Reflectance and Emissivity Spectra of Grafite as Darkening Agent for Mercury from the UV to TIR: Comparison with MESSENGER and BepiColombo (MERTIS)

A. **Maturilli**[1], J. Helbert[1], I. Varatharajan[1]

[1]Institute for Planetary Research, DLR, Berlin, Germany – alessandro.maturilli@dlr.de,

Deutsches Zentrum für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft

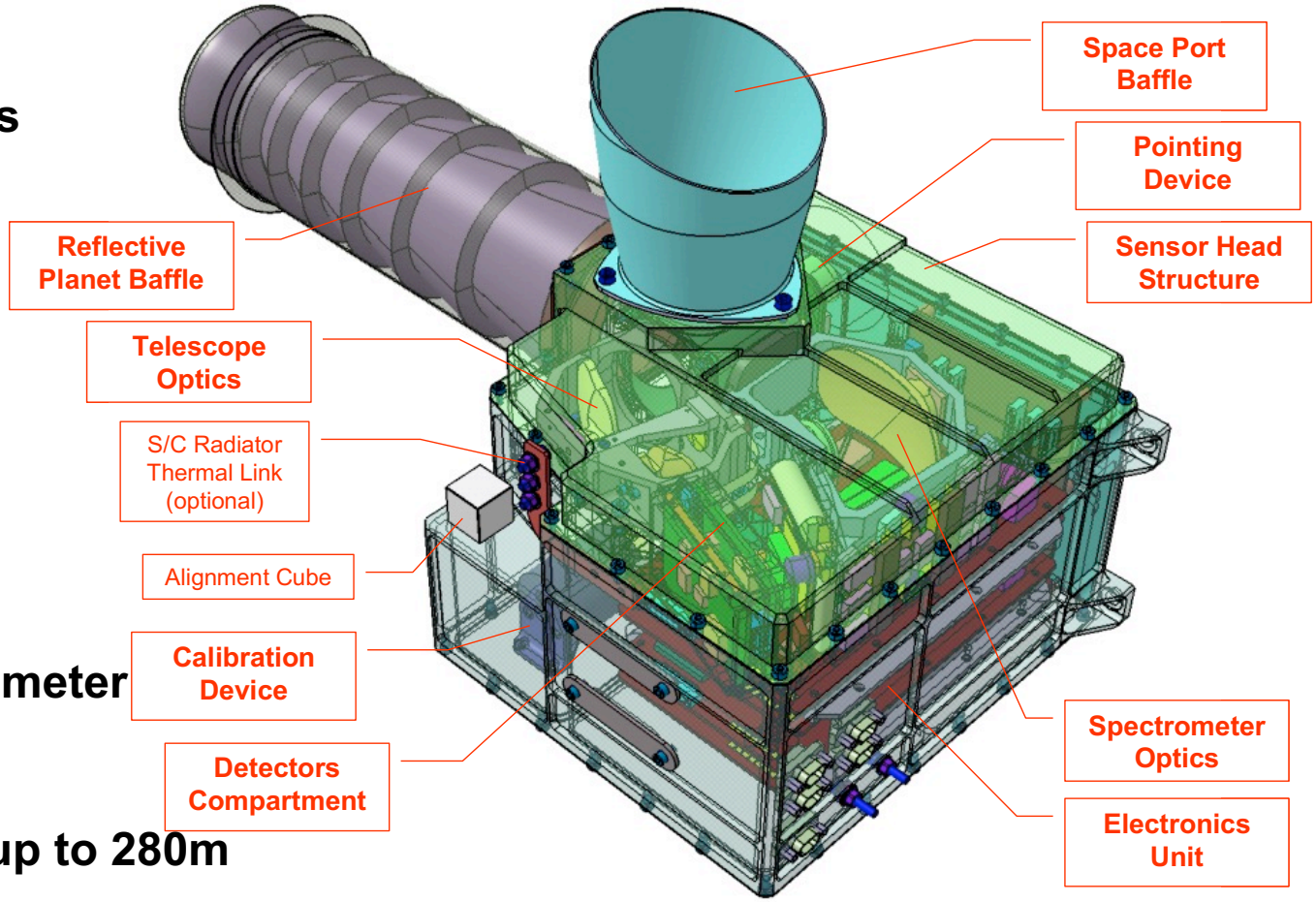
Introduction

- For long time Mercury was considered a planet very similar to the Moon
- Both small rocky bodies in the inner solar system with thin exospheres and no large scale traces of recent geological activity
- Mercury's surface reflects much less sunlight than the Moon
- NASA MESSENGER instruments found only small abundances of iron, confirming earlier ground-based spectroscopy observations, and virtually no titanium
- MESSENGER data acquired for the darkest regions suggest the unknown darkening material to be carbon: graphite abundance in the darker regions is predicted to be 1 to 3 wt% higher than the surroundings (Peplowski et al., 2016).

Spectral Measurements

- At Planetary Spectroscopy Laboratory (PSL) of DLR we measured reflectance spectra for several phase angles of graphite, from UV to TIR spectral range (0.2 to 20 μm).
- Samples measured fresh and after successive steps of heating at 400° C in vacuum for 8 hours.
- Reflectance spectra of Komatiite (Mercury surface simulant, after Maturilli et al., 2014) measured alone and mixed with few % of graphite for comparison with data acquired from MDIS + MASCS instruments on MESSENGER.
- Emissivity of same samples in vacuum (< 0.8 mbar) for successive cycles of 4 surface temperatures from 100° C to 400° C in the TIR spectral range (1 to ~18 μm) in preparation for the Mercury Radiometer and Thermal Infrared Spectrometer (MERTIS), onboard the ESA BepiColombo Mercury Planetary Orbiter (MPO), 2018.

