**CSQ-53 Summary**

| **Question** | **Knowledge Advancement Objectives** | **Observables** | **Measurement Requirements** | **Tools & Models** | **Policies / Benefits** |
|---|---|---|---|---|---|
| Can we map topography, surface mineralogic composition and distribution, thermal properties, soil properties/water content? | A) Improve the detection of minerals species and which compose surface materials both in natural and urban environments (including waste deposits)<br>Measure better resolution bare-earth topography at high spatial and vertical resolution (1 m) and measure surface deformations in areas of active mineral extraction | • Mineralogical species in natural outcrops for mining interest<br><br>• Surface composition in urban environment<br><br>• Spectral emissivity of surfaces<br>• Spectral reflectance of surfaces<br>• Surface texture<br>• Particle dimensions<br>• Physical characteristics<br>• Surface morphology<br>• Surface deformations | imaging spectrometers and cameras<br>VNIR<br>>200 spectral channels<br>1-10 m spatial resolution<br>measurements SWIR and MWIR-LWIR 10-200 spectral channels spatial resolution > 30m<br>Laser scanners<br>Measurements frequency<br><1 day<br>MWIR-LWIR night acquisitions<br>DTM with >0,5 m spatial and vertical resolution<br>Deformation<br><br>>10 mm/yr), and 5-50 m spatial resolution deformation monitoring | Radiative transfer models improvements (3D)<br>Use of AI and machine learning techniques for mineral species detection using satellite o airborne hyperspectral images.<br>Atmospheric modelling for dust transportations | Improve policy for soil protection and agriculture development<br>Mining activity planning and control<br>Support Air pollution control (better understand of particles sources)<br>Plans to protect human healt |
| | B) Improve the measurement of quality of soils which are very important ingredients | • Soil component mineral and organic | imaging spectrometers and cameras<br>VNIR<br>>200 spectral channels | | |

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| | for agriculture and ecology | • Water content nutrients, permeability, thickness | 1-10 m spatial resolution measurements SWIR and MWIR-LWIR 10-200 spectral channels spatial resolution > 30m | | |
| | C) Measure the composition of dust sources in atmosphere and AOD and particle size parameters analysis to sand/dust storms | • Mineral composition<br>• Extension of source areas<br>• Aerosols particles characteristics<br>• Particle shape and dimension<br>• Optical characteristics | | | |

**CSQ-53 Narrative**

Spectroscopic information about the mineral content of the ground, whether soft sediment, regolith or hard rock, constitutes a great tool in numerous geological, geomorphological and soil studies. It includes mapping of rocks and mineral

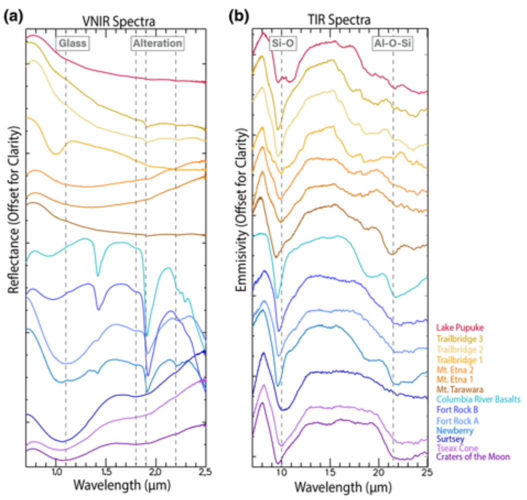
outcrops, assessment of rock weathering degree, soil studies, analysis of minerals, protection of the natural environment, analyses of geothermal deposits and studies of meteorites.

