VNIR and TIR SPECTRA of TERRESTRIAL KOMATIITES POSSIBLY ANALOGUES of SOME HERMEAN TERRAIN COMPOSITIONS?

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Introduction

The new MESSENGER data show regions proposed as possibly komatiitic lava flows in the hermean surface [1]. The GammaRay and XRay spectrometers data (onboard MESSENGER mission) provide elemental abundances and show some regional variations (e.g. northern smooth plains vs. older surrounding terrain) [2,3]. On the other hand, VNIR spectroscopy from the MASCS data [4] and Earth-based measurements [5] still high-lighting some surface variations, have not shown any Fe^{2+} absorbtion features. Comparison of Mg/Si, Ca/Si, Al/Si ratio (derived from GammaRay and XRay spectrometers) with terrestrial rocks shows a quite good fit with the composition of terrestrial komatiite and basalts [2,3]. In particular, komatiite has been proposed because several surface's features were interpreated to have formed emplacement in a flood-effusive style coupled with thermal erosion [1].

In this work we present spectra of komatiite and komatiitic basalt from Gorgona in both VNIR (reflectance) and TIR (emissivity) wavelength range. These are the spectral ranges that will be investigated by two different instrument (SIMBIO-SYS and MERTIS) on the BepiColombo mission to Mercury [6].

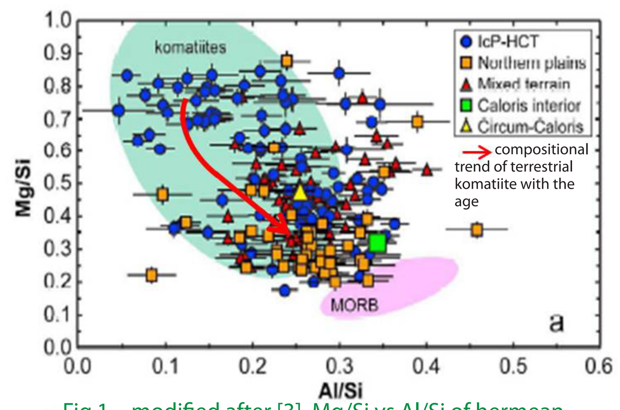

Fig.1 - modified after [3]. Mg/Si vs Al/Si of hermean terrains and terrestrial rocks. Terrestrial komatiites show a trend respect the age (red arrows).

Samples

Komatites are defined as an "High-Mg volcanic rocks" with a 52%>SiO2>30%, MgO>18%, (Na2O+K2O)<2% and a TiO2<1% [7], but also for the presence of a particular texture, defined, by plate-like crystals of olivine (spinifex texture) [e.g. 8]. Considering the ratios used by [2] and all the komatiite composition dataset from Geochemical Rock Database, we chose samples with ratios closer to the Mercury's norther plains. These samples were collected in the Carribean plateau at Gorgona's island, which is known for its upper Cretaceous ultramafic rocks sequence (~90Ma in age) [see 9 and reference therein]. Three "quite fresh" samples were selected and they were prepared as slab of rock and as powder at two grain sizes (<125, <250 µm). Moreover orthogonal surfaces were exposed on komatitic samples to investigate how the spinifex texture influences the VNIR spectra data. We measured both reflectance in VNIR and emissivity in the TIR, the spectral ranges where the BepiColombo mission will investigate the mineralogy of the hermean surface with VIHI (Visible Infrared Hyperspectral Imager Channel) and MERTIS (MErcury Radiometer and Thermal Infrared Spectrometer) [10,11].

Fig.2 - a) Example of a spinifex texture from [8], b) Picture of a spinifex lava flow from [15]. In both of these cases spnifex texture is evident in a macro scale. c) Example of a komatiitic lava flow, lamirar or turbulent sheet and succesive formation of lava channe are described as well as the formation of the thermal erosion processes [16].