MERTIS - Mercury Radiometer and Thermal infrared Imaging Spectrometer



Principle Investigators

Prof. H. Hiesinger
University of Münster

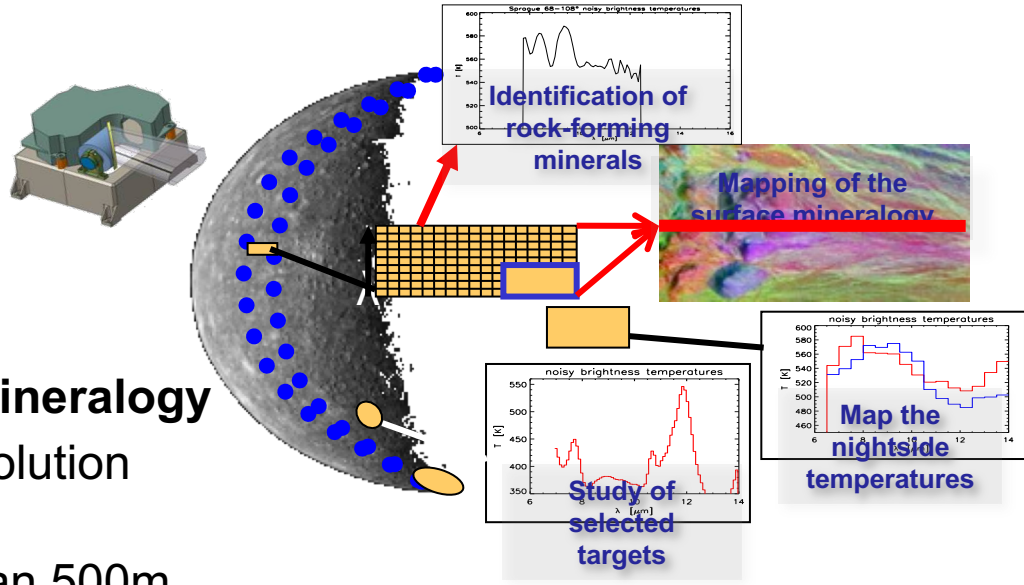
Dr. J. Helbert
DLR

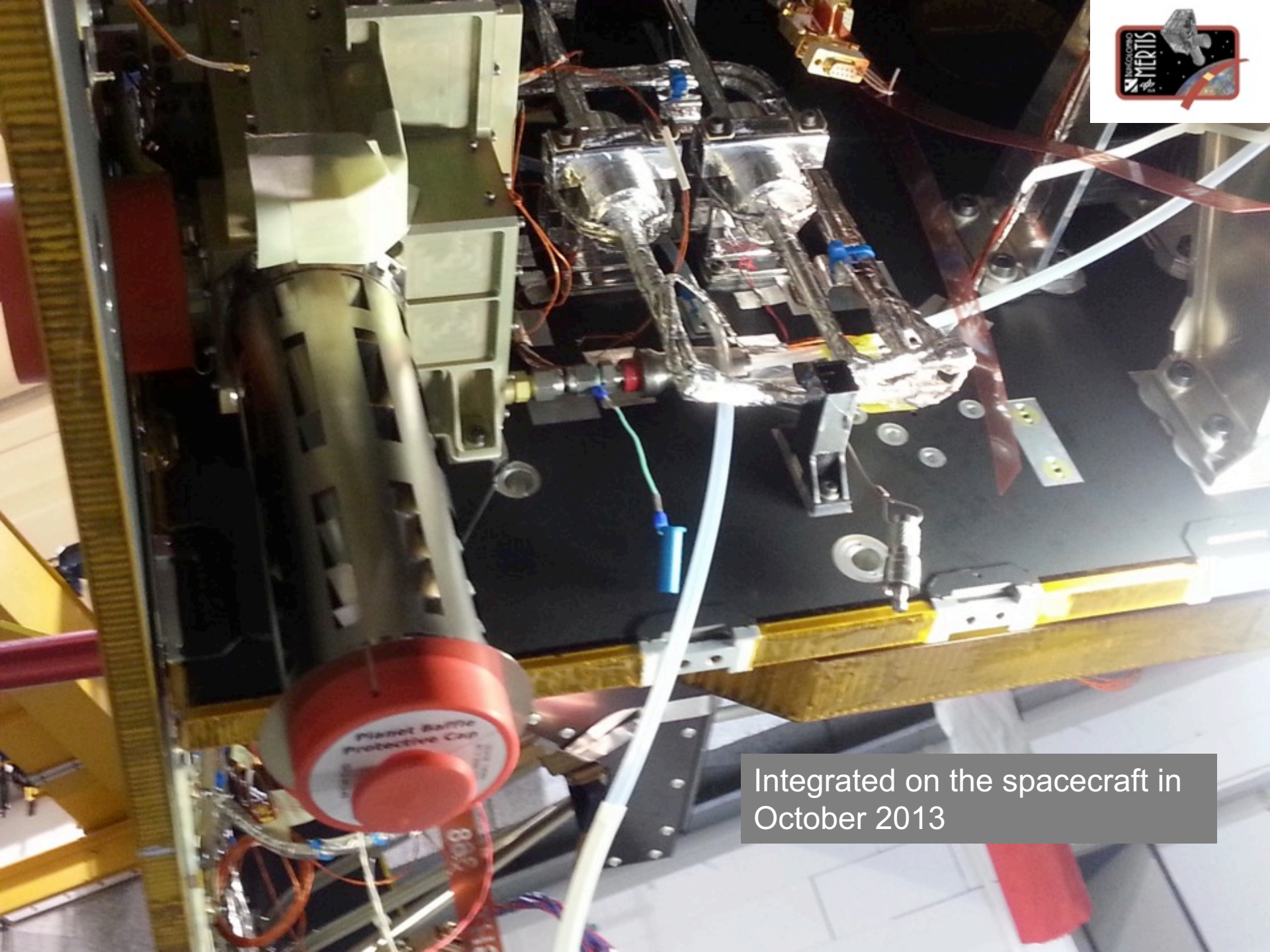
- **Monoblock**
- **3.1 kg - 10W**
- **Uncooled microbolometer**
- **7-14µm @ 200nm**
- **Global coverage @ up to 280m**
- **Integrated µ-radiometer 7-40 µm**
- **No comparable instrument on the NASA MESSENGER mission**

Scientific goals of MERTIS

MERTIS has four main scientific objectives, building on the general science objectives of the Bepi-Colombo mission.

1. **Study of Mercury's surface composition in the TIR**
2. **Identification of rock-forming minerals**
   - Spectral range 7-14µm
   - Spectral resolution better than 200nm
3. **Global mapping of the surface mineralogy**
   - Global mapping with spatial resolution better than 500m
   - 10% of the planet with better than 500m resolution
4. **Study of surface temperature and thermal inertia**
   - NETD <1K for typical nightside temperature of 80K





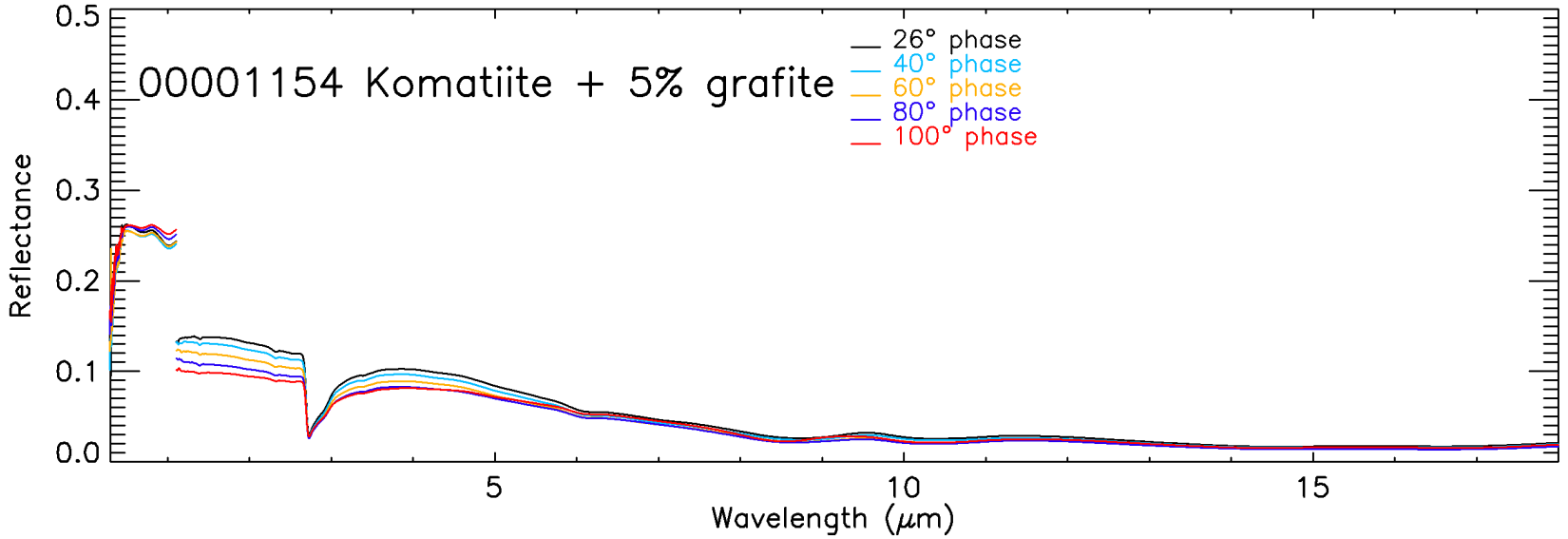
Integrated on the spacecraft in October 2013

