THE TECTONIC INVENTORY OF SMALL COMPLEX IMPACT STRUCTURES: A CASE STUDY AT JEBEL WAQF AS SUWWAN, JORDAN.

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Introduction: Jebel Waqf as Suwwan (N31°02.9'E36°48.4') is an eroded but well exposed complex impact structure of ~ 6 km diameter in Jordan [1]. Ejecta and allochthonous crater fill breccias have been removed but this circumstance uncovered the deformed crater sub-surface. The exposure of the central uplift and the tectonic crater rim are superb, and locally deformation could also be studied within the annular moat [2]. Moreover, two reflection seismic profiles as well as gravity data are available and allow for a complementary structural investigation at depth [3]. Jebel Waqf as Suwwan is regarded as a typical representative of small complex impact structures, formed in a horizontally layered sedimentary target by an oblique impact from the SW [2, 3]. The exposure level is at 300-400 m beneath the original target surface [3].

Here we list the structural characteristics of Waqf as Suwwan:

Central uplift, CU (Fig. 1): (i) The CU is ~1000 m in diameter. (ii) It correlates with a +2 mgal gravity anomaly [3]. (iii) The CU shows ~350 m of structural uplift. (iv) The oldest exposed strata (Kurnub sst., Albian) occur in the center. Alhisa/Amman Fm. (Maastrichtian) is the youngest formation and forms the collar of the CU. (v) Shatter cones occur in various stratigraphic levels, rare PDFs, PFs and FFs were found in Kurnub sst [1,2]. (vi) The target is disintegrated into fault-bounded, internally folded blocks, which range in size from 10-170 m (mean: 52 m limestone, 75 m chert); about 100 blocks >10 m are mapped [2]. (vii) Radial, outward plunging chevron-type anticlines and synclines exist in the SW (up range), whereas radial, inward plunging antiformal (overturned) synclines occur in the NE (downrange). (viii) A bilateral symmetry of the CU with a SW-NE trending symmetry axis is constrained by the outline of the central uplift, the exposure of geologic units, fold orientations, and characteristic concentric deviations of strata strike. (ix) The asymmetry of the SW and NE sectors indicates a strong NE vergency of the CU and top-to-NE shearing of the entire central uplift [2].

