Discovery of the source of the most common meteorites

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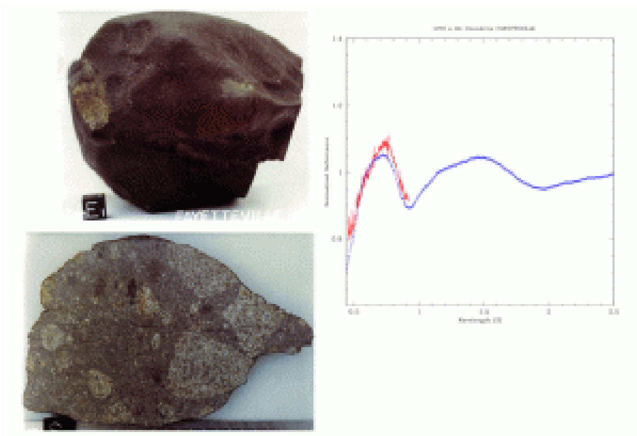

(Right) Comparison of the spectrum of asteroid (1270) Datura with the spectrum of the Fayetteville meteorite. (Left) Pictures of the Fayetteville meteorite (© Arkansas Center for Space and Planetary Sciences, University of Arkansas).

Astronomy & Astrophysics is publishing the first discovery by T. Mothé-Diniz (Brazil) and D. Nesvorný (USA) of asteroids with a spectrum similar to that of ordinary chondrites, the meteoritic material that most resembles the composition of our Sun. Most of the meteorites that we collect on Earth come from the main belt of asteroids located between Mars and Jupiter [1].

They were ejected from their asteroidal "parent body" after a collision, were injected into a new orbit, and they finally felt onto the Earth. Meteorites are a major tool for knowing the history of the solar system because their composition is a record of past geologic processes that occurred while they were still incorporated in the parent asteroid.

One fundamental difficulty is that we do not know exactly where the majority of meteorite specimens come from within the asteroidal main belt. For many years, astronomers failed to discover the parent body of the most common meteorites, the ordinary chondrites that represent 75% of all the collected meteorites.

To find the source asteroid of a meteorite, astronomers must compare the spectra of the meteorite specimen to those of asteroids. This is a difficult task because meteorites and their parent bodies underwent different processes after the meteorite was ejected. In particular, asteroidal surfaces are known to be altered by a process called “space weathering”, which is probably caused by micrometeorite and solar wind action that progressively transforms the spectra of asteroidal surfaces. Hence, the spectral properties of asteroids become different from those of their associated meteorites, making the identification of asteroidal parent body more difficult.

Collisions are the main process to affect asteroids. As a consequence of a strong impact, an asteroid can be broken up, its fragments following the same orbit as the primary asteroid. These fragments constitute what astronomers call “asteroid families”. Until recently, most of the known asteroid families have been very old (they were formed 100 million to billions of years ago). Indeed, younger families are more difficult to detect because asteroids are closer to each other [2]. In 2006, four new, extremely young asteroid families were identified, with an age ranging from 50000 to 600000 years. These fragments should be less affected than older families by space weathering after the initial breakup. Mothé-Diniz and Nesvorný then observed these asteroids, using the GEMINI telescopes (one located in Hawaii, the other in Chile), and obtained visible spectra. They compared the asteroids spectra to the one of an ordinary chondrite (the Fayetteville meteorite [3]) and found good agreement, as illustrated on Fig. 1.

This discovery is the first observational match between the most common meteorites and asteroids in the main belt. It also confirms the role of space weathering in altering asteroid surfaces. Identifying the asteroidal parent body of a meteorite is a unique tool when studying the history of our solar system because one can infer both the time of geological events (from the meteorite that can be analyzed through datation techniques) and their location in the solar system (from the location of the parent asteroid).

Notes:

[1] There are only a few exceptions, including the example of the famous meteorites coming from Mars.

[2] After the primary asteroid is disrupted, the fragments move away from each other. The older the collision, the greater the distance between fragments.

[3] Meteorites are named for the place they were collected. The Fayetteville meteorite fell near Fayetteville, Arkansas, on December 26, 1934.

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