PRE-ACCRETIONAL SORTING OF GEMS IN THE OUTER SOLAR NEBULA. P. Wozniakiewicz1, J. P. Bradley2, H. A. Ishii2, D. E. Brownlee3, M. C. Price1, M. J. Burchell1 and A. T. Kearsley4. 1School of Physical Sciences, University of Kent, Canterbury, Kent CT2 7NH, UK (pwozniakiewicz@yahoo.com). 2Institute of Geophysics and Planetary Physics, Lawrence Livermore National Laboratory, Livermore, CA 94550, USA. 3Department of Astronomy, University of Washington, Seattle WA, USA. 4Science Facilities, Natural History Museum, London, SW7 5BD, UK.

Introduction: Chondritic porous interplanetary dust particles (CP IDPs) are an important class of extraterrestrial material since their properties are consistent with a cometary origin and they do not show evidence of significant post-accretional parent body alteration [1-6]. Consequently, they can provide information regarding the conditions and mechanisms operating in the comet forming region of the solar nebula. Our recent comparative study of the sizes and size distributions of crystalline silicate and sulfide grains in the CP IDPs U220GCA, U211B6 and U212A34A and in comet 81P/Wild 2 samples collected by NASA’s Stardust mission shows evidence for a size-density relationship [7]. This relationship is indicative of a sorting mechanism operating in the outer solar nebula, although the exact mechanism responsible is unknown. Here we explore whether this relationship is also observed with other components of CP IDPs.

Methodology: Using scanning transmission electron microscopy (STEM) we compiled size data for GEMS (glass with embedded metals and sulfides) in the CP IDPs U220GCA, U211B6 and U212A34A for comparison against their silicate and sulfide datasets reported in [7]. The method of collection for Stardust samples prevents positive identification of any GEMS they may have contained [8], therefore we have performed measurements of GEMS, silicates and sulfides in an additional CP IDP (a Grigg-Skjellerup particle, GS1) to more reliably identify trends and determine whether the silicate and sulfide size-density relationship identified in [7] still holds. All samples were disaggregated into component grains and dispersed onto thin carbon support film substrates on copper mesh TEM grids: Due to their fragile, loosely aggregated structures, the constituent grains readily separate without significant fragmentation [9].

Results and Discussion: Kolmogorov–Smirnov (K-S) tests comparing the size distributions indicate that GEMS, silicate and sulfide populations are statistically different both within and between the four CP IDPs. Cumulative frequency distributions of grain sizes for these components are shown in Fig. 1, with vertical lines marking geometric mean radii. In Fig. 2, the geometric mean radii of the silicates ($r_{silicates}$) are plotted against the sulfides ($r_{sulfides}$). Here, error bars represent the standard error on the mean and an error-weighted trend line has been fit ($r_{sulfides} = 0.61 r_{silicates}$).

With the addition of the CP IDP GS1 datum, sulfides remain consistently smaller than silicates and the size-density relationship reported in [7] holds: the
slope of the error weighted fit is approximately equal
to the ratio of the average grain densities. These results
support a sorting mechanism operating on the silicates
and sulfides that accreted in comets. (Although only
measured in U220GCA rare metal grains appear to
have been similarly sorted with silicates and sulfides.)

GEMS do not exhibit the same size/sorting trend as
the crystalline silicates and sulfides in CP IDPs. Their
geometric mean radii (r_{GEMS}) do not vary consistently
with those of the silicates and sulfides: although the
largest GEMS are found in the IDP with the largest
silicates and sulfides and the smallest GEMS are in the
IDP with the smallest silicates and sulfides, GS1 has
larger GEMS than U211B6 despite having smaller
silicates and sulfides (Fig. 1). In addition, the GEMS in
U220GCA and U211B6 are larger than their accompa-
nying sulfides and smaller than their silicates while
those in GS1 and U212A34A are larger than both their
silicates and sulfides. This is evident in Figure 3
where, although the error weighted fitted are plausible
(point to a GEMS density greater than silicates
and less than sulfides), they are poorly defined. Since
the size distributions of GEMS are, in several cases,
better constrained than those of silicates and sulfides, it
does not appear that GEMS were simply sorted less
efficiently. This suggests that, although the CP IDPs
sample different populations of GEMS, they do not
exhibit the size-density relationship consistent with the
sorting observed in the silicates and sulfides. It could
be argued that the GEMS density is poorly constrained,
varying between GEMS as their porosity and silici-
at/sulfide/metal abundances vary. This could obscure
a size-density relationship with the silicates and sul-
fides, despite sorting via the same mechanism. Howev-
er, again, it is difficult to explain the different yet tight-
ly constrained size ranges for GEMS in different IDPs.

Unlike the crystalline silicates in CP IDPs, GEMS
did not form in the hot inner nebula [10], and GEMS’
physical properties as well as non-solar oxygen isotope
abundances measured in some implicate the presolar
interstellar medium as their most likely source [11].
The disparate sorting trends between GEMS and the
crystalline grains in CP IDPs may simply be a reflec-
tion of these two different source environments.

Acknowledgements: This work was funded in part
by a grant from NASA’s Cosmochemistry program
(JPB) and LDRD grant 09-ERI-004 (JPB). H.A. Ishii
was supported by NASA’s Laboratory Analysis of
Returned Samples program. Portions of this work were
performed under the auspices of the U.S. Department
of Energy by LLNL under contract DE-AC52-
07NA27344.

285, 1716 [4] Nguyen et al. (2007) LPS XXXVIII Ab-
GCA in press.