

Supporting Text

The THEMIS instrument consists of separate infrared and visible imagers providing 100-m per pixel resolution in nine $\sim 1.0 \mu\text{m}$ wide infrared bands centered from 6.78 to 14.88 μm , and 18-m per pixel resolution in five $\sim 0.05 \mu\text{m}$ -wide visible/near-IR wavelengths centered from 0.42 to 0.86 μm . The IR imager produces 32-km wide images of variable length; the visible imager produces 18.4 km wide images up to 59 km long in one band at full spatial resolution. An internal calibration flag, the only moving part in the instrument, provides thermal calibration and IR flat-fielding, and is used to protect the detectors from direct illumination from the Sun. The instrument weighs 11.2 kg, is 29 cm by 37 cm by 55 cm in size, and consumes an orbital-average power of 14 W.

Thermal images in common experience are largely of temperatures resulting from internal heat sources, such as medical thermography, people at night, or industrial trouble spots. Interior heat flow on Mars is modeled to be about 30 mWm^{-2} (1), about 2×10^{-4} of mean insolation, and has a negligible effect on surface temperatures (15 mK on average). Observation of temperatures higher than expected from solar heating, hence indicating localized "geothermal" heat flow, is a major goal of THEMIS. Temperatures in response to the diurnal variation of sunlight (insolation) have an average value related to the surface reflection coefficient for sunlight (albedo, A) and the diurnal amplitude is primarily related to the thermal inertia, $I = (k\rho c_p)^{1/2}$, where k is the thermal conductivity, ρ is the density, and C the specific heat; on Mars, k is the dominant factor. Although analytic solutions exist for homogeneous materials and periodic insolation (2), numerical models are used for the greater complexity of the martian surface and atmosphere (3-5). On Mars, daytime temperatures for extensive horizontal surfaces are influenced about

equally by increasing A and decreasing I, with the effect of slope on thermal radiance similar to its effect on reflected brightness so that topography yields a familiar appearance. Nighttime temperatures are influenced dominantly by increasing thermal inertia; thus day-night thermal image pairs commonly have dramatically different appearance and allow separation of A and I effects.

The surface-sensing bands in the THEMIS IR camera measure emitted spectral radiance, which is converted to a brightness temperature in each band by assuming unit emissivity; no atmospheric corrections have been applied to the data presented here. The physical (kinetic) temperature is assumed to be equal to the maximum brightness temperature. Typical equatorial to mid-latitude daytime temperatures at the seasons discussed here range from ~240 to 280 K; typical nighttime temperatures range from 155 to 200 K. THEMIS has a single-pixel noise equivalent spectral radiance (NESR) of $2.72 \times 10^{-6} \text{ W cm}^{-2} \text{ sr}^{-1} \mu\text{m}^{-1}$ in Band 9, corresponding to a $1-\sigma$ noise equivalent delta temperature of ~0.4 K at 245 K; and 1.1 K at 180 K.

The data presented here were collected during the initial Mars Odyssey mapping phase between February 15 and Oct. 1, 2002, corresponding to orbits 836 to 3536 and covering the northern winter and spring season from solar areocentric longitude (Ls) 329 to 76° at local times from ~3.0 to ~4.3 H (24 H equals one martian day) both day and night. The data have been calibrated to spectral radiance ($\text{W cm}^{-2} \text{ sr}^{-1} \mu\text{m}^{-1}$) to remove the instrument response function and stray light reflections, and a geometric projection applied where appropriate to provide sub-pixel band-to-band registration. THEMIS images identified by 'I' (infrared) or 'V' (visible), followed by a five-digit orbit number and a three-digit image number within each orbit; e.g. I00903005.

Slopes are distinct in daytime images because the temperature varies with illumination angle. Slopes are not thermally distinct at night, except where differences in thermophysical properties correlate with local scarps. Areas that are relatively warm in both day and night images must have low albedos to be warm in the daytime and a relatively high thermal inertia to remain warm at night. Such areas generally have diffuse spatial boundaries, often correspond to dunes in high-resolution visible images, and are interpreted to be accumulations of coarse and dark wind-blown sand.

