Thermally Distinct Olivine-rich Dikes in Thaumasia Planum, Mars. J. Huang[1,2], C. Edwards[2], P. Christensen[2], B. Horgan[2], L. Xiao[1], [1]Planetary Science Institute, China University of Geosciences, Wuhan, 430074, P. R. China (junhuang@cug.edu.cn), [2]Mars Space Flight Facility, Arizona State University, Tempe, AZ, 85287-6305, USA

Introduction: Dikes are igneous intrusions into pre-existing layers or bodies of rock and they record fundamental processes in the geological evolution of terrestrial planets [1]. As a volcanically active planet, Mars has been extensively studied and several occurences of dikes have been reported through associated surface morphologies [2], magnetic [3] and topographic anomalies [4], and higher spatial and spectral resolution remote sensing data [1, 5-7]. Here we report several new occurrences of dikes in Thaumasia Planum (Fig. 1a), which are marked by long, nearly parallel, linear features cutting sinuous wrinkle ridges (Fig. 1b) and mapped as Older Ridged Plains Material (HNr) [8]. These dikes have distinct thermophysical and compositional characteristics and they provide significant clues for understanding the magmatic properties and processes in early martian geological time both regionally and globally.

Approach: To assess the morphological characteristics of the dikes and the surrounding areas, we used a variety of data sets from imaging instruments orbiting Mars. The Thermal Emission Imaging System (THEMIS) Daytime IR global mosaic with a spatial resolution of 100 m/pixel, highlights the relative surface temperatures of different geological units. Context Imager (CTX) data with spatial resolution 6 m/pixel, and HiRISE images with spatial resolution of 25 cm/pixel are used to identify different morphological features in detail. In order to evaluate topographic information of different volcanic features, we used the Mars Orbiter Laser Altimeter (MOLA) 128 pixel per degree global gridded elevation dataset and Digital Topographic Model (DEM) derived from High Resolution Stereo Camera (HRSC) data. The Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) hyperspectral and THEMIS multispectral datasets were used for compositional analysis.

Results: We have identified seven new potential dikes in Thaumasia Planum region. Each dike is remarkably linear and all of them are west-east trending (Fig. 1b, c). The length of the dikes ranges from ~22 km to ~60 km, while the width ranges from ~0.3 km to ~2.2 km. Within each dike, the morphology is consistent over its extent: there is a rougher base comparing with the surrounding area, and some of the dikes have central steep-sided liner ridges with a typical width of ~35 m (Fig. 1d-f). In addition, these dikes typically cross cut the winkle ridges in the region, indicating that they are younger than these ridges.

In addition to the morphological differences, the dikes are quite distinct in THEMIS IR images. They are relatively cool in the daytime (Fig. 1b, c) while warmer at night, indicating that the dikes have a higher thermal inertia and are likely rockier than the surrounding terrain. Overall this region is relative dust free based on a high Dust Cover Index (DCI) [9], so the temperature variation is not likely the result of different dust thicknesses.

In both CRISM summary parameter products [10] (Fig. 2a) and THEMIS Decorrelation Stretch (DCS) products, the dikes exhibit stronger olivine spectral signatures than the country rocks. CRISM spectra extracted from the olivine-rich dikes are shown in Figure 2b. Spectra were ratioed over a mean spectrum of off-dike regions located in the same CRISM column. Ratioed spectra generally show a strong and wide absorption band near 1 μm, which is consistent with olivine.

Discussion: Dike emplacement is considered to be linked with regional tectonics, and there are two likely origins for these dikes: 1) the dikes were emplaced during the formation of grabens [2, 11]; or 2) the dikes were emplaced through pre-existing fracture and fault systems [7]. In the neighboring area, there are extensive faults and grabens consistent with the East-West-oriented stress regime of Valles Marineris, but dikes are not directly associated with these features. Because the dikes cross-cut the wrinkle ridges, they most likely post-date the graben-forming event, so we favor the second formation mechanism, which is contrary to dike emplacement mechanism suggested by [7].