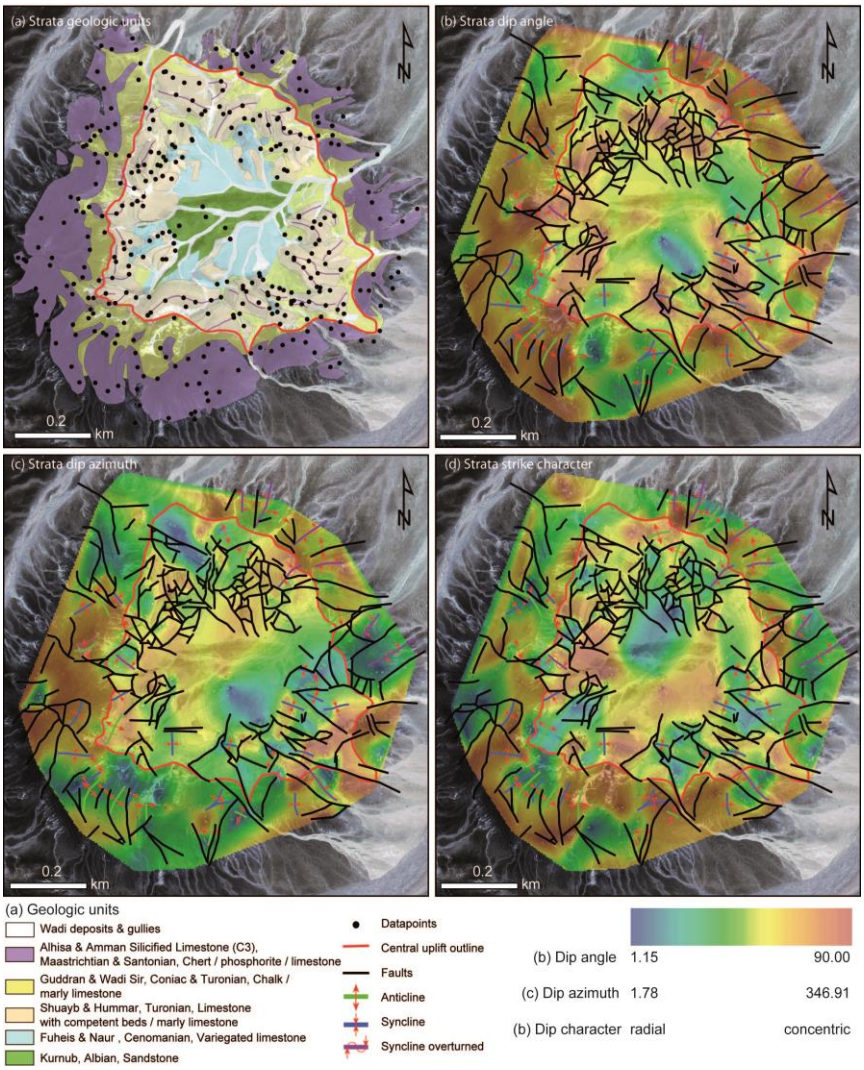

Fig.1 Central uplift: a. Geologic map. b. Strata dip c. Dip azimuth d. Concentric deviation

***Annular moat (Fig. 2)*:** (i) This region is partly covered by Wadi deposits. (ii) The exposed target is formed by limestones, chert, and chalk of Muwaqqar Fm. (Paleocene/Eocene). (iii) An annular high exists half way between the center and the crater rim. This is

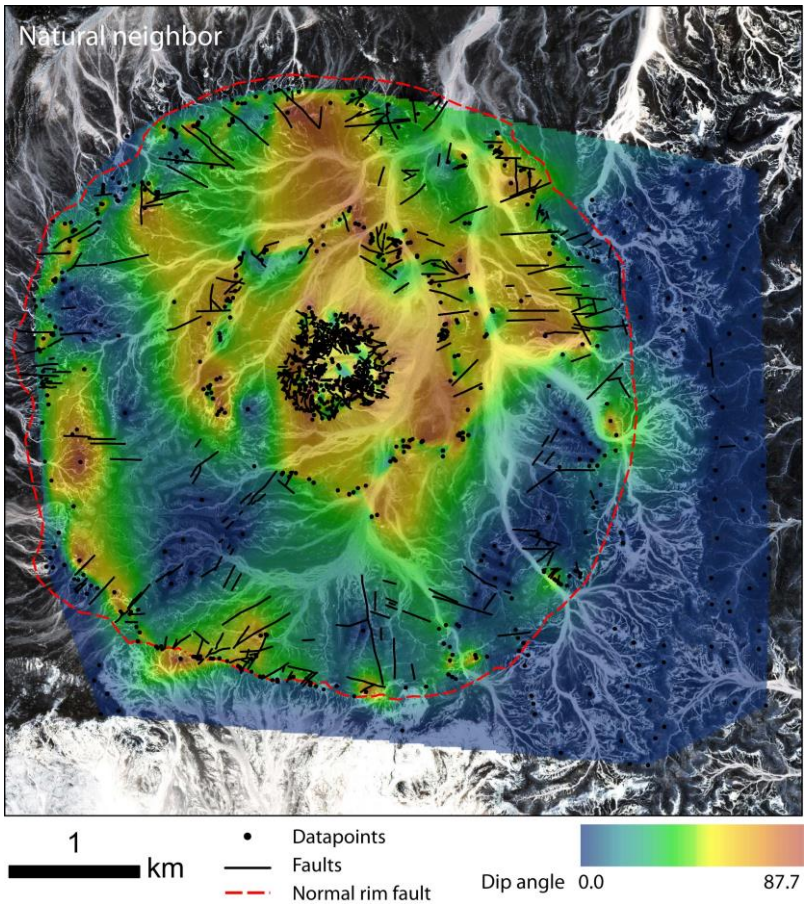

Fig. 2 Dip angles in the entire crater. Interpolation by natural neighbor technique.