Radiative coupling between sloped and flat-lying surfaces can elevate the nighttime temperatures of both surfaces relative to the temperature of an isolated horizontal surface. This effect should be symmetrical on either side of the boundary between the sloped and flat-lying surfaces, but observations show that only the sloping surfaces are warmed above their surroundings. Further, the lack of azimuthal temperature variations demonstrates that the effect is not due to the setting Sun.

The mean global annual abundance of water vapor in the martian atmosphere is about 10 precipital micrometers, corresponding to a mixing ratio of 10^{-4} and a saturation temperature of about 190K. Both dust and H₂O-ice are probably incorporated in CO₂ condensation as the atmospheric temperature drops to near 145K, a process that involves about 1/4 of the entire atmosphere each year. Thus dust and H₂O are tied into solid CO₂ with their global abundance ratios and remain immobile relative to CO₂ during the polar night.

The majority of 18 m per pixel visible images are obtained using the red (654 nm) filter in order to maximize surface area coverage at a wavelength that is highly sensitive to surface albedo variations. As of Oct. 1, 2002, just over 1.2% of the surface had been

imaged in this mode. The five visible to near-infrared wavelengths (425, 540, 654, 749, and 860 nm) were chosen to provide the ability to discriminate bright icy vs. dusty regions at high latitudes, to provide sensitivity to certain ferric and ferrous minerals, and to allow the generation of true-color RGB images of the surface. Because of memory buffer limitations, most color images are obtained at 36 m/pixel or 72 m/pixel scale. As of Oct. 1, 2002, just over 1.3% of the surface had been imaged in two to (usually) five colors.

1. G. Schubert, S. C. Solomon, D. L. Turcotte, M. J. Drake, N. H. Sleep, in *Mars* H. H. Kieffer, B. M. Jakosky, C. W. Snyder, M. S. Matthews, Eds. (University of Arizona Press, Tucson, AZ, 1992) pp. 147-183.
2. H. S. Carslaw, J. C. Jaeger, *Conduction of heat in solids* (Clarendon Press, Oxford, 1959).
3. H. H. Kieffer *et al.*, *J. Geophys. Res.* **82**, 4249-4292 (1977).
4. R. M. Haberle, B. M. Jakosky, *Icarus* **90**, 187-204 (1991).
5. M. T. Mellon, B. M. Jakosky, H. H. Kieffer, P. R. Christensen, *Icarus* **148**, 437-455 (2000).

