VENUSIAN POLYGONAL IMPACT CRATERS. T. Öhman[1,2], M. Aittola[1], J. Leitner[3] and J. Raitala[1] [1]Division of Astronomy, Department of Physical Sciences, P.O. Box 3000, FI-90014 University of Oulu, Finland (marko.aittola@oulu.fi) [2]Department of Geosciences, University of Oulu, Finland. [3]Institute for Astronomy, University of Vienna, Austria.

Introduction: The polygonal impact craters (PICs) are craters that are more or less angular instead of circular or ellipsoidal. They are present and often common on the Moon, Venus, Mercury, Mars and several asteroids and icy moons (e.g. Europa & Iapetus). Thus, they exist on all kinds of bodies that have craters and fractured crusts [1]. Polygonal craters are also found on the Earth and are supposedly formed by two mechanisms: Simple polygonal craters resulted when the excavation flow opened the crater tearing the target more easily along pre-existing planes of weakness while complex polygonal craters are formed in the modification stage, when the crater rims slumped along the fractures in the target. Both mechanisms lead to straight segments of the rim [2].

Goals of the study: The polygonal impact craters on the moon have been studied to some extent [e.g. 2, 3, 4] and recently especially on Mars [1, 5]. It is known that the polygonal impact craters are at least present on the Venusian surface [1], among almost 1000 impact craters of 1.5 – 280 km in diameter [6-9]. However, there are no detailed studies of them despite the rather high-quality Magellan radar image data. Therefore, the main goal of the study was to resolve if we can find polygonal impact craters also on Venus, and how abundant they are. On Mars, the polygonal impact craters, and especially their straight rim segment orientations, are definitely not randomly distributed, but they follow the large scale tectonic environments, e.g. Hellas and Isidis Basins. Thus, if these kinds of craters are found also on Venus, it is natural to analyze if there are some correlations between their distribution and large scale geologic provinces (e.g. equatorial deformation zones, tessera terrains and the vast lowland plains with compressional features). We compared also the characteristics of the PICs to the "normal" impact craters to find out if there are some properties which would be typical just to PICs. All these would help us to find out the possible reason for the formation of straight rim segments of craters on Venus and to clarify if the origin is the same as on Mars [1,5].

Data: For the study we have used the Magellan SAR images which cover 98% of the surface [10]. For the analysis we used the full-resolution mosaicked image data records, which are resampled to have a 75 m/pixel size. In the areas, which are not covered by these high-resolution data sets, we used C1-MIDRs with a resolution of 225 m/pixel. Together with the SAR data we have used also the altimetry data, although the relatively rough resolution of the data prevents the study of smaller craters. The properties of the Magellan radar data cause some problems when analyzing the rims of Venusian impact craters. We have to consider the nature of the radar data, which highly depends on the surface roughness, surface slopes, incidence angle and especially the looking direction. The roughness of the crater rim together with the resolution makes the interpretation of the crater rim difficult in some cases. In addition, the looking direction – right or left – makes the analysis of the northern and southern rims (if they are straight or not) more difficult. We can identify the straight rim segments also in some smaller craters, but in many cases the surface roughness together with the resolution makes the interpretation impossible. Therefore, to be able to make statistical analyses of the polygonal impact craters, we studied only the impact craters whose diameter is larger than 12 km. In the cases of smaller craters, the possible straight walls are too difficult to define and they may be even mixed up with craters formed by clustered impacts.

A survey of polygonal impact craters: We studied the craters larger than 12 kilometers in diameter from the catalog of Herrick et al. [11] and considered as polygonal craters those, which have at least two straight rim segments and a clearly discernible angle between them. We selected only the most obvious cases, thus all those craters which had some uncertainties due to the data restrictions were rejected. In our search we found 131 impact craters showing clearly at least two straight rim segments, which proves the abundance of polygonal impact craters also on Venus.

Distribution: The distribution of Venusian impact craters is basically more or less random and the situation appears to be same in the case of polygonal impact craters. There are no clear concentrations of PICs. Furthermore, rift zones, tessera terrains or lowland plains with compressional tectonics do not show distinct correlations with the distribution of PICs. Thus, we can conclude that there are no evident large scale geologic events or provinces, which would enhance the formation of straight rim segment of the crater rims. There are, however, smaller areas where PICs seem to be more closely spaced. One important aspect in the future studies will be the analysis of these environments: the correlations between the local tectonics and the orientations of the straight rim walls.

