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Spectral methods to detect cometary minerals with OSIRIS on board Rosetta

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Abstract

Comet 67P/Churyumov-Gerasimenko is going to be observed by the OSIRIS scientific imager (Keller et al. 2007) on board ESA's spacecraft Rosetta in the wavelength range of 250-1000 nm with a combination of 12 filters for the narrow angle camera (NAC) and 14 filters in the wavelength range of 240-720 nm for the wide angle camera (WAC). NAC filters are suitable to surface composition studies, while WAC filters are designed for gas and radical emission studies. In order to investigate the composition of the comet surface from the observed images, we need to understand how to detect different minerals and which compositional information can be derived from the NAC filters. Therefore, the most common cometary silicates e.g. enstatite, forsterite are investigated with two hydrated silicates (serpentine and smectite) for the determination of the spectral methods. Laboratory data of those selected minerals are collected from RELAB database (http://www.planetary.brown.edu/relabdocs/relab.htm) and absolute spectra of the minerals observed by OSIRIS NAC filters are calculated. Due to the limited spectral range of the laboratory data, Far-UV and Neutral density filters of NAC are excluded from this analysis. Considered NAC filters in this study are represented in Table 1 and the number of collected laboratory data are presented in Table 2.

Detection and separation of the minerals will not only allow us to study the surface composition but also to study observed composition changes due to the cometary activity during the mission.

Spectral analysis methods and results

One example spectrum per selected minerals are presented in Fig. 1 for the detection of their spectral features and determine the applicable spectral methods. OSIRIS NAC will be able to detect 0.9 micron bands of enstatite, smectite and serpentine. Additionally detection of 0.7 micron ferric ion band, which is an indicator of altered hydration (Vilas 1994) of serpentine is also possible.

Table 1: Selected filters of the narrow angle camera

Name	Wavelength (nm)	Bandwidth (nm)
Near-UV	360.0	51.1
Blue	480.7	74.9
Green	535.7	62.4
Orange	649.2	84.5
Hydra	701.2	22.1
Red	743.7	64.1
Ortho	805.3	40.5
Near-IR	882.1	65.9
Fe_2O_3	931.9	34.9
IR	989.3	38.2

Table 2: Selected minerals

Minerals	# data
Forsterite	20
Enstatite	35
Serpentine	12
Smectite	10

Due to the visible/near-infrared range of the filters, we cannot observe the 1.1 micron band of forsterite, and due to the low spectral resolution we cannot get the band parameters like band depth, band areas of the detected bands precisely in order to detect minerals on cometary terrains. But we can use reflectance ratios, spectral slope, and spectral tilt methods for the identification of species.

Reflectance ratios

Reflectance ratios describe the ratio of two filter value from the resampled spectra. According to the shape of the spectrum or the existing features, these ra-

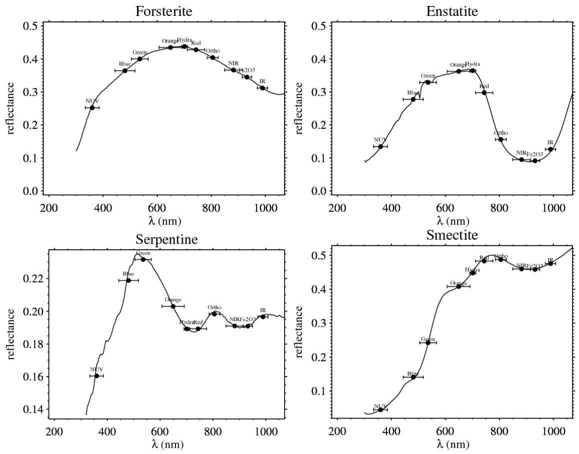

Figure 1: Absolute spectrum of selected silicates as seen by OSIRIS NAC filters listed in Table 1. Solid lines are laboratory data of corresponding mineral, while dots are sampled spectra. Bandwidths are indicated with horizontal bars.

tios can be use to distinguish different minerals. The main diagnostic here we concentrate on is the ratio of Fe_2O_3/IR filters in order to use the 0.9 micron band as a diagnostic. The ratios presented in Fig. 2 allows us to separate enstatite from the other minerals but not to distinguish hydrated silicates from each other.

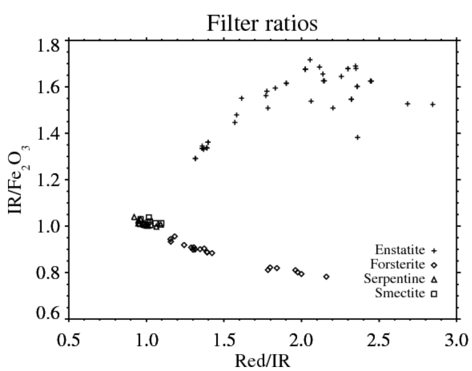

Figure 2: Filter ratios.

Spectral slopes

Spectral slope is defined here as the slope between Red and Fe_2O_3 filtes. Then slope is used with Fe_2O_3/IR ratio as a diagnostic tool. With the spectral slopes in Fig. 3, we are able to separate all selected minerals.

Spectral tilts

Band tilt is defined as the ratio between Fe_2O_3 and IR while visible tilt is define as a ratio of Green and Orange filters. As seen in Fig. 4, we see the best separation of all minerals compared to spectral ratios and spectral slopes with this method.

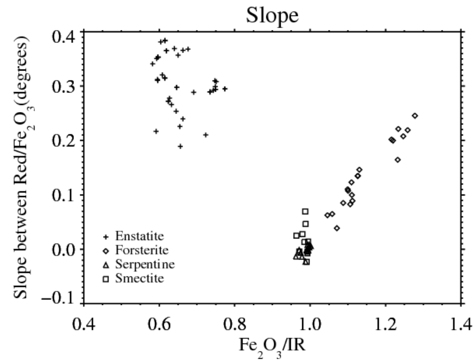

Figure 3: Spectral slopes.

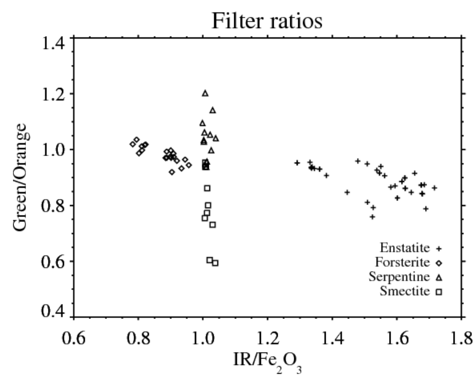

Figure 4: Visible tilt vs. band tilt.

Outlook

This work will be extended to include cometary ices, in order to improve the detection of icy patches of the comet's surface.

Acknowledgements

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References

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