

Meteorites

Meteorites are rocks that originate in our solar system and have survived impact on the surface of planets and moons. Humans have been actively searching for meteorites on Earth for many years, to help us understand how the solar system formed.

Rocky bodies in our solar system, like those in the asteroid belt between Mars and Jupiter, are one of the sources of meteorites. Scientists from the USA and Japan have even sent robotic space missions to those asteroids to collect samples. One



recent example of this is the Osiris Rex mission to asteroid Bennu. To the left you can see an artist's impression from NASA of the spacecraft descending to the asteroid surface to collect some of the surface material. This material will then be analysed by scientists on Earth

On Earth we have large scale searches in deserts and on ice to find meteorites. Their passage through our atmosphere heats up the outside of the meteorite due to air pressure melting the surface and colouring it almost black. This allows us to identify them in deserts against the pale backgrounds of sand and ice.



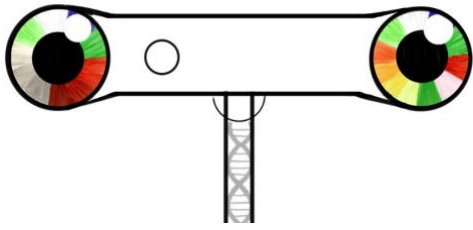
Credit: Antarctic Search For meteorites programme. Katherine Joy.



Credit: Meteorite Recon licenced under CCBY-SA 3.0

Meteorite Types

1. Iron Meteorites
2. Stony Meteorites
3. Stony-Iron Meteorites
4. Martian Meteorites
5. Lunar Meteorites

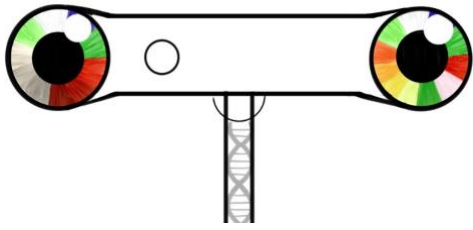


Where do meteorites come from?

Most meteorites we find on earth come from asteroids in our solar system, these are the Iron, Stony and Stony Iron meteorites.

Meteorites can also come from the rocky planets and bodies in our solar system. This happens when a big impact, like an asteroid, hits a planetary body, and causes some of the surface material to fly off into space, a bit like when you drop a pebble in a puddle, and some of the water in the puddle splashes upwards. So far, we have been able to conclusively identify meteorites from Mars and the Moon. Astronauts have even found bits of Earth on the Moon, too!

Below are summaries and examples of each of these meteorites, alongside their spectra. Use the photos and spectrum from each target to see if your rover has found any of them on Mars!



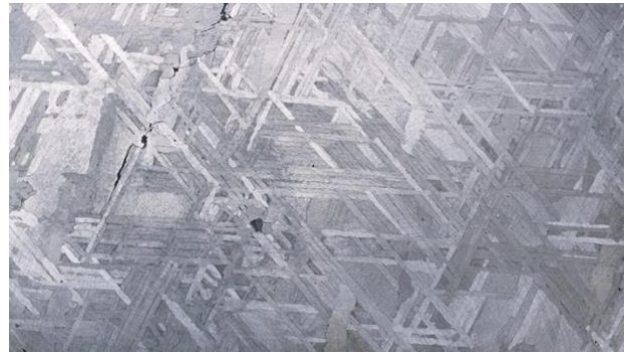
Iron Meteorites

Target Summary

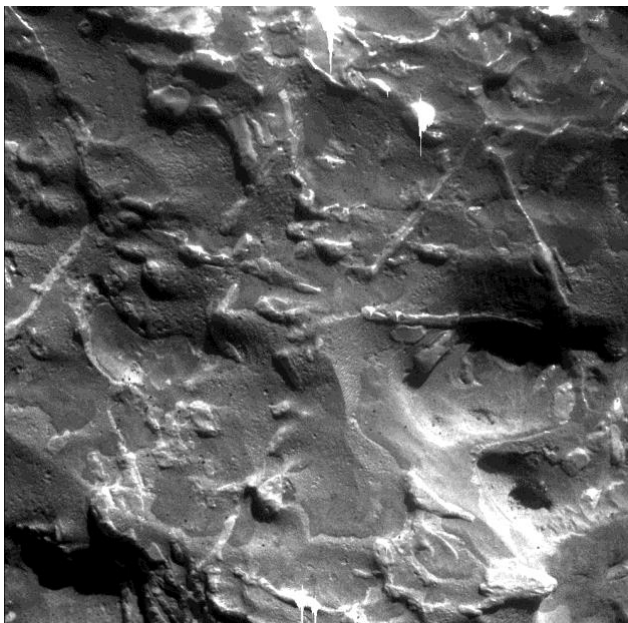
Iron meteorites consist mostly of Iron-Nickel alloys. These meteorites come from the cores of early planets and small bodies in our solar system. When iron meteorites are heated significantly and cool very slowly, the iron and Nickel cool at different rates. This leaves behind a feature called the Widmanstätten pattern that we can see when we cut Iron meteorites open. We have actually seen the 3D structure of the Widmanstätten pattern of meteorites that have significant weathering.



