WHAT CAN WE LEARN ON VESTA FROM THE PETROLOGY OF IMPACT MELTS? J. A. Barrat[1], J. D. Bodenan[1,2], A. Yamaguchi[3], P. C. Buchanan[4], M. Toplis[5], C. Bollinger[1]. [1]UBO-IUEM, UMR 6538, place Nicolas Copernic, 29280 Plouzané Cedex, France, (barrat@univ-brest.fr), [2]Open University, PSSRI, Milton Keynes, UK, [3]National Institute of Polar Research, Tokyo 173-8515, Japan, [4]Kilgore College, 1100 Broadway, Kilgore TX USA 75662., [5]University of Toulouse, OMP, IRAP, Toulouse, France.

Introduction: Polymict eucrites and howardites frequently contain impact melt (IM) clasts and glassy spherules [e.g., 1]. These objects are interesting because they provide a complementary view of the composition of the surface of Vesta. Is the surface of Vesta covered only by howardite-eucrite-diogenite (HED) lithologies? Were some areas chemically modified by secondary processes such as metasomatism? These questions are very important and could be partly answered by the geochemistry of the impact melts. Here, we present a synthesis of petrographical observations and geochemical data (major and trace element abundances) obtained on these fascinating objects and we show that they provide valuable constraints on the geology of Vesta.

Geochemistry of the impact melts: A variety of impact melt types is found in HED polymict breccias, ranging from completely glassy objects (e.g., spherules) to vitrophyres, hyaloporphyric types, or finely crystalline rocks. We have focused our geochemical investigations on the most glassy or homogeneous samples, for which the bulk composition can be easily determined. Chemically, IMs are extremely diverse. However, they rarely display high Ni or Co abundances, indicating minor contributions of chondritic projectiles (<a few percent).

Low Fe/Mg IMs (FeO/MgO<5). Three types of low Fe/Mg IMs are arbitrarily defined: low alkali glasses, K-rich IMs (K_2O>0.2 wt%) and Na-rich IMs (Na_2O>0.6 wt%). Most of these IMs are scattered all over the HED field in diagrams involving ratios of nearly all refractory elements (e.g., Ca/Mg vs. Fe/Mg, fig. 1). The situation is very different for diagrams involving volatile or mobile elements such as Cs, Li, Na, Rb, P, and K, for which K and Na-rich IMs display compositions unlike any known HED meteorites. The compositions of most low alkali glasses are easy to explain by the total melting of typical HED targets with no significant loss of alkalies. The compositions of the other types are much more problematic, and three hypotheses can be suggested: 1/ their unusual compositions can be the result of vaporization-recondensation of alkalies upon impact, 2/ total melting of HED targets with compositions modified by secondary processes, and 3/ involvement of distinct K-rich or Na-rich lithologies.

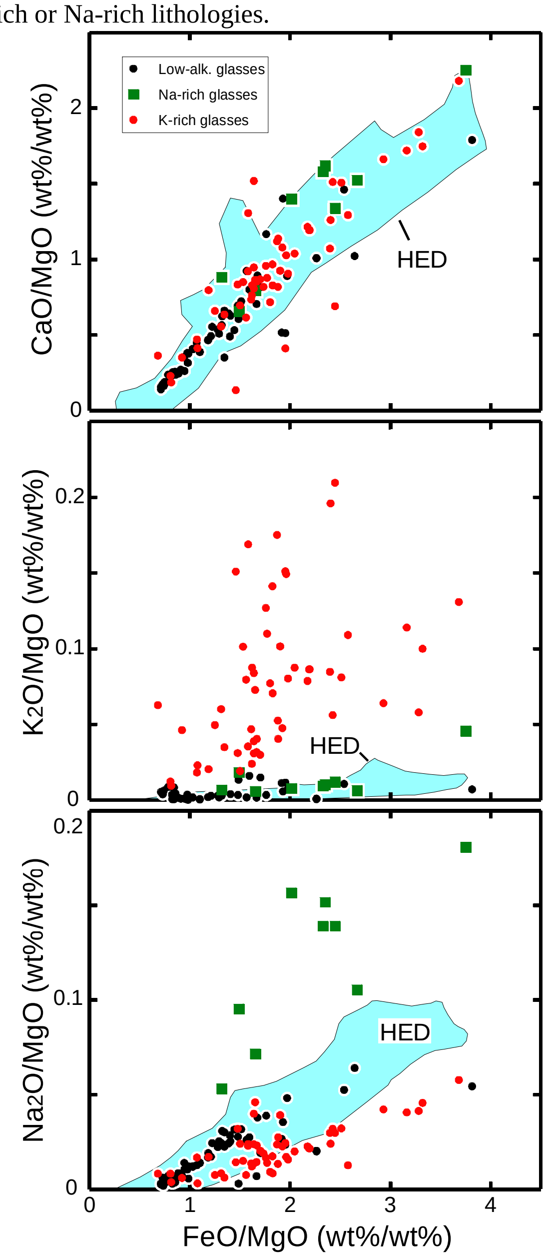

fig.1. CaO/MgO, K_2O/MgO, Na_2O/MgO vs. FeO/MgO plots for HEDs and low FeO/MgO IMs (this study and literature data, the references are too numerous to be cited).

