MELTING ROCKS BY SHOCK: LOCALIZED SHOCK MELTING IN MARTIAN METEORITES AND TARGET ROCKS FROM THE MANICOUAGAN IMPACT STRUCTURE. E. L. Walton[1], J. G. Spray[2] and C. D. K. Herd[1], [1]Earth & Atmospheric Sciences, 1-26 Earth Sciences Building, University of Alberta, Edmonton, AB, T6G 2E3 Canada, [2]Planetary and Space Science Centre, Department of Geology, 2 Bailey Drive, University of New Brunswick, Fredericton, NB, E3B 5A3 Canada (email: ewalton@ualberta.ca).

Introduction: In the absence of a sample return mission, our current inventory of planetary materials exist largely as 'free' samples of asteroids, Mars and our Moon. These meteorites have been shocked as a result of the impact event that excavated them their parent body. At present, a number of unresolved or only partly resolved problems limit understanding of the impact cratering process, and the inferences concerning the evolution of our solar system and the exchange of material between planets, that can be drawn from them.

To date, there exist 32 samples in the world's meteorite collection that come from Mars. These rocks are from unknown locations on the Martian surface. Considerable research effort has been made to constrain this parameter through remote observation of Martian impact craters and surface mapping (relative surface ages), in addition to direct studies of shock effects recorded in Martian meteorites as well as numerical modeling of impact dynamics. This study presents observations of localized shock melting phenomena (pockets and veins) in two Martian lherzolitic shergottites: EET 79001 and ALH 77005. Shock-generated melt networks in target rocks located beneath the melt sheet of the ~100 km diameter, 214 Ma Manicouagan impact structure of Quebec, Canada [1, 2] have also been investigated. These rocks have been excavated from depth, now located in the central uplift zone [3].

Melt pockets occur as subrounded to rounded enclaves of silicate glass and crystals, distributed heterogeneously throughout highly shocked Martian meteorites. Melt pockets in meteorites have no known terrestrial equivalents. Comparison between localized melting phenomena in meteorite samples and naturally shocked rocks from terrestrial impact craters may provide important links that enable us to place the development of this type of shock response in a spatial context with an impact crater. This may enable us to relate the lofting site of meteoroids to favorable launch positions within source craters on other planetary bodies.

Analytical Methods: Polished thin sections of ALH 77005, EET 79001 and Manicouagan samples were initially investigated using optical microscopy (Fig. 1, 2). Detailed observation of shock melt textures utilized a JEOL 6301 field emission scanning electron microscope (FE-SEM) at beam operating conditions of 20 kV and a working distance of 7 mm. X-ray elemental maps and quantitative analyses were obtained using a JEOL 8900 microprobe equipped with 5 wavelength dispersive spectrometers (Fig. 3, 4).

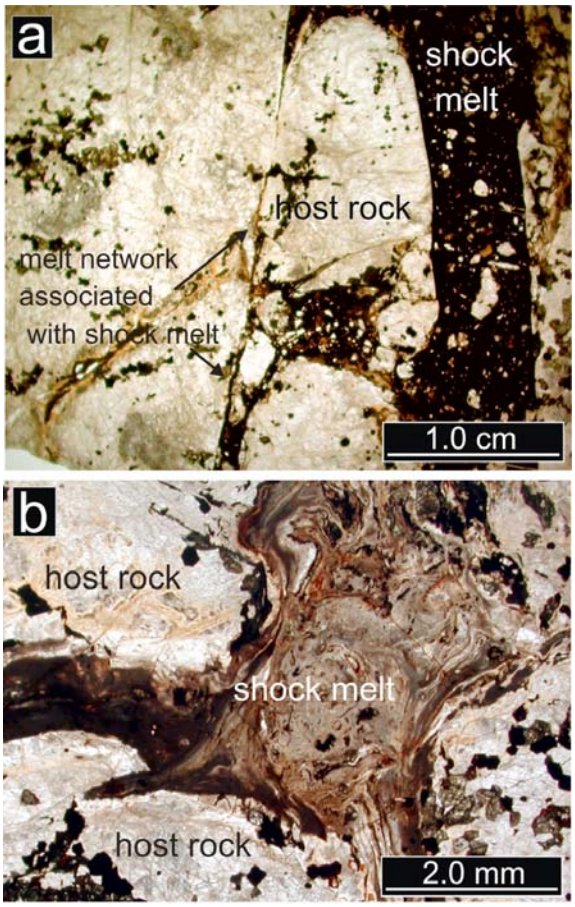

Fig. 1. Shock melts in target rocks from the Manicouagan impact structure, Quebec. (a) Optical photomicrograph showing the contact between melt networks and host rock. (b) Optical photomicrograph of schlieren-rich shock melts from the central uplift zone.

Petrography of shock melts: Based on detailed SEM BSE and EMPA, in conjunction with observations using optical microscopy, it is concluded that melt pockets in Martian meteorites form by local *in situ* melting of host rock minerals, as opposed to forceful injection of extraneous impact melt along fractures in the host rock.

