ADAPTED MODIFIED GAUSSIAN MODEL: NO DETECTION OF OLIVINE IN REGIONS PREDICTED TO BE MANTLE-RICH FROM MODELS OF PLANET-SCALE COLLISIONS.
H. Clenet[1], M. Jutzi[2], J.-A. Barrat[3] and Ph. Gillet[1], [1]Institute of Condensed Matter Physics, Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland (harold.clenet@epfl.ch), [2]Physics Institute, University of Bern, Switzerland, [3]Université de Bretagne Occidentale, Institut Universitaire Européen de la Mer, France.

Introduction: Despite many studies on the Howardite-Eucrite-Diogenite (HED) meteorite suite, the internal structure of asteroid 4-Vesta is still debated. Some studies favor the hypothesis of a global magma ocean, leading to a layered structure and a relatively thin crust [e.g. 1]. Other petrological and geochemical evidences tend to favor a more complex structure, involving intrusions, which also implies a thicker crust [e.g. 2]. Recent data from the Dawn mission now shed a new light on this question.

Dawn's global mapping have revealed that the south polar depression is actually composed of two overlapping basins, Veneneia and Rheasilvia [3]. While only one impact cannot excavate rocks from deep, the most recent numerical simulations taking into account both events show that rocks exposed in the Rheasilvia region could come from a depth of much more than 40 km [4,5]. In the case of a thin crust, a succession of two impacts would have then surely digged into the mantle, producing large outcrops of olivine-rich rocks.

The Dawn spectrometer (VIR) is perfectly designed to detect mafic minerals [6]. However, no trace of olivine has been found up to now in the southern hemisphere [7,8]. It is nevertheless true that detecting olivine on the surface of Vesta is challenging [9].

An adapted version of the Modified Gaussian Model (MGM, [10]) has been recently developed to take into account the olivine-pyroxene(s) mixtures [11]. This procedure has been successfully applied to Mars

