PRELIMINARY STUDY OF POLYGONAL IMPACT CRATERS IN ARGYRE REGION, MARS. T. Öhman[1,2], M. Aittola[2], V.-P. Kostama[2], M. Hyvärinen[2] and J. Raitala[2]. [1]Department of Geosciences, Division of Geology, P.O. Box 3000, FI-90014 University of Oulu, Finland, <teemu.ohman@oulu.fi>; [2]Department of Physical Sciences, Division of Astronomy, P.O. Box 3000, FI-90014 University of Oulu, Finland.

Introduction: Impact craters having a clearly polygonal plan view are common throughout the Solar System [e.g. 1,2,3]. Simple polygonal craters are formed in the excavation stage, when the excavation flow utilizes fractures in the target, leading to more enhanced excavation along the fractures [4]. Thus, the fracture strikes are usually at an angle (often, but not always ~45°, see [1]) to the straight segments of the crater wall. The Barringer (Meteor) crater is a good example [5]. Complex polygonal craters, however, are thought to have the straight rim segments parallel to fractures, because the walls slump along them in the modification stage [2,3,4,1]. Complex polygonal craters often tend to be hexagonal [1,2], like the Söderfjärden crater [6]. For a more thorough review on polygonal craters, see [1] and references therein.

Our earlier study [1] from the greater Hellas region, Mars, indicated that data gained from the study of polygonal craters matches, yet significantly augments the structural data from other features like graben or wrinkle ridges. The strong point of polygonal craters compared to other indications of tectonism is that craters are usually ubiquitous on planetary surfaces, whereas e.g. graben are much more rare. The purpose of our current study is to find out what polygonal craters around the Argyre impact basin in the southern hemisphere of Mars can tell us about the structural evolution of the region. We are also refining our methodology to have a deeper insight into the formation of the polygonal shape and the factors possibly affecting it (target material, erosion, crater size etc.).

Methods: We used Viking MDIM2 photomosaics with a nominal resolution of 0.231 kilometers per pixel in the equator, but significantly less closer to the poles. A crater was designated as “polygonal” only when two researchers had classified it as such. “Polygonal” craters had to have at least two straight rim segments and a clearly definable angle between them (Fig. 1). Craters, where the polygonal outline results from post impact processes, e.g. a later impact or a lava flow etc., were not included (see [1] for a more detailed discussion). Thus, our study only reveals the minimum number of polygonal craters in the study area, which covers 10°W–74°W, 26°S–72°S. The area was arbitrarily divided into blocks 16° in longitude and 14°–16° in latitude. Polygonal crater rim measurements from each specified crater were compiled with 10° class intervals in rose diagrams depicting the measurements from the corresponding block as percentages. The reproducibility of each measurement is estimated to be better than ±5°. In the near future, polygonal craters in our database will also be classified according to their erosional state, size and geologic environment.

Geological background: Argyre basin is a large and rather well preserved impact basin on the southern hemisphere of Mars, locating at 51ºS and 43ºW [e.g. 7,8]. Its diameter is ~1500 km, thus being slightly smaller than Hellas basin. According to Hiesinger and Head [8], the Argyre basin exhibits several concentric ring structures with diameters of 650, 780, 870, 1050, 1290, 1470, and 1700 km. In addition, they argued that Argyre Rupes and a scarp at about 45ºS and 5ºW could mark an additional ring of about 2750 km in diameter.

The geologic history of Argyre basin has been complex and several possible explanations have been proposed for it. However, the recent study proposes that glacial and fluvial/lacustrine processes and to a lesser extent eolian modification were the most important factors in the evolution of the basin [8].

Results and discussion: So far the rim strikes from the four northernmost blocks (26°S–42°S) and the one west from Argyre (58º–74ºW, 42ºS–58ºS, N=number of polygonal craters=45, n=number of strike measurements=140) have been measured. Almost all the measured craters were complex ones, and most were, or at least the tendency towards being hexagonal. The resulting rose diagrams (Fig. 2) clearly indicate a non-random distribution of polygonal crater rim strikes. A prominent feature in each diagram is an E–W peak. We interpret this in the northern blocks as caused by a fracture pattern associated with roughly ESE-trending Valles Marineris just north and northwest of our study area. The direction is also parallel to the graben in the region.

The 030°–040° peak in block centered at 34°S/018°W (N=56, n=167) and 010°–020° peak in block 34°S/034°W (N=42, n=135) are interpreted as a signature of radial fractures emanating from the Argyre basin. The radial pattern is manifested in the block 50ºS/066ºW as a prominent E–W peak. The broad peaks at 130°–160° in blocks 34ºS/034ºW and 34ºS/018ºW may perhaps indicate concentric fractures around Argyre. The same peak in 34°S/050°W (N=32, n=97) is close to being radial to Argyre, and the same direction is present in graben as well. In the northwesternmost block 34ºS/066ºW (N=35, n=105) only the E–W peak is clearly manifested. The broad NNE peak is parallel to graben and could have a connection to concentric fracturing around Argyre. Radial fracturing may be indicated by the rather indistinct roughly NW-trending peak.

The 020º–050º striking polygonal crater rims in the block 50ºS/066ºW are again parallel to graben, but the geological agent causing the graben and the straight rims is currently unknown. The same holds for the 310º–330º oriented rims, which have a same strike as a few graben-like features, but more notably are roughly parallel to the local drainage pattern. In general, all the roughly NW-trending rims, especially in the western part of the study area, may be influenced by Tharsis bulge.

Summary and conclusions: Polygonal impact crater rim strikes north and west from the Argyre basin indicate a presence of fractures (or other such structural weaknesses) trending E–W, a direction parallel to and probably in the northern part of the area genetically linked to Valles Marineris. The significance of this is also manifested in the numerous graben having a similar easterly strike. Dominant rim orientations approximately radial, as well as possibly concentric to Argyre basin are also present, similar to Isidis and Hellas basins [1]. In addition, fractures caused by the Tharsis bulge seem to be affecting crater shapes. Thus polygonal impact craters prove to be an important tool in interpreting large-scale crustal features, especially in regions like some areas around the Argyre basin where impact craters are numerous, whereas e.g. graben or wrinkle ridges are relatively scarce.

Further work: We are creating a database of polygonal craters in Argyre region, allowing us to study if polygonal craters of different sizes, erosional stages and geologic environments show any statistically significant differences in their abundances or rim strike directions. This will help us to establish, whether – like we believe along with Eppler et al. [4] – the polygonal plan view is indeed primarily created at the cratering process itself and not to any significant amount caused by later processes. We have also initiated a study focusing around the Tharsis bulge. This allows us to compare data based on polygonal craters with the numerous studies on the tectonism related to Tharsis' rise. Other datasets, such as the continuously accumulating Mars Odyssey THEMIS visual and infrared images and Mars Express HRSC images will be utilized in detailed studies of a few selected polygonal craters. Laboratory experiments for determining the relation between fracture orientations in the target and simple polygonal crater rim strikes (see [1] for a discussion on the problematics of simple polygonal craters) are also planned.

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Acknowledgements: This work was made possible by funding from the Finnish Graduate School in Geology, the Väisälä Foundation and the Magnus Ehrnrooth Foundation.

Figure 1 (below left). Viking Orbiter MDIM2 image of two polygonal craters at 36.3ºW 30.5ºS. Note the roughly parallel straight rim segments in the SW.

Figure 2 (below right). Study area (southern part omitted) with rose diagrams of rim strikes plotted on MOLA topography.