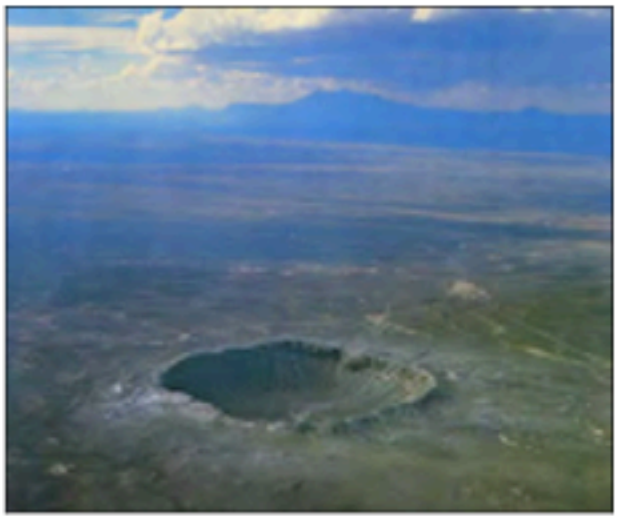
CENTER FOR METEORITE STUDIES
ARIZONA STATE UNIVERSITY
http://meteorites.asu.edu

HAVE YOU SEEN A METEORITE?

What are meteorites and where do they come from?

A meteorite is a solid body from outer space that has fallen to the Earth's surface. A "fall" is a meteorite that was observed to fall and then collected. A "find" is a meteorite that was not observed to fall but that was recognized by diagnostic features. Most of the "shooting stars" that are observed in the night sky are actually pieces of dust rather than large objects. However, the biggest objects that fall to Earth may result in large craters, such as Barringer Meteor Crater, on the planet's surface.

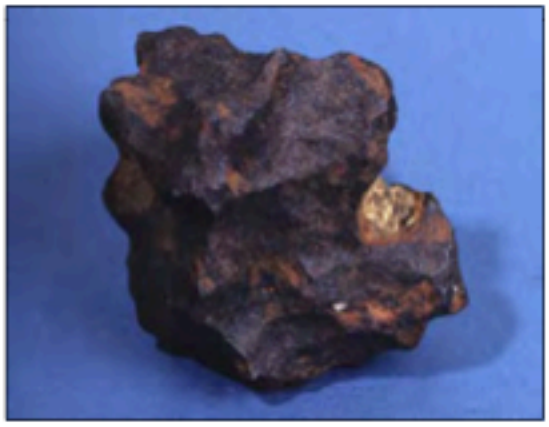
Most meteorites are believed to originate from the asteroid belt between Mars and Jupiter. They are the remains of a planet that never formed and are considered to represent the building blocks of the terrestrial planets, including Earth. A handful of meteorites appear to come from the Moon and Mars. Meteorites escape their parent bodies through collisions with other objects in the solar system or they are pulled from their orbits by the Sun's large gravitational field.



Barringer Meteor Crater near Winslow, Arizona. The crater is believed to have formed from the impact of a large (30-50 m across) iron meteorite 50,000 years ago. The crater is about 1.2 km in diameter.

How do we know they're from space?

Meteorites that come from the asteroid belt are about the same age as the solar system, approximately 4.5 billion years old. No Earth rocks are this old because they have been processed by plate tectonics and erosion. Meteorites from Mars and the Moon are distinguished from Earth rocks and other meteorites by their chemical and isotopic compositions, mineralogy, and age. Lunar meteorites are also distinguished by their resemblance to the lunar rocks returned by the Apollo astronauts. One day scientists hope to return samples from Mars for a direct comparison as well!



Canyon Diablo, AZ, octahedrite. This iron meteorite is part of the object that formed Barringer Meteor Crater, pictured above. Its weathered, rusty exterior appearance is typical for iron meteorite finds. Because it is mostly nickel-iron metal, it is very heavy for its size. It measures ~ 15 cm tall and weighs ~ 8.1 kg (~ 18 lb). Photo by D. Ball, ASU.

What are the different types of meteorites?

Stony meteorites: These meteorites, the most common type, contain 75-90% silicate minerals (like olivine), 10-25% nickel-iron metal alloy, and iron sulfide.

Chondrites – Chondrites, the most abundant type of stony meteorite, are very primitive in terms of chemistry. They also contain many of the first objects to have formed in the solar system, such as calcium-aluminum-rich inclusions and chondrules (from whence they get their name).

Achondrites – These meteorites underwent melting or other types of processing on their asteroid or planetary parent body (lunar and martian meteorites included).

Stony-iron meteorites: These meteorites contain ~ 50% silicates and 50% nickel-iron metal. *Pallasites* formed where an asteroid's silicate mantle and metal core mixed. *Mesosiderites*, the other type of stony-iron, likely formed from the collision of a metal-rich asteroid with a silicate-rich asteroid.

