PETROLOGY AND NOBLE GASES OF THE REGOLITH BRECCIA MAC 87302 AND IMPLICATIONS FOR THE CLASSIFICATION OF ANTARCTIC METEORITES. L.C. Welzenbach[1], T.J. McCoy[1], A. Grimberg[2] and R. Wieler[2] [1]Dept. of Mineral Sciences, National Museum of Natural History, Smithsonian Institution, Washington, DC 20560-0119 USA (welzenbl@si.edu), [2]ETH Zürich, Isotope Geology and Mineral Resources, NO C61, CH-8092 Zürich, Switzerland.

Introduction: Over the last 30 years, Antarctica has proven to be the most fertile location on Earth for collecting meteorites. Through the 2003-2004 field season, the U.S. Antarctic Search for Meteorites has collected nearly 14,000 meteorites. Among these are ~12,800 equilibrated ordinary chondrites, including 261 that are over 1 kg in mass. Most of these equilibrated ordinary chondrites have not been studied petrologically beyond the initial classification, which typically involves examination of a chip of only 1-3 g in mass. These large, unstudied ordinary chondrites can provide important clues about the bombardment history of asteroids. Nearly 40 years ago, [1] studied large masses of ordinary chondrites from the collections of the Natural History Museum in London and found nearly 20% of all ordinary chondrites were breccias and brecciation is often revealed during study of the largest masses of some meteorites (e.g., Paragould). A comparable study of Antarctic meteorites has never been undertaken.

Our interest in MAC 87302 began with its transfer to the Smithsonian in 1995 and recognition as a breccia two years later. It was initially classified as an L4 chondrite and the type section displays textures and mineral compositions typical for this classification. However, hand sample examination revealed a mixture of light and dark clasts in a dark matrix (Fig. 1), reminiscent of some regolith breccias [2]. We were further motivated when one of us (LCW) served on the ANSMET team in the 2002-2003 season and collected several meteorites in the MacAlpine Hills texturally similar in hand sample to MAC 87302.

In this work, we report on the petrology and noble gas composition of MAC 87302, note meteorites with which it is likely paired, and discuss implications for the future study and pairing of Antarctic meteorites.

Petrology: MAC 87302 had an initial mass of 1094.6 g. We examined two slices and 9 thin sections, documenting several clast types:

Matrix. The matrix of MAC 87302 is texturally similar to a high type 3 or type 4 ordinary chondrite. Chondrules exhibit distinct outlines, with microcrystalline mesostasis. Shock effects are extensive, including mosaicism in the olivine. Olivine compositions exhibit a distinct peak at Fa_{23-24} (Fig. 2), within the range for equilibrated L chondrites, with a tail of values down to Fa_5. Low-Ca pyroxenes exhibit a peak at Fs_{20-21}, with a tail to Fs_1.

White Clasts. Metamorphosed, white clasts that can exceed 1 cm in maximum dimension occupy 10-20% of the slabs we examined. These are distinctly more metamorphosed than the host, with homogeneous olivine compositions (Fa_{24-25}) and textures typical of type 5 chondrite.

Shock-Darkened Clasts. Somewhat less abundant than the white clasts, shock-darkened clasts can exceed 1 cm in size. Like the white clasts, they are more metamorphosed than the host, with olivine Fa_{24-25} and low-Ca pyroxene of Fs_{20-21}. Typical of shock-darkened meteorites, they exhibit a fine-network of metal and sulfide injected in and around silicates.

Melt clasts. We identified impact melt clasts in two thin sections. Both are small, measuring ~0.5 cm in diameter. They are distinct in hand sample for being virtually devoid of metal and sulfide. Texturally, they are dominated by small, equant olivines with a silicic mesostasis, although larger relic grains are present (Fig. 3). Compositionally, these clasts are quite distinct from the matrix, exhibiting more magnesian compositions, and from each other. Equant olivine in one clast are Fa_{20-24}, intermediate between H and L chondrites, while the other is Fa_{15-18}, at the lower range for H chondrites. In PTS ,29, a large, relic grain exhibits reverse zoning in BSE imaging. No low-Ca pyroxenes of sufficient size for microprobe analyses were noted.

Noble gases: He, Ne and Ar concentrations and isotopic ratios were measured in 1 matrix sample, 2 shock-darkened clasts and 4 white clasts. The Ne data are shown in Fig. 4. The matrix sample and two light samples which had adhering matrix contain trapped Ne with a $^{20}Ne/^{22}Ne$ ratio of ~11.7±0.3, in-between the values for the components solar wind (SW) and solar energetic particles (SEP). Therefore, MAC 87302 is a regolith breccia irradiated by the solar corpuscular radiation. The relatively low trapped $^{20}Ne/^{22}Ne$ ratio close to the SEP value suggests that the grains lost part of their outermost surfaces containing the SW component by weathering. In contrast, the shock-darkened clasts and white clasts uncontaminated by matrix are free of solar noble gases and their data points plot close to the composition of Ne produced by galactic cosmic rays (GCR). These data yield an ^{21}Ne cosmic ray exposure age of ~27 Ma.

