ON THE FORMATION OF THE SILJAN IMPACT STRUCTURE (SWEDEN) – COMBINING SHOCK BAROMETRY WITH NUMERICAL MODELING.

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Introduction: The Siljan impact structure (Sweden) was formed in the late Devonian, at ~380 Ma [1]. Today, the structure is defined by a central area, 30 km in diameter, composed of crystalline basement rocks surrounded by a 10 km wide, partly lake-filled, annular depression [2]. Estimations regarding the level of erosion and original size and morphology remain elusive to date, and a wide range of possible diameters have been suggested for the original structure (from 52 to 90 km [2,3]). The pre-impact conditions in the region have been the subject of intense debate, due to the fact that Devonian sediments are not only lacking among sediments preserved in the annular depression of the Siljan structure, but have also been eroded in Sweden in general. Thickness estimates of the pre-impact sedimentary sequence range from the commonly quoted 400-500 m up to 4 km [4,5].

In this study, we provide new shock barometry data (obtained using the same methodology as in [2]) from two drill cores retrieved from the central plateau of the Siljan impact structure, Hättberg (602.83 m deep) and Vålarna (112.78 m deep). These data are combined with the radial surface shock barometry profile of [2] and compared with the results of numerical models of the formation of the Siljan structure. Numerical modeling was carried out using the iSALE shock-physics code ([6] and references therein), with the aim of constraining the pre-impact sedimentary thickness, the original size and morphology of the structure, and also to gain insight into the formation of large, complex, impact structures in general.

Results, Discussion, and Conclusions: Recorded shock pressures in the Hättberg core, located 3.3 km from the center, start at 15-20 GPa for the two uppermost samples (5 and 45 m), and decay to 10-15 GPa in the rest of the core. The Vålarna core, located at 4.4 km from the center, yields a more complicated shock pressure pattern, where recorded pressures are higher at the bottom of the core (15-20 GPa), compared to 10-15 GPa at the surface, suggesting a complicated fracture/fault system in the central uplift of Siljan.

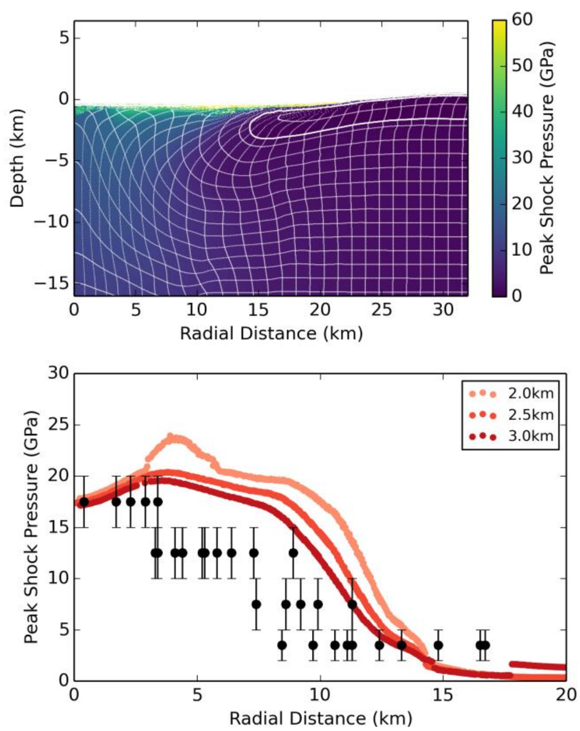

Figure 1: (above) Final peak shock distribution in our best fitting iSALE simulation of the Siljan impact event. (below) Simulated radial attenuation patterns after 2.0, 2.5, and 3.0 km of erosion, plotted with the shock data (black circles) reported in [2].

The distribution of peak shock pressures, the existence of sediments at 15 km radial distance within the structure, and a minimum final crater size of 50 km were used as constraints on numerical simulations of the Siljan impact, whilst impactor size, sedimentary thickness, and acoustic fluidization parameters were varied. Our models (Fig. 1) show that the pre-impact sedimentary thickness at Siljan was at least 1.75 km, and that there has been ~2-3 km of denudation since the time of impact. The final crater (rim) diameter in the model is ~60 km. Our results demonstrate that a larger final crater size, as previously suggested, requires a substantially thicker pre-impact sedimentary sequence and deeper erosion to be consistent with observations.

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References: [1] Jourdan F. and Reimold W.U. 2012. Abstract #5093. 75th Annual Meeting of the Meteoritical Society. [2] Holm S. et al. 2011. *Meteoritics & Planetary Science* 46:1888–1909. [3] Grieve R.A.F. 1988. In Bodén A., and Eriksson K.G (eds.) *Deep drilling in crystalline bedrock volume 1: The deep gas drilling in the Siljan impact structure, Sweden and astroblemes*. Springer Verlag. pp. 328–348. [4] Lindström M. et al. 1991. *Sveriges geologi från urtid till nutid*. Lund: Studentlitteratur. 398 p. [5] Tullborg E-L. et al. 1995. *SKB Technical Report* 95-18. Svensk Kärnbränslehantering AB. 38 p. [6] Wünnemann K. et al. 2006 *Icarus* 180:514–527.