REVIEWING THE IMPACT PARAMETERS FOR METEOR CRATER USING AUTODYN. E. C. Baldwin[1], L. Vocadlo[1], and I. A. Crawford [1] [1]University College London, Department of Earth Sciences, Gower Street, London WC1E 6BT, e.baldwin@ucl.ac.uk

Introduction: Meteor Crater, Arizona, is a young (50,000yr old), relatively pristine, simple crater, and is one of the most famous and most studied on the planet. Its diameter is 1.2km with a somewhat eroded rim that originally stood at 67m, but now lies at 47m [1]. Its original depth below the surface was 180m [2] but this has been partially infilled by lake bed deposits. In addition, the floor of Meteor Crater is underlain by a lens of mixed breccia ~150m thick (Figure 1). There is a wide range of parameters suggested for the iron projectile that created Meteor Crater; estimates in diameter range from 30 to 50m, while predictions for the impact velocity span from 9.4 to 20km/s [3]. We have used AUTODYN [4] to consider projectiles of varying size and velocity as part of a series of investigations to determine AUTODYN's suitability for replicating large planetary impact events, as this is an application yet to be fully explored using this hydrocode.

Model Initialisation: *Grid setup.* A 20x20km domain was defined, using axial symmetry. For Euler solvers a grid of 1000x1000 cells was used; comparable simulations using coupled SPH and Lagrange solvers used approximately 90,000 particles and 80,000 cells initialised with gravity. Inquiries into the most appropriate resolution of the model are ongoing. Current limitations result from the large area required to represent the target in comparison to the extremely small projectile. Projectiles must be defined by at least 10-20 particles per projectile diameter in AUTODYN, a resolution which must also be maintained for the target to ensure correct interaction between the projectile and the target. It is therefore not difficult to exceed a prohibitive number of particles if the resolution must accommodate very thin layers of different materials. The implications of this are discussed in the following subsection.

Materials. The stratigraphy of the impact site is well defined, and is modelled by [5] as 9m of Moenkopi sandstone overlying 81m of Kaibab limestone, overlying 200m of Coconino Sandstone. Preliminary tests to investigate the most appropriate resolution for the model have been performed with a single layered target of Coconino Sandstone. This layer is extended to a depth of several kilometers to allow propagation of the shock pressure wave. The definition of the material underlying the Coconino sandstone is deemed unimportant for the numerical simulation, given the crater does not penetrate through this layer [2]. The data presented in this report uses a Shock equation of state for Coconino Sandstone [6] and a Drucker-Prager strength model [7]. Other strength models will be examined in future work for their applicability to planetary impact events, given that the inputs required could significantly affect the final crater dimensions [8].

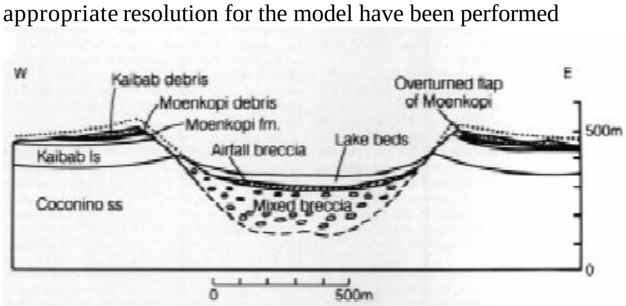

Figure 1. Simplified cross section of Meteor Crater, from Melosh (1989)

Preliminary results: For preliminary tests, an impact velocity of 12 km/s was selected, as favoured by [3], for an iron projectile with a diameter of 50m. We have also investigated the effect of (a) reducing the dimensions of the impactor and (b) increasing the impact velocity to concentrate on refining both the projectile size and velocity until a satisfactory result is produced. Initial modeling results are presented in Table 1.

The crater diameter obtained from the modelled 50m diameter projectile is ~1.75 times that observed. The output from the 25m simulation predicts a more realistic depth, however the diameter of the crater is now ~0.75 that observed. Interpolating between the two data points for crater diameter suggests a projectile of ~30m; this simulation is running at the time of submission.

	Proj D, m	**Vi, km/s**	**D, m**	**d, m**	**d/D**
Published ranges	<50	9.4-20	1200	180-350	0.15 -0.3
Modelled results	50	12	2080	796	0.38
	25	12	865	441	0.51

Table 1. Details of preliminary results, compared to observed dimensions. Proj D = projectile diameter, Vi = impact velocity, D = crater diameter, d = crater depth, d/D

Discussion: Typical simple craters have a depth to diameter (d/D) ratio of 1/3 to 1/6, while transient craters have a d/D ratio of ~1/3 [1]. Considering the depth of Meteor Crater lies between 180 and ~350m (Figure 1), i.e. either to the top of the infilled sediments or to the base of the brecciated zone, then this produces a d/D ratio lying in the range 0.15

and 0.3 respectively. Clearly the upper limit is more conforming to the typical d/D for idealised simple craters. AUTODYN will not account for any late-stage modification processes, such as infilling by lake bed deposits. Indeed, the results presented here are for the first 24 seconds after the impact, preventing any signification modification to be recorded in the model.

Future work: Within the context of our material models, current output is revealing a crater that was formed by a projectile ~30m in diameter, consistent with calcutations by [3]. We suggest, however, that the material models need to be examined further in order to determine the cause of the somewhat elevated d/D ratio of the models. This is of particular importance given the possible range of data available to input into the material models and their potential influence on the final crater dimensions [8]. Moreover, the current status of AUTODYN precludes analysis of damage unless a Tillotson equation of state is used, therefore zones of brecciated material cannot yet be delineated. Advanced work will probe AUTODYN for suitable fracture and porosity models, which may also play an important role in defining the dimensions of Meteor Crater. In any case, more work is needed to further constrain the results from this preliminary analysis.

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