Supporting Figures

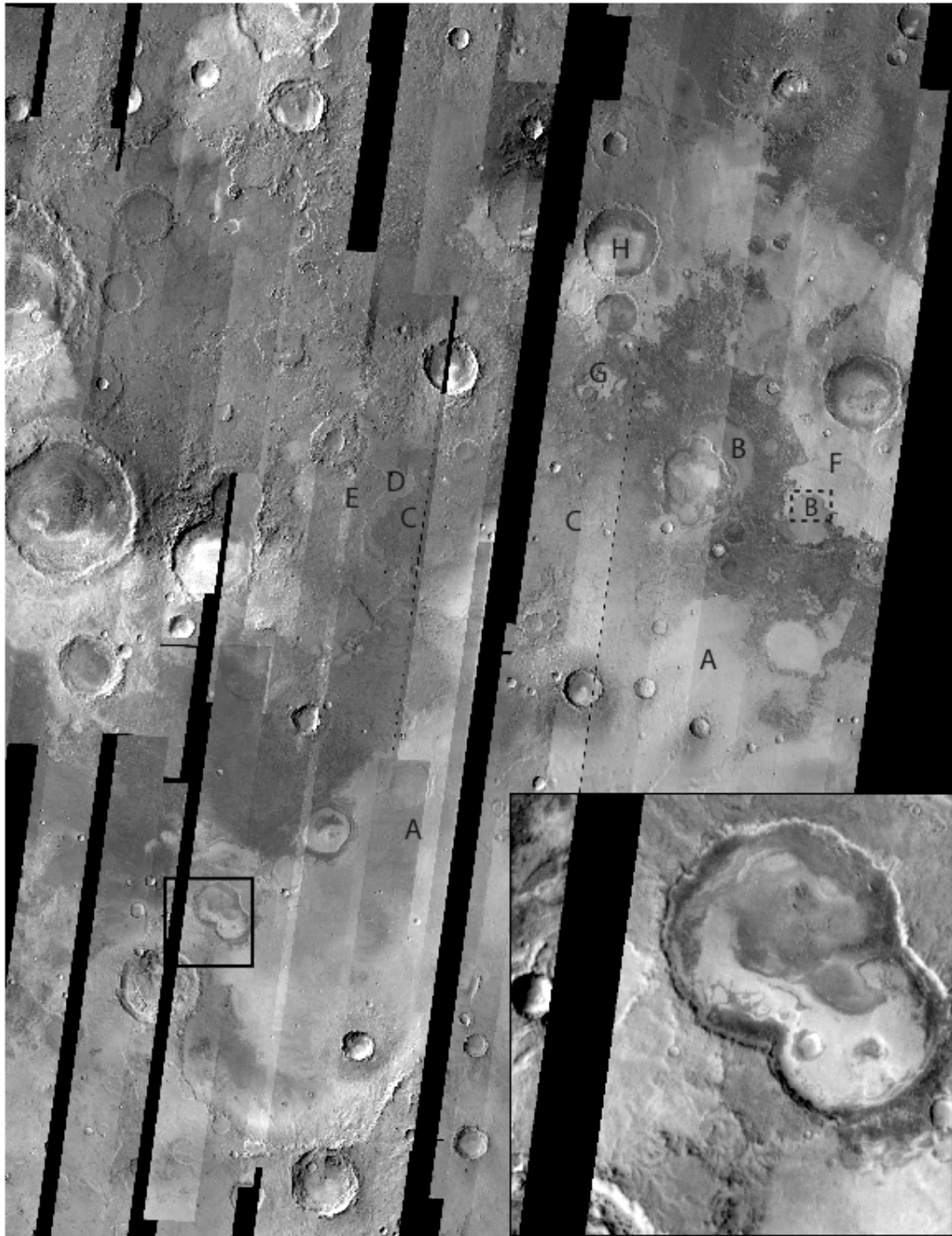


Figure S1. Mosaic of temperature images of Terra Meridiani. Mosaic covers the region from 2° S to 6°N, 352 to 360° E., north is toward the top. The individual image strips are ~32 k m wide with 100-m per pixel resolution. The calibrated radiance in each strip was normalized to reduce changes due to the local time variation of the Odyssey orbit. Dark regions are cooler, bright regions are warmer in each mosaic. The letters indicate

locations or units discussed in the text; e.g. hematite-rich Unit B is stratigraphically above Unit C (Etched Terrain), which is above Unit F (Dissected Crater Terrain). The insets show the full resolution of the region outlined by the small box. Mosaic of daytime temperature images; normalized temperatures vary from approximately 230-255 K. Solar illumination is from the left. Dashed box indicates location of **Fig. 2**.

