MOMENTUM ENHANCEMENT FROM LARGE IMPACTS INTO GRANITE. J. D. Walker[1] , S. Chocron[1], D. D. Durda[2], D. J. Grosch[1], N. Movshovitz[3], D. C. Richardson[4], E. Asphaug[5], [1]Southwest Research Institute, P.O. Drawer 28510, San Antonio, TX 78238 USA (james.walker@swri.org), [2]Southwest Research Institute, 1050 Walnut St., Suite 300, Boulder, CO 80302 USA, [3]Dept. of Earth and Planetary Sciences, University of California at Santa Cruz, Santa Cruz, CA 95064 USA, [4]Dept. of Astronomy, University of Maryland, College Park, MD 20742 USA.

Introduction: When an impactor strikes a body at hypervelocities, the momentum transferred to the impacted body is greater than the initial impactor momentum. This effect is due to the crater ejecta; when the impacted body's mass provides some of the momentum change, the effect is referred to as momentum enhancement. The small amount of data on this question implies that there is a scale effect – that is, as the projectile size increases there is an increase in the imparted momentum beyond that anticipated due to the increase in projectile size. Recently, we gathered data on the increase in momentum caused by crater ejecta when 4.45-cm diameter aluminum spheres struck granite targets at 2.01 km/s.

Impact Tests: Two impact tests were performed into 1-meter diameter granite spheres using a 50-mm caliber powder gun at Southwest Research Institute. The granite spheres had previously been used in coefficient of restitution studies [1]. These impacts tests are at a large scale compared to available momentum enhancement data. The impacts were imaged at high rate and the rocking of the test stand was measured to determine the momentum imparted to the granite. In both tests, the amount of momentum of the residual granite sphere was twice that of impacting projectile, i.e., $\beta > 2$, where β is the final impacted granite sphere's momentum divided by the initial impactor momentum.

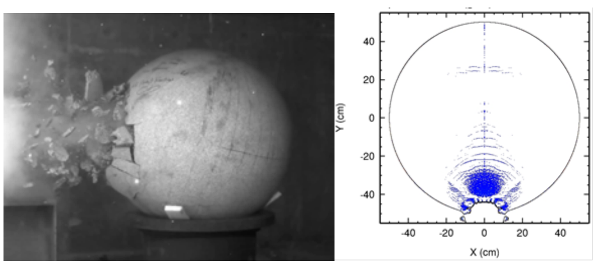

Figure 1. Left: impact of a 4.45-cm diameter aluminum sphere into a 1-meter granite sphere at 2.01 km/s. Right: pre-test computation with CTH showing impact cratering and porosity development in the granite sphere due to the impact.

Analysis and Comparison with Other Work: These experiments were compared with previous work of impacts into basalt and into aluminum. The intent for these comparisons is to understand the scale effect, which can be clearly seen in the data. As stated above and shown in Fig. 2, the momentum delivered to the granite sphere was more than twice the impacting projectiles' momentum for our 2.01 km/s impacts into granite. Compared with other data at much smaller scale, these tests imply an impactor scale and an impactor density effect for hypervelocity strikes into rock. Through a careful analysis of all the data, it is demonstrated, at scales ranging from 0.16-cm diameter impactors to 4.45-cm diameter impacts, that momentum enhancement is scaling to a power 0.4, which is a large amount. In order to determine this factor with the available data, it was also necessary to determine the impactor density scaling, which is to a power of 0.5.

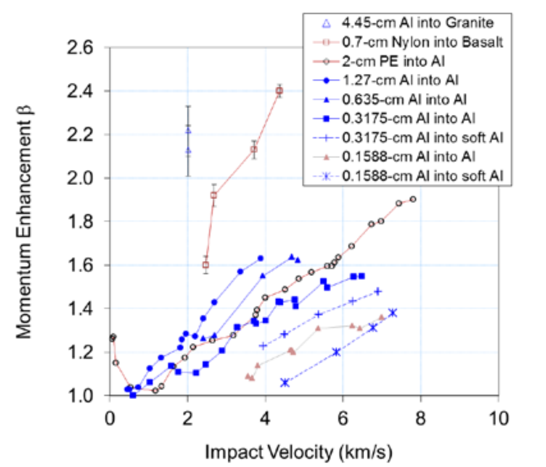

Figure 2. Momentum enhancement from this work (two points upper left), small scale impacts into basalt (four points center left) [2], and a range of small scale impacts into aluminum [3,4] show size scale effects.

Conclusions. Scaling is an important effect in cratering phenomena, including momentum enhancement. It affects the interactions of small body collisions and is relevant to discussions regarding deflection of small bodies. These impacts into granite are at a large scale for hypervelocity impact tests, and provide data points for determining scale size effects in these materials.

References: [1] Durda, D. D. et al. (2011) *Icarus*, 211, 849-855. [2] Yanagisawa, M. and Hasegawa, S. (2000) *Icarus*, 146, 270-288. [3] Denardo, B. P. (1962) NASA Technical Note D-1210. [4] Denardo, B. P. and Nysmith, C. R. (1964) *AGARD-NATO Specialists, Vol. 1: The Fluid Dynamic Aspects of Space Flight*, Gordon and Breach Science Publishers, New York, 389-402.