Weathered chunk of the Henbury meteorite. Its rusty colour tells us it has been weathered.
Natural History Museum, London



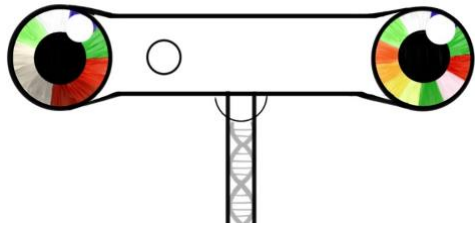
Interior of Canyon Diablo meteorite. The 'criss cross' pattern of the metal is known as the Widmanstätten pattern, formed when the iron solidifies really slowly.



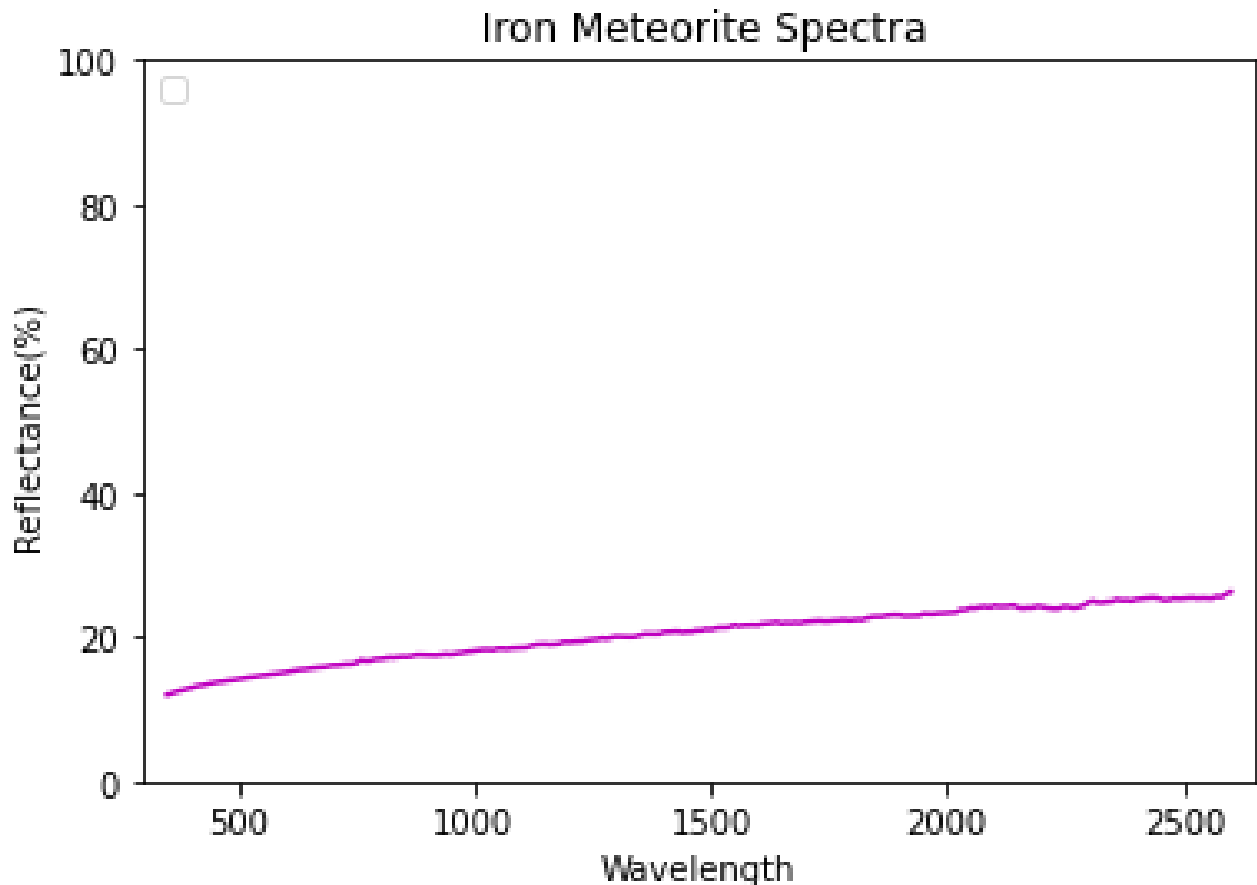
Weathered 3D Widmanstätten pattern of an iron meteorite found on Mars by the NASA Opportunity rover



