# Mineralogy of Natural Dust Samples from LWIR Reflectance and Transmission Spectroscopy

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**Abstract**

Mineral dust particles are ubiquitous in the atmosphere and can be transported vast distances affecting climate, air quality, and human health on a global scale. Mineralogical composition has a substantial impact on dust properties and their effects. Natural dust samples are both fine-grained and composed of many different minerals. Most commonly, X-ray diffraction (XRD) has been used to characterize dust mineralogy; however, this technique is less effective for identifying poorly crystalline or amorphous phases. We used Fourier Transform Infrared (FTIR) spectroscopy as a complementary method to identify minerals and their abundances. Long wave infrared (LWIR) spectra (2.5 to 25 µm) are sensitive to molecular bonds rather than crystallography providing additional details. We performed both XRD and reflectance spectroscopy to characterize 37 atmospheric dust samples collected in Ilam City, Iran. The dominant minerals in these samples are quartz, feldspar (albite), calcite and clays (illite, montmorillonite, kaolinite). LWIR reflectance is strongly dependent on particle size but published data of pure silicate minerals in the size range of the Ilam samples (0-63 µm) still show characteristic signatures between 8 and 10 µm (Salisbury et al. 1991; Wenrich and Christensen, 1996). Surprisingly, diagnostic silicate features were not observed in any of the samples although carbonate and OH bonds in the clay minerals were readily identified. Past studies have shown that porosity, grain size and packing can reduce the spectral contrast in the LWIR and additional effects include grain coatings or the interaction of multiple minerals. We also identify a peak at 7.8 µm which may be attributed to anomalous dispersion or the interaction of quartz and calcite in this spectral range. In order to understand the absence of Si-O features we made transmission measurements of representative samples in KBr pellets. Transmission is not influenced by multiple scattering and should clearly detect fundamental Si-O absorptions. Transmission spectra show broad features that include contributions from all silicate minerals (quartz, feldspar and clays) both near 10 µm and at longer wavelengths. We are using various spectral modeling techniques and will compare abundances derived from reflectance and transmission measurements.

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## Introduction- Materials

Mineral dust particles dominate aerosols mass in the atmosphere, heavily modifying Earth's energy budget through interfering with incoming and outgoing radiation. Airborne minerals contribute to radiative forcing and consequently changing the climate through radiation perturbation including absorption and scattering processes. Physico-chemical characteristics of dust particles (e.g. mineralogical composition) are the main sources of uncertainties and are important to estimate dust radiative impact.

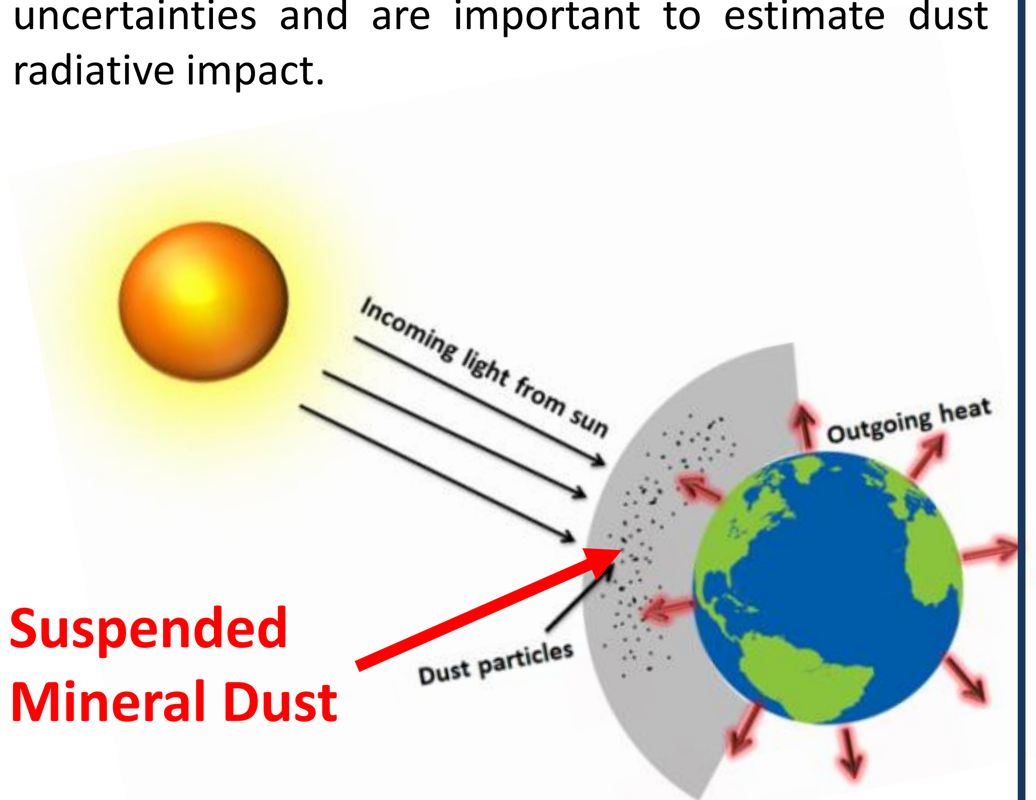


Figure 1. Schematic illustration of mineral dust influences on the atmosphere by blocking the solar and terrestrial radiation.