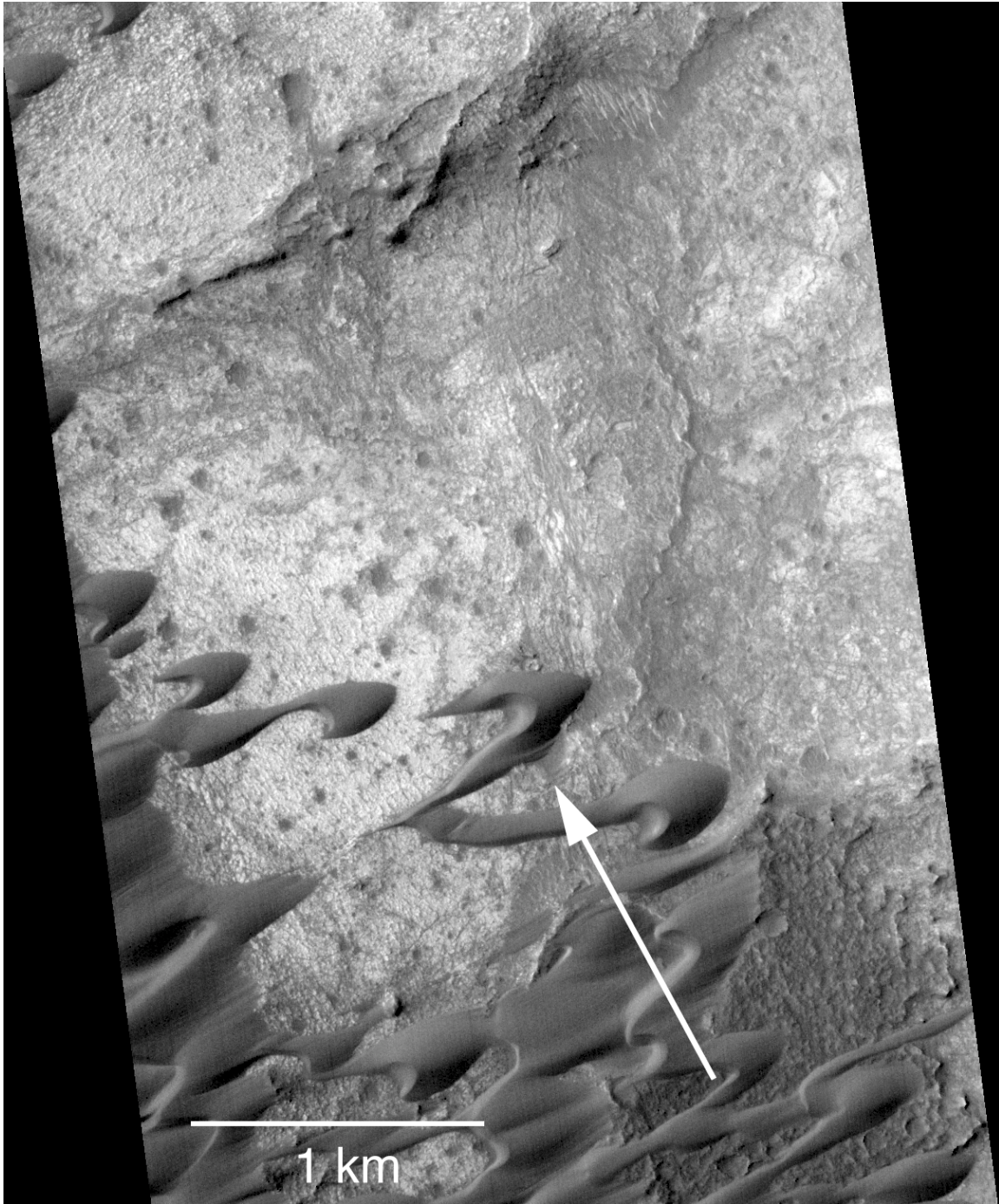


Figure S2. MOC image (portion of FHA00451) of barchan dunes in Nili Fossae. The image covers an area approximately 3 km wide. The dunes are moving from right to left across an exposed rock (I=2000) surface. The arrow indicates the individual dunes seen in **Fig. 3**.