High Fe/Mg IMs (FeO/MgO>>10). Two types of these rare IMs have been discovered. High-K felsitic glasses have been found in howardites by [2, 3] and strongly suggest that high-K evolved lithologies are present on Vesta. During the course of the study, we analyzed an unusual basic clast (SiO_2 50 wt%, FeO 17.8, MgO 1.08, Na_2O 1.4 wt%), and with relatively high REE abundances (Fig. 2)). This composition corresponds to a new and distinct lithology.

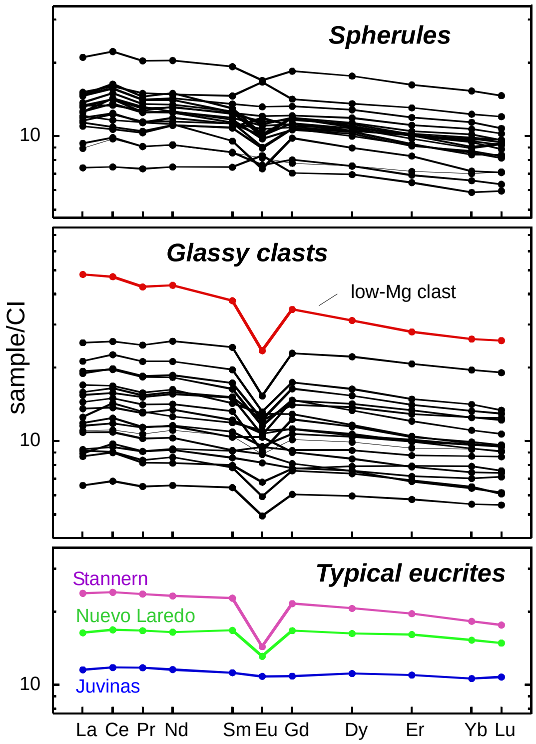

Fig. 2. REE patterns of selected spherules and impact melt clasts compared to typical eucrites (this study and 4). The low Mg-clast displays the highest REE abundances and is more LREE enriched than usual basaltic eucrites.

Our data strongly suggest that HED meteorites do not cover the full range of lithologies exposed on Vesta. It is not clear at present if the involvement of high Fe/Mg lithologies can explain the full spread of compositions shown by the low Fe/Mg IMs. Redistribution of volatile elements on the surface of Vesta is plausible and cannot be ruled out with the available data.

Metasomatism on Vesta. Quartz veinlets in Serra de Magé [5], Fe-enrichment along fractures in pyroxenes, and deposits of Fe-rich olivine and anorthite in some eucrites point to possible fluid/rock interactions [6, 7]. The composition of the metasomatic agent is at present not firmly identified but could be aqueous. Were the Fe-enrichments linked to very early events such as magmatic events? Were they linked to more recent events? The ages of the secondary phases have not been determined during the course of the previous studies.

In addition to eucrites, some IMs have been metasomatized, and display Fe-enrichments along cracks in pyroxenes [6]. Clast Q from EET 87509 is a fragment of a metasomatized IMs (Fig. 3). It has been dated by the Ar-Ar method, and [8] suggest that this melt cooled 4.05 (+/-0.02) Ga ago. Because the metasomatism postdates the formation of the IMs, this result shows that this process is not necessarily related (at least in this case) to the early igneous activity of the parent body. Because of the "young" age of clast Q, it is likely that the Fe-metasomatism results from post-impact processes, or accompanied a subsequent impact event.

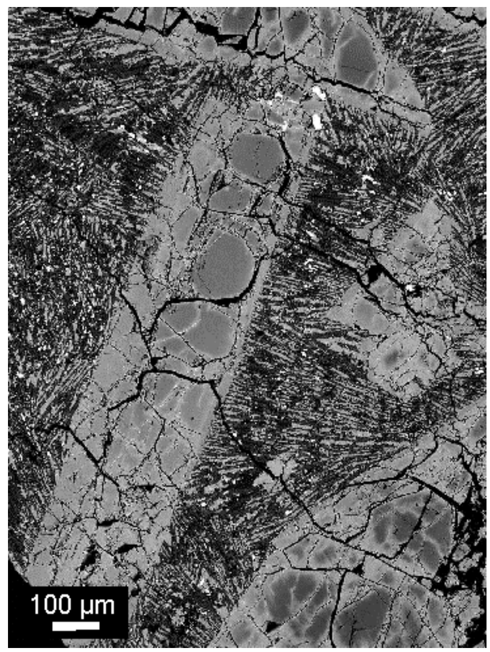

Fig.3. BSE image of clast EET 87509,62 (clast Q). This IM clast is a vitrophyre displaying large pigeonite crystals in a groundmass. The crystals are fractured and the Fe-enrichment along the cracks (light grey) is obvious.

References: [1] Noonan A.F. (1974) *Meteoritics 9*, 233-242. [2] Barrat J.A. et al. (2009), *Meteoritics & Planet. Sci. 44*, 359-374. [3] A. Beck et al. (2012) *Meteoritics & Planet. Sci*. (submitted). [4] Barrat J. A. et al. (2009) *Geochim. Cosmochim. Acta 73*, 5944-5958. [5] Treiman A. H. et al. (2004) *Earth Planet. Sci. Lett. 219*, 189-199. [6] Mittlefehldt D. W. and Lindstrom M. M. (1997) *Geochim. Cosmochim. Acta 61*, 453-462. [7] Barrat J. A. et al. (2011) *Geochim. Cosmochim. Acta 75*, 3839-3852. [8] Bogard D. D. and Garrison D. H. (2003) *Meteoritics & Planet. Sci. 38*, 669-710.