New spectroscopic measurements of the Earth's exposed surface to derive mineralogy are required to address key science and application targets. These measurements will advance understanding of fundamental geological processes, natural and anthropogenic hazards, soil geochemistry and evolution, and the location of energy and mineral resources

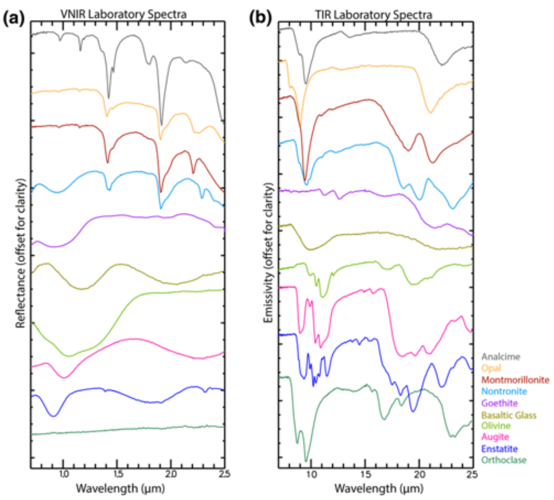
In the last few decades, hyperspectral imaging (HSI) has evolved as a method for remote detection with many applications, including identification of plants, earthen materials, and natural events as volcanic eruptions.

Surface spectroscopy in the full spectral range of VIS-SWIR and MWIR-LWIR is very important reconstruct the eruption historical phases. Hyperspectral MWIR-LWIR (3-5 and 8-12 microns) spaceborne instruments are not yet available but should be considered as a goal as future missions

Spectral analysis by means of laboratory instruments and remote sensing data is also very important to better understand geology and lithology in fault areas




(a) Visible/near-infrared (VNIR) reflectance spectra and (b) thermal infrared (TIR) emission spectra of volcanic tephra samples, ordered by X-ray diffraction (XRD) crystallinity, decreasing from top to bottom, and colored by eruption type (purple = magmatic cinders, blue = phreatomagmatic, yellow/orange/red = magmatic). Dashed lines indicate wavelength positions of major absorption bands.