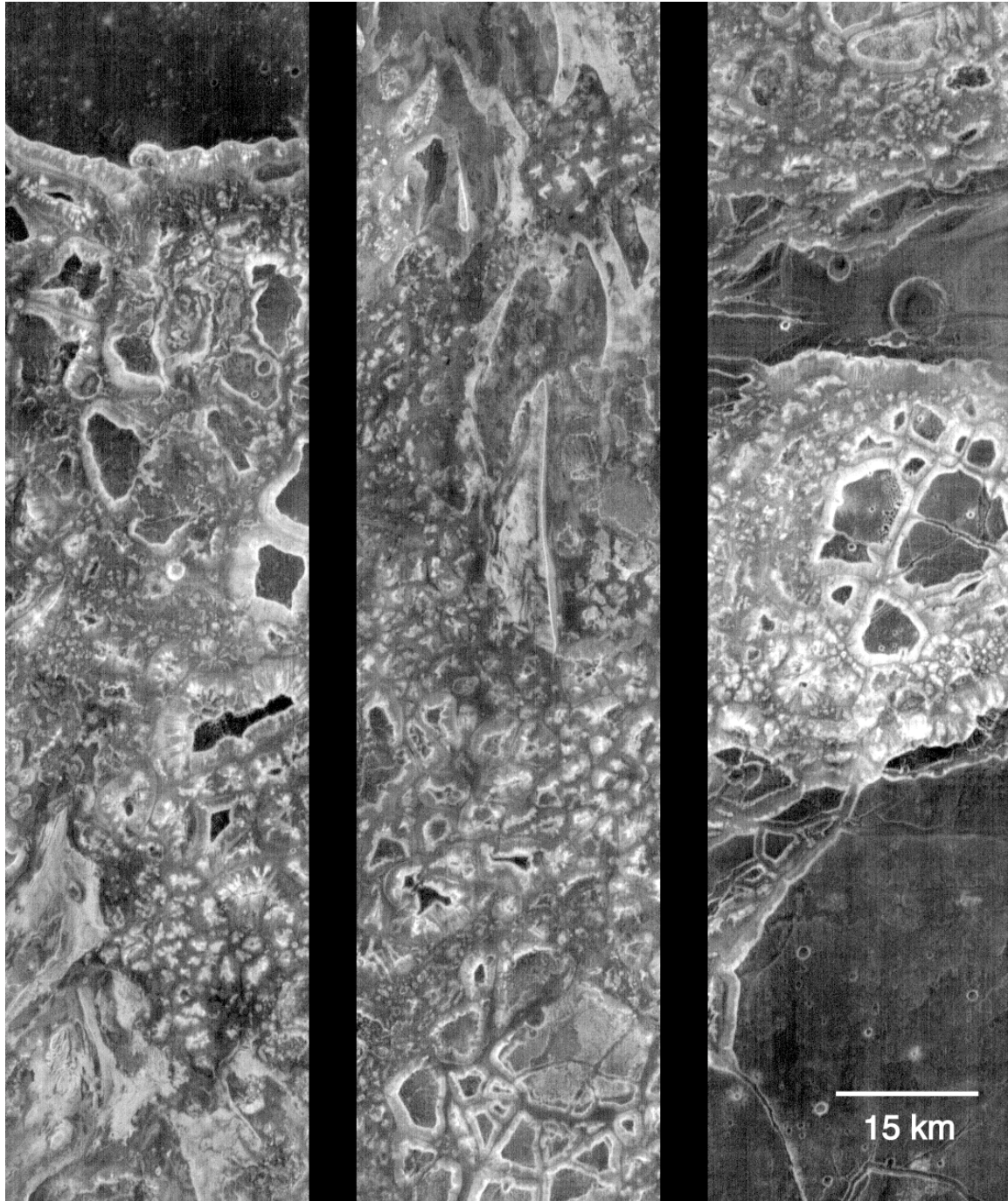


Figure S3. Nighttime temperature showing a complex array of rocky slopes and exposed rocky layers. Portion of mage I01855003 from 2° S to 7.5° S, at approximately 332° E covering portions of Aureum Chaos. Temperatures in this image vary from 185.0 K (black) to 205.7 K (white); rocky slopes are warm (bright) in this image. The original image is ~ 32 km wide and ~ 380 km long, and has been arranged with each successive image portion placed to the right, beginning with the top (north) of the image on the left. North is toward 1 o'clock.