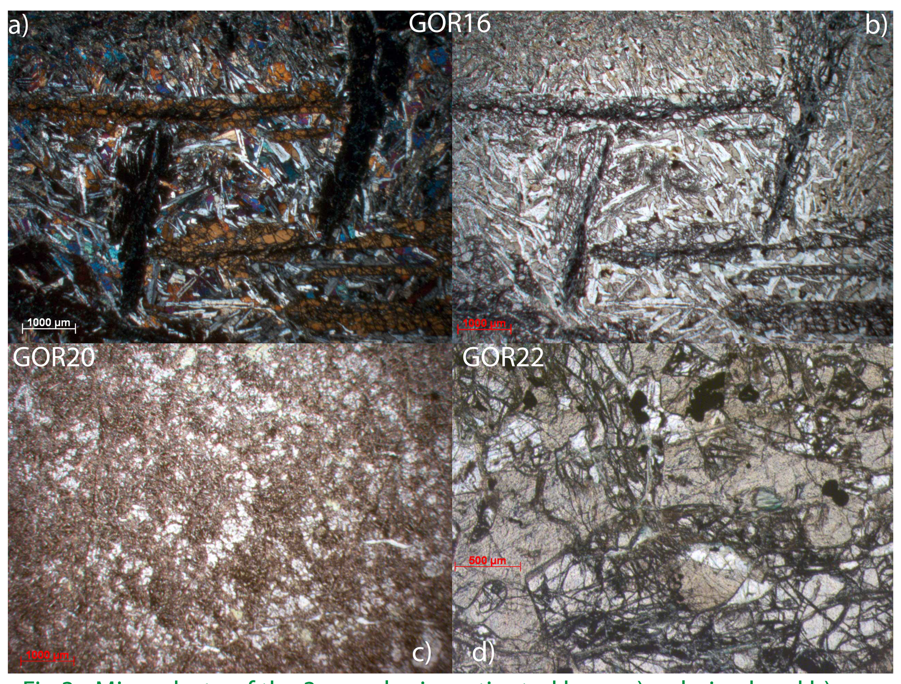

Fig.3 - Microphoto of the 3 samples investigated here. a) polarized and b) parallel light of a Komatiite, GOR16; c) parallel light of a komatiitic basalt, GOR20, d) parallel light of a Komatiite, GOR22. The petrography and mineralogy of these rocks were characterized by **[15].**

VNIR reflectance

The bidirectional reflectance spectra were measured with a Fieldspec-Pro spectrophotometer mounted on a goniometer in use at the Institute of Space Astrophysics and Planetology, INAF, under standard laboratory conditions. The spectra were acquired with 1 nm spectral sampling between 0.35 and 2.50 µm, and with i=30° and e=0°. The source used was a QTH lamp. The calibration was performed with Spectralon optical standard (registered trademark of Labsphere, Inc.). The illuminated spot was ca. 0.5 cm^2.

