A NEW MODEL FOR THE STEINHEIM IMPACT BASIN USING ISALE2D. M. L. Harwell[1] and K. Wünnemann[2,3], [1]Purdue University, 610 Purdue Mall, West Lafayette. IN 47906, USA, mharwell@purdue.edu [2] Museum fur Naturkunde Berlin, Invalidenstrasse 43, D-10099 Berlin, Germany, [3]Institute for Geological Science-Freie Unversität Berlin, 12249 Berlin, Germany.

Introduction: The Steinheim impact crater is a complex crater located with an apparent diameter of 3.8 km located ~40 km to the southwest of Ries Crater in Southern [1]. It is widely accepted that both craters formed in the same impact event some 14.5 million years ago. Like its companion crater, Steinheim is a complex crater and is defined by a central peak with a diameter of 900 m, that rises 50 m above the basin floor. The presence of the pronounced central peak within Steinheim is unusual as the diameter of the crater sits near the transition between a simple and complex crater of 3 to 5 km on Earth.[2].

Though research has continued in the decades since Steinheim was identified as in impact crater, questions remain over its formation. Physical and numerical studies have provided insight into the crater's formation and morphology, and continue to provide useful constraints on potential models produced for the crater. In the 1960s, a series of drill cores were taken throughout the impact structure that allow for the comparison of the internal structure of the crater and the undisturbed stratigraphy. A buildup of lake sediment of up to 50 m and fallback breccia from 20-70 m serves as the modern floor of the impact basin. This overlays a series of limestone, sandstone, and shale layers. The Malmian Limestone (422 m) extends from the upper Jurassic to middle Jurassic era. The Dogger (186 m) to lower Jurassic (169 m) sediments include sandstone intermixed with shale and limestone. The Triassic to Permian (500 m) sandstone, included in the Keuper formation, is followed by the granitic basement at a depth of 1180 m [3,4]. Keuper Sandstone marks the extent of the central uplift as measured by the central drill core. The upper Jurassic limestone formation that dominates the uneroded surfaces of the central peak formed during the uplifting event rather than during the modification stage [1].

Further constraints on the target surface and impactor are offered by additional studies, including a detailed gravity study in which the average Bouguer Anomaly across 9 radial paths from the center of the crater were interpreted to suggest a final crater closer to 7 km [5]. The finding of melt particles composed of Dogger sandstone in the fallback breccia corroborates a larger impact velocity [6,7] as a peak pressure of 25 GPa is required to produce melt in carbonate rock [8]. Contradictions arise when these two findings are compared with the limestone layer included in the central uplift of the crater, which suggests a smaller impact energy or greater erosion since the formation of the crater.

Though the crater has experienced an unknown level of erosion since its formation, the cores provide a structure to the crater and a constraint on the extent of uplifted material.

Past studies to model the Steinheim impact crater include a detailed study confirming an oblique impact angle [9] and an iSALEB model, in which the stratigraphy was simplified to a 350 m of limestone, 700 m of sandstone, followed by the granitic basement [10]. This study builds on latter the numerical study.

Methods: The eulerian shock-physics code iSALE-2D is used in this study to model the crater mechanics [11]. Though the drill cores provide a detailed layout of the undisturbed stratigraphy, the stratigraphy used in the model had to be greatly simplified to account for computation time and resolution of the models. The target layering used in the following models consist of limestone (Calcite, ANEOS EOS) extending 422 m from the surface, sandstone (quartzite, ANEOS) with a thickness of 602 m, another layer of limestone (131 m), followed by the granitic basement extending from 1155 m to the base. The resolution of each run depends on the size of the impactor of CPPR 12. Each run was done in spherical geometry.

Following the settling of the pre-impact stratigraphy, the acoustic fluidization parameters and impactor energy were focused on. The size of the limestone impactor's radius was varied between an 80 m and a 120 m while the impact speed remained 12 km/s. To limit the degrees of freedom within the study, typical values were assumed for the characteristics of each distinct lithographic unit. The acoustic fluidization parameters included are gamma_eta and gamme_beta, which relate to the seismic shaking and attenuation of the acoustic field. Both values are linearly proportional to the projectile size.

Erosion was accounted for in various models with the addition of extra material to the uppermost limestone layer.

Results: Preliminary results suggest an impactor with a 110 m radius and acoustic fluidization parameters on the order of -3 and +3 for the gamma_eta and gamma_beta respectively. Variations in the acoustic fluidization parameters with impactor energy can result in simple craters being formed at very high impact energies and complex craters formed with smaller impact energy in the same target (see image 1). The values on the order of 3 were settled upon as they produced realistic results and central peak with the impactor of radius 110 m. For larger impactors, regardless of the acoustic fluidization values and erosion assumed, the uppermost layer of limestone is completely removed near the point of impact and merely slumps onto the central peak, rather than uplifts with the material in the center of the crater.

The uplifted limestone suggests a smaller impactor or a greater amount of assumed erosion. As both values lean towards their, the peak pressure required to produce melt in the sandstone layer is less likely to extend to the Dogger layer.

As a more concise approach to estimating erosion is underway and depends on the synclines and anticlines where the central uplift and edge of the crater underground. Values resulting from numerical models are compared to data from the drill cores. This method reveals a suite of potential impact energies and target parameters.

Conclusion: Both the acoustic fluidization parameters and the impactor energy greatly affect the final morphology of the craters in these models. While the strength of material within the model does affect the final morphology, the effects are not as significant as target fluidization and impactor energy. This value, along with porosity, will be included to tune the best crater candidate to a best fit.

Though the amount of erosion remains still elusive, the method of comparing the edges of the material disturbed in the crater formation process and the extent of the central uplift will provide several likely candidates for the original Steinheim crater formation.

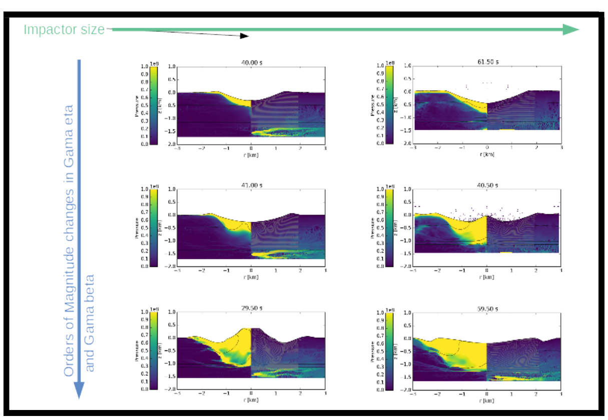

Image 1: Effects of variation in impactor energy values from 80 m (left column) to 110 m (right column) and acoustic fluidization values in both gamma_eta (8e-1 to 7.2e-3 descending from the top) and gamma_beta (2e+1 to 2e+3 descending from the top).

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