REHEATED IRON METEORITES: RELATION TO ASTEROIDAL BODIES AND THEIR IMPACT HISTORIES

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Introduction: Most iron meteorites have been shocked due to impact in space. The result of the shock process can be observed in the microstructure [1-3]. With increasing shock level, the release of high pressure after the shock event increases the residual temperature altering the microstructure and microchemistry of the metal [1,2, 4]. We have applied high resolution SEM, EBSD, and analytical TEM to detail shock features which cause major changes in the Widmanstätten pattern, recrystallization at kamacite/taenite interfaces, and removal of the cloudy zone. We have examined members of the IVA and IVB irons as well as several ungrouped meteorites (ex: Hammond) to obtain information about the phase reactions, shock pressure, and reheating temperatures, and subsequent cooling rates which take place on the surface or within parent or secondary asteroidal bodies after slow cooling and formation of a Widmanstätten pattern.

Results and Discussion: Many of the IVA irons have been reheated and the cloudy zone has been removed by shock induced reheating of 5 of 16 IVA irons [2]. Reheating varied from a few seconds at 1000ºC to more than a year at <550ºC. Some of these same IVA irons display diffusion gradients from 20nm to 400nm across kamacite/taenite boundaries, recrystallization of kamacite, and the formation of taenite grain boundaries [2]. On the other hand, Fuzzy Creek which has the highest Ni content IVA, 12.4 wt% Ni, is the only member that does not have a Widmanstätten pattern. The microstructure of Fuzzy Creek contains polycrystalline kamacite with taenite and phosphide at junctions of kamacite grains. Compositions of the 3 phases indicate reheating to more than 500^0C at a shock level of 110 GPa. TEM and EBSD results show Ni gradients in the taenite and we have estimated cooling rates after reheating of about 0.5 K/yr. Although this meteorite first cooled close to the center of IVA metal core, the measured cooling rate is considerably higher than that of other high Ni IVAs. It is probable that the shock reheating event which produced this microstructure took place after the initial IVA core was broken up. Maria Elena, another IVA displays a Widmanstätten pattern when viewed by eye, but has been severely reheated with the formation of rounded taenite in original taenite regions and new taenite in original kamacite bands. The IVA irons are most likely the product of at least three different impacts: 1) Collision between protoplanets that created a 150 km radius molten metal body. 2) Breakup of this IVA asteroid soon after cooling (at low temperature) producing a fragment perhaps 30 km in size or a smaller rubble pile. 3) Meter-sized fragments produced by a third impact 400 Myr ago [5]. Shock reheating in other meteorites constrains the process for the break up of IVB and other asteroidal bodies.

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