

METEOR AIRBURST SHAPE AS ANOTHER INDICATOR FOR SMALL OBLIQUE IMPACTS. Tomasz Walesiak¹, ¹65/4, Skarbka z Gor Street, Warsaw, 03-287, Poland (tomasz.walesiak@wp.pl).

Introduction: However Chelyabinsk Meteor did not produce own crater (excluding pit in the ice covering Cherbakul lake), event may be very useful in researches of small craters, especially created during oblique impact. Shape of its airburst generated in the atmosphere, can be recognized in at least 4 structures. 3 of them are located on Earth, in a weak targets (sands, clays, sedimentary rocks). and 1 object was discovered by Mars Reconnaissance Orbiter on Planum Boreum, Mar's north polar cap.

Analysis details: There are a lot of video records of Chelyabinsk superbolide. For purpose of our analysis we will show 2 pictures presenting evolution of its shape (Fig. 1.) (source: www.youtube.com), which will be applied to topography of known impact structures.

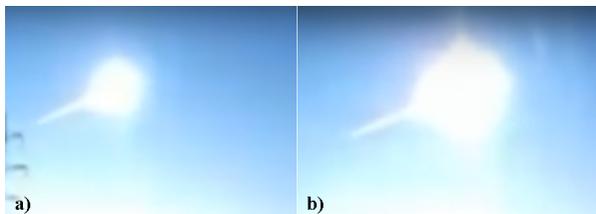


Fig. 1. Meteor seen over Russia February 15, 2013

Morasko crater: It is over 100 years after discovery of the first meteorite in this area, but there is still discussion on impact direction and age of cavities. As we know the main ejecta plume is towards SE and the same feature can be observed in structures located few kilometers north, as well as in area surrounding Umultowskie lake, (shallower, very circular object with well-developed side walls like in main crater). The relative location of the structures and eject distribution are strong evidence that impact was from NW. Same direction can be confirmed by shape corresponding to Chelyabinsk Meteor fall (Fig. 1a).

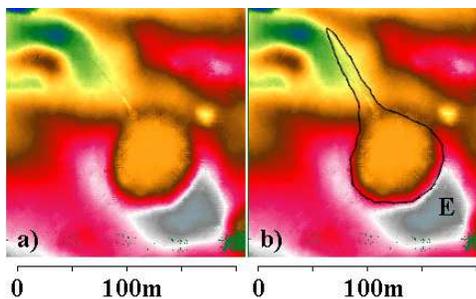


Fig. 2. Morasko main crater with shape from Fig. 1a

Recent researches, including verification of past results, study of historical and archeological data, lead to conclusion, that impact near Morasko took place in February 14, 1271 and had catastrophic influences on nearest villages and cities e.g. Poznan.

Porzadzie structure: This oblique impact structure, discovered in 2014, was announced in abstracts [1][2] and widely described in annual book of Polish Meteoritical Society [3](available online). Shape of cavity also corresponds to appearance of meteor over Russia, but in this case observed in the stage shown in Fig. 1b. The front of impactor can be recognized downrange (due to SE) and it is consistent with direction determined by main ejecta plume (marked with letter "E" in Fig. 3b). Please note side "wings" observed also in other structures (Fig. 5, Fig. 7). Few days ago, in January 2017, there were collected samples from 2 locations around Porzadzie crater. The purpose was to verify if there exists magnetic fraction. As a result we were able to separate abundant amount of very small particles (Fig. 4), which remind microtektites. The next step will be chemical analysis of their elements to get know their real origin.

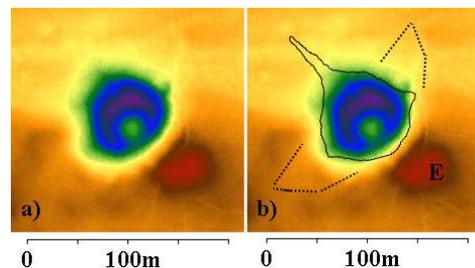


Fig 3. Porzadzie structure with shape from Fig. 1b

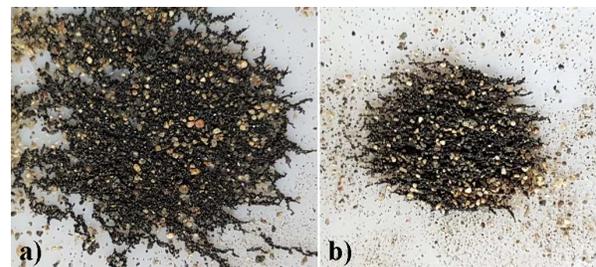


Fig. 4. Magnetic particles (each field view is 2x2 cm): a) from depth of 45cm, b) from depth of 65cm