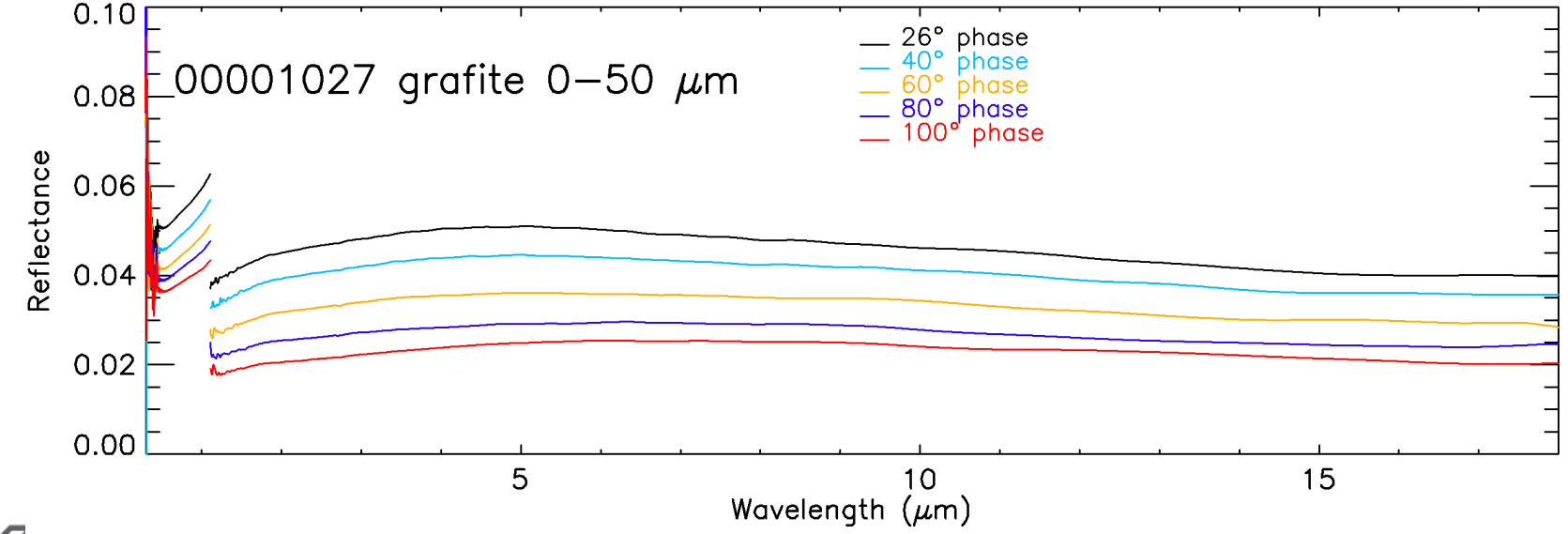
Spectral Measurements at PSL

PSL Overview

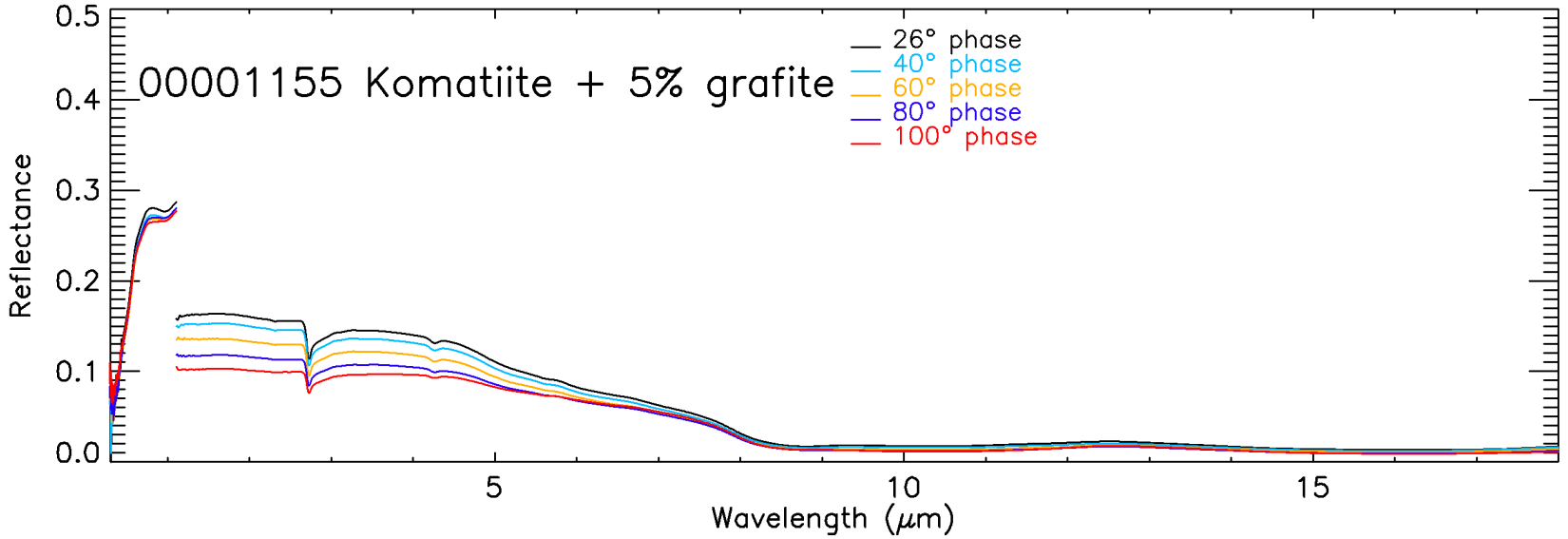
- Two FTIR spectrometers, both same exact model Bruker Vertex 80V
- Optical units (Detectors, Beamsplitters, Accessories, …) can be shared between the 2 instrument, maximizing the data collection
- With Spectrometer 1 (S1) we measure in vacuum bi-directional reflectance in the UV+VIS+NIR+MIR spectral range; the same we do with Spectrometer 2 (S2) covering the MIR+FIR spectral range
- Same wide spectral range is covered for under purging hemispherical reflectance measurements (by means of 2 integrating spheres)
- Both spectrometers have attached emissivity chambers: S1 has a purged chamber for measurements from 30° to 150° C, S2 has a vacuum chamber for measurements from 50° to at least 600° C
- Emissivity of Hi-T samples (fine powders to chunks and slabs) can be measured from 0.7 to above 100 µm
- Transmittance measurements (filters, optical windows, pellets, …) made in vacuum in the whole 0.2 to above 100 µm spectral range

