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VNIR reflectance spectroscopy of natural carbonate rocks: implication for remote sensing identification of fault damage zones

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Reflectance spectroscopy in the visible and near-infrared (VNIR) is a common technique used to study the mineral composition of Solar System bodies from remote sensed and *in-situ* robotic exploration. In the VNIR spectral range, both crystal field and vibrational overtone absorptions can be present with spectral characteristics (i.e. albedo, slopes, absorption band with different positions and depths) that vary depending on composition and texture (e.g. grain size, roughness) of the sensed materials. The characterization of the spectral variability related to the rock texture, especially in terms of grain size (i.e., both the size of rock components and the size of particulates), commonly allows to obtain a wide range of information about the different geological processes modifying the planetary surfaces.

This work is aimed at characterizing how the grain size reduction associated to fault zone development produces reflectance variations in rock and mineral spectral signatures. To achieve this goal we present VNIR reflectance analysis of a set of fifteen rock samples collected at increasing distances from the fault core of the Vado di Corno fault zone (Campo Imperatore Fault System - Italian Central Apennines). The selected samples had similar content of calcite and dolomite but different grain size (X-Ray Powder Diffraction, optical and scanning electron microscopes analysis). Consequently, differences in the spectral signature of the fault rocks should not be ascribed to mineralogical composition. For each sample, bidirectional reflectance spectra were acquired with a Field-Pro Spectrometer mounted on a goniometer, on crushed rock slabs reduced to grain size $<$800, $<$200, $<$63, $<$10 μm and on intact fault zone rock slabs. The spectra were acquired on dry samples, at room temperature and normal atmospheric pressure. The source used was a Tungsten Halogen lamp with an illuminated spot area of ca. 0.5 $cm^2$and incidence and emission angles of 30° and 0° respectively.

The spectral analysis of the crushed and intact rock slabs in the VNIR spectral range revealed that in both cases, with increasing grain size: (i) the reflectance decreases (ii) VNIR spectrum slopes (i.e. calculated between wavelengths of 0.425 - 0.605 μm and 2.205 - 2.33 μm, respectively) and (iii) carbonate main absorption band depth (i.e. vibrational absorption band at wavelength of $\sim$2.3 μm) increase.

In conclusion, grain size variations resulting from the fault zone evolution (e.g., cumulated slip or development of thick damage zones) produce reflectance variations in rocks and mineral spectral signatures. The remote sensing analysis in the VNIR spectral range can be applied to identify the spatial distribution and extent of fault core and damage zone domains for industrial and seismic hazard applications.

Moreover, the spectral characterization of carbonate-built rocks can be of great interest for the surface investigation of inner planets (e.g. Earth and Mars) and outer bodies (e.g. Galilean icy satellites). On these surfaces, carbonate minerals at different grain sizes are common and usually related to water and carbon distribution, with direct implications for potential life outside Earth (e.g. Mars).