## Background

- ❖ 37 dust samples were collected in Ilam city, Iran.
- ❖ These dust samples were measured with visible, near infrared (VNIR ~ 0.5 to 2.5 μm) and X-ray diffraction (XRD) (Sadrian et al., 2021):
- ❖ VNIR identified diagnostic absorption features for clay minerals along with some manmade materials such as asphalt.
- ❖ XRD identified quartz and feldspars and underpredicted clays abundances.
- ❖ VNIR does not see quartz and feldspars, therefore we proposed using long-wave infrared (~ 2.5 to 25 μm, LWIR) to identify these minerals in the samples.

## Dust Samplers Location

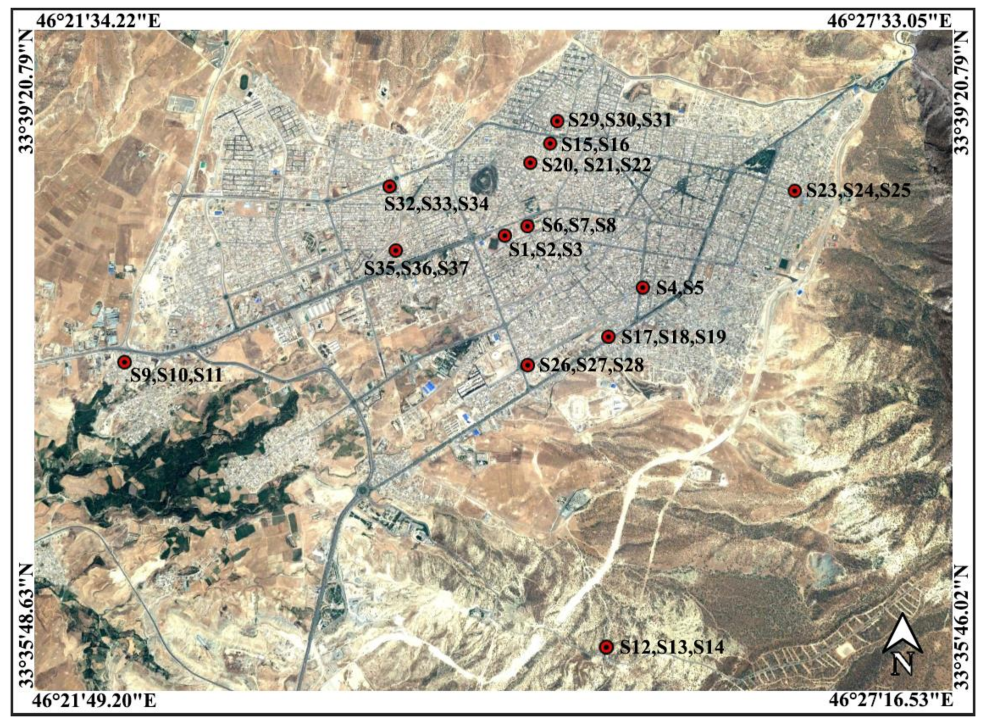


Figure 2. Map from Google Earth shows the distribution of samplers throughout the Ilam city, Iran. Annotations note sample number.

## Methods

- ❖ This study used long-wave infrared (~ 2.5 to 25 μm, LWIR) and transmission spectroscopy (~ 2.5 to 25 μm, TS) to obtain mineralogy for dust samples:
- ❖ We used FTIR instrument for LWIR measurements. All samples reflectance measurements were automatically ratioed to a gold plate reflectance resulting in final reflectance spectra that are solely due to the samples.
- ❖ Transmission spectroscopy was performed with means of FTIR and KBr pellets. Pellets contained mixtures 0.5 mg of dust and 200 mg of KBr. Sample transmission measurements were ratioed to blank measurements.

