MINERO-PETROLOGIC INVESTIGATION OF BONINITES FROM CYPRUS ISLAND AS POTENTIAL ANALOGUES OF MERCURY LAVAS.

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Introduction: Despite the clearly different conditions during their formation, in terms of oxygen fugacity and water contribution, terrestrial boninites and komatiites are considered good candidates as analogues of Mercury lavas on the basis of MESSENGER Mission XRS and GRS measurements on Mercury's surface [1 and references therein].

The aim of this work is to make a comparison between terrestrial boninites and Mercury lavas taking into account geochemical and petrological features pertaining to these rocks, as well as their mineralogy. In fact, the mineralogical characterization of potential analogous materials could be used in the future for comparison with the mineralogical information expected from SIMBIO-SYS and MERTIS instruments on board of the BepiColombo mission [2]. So far, we investigated the mineralogy and petrology of some boninites samples from the Troodos Ophiolite (Cyprus).

Materials and methods: The boninites samples under investigation come from three different localities of the Troodos massif, corresponding to different geological units [3,4]. We chose one representative sample, with a relatively low weathering, for each locality (labeled PAR, ARA and ATH) and we performed X-ray Fluorescence (XRF), scanning electron microscope (SEM) and electron microprobe (EPMA) analysis.

Results: The bulk compositions obtained with XRF analysis (and EPMA analysis on the glass portion of PAR sample, labeled as G) confirmed that the samples are boninites, since they have SiO_2> 52 wt%, MgO> 8 wt% and TiO_2< 0.5 wt% [4,5]. The compositional range of all the three sample is: SiO_2 52.0-54.4 wt%, Al_2O_3 8.9-14.7 wt%; FeO 7.5-8.3 wt%; MgO 8.9-17.8 wt%; CaO 5.8-12.5 wt%; Na2O 0.5-5.0 wt%; TiO_2 0.2-0.3 wt%; K_2O 0.1-0.2 wt%.

The average compositions of each investigated sample were compared with the average compositions of Mercury's geochemical terranes as derived from MESSENGER data [1] and with the average compositions of other samples from Cyprus [6]. We can observe (Fig.1) that our samples present SiO_2 and Al_2O_3 contents right in the ranges of Mercury's terranes, with, on average, a slightly lower MgO abundance and a slightly higher CaO abundance; the only major difference is the higher FeO content, as expected.

The compositional differences observed between the three samples reflect the different mineralogy. Sample PAR shows vitrophyric texture with olivine and clinopyroxene phenocrysts in glassy groundmass (Fig.2). Glass average composition is: SiO_2 57 wt%; TiO_2 0.3 wt%; Al_2O_3 19 wt%; FeO 5 wt%; MgO 2 wt%; CaO 9 wt%; Na_2O 1 wt%; K_2O 0.2 wt%. Olivine phenocrysts (average composition Fo_{89}), up to 300 μm, often show zoning with an increase of FeO content (10 wt% to 18 wt%) from cores to rims and some of them have an augitic rim ($En_{28}Wo_{51}Fs_{21}$). Clinopyroxene phenocrysts have elongated, up to 600 μm in length, and often skeletal shapes (average composition $En_{48}Wo_{38}Fs_{14}$), or they are present as not elongated smaller (max 50 μm) grains (average composition $En_{64}Wo_{24}Fs_{12}$). In both cases crystals show zoning with an increase of CaO (6 wt% to 19 wt%) from core to rim. Abundant clinopyroxene acicular microcrystals (average composition $En_{34}Wo_{42}Fs_{24}$) are present in the glass. Plagioclase crystals are not detected. Opaque minerals are represented mostly by chromite, commonly as inclusions in olivine, and pyrite, as inclusion in clinopyroxene microcrystals. Only minor weathering is visible, and sporadic calcite grains, up to 500 μm, were detected.

Sample ARA is composed of clinopyroxene phenocrysts (average composition $En_{47}Wo_{30}Fs_{13}$) up to 300 μm in an albitic groundmass ($Ab_{98}An_2$). Weathering is clearly visible in this sample with olivine phenocrysts being completely altered in clinochlore. Minor micrometric titanite grains are present. Opaque minerals are mostly represented by Fe-Ti oxides, with minor pyrite.

