POST-IMPACT STRUCTURAL CRATER MODIFICATION DUE TO SEDIMENT LOADING: AN OVERLOOKED PROCESS. Filippos Tsikalas and Jan Inge Faleide, Department of Geosciences, University of Oslo, Oslo, Norway (filippos.tsikalas@geo.uio.no, j.i.faleide@geo.uio.no)

Post-impact sediments above crater structures can, in some cases, reach considerable thicknesses. Although protective at initial stages, extensive burial and associated processes such as mechanical- and chemical-compaction, and diagenesis may eventually lead to considerable changes in the immediately-after-impact crater structure and morphology as a result of differential compaction. The post-impact structural crater modification is, generally, an overlooked process as planetary research of impact structures (where post-impact sediment loading is mostly absent) dominated the impact-related research until recently, and due to the fact that the terrestrial impact record is dominated by crystalline-target impacts on land [e.g. 1].

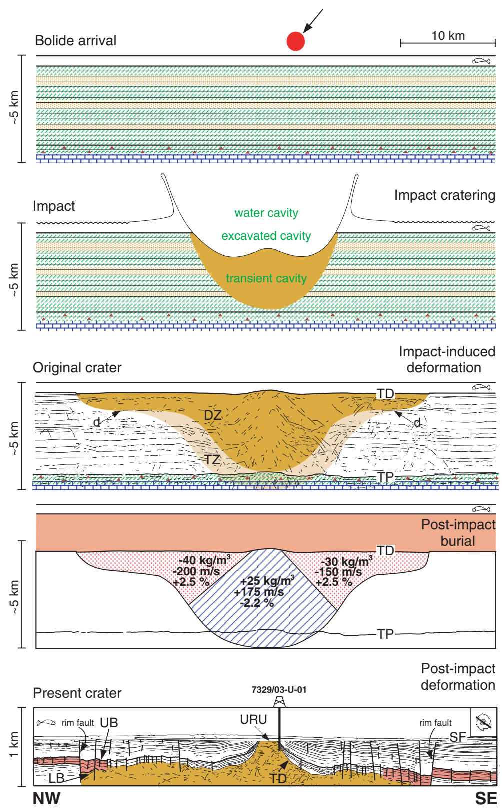

Fig. 1. Schematic cross-section showing the Mjølnir impact, induced radially-varying physical property changes, and deformation types. SF, seafloor; URU, Late Cenozoic unconformity; UB, lower Barremian; TD, impact horizon; LB, Upper Callovian; TP, Top Permian; d, low-angle décollement; DZ, intense disturbance; TZ, transitional disturbance. Modelled impact-induced physical property changes (second panel from bottom): density-contrasts in kg/m^3, seismic velocities in m/s, and porosity anomalies in %.

In this study, post-impact crater structure modifications are examined in detail and exemplified in several well-preserved impact craters such as Mjølnir, Chesapeake Bay, Chicxulub, Montagnais, and Bosumtwi, and the Silverpit structure. Direct post-impact effects in geophysical crater response are further quantified contributing to a better understanding of the post-impact operating processes and evolution due to sediment loading. In this way, the potential better identification and recognition of marine impact craters on sedimentary targets can be achieved.

On marine impact craters, the impact event leaves a crater relief on the sea floor which acts as a substratum on which a considerable amount of sediments are subsequently deposited (Fig. 1). The sedimentation gradually fills in the original crater relief, resulting in considerable thickening and sagging both inwards the faulted rim region at the periphery of the structure, the morphological depressions surrounding the possible peak-ring or inner-rings, and eventually the annular trough/basin surrounding the central high/peak (Fig. 1). These effects, together with lateral facies changes, are observed within post-impact subunits at several well-studied craters. Furthermore, the geometry and the structural relations of post-impact strata provide information about the amplitude, the spatial distribution, and the mode of post-impact deformation that is usually expressed by reactivation of impact-induced faults, initiation of small-offset faults restricted to the post-impact sediments, and differential vertical movements (Fig. 1). The effects of extensive deformation are cumulative and may enhance or subdue the underlying structural morphology.

