CHARACTERIZATION OF A NEWLY RECOGNIZED 2000 KM LONG BOLIDE AIRBURST CHAIN, PHOEBE REGIO, VENUS. E. G. Antropova1, C. H. G. Braga1, R. E. Ernst1,2, H. El Bilali1,2, J. W. Head3, and B. A. Ivanov4. 1Faculty of Geology and Geography, Tomsk State University, Tomsk, Russia; ekatantropova@yandex.ru, 2Department of Earth Sciences, Carleton University, Ottawa, Canada; 3Department of Earth, Environmental and Planetary Sciences, Brown University, Providence, RI 02912, U.S.A.; 4Institute for Dynamics of Geospheres, Russian Academy of Science, Moscow, Russia

Introduction: One of the most important planetary geological processes is the formation of impact craters, which is widespread on most bodies in the Solar System. The density of surface craters depends on several factors, including the level of geological (tectonic and volcanic) activity of the planet and the thickness of its atmosphere. The surface of Venus is characterized by the presence of numerous impact craters of various types seen in Magellan SAR images, which were previously classified by [1] into six main types (multi-ring basins, double-ring basins, central peak craters, structureless floor craters, irregular craters with central peak and multiple craters). The origin of the splotches, which we consider in detail in this work, are closely related to impact craters. However, these features were identified as an intermediate complex of dark and bright surface patterns, resulting from interactions between impact bodies and the atmosphere. In addition to the splotches themselves, this group includes dark margins, streaks, enormous parabolic patterns, and halos bordering craters. We have studied in detail an elongated cluster of 12 spots in Phoebe Regio and assess their relation to atmospheric effects on impactors.

Origin of splotches: The thick and dense atmosphere of Venus affects bolides in different ways. If the dimensions of a bolide are very small, then such bodies are destroyed in the upper layers of the atmosphere [2]. A bolide of a size sufficient to penetrate the atmosphere, can form a geological feature on the surface whose morphology depends directly on whether the bolide has undergone destruction, and if so, at what height, whether it reached the surface and formed a crater, and whether the event was sufficient to form impact melts at the periphery of the impact [3; 4]. Terrestrial airbursts are discussed in Brown et al. (2016) and well-known examples include the Tunguska event [6; 7], and a recently proposed example Tall el-Hammam event [7].

Splotches are formed during the interaction of the bolide and the dense atmosphere of Venus [1; 8]. The result of such interaction is determined by several parameters that characterize the impactor: its size, mass, speed, angle of incidence, etc., as well as the force of the explosion (airburst) of the body in the atmosphere. The shockwave from such an air-blast could affect the surface in different ways, leading to both radar darkening and brightening [1; 9]. Where a fragment(s) of the impactor reaches the surface, a small crater is created in the center of the splotch. The absence of craters at the centers of the splotches is a good indicator that the bolides were destroyed in the atmosphere and did not reach the surface. However, the shockwaves from these bolides were sufficient to form large features on the surface [8]. According to [10], the splotches can be formed by bolides ranging in diameter from several hundred meters to several kilometers.

Splotches in Phoebe Regio: According to [11], the Phoebe Regio area is characterized by an abnormally high density of splotches. On the basis of our mapping in Hinemoa Planitia, NW of Phoebe Regio in the southeastern part of the Beta-Atla-Themis region, we have identified a NNE trending cluster of at least 12 multiple bright splotches (circles B-M in Fig. 1). The diameters of the splotches vary from 70 to 180 km. There are some additional features (marked by stars in Fig. 1 (A)) which resemble splotches and it is currently uncertain whether their origin is bolide airburst or volcanogenic features.

The splotch shape is predominantly circular and the centers of these splotches are dark (which may or may not include a faint central crater) and they are surrounded by wide radar-bright annuli. The inner dark circle can vary in diameter from 10 to 35 kilometers. The dimensions of the bright outer ring vary from ≈50 to 80 km or more, and its boundaries are often quite blurred.

The detection of an extended linear trend of splotches (=2,000 km long) elongated in a NNE direction requires explanation. Possible scenarios of the cluster formation are still enigmatic. Estimates with a standard models [12; 13] result in ~30 km maximal transverse separation of single-body fragments even for oblique impacts.

Therefore, we are forced to study in a future an alternate interpretation, that the elongate distribution of splotches was formed by a chain (stream) of individual fragments of a parent body disrupted in orbit well before to entry the Venusian atmosphere. These could represent a meteoroid stream [14; 15] or a single body that broke up in the vicinity of Sun, Venus, or Earth due to tidal disruption [16; 17]. An analogous example is the
21 fragments of Shoemaker-Levy 9 which sequentially impacted on Jupiter [18]. However, the possibility to preserve fragment’s chain from disruption till the atmospheric entry should be discussed more in a future.

In the case of the Phoebe Regio Splotch Chain, the SSW-NNE trend is likely explained by a combination of Venus’ retrograde rotation and orbital movement as the bolide stream enters the atmosphere from either the SSW or NNE.

We infer that these splotches are among the youngest features on the surface of Venus given that the material of the splotches is rather heterogeneous, is not very thick and would be easily covered with other materials or removed by wind.

Acknowledgments: Magellan SAR images obtained from https://astrogeology.usgs.gov/search/?p=mi-target=venus based on data from https://pdsimaging.jpl.nasa.gov/volumes/magellan.html#mgnFMAP.


Figure 1 – Magellan SAR image of the study area showing splotches (circles) and similar appearing features (stars) that have ambiguous origin and may be volcanic (see discussion in text). Detailed images of each of the confirmed splotches are in parts B-M.