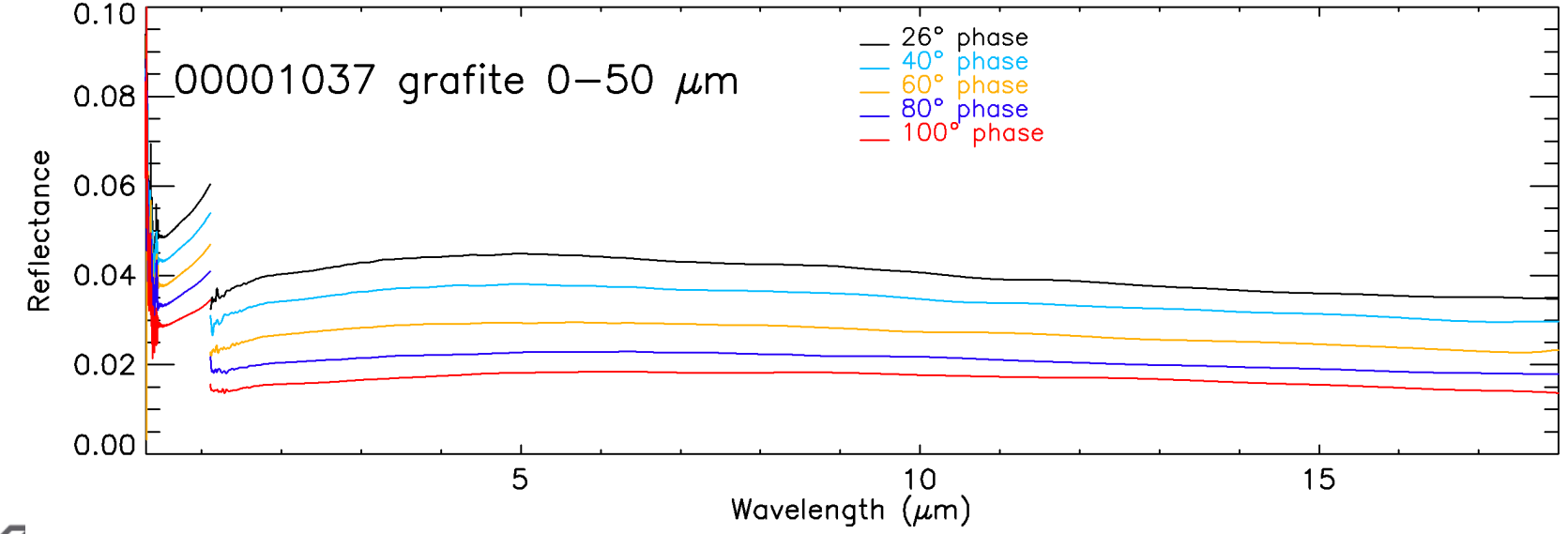
Spectral Measurements on fresh samples





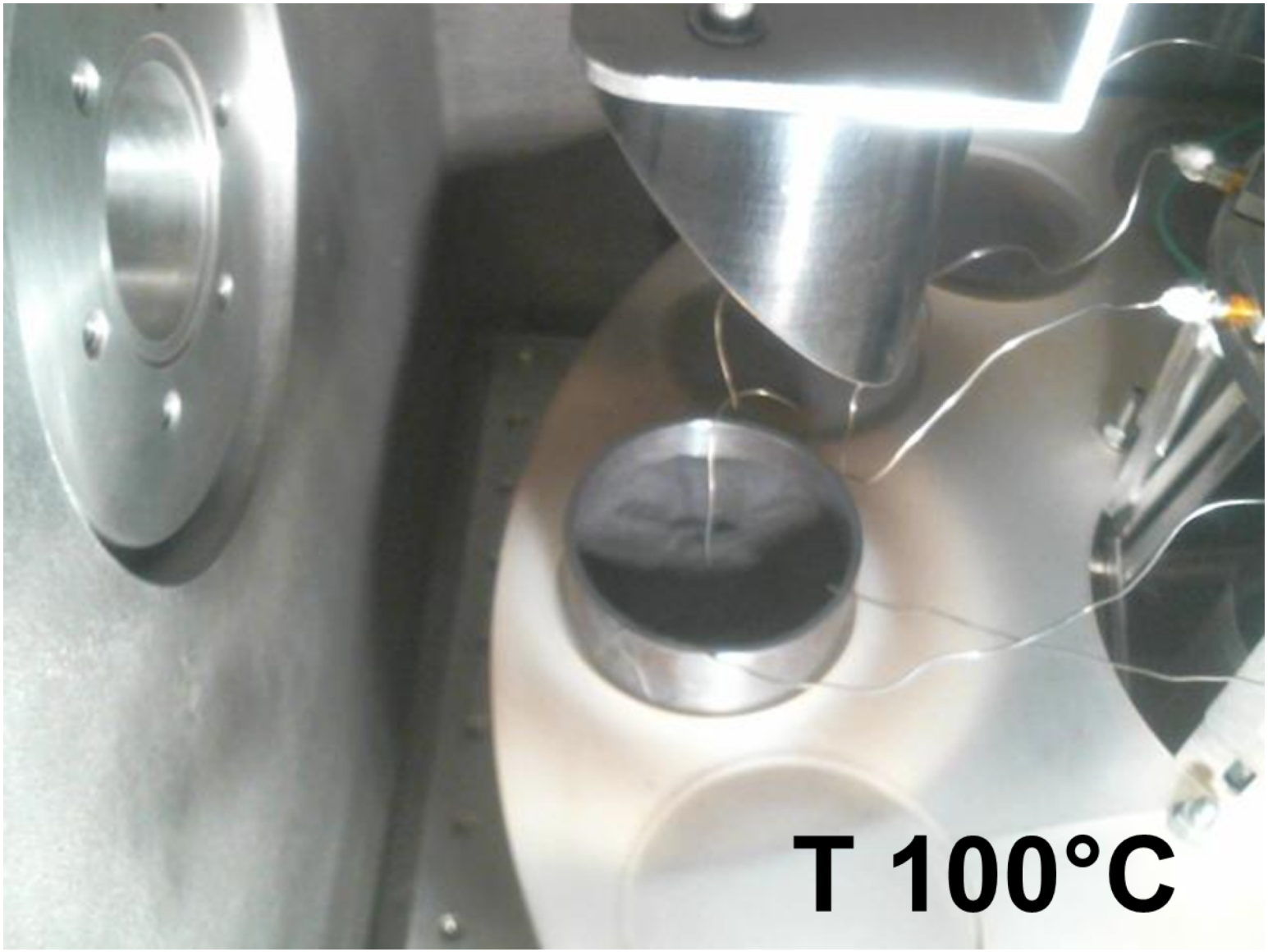
Spectral Measurements on heated samples





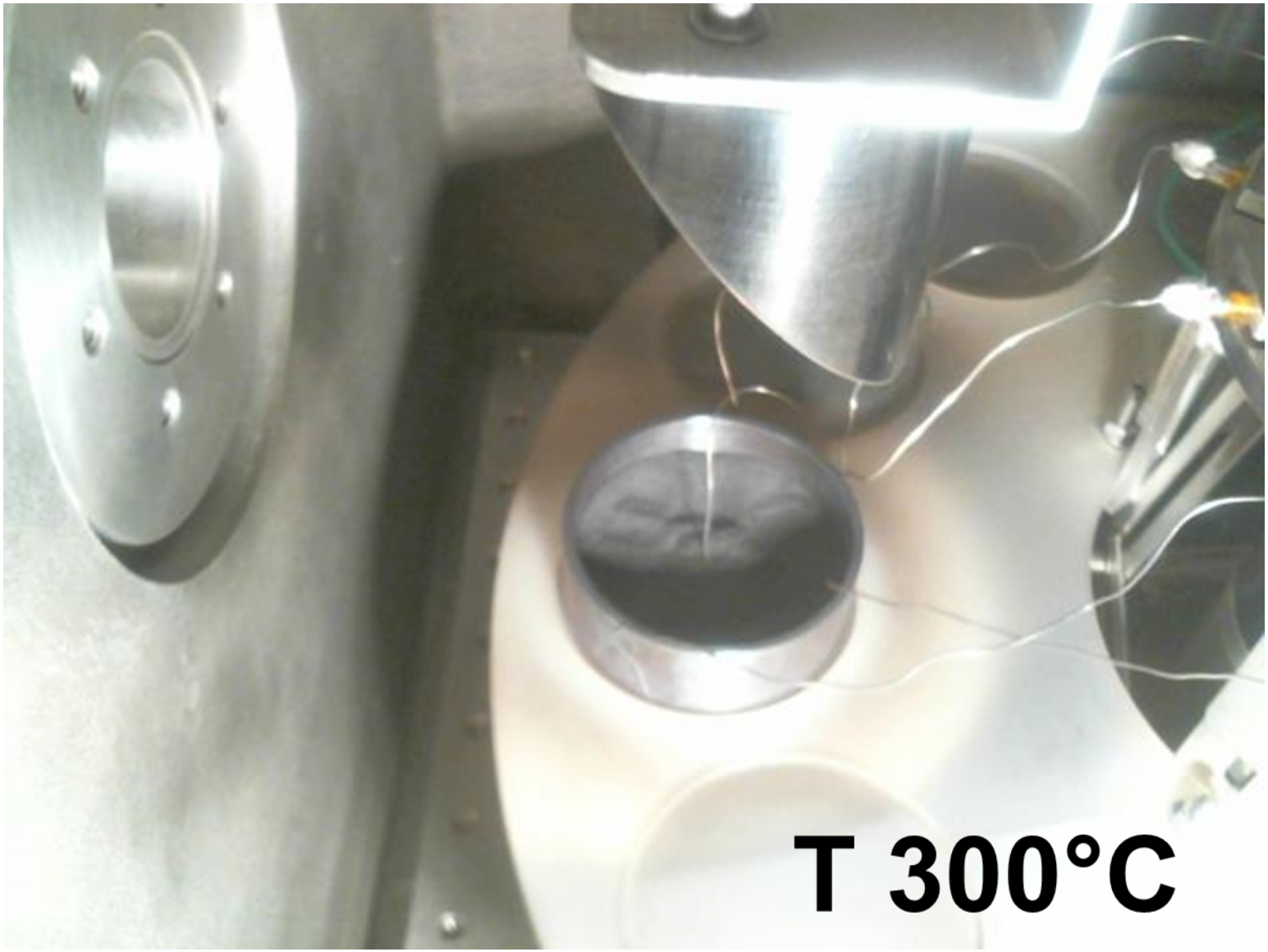
Emissivity Measurements

Emissivity Measurements



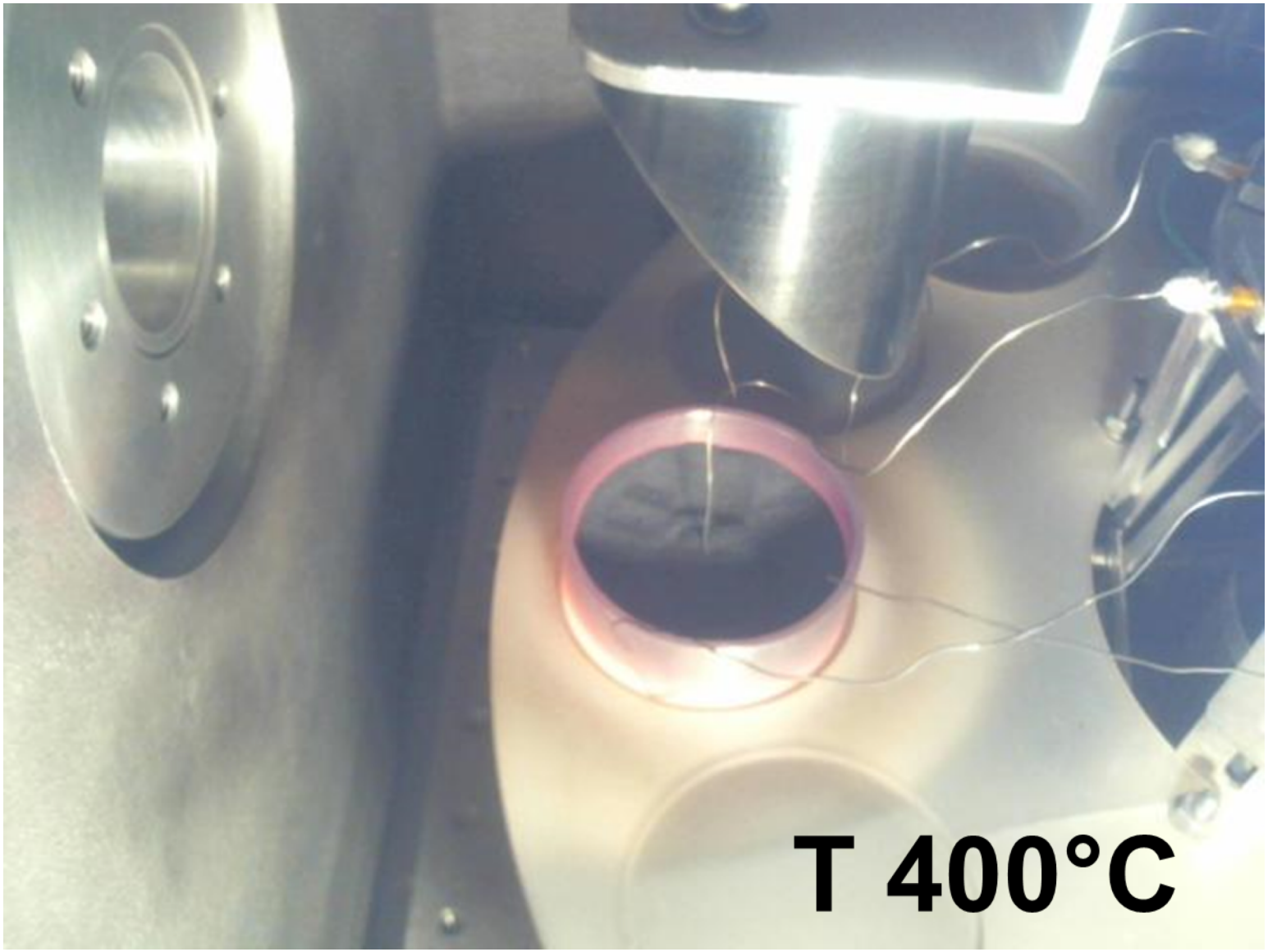
Emissivity Measurements

Emissivity Measurements