## Results-Summary

- **LWIR found calcite and clays in the samples.**
- **Surprisingly, LWIR could not find quartz and feldspars in some samples.**
- **Using transmission spectroscopy, we were able to identify a combination of quartz and other silicates both near 10 μm and at longer wavelengths.**

***Identified with all four methods**, **only identified in VNIR**, **not identified with VNIR and LWIR**, **not identified in TS****

| Samples | Location | VNIR, LWIR, TS, or XRD identification. |
|---|---|---|
| S20 | Ilam City | ***calcite, illite, montmorillonite*, quartz, kaolinite, albite, asphalt*** |
| S31 | Ilam City | ***calcite, illite, montmorillonite*, quartz, kaolinite, albite, amphibole*, asphalt*** |

## Measured Spectra

**LWIR identifies most common minerals previously identified.**

Surprise!! We don't see Si-O features in reflectance, only in transmission!

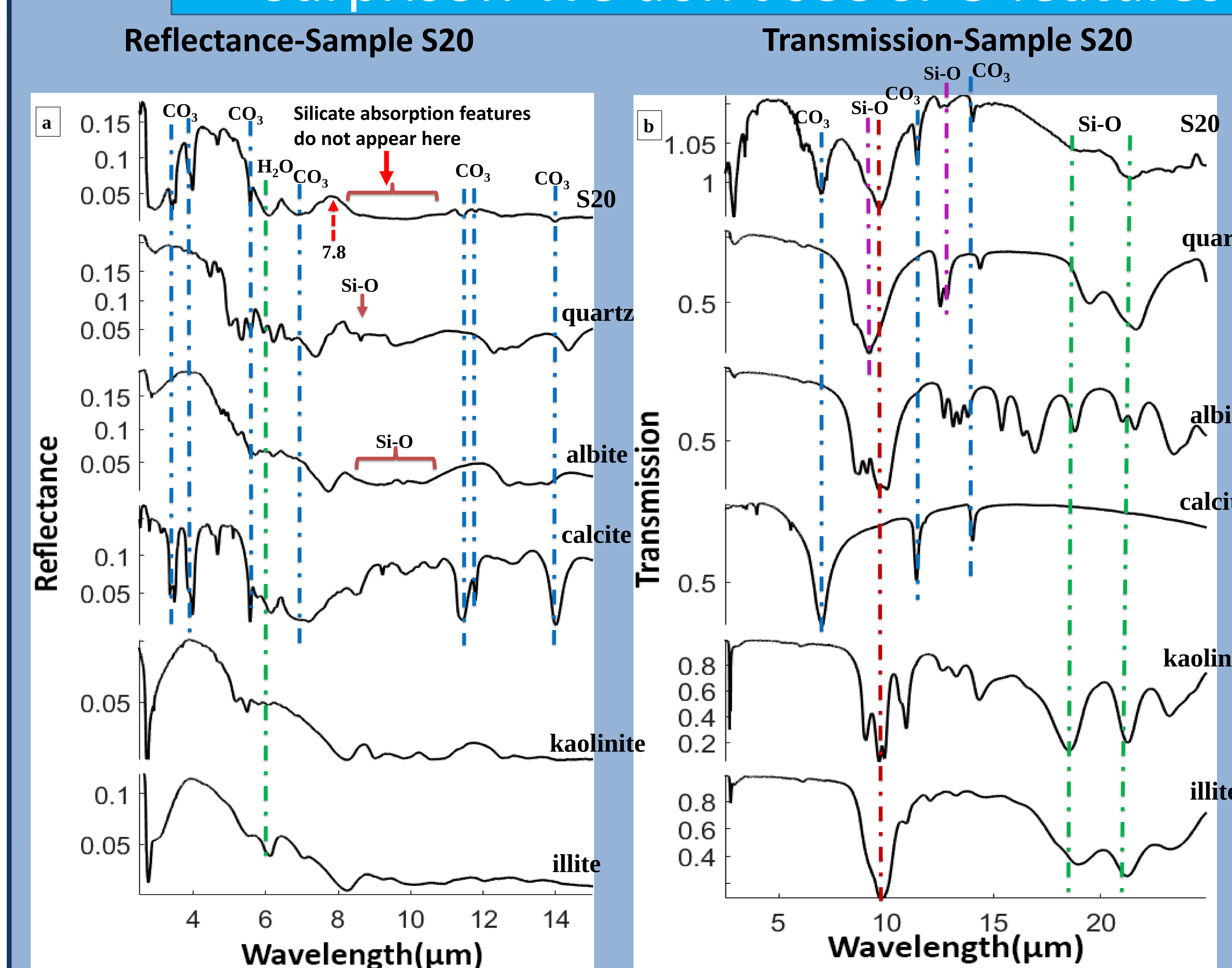


Figure 3. (a) and (b) are LWIR reflectance and transmission spectra of sample S20 and library minerals. Arrows call absorption features related to various minerals in dust samples.

