LUNAR EXCAVATION SYSTEMS AT THE COLORADO SCHOOL OF MINES. C. B. Dreyer[1] and P. J. van Susante[2], Center for Space Resources, Colorado School of Mines, 1310 Maple Street, Golden, CO 80401; Ph: (303)-273-3890; email: cdreyer@mines.edu, [2] Center for Space Resources, Colorado School of Mines, 1310 Maple Street, Golden, CO 80401; Ph: (720)-272-8892.

Introduction: Small scale mining and benificiation systems are needed if ISRU is to be incorporated into NASA mission plans. In this abstract we review the Colorado School of Mines (CSM) projects in excavation and related mining equipment. These systems demonstrate the possibility of low-cost development of small scale systems. At CSM we have built several systems over the course of several years involving dozens of undergraduate students every year.

Excavation Systems: The excavation systems developed at CSM have been built by several funded NASA projects and as senior design projects. Most excavators use a bucket ladder design [1], [2] (Fig. 1). A CSM bucketladder excavator was entered in the NASA ESMD Lunar Regolith Excavation Competition which was held in May 2010 (Fig. 1). The CSM excavation rover prototypes are relatively low mass (<80kg) and require relatively low power (150 Watts), yet can excavate at 1000-1500 kg/hr. The bucketladder has become the preferred method of regolith excavation at CSM as it combines low force excavation and material transport in the same unit. A bucketladder also can support small scale and large scale excavation requirements for science, civil engineering, and ISRU operations.

Related Mining Systems: CSM has also developed systems that can be added to excavators to augment their capabilities.

Backhoe and Claw. The CSM Lunar Backhoe (Fig. 2) is compatible with the bucketladder mount of the CSM Centennial Challenge excavator. The backhoe scoop can hold 30 in^3 of material. The claw can lift a 3-kg rock of demisions less than 4in x 4in x 4in.

Trommel Regolith Sorter. The CSM Trommel Regolith Sorter (Fig. 3) uses gravity to sort >2-mm regolith fragments from fines. The trammel was sized to be compatiable with typical excavation rates of CSM excavators. We have also developed a basalt based regolith simulant with large size particles in order to test the trommel.

Conclusions: The lunar excavation and related systems developed at CSM demonstrate what is possible with motivated students working with a relatively small budget.

References: [1] Johnson, L.L. and van Susante, P. J, SRR VIII, Golden, 2006. [2] van Susante, P. et al., 2009 Southeast Region Space Grant Meeting, Puerto Rico, Jan. 2009.

Figure 1: Bucketladder prototype and continuous feed setup to measure excavation rate and power use [3] (top left). CSM bucketladder NASA Centennial Challenge excavation rover [4] (top middle). CSM Excavation Challenge Rover (top right, bottom).

Figure 2: CSM Lunar Backhoe which can be integrated with CSM Centennial Challenge Rover. Bucket end effector (top left). Gripping claw end effector (bottom left). Backhoe in action (top right, bottom middle & right).

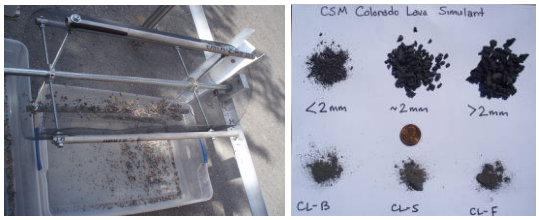

Figure 3: Left: CSM Trommel Regolith Sorter. Right: Basalt Simulant for sorting tests.