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Search for olivine in the Vesta surface from the Dawn-VIR hyperspectral data

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Abstract

We study the possibility to discern the infrared spectral signature of olivine in pyroxene based multimineralic mixtures. Different spectral indexes are selected and tested onto laboratory controlled spectral set of mixtures. The best index able to detect even low amount of olivines, will be applied to the VIR-Dawn dataset to search for olivine on the surface of Vesta.

1. Introduction

The occurrence of olivine on Vesta was postulated from petrogenetic models [1] and confirmed by their presence as a minor component in some samples of diogenite meteorites and as mineral clasts in howardites [2]. Ground-based and Hubble Space Telescope observations also suggested the presence of local olivine-bearing units on the surface of Vesta [3].
Dawn's Visible and Infrared spectrometer (VIR) [4] has been acquiring hyperspectral images (0.25-5.1 µm) of Vesta. During Approach, Survey and High Altitude Mapping orbits about 2/3 of the entire asteroid surface have been mapped. The VIR operative spectral interval, resolution and coverage is suitable for the detection and mapping of any olivine rich regions that may occur on the Vesta surface.
However, this search is made difficult by the expected low olivine abundance (i.e. <10% [5]) and the partial overlap of olivine and pyroxene spectral signatures. Different spectral parameters have been used to detect olivine in mineral mixtures [6,7]. Here we select some of them and discuss their applicability to the Vesta spectral cubes.

2. Spectral data

Spectral data were acquired by the RELAB dataset and kindly provided by the UJF-Grenoble [8]. Five spectral families were considered: a) binary mixtures at different abundances of olivine and low-calcium pyroxenes (LCP); b) ternary mixtures of olivine, LCP, high-calcium pyroxenes (HCP), with high HCP content; c) ternary mixtures of olivine, LCP, HCP, with different olivine abundances and with low HCP content; d) two samples of olivine-rich diogenite, NWA 4223 (50% of abundance) and NWA 5480 (57% of abundance) [8]; e) olivine-free HED meteorites [8]. Some of the used spectra are shown in Fig. 1.

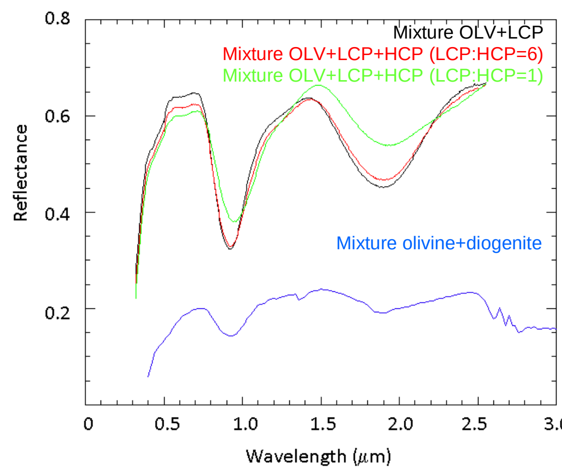

Fig. 1. Laboratory spectra considered for our study.

3. Spectral indexes

BAR. Band Area Ratio (BAR) is defined as the ratio between 2 and 1 µm band areas. It can be considered as an olivine content indicator [6]. We verified that it does not work for high HCP content mixtures.
Forsterite Index. Forsterite Index is defined in [7] as

$$\frac{0.5R_{1.54}+0.5R_{1.56}}{0.1R_{1.01}+0.2R_{1.21}+0.7R_{1.36}}-1 \qquad (1)$$

where R_λ is the reflectance at the wavelength λ (in µm). There is a clear relation between this index and the olivine abundance. However, the presence of HCP tends to increase the Forsterite Index value (Figure 2) hence it is needed to remove this dependence by defining a Modified Forsterite Index.