Ostrow-Grady structure: This formation, the largest in group of possible oblique impact objects, was discovered in 2015, but because of involvement in other studies, researches had to be postponed. More

detail analysis was initiated in Octoberber 2016, after receiving complete LIDAR data of this area. Naturally promising shape of the structure (Fig. 5) was not enough to be sure of its impact origin. So it was assumed, that excavated soil could cover surrounding humus layer of sedimentary rocks. There were chosen locations (1 is marked on Fig. 5b) to investigate soil profile. Results were exactly as expected – on the evaluated level of pre-impact area, in chosen locations, on the depth of 40cm, there was discovered 20cm-wide layer of old organic component soil (marked with “M” on Fig. 6b). In a very small mass of collected sand (sample was taken from point marked with “S”), there was abundant amount of small metal particles (Fig. 6a). Even more was gained from sample captured in second location (in the main ejecta direction). Probes are currently under investigation in laboratory. I hope that base on topography, geological profile and results of chemical analysis, this candidate will be confirmed soon as new oblique impact structure. Object is located near the Grady village, close to Ostrow Mazowiecka city (GPS coordinates: 52°51'36.0"N, 21°47'22.0"E).

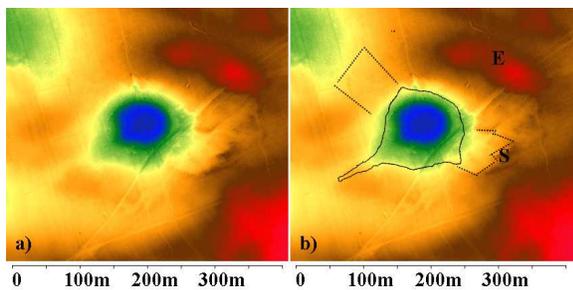


Fig. 5. Ostrow-Grady structure (with shape Fig. 1b)

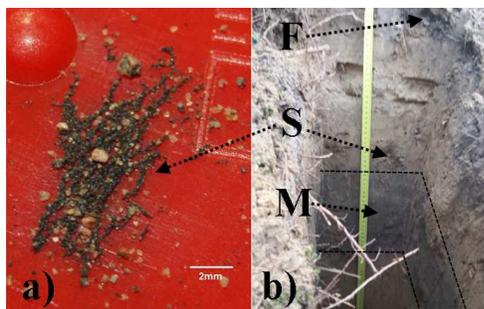


Fig. 6. a) Magnetic particles, b) soil profile

Planum Boreum in Mars: This small impact crater (approximately 115m in diameter) was discovered by Mars Reconnaissance Orbiter (HiRISE)[6] on Planum Boreum, north polar cap of the Mars (Fig. 7.) (source: NASA/JPL/University of Arizona). This object has shape similar to Porzadzie (except uplift), so it can be also matched with observation over Russia (Fig. 1b).



Fig. 7. Small crater (115m) in Planum Boreum on Mars (with Chelyabinsk meteor shape from Fig. 1b)

Conclusions: In this short paper, I've presented additional method recognition of new impact structures. This indicator is recommended to be used especially in case of suspected low angle trajectory. It can bring better results for weak and/or wet targets (e.g. sands, sedimentary rocks etc.). It can be also important factor during determination of impact direction and should be compliant with ejecta asymmetry, cavity elongation and other features characteristic for oblique impacts.

I've also introduced new Ostrow-Grady structure with explored geological profile of side ejecta. In the area around this cavity, as well as previously described Porzadzie, there were collected magnetic particles which we suspect to be related to impacts, so they will be examined soon to gain another proof of structures origin. Base on study of micrometeorites near Morasko [4] or small particles of meteoritic dust around Kaali crater [5], we should take into account that usually they do not contain more than 0,1% of Ni. However indication of other chemical elements should give final confirmation if Porzadzie, Jaszczulty, Ochudno and the newest discovery – Ostrow-Grady structure, can be officially accepted as small oblique impact craters on Earth.

References: [1] Walesiak, T. M. LPSC 46#2233 The possibly smallest complex impact crater on Earth [2] Walesiak, T. M. LPSC 47#1104 Analysis of traces suggesting multiple oblique impact event [3] Walesiak, T. M. (2016) Analysis of oblique impact features. A case study of Porzadzie, Jaszczulty and Ochudno structures. *Acta Societatis Meteoriticae Polonorum* vol.7, p.151-176 [4] Stankowski, W et al. (2002), *Mineralogy of Morasko meteorite and the structure of the craters*, *Proc.Estonian Acad.Sci.Geol.*, 2002, 51, 4, p.227-240 [5] Uscinowicz, G, 2008, *Extraterrestrial material from the surroundings of the Kaali meteorite craters (Estonia)*, *Geologos* vol. 14 (2), 2008, p. 211-219. [6] McEwen A., et al., 2010, *The High Resolution Imaging Science Experiment (HiRISE) during MRO's Primary Science Phase (PSP)*, *Icarus* 205, p. 2–37