An Incompletely Differentiated Asteroid

Chondritic meteorites represent primitive Solar System materials that accreted into **asteroids** and were heated, but not melted. In contrast, **iron** meteorites formed in parent bodies that **differentiated** into metallic cores and surrounded by rocky mantles. It requires substantial melting to allow dense metallic iron (along with iron sulfide) to dribble downwards and accumulate in the center of an asteroid, forming a core. If some bodies did not melt and others melted substantially, there ought to be some in between, bodies that partially melted but not enough to completely differentiate. A group of 138 meteorites comprising the Acapulcoite-Lodranite group [Meteoritical Bulletin **Database link**] represents just such an asteroid.

Meteorite Larkman Nunatak 06605

(Tim McCoy, Smithsonian Institution)

Photomicrograph in polarized light of a lodranite, Larkman Nunatak 06605, found in Antarctica [Meteoritical Bulletin **Database link**]. The minerals **olivine** (blue, red, white) and **orthopyroxene** (mostly grayish) dominate the rock. The dark area is metallic iron, which is surrounded by a rim of **plagioclase feldspar** (gray), which represents a **basalt**-composition partial melt. Photomicrograph courtesy of Tim McCoy, Smithsonian Institution.

Anyone interested in asteroid differentiation and early Solar System history can start their studies by reading a thorough review article about this fascinating group of meteorites, written by Klaus Keil (University of Hawai‘i) and Tim McCoy (Smithsonian Institution). Keil and McCoy show that the meteorites formed by 1 to 35% partial melting of a chondritic asteroid less than 100 kilometers in diameter and suggest that the wide range in cooling rates recorded by various thermometers in the meteorites is the result of the body breaking up while it was still hot. The authors also explain that the variation in the amount of heating shown by iron meteorites, Acapulcoite-Lodranites, and chondrites represents a difference in the time of ***accretion***: those accreting earliest (irons) had more short-lived ^{26}Al (an important source of heating because of ***radioactive decay***) than those accreting later. By the time the chondrite parent bodies had formed, the amount of ^{26}Al was too low to heat to the melting point. The Acapulcoite-Lodranite parent body had just enough ^{26}Al to do some melting, but not enough for full-fledged, core-forming differentiation, thereby leaving behind a record of the early stages of differentiation in planetesimals. For all the details, see this lavishly-illustrated review article.

See Reference:

· Keil, K. and McCoy, T. J. (2018) Acapulcoite-Lodranite Meteorites: Ultramafic Asteroidal Partial Melt-Residues, *Chemie der Erde,* v. 78, p. 153-203, doi: 10.1016/j.chemer.2017.04.004. [***abstract***].

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