Iron meteorites: Composed of almost entirely nickel-iron metal, these meteorites come from the cores of large differentiated asteroids. Therefore, they are considered analogous to the Earth's core.

Rancho Gomelia, Mexico, octahedrite. This iron meteorite has been cut, polished, and etched with acid on one face to reveal an interlocking crystal structure of variable composition nickel-iron alloys. This pattern, called the "Widmanstätten" pattern, is unique to the subgroup of iron meteorites called octahedrites. The etched face is ~ 14 cm from bottom to top. Photo by D. Ball, ASU.

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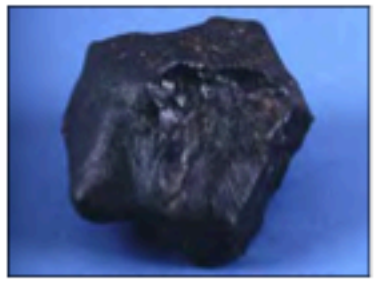
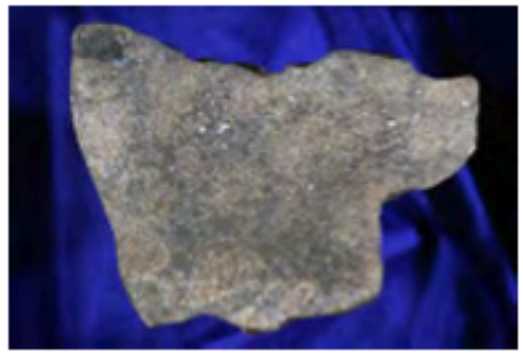
What do most meteorites look like?

Size – Meteorites vary in size from a few centimeters across to several feet in diameter.
Shape – Meteorites are rarely round in shape. Typically, they are irregular in shape with rounded edges.
Weight – In general, meteorites are heavier than Earth rocks of the same size due to their increased abundance of iron. *Due to such large amounts of iron and metal, almost all meteorites will be attracted by a magnet!*
Color and surface features – The surface of a freshly fallen meteorite will appear black and shiny. This is due to the presence of fusion crust. Most meteorites have very smooth surfaces with no holes. In some cases, a meteorite's surface will exhibit flow lines or "thumbprints". Meteorites will weather to a rusty-brown color over time, which may cause the fusion crust to completely disappear.
Interior features – Iron meteorites will be made almost entirely of metal while stony-iron meteorites will be about half metal. Most stony meteorites will show tiny metallic flecks on a cut, broken, or polished surface. In addition, stony meteorites may exhibit the presence of small, round, crystalline spherules called chondrules.




Left: Camel Donga, Australia, eucrite. Because this complete specimen (~ 19 cm from left to right) is a fall, it exhibits a shiny, black fusion crust with flow lines. **Right: Plainview**, Texas, ordinary chondrite. The exterior of this complete specimen (~ 19 cm from left to right) is typical for stony meteorite finds. It is blocky in shape with rounded edges, has a smooth surface with a few regmaglypts ("thumbprint" shapes), and is black to brown in color. Both photos by D. Ball, ASU.



Left: Warden, Australia, ordinary chondrite. Ordinary chondrites, the most common type of meteorite to fall, typically contain flecks of metal, as can be seen in this polished slice of Warden (~16 cm across). Photo by D. Ball, ASU.

Right: Plainview, Texas, ordinary chondrite. Visible in this cut and polished specimen (~10 cm from top to bottom) are numerous small, round chondrules. Flecks of metal are also present; however, they are difficult to see in this photo. Photo by D. Ball, ASU.

What can we learn from meteorites?

- *Star evolution* – Some meteorites actually contain chemical species and grains of dust that were produced by stars before the formation of our solar system. Study of the behavior of these chemical species and the composition of the dust can increase our understanding of stars and their role in the universe.
- *Solar system evolution* – We can discern the changing chemical, temperature, and pressure conditions within the early solar system from the study of different meteorite components.
- *Age of solar system and components* – By measuring the abundances of particular isotopes in meteorites, we can estimate the age of the solar system and the relative order in which different meteorite components formed.
- *Geologic history of the Earth and Moon* – Large meteorite impacts have helped shape the face of our planet and the Moon. Many scientists believe that a very large impact was even responsible for the formation of the Moon.
- *History of life* – Meteorites may have delivered to Earth the chemicals necessary for life!

SUSPECT METEORITE CHECKLIST

Ask yourself these questions about your sample:

Is your rock's exterior black or brown and possibly shiny?
Is the surface of your rock smooth (i.e. no holes)?
Is your sample attracted by a magnet?
Does your rock exhibit metal or metallic iron specks on a cut, broken, or ground surface?
Is your rock heavy compared to a "normal" rock of the same size?
If you answer "yes" to all or most of the questions above, you may have a meteorite!

For more information on meteorites, visit the Center for Meteorite Studies webpage:

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