# MEASUREMENTS OF ADHESION IN CM2 CARBONACEOUS CHONDRITES AND ASSOCIATED MINERALS FOR APPLICATION TO SMALL C-TYPE ASTEROIDS.

R.P. Harvey[1], Z. Zeszut[1], J. Gaier[2], J. Kleinhenz[2], D. Waters[2] and P. Shober[1] [1] Dept. Earth, Environmental and Planetary Sciences, Case Western Reserve University, Cleveland OH 44106 (rph@case.edu) [2] NASA Glenn Research Center, Cleveland OH 44135

There is a growing need for accurate measurements of the mechanical properties of asteroidal material to support missions to small bodies (most to C-type asteroids) as well as other scientific, planetary defense and ISRU studies [1-3]. Adhesion values in particular (here treating *cohesion* as a special case, adhesion in homogenous materials) are critically important in explaining several intriguing observations related to the strength and rigidity of small asteroids. Detailed observation of spin rates in small Near Earth Objects (NEOs) show a near complete absence of fast rotating asteroids smaller than a few 100 m across, while those slightly larger are often oblate, top-shaped spheroids (with pronounced equatorial bulges), binary or have multiple satellites [4-5]. Taken together these observations suggest that asteroids between 300 meters and 1000 meters across behave as loose granular aggregates and are subject to YORP spin-up severe enough to disrupt them [e.g. 6, 7]. Models of these processes are highly dependent on values for adhesion, but in the absence of *in situ* or laboratory measurements on appropriate materials these models are forced to either assume or derive values [8, 9].

We are currently engaged in a series of experiments making the first measurements of adhesion in "real" asteroidal materials, aka meteorites. Our focus so far has been on CM2 meteorites as proxies for the regolith of C-type asteroids, given these are a common choice of target for several upcoming missions [1-3]. Our experiments are being conducted using the NASA Glenn Research Center's “Adhesion Rig”, a custom instrument consisting of a torsion balance in an ultrahigh vacuum ($10^{-10}$ torr) chamber. Simply described, these experiments gently push a pin of a specified material against a plate (also of a specified material). When the pin is retracted, any attractive force occurring is seen as a deflection past the zero point of the balance. This system primarily measures adhesion caused by Van der Waals and electrostatic forces (the two adhesive forces considered most important in the asteroid surface environment). Our current results include measurements of adhesion within both natural meteorite specimens (which are mixtures of distinct minerals and phases) and single minerals. The latter were included in the study for two reasons: to aid the search for plausible, relatively inexpensive terrestrial analogs to asteroidal regolith, and to increase the relevance of our measurements given the observed mineralogical variation among C-type asteroids (including, perhaps unfairly, D-, P- and B-types after [10].

Our results so far suggest that adhesion within CM2 material as a whole is low relative to some individual minerals, but not negligible. Results also suggest the use of some suggested terrestrial proxies for asteroidal regolith (such as common terrestrial serpentine-group minerals) may overestimate adhesion and thus the overall strength and rigidity of small C-class bodies.

**References**: [1] Lauretta D.S. et al., (2014) *Meteoritics & Planetary Science*, 50: 834-849. [2] Tsuda Y. et al., (2016) *Acta Astronautica* 127: 702-709. [3] Mazanek D. D. et al. (2015) *Acta Astronautica* 117: 163-171. [4] Polishook D. et al., (2016) *Icarus* 267: 243-254. [5] Polishook D. (2014) *Icarus* 241: 79-96. [6] Walsh K. J. et al (2012) *Icarus* 220: 514-529.[7] Denneau L. et al. (2015) *Icarus* 245: 1-15. [8] Hatzwell C.M. and Scheeres D.J. (2011) *Planetary and Space Science* 59: 1758-1768. [9] Scheeres D. J.et al (2010) *Icarus* 210: 968-984. [10] Binzel R.P. et al. (2015) in *Asteroids IV* (P. Michel et al., eds.) 243-256.