IMPACT GLASSES IN HOWARDITES: EVIDENCES FOR K-RICH LITHOLOGIES ON 4-VESTA. J. A. Barrat[1,2] , M. Bohn[1,2], Ph. Gillet[3] and A. Yamaguchi[4]. [1]Université Européenne de Bretagne, [2]UBO-IUEM, CNRS UMR 6538, place Nicolas Copernic, F-29280 Plouzané Cedex, (e-mail: barrat@univ-brest.fr), [3]CNRS UMR 5570, Université de Lyon, Ecole Normale Supérieure de Lyon, 46 Allée d'Italie, F-69364 Lyon Cedex 7, [4]Antarctic Meteorite Research Center, National Institute of Polar Research, 1-9-10 Kaga, Itabashi, Tokyo 173-8515, Japan.

Introduction: The howardite-eucrite-diogenite (HED) clan is a group of meteorites that probably originate from the asteroid 4-Vesta. Some of them, the howardites, are complex breccias that contain occasionally, in addition to typical eucritic and diogenitic fragments, impact melt clasts, glass beads or debris, whose compositions mirror that of their source regions. Some K-rich impact glasses (up to 2 wt% K_2O) found during the course of this study, demonstrate that in addition to basalts and ultramafic cumulates, K-rich rocks are exposed on the 4-Vesta's surface. Additional K-rich glasses, with a granitic composition, provide the first evidence of highly-differentiated rocks on a large asteroid. They can be compared to the rare lunar granites [1] and suggest that magmas generated in a large asteroid are more diverse than previously thought. These findings question our current view of planetesimal chemical differentiation in the early history of the solar system.

Samples and methods: In order to discuss the origin of glasses in HED, six glass-bearing howardites (Bununu, Kapoeta, Northwest Africa (NWA) 1664 and 1769, Yamato (Y) 7308 and 791208) have been selected. We determined the major-element compositions of the glasses by electron microprobe analysis using mainly a Jeol JXA8200 at NIPR, Tokyo, and a Cameca SX100 at Ifremer, Plouzané. All analyses used wavelength dispersive spectrometers at 15 KV accelerating voltage, 10-12 nA beam current, and in most cases a spot size ranging from 10 to 30 µm. The structure of some of the beads has been investigated by Raman spectrometry using a Labram HR800 model of Jobin-Yvon Horiba spectrometer equipped with a microscope for collection of backscattered Raman signal and equipped with a CCD detector (ENS, Lyon).

Results: More than fifty glassy clasts or spherules have been analyzed. Three chemically different types of glasses have been recognized (fig. 1):

-Glasses from Bununu, Kapoeta, Y-7308 and Y-791208 display a wide range of compositions, with Mg# (=100 x Mg/(Mg+Fe), atomic) from 41 to 72 (including data from [2-6]), that overlap those of eucrites and howardites. These glasses are K-poor, with K_2O generally less than 0.1 wt%.

-Mafic glasses found in NWA 1664 and NWA 1769 display a range of compositions similar to the previous ones, with Mg# from 35 to 66, but some of them contains significantly less Ca and Na than expected for typical HED lithologies. More importantly, they are unusually K-rich, with K_2O concentrations ranging from 0.18 to 2.33 wt%. High-K abundances were previously noticed in glasses from NWA 1664 [7], and from the Malvern howardite [8,9]. These K-abundances are much higher than those reported for most of the HED, which contain in most cases less than 0.1 wt% K_2O.

-A silica-rich glass has been found in a fragment of a spherule from NWA 1664, and displays high K_2O abundances ranging from 4 to 6.12 wt%. The compositions correspond to a high-K, low Na monzogranite. Interestingly, this glass resembles the lunar granites, but exhibits much higher Al_2O_3 abundances (about 18 wt% compared to 8.8-13 wt% in the lunar granites [1]).

