Assessing the Incorporation of Portable Infrared Imaging into Planetary Geological Field Work

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Introduction

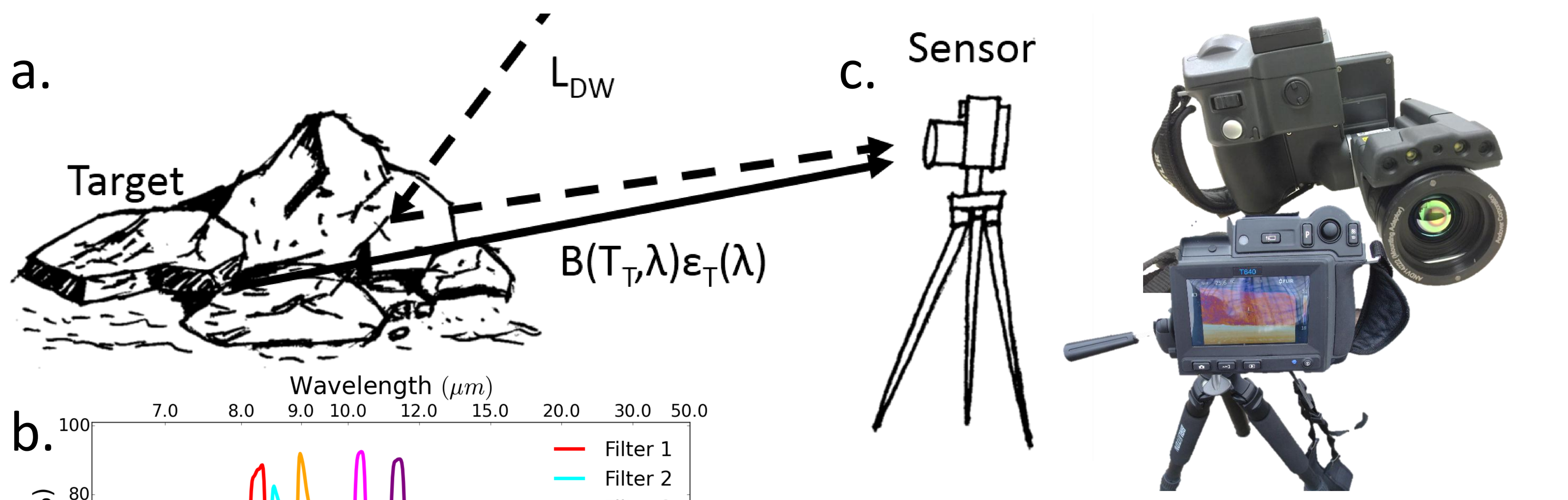
Portable/hand-held infrared spectral imaging instruments have the potential to provide helpful information in human planetary missions.

Astronauts could use these instruments to analyze geological materials in-situ, document the sampling site, and contribute to making strategic decisions in the context of predefined scientific objectives.

We test the integration of portable infrared spectral imaging into geological field work at Kilauea, Hawaii.

Instrument

Multi-band imaging camera assembled from FLIR T-640 Thermal Imager and 5 narrow-band filters (Fig. 1).



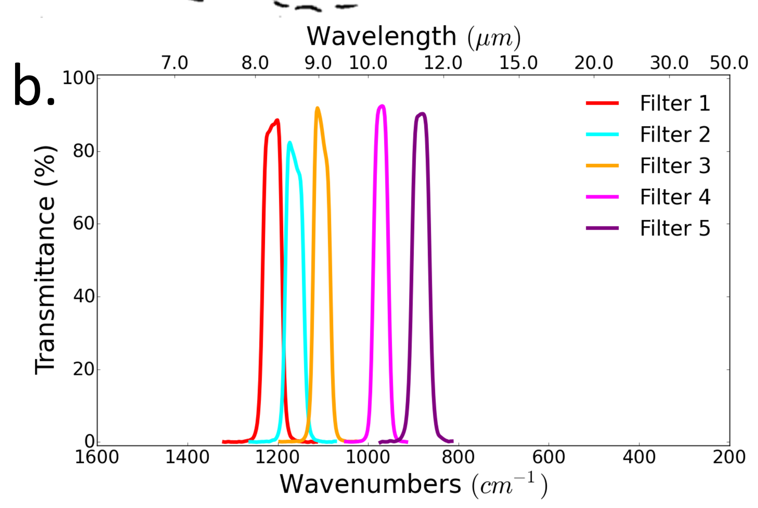


Fig. 1. a. Schematic of how emitted and reflected light are measured in the field. L_{DW}: downwelling radiance from the sky. $B(T_T,\lambda)\varepsilon_\lambda(\lambda)$: Emitted radiance from targets, dependent on Plank blackbody radiation $B(T_T,\lambda)$ and emissivity $\varepsilon_\lambda(\lambda)$. b. Transmittance of the narrow-band filters. c. Front and back view of FLIR T-640 Thermal Imager. Filters are manually mounted on to the lens of the camera.

