EMISSIVITY EFFECTS ON THE SURFACE TEMPERATURE OF MARS AS MEASURED BY THE INFRARED THERMAL MAPPER; David F. Vaughan[1] and James R. Zimbelman[2], [1]Dept. of Physics, Baldwin-Wallace College, Berea, OH 44017, [2]Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, Washington, DC 20560

Emissivity effects on Viking Infrared Thermal Mapper (IRTM) measurements of the surface temperature of Mars may provide useful information about the composition of surface materials on Mars. In particular, what are the magnitudes of the variance between IRTM temperatures derived from "ideal" and real materials? This question was addressed through the use of published emissivity data for geologic materials and the spectral properties of the IRTM thermal bands.

The IRTM instruments on the Viking orbiters measured emitted infrared flux from Mars in four bands designed to look at the surface (T_7, T_9, T_{11}, and T_{20}) and one band for the atmosphere (T_{15}) (1). By assuming that the surface is a black body (emissivity = 1), the measured fluxes were converted to brightness temperatures. Non-unit emissivity of surface materials could result in brightness temperatures which underestimate the actual kinetic surface temperature, as was the case in some lunar studies (2).

Emissivity values as a function of wavelength were digitized from published graphs determined from laboratory reflectance data (3,4). Published emissivity data for particulates (40 to 400 um diameters) and whole rocks (cut plates) of both silicic and mafic materials were used in this study (Table 1). The spectral response of the individual IRTM bands (1) were combined with the emissivity data files in a BASIC program which calculated the emitted flux, using the Planck equation for a specified kinetic temperature, that would be detected in each IRTM band. The calculated flux was then used to determine the equivalent brightness temperature which would result if the flux originated from an ideal emitter viewed in the same IRTM spectral band. The variance between the input kinetic temperature and the brightness temperature obtained by the IRTM (with unit emissivity) was recorded for each of the surface-sensing bands (Table 1). The magnitude of the variance is directly related to the particle size of the materials, with smaller particles showing less deviation from unit emissivity; this result is likely the result of increased scattering among the small particles (4). The IRTM thermal bands showed differing variance as a function of composition, with T_7 showing the greatest effect for mafic materials and T_9 being reduced for silicic materials.

IRTM data from seven representative areas of the martian surface were then investigated to evaluate the observational implications of the calculated temperature variances. The seven areas were representative of distinctive regions of the planet: Arabia, Syrtis Major, Amazonis, Memnonia, Hesperia, Acidalia, Chryse, and Ascraeus Mons. Investigation focused on day/night crosspoints in high resolution IRTM data, where diurnal temperature properties could be evaluated within localized areas

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(<500 km^2). Observed brightness temperatures were also compared to calculated model surface temperatures obtained using the Mars Thermal Model (MARSTHERM)(5). Each location was examined for possible atmospheric contributions to the IRTM temperatures (6,7); the widespread effects of atmospheric condensates and particulates eliminated five areas from further consideration. The two remaining areas, Arabia (31.8°N, 320.6°W) and Acidalia (38.9°N, 37.3°W), display some subtle variations between thermal bands (Table 2) which can be compared to calculated variances (Table 1). The primary result of this comparison is that quartz-rich (silicic) materials must not be significant components of either fine particulates or coarse rock fragments exposed at the surface in these two locations. The broadband nature of the IRTM thermal bands does not allow discrimination between possible mafic materials which may be present at the surface.

REFERENCES: 1) H.H. Kieffer et al., J. Geophys. Res. 82, 4249-4291, 1977. 2) E.A. Burns and R.J.P. Lyon, J. Geophys. Res. 69, 3771-3778, 1964. 3) J.W. Salisbury and L.S. Walter, J.Geophys. Res. 94, 9192-9202, 1989. 4) E.A. Burns and R.J.P. Lyon, ln Lunar Surface Layer (J.W. Salisbury and P.E. Glaser, eds.), pp.469-490, Academic Pr., 1964. 5) S.M. Clifford and C.J. Bartels, LPS XVII, 142-143, 1986. 6) G.E. Hunt, J. Geophys. Res. 84, 2865-2874, 1979. 7) P.R. Christensen and R.W. Zurek, J. Geophys. Res. 89, 4587-4596, 1984.

Table 1: Variance between surface kinetic temperature and IRTM brightness temperature for several geologic materials.

	150K				225K				300K			
MATERIAL (µm)	T_7	T_9	T_{11}	T_{20}	T_7	T_9	T_{11}	T_{20}	T_7	T_9	T_{11}	T_{20}
ANORTHOSITE(74)	-.48	-.33	-.49		-1.2	-.72	-1.1		-2.4	-1.3	-1.9	
BASALT (74)	-.66	-.32	-.46		-1.8	-.70	-.99		-3.6	-1.2	-1.7	
DUNITE (74)	-1.7	-.53	-.90		-4.2	-1.9	-1.9		-7.7	-2.1	-3.3	
GRANITE (74)	-.75	-1.1	-1.4		-1.7	-2.4	-3.2		-3.1	-4.3	-5.5	
RHYOLITE (74)	-.35	-.38	-.60		-.90	-.84	-1.3		-1.8	-1.5	-2.4	
QUARTZ (400)	-1.3	-3.4	-.65	-4.7	-2.5	-8.0	-1.5	-9.7	-4.1	-14	-2.7	-16
DUNITE (100)	-.58	-1.1	-2.1		-1.3	-2.2	-4.9		-2.4	-3.8	-8.6	
QUARTZ (40)	-1.1	-2.6	-1.3	-3.2	-2.3	-6.0	-3.0	-6.6	-3.8	-14	-5.4	-11
GRANITE (100)	-2.6	-1.9	-1.3		-1.2	-4.2	-3.0		-4.6	-7.4	-5.3	
DUNITE (PLATE)	-1.1	-1.9	-9.1		-2.5	-4.1	-20		-4.4	-6.9	-35	
GRANITE (PLATE)	-2.0	-5.4	-2.5		-4.2	-12	-6.2		-7.3	-20	-11	
QUARTZ (PLATE)	-2.7	-12	-2.2	-16	-4.9	-27	-5.1	-33	-7.6	-40	-9.2	-40

Table 2: IRTM temperatures in Acidalia and Arabia, expressed as a difference from the maximum observed temperature.

	Acidalia		Arabia	
	Day	Night	Day	Night
Tmax (K)	265.9	200.3	275.5	174.5
Tmax-T_7	-1.0(.7)	-2.2(1)	-5.3(1.9)	-8.5(1.9)
Tmax-T_9	-6.7(.4)	-1.5(1.1)	-5.5(2.3)	-3.9(1.2)
Tmax-T_{11}	-6.4(.6)	-2.7(.9)	-6.5(2)	-8.6(1.3)
Tmax-T_{20}	-10.0(.6)	-4.0(.7)	-7.0(2.1)	-10.9(1.1)

[Values in parentheses are 1-sigma variations for 8 to 60 individual brightness temperatures within each area]

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