PSRD-ParkForest.pdf

Hot Idea

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Meteorite Shower in Park Forest, Illinois

--- An L5 chondrite strewnfield is centered at Park Forest, Illinois, a southern suburb of Chicago.

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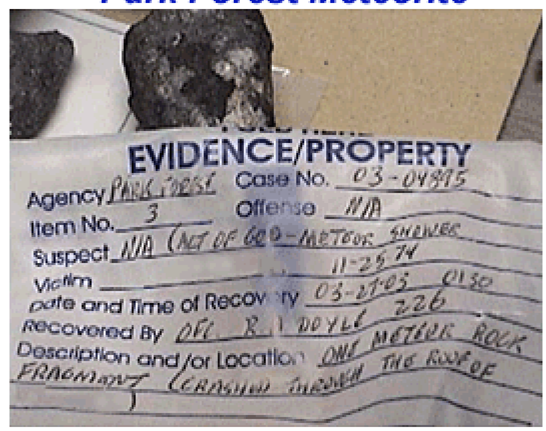
Park Forest Meteorite



(Photo courtesy of Steven Simon, Univ. of Chicago.)

Steven Simon (University of Chicago) and seven colleagues from the University of Chicago, the Planetary Studies Foundation, Harper College, Pacific Northwest National Lab, and the Field Museum in Chicago have classified the meteorite fragments that fell on Chicago's southern suburbs on the night of March 26, 2003. Described as ".. the most densely populated region to be hit by a meteorite shower in modern times," the village of Park Forest is at the center of the strewnfield and fortuitously also happens to be home to the Simon family, who answered scores of phone calls from neighboring meteorite finders. No injuries were reported though plenty of roofs, windows, walls, and cars were hit, and the police department took individual fusion-crusted fragments into custody as evidence (see picture above).

Its chemical and mineralogical compositions establish the Park Forest meteorite as an L5 chondrite, one of the most primitive groups of known meteorites. It is a strongly shocked monomict breccia (a term applied to a breccia made of one kind of rock) with light-colored clasts in a very dark matrix. The team measured cosmic radionuclides in Park Forest and found nearly zero ^{56}Co and high ^{60}Co, values that indicate a large preatmospheric mass. They estimate the meteoroid was at least 900 kilograms and possibly as large as 7000 kilograms before it broke apart in the atmosphere, of which only about 30 kilograms of fragments have been recovered.

Reference:

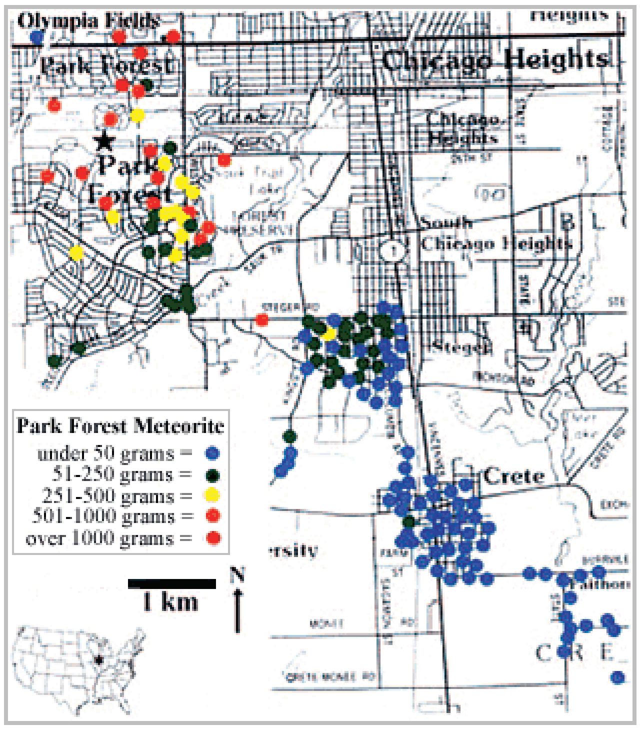
Simon, S. B., Grossman, L., Clayton, R. N., Mayeda, T. K., Schwade, J. R., Sipiera, P. P., Wacker, J. F., and Wadhwa, M. (2004) The fall, recovery, and classification of the Park Forest meteorite, ***Meteoritics & Planetary Science,*** v. 39, p. 625-634.

