OUTER SOLAR SYSTEM MATERIAL IN INNER SOLAR SYSTEM REGOLITH BRECCIAS. M.Zolensky[1], M. Fries[1], Q.H.-S. Chan[2], Y. Kebukawa[3], A. Steele[4], R.J. Bodnar[5], M. Ito[6], D. Nakashima[7], T. Nakamura[7], R. Greenwood[2], Z. Rahman[8], L. Le[8], D.K. Ross[8], K. Ziegler[9], W. Bottke[10], J. Martinez[8]. [1]NASA Johnson Space Center, Houston, TX 77058, USA (michael.e.zolensky@nasa.gov); [2]Open Univ., Milton Keynes, UK; [3]Yokohama Nat. Univ., Yokohama 240-8501, Japan; [4]Carnegie Geophys. Lab, Washington, DC 20015, USA; [5]Virginia Tech, Blacksburg, VA 24061, USA; [6]JAMSTEC, Kochi, 783-8502, JAPAN; [7]Tohoku University, Sendai 980-8577, JAPAN; [8]Jacobs ESCG, Houston, TX 77058 USA; [9]Inst. Of Meteoritics, Univ. New Mexico, Albuquerque, NM, 87801 USA; [10]Southwest Research Inst., Boulder CO, 80302 USA.

Introduction: There is excellent evidence that a dynamical instability in the early solar system led to gravitational interactions between the giant planets and trans-Neptunian objects (TNOs). Giant planetary migration triggered by the instability dispersed a disk of primordial TNOs and created a number of small body reservoirs (e.g. the Kuiper Belt, scattered disk, irregular satellites, and the Jupiter/Neptune Trojan populations). It also injected numerous bodies into the main asteroid belt, where modeling shows they can successfully reproduce the observed P and D-type asteroid populations [e.g. 1]. During the injection era and after implantation, some of these “main belt TNOs” would have collided with S-class asteroids. Some of this material may have survived as a component of asteroid regolith breccias.

Thus, we have been searching for evidence of these impact events in the form of carbonaceous xenoliths in brecciated ordinary chondrites. These xenoliths would have experienced a wide range of impact velocities, and therefore we should expect to see everything between relatively unaltered material to completely shock-melted lithologies. This material might also be different from the carbonaceous chondrites that represent standard C-complex asteroids. A goal of this research is to define useful criteria for distinguishing between these two classes of materials, including O, Cr, N and C isotopes, petrographic characteristics, and chronology.

Experimental: E-beam work was performed at the labs of ARES, NASA JSC. New oxygen isotope analyses were performed at the Institute of Meteoritics, University of New Mexico, using a Finnigan 253 mass spectrometer.

Hydrated Lithologies: Some H3-6 chondrite breccias contain C1 to C2 xenoliths, which have been variously called CI-, CM-, CR-, and micrometeorite-like [3], but differ in important aspects from these materials. They vary in detail, but are usually dominated by phyllosilicates, have abundant magnetite, carbonates, and pyrrhotite, and sometimes have minor olivine and low-Ca pyroxene (Fig. 1). They lack chondrules or CAI. The few that have been well characterized display a remarkable diversity of organics, but this aspect has been little explored. The best studied clasts are in Zag, Tsukuba, Plainview (1917), NWA 8369 and Carancas [4,7], while the Zag clast (clast A in this meteorite) is described in two recent publications [5,6]. Similar clasts are found in ureilites, HEDs and other meteorites (Fig. 1e). Studies of bulk H, O and Cr isotopes of these clasts are presently underway to better constrain their origin; whether their parent worlds were a TNO or asteroid 1/Ceres (as we have also proposed), or (very likely) both, remains to be settled. Zag clast A has a very heavy bulk O isotope composition: $\delta^{18}O$=+23.68‰, $\delta^{17}O$=+13.71‰, $\Delta^{17}O$=+1.41‰ [2,6], has organics with correlated hotspots of ^{15}N and ^{2}H [6], and very high ^{54}Cr [7] all suggesting a very cold formation location - consistent with the outer solar system.

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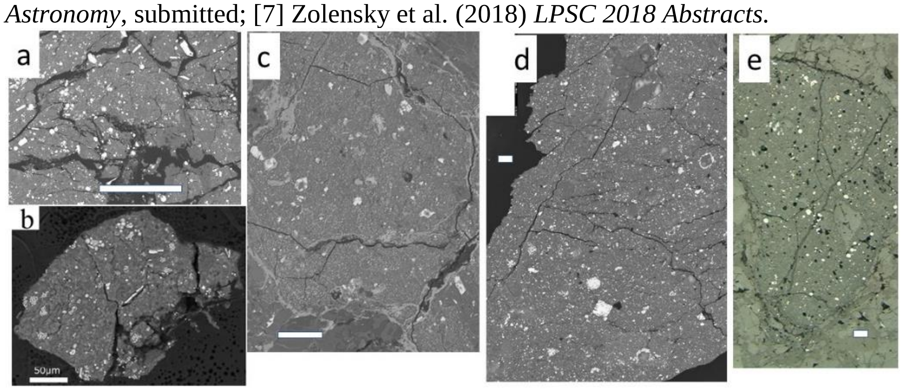

Figure 1. (a-d) BSE images of five carbonaceous clasts in H chondrites, and (e) a reflected light image of one in a eucrite. Clasts are from (a) Carancas, (b) Tsukuba, (c) NWA 8369, (d) Zag, (e) Y-791834. Scale bars are 50 µm.