also indicated by an annular gravity high. The ring syncline is very shallow and complicated by annular buckling. (iv) Strata commonly dip gently in the cross range and up range sectors and are generally steeper dipping downrange. (v) In the downrange sector chevron-style folding with radial as well as concentric strike is recorded. (vi) Faults predominantly strike radially in the up range sector and occur most frequently downrange where they converge. A subdued symmetric arrangement of faults seems to exist with respect to the impact trajectory.

Crater rim, CR (Fig. 3): (i) The CR has a somewhat polygonal outline, at least in the S. (ii) The morphologically elevated CR region represents the outermost terraces, not the crater rim itself. (iii) The CR fault is exposed outside of this ridge. (iv) The apparent crater diameter is ~6.1 km. (v) Strata dip very gently in the cross-range sectors. Moderately steep dips into the crater occur downrange, in contrast to steep outward dips in the up range sector. (vi) This suggests antithetic terracing up range and synthetic terracing downrange. (vii) Concentric strike predominates near the rim with the exception of the exposed rim in the up range sector. (viii) The southern crater rim is superbly exposed. The rim fault here is highly localized, and mostly dips at 45-60° towards the center (outward dip also occurs), and was activated as a normal fault. (ix) Fault gouge and fault breccias, as well as Riedel shears are present, but datable pseudotachylites are absent. (x) At depth the rim fault is a reverse fault with outward shear. The Paleozoic basement in the footwall of the boundary fault shows upbending in the N and E. Uplift in the N and E rims is about twice that in the S and W rims [3].

Conclusions: The statistical analysis of tectonic features at the Jebel Waqf as Suwwan impact structure indicates, in accordance to other impact studies reviewed in [5], that impact obliquity influences crater modification. Buckling of the shallow ring syncline has not been observed in other terrestrial craters of this size.

References: [1] Salameh, E. et al. (2008) MAPS, v. 43, [2] Kenkmann, T. et. (2010) GSA-SP 465: 471-487. [3] Heinrichs, T. et al. (2014): Int. J. Earth Sci. 103, 233-252. No.10. [4] Poelchau, M.H. and Kenkmann, T.(2008) MAPS, v.43: 2059-2072. [5] Kenkmann, T et al. (2014) J. Struct. Geology 62: 156-182.

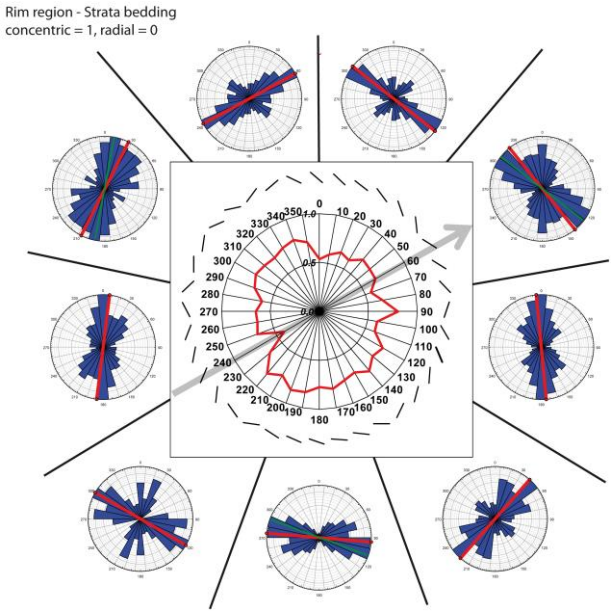

Fig. 3 Strata strike along the crater rim. See [4] for method.