indicate an extraordinary bulk composition. A comparable composition had been reported previously for a portion of eucrite ALHA78158 [2], but since ALHA78158 is polymict, its composition is petrogenetically ambiguous. Compared to noncumulate eucrites, RKPA80224 has significantly lower contents of REE (*e.g.*, Sm = 0.87 μg/g) and other incompatible elements (*e.g.*, Ti = 3 mg/g); and much lower Sm/Eu (1.19, *vs.* ~2.63 for typical low-Sm noncumulate eucrites such as Juvinas). On the other land, RKPA80224 differs from recognized cumulate eucrites in many respects, including lower Mg/(Mg + Fe) (0.398, *vs.* 0.49–0.64 for cumulate eucrites) and higher Eu/Al (1.02×10^{-5}, *vs.* $2\text{–}8 \times 10^{-6}$). Conceivably RKPA80224 represents an extension of the Stannern Trend, characterized by sharply increasing Sm with constant or moderately decreasing Mg/(Mg + Fe), and putatively formed as primary partial melts. However, the low overall REE, Ti, *etc.*, and especially the low Sm/Eu (positive Eu anomaly) strongly suggest that RKPA80224 formed as a partial cumulate. Its relatively coarse, largely ophitic texture is comparable to the textures of unbrecciated portions of Pomozdino, a eucrite completely unlike RKPA80224 in composition but also interpreted as a partial cumulate [3, 4]. The pyroxenes are thoroughly exsolved (exolution lamellae up to 12 μm across), indicating a prolonged history of slow cooling comparable to those for recognized cumulate eucrites [5]. Mass balance calculations, assuming that the K_D(Fe/Mg) for pigeonite = 0.30 [6], indicate that the parent melt of RKPA80224 may have been along an extension of the Nuevo Laredo Trend, characterized by moderately increasing Sm with sharply decreasing Mg/(Mg + Fe), and putatively formed by fractional crystallization of a melt (or melts) similar to relatively magnesian members of the Main Group eucrites [*e.g.*, 2, 3, 6]. This model requires that the "trapped liquid" content of RKPA80224 be no more than ~40 wt.%, because a TL content ≫40 wt.% would imply a Sm content for the parent melt far lower than any plausible extension of the Nuevo Laredo Trend. The Mg/(Mg + Fe) implied for the parent melt is only about 0.20. Stolper [6] noted that surprisingly ferroan melts, more ferroan than any known eucrite, are required to account for most cumulate eucrites. Meteorites such as RKPA80224 and Pomozdino tend to blur the distinction between cumulate and noncumulate eucrites. However, the putative genetic distinction between Nuevo Laredo (Main-Group-linked fractional crystallization residue) and Stannern (primary partial melt) types of noncumulate eucrites still appears valid, and RKPA80224 appears to stengthen the case for most cumulate eucrites being linked to the Nuevo Laredo Trend. References: [1] Score R. and Mason B. (1982) *Ant. Met. Newsl.* **5,** 31. [2] Smith M. R. and Schmitt R. A. (1981) *LPS* **12,** 1014–1015. [3] Warren P. H. and Jerde E. A. (1988) *LPS* **19,** 1234–1235. [4] Yaroshevsky A. A. *et al.* (1988) *LPS* **19,** 1311–1312. [5] Takeda H. *et al.* (1988) *Abs. Sym. Ant. Met.* **13th,** 142–144. [6] Stolper E. (1977) *GCA* **41,** 587–611.

Ice Patterns and Surface Wind in the Setting of Antarctic Meteorites. Peter J. Wasilewski,[1] Gary R. Huss,[2] Jerry Wagstaff[3] and Carl Thompson.[4] [1]NASA/Goddard Space Flight Center, Code 691, Greenbelt, MD 20771 USA. [2]Enrico Fermi Institute, U. of Chicago, Chicago, IL 60637 USA. [3]Lockheed EMSCO, 2400 NASA Rd. 1, Houston, TX 77058 USA. [4]9 Exmouth Rd., Northcote, Auckland, New Zealand.

During the 1987–88 Antarctic field season, about 370 meteorite pieces were picked up by the reconnaissance team on exposed blue ice patches west and northwest of Elephant Moraine. The ice patches exhibited distinctive surface texture and other features, such as topography, which suggest differences in horizontal and vertical velocities and consequently different ablation rates. In some cases, different velocity vectors and evidence of submergent and emergent patches could be implied by noting the appearance and orientation of the surface texture of the ice and the presence of shear bands and other structural characteristics. It is clear that a considerable differential movement within and between ice patches is characteristic and these dynamics must figure in the appearance of meteorites at the surface.

In one location (Texas Bowl), surface winds appear to locally concentrate meteorites. The size distribution is narrow and the meteorite materials appear localized in an oriented, superimposed texture produced by shear which is subparallel to the prevailing wind direction on a steep slope. At the western end of Meteorite City near a discontinuity marked by pinnacles, a few heavily weathered meteorites were found, indicating long surface residence times for this site. On the farthest ice fields we visited, no meteorites were found. The surface of these fields was dominated by a regular and continuous oriented ripple pattern suggesting little or no significant ablation.

From the field evidence, meteorites appear in greatest concentration on blue ice patches that have specific surface textures and related larger scale structural patterns. It is also clear that surface winds may be important locally in concentrating meteorites.

Identification of Shock Induced Changes in Fe Spheres Using Magnetic Techniques. Peter Wasilewski. NASA/Goddard Space Flight Center, Code 691, Greenbelt MD 20771 USA.