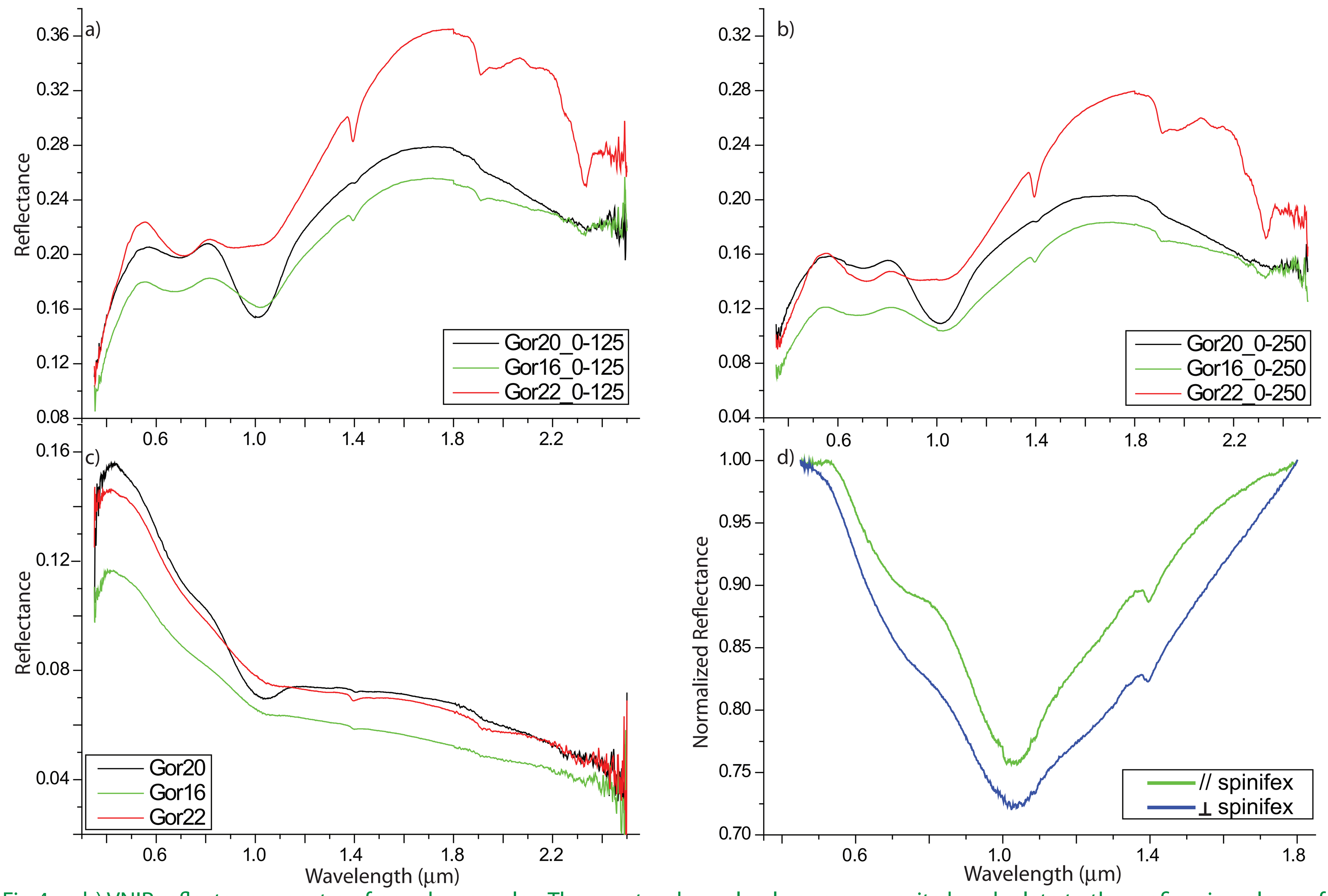

Fig.4 - a,b) VNIR reflectance spectra of powder samples. The spectra show clearly one composite band relate to the mafic mineralogy of both komatiitic and basaltic samples. The komatiitic basalt slighlty differentiate at 1 mm were Cpx absorption is more evident. c) Slab spectra show a typical blue slope with a wide 1 mm band, still the basaltic samples show a better define 1 mm absorption. d) Continuum removed averaged spectra of GOR16 on two different direction (//parallel and ⊥ orthogonal show the same mineralogical information with a sligth diferance in the absorption structure. Further investigatio are needed to associate this with the spinifex structure.

TIR emissivity

The emissivity spectra were measured at the Planetary Emissivity Laboratory, DLR using a Bruker VERTEX 80V Fourier Transform Infrared, operating under vacuum to remove atmospheric features. The Bruker is coupled to a planetary simulation vacuum chamber that allows measurements at different temperatures. In our experiments we measured each sample at low T (ca.70°C), intermediate T (ca.250°C) and high T (ca.450°C).All the spectra have a Christiansen features (C.F.) at a similar position, ca. 8.07 µm, indicating a similar basic composition. Also the restrahlen band shows similar minima position for all the samples, with very small variations.

