A GEOLOGIC MAP OF THE SINAI THOLUS REGION REVEALS CLUES TO EARLY TECTONIC AND CLIMATIC HISTORY OF MARS. H. D. Mosher[1], E. H Christiansen[1], J. Radebaugh[1] [1]Brigham Young University, Department of Geological Sciences. (hmosher@byu.edu)

Introduction: Mars' geologic history is complex and in the Tharsis region much of the older terrain has been covered by younger volcanic deposits that obscure the early geologic record [1]. Fortunately, local exposures of the pre-volcanic basement provide insight into the ancient tectonic and climatic history. One such exposure is Sinai Tholus [2], a 200 km diameter rise south of Valles Marineris on the Thaumasia Plateau [3]. To elucidate its history, we constructed a new 1:200,000 scale geologic map (Fig. 1a) of this region.

Geologic Units: Our map builds on the 2014 Geologic Map of Mars by Tanaka et al. [3]. THEMIS-IR Day and Night and CTX images, as well as MOLA topography were used in ArcGIS Pro to make distinctions between units and construct the map.

Late Noachian highland unit (lNh). The oldest unit is exposed on Sinai Tholus and in an isolated region to the east. It is characteristically faulted and raised above other terrains. On Sinai Tholus, it can be divided into a capping layer (*lNhb*) that is tilted to the NW and cut by NW- and NE-trending grabens. An underlying deeply eroded unit (*lNha*) has irregular but laterally continuous scarps, which indicate erosion of a stratified sequence of rocks. It is cut by normal faults and grabens trending NW, NE, and EW that appear to have formed at separate times. Linear ridges mostly trend NE and are interpreted to be exhumed igneous dikes. Underlies *lNv* and *eHv*.

Late Noachian volcanic unit (lNv). This volcanic plains unit is exposed along the southern margin of Valles Marineris. NW- and EW-trending normal faults are characteristic. Locally, it is mantled by eolian deposits—including dunes and sheets of dust that are dark in THEMIS-IR nighttime images. Boundaries between *lNv* and *eHv* typically are bright in THEMIS-IR night images. Overlies *lNh* and underlies *eHv*.

Early Hesperian volcanic unit (eHv). A large smooth plains unit with variable IR brightness and abundant parallel wrinkle ridges overlies *lNv* and *lNh*.

Impact features (AHNi). All impact craters larger than ~2 km and their ejecta are included in this unit. Impact craters have not been categorized by age or degradational state at this time. Craters larger than 500 m have been mapped separately for chronological studies.

Structural Features: Normal faults formed in three dominant orientations—NW, NE, and ~EW, resulting in horsts and grabens. The extensional structures are largely confined to *lNh*, but some are preserved in *lNv* (Fig. 1b). EW faults are most prominent in *lNhb*. Most normal faults are not parallel to the radial system around Tharsis and only a few are parallel to Valles Marineris. Linear ridges are well exposed only in *lNhb*, where multiple, locally en echelon segments with lengths up to 5.5 km and widths as much as 1 km generally strike NE; we interpret these to be erosionally resistant exhumed dikes. Wrinkle ridges are abundant in *eHv* and predominantly trend NNE. Wrinkle ridges are also apparent beneath the mantling deposits of *lNv* but are weakly developed in *lNh* including Sinai Tholus. There also appears to be a partially buried caldera-like collapse feature obscured by ejecta and younger volcanic deposits. A terrace of step-like normal faults forms an anulus on three sides of the oval depression (Figs. 1 and 2).

Mineralogical Variations: CRISM data show that olivine abundance on Sinai Tholus is low (Fig. 1c) compared to the surrounding plains. Moreover, spectral data indicate *lNhb* and *lNha* have different compositions (Fig. 1c). Monohydrated sulfates, kaolinite group minerals (Fig. 1c), minerals with bound H_2O, and grains with ferric iron coatings are enriched in *lNhb* compared to the older *lNha* and the surrounding plains. This cap layer (*lNhb*) seems to have formed as a result of extensive weathering in a wet climate.

Discussion: Geologic relationships reveal a more detailed history of Sinai Tholus. First, rocks of the basement (*lNhb)* formed and were cut by a series of N-trending igneous dikes, likely representing pre-Tharsis magmatism. The subsequent deposition of *lNhb* may have involved sedimentation during a wet episode of the Noachian. Grabens then formed, first oriented NW then EW. Uplift of *lNh* was likely contemporaneous with normal faulting and may have been driven by addition of magma to the crust. Erosion then stripped off part of *lNhb* and differential erosion of dikes formed linear ridges and highlighted basement faults creating a rugged surface. Flood volcanism (*lNv)* partially buried the eroded terrain and was then deformed via extension. A later episode of Tharsis-related volcanism formed the *eHv* plains. Wrinkle ridges formed as Tharsis rose. Eventually, the Valles Marineris rift formed and was erosionally modified across the north part of this region.