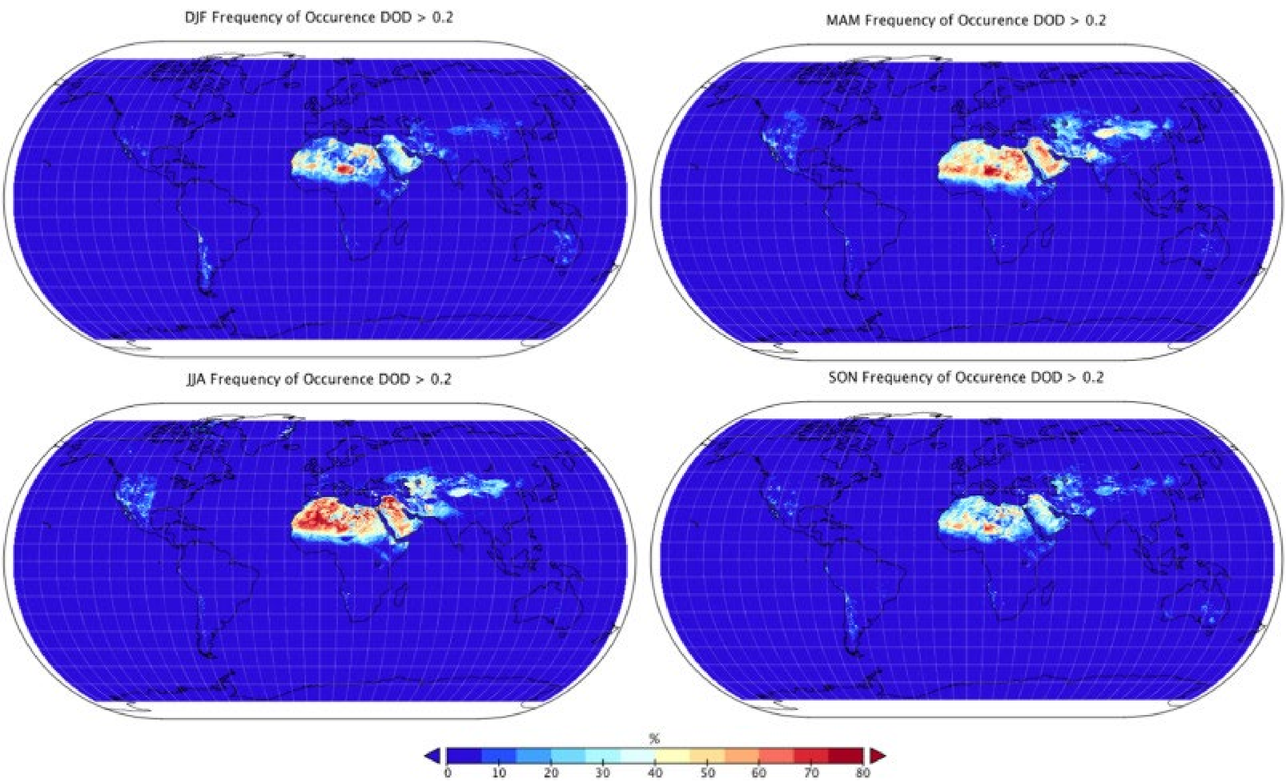



Laboratory reference spectra of minerals common in volcanic environments in the (a) visible/near-infrared (VNIR) (Horgan et al., 2017; Kokaly et al., 2017) and (b) thermal infrared (TIR) (see citations in Table 2).

Reference: Henderson, M. J. B., et al. 2020 https://doi.org/10.1029/2019EA001013

Dust sources

Oceans and arid regions provide most of the atmospheric aerosol load of the Earth, with 6.3–10.1 and 1.2–1.8 Giga (109)-tons (t)/year (yr) of sea salt and PM10 soil dust, respectively, emitted into the troposphere. Sea salt is made of PM derived from sea/ocean droplets suspended into the atmosphere that are subsequently evaporated and yielding salts, such as sodium, chloride, magnesium, calcium, potassium, and sulphate. Soil dust aerosols are created by wind erosion within arid regions, where soil particles are loosely bound by the low soil moisture and absence of vegetation. Dust sources have been identified empirically from satellite radiance measurements over the last few decades




Frequency of occurrence of dust optical depth (DOD) > 0.2 by season. Aerosol optical depth was retrieved at 10 km resolution using the MODIS Deep Blue algorithm

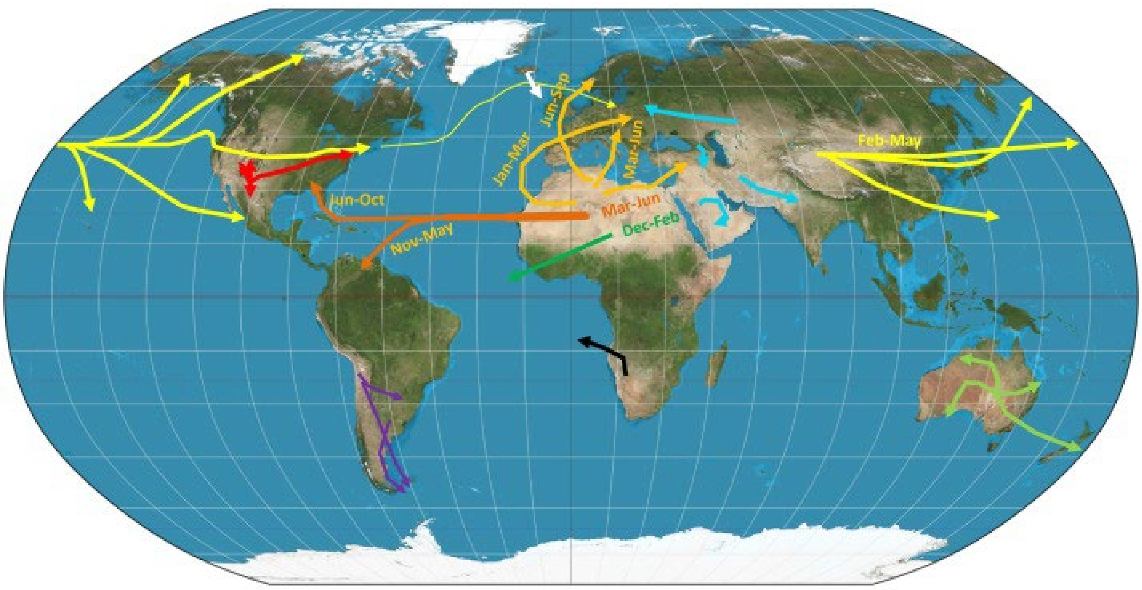



Figure Major desert dust transport fluxes, modified from Griffin (2007).