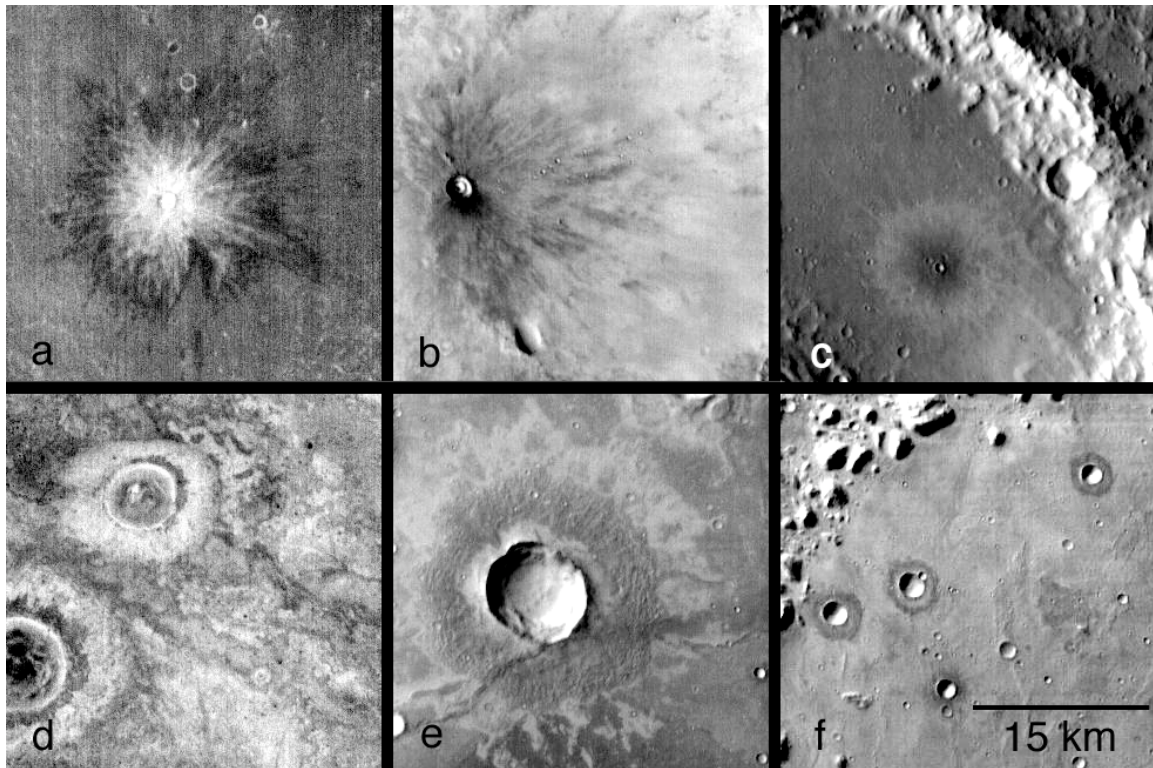


Figure S4. Collage of temperature images of crater ejecta. Each frame is a portion of an IR image covering an area ~ 32 km by 32 km. (a) I02028002 (night, 6° S, 24° E), minimum temperature (T) 167.0 K, maximum T 185.2 K. (b) I01061005 (day 1° N, 358° E), min T 266.3 K, max T 276.9 K. (c) I01254012 (day 5° S, 190° E), min T 255.2 K, max T 279.6 K. (d) I01096002 (night, 23° S, 266° E), min T 184.5 K, max T 198.6 K. (e) I01501005 (day, 24° S, 293° E), min T 247.4 K, max T 253.7 K. (f) I01692003 (day, 35° S, 183° E), min T 227.1, max T 256.3 K.

