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ORIGIN OF MESOSIDERITES AS A NATURAL CONSEQUENCE OF PLANET FORMATION. John T. Wasson and Alan E. Rubin, Institute of Geophysics and Planetary Physics, University of California, Los Angeles, CA 90024, USA.

Of the three basic types of meteorites that fall to Earth (stone, iron and stony-iron), the stony-irons are rarest. There are two main groups of stony-iron meteorites: pallasites, which are mixtures of metallic iron and olivine, and mesosiderites, which are mixtures of metallic iron and basaltic silicates. Although there is general agreement that pallasites formed at the boundary between a silicate (olivine) mantle and a metallic core of a once-molten asteroid, it has proven much more difficult to reach agreement on the origin of mesosiderites.

Basalts are formed by partial (generally 5-10%) melting of mantle rocks followed by the squeezing ("extrusion") of the liquid out onto the surface of the planet, where it solidifies.

Because bodies with basaltic crusts are expected to have olivine-rich silicate mantles and metal-rich cores, models of mesosiderite origin calling for the basalt and metal to originate in the same body have been hard-pressed to explain the scarcity of olivine in these stony-iron meteorites.

Mesosiderite textures show these meteorites to be mixtures of metal grains and nuggets with millimeter-to-centimeter-size angular fragments of basaltic silicates. This "breccia" texture clearly indicates that mesosiderites formed on an asteroid surface that was subjected to intense meteorite bombardment. Some mesosiderites exhibit clear evidence of impact-melting.

Basalts like those that make up the silicate portions of the mesosiderites are common in the inner solar system. Mercury, Venus, Earth, Moon and Mars all have basalt exposed at their surfaces. The large asteroid Vesta is covered with basalt and certain groups of stone meteorites are made up of basalt and very little metallic iron. The meteoritic basalts are very old; they formed about 4.3 to 4.4 billion years ago. Plausibility arguments indicate that heat sources capable of melting asteroid-size bodies in such a brief period would have been nonselective; they would have melted all bodies of similar or larger size at that distance from the Sun. Within one particular radial distance from the Sun, it seems likely that almost all of the asteroid-size bodies were melted; we do not know this radial distance, but the presence of basalts on Vesta (orbital radius of 2.4 AU) suggests that it may have extended out past the orbit of Mars to about 2 AU from the Sun. The mesosiderites formed in this broad region where nearly every asteroid-size body melted.

We follow a common picture of planet formation that calls for bodies to gradually grow as a result of low-velocity collisions. According to this picture, asteroids (typical radius of

100 km) are intermediate products of this process.

We suggest that the asteroid parent body of the mesosiderites also formed in the inner solar system, perhaps just within the orbit of Mars. At this location, the gravitational influences of Jupiter and Earth (the largest terrestrial planet) are relatively small and many of the asteroids remained in low-inclination, nearly circular orbits. However, as a result of close planetary encounters, some bodies that formed near Earth or Venus were gravitationally perturbed into non-circular orbits; a few such bodies passed through the mesosiderite region at high relative velocities, colliding with and destroying a few of the native asteroids. Olivine-rich silicate mantles shattered into small pieces, but the stronger metal cores remained as large fragments.

Much of the debris remained in circular orbits and accreted to (i.e., was collected by) the basaltic regoliths of intact native asteroids at low relative velocities, perhaps 1 km/s. The small pieces of the olivine mantles formed a more-or-less uniform diluent in the indigenous basalt; examination of mesosiderites and the closely related howardite meteorite regolith breccias shows them to contain about 2% of a foreign olivine component. The large core fragments that collided with the crust greatly enriched restricted regions of the surface in metal. These localized regions were the mesosiderite progenitors; they accounted for only about 1% of the surface area of the parent bodies.

Because mesosiderites are tough, durable objects, they preferentially survived the rigors of impact-ejection from their parent body, erosion by collisions with space debris, and ablation and fragmentation during passage through the Earth's atmosphere. These selection biases account for the enhancement (by a factor of 30) of mesosiderites among meteorite falls compared to the metal-poor basaltic howardites.