SEDIMENTATION IN THE RITLAND IMPACT STRUCTURE, WESTERN NORWAY.

A. S. Azad[1], H. Dypvik[1], E. Kalleson[1] and F. Riis[2]
[1] Department of Geosciences, University of Oslo, P.O. Box 1047, Blindern, NO-0316 Oslo, Norway (m.a.s.azad@geo.uio.no, henning.dypvik@geo.uio.no and elinkal@geo.uio.no)
[2] Norwegian Petroleum Directorate, P.O. Box 600, NO-4003 Stavanger, Norway (Fridtjof.Riis@npd.no).

Introduction: Syn- and post-impact sedimentation within impact craters often start by collapse of the transient cavity and sediment transportation towards the crater centre by different gravity and mass flow processes. These could include rock avalanches, debris avalanches, scree and debris flows depending on the physical properties of the target rock, degree of slope failure, and temporal fluidization of the sediments [1]. The sedimentary processes also vary depending on the overall paleo-geographical setting of the target area (subaerial, subaqueous/shallow marine, deep marine) [2]. In the Ritland case the target area was a shallow epeiric sea, with basement rocks covered by a thin blanket of sediments. In such shallow water setting a crater rim is formed in much the same way as for land-target craters in contrast to deep marine impacts lacking well developed crater rims [3]. The crater rim height and its relation to the sea water depth during impact may significantly control the sedimentation in such craters. An instantaneous powerful resurge of sea water might not be expected if the crater rim is high enough compared to the sea water depth. Sea water may eventually fill the crater with reduced resurge energy through breaching of the crater rim and mass flow events such as debris flows and suspension flows would dominate in the water filled crater soon after the rock-avalanches/debris-avalanches processes. Suspension-dominated sedimentation e.g., turbidity currents are to be expected dominating in a later stage with a comparatively stable crater cavity [4].

Ritland Impact Structure: Ritland is the third and most recently confirmed Norwegian impact structure, located in the Hjelmeland municipality, Rogaland, western Norway (Fig. 1) [5]. The structure shows a nearly circular depression (2.7 km in diameter and 350 m deep) excavated in the gneissic Precambrian terrain. The crater was probably formed during Cambrian time, filled by sediments and eventually deeply buried [5]. Several succeeding events of uplift, erosion, and finally the Pleistocene glaciations helped to disclose the structure. At present, highly deformed and fractured basement rocks and the exposed crater filling sediments display the remnants of this simple impact structure. The sub-Cambrian peneplain, covered by a thin (5-15 m) marine Cambrian sedimentary cover and about 100 m of water, probably was the target surface of the Ritland impact [5]. Detailed study of the sedimentary features of the Ritland impact structure has not yielded evidence of powerful resurge within the crater. The crater rim was probably elevated above sea level, damming more powerful instantaneous resurge. Delayed and reduced resurge effects may be suggested in Ritland crater as evidenced by the characteristics of the crater filling sediments, partly described below.

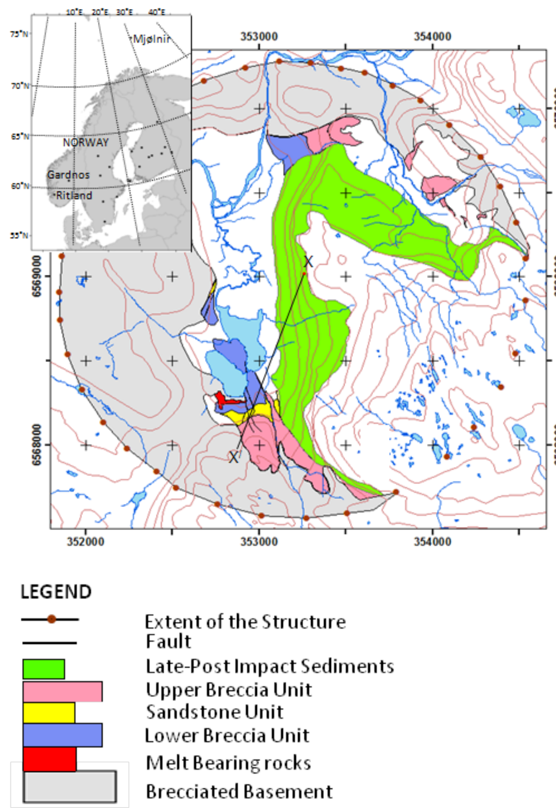

Fig. 1: Lithofacies distribution map of the Ritland impact structure. Red dot (point X) indicates the reconstructed crater centre, the cross section along XX/ is shown in Fig. 2