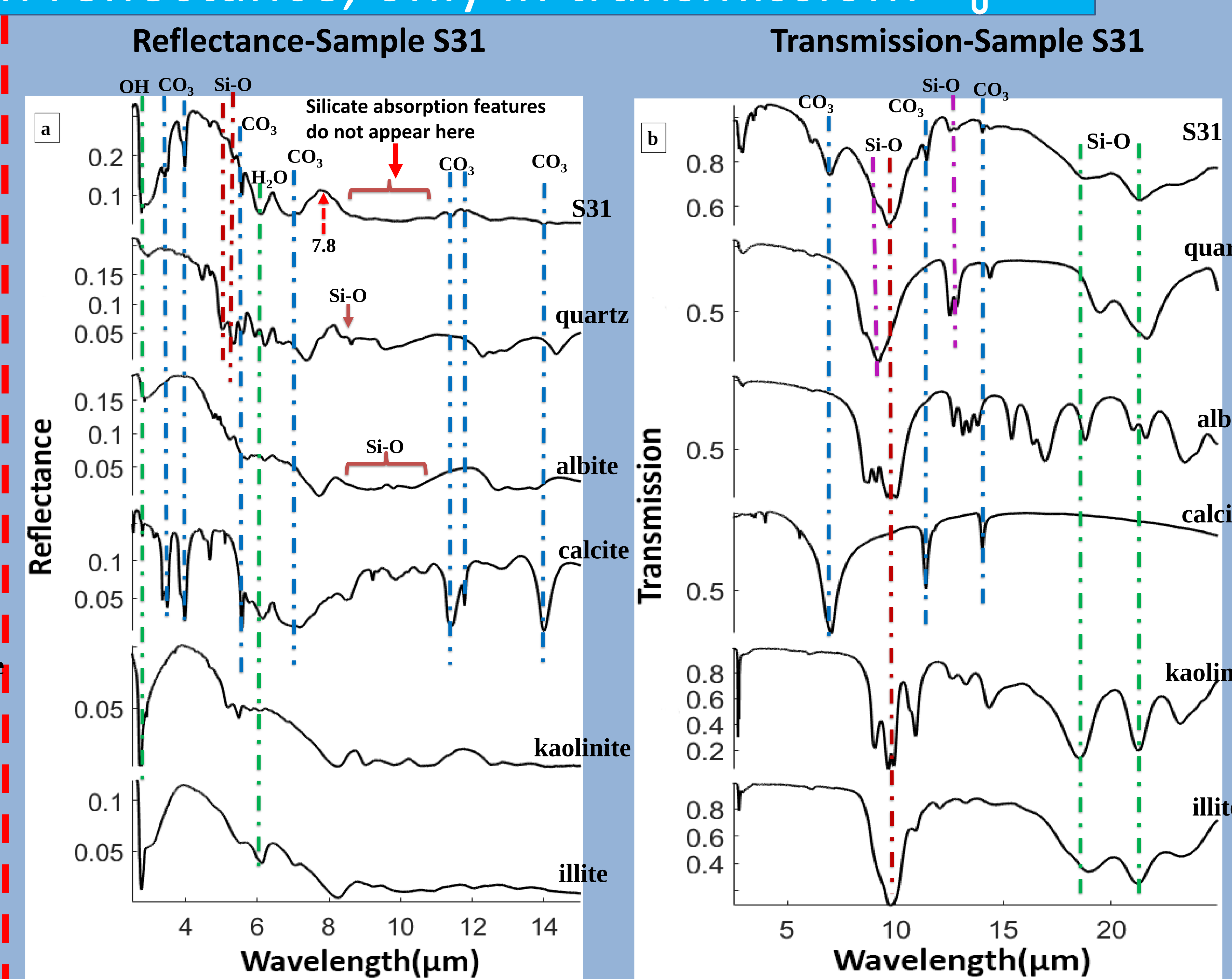


Figure 4. (a) and (b) are LWIR reflectance and transmission spectra of sample S31 and library minerals. Arrows call absorption features related to various minerals in dust samples.

## Conclusion

- ✓ We are trying to understand why diagnostic absorption features attributed to silicates (Si-O bands) are not found in the region between 8-12 μm.
- ✓ Transmission spectra could detect quartz and other silicates (feldspars and clays) both in a big envelope around 10 μm and at longer wavelengths (~ 17.9-22.5 μm).
- ✓ We also identified a peak at 7.8 μm which may be attributed to anomalous dispersion or the interaction of very fine grain quartz and calcite in this spectral range.
- ✓ ***We propose that for identification of minerals in dust samples, transmission spectroscopy (TS) should be used to detect the phases that might be missed by LWIR.***
- ✓ ***Next Step:*** ***We will run linear spectral mixing for TS to measure what proportion of each mineral exist in the dust samples.***

## Affiliation

Desert Research Institute

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## References


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