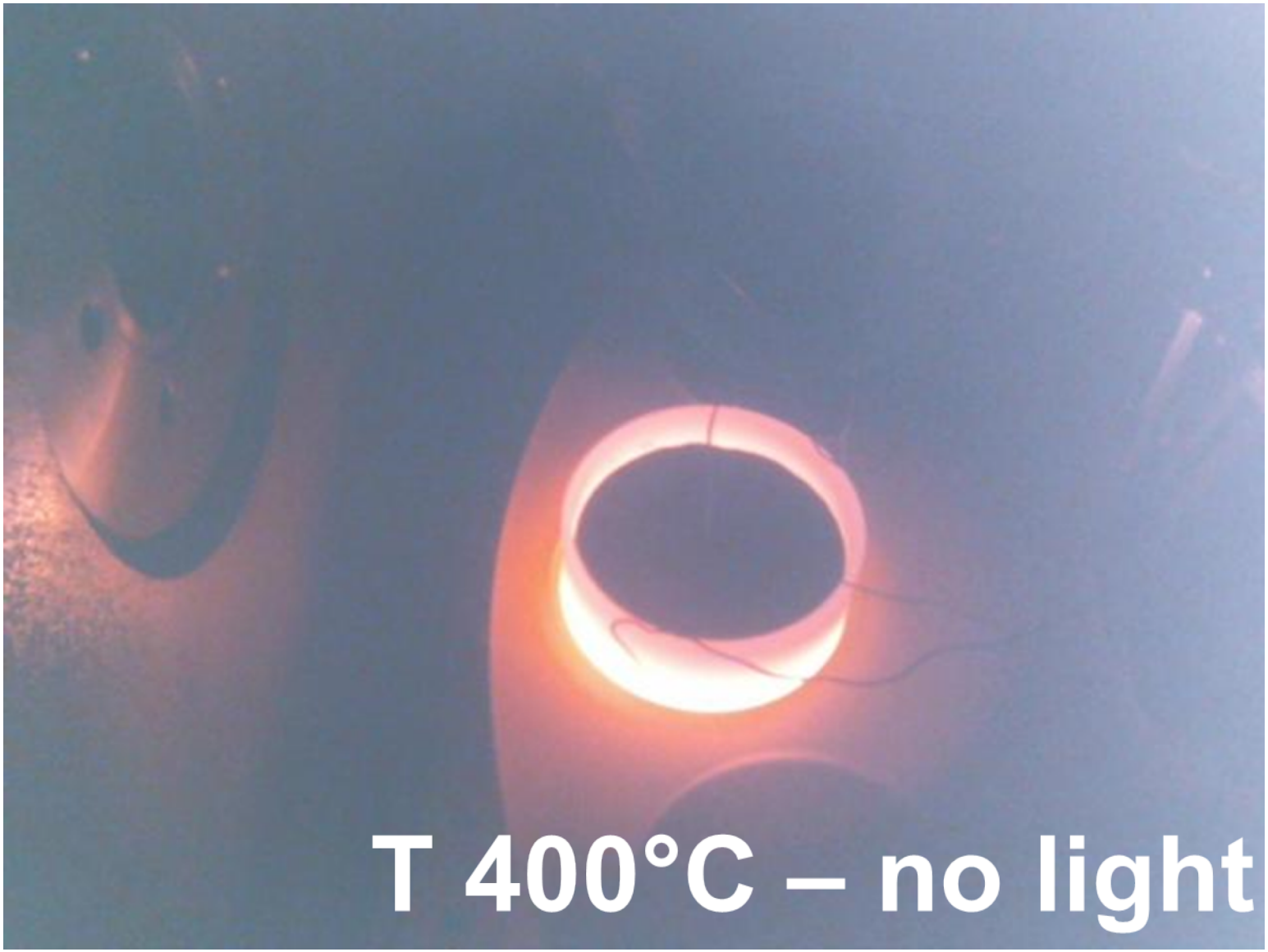


Emissivity Measurements

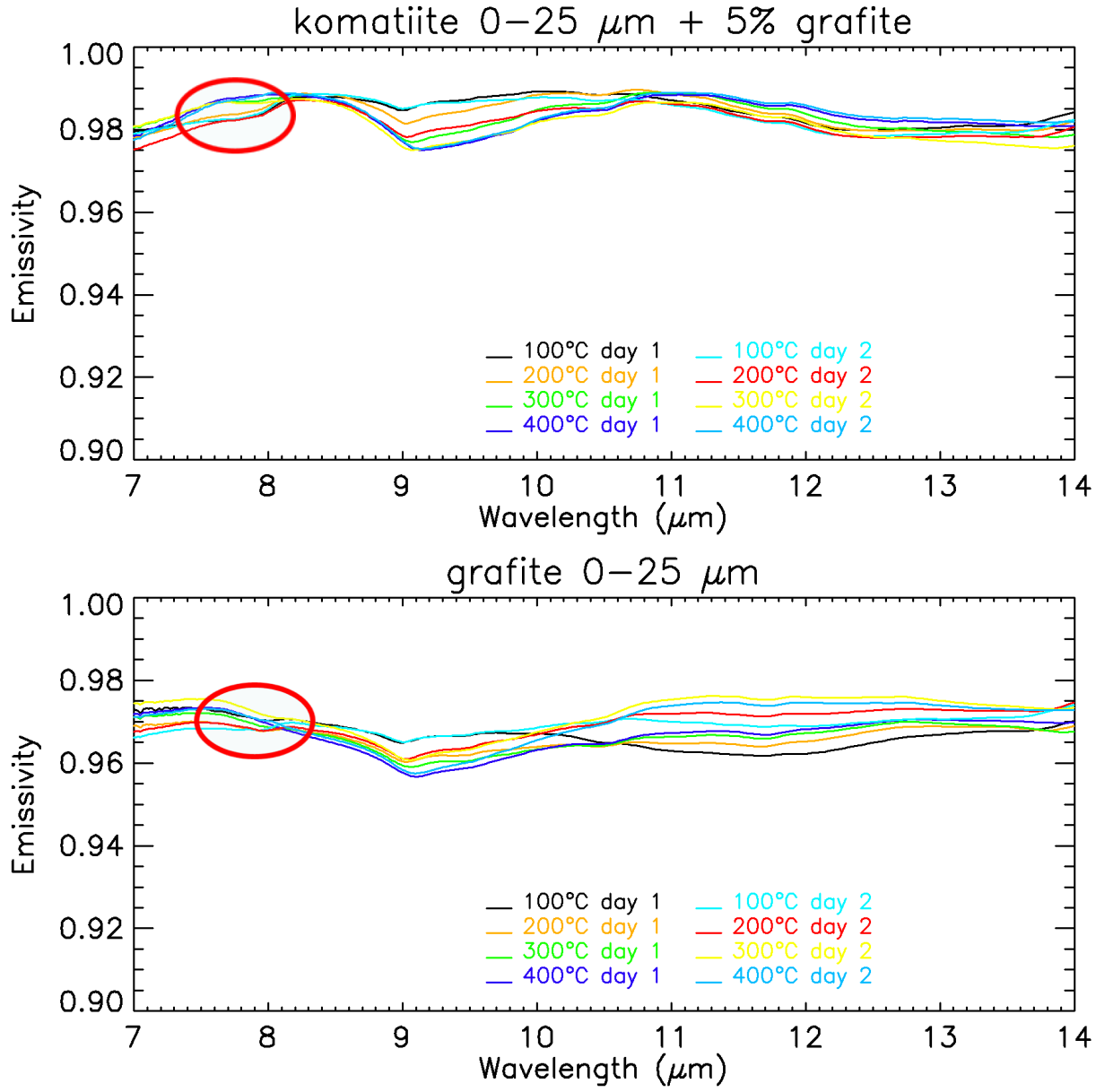
Emissivity Measurements



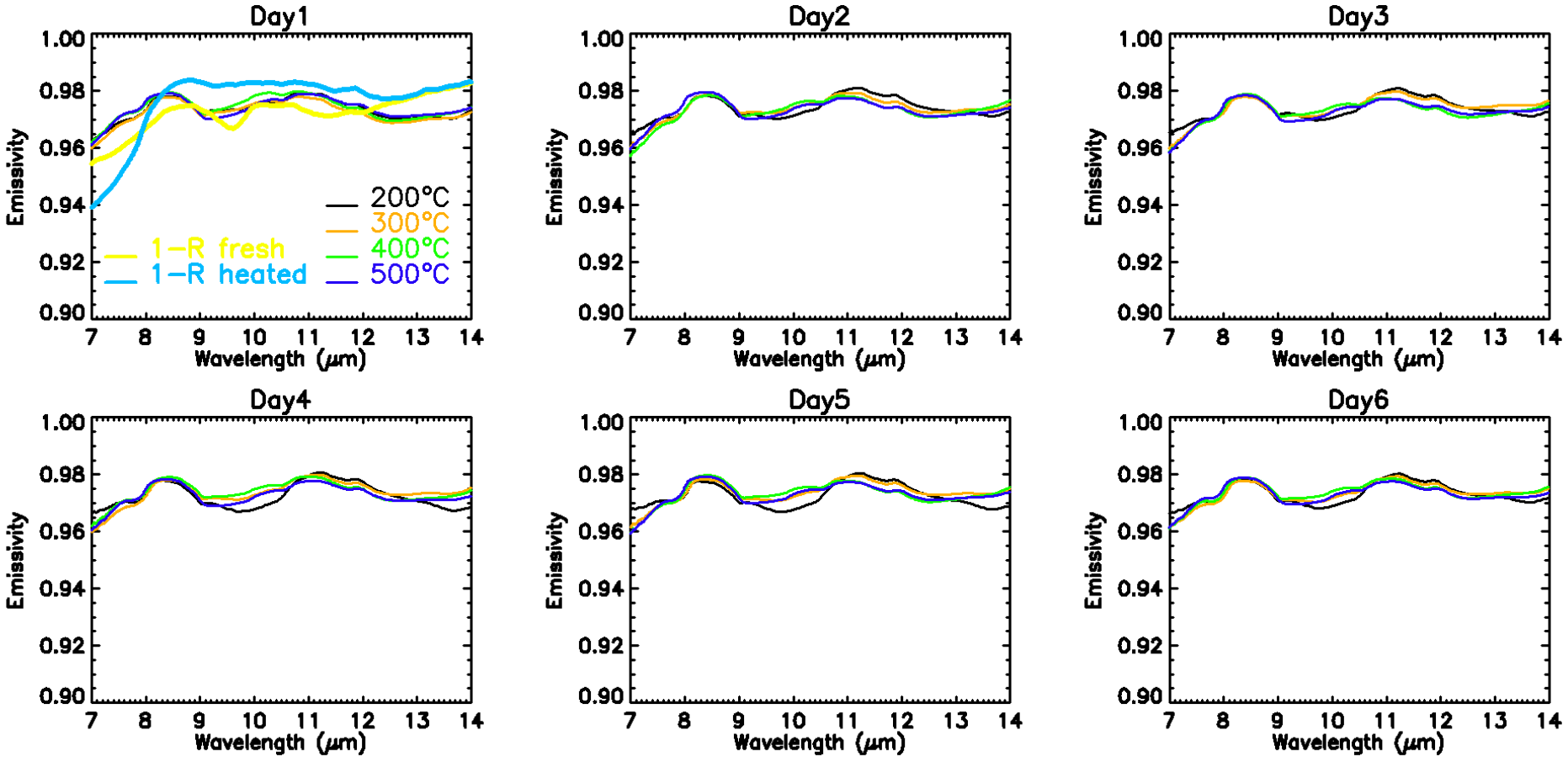
Emissivity Measurements



Emissivity Measurements

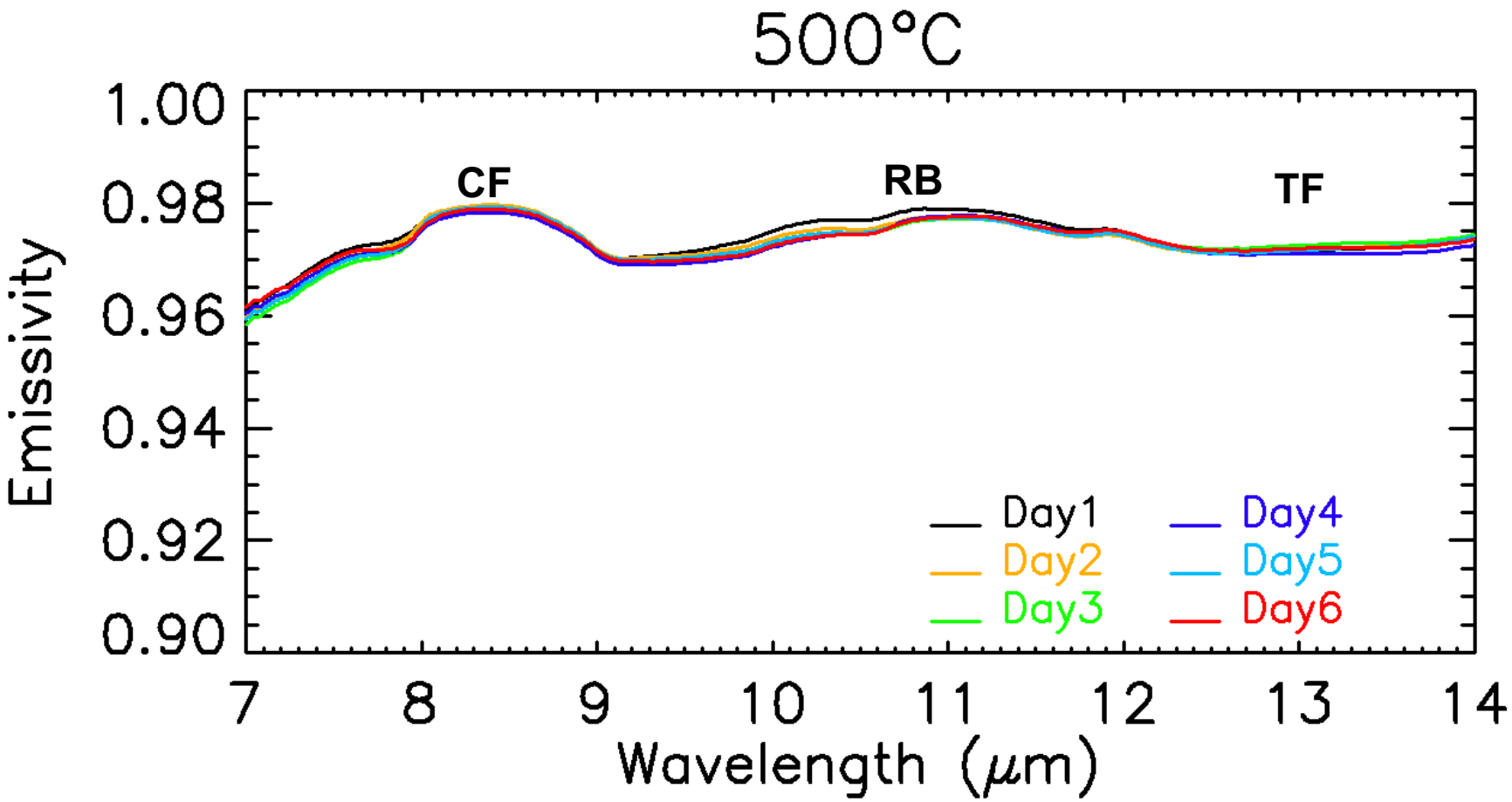


Stability of komatiite + 5%grafite

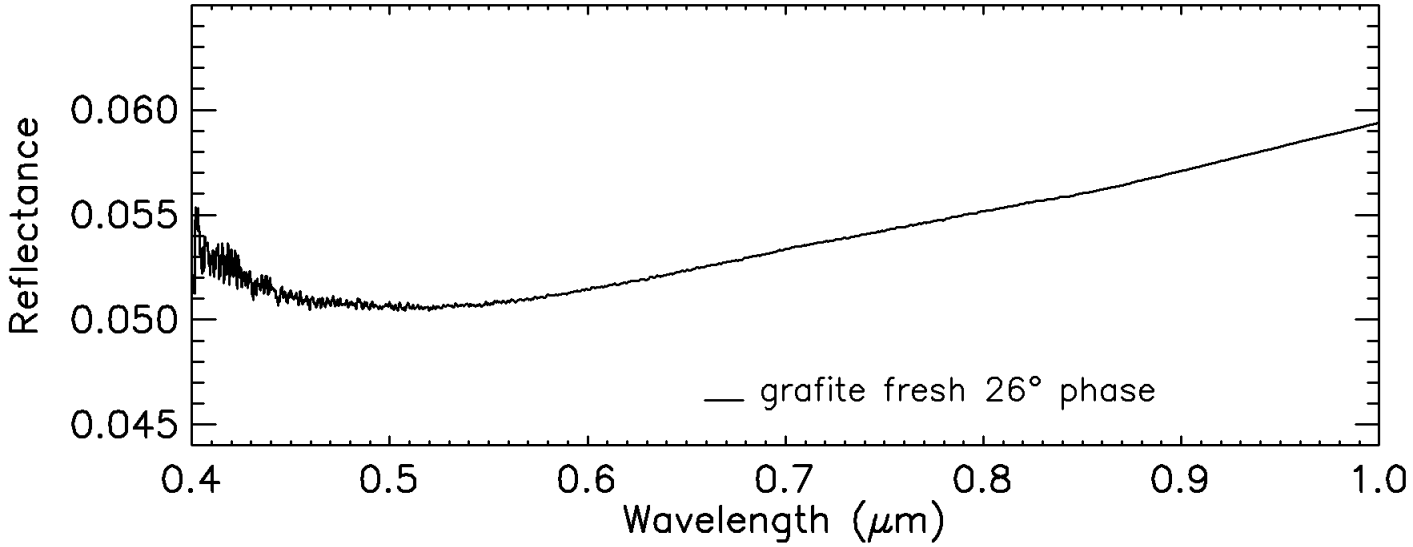