The compositions of impact glasses in howardites strongly suggest that they formed by melting of howardite to eucrite-like targets [2-6, 8-9]. Indeed, calculations indicate that their major element compositions are correctly reproduced by mixing involving three endmembers: a diogenite, a cumulate eucrite and a low-Mg# eucrite. The origin of K-rich glasses is more complex, and require the contribution of at least an unusual component either from the impactor or the impacted area. The first hypothesis is unlikely because many of the impact glasses studied here contain much more K than all chondritic or achondritic meteorites. Therefore, their high-K concentrations are certainly linked to the compositions of the molten lithologies. The very good correlation obtained for the NWA 1664 and NWA 1769 glasses in a K_2O/CaO vs. Al_2O_3/CaO plot rules out condensation/volatilization processes, and confirm the presence of K-rich components in their source region (fig. 1). This conclusion is strengthened by the occurrence of a granitic glas in a spherule, whose composition can potentially explain part (but not all) of the scattering of the data from the HED field (fig. 1).

The implications of this work are twofold. Firstly, some of impact glasses observed in howardites formed from evolved lithologies unknown in the HED collection. They could have been ballistically transported from distant impact sites and mixed to the regolith before the impact responsible for the launch of the meteorites from the parent body. Consequently, these glasses may originate from terrains not directly sampled by typical HED meteorites. They could therefore provide, in addition to the remote sensing observations, a complimentary view of the composition of the surface of the 4-Vesta asteroid. Secondly, magmas generated in a large asteroid are more diverse than previously thought. The K-rich impact glasses found in howardites indicate that the rocks that outcrop on Vesta are not restricted to a series of mafic cumulates and basaltic flows, and we speculate that granites and rocks more evolved than those actually known in the HED collection will probably be observed during the surface mapping of Vesta by the Dawn spacecraft.

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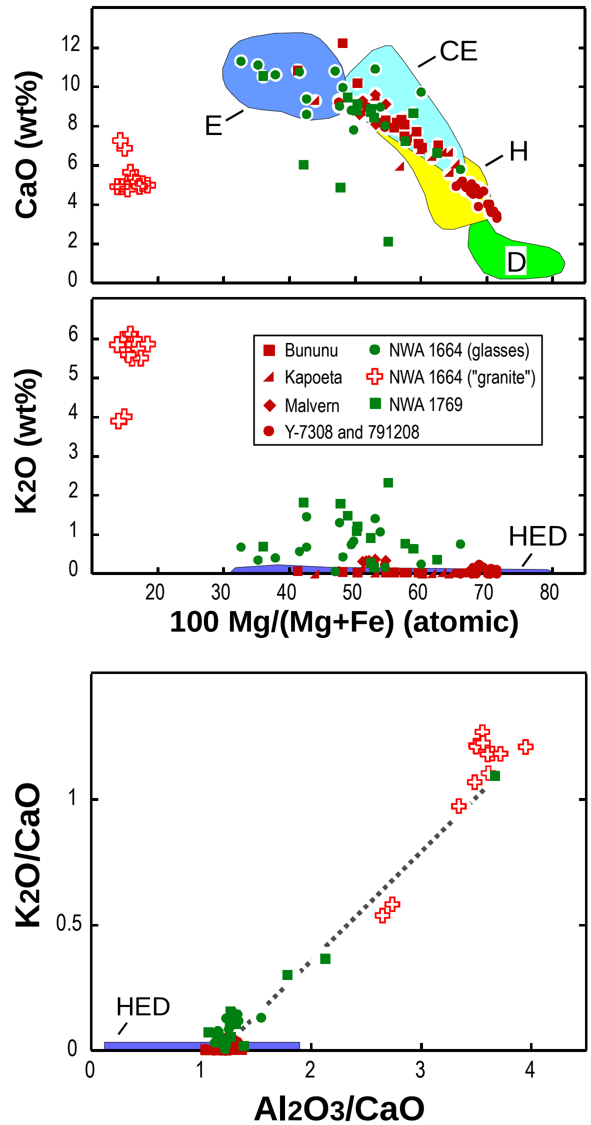

Fig. 1. CaO, and K_2O (wt%) vs. 100 Mg/(Mg+Fe) (atomic), and K_2O/CaO vs. Al_2O_3/CaO (wt%/wt%) plots for impact glasses from howardites (this study and [2-6, 8-9]). The fields for eucrites (E), cumulate eucrites (CE), diogenites (D), and howardites (H) are drawn mainly from references in [10-11].