Asteroids Don't Usually Drop on Neighborhoods

Most meteorites are samples of asteroids and most are recovered from one of the world's cold or hot deserts (eg. Antarctica, north Africa, Oman) a long time after striking ground. [See, for example, PSRD article Searching Antarctic Ice for Meteorites.] Witnessed falls, on the other hand, have a better chance of being recovered and transferred quickly into the laboratory for analyses while still in relatively fresh, uncontaminated condition. About 33% of the meteorites in the world's collections are witnessed falls, but not necessarily in heavily populated areas. Allende (Mexico, 1969), Murchison (Australia, 1969), and Tagish Lake (British Columbia, Canada, 2000) are examples of observed falls that have greatly expanded our understanding of the solar system's formation. [See **PSRD** article Tagish Lake -- A Meteorite from the Far Reaches of the Asteroid Belt.]

The Park Forest meteorite is one of the most recent observed falls in the United States. And it happened to land in the midst of a group of highly talented and busy cosmochemists--men and women who specialize in the study of meteorites. Talk about a lucky break! The newly established Chicago Center for Cosmochemistry is one example of how the cosmochemistry communities at the University of Chicago, Argonne National Laboratory, and the Field Museum have combined their expertise and facilities to study solar system science.

The fireball approached from the southwest and was visible from parts of Illinois, Indiana, Michigan, and Missouri. The subsequent meteorite shower hit the southern suburbs of Chicago at approximately 11:50 p.m. on March 26, 2003. Hundreds of meteorite fragments ranging from a few grams to 5.26 kilograms were recovered from the elongate strewnfield (approximately 8 x 3 kilometers), which spread by strong westerly winds over residential neighborhoods and a forest preserve (see the map below). The smallest pieces were deflected the furthest eastward and the largest pieces, carrying more momentum, were deflected the least.



(From Simon *et al.*, 2004, *Meteor. & Planet. Sci.*, v. 39, p. 626.)

The center of the strewnfield is Park Forest, about 40 kilometers south of Chicago. "I don't know of any other time when a meteoriticist was in the middle of a strewnfield," quipped co-author Lawrence Grossman (University of Chicago) referring to colleague Steven Simon's residence, which is marked with a star on the map shown above. The colored dots show the locations where meteorites were recovered. The colors represent different sizes of individual stones. A total of three kilograms are now in the meteorite collection at the Field Museum in Chicago, including the type specimen, a 545-gram fragment recovered from the Park Forest fire station (see photos below).

Park Forest Meteorite

LEFT: Hole in the roof of the Park Forest fire house created by the meteorite shown on the RIGHT. The fireman is holding the 545-gram type specimen that is now housed at the Field Museum in Chicago.

(Photos courtesy of Steven Simon, Univ. of Chicago.)

Park Forest Meteorite

LEFT: Holes in a bedroom ceiling caused by infalling meteorites.

RIGHT: Impact damage to window blinds and sill.

The 2.5-kilogram meteorite fragment that caused the damage. It displays a typical black fusion crust, which is broken in places revealing the lighter-colored interior.

(From Simon *et al.*, 2004, *Meteor. & Planet. Sci.*, v. 39, p. 627.)

