Geological features and valley networks of terrestrial impact structures

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Introduction: Geological and morphological features of meteorite craters, as results of very high energy processes (caused by the kinetic energy of the impactor [meteorite]) usually reflects the circular heading-directions of impact generated shock-waves in target rocks during impact, forming a central symmetric (concentric and/or radial) geological and morphological pattern-structure for impact site. However, some impact structures display unusual patterns [2]. ***Keys:*** figures without **"N"**-marked north-arrow are in northern orientation. ***D:*** diameter; ***Ma:*** age in million years (Earth Impact Database, 2008).

Acraman meteorite crater (South-Australia, D=90 km [4], age: ~590 Ma [4])

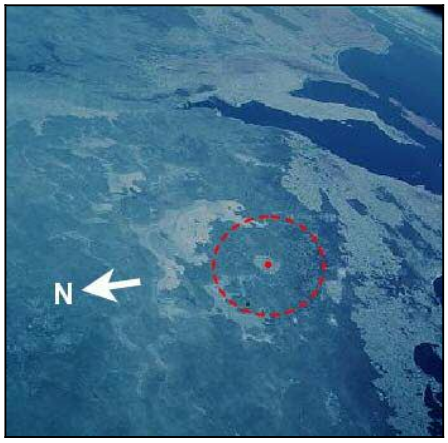

Figure 1. Acraman meteorite crater (red dashed line is the margin, D=90 km). Red dot: centre of Lake Acraman. White arrow: northern direction. (Space Shuttle image, modified)

Figure 2. Relief map of Acraman meteorite crater. Main direction of geological structures is NE-SW. Red dashed line: margin of the structure (D=90 km). Blue dotted line: Acraman Lake basin, without significant morphology. Blue dashed line: separate the two main slope-systems of Acraman-structure – *inwarding* slopes on the SW half and *outwarding* slopes on the NE half of the structure (green arrows show primal slope directions). Parallel faults and uneven slope-systems are unusual for impact structures (see also Figs. 3. and 4.). Yellow dotted areas: morphological elements in deranged array or smooth relief, resulting deranged drainage (see also similar areas on Fig. 4). (Google Maps 2008, modified)

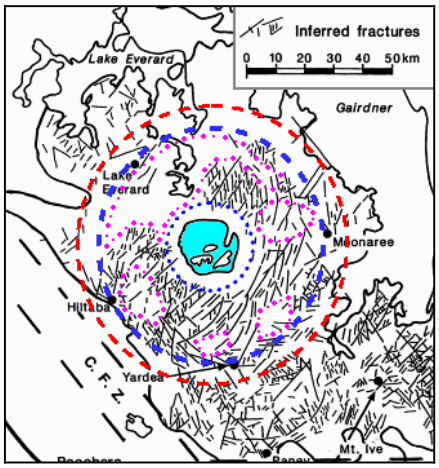

Figure 3. Inferred fractures of Acraman-structure (red dashed line, D=90 km). Blue dashed line: range of main fractured zone of the structure. Purple dotted areas: lack or decreased number of fractures in main fractured zone. Blue dotted line: inner basin without large fractures (Lake Acraman at its centre). (Twidale 2004, modified)

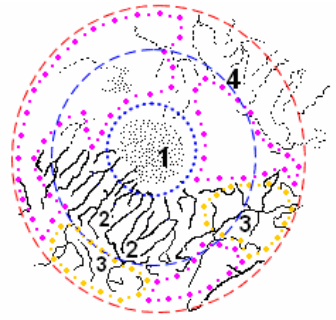

Figure 4. Drainage of Acraman meteorite crater. Red dashed line: margin of structure (D=90 km). Blue dashed line: separate pattern types (especially at SW and NE parts). Purple dotted line: lack, or decreased number of rivers. Blue dotted line: Acraman-basin. (1): Lake Acraman. (2): parallel or near parallel rivers at the SW parts of the crater. (3)-[orange dotted]: deranged pattern. (4): nearly parallel flows on outwarding slopes at NE area. (Mihályi 2008, modified)

Compared Figs. 2., 3. and 4., it can bee seen relations between geological features (fractures) and hydrological features: where fractures are lack or decreased, rivers are in deranged array (yellow bounded areas) or missing (purple bounded areas).

Flow directions are primarily determined by larger fractures runs along NE-SW direction.

Vredefort impact structure (South Africa, D=300 km [4], age: 2023 Ma [4])

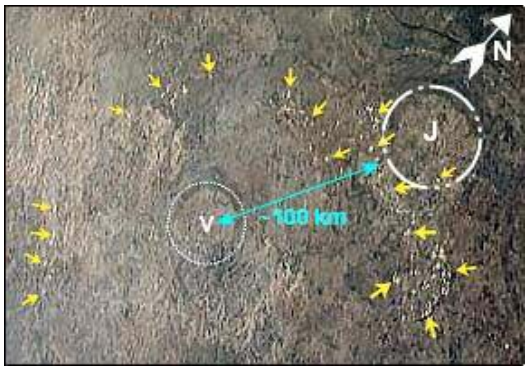

Figure 5. Vredefort impact structure. „V" in dotted circle: Vredefort-dome (central region). Yellow arrows: groups of waste dumps (white patches) from the gold mines of outer regions. Remarkable their arcuated-concentric arrangement in a range of ~70-130 km from centre, which is similar to its river-arrangements (Fig. 6.) and probably, there is a causal link between them [2]: impact generated concentric faults led to accumulate gold by upwelling hydrothermal liquids, and later the same faults preformed river valleys. „J" in circle: Johannesburg. (NASA-JSC, modified)