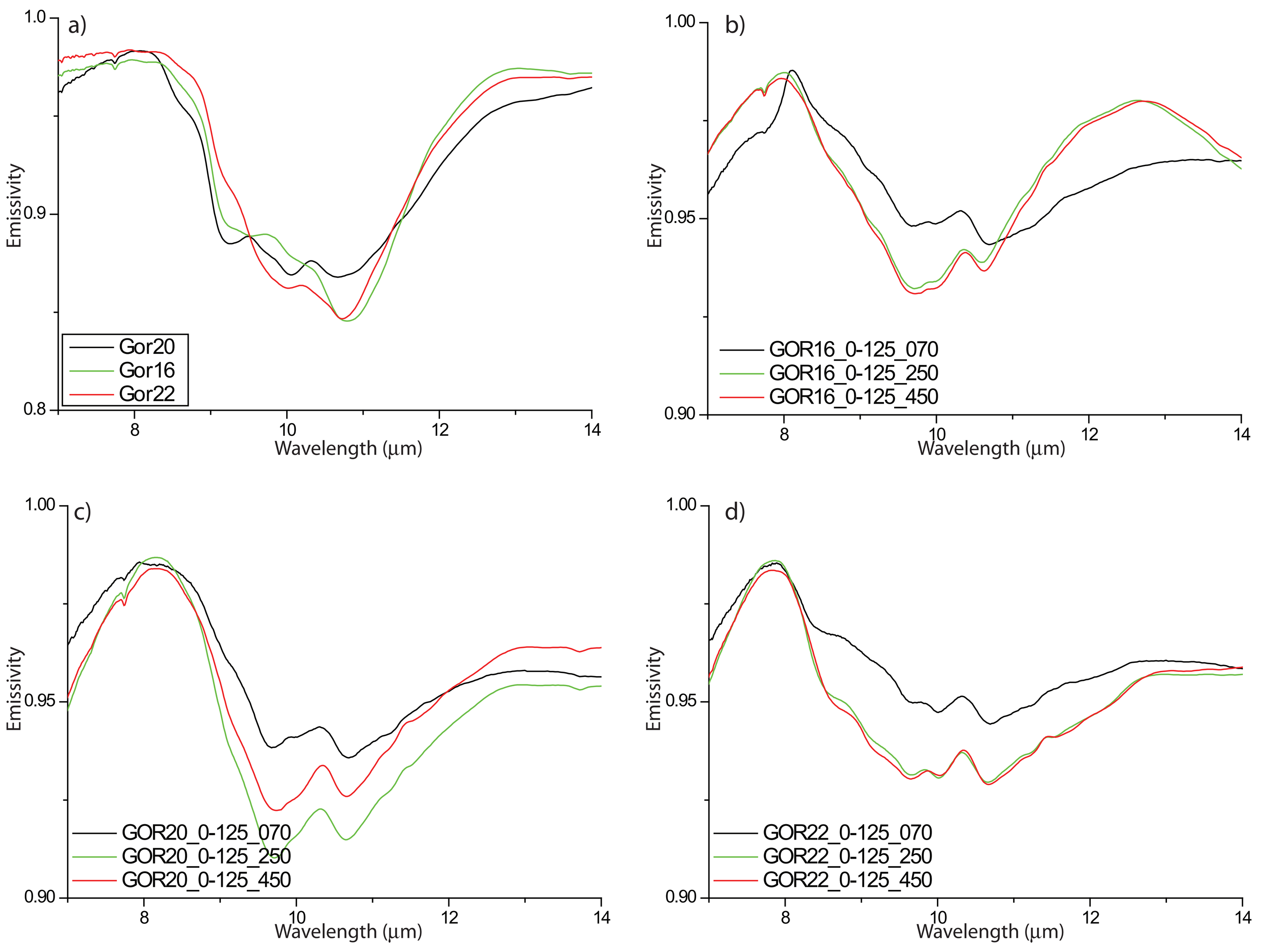

Fig.5 - a) TIR spectra of slabs at ca. 450°C. Spectra show an absorption band at ca. 10 µm with similar minima. Komatiite and basalt are not differenziable. b,c,d) TIR spectra of powders (<125 µm) at 3 different T. C.F. and Restrahlen band are in similar position. Sample GOR22 show a slight different behaviour in the region between 8.5 and 10 µm. Restrahlen minima slightly vary with the T (Δ=___), and a clear variation it is present in the 12-14 mm region, where at higher T for sample with finer crystal size GOR16 and GOR 20 the emissivity is higher the of 70°C spectra.

