UCLA METEORITE COLLECTION

Descriptions of Display Cases in Meteorite Gallery

Case 1

When an asteroid melts, two immiscible liquids form – a dense metallic liquid that sinks to the center of the body and a silicate-rich liquid that floats above it. The metallic melt eventually crystallizes to form an asteroidal core much like the iron core of the Earth. The silicate melt crystallizes to form the mantle and crust of the asteroid. An asteroid with this structure is called "differentiated." Rocks derived from these asteroids are the "differentiated meteorites."

The top shelf of this case shows some examples of iron meteorites that came from the cores of differentiated asteroids. The irons are divided into different chemical groups designated with a Roman numeral and one or two capital letters, e.g., IAB, IID, IIIAB, IVA, etc. Each group is derived from a separate asteroid. The samples on the top shelf include Kinsella (IIIAB) [found in Alberta, Canada in 1946], Nazareth (iron) (IIIAB) [found in Castro County, Texas in 1968], Mount Dooling (IC) [found in Australia in 1909; this particular piece is shrapnel, formed by mechanical deformation of large iron masses during crater-forming impacts on the Earth's surface], Turtle River (IIIAB) [found in Minnesota in 1953] and Carbo (IID) [found in Sonora, Mexico in 1923].

The second shelf includes samples from asteroids that never melted. These are the chondrites. Several different kinds of chondrites are represented here: Zhaodong (L4 ordinary chondrite) [fell in Zhaodong County, China on 25 October 1984], Bruderheim (L6 ordinary chondrite) [fell in Alberta, Canada in 1960], La Criolla (L6 ordinary chondrite) [fell in Entre Rios, Argentina on 6 January 1985], Richfield (LL3 ordinary chondrite) [found in Kansas in 1983], NWA 1668 (R5) [found in Northwest Africa in 2002], Indarch (EH4 enstatite chondrite) [fell in Azerbaijan in 1891] and NWA 3118 (CV3 carbonaceous chondrite) [found in Morocco in 2003].

Different kinds of differentiated meteorites are exhibited in the bottom half of the case. The Campo del Cielo IAB iron meteorite [found in Argentina in 1576] may have formed as part of an impact crater on the surface of a chondritic body after metal separated from silicate and pooled at the crater floor. Muonionalusta is a IVA iron meteorite [found in Sweden in 1906] that formed in the core of a melted and differentiated asteroid. Canyon Diablo is a IAB iron, part of the massive projectile that formed Meteor Crater about 50,000 years ago; this particular piece is a chunk of shrapnel, formed during the explosion that created the crater. (A 162-kg piece of Canyon Diablo is located in the center of the room.) NWA 468 is an ungrouped silicated iron meteorite found in Northwest Africa in 2000. NWA 5549 is a IAB iron found in Northwest Africa in 2008. NWA 854 is a IAB iron found in Northwest Africa in 2000. Pallasites are meteorites made of half metal and half olivine; the metal is from the top of the core of a differentiated asteroid and the olivine is from the bottom of the mantle. The two pallasites here are Springwater [found in Canada in 1931] and Seymchan [found in Russia in 1967]. Differentiated stony meteorites include the Millbillillie eucrite [fell in Western Australia in October 1960]; this rock is a basalt that formed as a lava flow at or near the surface of its parent asteroid. Nearby are NWA 6694, a polymict eucrite found in Morocco in 2011, and NWA 6693, an ungrouped achondrite found in Morocco in 2010. Two other differentiated stony meteorites on display are

Johnstown, a diogenite that fell in Colorado in 1924, and Cumberland Falls (an aubrite, also known as an enstatite achondrite), that fell in Kentucky in 1919.

Case 2

Carbonaceous chondrites comprise the most diverse class of chondritic meteorites. There are five major groups, derived from five separate asteroids, that appear to reflect processes that occurred in the solar nebula: CI, CR, CM, CO, CV-CK. Each group has a distinct set of chemical and textural properties, including the abundance of refractory lithophile elements (chemical property), and a narrow range of chondrule sizes (physical property).

