L18 Meteorite samples of Mars

< stony planet fragments, PAHs (polycyclic aromatic hydrocarbons) >

> In the 1790s, European scientists accepted the once preposterous notion that meteorites—rocks that fall from the skies—were of cosmic origin and not lightning bolts, volcanic ejecta, or the eighteenth-century equivalent of ghosts or UFOs.
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> —Clark R. Chapman.[1]

Meteorites are fallen-to-Earth asteroids, mostly but not all.

Since it has been possible to examine *Apollo 11-12,14-17* returned lunar rocks at first hand, some meteorites (achondrites) from their composition (similar to terrestrial basalts) can now be confidently identified as Moon fragments. These can only have been knocked off that body by meteor-impact explosions.

Large meteorite impacts upon planets excavate a deep conical hole in atmosphere, oceans and rock, followed by the outward streaming of a great plume of spray, vapor and gas that can exceed the escape velocity (in km/sec: 2.38 for Moon, 2.8 for Mercury, 5 for Mars, 10.2 for Venus, 11.2 for Earth) and pluck rocks from the surface, and accelerate them relatively gently to escape.[2] The dated history of Moon's impact cratering allows for interpolation to the age of martian landscapes by their crater density.[3] The northern hemisphere of Mars is not heavily cratered. In this region, Olympus Mons dates 0.1-2.5 Gy.[4] The most heavily cratered martian regions, termed *Noachian-age terrains*, lie in the southern hemisphere. The ancient terrains have an estimated age of 3.0-4.4 Gy.

George West Wetherill (1925-2006) in the 1960s calculated that the highest-velocity fragments launched by the impact of a straying asteroid with Mars could have intersecting Earth orbits.[5] Fourteen meteorites (all achondrites) are currently identified as possible Mars fragments.[6] The age of these martian meteorites (***Figure L18.1***) allows them to be evaluated as samples from the different martian terrains and petrographic and chemical analyses of them provides information bearing on the geological and atmosphere evolution of Mars.

About 4 percent of the martian surface is mapped as unchanged or not covered-over primordial crust. A sample of the primordial martian crust described in 1996 by Richard A. Ash, Stephen F. Knott, and Grenville Turner, is a meteorite with a radiometric age of 4±0.1 Gy.[7] This meteorite, designated ALH84001, has a high carbonate content and contains PAHs (polycyclic aromatic hydrocarbons). One interpretation is that a thick, mostly carbon dioxide, atmosphere originally allowed water to flow on the surface of Mars. This water, with dissolved carbon dioxide, percolated into the primordial crust and deposited carbonates. Under such conditions PAHs could have an organic origin as on Earth where PAHs are known to be products of biological activity. Alternatively, PAHs can have inorganic origins. This is known, as PAHs have been spectrographically identified in the materials of comets. ❑

Figure L18.1 [8] Shock ages (Ar-Ar) of 10 meteorite samples of Mars.
(Each plotted time interval is 0.1 Gy)