

ANALYSIS OF TRACES SUGGESTING MULTIPLE OBLIQUE IMPACT EVENT. T. M. Walesiak, 65/4, Skarbka z Gor Street, Warsaw, 03-287, Poland (tomasz.walesiak@wp.pl).

Introduction: One year after 1st publication with short introduction presenting "Possibly the smallest complex impact crater"[1] located in Poland I would like to share more information relative to this subject. Laser Air Scanning data supported by few onsite expeditions lead to the conclusion that multiple impact event occurred and 3 major objects were created as well as at least 1 smaller. Their features are consistent with numerical modeling, experiments of oblique impacts and also observations of similar structures on other planets giving strong arguments to confirm their origin.

Observations: Below topography maps prepared using Laser Air Scanning (LIDAR) detail data (grid of points every 0.5m).

Structure "Porzadzcie" (Fig.1.) was presented a year ago. It is best preserved, however remnants of 2 former smelters were discovered inside.

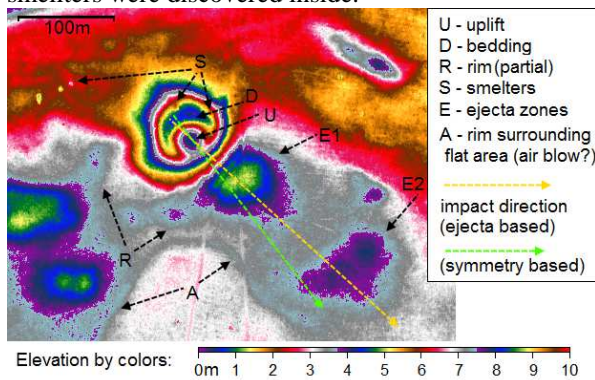


Figure 1. Object no.1 - "Porzadzcie"

Structure "Jaszczuly" (Fig.2.) was affected by railway development between 1896-1897. There is also evidence of exploration estimated as not older than 100-120 years. This area was occupied by Russia till 1918. It's also possible to find signs of battles during 2nd World War in close neighbourhood.

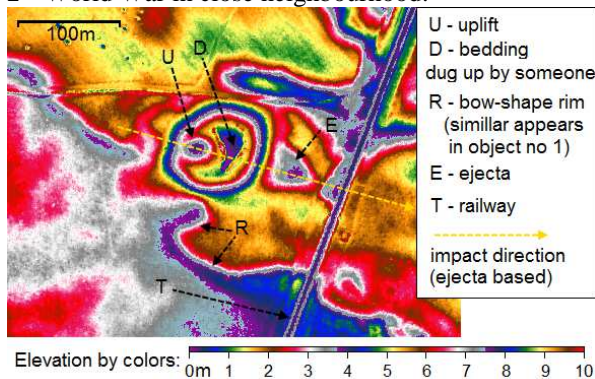


Figure 2. Object no.2 - "Jaszczuly"

Both structures "Ochudno" have "cardioid" pattern and were modified (aligned) by forestry (smaller one in 2nd half of 19th century). In bedding area of larger object there were discovered remnants of 2 old smelters.

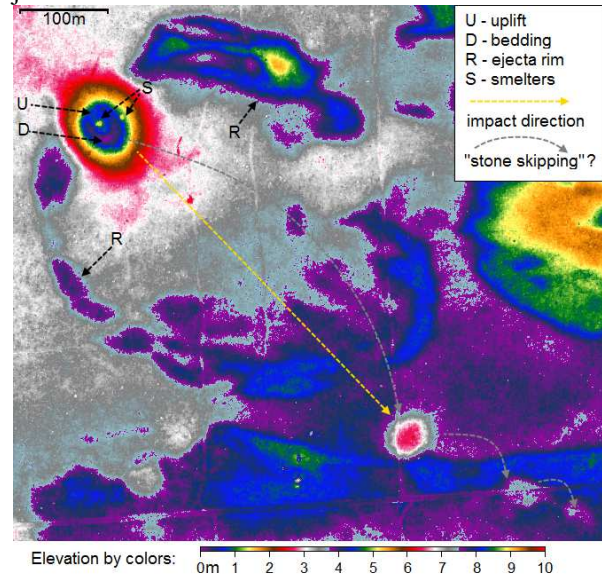


Fig.3. Object no.3 (above) "Ochudno 1"

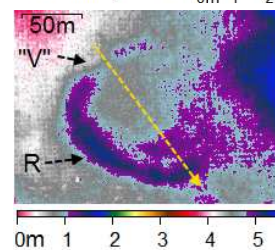


Fig.4. Object no.4 (left) "Ochudno 2"

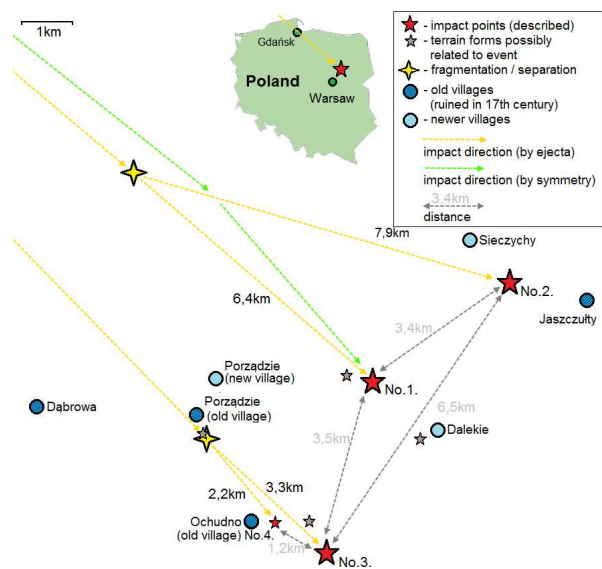


Figure 5. Location of objects and close villages

[in meters]	No.1.	No.2.	No.3.	No.4.
Diameter	115-120	95-100	100x140	(?)20
Rim diam.	(?)230x310	(?)200x280	360x460	95x115
Depth	6.5	5	3	(?)0.5
Inner uplift	4.5	3-3.5	(?)1	-
Ejecta height	9	8-8.5	5.5	1

Table 1. Measured features for each structure. Some of them are uncertain (marked with “?”).