The top shelf contains Gao-Guenie (b) (CR2) [found in Burkina Faso in 2002], Leoville (CV3) [found in Decatur County, Kansas in 1961], Colony (CO3) [found in Washita County, Oklahoma in 1975], Moapa Valley (CM1) [found in Nevada in 2004], Murchison (CM2) [fell in Australia in 1969], NWA 060 (CK5) [found in Northwest Africa in 2000] and Allende (CV3) [fell in Chihuahua, Mexico in 1969].

One of the principal components in all chondritic meteorites except CI chondrites are chondrules, typically sub-millimeter-size igneous spherules, that formed as molten or semi-molten silicate-rich droplets in the solar nebula. Shelf 2 contains some chondrules mechanically separated from the Bjurböle, an L/LL4 ordinary chondrite [fell in Finland in 1899].

The bottom of the case exhibits ordinary chondrites, the most abundant class of meteorites observed to fall (74% of falls). Displayed are cut slabs of the following ordinary chondrites: Wellington (H5) [found in Texas in 1955], Faucett (H5) [found in Missouri in 1966], Mount Tazerzait (L5) [fell in Niger in 1991], Shelburne (L5) [fell in Canada in 1904], NWA 7789 (LL3-6 breccia) [found in Northwest Africa in 2011] and Saint-Séverin (LL6) [fell in France in 1966].

Large ordinary-chondrite whole rocks are on the bottom shelf. These include al-Jimshan (H4) [found in Saudi Arabia in 1955] and Sappa (L6) [found in Kansas in 1983]. The Sappa stone retains some regions of black fusion crust.

The three groups of ordinary chondrites are H, L and LL, standing for *high total iron*, *low total iron* and *low total iron – low metallic iron*, respectively. One of the diagrams on the bottom shelf shows these differences in metallic iron; the other diagram shows that the ordinary chondrite group with the lowest amount of metallic iron (the LL group) has the highest amount of oxidized iron (FeO) in its constituent olivine grains.

Case 3

The case displays some of the beautiful iron meteorites and pallasites from the Schlazer Collection, a portion of which was donated to UCLA in 2013. The irons include Henbury [found in Australia in 1931], Mundrabilla [found in Australia in 1966], Gibeon [found in Namibia in 1836], Toluca [found in Mexico in 1776] and Campo del Cielo [found in Argentina in 1576]. The Widmanstätten pattern, produced by the intergrowth of two iron-nickel minerals (kamacite and taenite), is quite visible in the Henbury and Gibeon specimens. The cube fashioned from Mundrabilla shows coarse intergrown grains of troilite (dark yellow) and metal. Large nodules of troilite and graphite occur in the slice of Toluca. Two specimens of Campo del Cielo are on exhibit - an uncut complete individual and a slice showing numerous elongated and massive silicate grains.

Three back-lit pallasites are exhibited below the irons. These include Imilac [found in Chile in 1822], Seymchan [found in Russia in 1967] and Esquel [found in Argentina in 1951].

Case 4

Small meteoroids do not strike the Earth's surface at cosmic velocity because they are slowed down by the atmosphere. In contrast, smaller bodies like the Moon and asteroids have no atmospheric filter, so even small meteoroids impact their surfaces at very high velocities (typically several kilometers per second). The resultant impacts can produce dramatic changes in the target rock. Impact processes affecting the targets include impact melting, impact vaporization, and brecciation.

Exhibited on the top shelf are Tanezrouft 057 (CK4) [found in Algeria in 2002], Naryilco (L/LL6) [found in Queensland, Australia in 1975], Mifflin (L5) [fell in Wisconsin in 2010] and Beeler (LL6) [found in Kansas in 1924].

The second shelf holds Shaw (L6 impact-melt breccia) [found in Lincoln County, Colorado in 1937], Chico (L6 impact-melt breccia) [found in New Mexico in 1954] and Portales Valley (H6 impact-melt breccia) [fell in New Mexico in 1998].

The bottom half of the case shows Estacado (H6) [found in Texas in 1883], which contains a long shock vein of metallic iron-nickel, and Mayfield (H4) [found in Sumner County, Kansas in 1972], which contains a large (3 cm) impact-produced metal-sulfide nodule. Two shock-blackened chondrites are also exhibited: Farmington (L5) [fell in Kansas in 1890] and Taouz 001 (L6) [found in Morocco in 1991].