Sedimentary Units: The crater infill sediments of the Ritland impact structure (Fig. 1) can be broadly classified as: A) syn-and early post impact sediments and B) late-post impact sediments. The syn- and early-post impact sediments are composed of a minor, basal melt-rock unit succeeded by a relatively thick succession of coarse grained clastics; breccias, conglomeratic and arkosic sandstones. These were deposited at the early stages of crater modification and can further be subdivided into; i) Lower Breccia Unit (LBU) ii) Sandstone Unit (SU) and iii) Upper Breccia Unit (UBU) (Fig. 1). The succeeding late-post impact sediments consist of finer grained clastics; forming a thin lower unit of very fine sand and silty-shales in the lower part, overlain by a thick unit of dark grey to black shales.

Sedimentary Processes: The lower-most LBU sediments (Figs. 1, 2) were sourced from intense *in situ* brecciated transient cavity walls and rims, particles eventually sliding down towards the crater centre and deposited as rock-avalanches. Clast supported breccia with similar clast and matrix composition compared to the basement breccia (target surface) as well as occurrences of dispersed, reworked melt particles in the lower-most part of the Lower Breccia Unit and a basal melt bearing rock unit underneath (Fig. 2) suggest that these sediments were deposited during an early stage of crater modification. Debris flow deposits dominates on top of these avalanche formations, probably reflecting prevailing water saturated conditions due to delayed resurge of the sea water through the breached crater rim. The rock debris was transported down from the unstable crater walls and rim as multiple depositional lobes.

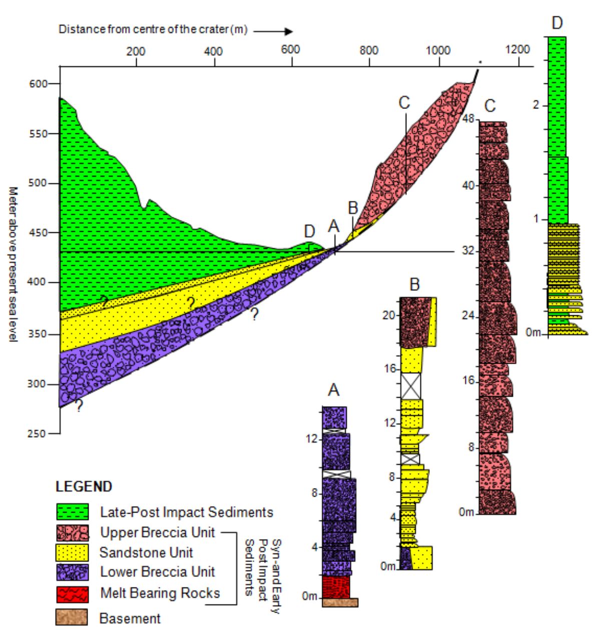

Fig. 2 Geological cross section (XX/ in Fig.1) illustrating stratigraphic relation of the different sedimentary units. The sections A, B, C, and D show the generalized stratigraphy of the crater filling successions based on field lithologs.

A marked shift from clast-supported to matrix-supported texture appears in the upper part of the Lower Breccia Unit sediments. This transition represents a shift towards hyperconcentrated density flows, generated by mixing of water and dilution at the flow head with gradual entrance of sea water into the crater. The crater eventually filled with water and suspension-dominated sedimentation dominated. The Sandstone Unit (Fig. 2) were probably deposited by turbidity currents under submarine fan settings towards the centre of the crater basin and the sediments may have been derived from base-slope erosion and further reworking of the crater wall sediments. The Upper Breccia Unit sediments represent the marginal part of the crater basin where the sediments were derived from renewed, local erosion of the steep, unstable crater wall and rim. These sediments wedge out from the rim to the crater centre showing fan like distribution. Different gravity and mass flow processes dominates within this unit. The late-post impact sediments (Fig. 2) were deposited during a long (millions of years) and quiet period of sedimentation through suspension-deposition during mainly anoxic bottom water conditions.

References:

[1] Melosh H.J. (1989) New York: Oxford University Press. 245. [2] Dypvik H. and Jansa L.F. (2003) *Sedimentary Geology.* 161, 309-337. [3] Ormö J. and Lindström M. (2000) *Geological Magazine.* 137, 67-80. [4] Dypvik H. and Kalleson E. (2010) *Geological Society of America.* 465, 301-318. [5] Riis F., Kalleson E., Dypvik H., Krøgli S. O. and Nilsen O. (2011) *Meteoritics and Planetary Science.* 46, 748-761