Conclusions

Infrared spectral imaging more easily captured compositional and textural variabilities than observation with visible light (Fig. 2, Fig. 3 a,b).

Field spectra from the instrument were compared to laboratory measurements of thermal infrared (TIR), as well as visible near infrared (VNIR) spectra and hand-held X-ray fluorescence elemental abundance, to obtain a general sense of instrument's genuineness (Fig. 3).

Sample collection workflows using infrared spectral imaging were explored, both in limited and ideal technology conditions.

Infrared spectral imaging holds a potential to benefiting planetary geological field work and science return in future human missions.

Results

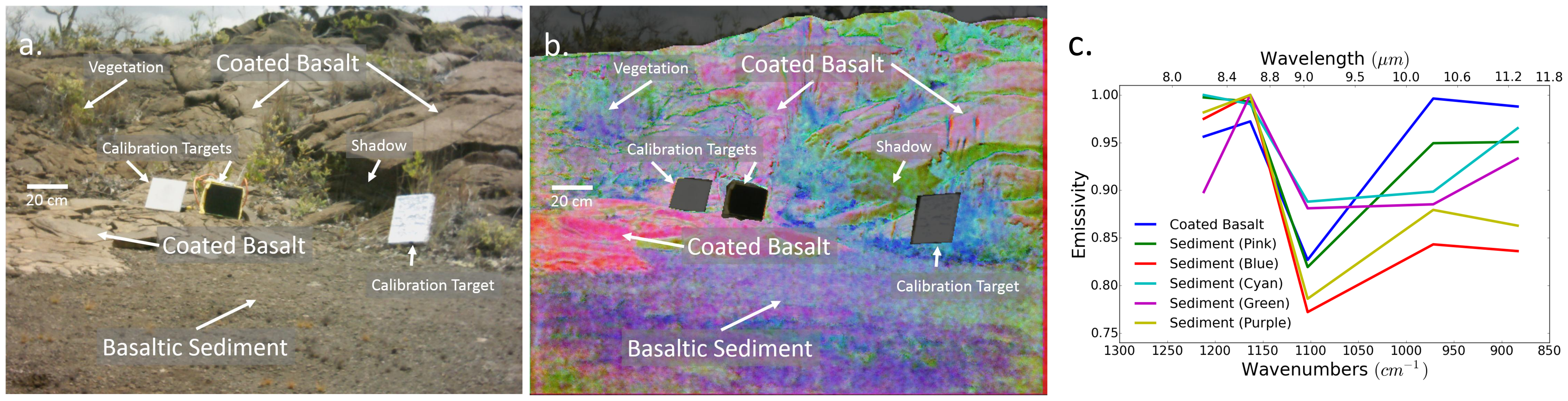


Fig. 2. a. An example scene from our field site seen in visible light. b. Image product from the instrument after processing. Processed image has been decorrelation stretched where red, green, and blue were assigned to wavelengths 11.3, 9.1, and 8.6 µm. Calibration targets are placed in the scene due to technological constraints, but are expected to be incorporated inside the instrument in future instruments. c. Spectral variability observed in the basaltic sediments and coated basalt from the scene. Representative emissivity spectra for each category are averaged.