Also shown is a photograph of the LL impact-melt breccia LAR 06299. This rock contains many vesicles (holes derived from gas bubbles), formed by vaporization of volatile constituents during impact heating.

The bottom shelf holds samples of an H-chondrite regolith breccia called Plainview (1917). This meteorite formed at the surface of its parent asteroid and contains solar-wind-implanted noble gases, impact-melt-rock clasts, and fragments of carbonaceous chondrites. The latter samples were derived from foreign meteorite projectiles that collided with the Plainview parent asteroid at sufficiently low velocities to remain intact.

Case 5

Tektites are terrestrial sediments that have been melted by large impact events and cooled quickly to form silica-rich glass. Splash-form tektites come in several basic shapes, mainly disks, dumbbells and teardrops. Tektites with these shapes formed as partly-molten/partly-plastic objects spinning freely in the atmosphere after melting and launch from the Earth's surface in the wake of a large cratering event. Layered tektites, also known as Muong-Nong tektites, formed as puddles of silicate melt at the Earth's surface.

The top shelf contains moldavites (tektites from Central Europe); these are typically green in color. Black-colored Southeast Asian splash-form tektites are also on the shelf. Additional examples of splash-form tektites and a few layered tektites are on the second shelf.

Examples of Libyan Desert Glass (LDG) are exhibited in the bottom half of the case. These chunks of layered glass are nearly pure silica (like quartz sand) and formed from such sand by a large cratering event. Many of the specimens are banded; the differences in band color may be related to differences in the amount of bubbles trapped within the glass.

Case 6

The upper half of the case displays iron meteorites. Although these meteorites constitute only about 4% of observed falls, they are readily recognized on the ground. The names of the different iron meteorite groups consist of Roman numerals followed by one or two letters. Iron meteorites are classified based on their bulk elemental compositions and are divided into two broad categories: magmatic irons and non-magmatic irons. Magmatic irons are formed by fractional crystallization in the molten cores of asteroids; non-magmatic irons are formed by impact melting of chondritic material followed by partial separation of molten metal from silicates.

On display are magmatic irons (Ainsworth IIAB, Gibeon IVA, Buenaventura IIIAB, Muonionalusta IVA, Cerro del Inca IIIF, and Sikhote-Alin IIAB) and non-magmatic irons (Anoka IAB, Morasko IAB, NWA 6931 IAB, and Watson 001 IIE).

The bottom half of the case displays some mesosiderites. These are stony-iron meteorites that consist of about half metallic iron-nickel and half silicate. The silicate portions consist of rocks related to the eucrites, diogenites and howardites. On display are cut faces of Vaca Muerta [found in Chile in 1861], Mincy [found in Missouri in 1857], Patwar [fell in India (now Bangladesh) in 1935], Clover Springs [found in Arizona in 1954], Veramin [fell in Iran in 1880] and Emery [found in South Dakota in 1962].

The Vaca Muerta mesosiderite contains multi-centimeter-size igneous pebbles, consisting of basalts, coarse-grained rocks called gabbros, and impact melts. Three of these pebbles are on display; also shown (outlined in black) is a large (12 cm) igneous pebble still enclosed in an individual specimen of Vaca Muerta.

Late-stage impact melting in the near-surface environment on the mesosiderite parent asteroid transformed fine-grained mesosiderites like Emery and Vaca Muerta to coarse-grained ones like Estherville [fell in Iowa in 1879]. The metal in Estherville has segregated into veins and rounded nodules.

Case 7

Numerous meteorites have been found in California including chondrites, achondrites, and irons. Many of these are housed in the UCLA Collection of Meteorites. A few examples are exhibited in the top half of the case: Chuckwalla (IAB iron), Cargo Muchacho Mountains (CO3), Stewart Valley 009 (LL5), Chocolate Mountains (ureilite), El Mirage Dry Lake 004 (LL6), Neenach (L6), Red Rock (IIIAB iron), Needles (IID iron) and Pinto Mountains (L6). Also on display is the type specimen of Novato (L6) that fell in Marin County on 17 October 2012.

