STUDYING IO'S VOLCANIC HISTORY USING THERMAL INFRARED MEASUREMENTS. J. Helbert[1], A. Maturilli[1], S. Ferrari[1] , D. Breuer[1], T. Spohn[1], [1]Institute for Planetary Research, DLR, Rutherfordstrasse 2, 12489 Berlin, Germany (joern.helbert@dlr.de)

Introduction: Io is the Galilean satellite nearest to Jupiter and the most volcanically active body in the Solar system. Its surface heat flow can be estimated from remote observations of its thermal emission and values range from 1.5 to 4 W m^{-2} (60 to 160 TW total) [1,2]. The heat production rate implied by the high surface heat flow far exceeds that which can plausibly be produced by radioactive decay, thus, a different internal heat source must be active. The reason for Io's extreme heat flow is due to the intense tidal forces it experiences because of its proximity to Jupiter, and due to its interaction with the moons Europa and Ganymede. Silicate volcanism is likely the result of the tremendous heat flow measured at the surface of Io. However, the global extent of sulfur on Io indicated by the surface colors caused considerable debate as to whether Io's volcanic features were produced by molten rock (silicate volcanism) or molten sulfur. The arguments favoring silicate volcanism were supported by the fact that the tall mountains and steep-sided calderas on Io require a material of considerable strength to support them. Furthermore, Galileo spacecraft and Earth-based telescopes detected typical inferred eruption temperatures at hot spots ranging from 1200 K to 1800 K [3,4]. This is far too hot for sulfur to remain liquid, so silicate magma has to be involved in these high temperature eruptions. Nevertheless that does not rule out the possibility that some of the lava flows on Io are composed primarily of sulfur. In fact, the distribution of sulfur on Io is still a subject of some debate. It may be that sulfur constitutes a relatively thin coating on Io's surface, or it could form relatively thick deposits in localized areas. SO_2 frost covers most of Io's surface, except over hot spots where it is not stable.

Thermal infrared measurements are an ideal tool to study the volcanic activity, the heat flow and the surface composition of Io. However dedicated laboratory measurements are required to support remote-sensing observations.

The Planetary Emissivity Laboratory (PEL): PEL currently operates two Bruker Fourier transform infrared (FTIR) spectrometers, both located on an optical table and equipped with external chambers for emissivity measurements (Figure 1). The laboratory is located in a temperature-controlled room at the Institute for Planetary Research in Berlin.

The main feature of the PEL is a high-temperature chamber attached to the Vertex 80V that allows heating of samples to temperatures up to 1300 K under vacuum conditions (medium vacuum - 10-100Pa)

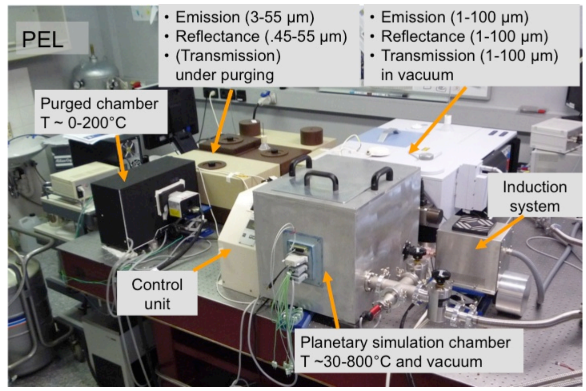

Figure 1. Overview of the setup at the Planetary Emissivity Laboratory (PEL).

[5,6,7]. This configuration is ideal to obtain measurements on analogs under simulated Io conditions.

Samples are placed in steel cups equipped with type K thermopiles as temperature sensors. A copper induction coil installed in the chamber and connected to a Linntherm 1.5kW induction system allows contactless heating of the ferromagnetic sample cups by induction. Spectral coverage is achieved with a combination of a liquid nitrogen-cooled MCT detector and KBr beamsplitter for the spectral range up to 16 µm and a DTGS detector with a multilayer beamsplitter for the remaining spectral range. In addition, a InSb/MCT sandwich detector is used. This detector provides significantly increased sensitivity in the spectral range from 1-5 µm.

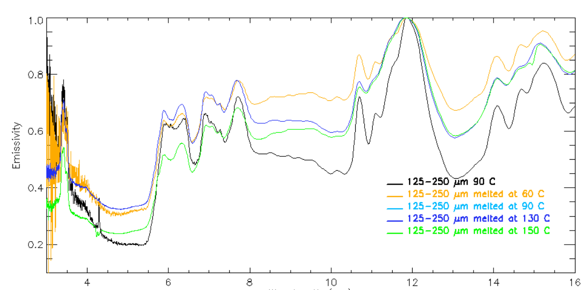

Figure 2: Normalized emissivity of sulfur before and after melting from near to thermal infrared.

Laboratory experiments: Measuring analogs for Io in the thermal infrared pose a unique set of challenges. Io's surface exhibits a large range of temperatures from ~80K to 1600K or higher. Sulfur rich analog samples will produce significant outgassing especially at high temperatures [8]. PEL has unique experience working on difficult samples, including high-temperature measurements obtained on sulfides [9]. The simulation chamber can be sealed to protect the spectrometer optics and optical surfaces in the chamber can be easily replaced. A monitoring system in the chamber allows observing and assessing the amount of outgassing.

As a first test the change in spectral characteristics of elemental sulfur during melting has been measured (see Figure 2). We are currently preparing a set of analog materials that we are characterizing in the thermal infrared under a wide-range of temperatures.

TMAP on IVO: The Thermal Mapper (TMAP) is part of the payload of the proposed Discovery mission IVO [10]. TMAP will provide near-global coverage at 0.1–20 km/pixel to map heat flow and monitor volcanism. It is a high spatial-resolution thermal imaging system optimized for observing Io, with heritage from the ESA AIDA mission's Minaturized Asteroid infrared Imager and Radiometer (MAIR) instrument and the Bepi-Colombo mission's MErcury Radiometer and Thermal Infrared Spectrometer (MERTIS) [11,12,13,14]. Minor modifications of the three-mirror antistigma (TMA) optics and the updating of the discontinued ULIS microbolometer provide over five times better spatial resolution than the MERTIS and MAIR instrument.

Discussion: TMAP will provide information on the surface composition of Io, map volcanic centers, the thermal inertia and constrain the heat flow. The combination of a new generation of thermal infrared instrumentation to observe Io with the unique capabilities to obtain analog measurements at PEL will provide new insights into the evolution of this highly active volcanic world.

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