Weathered Widmanstätten pattern of meteorite Richa BM 1996M55, at the Natural History Museum of London

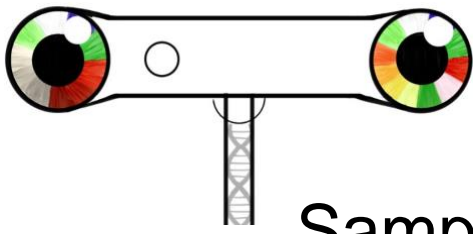


VNIR (Visible Near InfraRed) Hyperspectral Data



Spectra of iron meteorites can look different depending on the lighting conditions, they can reflect the spectra from other targets, outcrops or the sky as they are metallic.

Iron meteorite spectra don't have to many identifying features. The main feature to note is the **positive slope** from the blue side (500nm) of the spectrum to the infrared (1000nm +), this is called reddening. On Mars iron meteorites actually reflect the Martian sky because they are metallic, this is one way we can hunt for these meteorites on Mars.



Sample: Stony-Iron Meteorites

Target Summary

Stony-Iron meteorites consist mostly of **meteoritic iron** and **silicates**. These meteorites have **differentiated**, showing signs of alteration. Stony-Iron meteorites are split into two categories: **Mesosiderites** and **Pallasites**.

Mesosiderites

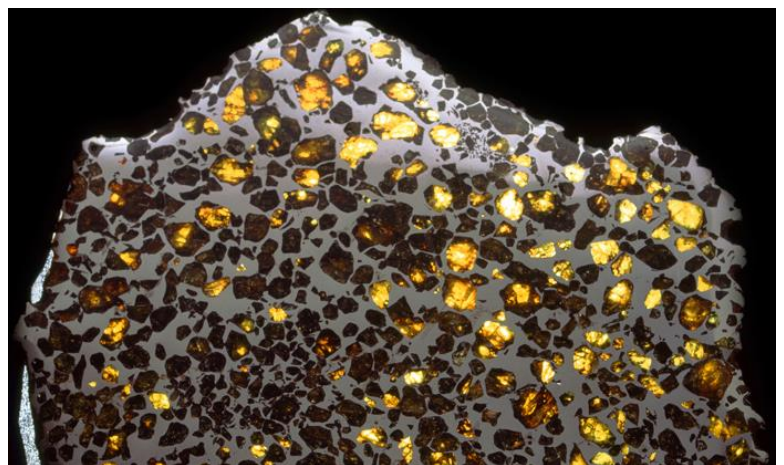
Mesosiderites are made up of broken fragments of multiple rocks and show signs of **metamorphism**. They can be identified from the presence of the bright and reflective metal inside, but the absence of silicate crystals embedded in the matrix. Mesosiderites form when debris from multiple asteroid collisions mix together.



