A NEW VIEW OF ASTEROID PARTIAL DIFFERENTIATION: A LEGACY OF BRIAN MASON'S WORK ON ANTARCTIC METEORITES.

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Introduction: In his 1962 classic *Meteorites*, Mason [1] argued that HED meteorites formed by sequential crystallization of a bulk chondritic magma, forming dunites (the pallasites), orthopyroxenites (the diogenites) and basalts (the eucrites). At that time, HEDs were the only major group of achondrites, joined by the small group of aubrites and a handful of oddities (Chassigny, Angra dos Reis, Lodran, Winona, 3 ureilites and 2 nakhlites) [1]. While HEDs and Vesta still dominate much of the debate about asteroid differentiation, it was Brian's 20+ years of classifying more than 10,000 Antarctic meteorites that revealed the complexity of asteroid differentiation and the influence of a wide range of parameters (starting composition, peak temperature, fO_2) [2].

The rise of the achondrites. With ~19,000 new meteorites from Antarctica in the U.S. collection, small groups have grown and oddball meteorites are now namesakes of their own groups. Ureilites, angrites, acapulcoites, lodranites, brachinites and winonaites provide new insights into asteroid partial melting. Collectively, they have given rise to the term "primitive achondrites", residues formed by partial melting and melt migration, and conceptually at least, complements to the "achondrites" formed by crystallization of those melts.

Diverse materials and perplexing processes. The "chondritic" precursors that formed achondrites had a range of compositions (e.g., anhydrous, hydrous, carbon-rich) and intrinsic fO_2 (e.g., highly-reduced enstatite chondrite-like to oxidized carbonaceous chondrite-like). Indeed, most achondrite groups derived from chondrites not currently sampled by our collections and few achondrites (silicate-bearing IVA and IIE irons?) derived from melting of the most common (ordinary) chondrites.

The importance of partial melting as a fundamental process in asteroid differentiation was bolstered by the suggestion of a partial melt origin for eucrites [3] and recognition that a range of peak temperatures and degrees of partial melting formed primitive achondrites [2]. While silicate partial melting was common, metal-sulfide veins in acapulcoites-lodranites record the onset of partial melting and suggest complex chemical reactions. [4]

The ultimate fate of the partial melts complementary to many primitive achondrites is unclear. Expanding gases might drive eruption velocities of melts in excess of the escape velocity of the small parent asteroids, leading to melt loss [5]. This process was not 100% efficient, as complementary melts have been identified in lodranites and ureilites. The recent finding of sodic plagioclase-rich GRA 06128/129 meteorites related to brachinites [6] suggest retention of some melts and might require a physical mechanism for plagioclase enrichment.

A new view. At the threshold of Dawn's exploration of differentiated asteroid 4 Vesta, Brian Mason's work classifying Antarctic meteorites has enriched our record of early asteroid differentiation to a point unimagined in 1962. We now appreciate – if only incompletely understand – the interplay between materials and processes that produced the dizzying array of achondrites.

References: [1] Mason (1962) *Meteorites* [2] McCoy et al. (2006) *MESS II*, 733. [3] Stolper (1977) *GCA* **41**, 587. [4] McCoy et al. (2006) *GCA* **70**, 516. [5] Wilson and Keil (1991) *EPSL* **104**, 505. [6] Day et al. (2009) *Nature* **457**, 179.