THE VESTA – HED METEORITE CONNECTION. M. J. Drake, Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85921-0092 (drake@lpl.Arizona.edu)

Introduction: There are two planets and one Moon from which we have samples. Earth and Moon have been sampled directly by humans. The connection of the Martian meteorites to Mars comes from young ages implying a relatively large planet, the match of noble gas patterns and isotopes in glasses in some Martian meteorites with the Martian atmosphere as measured by Viking, and by direct geochemical analysis of primitive basaltic rocks by instruments on the rover on the Mars Pathfinder mission [1-3]. Figure 1 shows the major element constraints.

Meteorites: Many lines of evidence indicate that meteorites are derived from the asteroid belt but, in general, identifying any meteorite class with a particular asteroid has not been possible. One exception is asteroid 4 Vesta, where a strong case can be made that it is the ultimate source of the howardite-eucrite-diogenite (HED) family of basaltic achondrites. Visible and near infrared reflectance spectra (Fig. 2) first pointed to a connection between Vesta and the basaltic achondrites [4]. Experimental petrology demonstrated that the eucrites (the relatively unaltered and unmixed basaltic achondrites) were the product of approximately a 10% melts [5]. Studies of siderophile element partitioning suggested that this melt was the residue of an asteroidal-scale magma ocean [6]. Mass balance considerations point to a parent body that had its surface excavated, but remains intact [7]. Modern telescopic spectroscopy has identified kilometer-scale "Vestoids" between Vesta and the 3:1 orbit-orbit resonance with Jupiter [8]. Dynamical simulations of impact into Vesta demonstrate the plausibility of ejecting relatively unshocked material at velocities consistent with these astronomical observations [9]. Hubble Space Telescope images (Fig. 3) show a 460 km diameter impact basin at the south pole of Vesta [10]. Spectroscopic studies of near-Earth asteroids revealed three small objects with basaltic composition which are arguably the proximal source of the HED meteorites, having reached one of Jupiter's resonances faster than the objects observed by [10] after which they quickly evolved into Mars crossing objects and then near-Earth objects. [11].

Conclusions: It seems that Nature has provided multiple free sample return missions to a unique asteroid. There is a conveyor belt of objects ejected from Vesta's surface stretching from Vesta to the 3:1 orbit-orbit resonance and into near-Earth space, with the near-Earth "Vestoids" being the proximal source of the HED meteorites.

References: [1] McSween H.Y, and Stolper E.M. (1980) *Sci. Am. 242, 54-63*. [2] Becker R.H. and Pepin R.O (1984) *Earth Planet. Sci. Lett. 69, 225-242*. [3] Drake M.J. and Righter K. (2002) *Nature 416*, 39-44. [4] McCord T. et al. (1970) *Science 168, 1445-1447.* [5] Stolper E.M. (1975) *Nature 258, 220-222.* [6] Righter K. and Drake M.J. (1997) *MAPS 32, 929-944.* [7] Consolmagno G. and Drake M.J. (1977) *Geochim. Cosmochim. Acta 41, 1271-1282.* [8] Binzel R.P. and Xu S. (1993) *Science 260, 186-191.* [9] Asphaug E. (1997) *MAPS 32, 965-980.* [10] Thomas et al. (1997) *Science 277, 1492-1495.* [11] Cruikshank et al. (1991) *Icarus 89, 1-13.*

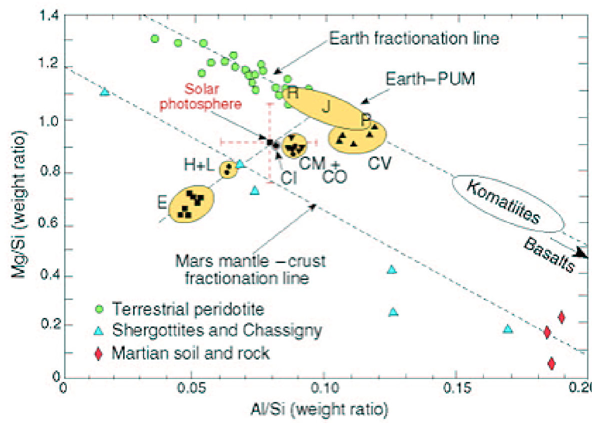

Figure 1. Mg/Si vs. Al/Si in primitive meteorites and Earth and Mars [3]. Note that Earth and Mars have distinct arrays implying different bulk compositions.

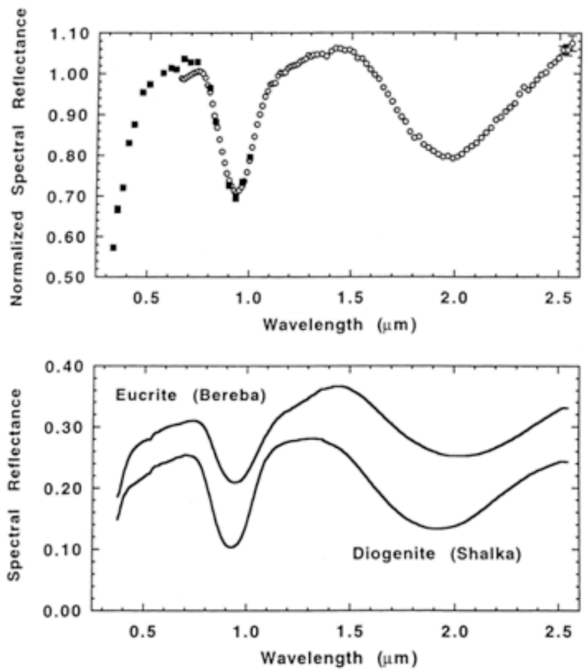

Figure 2. Modern reflectance spectra of Vesta (top panel) and eucrites (bottom panel) confirm the results of [4].

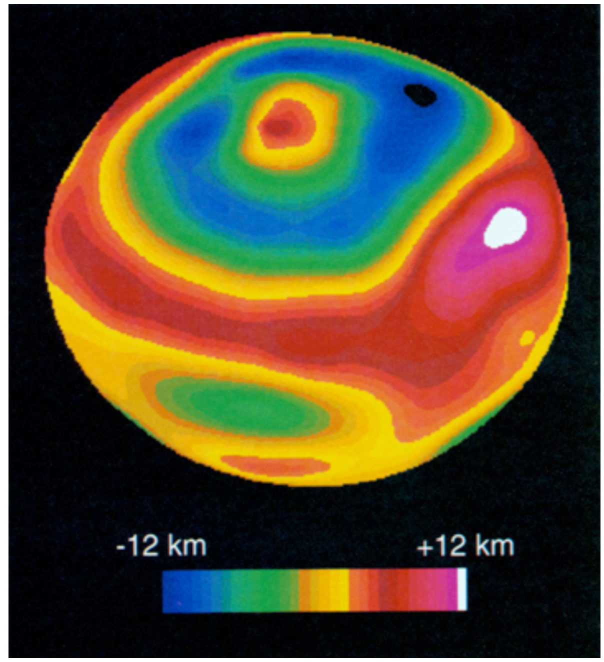

Figure 3. Hubble Space Telescope images of Vesta [[10]. Note that south is up in this image. A large crater surrounds the south pole.