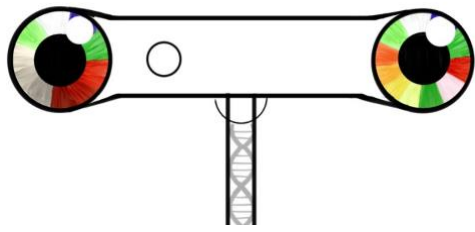
Estherville Mesosiderite NHM London

Pallasites

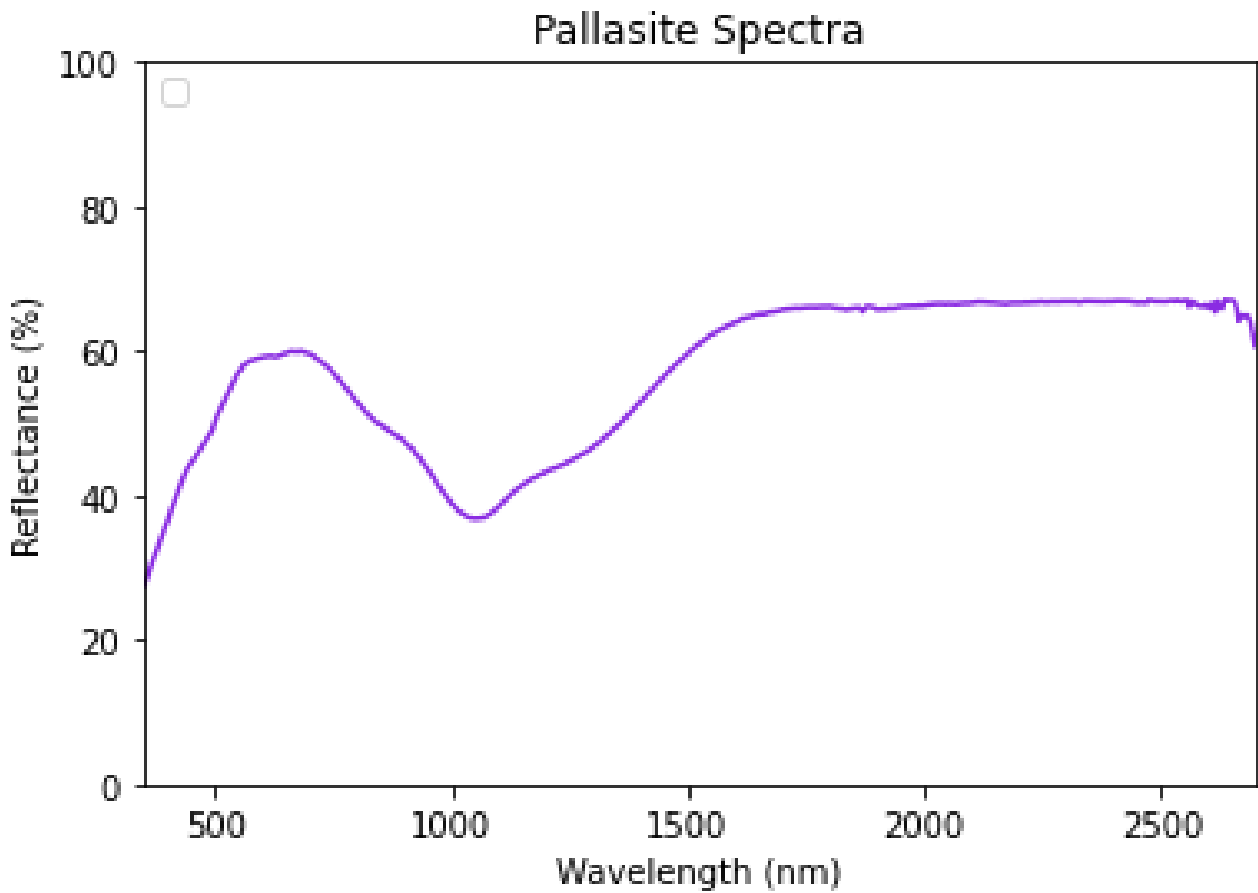
Pallasites have a matrix of meteoritic iron with silicates embedded in the matrix. They can be identified from the presences of the reflective metal inside surrounding the (mostly) olivine crystal (Orange bright inclusions shown).



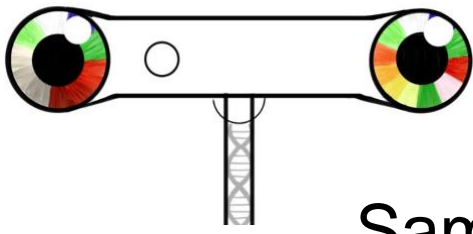
Pallasite meteorite Esquel, NHM London



VNIR Hyperspectral Data



Pallasites have a slightly more interesting shaped spectra depending on where the sample is taken. If the spectra were collected on a section with only metal present, the spectra would look much the same as the iron spectra. The silicates embedded in the meteorite matrix provide a much more interesting spectrum, shown above.



Sample: Stony Meteorites

Target Summary

Stony meteorites are mostly composed of **silicate** minerals and are split into two groups: chondrites and achondrites. These meteorites are some of the oldest material in our solar system, they are composed of material that formed in the **solar nebula** before planets formed.

Chondrites

Chondrites are some of the oldest material in our solar system, over 4.5 billion years old. They have experienced some thermal and aqueous alteration but not **significant** melting. Mineralogy of chondrites can vary significantly depending on the parent asteroid, but they all contain **chondrules**. These are the millimeter sized round features you can see in Parnalee. Carbonaceous chondrites (rich in water, sulphur and organic material) are thought to be one way the ingredients for life could have arrived at Earth.



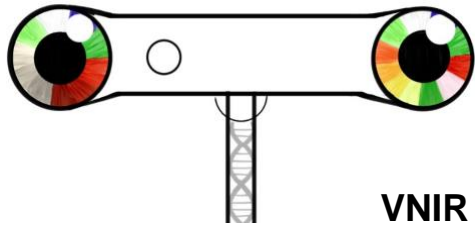
Parnalee chondritic Meteorite NHM

Achondrites

Achondrites are produced on parent bodies with significant enough heating to facilitate melting- like large asteroids, planets and moons. These meteorites don't have the round chondrules we see in chondrites because the parent body has had significant melting and at some point, have been melted into magma. When the magma cooled it created the layered structure, we see in the Stannern achondrite.



Stannern Achondrite NHM



VNIR Hyperspectral Data: Ordinary Chondrites

