Emplacement of the Steen River impact structure: Insights into mixed-target impact cratering

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The Steen River impact structure (SRIS) is an ancient, buried complex crater located in Northwestern Alberta. The target rocks at the time of impact consisted of ~1.6 km of Devonian carbonates, shales and sandstones that were overlying Precambrian crystalline basement material of the Canadian Shield. This mixed-target lithology is found at many other terrestrial craters, two of which – the Ries crater in Germany and the Haughton structure in the Canadian High Arctic – are comparable to the SRIS. Crystalline and sedimentary rocks respond differently to the high pressures and temperatures induced by propagating shock waves; the higher porosity and volatile content in sedimentary rocks compared to igneous materials affects the amount of melt that is produced during an impact and how the crater-fill material is distributed post-impact. Explosive events, resulting from decompression and release of volatiles, result in higher quantities of material to be ejected from the crater. Studies of a continuous drill core from the central uplift region of the SRIS enabled estimation of transient cavity volume, amount of melt produced, and relative proportions of target material that contributed to the melt. The results show that much of the matrix melt clasts (<1 mm) are derived from melting of shales while the larger clasts and melt associated with granitic clasts are melted crystalline basement material. When compared to the Haughton and Ries structures, it is evident that the vertical extent of the target sedimentary cover influences the amount of melt produced – a thicker sedimentary succession results in more melt forming, but also more melt ejected from the crater. The lack of a coherent melt sheet in all three of these craters and the presence of heterogeneously distributed melt fragments is a result of the volatile-induced disruption following the impact.

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