Characteristics of PICs: We compared the polygonal impact craters to "normal"-shaped craters by using different characteristics defined by [11]. Those properties were diameter, altitude, geologic setting, morphologic class, floor reflectance and degradation stage. It turned out that the only characteristic, which

makes difference between normal and polygonal impact craters is the diameter. It is obvious that relative abundance of polygonal impact craters increases among the smaller craters compared to larger craters. In the cases of other studied characteristics no differences were found. For example, degradation stage and floor reflectance could reflect the age of the impact crater. However, we found no discrepancies between PICs and other craters based on these classifications. Thus, it seems to be evident that the smaller crater size favors the formation of straight rim segments, but otherwise these craters show characteristics similar to other craters.

Geological environments: Recent studies of the polygonal craters and their straight walls are in correlation with the local tectonics in the Hellas area on Mars and therefore these craters can be used in determining the systematics in the directions and distributions of fractures or other zones of weakness in the crust [1]. This method should be applicable also on Venus, which has a rigid cratered crust and thus the craters could be used as a tool to reveal some properties of the target material and to determine regional stresses present during the crater formation.

Our preliminary results show that there are regions where the straight segments of the crater rims most clearly follow the orientations of the dominant tectonic features of the area. Unlike in the case of Mars, there is not a large population of impact craters on Venus. Therefore we cannot use statistically reliable population of PICs on Venus to determine their correlation with the local tectonics, which in most cases is much more complex than on Mars. However, the regions where the orientations of straight rim segments of the craters are different to each others, but still follow the tectonics close to the craters, indicate the correlation between crater formation process and tectonics. In the areas, in which we do not see this kind of parallel orientations, there still might be parallel tectonics covered by the vast lava plains. Thus, if the orientations of the straight rim of the Venusian craters reflect the local tectonics and zones of weaknesses as they do on Mars [1,5], they might be good tools to determine the tectonism beneath the young surface.

Summary: We found 131 impact craters, which show at least two straight adjacent rim segments. The actual number is most probably higher, but we rejected all the cases, which had some uncertainties due to the data restrictions and studied only the structures larger than 12 kilometres. This survey proves that there are polygonal impact craters on Venus and they could provide a good tool to analyze the properties of both the planet's surface/crust/lithosphere as well as the impact process.

We compared the polygonal impact craters to "normal"-shaped craters and it turned out that the only characteristic, which makes difference between "normal" and polygonal impact craters is the diameter, indicating that smaller crater size favors the formation of straight rim segments. In the cases of other studied characteristics no differences were found.

In addition, the orientations of crater walls reflect – at least in some places – the local tectonics and zones of weaknesses also on Venus and could thus tell us about the directions and distributions of fractures or other zones of weaknesses in the crust.

This study showed that there are polygonal-shaped impact craters on Venus and they do show some correlations with local tectonics and that the diameter affects their abundance. However, the study also initiated some questions: What is the reason for the diameter-dependence? What these craters can actually tell about the tectonics – both visible on the surface and hidden tectonics beneath the uppermost layer? These are the questions, which should be analyzed, in future studies.

References:

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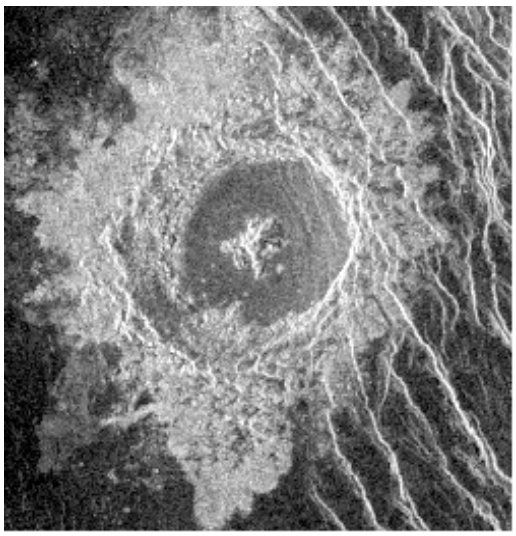

Fig. 1. Magellan left-looking radar image shows an example of impact crater with more than one straight rim segment. The diameter of the Behn Crater is 25.8 km and it is situated at 32.5S/142E.