Every week several rocks are sent in to UCLA by people who suspect them of being meteorites. Very few are real meteorites; those that are not are called “meteor-wrongs”. Several examples of common (and not-so-common) meteor-wrongs are shown in the bottom half of the case. Such samples include copper ore, a sulfide nodule, magnetite, hematite, iron slag, green silicate slag containing manganese spherules, petrified wood, basalt, obsidian and volcanic scoria.

Among the most common meteor-wrongs are the iron ores magnetite and hematite. These rocks can be distinguished by the colored streaks they make when scratched against an unglazed tile – black for magnetite and red for hematite. A tile showing these streaks is on display.

Case 8

The most common type of volcanic rock on solar-system bodies is basalt, a dark, fine-grained igneous rock composed mainly of the minerals plagioclase and calcium pyroxene. Basalts occur on Earth, the Moon, Mars and differentiated asteroids.

Eucrites are basaltic meteorites that come from a differentiated asteroid, perhaps Vesta. Four eucrites are on the top shelf: Palo Blanco Creek [found in New Mexico in 1954], NWA 6694 (polymict eucrite) [found in Northwest Africa in 2011], NWA 999 [found in Morocco in 2000] and Pasamonte [fell in New Mexico in 1933]. Also on the top shelf is Los Angeles, a martian basalt (shergottite) [found in Los Angeles, County, California in 1999]. The second shelf contains basalts and related rocks from different parent bodies: Millbillillie (from the eucrite parent body), D'Orbigny (an angrite from a different differentiated asteroid), Zagami (a basalt from Mars) and a lunar impact melt rock (not a basalt) – NWA 482.

The bottom of the case includes a variety of terrestrial basalts – vesicular basalt, an alkali basalt with olivine inclusions, pahoehoe lava (i.e., ropy lava) and a fine-grained basalt.

Clark Iron

This 162 kg (357 pound) meteorite in the center of the room is called Canyon Diablo. It is a IAB iron meteorite formed by impact melting near the surface of a chondritic asteroid. This process is also discussed in connection with the Campo del Cielo poster near the center of the north wall.

This fragment was derived from a 300,000-ton projectile that formed Meteor Crater about 50,000 years ago. The impact generated about 150 times more explosive energy than the atomic bomb dropped on Hiroshima.

Meteor Crater is the freshest impact crater on Earth. It is 1.2 km (0.75 mile) across, 3.9 km (2.4 miles) in circumference, and 168 meters (550 feet) deep. It is located 56 km (35 miles) east of Flagstaff, Arizona and 32 km (20 miles) west of Winslow.

The meteorite was given to UCLA in 1934 along with the Clark Library. The library is an attractive building in 19th-Century style, located in Los Angeles at 2520 Cimarron St., near the Arlington exit on the Santa Monica freeway. It specializes in textual publications from the 17th and 18th Centuries. William Andrews Clark, Jr., the founder of the LA Philharmonic, was the son of the copper baron (and U.S. senator from Montana) W. A. Clark, Sr. (1839-1925).

Camp Wood Iron

This 148 kg (326 pound) meteorite is a IIIAB magmatic iron meteorite formed by fractional crystallization in the molten core of an asteroid. Compared to most IIIAB irons, its composition implies that it formed from a moderate amount of trapped melt. It is an octahedrite with bands of low-Ni metal that are typical of IIIAB irons. The bowl shaped depressions are unusual; they must have formed by erosion during atmospheric passage.

The Camp Wood iron was first recognized by a hunter in Texas around 1968 who left it on his front porch until it was sold to the Utas family in 2007. The specimen is on a long-term loan from the Utas Meteorite Collection to the UCLA Meteorite Gallery.

Gibeon Iron

This 368 kg (811 pound) meteorite is a IVA magmatic iron meteorite that formed by fractional crystallization in the molten core of an asteroid. It is a fine octahedrite with parallel bands of low-Ni metal about 0.3 mm thick. A polished and etched slab of Gibeon is displayed in Cabinet 6.

Gibeon has the second or third largest total mass among collected iron meteorites, probably in excess of 70 tons. The specimen is on a long-term loan from the Utas Meteorite Collection to the UCLA Meteorite Gallery.