The olivine detected in this study has a different spectral shape than the Fe-rich olivine in [7]. The dike olivine spectrum does not exhibit the ~1.3 micron shoulder or breadth of absorption often found in fayalite and/or large-grained size olivine spectra [12], perhaps suggesting that the dike olivines are relatively Mg-rich compared to the Fe-rich olivine found in Valles Marineris. This composition may represent a primitive magma source for the dike olivines.

In addition, the dikes are thermally distinct from the adjacent terrains, which are different from other dikes reported elsewhere on Mars [1, 4-7]. Thaumasia Planum was emplaced in the late Noachian – early Hesperian [8] and it experienced extensive geological modifications. However, dust and regolith did not mask the differences between the dikes and surrounding areas, both in composition and thermal characteris-

tics. The cause and nature of these thermophysical differences is an area of on going work.

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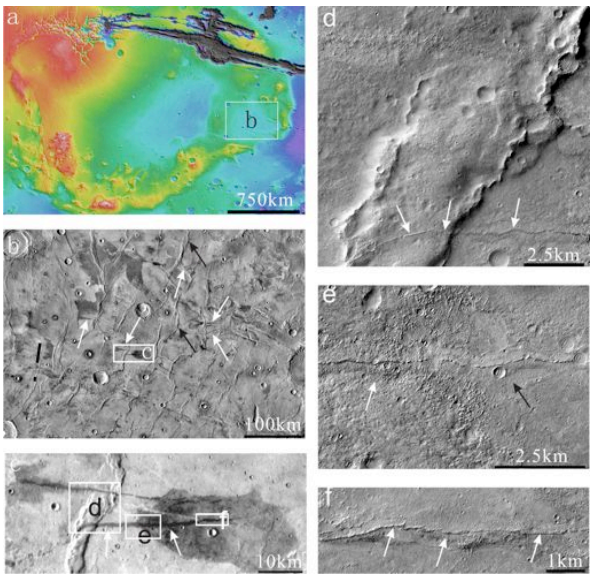

Fig. 1 (a) Color MOLA over THEMIS Day IR mosaic of Syria-Thaumasia Block (rainbow scale: low=black, high=white); (b) THEMIS Day IR mosaic of Thaumasia Planum, white arrows show possible dikes, black arrows indicate winkle ridges; (c) Two thermally distinct dikes in THEMIS Day IR mosaic, the eastern part of the southern one stays cooler (white arrow) than the west part (black arrow); (d) A dike cut a winkle ridge indicated by white arrows, CTX image; (e) A close view of the different temperature parts within the southern dike in (c), white arrow indicates the warmer part while the black arrow indicates the cooler part, CTX image; (f) A rougher base with a central steep-side liner ridge (indicated by white arrows) within the dike, CTX image.

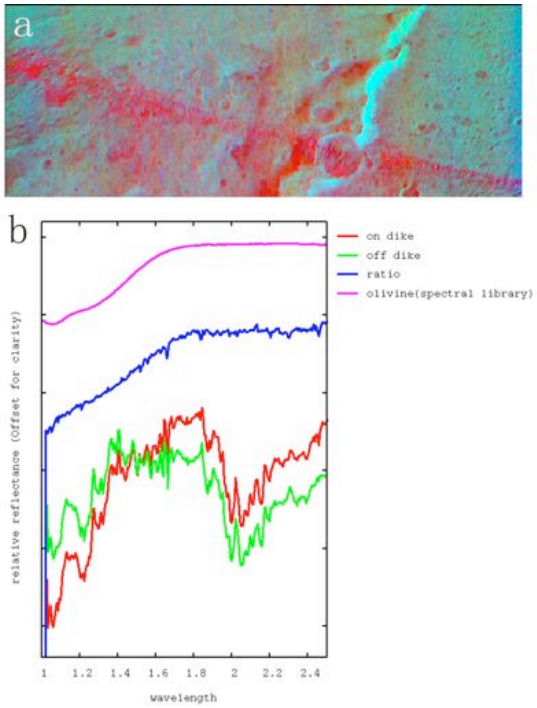

Fig. 2 (a) CRISM FRT data. RGE composition of the dike area R=OLINDEX2; G=LCPINDEX; B=HCPINDEX; (b) CRISM FRT Spectra of on dike, off dike, on dike ratioed off dike, and Mg-rich olivine spectra in library.