At Mjønir, a quantitative model for the porosity change induced by the impact using density and seismic traveltime/velocity distributions, and post-impact sediment deformation has been developed (Fig. 1) [2-3]. Based on the methodology developed for Mjølnir, we have now produced a preliminary quantitative model for the porosity change induced by the Chesapeake Bay impact (Fig. 2) using the resulted density distribution of [4]. Compared with the surrounding platform, the porosity increased immediately after impact up to 8.5% in the collapsed and brecciated crater centre, whereas porosity decreased by 2-3% in the peak ring region. The lateral differentiation of density and porosity, and most probably seismic velocity, is attributed similar with Mjølnir [5-8] to the interaction and local spatial prevalence of cratering processes, including brecciation, gravitational collapse, and structural uplift. These processes were responsible for the large seismically disturbed rock volume at the impact-site (Fig. 2). Following impact, the crater was progressively buried by a ~800 m (range of 700-950 m) thick overburden, which caused differential compaction of the extensively brecciated central part of the structure. This compaction has significantly affected the post-impact crater evolution, and decreased the porosity anomaly to values of +6% in the centre and -3 to -4.5% in the peak ring region (Fig. 2). Furthermore, a structure of the size of Chesapeake Bay Crater should produce an annular gravity low of about -15 mGal [9]. Nonetheless, the observed value of -8 mGal (Fig. 2) [e.g. 4] is still within the -7 to -20 mGal annular gravity anomaly range determined by a number of craters. In contrast to Mjølnir, the relatively thin pre-impact sedimentary sequence at Chesapeake Bay (1-1.5 km; [e.g. 4]) above crystalline basement cannot argue for less pervasive, soft sediment, brecciation. Therefore, the moderate Chesapeake Bay gravity signature, in accordance to a similar behaviour of the Mjølnir gravity response, may be partly ascribed to lesser, long-term alteration due to post-impact burial, abating the porosity, and thus, density contrasts between the crater structure and the surrounding platform (Fig. 2).

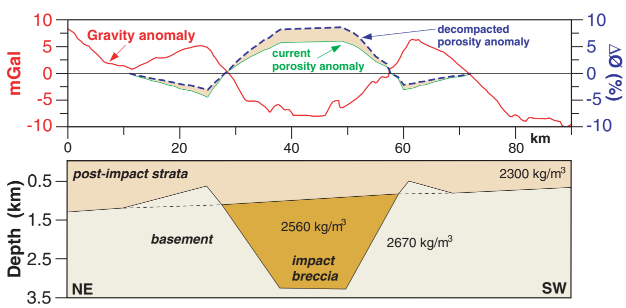

Fig. 2. Simplified Chesapeake Bay crater structure and observed residual gravity anomaly (modified from [4]), and calculated current and immediately-after-impact porosity anomaly using the modelled density distribution.

The study has further shown that several crater morphological parameters are prone to post-impact burial modification, like the estimate of structural uplift, transient crater diameter (true and apparent), peak-ring height, rim-height, and annular trough depth. These parameters are exaggerated or subdued during post-impact burial and related deformation. At Chicxulub, the reconstructed, originally less prominent peak-ring introduces some interesting geometrical relations in the context of both the true and apparent transient crater diameters that may reduce their estimated extent (Fig. 3). In particular, the fit and height of the paraboloid of resolution which approximates the form and vertical extent of the transient crater cavity is quite different when an originally less prominent peak-ring (relict of the transient rim uplift) is introduced (Figs. 3b-c). Figure 3 shows that incautious use of the current peak-ring height dimensions without any correction for post-impact burial enhancement may lead to overestimation of the true and apparent transient crater diameters that, in turn, together with the exaggerated peak-ring and crater rim heights are utilized in scaling-law calculations and to infer the level of anticipated impact-released energy and environmental perturbations.

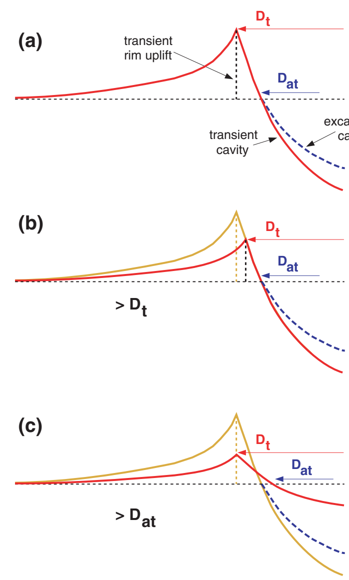

Fig. 3. Schematic diagram of the transient cavity, transient rim uplift, and excavation cavity reconstructions without **(a)** and with **(b)**, **(c)** considerations of post-impact burial enhancement and relief exaggeration. D_t, true transient crater diameter; D_{at}, apparent transient crater diameter (referred also as the excavated crater diameter).

References: [1] Earth Impact Database (2006) *http://www.unb.ca/passc/ImpactDatabase*. [2] Tsikalas F. et al. (1998a) *Tectonophysics*, *289*, 257-280. [3] Tsikalas F. et al. (2002) *Deep-Sea Research Part II*, *49*, 1103-1120. [4] Poag C.W. et al. (2004) *The Chesapeake Bay Crater*, Springer-Verlag, 522 p. [5] Tsikalas F. et al. (1998b) *GSA Bulletin*, *110*, 537-552. [6] Tsikalas F. et al. (1998c) *JGR*, *103*, 30469-30484. [7] Tsikalas F. et al. (1999) *GSA Special Paper*, *339*, 193-204. [8] Tsikalas F. and Faleide J.I. (2003) *Cratering in Marine Environments and on Ice (Impact Studies) Springer Verlag*, 39-55. [9] Pilkington M. and Grieve R.A.F. (1992) *Reviews of Geophysics*, *30*, 161-181.