Sample ATH is holocrystalline and composed by euhedral clinopyroxene (average composition $En_{48}Wo_{42}Fs_{10}$) and orthopyroxene crystals (average composition $En_{82}Wo_4Fs_{14}$) up to 300 μm surrounded by plagioclases presenting a wide range of composition (from $Ab_{97}An_3$ to Ab_7An_{93}). Occasional micrometric titanite grains were observed. Some areas of this sample are interested by important alteration. No olivine is detected. Opaque minerals are Fe-Ti oxides and chromite, as inclusion in pyroxene.

Discussion and future work:

According to these preliminary results, one of the investigated samples (Sample PAR) have bulk composition, mineralogy and texture typical of boninites [7] with no evidence of important alteration. This sample will be used for future experimental petrology work with the aim of studying minero-petrologic features of these materials at the condition of formation expected for Mercury lavas, in particular oxygen fugacity conditions.

Further investigations (e.g. EBSD, LA-ICP-MS, VNIR reflectance and TIR emittance spectroscopy) are ongoing on these samples to complete the minero-petrologic characterization and to consider for a comparison with remote sensed data. Also, the dataset will be implemented with the study of more boninites samples from the Troodos massif and from other localities (e.g. from Izu-Bonin for-arc) that will be investigated with the same analytical techniques.

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References:

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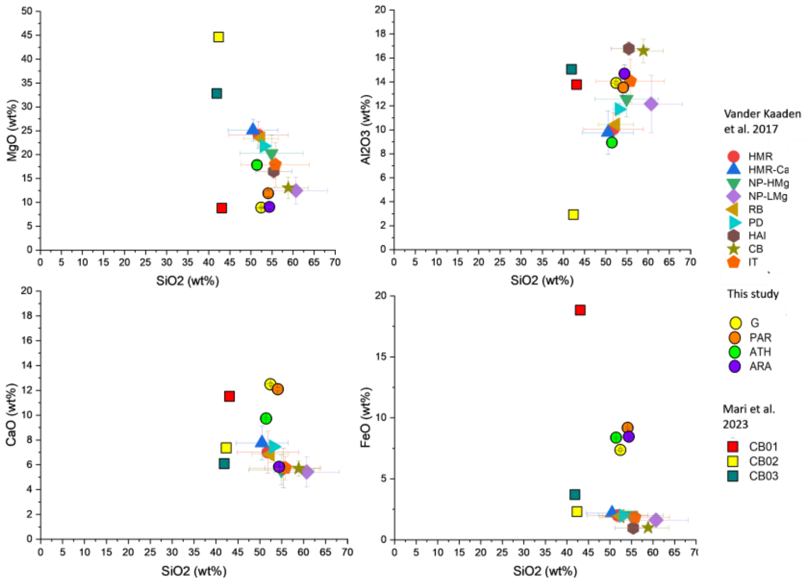

Fig.1. Average bulk compositions of boninite samples investigated in this study (G, PAR, ARA, ATH) and average composition of other samples from Cyprus (Mari et al. 2023) compared to the average compositions of Mercury's geochemical terranes (Vander Kaaden et al. 2017). HMR= high-Mg region; HMR-CaS= high-Mg region with highest Ca and S; NP-HMg= northern volcanic plains with high Mg; NP-LMg= northern volcanic plains with low Mg; RB= Rachmaninoff Basin (RB); PD= pyroclastic deposits; HAI= high-Al region; CB= Caloris Basin; IT= intermediate terrane.

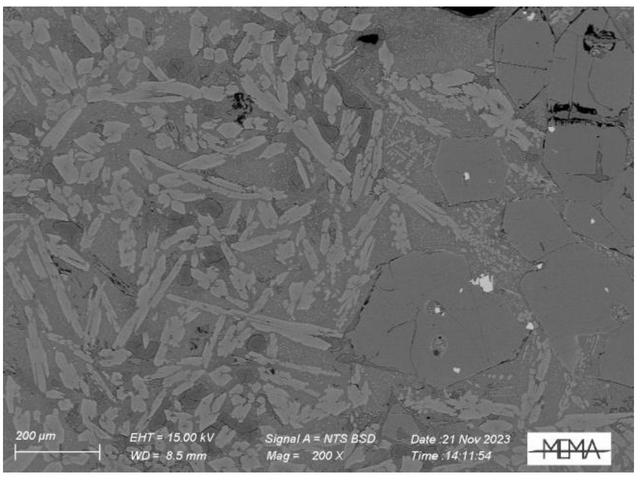

Fig. 2. BSE images of Sample PAR. Olivine phenocrysts show chromite and melt inclusions. Clinopyroxene is present as elongated and not-elongated zoned phenocrysts and as acicular microcrystals in glass