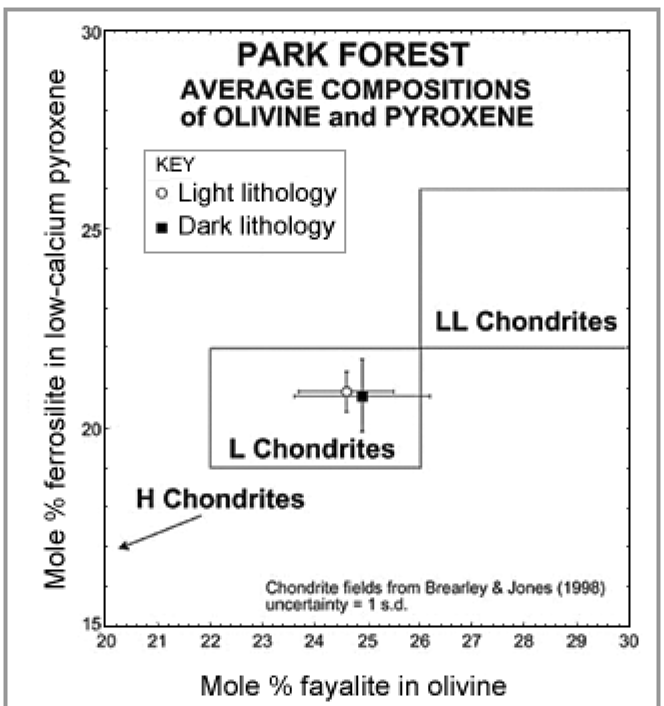
Classification of the Park Forest Meteorite

Park Forest is a breccia with light gray clasts in a very dark matrix, referred to as the light and dark lithologies, respectively. Most of the recovered meteorite fragments, especially the larger ones, are dominated by the light lithology. Olivine ($(Mg, Fe)_2SiO_4$), pyroxene ($(Ca, Mg, Fe)_2Si_2O_6$), metal (FeNi), sulfide (FeS) and chromite ($FeCr_2O_4$) grains are present in both lithologies, though only the dark lithology has a pervasive network of fine sulfide veins, which are opaque. They prevent light from penetrating into the rock, giving it a very dark appearance. Both lithologies contain chondrules with diameters ranging from ~600 microns to 1.3 millimeters. Olivine chondrules are the most abundant followed by olivine-free, pyroxene chondrules.

(Photo courtesy of Steven Simon, Univ. of Chicago.)

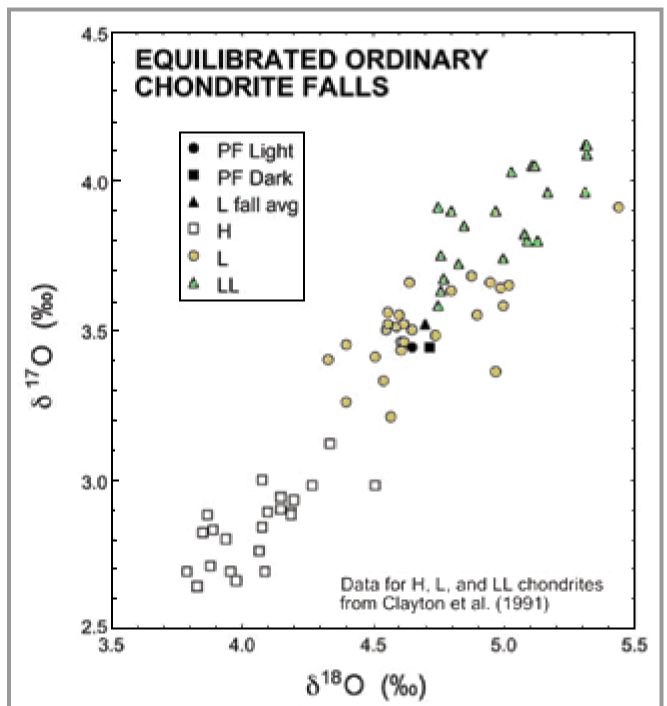
This 232-gram sample of the Park Forest meteorite shows the light-colored angular clasts in the dark matrix. This piece was recovered the night of the shower and was used to measure cosmogenic radionuclides. The small divisions on the scale bar are millimeters.