Modified Forsterite Index (MFI). We defined a Modified Forsterite Index (MFI) as a linear combination between the Forsterite Index and the HCP Index [6], which will be independent from the HCP content. By analysing the binary and ternary mixtures spectra, we found that: $MFI=OL-15HCP$, where *OL* and *HCP* are the Forsterite and the HCP Index, respectively. This new index depends only on olivine content, whatever is abundance of HCP in the mixture. However, the application of MFI to NWA 5480, gives olivine abundance 40% lower than the expected value for this diogenite.

MFI on normalised spectra. To overcome this discrepancy, we tried to apply the Modified Forsterite Index to normalised spectra, that were rationed to pure LCP spectrum. The definition of the index in this case is different: $MFI=OL+25HCP$. Now the MFI works both for the three olivine and pyroxene mixtures and for one of the olivine-rich diogenites. The spectrum of olivine-rich diogenite with metals does not follow the same trend (Figure 3). In addition, contrarily to the previous cases, the index is not unambiguous since olivine-free HED can have index values that are compatible with presence of olivine.

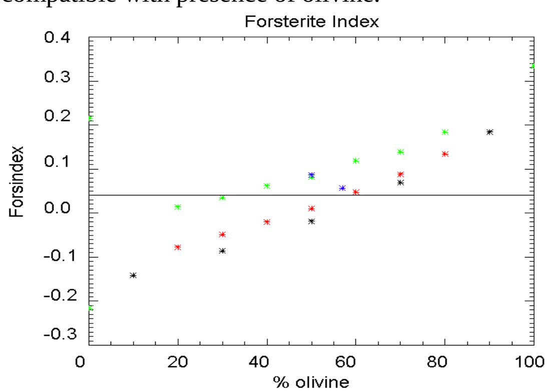

Fig. 2. Forsterite Index of laboratory spectra. Colour legend is the same of Fig. 1.

4. Conclusions

The spectral index most commonly used for olivine detection, i.e. BAR and Forsterite Index, can lead to a misinterpretation about the olivine abundance in the case of high-HCP mixtures. A new modified Forsterite index (MFI), which takes into account the HCP content, has been defined, but could lead to an underestimation of olivine abundance.

The MFI applied to normalised spectra seems to be promising with mixtures of olivine-HCP-LCP. Conversely, when applied to olivine-free HED spectra, wrong results are found. It is possible that the presence of plagioclases can affect on this index. The next step is to include this endmember in a multimineralic mixture to be tested with MFI.

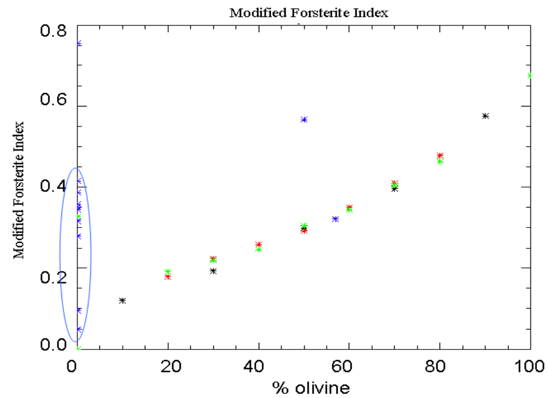

Fig. 3. Modified Forsterite Index of laboratory mixture spectra, normalised to pure LCP spectrum. Colour legend is the same of Fig. 1. The markers into the blue circle are relative to olivine-free HED.

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References

[1] Beck and McSween (2009), *72nd Met. Soc. Meet.*

[2] Righter and Drake (1999), *Icarus*, 124, 513-529

[3] Thomas et al. (1997), *Icarus*, 128, 1, 88-94

[4] McSween et al. (2011), *SSR*, 163, 141-174

[5] De Sanctis et al. (2011), *SSR*, 163

[6] Cloutis et al. (1986) *JGR*, 91, 11641-11653

[7] Poulet et al. (2007), *JGR*, 112, E08S02

[8] Beck et al. (2011), *Icarus*, 216, 570-571