

# Thermal infrared spectroscopy of Antarctic meteorites: its future application to TIR multi-band imaging of asteroids and planets

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## Introduction:

Thermal infrared spectroscopy is useful for understanding the composition and crystallinity of planetary materials. In this study, a collection of meteorites and rocks were measured with a portable Fourier-Transform IR Spectroscopy (FTIR) and the obtained spectra were converted into six narrow spectral bands used in the space multi-band thermal imager TIRI for ESA Hera mission [1]. The six bands in 7-14  $\mu\text{m}$  are selected for characterizing the composition and crystal-amorphous ratio for any kinds of meteorites and rocks. In this study, we focused on the S-type asteroids like Didymos and its moon Dimorphos, and its applicability for the estimate of materials.

Complementary to a visible to near-infrared spectroscopy which shows  $\text{Fe}^{2+}$  abundance in silicates, a thermal infrared (or mid-infrared) spectroscopy around 10  $\mu\text{m}$  is informative on silica ( $\text{SiO}_2$ ) abundance and crystallinity in rocks.

TIRI has a filter wheel with a wide band filter (8-14  $\mu\text{m}$ ) for thermal imaging and six narrow band filters (6.9-8.7, 8.1-9.1, 9.2-10.0, 10.2-11.0, 11.2-12.0, and 12.0-14.0 in  $\mu\text{m}$ ) for multi-band imaging [2]. Since TIRI is still under development, infrared spectra were observed using a portable FTIR and evaluated for the accuracy and applicability when converted to TIRI's six wavelengths.

## Methods:

The FTIR (Agilent Handy FTIR 4300) with the spectral range of 650-4000  $\text{cm}^{-1}$  and the resolution of 8  $\text{cm}^{-1}$  was used for this study. A collection of Antarctic meteorites preserved at the National Institute of Polar Research (NIPR) were used as thick and thin section samples, as well as the other rocks and minerals related to the S-type asteroid.

More than 200 samples of S-type related meteorites at NIPR were measured, such as ordinary chondrites (H/L/LL-chondrites, their petrologic types of 3-6), primitive achondrites (Acapulcoites, Lodranites, Ureilites, Winonaites, and Brachinites), and carbonaceous chondrites (CM2, CO3, CV3) for comparison, in addition to some rocks and minerals in our laboratory.

Christiansen Features (CF) related to the  $\text{SiO}_2$  abundance and Reststrahlen Features (RF) related to  $\text{SiO}_2$  abundance and crystallinity are obtained by spectral fitting. FTIR spectra are converted into six narrow bands of TIRI to estimate the  $\text{CF}_{\text{est}}$  and  $\text{RF}_{\text{est}}$  and its restorability of the original spectra. Intensity ratios between bands are also compared.

## Results and Discussion

CF and RF show negative trend (to shorter wavelength), with increasing molar abundance of  $\text{SiO}_2$  against Olivine. It is very useful for rock type identification. The subtypes also have a slight trend in ordinary chondrites and primitive achondrites, for  $\text{H} < \text{L} < \text{LL}$ , correlating with abundance of olivine. CF for achondrites varies for Winonaites < Acapulcoites < Lodranites < Ureilites, correlating iron abundance in olivine. Carbonaceous chondrites show a relatively large CF compared to ordinary chondrites and the

position of CF is  $CV3 < CO3 < CM2$ , correlating with olivine abundance. For minerals and rocks, CF and RF are  $Quartz < Plagioclase < Pyroxene < Olivine$ , due to less abundance of  $SiO_2$ .

Estimated CF and RF from the six bands become unclear than the original ones but still informative for composition.

Multi-band ratios are practically used for discriminating the different rock types and also their subtypes, because it does not need any detailed fitting technique.

Further detailed investigation is needed for the characterization of relatively similar rock types or the sub-types of the same rock types if quantitative analysis is expected. The band ratio itself has no significant meaning of physical properties, but just shows apparent features to compare with each other.

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#### **References**

[1] Michel, P. et al. (2022) Planet. Sci. J., 3, 160. [2] Okada, T. et al. (2022) Lunar Planet. Sci., #1319.

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