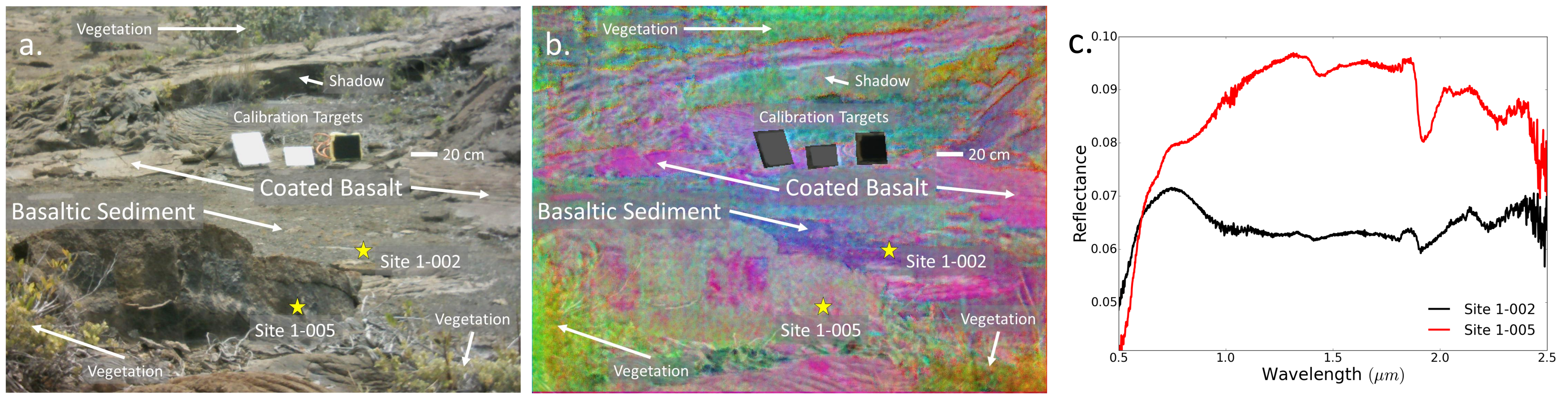
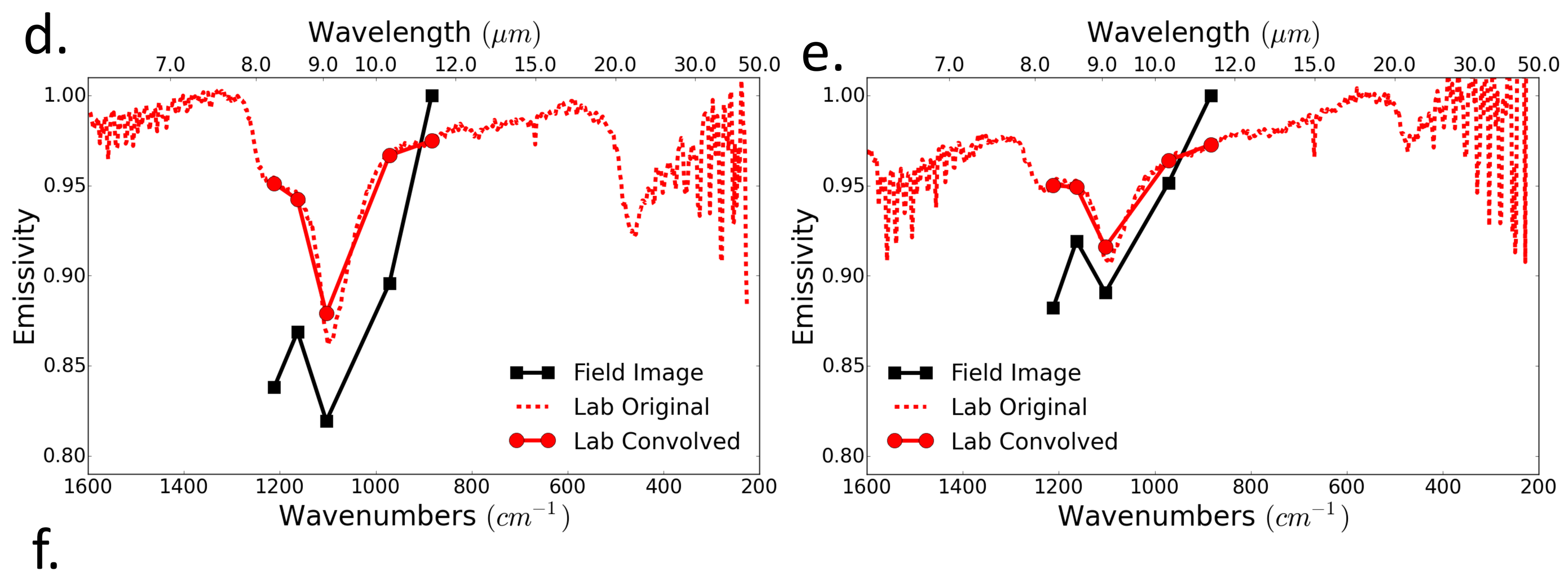


Fig. 3. a. An example scene of an older flow seen in visible light. b. Decorrelation stretched image product from the instrument. Samples were taken from this scene as indicated and their spectra were measured. c. VNIR spectra of the two samples acquired in this scene. d, e. Thermal infrared spectra of Site 1-002 and Site 1-005 samples, respectively. Laboratory spectral resolution has been adjusted to the 5 band resolution of our instrument and shown in bold red, where as the full lab resolution is shown in dashed red. Spectra from the instrument are included (black). Due to differences in the environmental conditions of the field and laboratory apparatus, highly satisfying match between field and lab spectra are not expected. Filter 1 has a systematic offset in emissivity across all images that is not yet explained. Still, the major absorption feature due to silica coating at 1,100 cm^{-1} is captured by the instrument. f. XRF elemental abundance (basic estimates). Measurements in TIR, VNIR, and XRF roughly match published data[1] and indicate that these samples are basaltic rocks with silica coating.



f.

	Mg	Al	Si	P	K	Ca	Ti	Mn	Fe
Site 1-002	0.01	14.43	60.09	1.12	0.52	7.42	2.53	0.23	14.79
Site 1-005	2.89	15.40	55.33	1.11	0.49	7.86	2.33	0.26	14.34

[1]Minitti M. E. et al. (2007) JGR, 112, E05015.