A CURSORY DISCUSSION OF THE MORPHOLOGICAL AND STRUCTURAL ANALYSIS OF ESIRA, A CENTRAL PIT CRATER ON MARS. A. Maine[1], N. G. Barlow[2] and L. L. Tornabene[3], [1]School of Earth Science and Environmental Sustainability, Northern Arizona University, Flagstaff, AZ 86011, am2935@nau.edu, [2]Dept. of Physics and Astronomy, Northern Arizona University, Flagstaff, AZ 86011, [3]University of Western Ontario, Centre for Planetary Science and Exploration, Earth Sciences, London, ON, Canada N6A 5B7.

Introduction and Background: Esira is a 16.3-km-diameter well-preserved partially-rimmed floor pit crater located at 8.95N, 313.40E. The crater is situated in the middle Noachian Highlands (mNh), according to the recent map published by the USGS [1]. This unit consists of sedimentary and volcanic materials, with climate conditions in that time period favorable to precipitation [2]. This crater is the first in our study to provide insight into understanding central pit crater morphologies, morphometries, and structures. Central pit craters display unique qualities that can conceivably help us answer questions about the past Martian climatic and geologic history. The origin of central pit craters is still debated and models include central peak collapse [3,4], layered target [5], melt drainage [6], volatile vapor release [7], and explosive origin [8]. In this study we are using multiple data sets to map selected, well-preserved central pit craters across Mars to gain an improved understanding of their original morphologic and morphometric characteristics. Esira was chosen based on the following criteria indicating its freshness: extensive impact melt deposits (“pitted material”), minimal infill, pristine morphologic features such as an ejecta blanket and sharp crater rim, and outcrops of bedrock.

Methods: This study utilized image and topography data for the Esira central pit derived from the Mars Global Surveyor’s Mars Orbiter Laser Altimeter (MOLA) at 128 pixels/degree resolution, Mars Odyssey’s Thermal Emission Imaging System (THEMIS; both visible at 19 m/pixel resolution and infrared at 100 m/pixel resolution) and the Mars Reconnaissance Orbiter’s Context Camera (CTX) at 6 m/pixel resolution and High Resolution Imaging Science Experiment (HiRISE) at 30 cm/pixel resolution. Data covering the central pit region of Esira were imported as layers into ArcMap 10.3, from which all mapping was conducted. MOLA was used to orient the two HiRISE images that were used as a basemap for the morphologic and structural maps. CTX stereopairs were used to create the contour maps. THEMIS was used for thermal inertia analysis to determine the location of dust-covered regions versus bedrock.

Five units were defined on the morphological map (Fig. 1): bedrock, impact melt, dark toned colluvium, light toned colluvium, and a vast eolian deposit. This map was drawn at a 1:1000 scale, but is shown at a 1:35,000 scale. Surficial dust often obscures fine-scale features in Esira, making the Structural mapping challenging. We therefore produced two structural maps, one where the features were mapped with certainty (Fig. 2) and one where the structural features under the dust cover were inferred. Both were also mapped at a 1:1000 scale. HiRISE was used as the basemap for all three maps.

Observations: The observations were made using HiRISE as well as the CTX digital terrain model. The central pit in the crater is centered and its diameter is roughly ¼ the diameter of the crater. The pit rim is raised above the crater floor for ~80% of its circumference and is made of angular megablocks that are likely uplifted bedrock due to their blocky, coherent nature. Layers within the bedrock show suggestions of rotations, although surface dust complicates this interpretation. The pit rim is not circular in planform but instead appears in the shape of a pentagon. The western section of the pit displays the highest rim elevations as well as a well-developed megablock assortment.

The northern section of the pit rim is the lowest and most discontinuous part of the pit rim. Using MOLA data, we calculated the elevation changes from the lowest part of the pit to the highest point on the pit rim to be roughly 1.4 km, with a pit rim of up to roughly 300 meters in height. The discontinuity within the pit rim reveals a continuous flow of the pitted material from the crater floor to the pit floor. No flow lobes are seen either on the crater floor or within the central pit

Results and Discussion: Our mapping reveals that pitted impact melt deposits flow from the crater floor into the pit, indicating that the pit formed before the impact melt solidified. The size of the pits within the pitted material are larger within the central pit than on the crater floor, suggesting that the impact melt sheet is thicker within the pit as might be expected for a material flowing into a depression. The presence of impact melt flowing into and ponding on the floor of the central pit is an essential observation because it constrains pit formation to the time period before the impact melt completely solidified which could take hours to days [9]. This observation proves that the central pit formed essentially coeval with the crater and contradicts models of post-crater pit formation such as preferential erosion of weaker material in the center of the crater.

The second significant conclusion from our mapping is that some degree of uplift and collapse had to occur in order for the pit and rim to exist. Jointing and fractures associated with the impact and compression stage may have influenced the shape of the pit rim and the amount of brecciation responsible for the collapse.

Conclusions: Our mapping has revealed that there is some component of uplift, not just collapse, involved in central pit formation and the pit forms before the impact melt solidifies (i.e., at the end of crater cavity formation). We are extending our mapping to other larger rimmed floor pit craters to determine if the trends seen at Esira are observed in craters formed from higher energy impacts.

References: [1] Tanaka, K.L., et al. (2014) Geologic map of Mars: U.S. Geological Survey Scientific Investigations Map 3292, scale 1:20,000,000, pamphlet 43p. [2] Irwin, R.P., III, et al. (2013) Journal of Geophysical Research, v. 118, 1–14. [3] Passey, Q. R. and Shoemaker, E. M. (1982) Univ. AZ Press, Tuscon, 379434. [4] Croft S. K. (1983) Journal of Geophysical Research 88:B71–B89. [5] Greeley, R., Fink, J. H., Gault, D. E., and Guest, J. E. (1982). Univ. AZ Press, Tucson, 340378. [6] Croft, S. K. (1981) Lunar Planet. Sci. XII (abstract), 196198. [7] Wood, C., Head, J., and Cintala, M. (1978) Proc. Lunar Science Conference 9, 3691–3709. [8] Williams, N. R., et al. (2015) Icarus, 252, 175-185. [9] Pope, K. O. (2006) Icarus, Volume 183, Issue 1, Pages 1-9, ISSN 0019-1035.

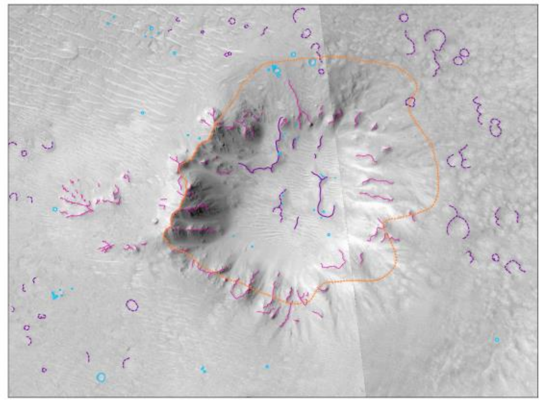

Figure 1. (below) Morphological map of Esira.
Figure 2. (above) Structural map of Esira.

Acknowledgements: This work is supported by the NASA MDAP award NNX12AJ31G. We thank MOLA,THEMIS, CTX, and HiRISE teams for their datasets. We also thank Trent Hare and Corey Fortezzo for their invaluable assistance with the mapping.