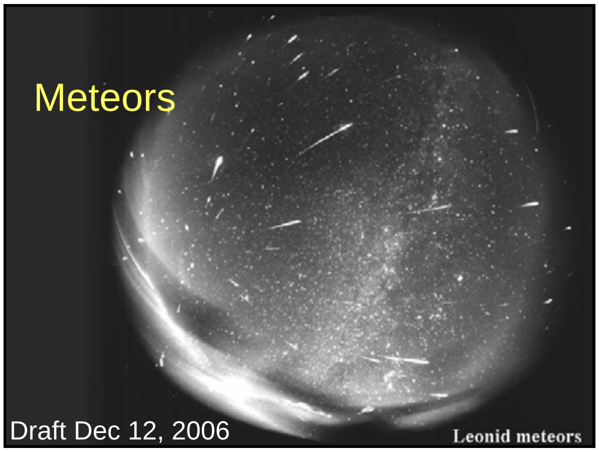


Meteors

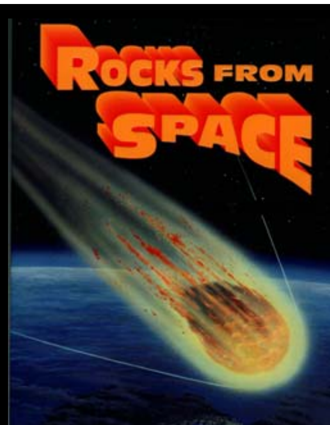
Draft Dec 12, 2006

***Meteors* –** Comet dust particles entering our atmosphere and burning up from the friction.

Every year about Nov. 18 the Earth goes through the path of an old comet.

Meteorites are …

Most come from the asteroids, but some are chips from the ***Moon*** and some are from ***Mars***.



The Peekskill, NY Meteorite Fall

In 1992, a meteor streaked across the skies of several states on a Friday night when many people were attending high-school football games with their video cameras. The meteor, which was brighter than the full moon, was captured on 16 different videos from several locations.

After it's 40-minute flight, it landed on a car in Peekskill, New York.

Peekskill Meteorite

The car and the meteorite

Now in the Smithsonian!

A meteorite the size of a car streaks across the sky, headed for Canada, but doesn't strike the ground. It "skips" off the atmosphere.

Sometimes they hit houses

Wethersfield, Connecticut, November 8, 1982.

6-pound meteorite crashed through roof.

Some meteorites are big

15-ton meteorite found in the Willamette Valley, Oregon

Known to native Americans, but "discovered" in 1902. Now in the Hayden Planetarium, New York City.

1906 photo

This is an iron meteorite

Many meteorites have been recovered in Antarctica

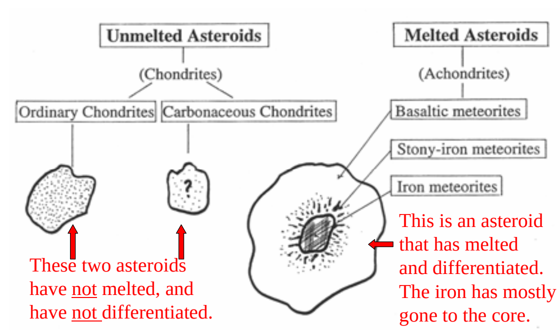
Meteorites are preserved in the Antarctic ice cap.

The are concentrated in certain areas by the motion of the ice.

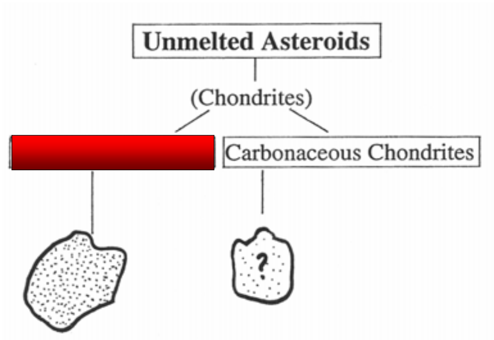
Meteorites are easier to find in the ice because there are very few "native" rocks.

A few thousand have been found so far.

Melted and <u>un</u>melted meteorites come from different kinds of asteroids



Let's consider the unmelted ones first



Chondrite meteorites

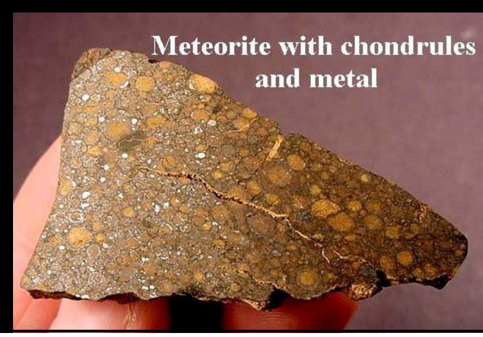
- Chondrites are meteorites that contain ***chondrules***
- ***Chondrules*** are little BB-size blobs of minerals and mineral glass that were once melted and quickly solidified. They look like gravel.

Chondrules and the early Solar System

- The chondrules in the ***ordinary chondrite*** meteorites formed very early in the history of the Solar System, before the Sun and planets had completely formed.
- We don't know the details of their origin.
- Ordinary chondrite meteorites come from asteroids that consist of this ancient material.

Section of an ordinary chondrite meteorite. The chondrules are about 1 to 4 mm in size.

Ordinary chondrites contain metal (iron and nickel). Note the tiny shiny flakes in this meteorite.