Discussion & conclusions: It is not possible to compare discovered structures with any known crater on Earth (however some similarities to “Porzadzie” can be found in 115m crater on Planum Boreum on Mars).

Studying several publications of hypervelocity oblique impacts (including experiments) and verifying collected data we can make conclusion that all above structures were created during low angle event. Objects “Ochudno” are very good example of cardioid-shape ejecta pattern[2][3][6]. On Fig.3. we can perceive possibility of “stone skipping” occurrence. If such an effect really appeared then we can suspect that impact angle could be around 20° and distance between depressions may be helpful in calculation of final velocity. Angle of 25° (or lower) can be estimated for objects “Porzadzie” & “Jaszczuly” (base on ejecta jet[7]) however both present different appearance because of more complex topography, probably one of the factors responsible for inner uplift development (which in fact according to numerical modeling of oblique impacts may be consequence of unequal transition from excavation to modification stage in different parts of craters[4]). Laboratory experiments[5] show that for low angles (such as 20°) uprange forbidden zone appears in shape of outward curving “V”. It is easily observed in NW part of both objects “Ochudno” and also may be noticed partially in angled rims of “Jaszczuly” and “Porzadzie” (marked with “R” on Fig.1. & Fig.2.) but in this case it is disturbed again by topography.

Impact angle can be also confirmed by analysis of historical data[8]. In 23 Feb. 1660 4:30AM (4 Mar. 1660 by Gregorian calendar) in Gdansk (city located roughly about 260km NW of discussed area) there was observation of large fireball going to SE with size compared to grenade or estimated as 3kg. There were also reported explosions heard roughly after 8-10 minutes (former clocks, if used, were able to measure time in hours, not minutes so possible discrepancy). According to report fireball, after appeared, was running beyond the city so estimated altitude is 90-100km. With distance of 260km it gives angle of 19-21°.

Another description was written in 1661[9] – from which we can understand that observation was done not only from Warsaw (distance roughly 60km SW from our area) but also by army returning from Ukraine

which before the campaign was stationed in Podlasie in winter 1660 (distance roughly 100km East from impact area). Phenomenon was described as 3 suns and was heard explosion comparable to fall down of 10 castles (report comes either from Warsaw or Podlasie).

Finally we can find historical notes related to suspected impact area[10]: “everything stays empty after peopled died from air” (1730), “it remains unknown how died all the people of Porzadzie, as in 1773 there were living only settlers”, “in Dabrowa buildings were totally ruined, same in Jaszczuly” (1677), “in Dabrowa in 1647 there were 23 farms but in 1666 left only 4”.

For this time no meteorites were identified however total spent time on expeditions was only about 30hours. Complete lack of metal fragments near “Porzadzie” can point to conclusion that structures were formed by not an iron-nickel body. Remnants of smelters, from 18th century, found in “Ochudno 1” and “Porzadzie” and melted rocks containing brecciated clasts suggest that iron was “extracted” from stones (probably rusty).

According to numerical modeling, observations and experiments we know that shock pressure, temperature and melt production (as well as cratering efficiency) is lower for oblique impact, especially if diameter <2km. Despite this stones with some planar fractures were collected (another possible proof of violent event).

It’s not enough space for further discussion in this presentation, but I can add that rough calculations base on whitness report & size of major craters (created by fragments approxim. 6-7m in diameter) show that asteroid could have over 100m in diameter. Only 0.1% of such a large mass could survive[11]. Other factors: velocity around 15km/s, density 3g/cm³, angle 20°, target was Quaternary, frozen/snowy/wet.

References: [1] Walesiak, T. M. LPSC 46#2233 The possibly smallest complex impact crater on earth [2] LPSC 37#2294 Schultz, P. H. et al. The deep impact collision: a large-scale oblique impact experiment [3] LPSC 40#2496 Schultz, P. H. et al. Origin & significance of uprange ray patterns [4] Poelchau, M. H. (2010) The subsurface structure of oblique impact craters [5] LPSC 39#2305 Herrick, R. R. et al. Constraints from laboratory experiments on crater excavation and formation of an uprange forbidden zone in an oblique impact [6] Anderson, J. L. B. & Schultz, P. H. (2003) Asymmetry of ejecta flow during oblique impacts using three-dimensional particle image velocimetry [7] O’Keefe, J. D. & Ahrens, T. J. (1986) Oblique impact: A process for providing meteorite samples of other planets [8] Buthner, F. (1660) Prodigium Ignitum [9] (1661) Merkuryusz Polski Ordynaryjny No. XXIV [10] Żywirska M. (1973) Puszcza Biała: jej dzieje i kultura [11] Hughes D. W. (1980) On the mass distribution of meteorites and their influx rate.