Shock melts observed in target rocks from the Manicouagan impact structure are likewise interpreted to have formed by in situ melting associated with shock. Brecciation and melting associated with the passage of the shock wave, followed by rarefaction and decompression, are considered the prime energy sources.

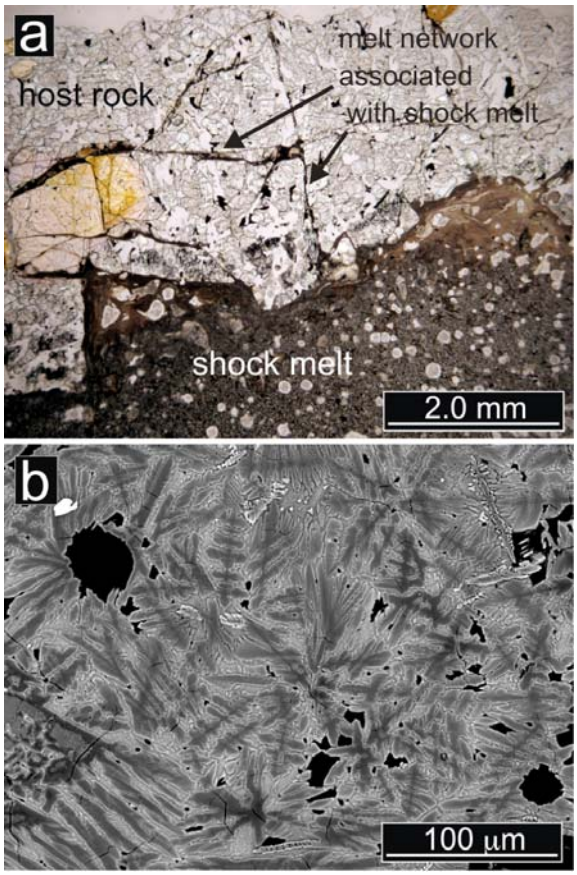

Fig. 2. Shock melts in EET 79001. (a) Optical photomicrograph showing the contact between host rock and shock melt, as well as the distribution of thin melt veins associated with the melt pocket. (b) Dendritic crystal shapes dominate the melt pocket texture (BSE photomicrograph).

Conclusions: In situ melting of target rocks have been observed in the Manicouagan impact crater, Quebec. Further studies of naturally shocked rocks from terrestrial impact craters may provide important information in context of the pre-launch location of Martian meteorites.

References: [1] Floran R. J. et al. (1978) *JGR, 83,* 2737-2759. [2] Dressler B. O. (1990) *Tectonophys, 171*, 229-245. [3] Spray J. G. and Walton E. L. (2005) *MAPS, 40,* Abstr. #5077.

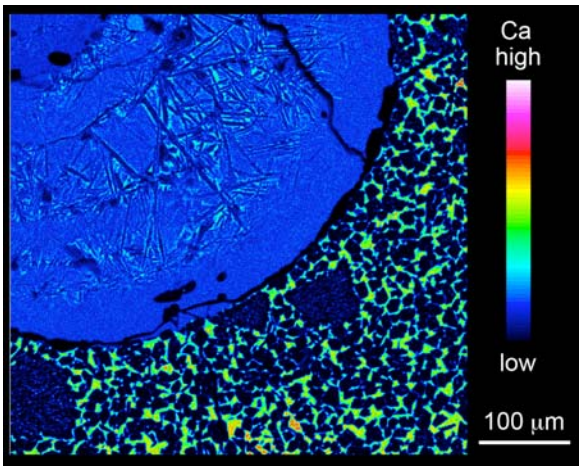

Fig. 3. Ca X-ray elemental map of a shock melt pocket in ALH 77005.

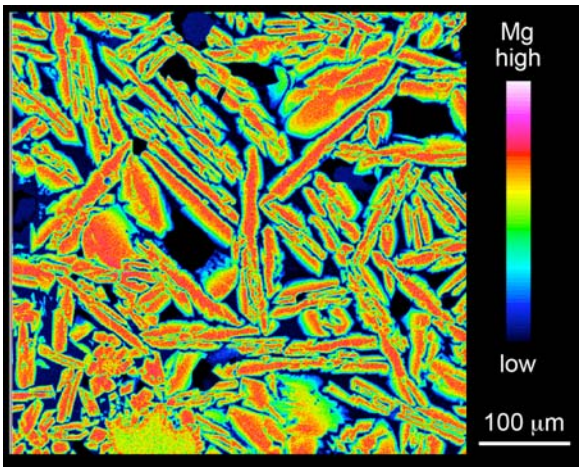

Fig. 4. Mg X-ray elemental map of a shock melt pocket in ALH 77005. Olivine crystals possessing crystal shapes indicative of rapid growth (swallowtail) are strongly zoned from Mg-rich cores to Fe-rich rims.