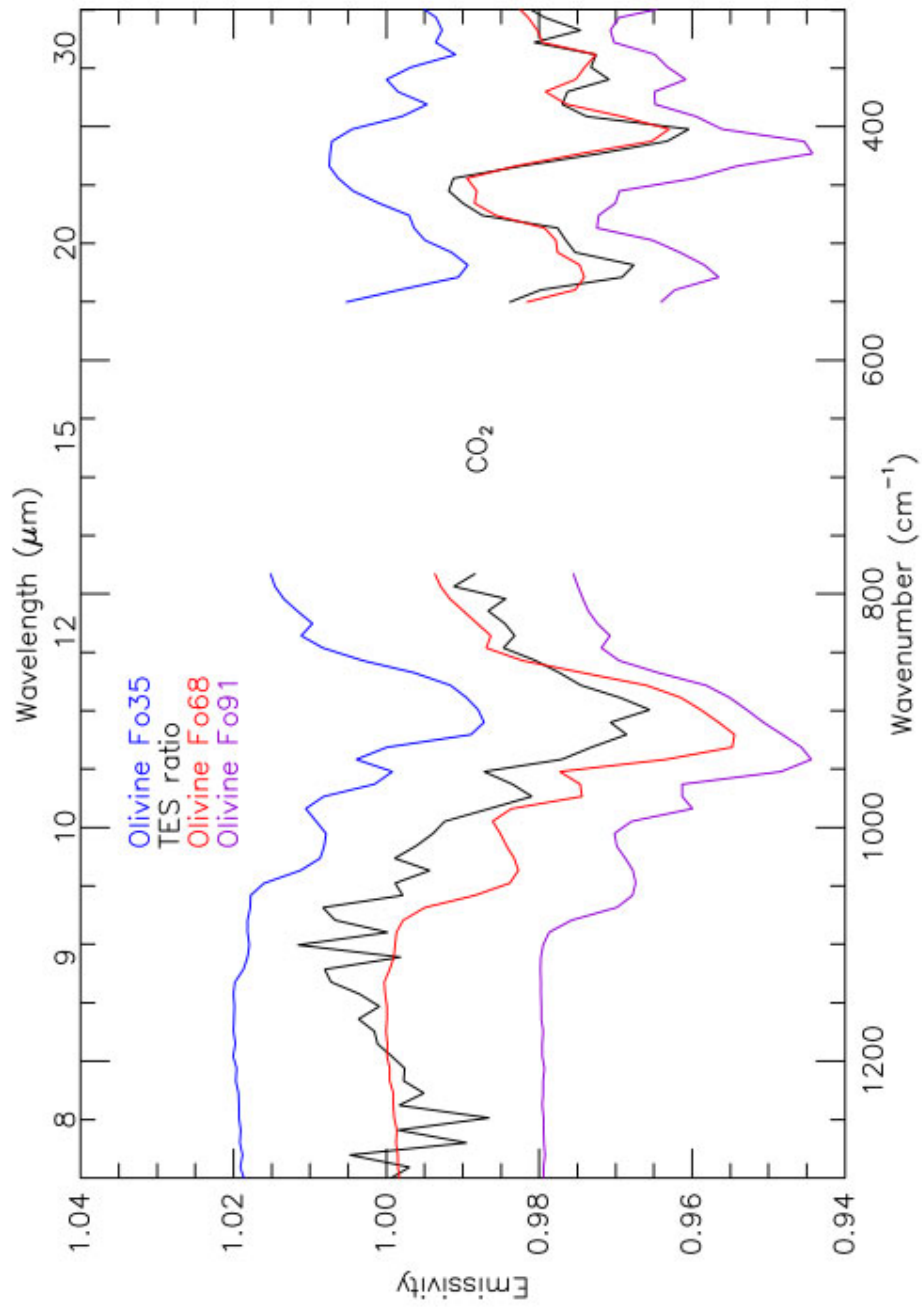


Figure S5. TES ratio spectra compared with laboratory olivine spectra of varying composition.