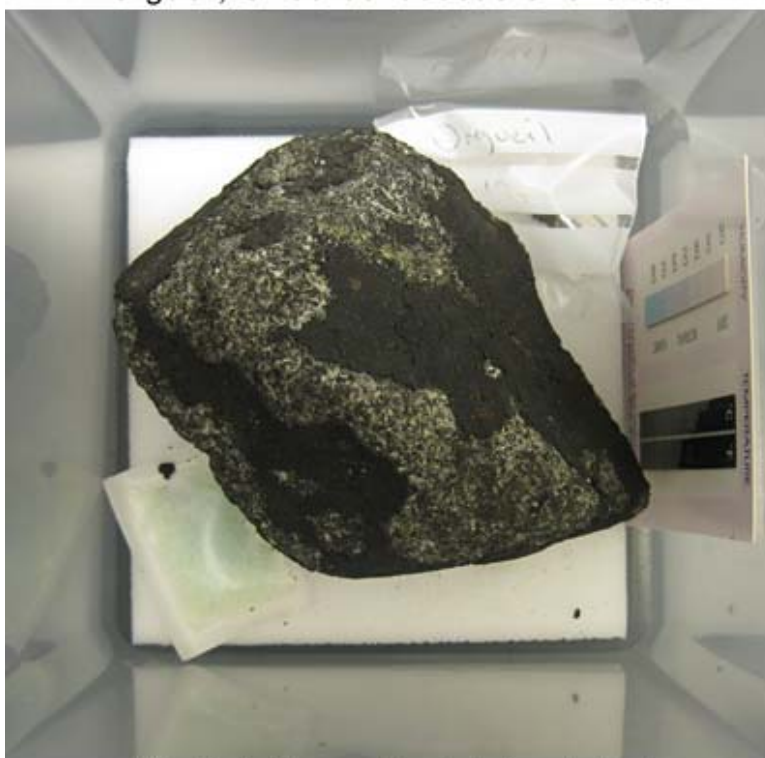


Photo by L. Martel, www.psr.d.hawaii.edu with permission of Natural History Museum, London.

View looking down on the Orgueil meteorite specimen in a plastic container with humidity sticker. The dark areas are patches of [fusion crust](#).

Laboratories: Worlds of Discoveries

The analytical instruments at the Natural History Museum in London are very impressive as are the scientists who use the well-equipped facilities. They study meteorites mainly by optical, electron beam, and X-ray techniques. The museum's online [listing of analytical imaging facilities](#) provides pictures and descriptions of the capabilities of the instruments. We highlight two of the many techniques.

One of the newest instruments is the micro-Computer Tomography scanner (micro-CT scanner), acquired by the museum in March, 2009. Dr. Richie Abel demonstrated this non-destructive technique used to visualize the external and internal structure of objects in three dimensions. Interestingly, Dr. Abel has a background in Zoology and early hominid studies and he presents a very nice [online introduction to micro-CT principles](#) [link opens in a new window] with wonderful images of a crocodile skull and shells. The 3D tomography of meteorites, new work in progress, will help researchers, for an example, see and better understand the relationship of silicates to opaque phases, such as metal and sulfide.

Micro-CT Scanner at the Natural History Museum in London



© Natural History Museum, London. Photo by Kevin Webb.

(Image courtesy of NHM, London.)

The micro-CT scanner at the Natural History Museum in London is used to scan specimens of biological and mineralogical materials, including meteorites, for scientific research and curation.

In another room, Dr. Kieren Howard explained how he is using X-ray Diffraction (XRD) to determine precise mineralogies of fine-grained components of carbonaceous chondrite meteorites. The laboratory uses a Position-Sensitive Detector (PSD) instead of the more common scanning detector for better accuracy and analysis speed. The minerals in carbonaceous chondrites were altered by water and the careful analyses by Dr. Howard and his coauthors Dr. Gretchen Benedix and Dr. Gordon Cressey (from the museum), and Dr. Phil Bland (Imperial College, London) are helping to determine how and to what extent that alteration happened in the chondritic parent body or bodies.

Using technical expertise and problem-solving skills to scrutinize the details they find in meteorites to address big questions about the very origin and formation of our Solar System, before there were planets and afterwards, is what cosmochemists love to do. It's worth a trip to a meteorite collection to look at these amazing, primordial bits and pieces.