Average olivine, low-Ca pyroxene, and bulk oxygen-isotopic compositions show that Park Forest is an L chondrite (see plots below). The researchers further classified the meteorite as petrologic type 5 based on their observations that ferromagnesian minerals are well equilibrated (they are the same composition everywhere in the rock), the chondrules are easily recognized, and maskelynite (a glass formed from plagioclase feldspar by high shock pressures) is relatively fine grained (mostly less than or equal to 50 microns across).



(From Simon *et al.*, 2004, *Meteor. & Planet. Sci.*, v. 39, p.631.)

This plot shows olivine and pyroxene compositions in the light and dark lithologies of Park Forest compared with typical ranges in ordinary chondrites. Higher values reflect higher concentrations of iron in each mineral. Park Forest plots in the L chondrite field.



(From Simon *et al.*, 2004, *Meteor. & Planet. Sci.*, v. 39, p. 632.)

Oxygen isotopic compositions of the light (PF Light) and dark (PD Dark) lithologies in Park Forest are similar to each other and to the average of L chondrites (L fall avg).

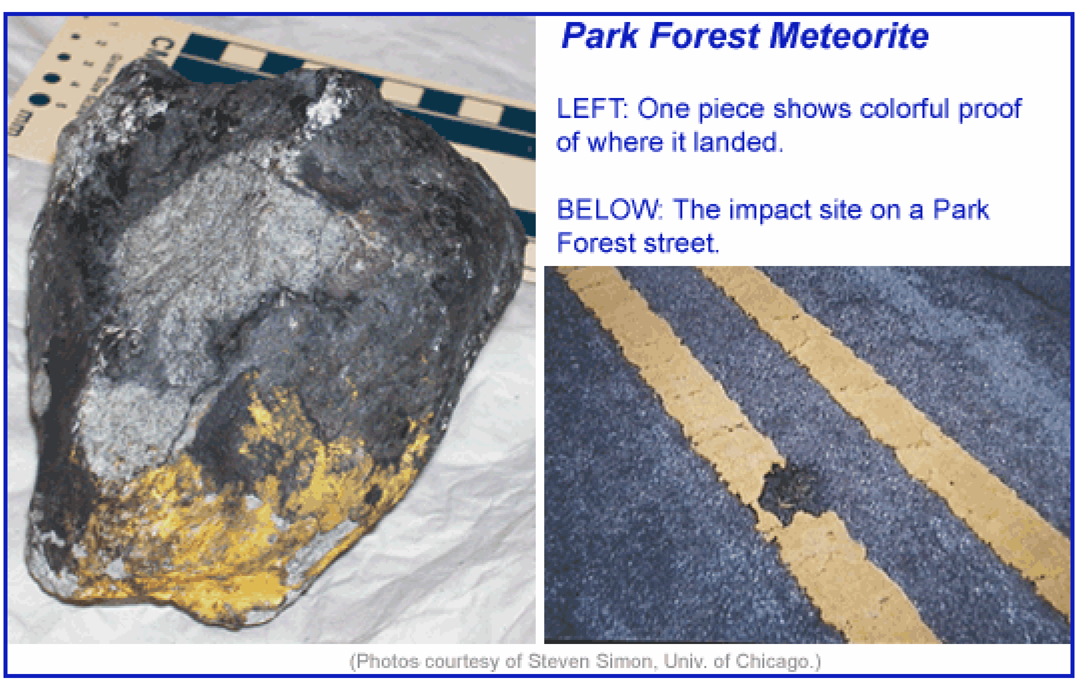
The conversion of plagioclase to maskelynite in Park Forest is one indication that it was strongly shocked. Other shock features in the meteorite include mosaicism and planar deformation in olivine, undulatory extinction in pyroxene, and glassy veins. Simon and his colleagues classify it as shock stage S5. [See **PSRD** article Asteroid Heating: A Shocking View for a good summary of the shock stages in chondrites, including movies of shocked and unshocked olivine grains rotated in polarized light using a petrographic microscope.]

About half the meteorites that fall today are L chondrites and many of them were shocked 465±15 million years ago, presumably when the parent asteroid body was smashed to pieces in a huge collision. Though the age of the Park Forest meteorite is yet unknown, its shock stage of S5 is consistent with the idea that it derived from the break-up of the L chondrite parent body. Some scientists consider the Flora family of S-type asteroids to be more remnants of the L chondrite parent body.