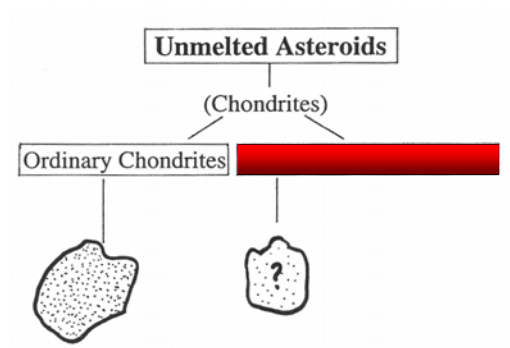


Very important !

- The ***ordinary chondrites*** have the overall composition (metal + silicate minerals) of the Earth and the other terrestrial planets.
- If we put the Earth in a giant blender and ground it all up (*core*, *mantle*, and *crust*) into small pieces, it would have the overall composition of an ordinary chondrite.

 +  = 

Now the Carbonaceous Chondrites



Carbonaceous Chondrites

- These meteorites contain a significant amount of *carbon*, in addition to the chondrules and metal.
- Much of the carbon is in the form of complex organic molecules, including many amino acids.
- Two of the most famous carbonaceous meteorites are Allende and Murchison; both fell in 1969.

Allende (Mexico)

Murchison (Australia)

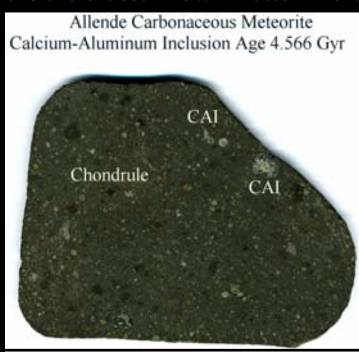
Carbonaceous Chondrites

- These meteorites may have brought water to the early Earth
- They also brought complex organic materials that ***may*** have aided in the origin of life on Earth.

Allende (Mexico)

Murchison (Australia)

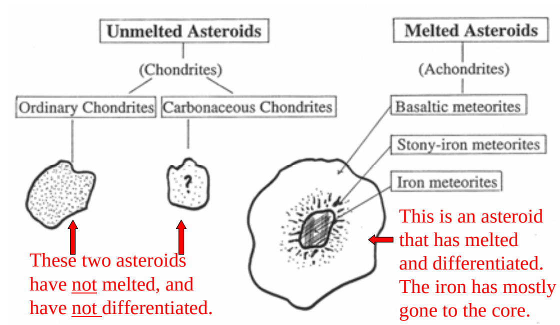
The carbonaceous meteorites are extremely old. The calcium-aluminum inclusions (CAIs) in them are the oldest known matter in the Solar System.



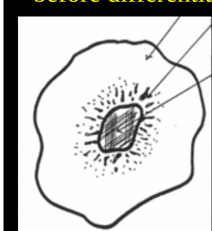
The CAIs solidified 4.566 billion years Ago.

We determine the age of the Solar System from the ages of the meteorites

Again, melted and unmelted meteorites come from different kinds of asteroids



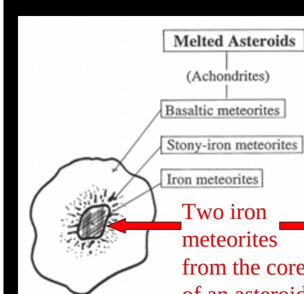
This sketch shows a cut through an asteroid that has melted and ***mostly differentiated***. The iron and other metals were sinking to form a core, and the lighter silicate minerals were floating to the top. The asteroid was small, and solidified before differentiation was entirely complete.



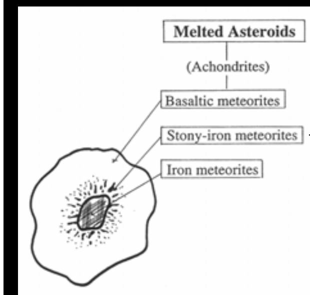
The ***outer layer*** is made of silicate rocks.
The ***core*** is made of iron + nickel.
The ***intermediate zone*** is a mix of metal and silicate minerals.

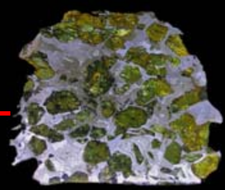
We can call this a ***differentiated asteroid***

When differentiated asteroids are shattered, they produce at least three kinds of meteorites.



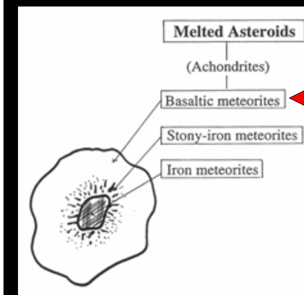
When <u>differentiated</u> asteroids are shattered, they produce at <u>least three kinds</u> of meteorites.





A stony-iron meteorite from the region near the core. Note the green olivine crystals.

When <u>differentiated</u> asteroids are shattered, they produce at <u>least three kinds</u> of meteorites.

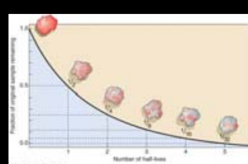


A basaltic meteorite from the volcanic crust of a differentiated asteroid

The Importance of Meteorites

- They are the oldest material that we have.
- Their ages are consistently 4.45 to 4.57 billion years.
- Meteorite ages are determined from the radioactive atoms in them.
- You have seen these two figures before …

Parent	Daughter	Half-Life (billion yr)
Samarium-147*	Neodymium-143	106
Rubidium-87	Strontium-87	48.8
Thorium-232	Lead-208	14.0
Uranium-238	Lead-206	4.47
Potassium-40	Argon-40	1.31



A final critical point …

- The age of the formation of the Solar System (that is, the condensation of solid material from gas and dust) is based on the ages of the meteorites.
- This is where we get the figure ***4.6 billion years*** for the age of the Earth, the other planets, and the Sun
- It is based on hundreds of independent age measurements on hundreds of different meteorites.