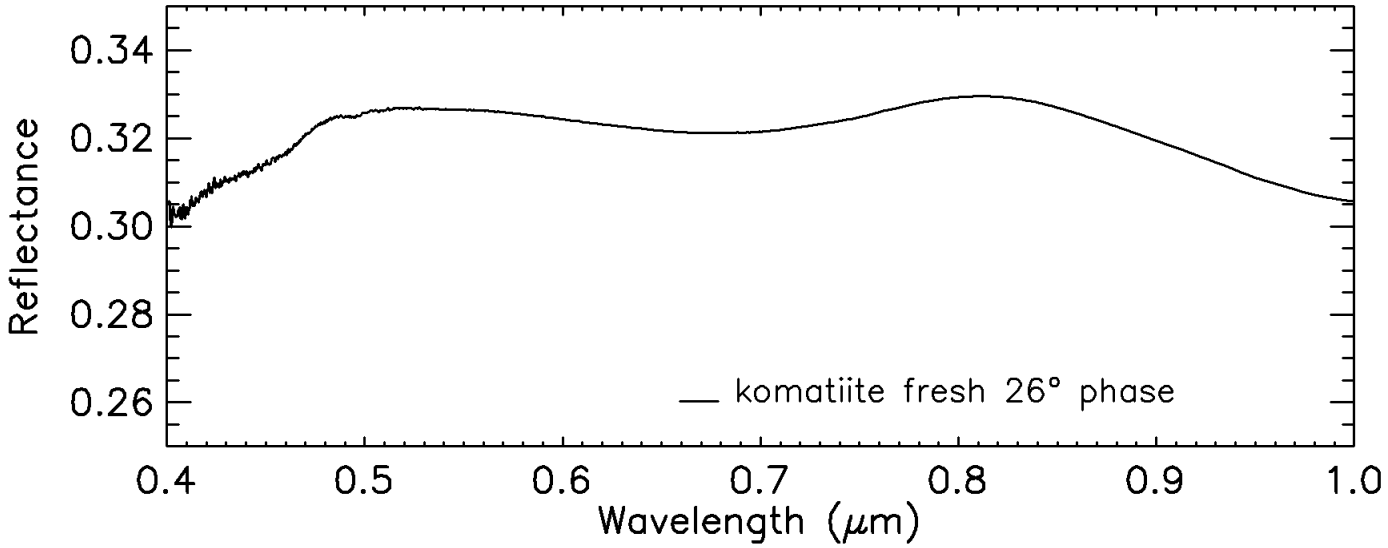
See Maturilli et al., 2014, EPSL 398

Stability of komatiite + 5%grafite

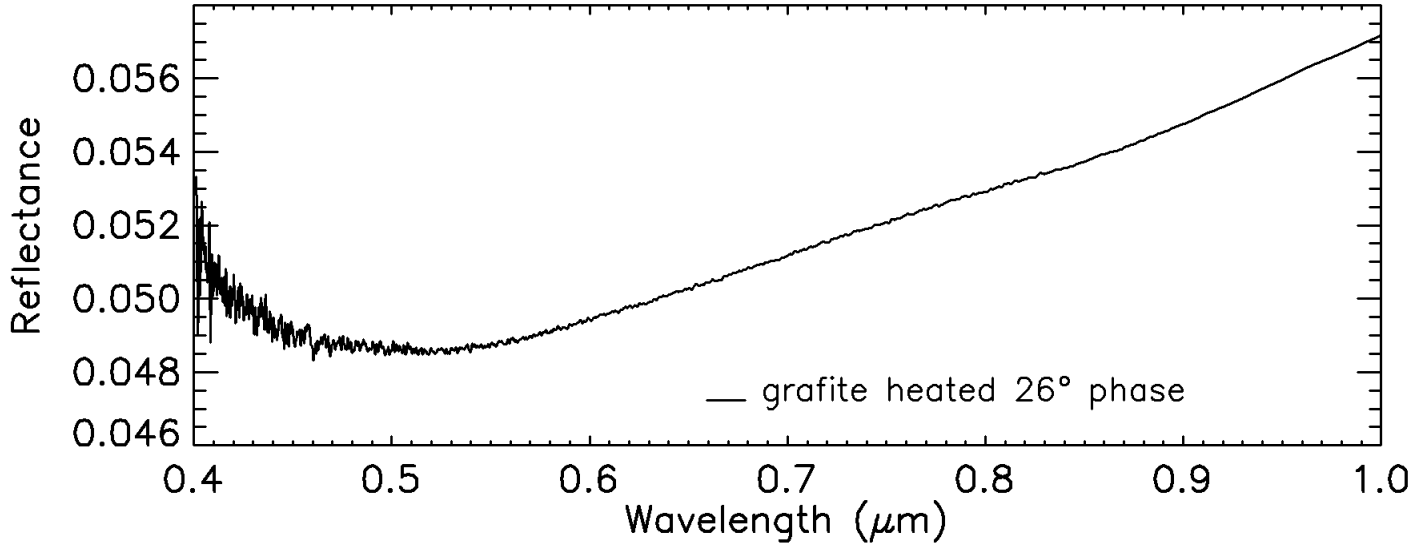


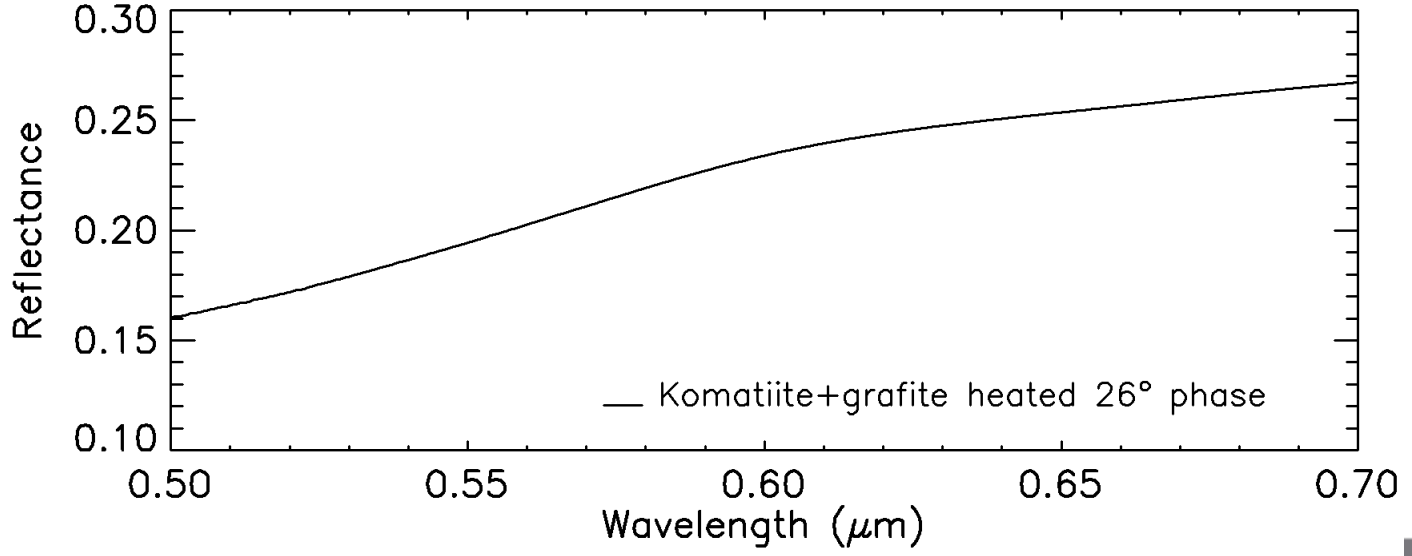
Carbon possible detection at 600 nm





Carbon possible detection at 600 nm





Summary and outlook

- Set of experiments to investigate detectability of grafite on remote sensing observations of Mercury surface
- VIS+NIR+TIR reflectance spectra of grafite are featureless
- TIR emissivity spectra of grafite show a tiny spectral feature around 8 μm, the same feature is absent in komatiite alone but can be found when komatiite is mixed with 5 wt% of grafite
- Komatiite+5%grafite spectra differs significantly from pure Komatiite.
- Further effects of grafite mixed to komatiite can be seen in the CF and surrounding regions
- MERTIS on BepiColombo will have the opportunity to detect grafite features in Mercury surface spectra in the 7-14 μm spectral range
- Grafite detection at 600nm could not be so far experimentally reproduced
- A follow-up experiment to use a finer grafite sample (g.s. < 10 μm)