Acknowledgements: We are grateful to PDS Geoscience Node for providing CRISM, MOLA, CTX, and THEMIS datasets in public domain, as well as JMARS – A Planetary GIS.

References: [1] Carr, M. H., Head, J. W. (2010), *Earth and Planet. Sci.* 294, 0-203. [2] Dohm, J. M., Tanaka, K. L., Hare, T. M. (2001) *USGS* I-2650. [3] Tanaka K. L., Skinner, J. A., Dohm, J. M., Irwin, R. P., Kolb, E. J., Fortezzo, C. M., Platz, T., Michael, G. G., Hare, T. M., (2014) *USGS* 3292.

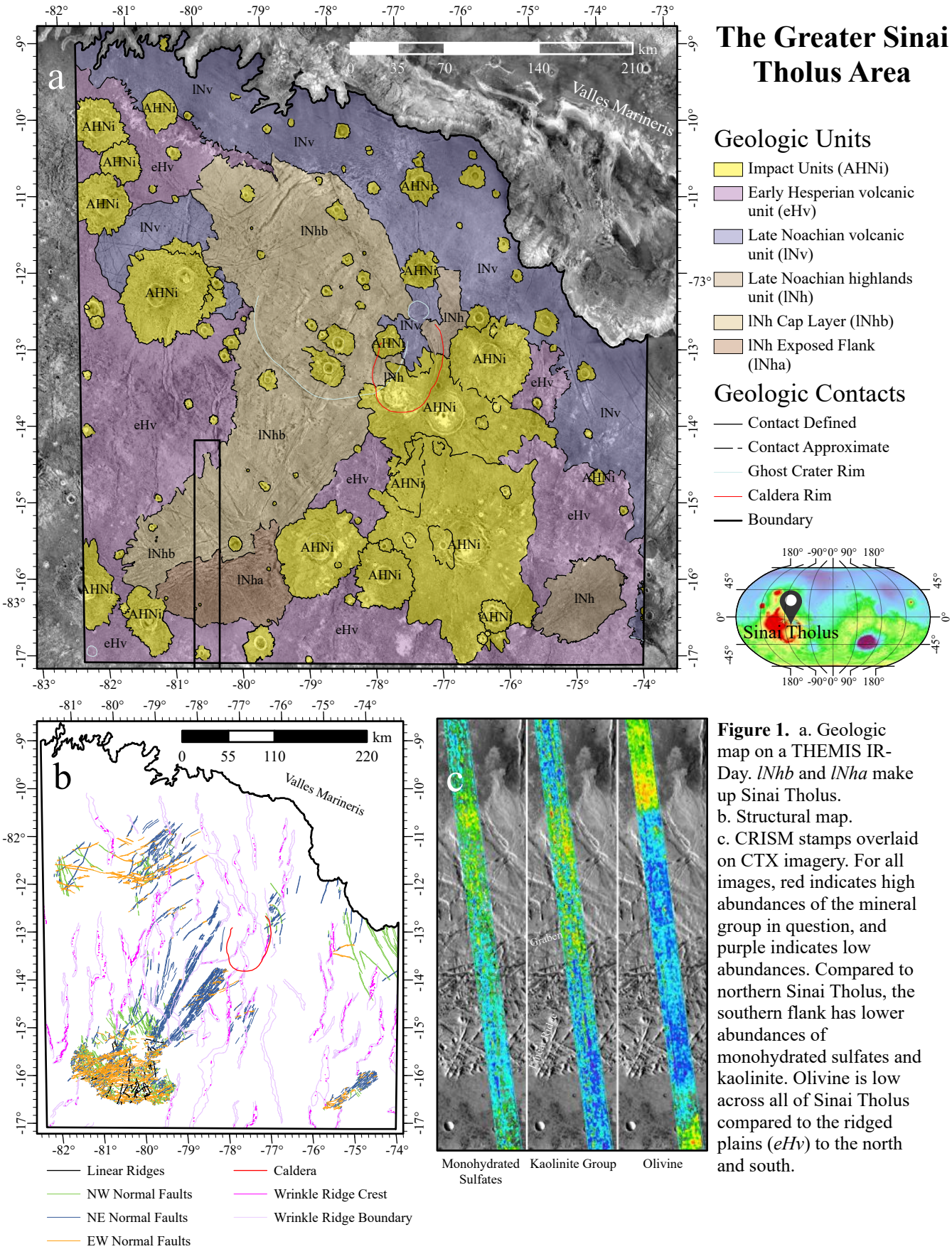

Figure 1. a. Geologic map on a THEMIS IR-Day. *lNhb* and *lNha* make up Sinai Tholus. b. Structural map. c. CRISM stamps overlaid on CTX imagery. For all images, red indicates high abundances of the mineral group in question, and purple indicates low abundances. Compared to northern Sinai Tholus, the southern flank has lower abundances of monohydrated sulfates and kaolinite. Olivine is low across all of Sinai Tholus compared to the ridged plains (*eHv*) to the north and south.