How Big was the Meteoroid?

One way of estimating the probable size range of a meteoroid before its breakup in the atmosphere (preatmospheric mass) is by measuring the concentrations (also called activities) of cosmogenic radionuclides in the meteorite. These are radioactive isotopes formed as a result of exposure to high-energy cosmic rays in space. Some of these, such as cobalt-56 (^{56}Co), can only form at the surface of a body, while others, such as cobalt-60 (^{60}Co), require some shielding and increase with depth in the parent body. If an object is too small, the cosmic rays will just pass through it and not make ^{60}Co.

Simon and colleagues used a fragment of the Park Forest meteorite recovered the night of the shower (pictured above) and began their measurements less than 72 hours after the fall. They found very low (essentially zero) ^{56}Co activity and high ^{60}Co activity, consistent with a large preatmospheric mass for Park Forest. When they compared these observed radionuclide activities with calculated production rates in chondrites they determined that the sample they measured came from a depth of about 40 centimeters and could have been from an object that was at least 900 kilograms and possibly as large as 7000 kilograms. Other ways of estimating the original size of the object, based on work by Peter Brown of the University of Western Ontario and his colleagues of the energy released (seismic, light, sound) give an even higher range of 8000-11000 kilograms. The hundreds of fragments of the Park Forest meteorite that have been officially documented total about 18 kilograms. The authors estimate that at least 30 kilograms in all were probably recovered. Assuming that some of the fragments simply burned up during atmospheric entry, that still leaves plenty of extraterrestrial material out there to be found.



(Photos courtesy of Steven Simon, Univ. of Chicago.)

Additional Resources

LINKS OPEN IN A NEW WINDOW

Additional meteorite photograph from Astronomy Picture of the Day, May 6, 2003.

Brearley, A. J. and Jones, R. H. (1998) Chondritic meteorites, in ***Planetary Materials,*** J. J.Papike editor, Mineralogical Society of America, Washington D. C., p. 3-1 - 3-398.

Brown, P., Pack D., Edwards W. N., ReVelle, D. O., Yoo, B. B., Spalding R. E., and Tagliaferri, E. (2004) The orbit, atmspheric dynaimics and initial mass of the Park Forest meteorite, ***Meteoritics & Planetary Science,*** in press.

Clayton, R. N., Mayeda, T. K., Goswami, J. N., and Olsen, E. J. (1991) Oxygen isotope studies of ordinary chondrites, ***Geochimica et Cosmochimica Acta,*** v. 55, p. 2317-2337.

Historical meteorite falls, 12-page pdf file, Lesson 15 in ***Exploring Meteorite Mysteries: Teacher's Guide with Activities,*** NASA EG-1997-08-104-HQ.

Martel, L. M. V. (2002) Searching Antarctic ice for meteorites. ***Planetary Science Research Discoveries.*** http://www.psrd.hawaii.edu/Feb02/meteoriteSearch.html.

Mittlefehldt, D. W. (2002) Tagish Lake--a meteorite from the far reaches of the asteroid belt. ***Planetary Science Research Discoveries.*** http://www.psrd.hawaii.edu/Dec02/TagishLake.html.

Park Forest fireball website with video clips and more information from Peter Brown, University of Western Ontario. (Wait for the videos to load.)

Simon, S. B., Grossman, L., Clayton, R. N., Mayeda, T. K., Schwade, J. R., Sipiera, P. P., Wacker, J. F., and Wadhwa, M. (2004) The fall, recovery, and classification of the Park Forest meteorite, ***Meteoritics & Planetary Science,*** v. 39, p. 625-634.

Stöffler, D., Keil, K., and Scott, E. R. D. (1991) Shock metamorphism of ordinary chondrites. ***Geochimica et Cosmochimica Acta,*** v. 55, p. 3845-3867.

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