METEORITE TYPES AND CLASSIFICATION

It is often said that when the average person imagines what a meteorite looks like, they think of an iron. It is easy to see why. Iron meteorites are dense, very heavy, and have often been forged into unusual or even spectacular shapes as they plummet, melting, through our planet's atmosphere. Though irons may be synonymous with most people's perception of a typical space rock's appearance, they are only one of three main meteorite types, and rather uncommon compared to stone meteorites, especially the most abundant stone meteorite group-the ordinary chondrites.

The Three Main Types of Meteorites

What Are Meteorites?

Although there are a large number of sub classes, meteorites are divided into three main groups: irons, stones and stony-irons. Almost all meteorites contain extraterrestrial nickel and iron, and those that contain no iron at all are so rare that when we are asked for help and advice on identifying possible space rocks we usually discount anything that does not contain significant amounts of metal. Much of meteorite classification is based, in fact, on how much iron a specimen does contain.

Iron Meteorites

When I give lectures and slideshows about meteorites to rock and mineral societies, museums, and schools, I always enjoy commencing the presentation by passing around a softball-sized iron meteorite. Most people have never held a space rock in their hands and when someone does pick up an iron meteorite for the first time their faces light up and their reaction is, almost without fail, to exclaim: "Wow, it's so heavy!"

Iron meteorites were once part of the core of a long-vanished planet or large asteroid and are believed to have originated within the Asteroid Belt between Mars and Jupiter. They are among the densest materials on earth and will stick very strongly to a powerful magnet. Iron meteorites are far heavier than most earth rocks-if you've ever lifted up a cannon ball or a slab or iron or steel, you'll get the idea.

In most specimens of this group, the iron content is approximately 90 to 95% with the remainder comprised of nickel and trace elements. Iron meteorites are subdivided into classes both by chemical composition and structure. Structural classes are determined by studying their two component iron-nickel alloys: kamacite and taenite.

These alloys grow into a complex interlocking crystalline pattern known as the Widmanstätten Pattern, after Count Aloys de Widmanstätten who described the phenomenon in the 19th Century. This remarkable lattice-like arrangement can be very beautiful and is normally only visible when iron meteorites are cut into slabs, polished, and then etched with a mild solution of nitric acid. The kamacite crystals revealed by this process are measured and the average bandwidth is used to subdivide iron meteorites into a number of structural classes. An iron with very narrow bands, less than 1mm, would be a "fine octahedrite" and those with wide bands would be called "coarse octahedrites."

Stone Meteorites

The largest group of meteorites is the stones, and they once formed part of the outer crust of a planet or asteroid. Many stone meteorites-particularly those that have been on the surface of our planet for an extended period of time-frequently look much like terrestrial rocks, and it can take a skilled eye to spot them when meteorite hunting in the field. Freshly fallen stones will exhibit a black fusion crust, created as the surface literally burned during flight, and the vast majority of stones contain enough iron for them to easily adhere to a powerful magnet.

Some stone meteorites contain small, colorful, grain-like inclusions known as "chondrules." These tiny grains originated in the solar nebula, and therefore pre-date the formation of our planet and the rest of the solar system, making them the oldest known matter available to us for study. Stone meteorites that contain these chondrules are known as "chondrites."

Space rocks without chondrites are known as "achondrites." These are volcanic rocks from space which formed from igneous activity within their parent bodies where melting and recrystallization eradicated all trace of ancient chondrules. Achondrites contain little or no extraterrestrial iron, making them much more difficult to find than most other meteorites, though specimens often display a remarkable glossy fusion crust which looks almost like enamel paint.

Stone Meteorites from Moon and Mars

Do we really find lunar and martian rocks on the surface of our own planet? The answer is yes, but they are extremely rare. About one hundred different lunar meteorites (lunaites) and approximately thirty Martian meteorites (SNCs) have been discovered on earth, and they all belong to the achondrite group. Impacts on the lunar and Martian surfaces by other meteorites fired fragments into space and some of those fragments eventually fell on earth. In financial terms lunar and Martian specimens are among the most valuable meteorites, often selling on the collectors' market for up to $1,000 per gram, making them worth many times their weight in gold.

Stony-Iron Meteorites

The least abundant of the three main types, the stony-irons, account for less than 2% of all known meteorites. They are comprised of roughly equal amounts of nickel-iron and stone and are divided into two groups: pallasites and mesosiderites. The stony-irons are thought to have formed at the core/mantle boundary of their parent bodies.

Pallasites are perhaps the most alluring of all meteorites, and certainly of great interest to private collectors. Pallasites consist of a nickel-iron matrix packed with olivine crystals. When olivine crystals are of sufficient purity, and display an emerald-green color, they are known as the gemstone peridot. Pallasites take their name from a German zoologist and explorer, Peter Pallas, who described the Russian meteorite Krasnojarsk, found near the Siberian capital of the same name in the 18th Century. When cut and polished into thin slabs, the crystals in pallasites become translucent giving them a remarkable otherworldly beauty.

The mesosiderites are the smaller of the two stony-iron groups. They contain both nickel-iron and silicates and usually show an attractive, high-contrast silver and black matrix when cut and polished-the seemingly random mixture of inclusions leading to some very striking features. The word mesosiderite is derived from the Greek for "half" and "iron," and they are very rare. Of the thousands of officially cataloged meteorites, fewer than one hundred are mesosiderites.

Classification of Meteorites

The classification of meteorites is a complex and technical subject and the above is intended only as a brief overview of the topic. Classification methodology has changed several times over the years; known meteorites are sometimes reclassified, and occasionally entirely new subclasses are added. For further reading I recommend The Cambridge Encyclopedia of Meteoritesby O. Richard Norton and The Handbook of Iron Meteorites by Vagn Buchwald.