Validation of AUTODYN in Replicating Large-Scale Planetary Impact Events. E. C. Baldwin[1], L. Vocadlo[1] and I. A. Crawford[1] [1]University College London, Earth Sciences Department, Gower St, London WC1E 6BT, e.baldwin@ucl.ac.uk

Introduction: A necessary procedure in validating a numerical code is to investigate its ability to replicate experimental data or results attained from another reputable code. AUTODYN 2D v4.3 from Century Dynamics [1] was employed to simulate 5-15km/s impacts of iron projectiles into geologically representative materials to verify the peak-pressure decay regimes during an impact event. Euler, Lagrange and Smooth Particle Hydrodynamics (SPH) solvers were examined and results compared with (a) The Planar Impact Approximation (PIA) technique [2] and (b) data obtained by [3].

(a) Validation with the PIA:
The largest shock pressures that can be attained in an impact event occur during the first instance of contact between projectile and target, and can be accurately estimated by the PIA [2]. The PIA was verified by calculating the peak pressures determined in [2] and [3], and compared with AUTODYN. SPH and Euler solvers produced excellent results. Increasing the impact velocity within AUTODYN is shown to adversely affect the accuracy of predicted peak pressures, probably due to the greater energies involved in higher velocity impacts. There are also deviations between the results from AUTODYN and those from the PIA for specific materials; this is largely attributed to the lack of high pressure data that the models use to generate the structural response of materials under impact conditions.

(b) Validation with Literature:
All solver types, notably SPH, are capable of replicating the pressure decay regimes. Lagrange, while offering clear definition of material interfaces and of the shock front, is subject to grid tangling problems that limit the accuracy of the results. This can be overcome, to some extent, by applying an erosion algorithm. Comparison of peak pressure behaviour for targets of basalt, dry sand, granite and calcite were found to compare well with [3] for all solvers, and has evidently constrained the decay profile at a greater resolution than previously achieved (Fig. 1). AUTODYN's estimate of higher initial pressures can again be attributed to material modeling problems but note that AUTODYN has produced data points for shallower depths than those presented in [3].

Conclusion: Is AUTODYN Reliable?
The majority of AUTODYN applications are for weaponry, defence and civil engineering problems. This study has shown that AUTODYN is also a powerful and proficient tool for replicating large scale impact events. AUTODYN's ability to represent earth sciences applications has also been demonstrated well by [4] and furthermore by [5] whereby consistent results between AUTODYN and SALES were presented.

Future Work with AUTODYN and Remotely Sensed Data from SMART-1:
Data anticipated from current ESA lunar mission SMART-1, in particular from the UK built X-ray spectrometer D-CIXS, will be used to study the South Pole Aitken (SPA) Basin and deduce whether or not this giant impact basin has penetrated the lunar mantle. D-CIXS will map global abundances of elements such as Mg, Si and Al. The Mg/Fe ratio will be of particular importance if the SPA basin is found to contain exposed mantle material, by providing us with information on lunar mantle geochemistry, vital for furthering our knowledge of lunar evolution, and ultimately, lunar origins. AUTODYN will be employed to model lunar impact events in order to provide constraints on understanding how compositional and mechanical properties of varied and stratified target materials dictate the final morphology of observed craters and of ejecta distribution. Melt generation and material emplacement will also be a high priority focus for proposed simulations, which will be of direct importance in interpreting D-CIXS observations of the SPA basin. It is the powerful combination of observational studies and hypervelocity simulations to be carried out with AUTODYN that will allow advances to be made in the field of lunar studies.

References:
[1] Century Dynamics Inc. (2003) *AUTODYN Theory Manual.* [2] Melosh H. J. (1989) *Impact Cratering, A Geologic Process.* [3] Ahrens T. and O'Keefe J. (1977) *Impact and Explosion Cratering, 639-656.* [4] Jones A. P. et al. (2002) *EPSL 202,* 551-561. [5] Wunnemann K. and Ivanov B. A (2003) *Planetary and Space Science 51,* 831-845.

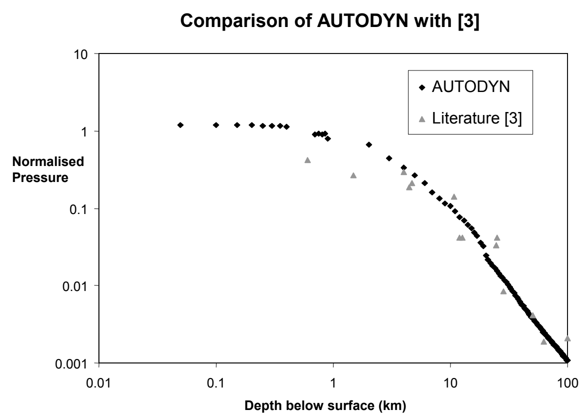

Figure 1. Graph of pressure variation with depth below impact surface. AUTODYN results are an average of data points obtained from SPH, Lagrange and Euler solvers for an iron into granite impact at 5km/s, normalised to compare with results from reference [3]. The decay regimes represent an initially constant or very slow decay from the maximum pressure to a depth of several projectile radii, indicative of the contact and compression stage, followed by a faster decaying regime characterising the excavation stage.