Discussion and preliminary results

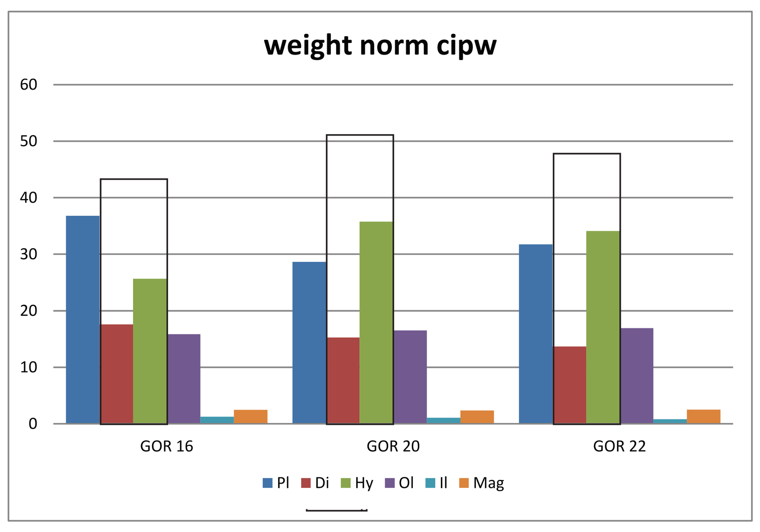

Fig.6 - Weight norm CIPW. The mineral phase calculated from the bulk rock composition [14] show a similar variation on the major mineral phases, the basalt GOR20 have a slightly higher amount of pyroxenes (Di+Hy) and lower plagioclase.

Pl=plagioclase, Di=diopside (high-Ca pyroxene), Hy=hyperstene (low-Ca pyroxene), Ol=olivine, Il=ilmenite, Mag=magnetite.

Terrestrial komatiitic samples that have Mg/Si, Ca/Si, Al/Si ratio comparable to some hermean terrains show clear information of their mafic mineralogy, due to the presence of FeO (ca. 10 wt%). The iron content is still an open question on the Mercury crust due to the absence of 1 µm band [4,5], but high neutron absorbtion [12]. Recent Xray data show as a etereogeneous amount of iron on the surface can be present, even if probably low [3]. Flood lava flow are generally characterized by high Mg, and low Si, but on terrestrial samples higher amount of iron are generally present compare to those predict for Mercury surface. Considering the komattiite ratios of Mg/Si, Ca/Si, Al/Si without the tipical iron content should imply higher value of Si, or higher abundance of other elements. If so the question will be if those compositions will still be compatible with features interpreated to have formed emplacement in a flood-effusive style coupled with thermal erosion [1].

Moreover from our preliminary work it is clear that komatiite and basalt, with similar composition, can not be easily differentiated from VNIR (Fig.4) and TIR (Fig.5) spectroscopy. Even if the slightly higher abundance of piroxenes, compare to olivine (Fig.6), and a similar crystal size of those phases in the basaltic samples (Fig.3), permit to better define the pyroxene 1 µm band (GOR20), whereas in the other samples the olivine absorption is more influent. Even in the TIR, different samples spectra show similar absorption. Anyway some spectral indications could help to potentially separate areas with different characteristics. Preliminary measurements on slab with parralel and orthogonal cuts to the spinifex show small variation in the 1 µm absorption band (Fig.4d).

Future works

Quantitative analisys of the VNIR and TIR spectra of this samples will be performed to compare with their actual mineralogy and petrography. Moreover spectra in the VNIR of the orthogonal surfaces, parallel and perpendicular to the spinifex orientation, can provide information to relate to mineral iso-orientation in komatiitic samples. A spectral mapping with high spatial resolution (ca. 40 µm/pixel) with SPIM facility [13] will be useful for this goal. The emissivity of these rocks acquired at different temperatures will be deeper investigated to highlight if the variations in the position of spectral minima, as already shown for olivine by [12], can be sistematically relate to one prevalent mineral phase or must be consider the influece of all the spectra phases.

References

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