Discussion: MAC 87302 is typical of many ordinary chondrite regolith breccias that include a wide variety

of cognate xenoliths [3]. In this case, the presence of the metamorphosed white clasts and shock-darkened clasts are consistent with mixing of materials of differenet metamorphic- and/or shock-state from the same parent body. The origin of the melt clasts is more problematic. It is possible that they sample a melt of the bulk chondrite. Interestingly, the average olivine composition of the melt clast in PTS ,24 is similar to that of the matrix. Alternatively, the clast could have been reduced during melting. Some support for this idea comes from the existence of reversed zoned relic olivines in the ,29 melt clast, although the compositional similarity to of this clast to H chondrites suggests to us that it is likely foreign to MAC 87302. Oxygen isotopic compositions of these clasts could further elucidate the origin of these melt clasts.

The presence of such diverse material within MAC 87302 has interesting implications for the classification and pairing of Antarctic meteorites. It is essentially unknown how many distinct meteorites are sampled by the ~14,000 specimens collected to date. Estimates for the ratio of distinct meteorites to specimens range from 4:1 to 10:1 [4]. Within MAC 87302, we find clasts which, if they were distinct meteorites, would not be paired during characterization. At least three of these materials (the matrix, white clasts, shock-darkened clasts) reach dimensions typical of the average Antarctic meteorite. During our examination of other specimens from the MacAlpine Hills, we have identified numerous specimens similar to the matrix, including 87303 and 87310. A large white clast has been observed in 02736 and metamorphosed L chondrites similar to the white clasts include 88118 and 88142. A shock-darkened clast is present in 02907 and 02750 and 02497 both sample L impact melts which could sample clasts similar to those in 87302. Examination of find locations and terrestrial ages for this diverse suite of samples could clarify whether they sample a single, texturally- and compositionally-diverse breccia. Studies of this type could significantly alter our view of the pairing of Antarctic meteorites and, we stress, have only been undertaken for a very small fraction of the large equilibrated ordinary chondrites recovered from Antarctica.

References: [1] Binns R.A. (1967) *EPSL*, *2*, 23-28. [2] Fredriksson K. and Keil K. (1963) GCA, 27, 717-739. [3] Taylor G.J. and Wilkening L.L. (1982) LPI Tech. Rpt. 82-02. [4] Lindstrom M.M. and Score R.(1995) LPI Tech. Rpt. 95-02, 43.

Fig. 1 Slab of MAC 87302 showing matrix, white clasts and shock-darkened clast. Cube is 1 cm on side.

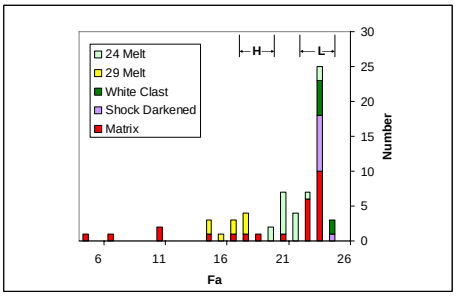

Fig. 2 Histogram of olivine compositions in MAC 87302. Note that the impact melt clasts are more magnesian than the matrix.

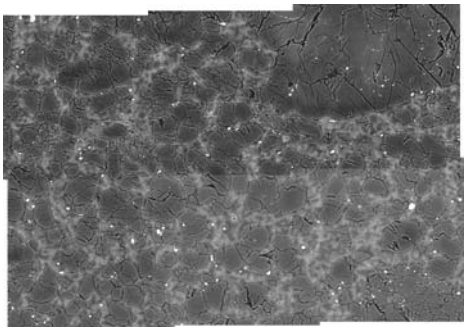

Fig. 3 BSE mosaic of a portion of the impact melt clast in PTS ,29. Note the equant, magnesian olivine crystallized from the melt and the reversely-zoned relic olivine. Width of field of view is 360 microns.

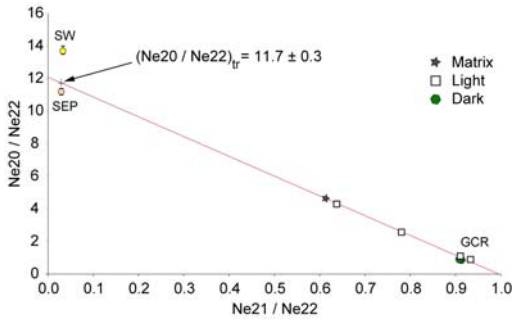

Fig. 4 Neon isotopic compositions in samples of MAC 87302. All data points fall on a mixing line, indicating that some samples contain solar Ne with a $^{20}Ne/^{22}Ne$ ratio of 11.7±0.3.