Visiting the Museum

Natural History Museum, London UK



L. Martel, www.psrh.hawaii.edu

Wold Cottage, L6 Chondrite



Photo by L. Martel, www.psrh.hawaii.edu with permission of Natural History Museum, London.

[LEFT] The Natural History Museum building at South Kensington opened to the public in 1881. By that time, the meteorite collection, which began in 1802, already numbered around 250 specimens. Today the meteorite collection contains about 5000 individual pieces, a portion of which is on public display. The famous Wold Cottage meteorite [RIGHT], which was an observed fall in 1795, is historically significant because it fell near the dawn of the science of meteoritics and is the first recognized British meteorite. [Data link from the Meteoritical Bulletin.] This large specimen in the U. K. collection is featured in the famous mineral sciences book, *British Mineralogy*, by James Sowerby, published in 1804-1817. A framed copy of the illustration rests on the table behind the specimen. Wold Cottage will have a place of honor in the exciting new gallery for meteorites planned for the near future. Curator Smith helped with the design of the new hall to feature eight or nine meteorite samples that she calls "hero specimens" because of their significance to the science of meteoritics. Wold Cottage will be featured in case number one.

Address: Natural History Museum, Cromwell Road, London SW7 5BD United Kingdom.

Hours: The museum is open from 10:00 a.m. to 5:50 p.m. daily, except 24-26 December.

Admission: Free

Website: <http://www.nhm.ac.uk/>.

Additional Resources

LINKS OPEN IN A NEW WINDOW.

- Anders, E., Cavaillé, A., Dufresne, A., Dufresne, E. R., Fitch, F. W., and Hayatsu, R. (1964) Contaminated Meteorite. *Science*, v. 146, p. 1157-1161.
- Howard, K. T., Benedix, G. K., Bland, P. A., Cressey, G. (2009) Modal Mineralogy of CM2 Chondrites by X-ray Diffraction (PSD-XRD). Part 1: Total Phyllosilicate Abundance and the Degree of Aqueous Alteration. *Geochimica et Cosmochimica Acta*, v. 73(15), p. 4576-4589. (Also an additional abstract by the same authors from the 40th Lunar and Planetary Science Conference [abstract #1235](#).)
- Martel, L. M. V. (2009) Better Know A Meteorite Collection: Natural History Museum in Vienna, Austria. *Planetary Science Research Discoveries*. <http://www.psrh.hawaii.edu/May09/Meteorites.Vienna.Museum.html>
- Martins, Z., Botta, O., Fogel, M. L., Sephton, M. A., Glavin, D. P., Watson, J. S., Dworkin, J. P., Schwartz, A. W., and Ehrenfreund, P. (2008) Extraterrestrial Nucleobases in the Murchison Meteorite. *Earth and Planetary Science Letters*, v. 270, p. 130-136.
- Natural History Museum, London: [Catalogue of Meteorites](#), database of all known meteorites. A long

tradition, the first Catalogue of Meteorites was published in 1923 by George Prior, NHM Keeper of Mineralogy.

- Natural History Museum, London: Kids Only > Earth and Space > [Meteorites](#).
- Natural History Museum, London: Nature Online > Space > [Meteorites](#).
- Natural History Museum, London: Nature Online > Virtual Wonders > [Meteorites: Rotating images](#).
- Natural History Museum, London: Nature Online > Meteorite Search Blog > [Meteorites: Search Expedition](#), a blog from the 2006 trip to the Nullabor Desert in Australia by meteorite Curator, Dr. Caroline Smith, and meteorite researcher Dr. Gretchen Benedix.
- PBS Program: Meteorites & Life: Murchison Meteorite [[website](#)].
- Russell, S. and Grady, M. M. (2006) A History of the Meteorite Collection at the Natural History Museum, London, in McCall, G. J. H., Bowden, A. J., and Howarth, R. J. (eds.) *The History of Meteoritics and Key Meteorite Collections: Fireballs, Falls and Finds*. Geologic Society, London, Special Publications, 256, p. 153-162.
- Taylor, G. J. (2006) Interstellar Organic Matter in Meteorites. *Planetary Science Research Discoveries*. <http://www.psr.d.hawaii.edu/May06/meteoriteOrganics.html>.
- *Educational activity*: [Exploring Meteorite Mysteries Lesson 15: Historical Meteorite Falls](#). The 12-page pdf document contains reading selections and questions for students about five historical meteorite falls; from NASA publication EG-1997-08-104-HQ [link to [entire Teacher's Guide with Activities](#)].



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