Laboratory Spectroscopy of Astrophysically Important Minerals

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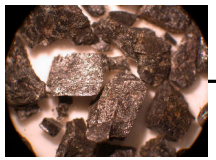
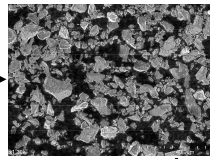
Introduction

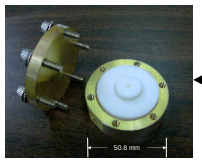
To further analysis of data from Herschel Space Observatory's Photodetector Array Camera and Spectrometer (PACS), we performed spectral characterization of 146 mineral species obtained from the American Museum of Natural History (AMNH) in the 15 to 250μm wavelength range. Species investigated included nesosilicate olivines, silicas, pyroxenes, feldspars, carbonates, phyllosilicates, oxides, and sulfides. Mineral grains and fragments were selected from the AMNH mineral collection and crushed to separate intergrowths when appropriate. Clean grains were hand picked and crystallographically verified via X-ray multigrain microdiffraction (Rigaku DMAX/Rapid) and powder diffraction (Philips 1710 Bragg-Brentano diffractometers). Electron microprobe analysis (Cameca SX100) of polished grains verified chemical composition, stoichiometry, and micron-scale homogeneity. A McCrone Micronizing Mill was used to reduce up to 0.5 mm particles to micron sizes. The powdered mineral was dispersed in polyethylene powder and melted into pellets. For initial room temperature measurements, samples were placed aluminum sample holders, with an aperture greater than the source beam. During low temperature measurements, room temperature measurements were made for comparison to initial data and data taken later at low temperature. Spectra were collected using a Bomem DA8 Fourier spectrometer fitted with a 4.2K Bolometer. Temperature dependence of the spectra down to 15 K revealed sharpening and blue-shifts of the characteristic absorption lines, and in some cases the resolution of additional spectral features. Generally, the spectra are highly characteristic of the chemical composition and crystalline structure of the mineral samples. We suggest the use of these results for mineral identification in the far-infrared emission spectra of intraplanetary dust, dust in protoplanetary disks, and comet dust tails.
All spectra will be posted in public data bases.

Experimental Methods

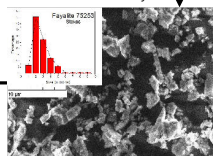

Olivine


Micronizing Mill


Coarse Grain Fayalite

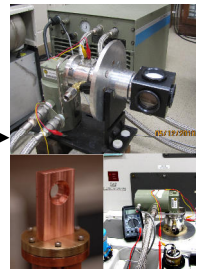

Pelletier used for 2% mass mineral studies


Mineral in Polyethylene Pellet


Grain Distribution after Stokes Precipitation


4.2K Bolometer (on right)


FTIR Spectrometer


Cryostat and Low T Sample Holder

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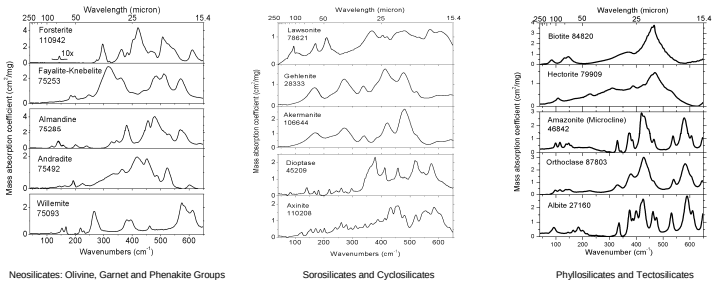
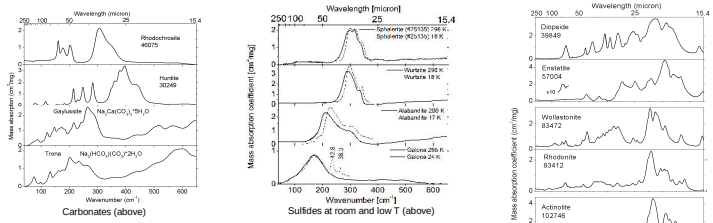
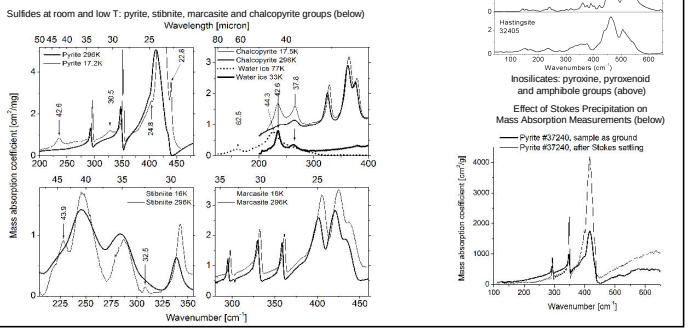
Results



Neosilicates: Olivine, Garnet and Phenakite Groups | Sorosilicates and Cyclosilicates | Phyllosilicates and Tectosilicates



Carbonates (above) | Sulfides at room and low T (above)



Inosilicates: pyroxine, pyroxenoid and amphibole groups (above)

Conclusion

The far-IR spectra of several groups of minerals have been presented. The study illustrates how particle size distribution of mineral in the polyethylene pellet can influence mass absorption coefficients. Observed low temperature effects in IR spectrum suggests the importance of low-temperature reference spectral data in the study cosmic-matter-relevant minerals; our studies provide a basis for an adequate comparison of the laboratory and astronomical peak wavelengths and intensities of astrophysically important mineral species. As measurements were taken at room and low temperature, the reference data will prove useful in the study of both cosmic dust sources and those in solar and extrasolar systems.


Comet C/2001 Q4: Credit & Copyright: Loke Kun Tan (Slarti)Scapes)
HSO – PACS / SPIRE: The Rosette molecular cloud Credit: ESA
The Moon, Orion Nebulae, and Mars. Credit: Doug Maukonen