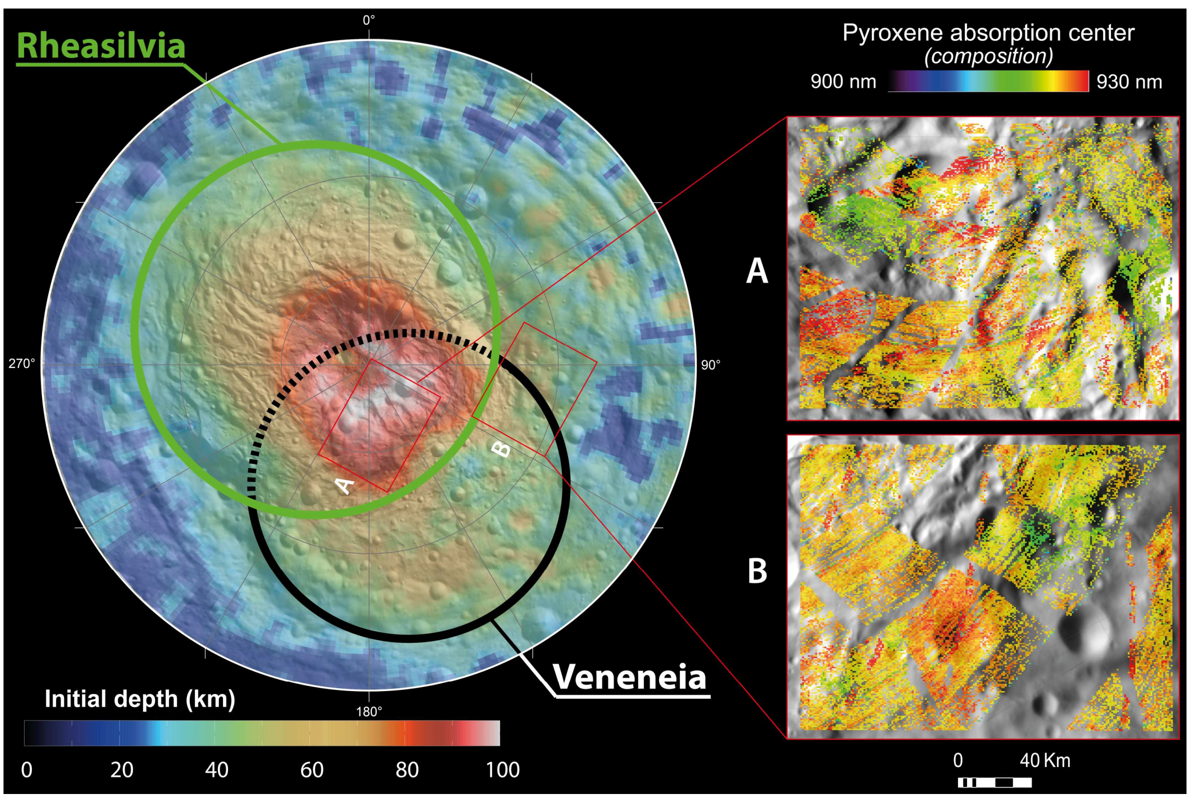

Fig. 1: Pyroxenes composition in the two areas tested. Left: Localization of the two zones relatively to Rheasilvia and Veneneia basins and to the initial depth of the rocks before impacts (determined from numerical simulations [4]); Right: Results of the adapted MGM procedure for the pyroxene absorption center at 1 µm. Region A corresponds to rocks supposed to come from the deepest while region B refers to a spot enriched in diogenite-like lithology [8]. In both areas, no olivine has been found.

[12] and the Moon [13]. Here we test this approach on VIR images in the Rheasilvia region to search for olivine and characterize pyroxenes compositions.

Data selection and processing: The VIR images were first processed through the classical ISIS pipeline. We include a photometric correction using parameters from [14,15,16]. Bad pixels were also filtered using the associated quality cubes. The combination of VIR visible and near-infrared was done after shifting the visible part to correct any geographical misalignment between the two detectors. Conversion to I/F was done using Kurucz solar irradiance spectrum resampled at VIR-IR sampling and resolution. Finally all the VIR images have been projected and assembled in a mosaic covering all the southern hemisphere of Vesta.

Due to the waiting period before the public release of the VIR dataset and the computing time required to run the MGM, we choose to focus on two particular areas (Figure 1). The first one, labelled A, corresponds to the place where we expect to find the rocks that come from the deepest, up to more than 80 km, according to [4]. The second place, labelled B, refers to a spot enriched in diogenite-like lithology according to [8]. Both areas are places where outcrops of rocks containing olivine could occur.

We then applied there our MGM procedure. MGM is designed to deconvolve absorption bands in reflectance spectra using a series of Gaussian functions and a spectral continuum modeled by a polynomial shape. An automated procedure involving different numbers of Gaussians, depending on the potential complexity of the mixture, has been implemented (all the details can be found in [11]). The resulting band parameters (center, strength, width) are finally used to interpret the spectrum in terms of modal abundances and chemical compositions.

Results: Before applying our MGM procedure blindly on the VIR dataset, we tested its capabilities on few HED spectra described in [17]. MGM results show that we were successfully able to predict the presence of olivine in two harzburigtic diogenites (NWA4223 and NWA5380).

We then applied our MGM procedure on the two selected areas. The first result is that we were unable to find any trace of olivine in accordance with observations made by the Dawn team.

Pyroxenes absorption centers, deducted from Gaussians parameters, fall within the HED fields as defined in [7,8]. Most of our detections corresponds to diogenite or howardite. We plot in Figure 1 the two maps of the absorption centers at 1 µm. In both areas, variations are observed at a local scale and on almost the same range of values. Those local variations seem to be mainly related to the distribution of small impact craters excavating the shallow subsurface. At first order, there is no evidence that a relationship between the very local surface composition observed today and the initial depth of rocks exists, or it has been masked by the late impact gardening. This relationship is only observed at the asteroid scale, as seen on the maps in [8].

Conclusion: The lack of olivine detection in the Veneneia/Rheasilvia region implies that olivine, if present, do not represent a large fraction of the whole rocks. This argue against the idea that mantle is excavated in this region. Considering the depth of excavation predicted in the case of two impacts, our results would favor the hypothesis of a thick crust with a crustal thickness of more than 80 km.

We now plan to extend the MGM processing to the rest of the mosaic. This will improve the statistics on pyroxenes compositions. In the same time, we will look at the olivine-rich region found very recently by [18] in the northern hemisphere. We will try to characterize their chemical composition to check how those detections relate to olivines in HED.

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