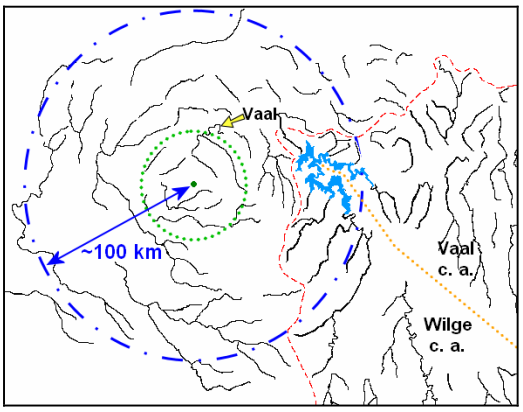

Figure 6. Arcuated-concentric river pattern elements (not complete rivers!) of Vredefort structure. Green circle: Vredefort-dome. Blue dash-dotted line: range of arcuated-concentric river-elements (D: ~200 km). Red dashed line: outer divide of catchment area (c. a.) of Vaal-Wilge river system. Orange dotted line: inner divide of Vaal-Wilge system (illustrative). Outside of red dashed line: catchment areas of Vaal (yellow arrow)+other rivers. (Mihályi 2008, modified)

Boltysh impact structure (Ukraine, D=24 km [4], age: 65 Ma [4], buried [4]) and **Haughton meteorite crater** (Devon isl., Canada, D=23 km [4], age: 39 Ma [4])

Boltysh impact structure in the Ukrainian shield is a buried meteorite crater. The crater depression is ~1km deep in the crystalline target. The crater is covered by post-impact sediments up to ~400 m in thickness [1], while Haughton in Canada is a complex ring-structured crater, overlain by crater-fill deposits, up to ~125 m in maximum thickness [3].

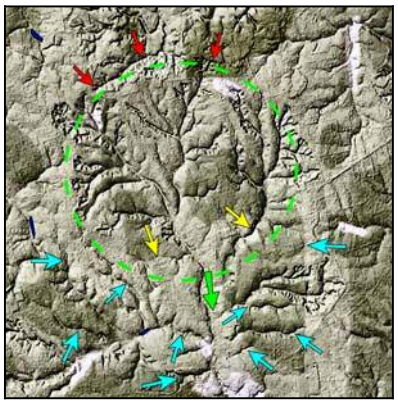

Figure 7. Boltysh impact structure (green dashed line, D=24 km), as it appears by its dendritic valley network. Yellow arrows: arcuated and incised valleys at the southern part of the structure. Green arrow: run off valley. Blue arrows: examples for arcuated and incised valleys at the southern foregruond. Red arrows: arcuated valleys at the northern background. (Google Maps 2008, modified)

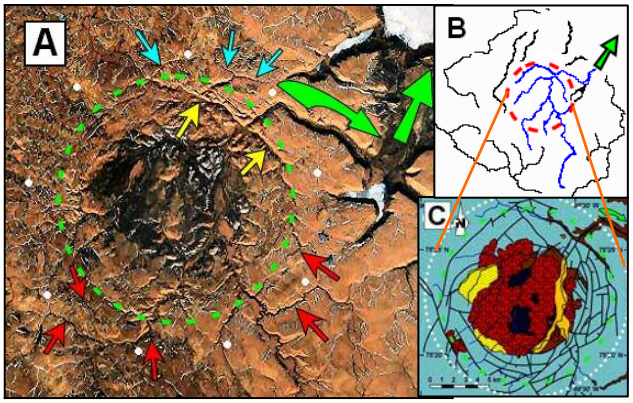

Figure 8 *(A, B, C)***. (Fig. A):** Haughton meteorite crater as it appears on satellite image. Green dashed line: morphologically most characteristic area (D: ~18 km; for real diameter -23 km- see white dotted line). Yellow arrows: arcuated and incised valleys at the NE part of the structure. Green arrows: run off valley. Blue arrows: arcuated valleys at the NE foreground. Red arrows: arcuated valleys at southern and SE parts. (Google Maps 2008, modified); **(Fig. B):** river patterns – blue rivers for crater basin (-red dashed line, D=23 km). (Mihályi 2008, modified); **(Fig. C):** geological map (green arrow and green/white lines are equal to *Fig. A*). Red area: crater-fill deposits. Black lines: faults. (Osinski & Spray 2001, modified)

Conclusion: As Figs. 1.-8. reveal, subsurface geological features of terrestrial impact structures (even if it is old, eroded or buried by post-impact sediments) can determine surface morphology, as well as river- and valley network patterns.

References: [1] Masaitis, V. L. (1999): Impact structures of northeastern Eurasia: The territories of Russia and adjacent countries *Meteoritics & Planetary Science, 34,* pp 694-695.

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