Solution annealed Cu (1.4 wt.% Fe) alloys were precipitation annealed at 650 °C and 750 °C to produce size controlled dispersions of non-magnetic fccFe spherical precipitates. Discs of these alloys were then impacted at levels up to 5 GPa and then magnetically characterized after recovery. The impact transforms the fccFe to magnetic bccFe. Substructure in the precipitates before and after shock was characterized. Specimens studied had particle size distributions of 20–35 nm, 40–60 nm, and 80–110 nm. The shock direction was located in the disc by measurement of angular variation of magnetic-coercivity. Magnetization reversal is unique because of the near ideal magnetic properties of fine Fe particles having a narrow size distribution, a mean interparticle spacing dependent on size distribution, no clusters or agglomerates of any kind, the same substructure in all Fe particles, and no significant variation in particle shape.

Magnetic hysteresis analysis is used to follow the magnitude of the shock induced magnetic anisotropy which is impact level dependent. The magnetic anisotropy can be eliminated by thermal anneal, suggesting that not only shape change but the transformation microstructure is dependent on the structure of the shock wave. Alternating field demagnetization before and after anneal and thermal demagnetization of saturation remanence illustrate the influence of shock impact on the magnetic stability of the spheres. These effects are superimposed on the size dependent properties of the spheres.

These results demonstrate that shock effects can be identified by magnetic techniques, and with calibration, the level of shock can be ascertained. Information about the structure of the shock in the material is also attainable. These results apply directly to lunar samples and are the basis for analysis of the meteorites.

Somewhere Over the Rainbow. G. J. Wasserburg. Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91125 USA.

The study of meteorites has produced a wealth of information about these objects. Petrologic and chemical observations of meteorites have shown the presence of planetary differentiates and of undifferentiated aggregates resulting from nebular condensation and the interaction of these aggregates due to metamorphism. Equilibrium chemistry in a solar gas and in planetary environments has been an excellent guide to our studies. Studies by several groups have yielded remarkable discoveries about the early stages of planetary evolution and of precursor components from the solar nebula and from the interstellar medium (ISM). The isotopic studies have established a rather well defined and short time scale (~10^6 y) between some types of nucleosynthesis and the formation of protoplanetary materials and planets. The diverse isotopic anomalies which are unconnected to radioactive parents appear to result from incomplete mixing of debris from different stellar sources before formation of the solar system; some anomalies may come from processes in the early solar system itself. The magnitude of the isotopic effects which have been discovered has grown enormously, and the geometric scales at which they are found have correspondingly decreased to far below optical microscopic dimensions. The number of distinct isotopic effects has increased to populate a zoo of anomalies. We have now found the rainbow of interstellar dust and debris in meteorites. The "earliest" material has been the object of search for over three decades.

The remarkable success of this venture is a testimony to the belief that meteorites are the key to our most ancient past. However, the astronomical sites where the components were produced is quite unclear, the nuclear astrophysical mechanisms are only generally defined (SPQR), and the fundamental processes in meteorites which governed their aggregation and formation are obscure. We have many strong hints of the precursor mechanisms; however, the chemical and physical processses which control the chemistry of the ISM and the collapsing gas and dust mixture and produced chondrules is at best poorly understood. We are in a stage where both meteoritical and astronomical studies are yielding marvelous discoveries and providing a general morphologic guide to the making of solar systems. What we now require is an understanding of the physical and chemical processes and reaction mechanisms which actually control the state of matter that went to make up the early solar nebula. Over the past two decades numerous astronomical observations have been made of dense molecular clouds—the placental medium from which the solar system formed. These clouds contain a rich range of compounds and diverse isotopic compositions. Recently a newly formed solar system has been found. We are rapidly discovering the morphology (fossils) of the phenomena leading to solar system formation and the relics which are our focus of attention.

Having found the rainbow, we must now seek beyond it, both in theory and experiment, to understand what actually took place. Establishing the relationships of our observations to the basic cosmochemical processes will lead us to real understanding.

Group and Type Compositions of Ordinary Chondrites: Excepting Volatiles, No Relationship Between Type and Composition. John T. Wasson, Gregory W. Kallemeyn and Alan E. Rubin. Institute of Geophysics, University of California, Los Angeles, CA 90024 USA.

We have determined 25 elements in replicate samples of 66 ordinary chondrites. Group compositions are in good general agreement with those determined in earlier studies. We observed some Mg-normalized abundance trends not previously defined: Na abundances are about 7% lower in H chondrites than in L and LL; LL Ga abundances are about 12% lower than in H and L; the Co/Ni ratio decreases by about 10% through H → L → LL. We cannot confirm earlier reports that refractory-lithophile/Mg ratios are higher in H than in L or LL.

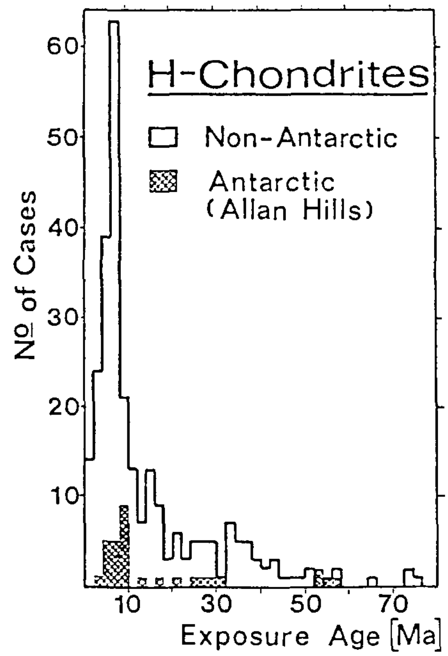
Considerable interest attaches to the question of compositional differences among petrographic types, since the common interpretation that types 4–6 reflect different degrees of metamorphic alteration of type-3 starting materials implies that, within each group, the different types should be isochemical except for highly volatile elements outgassed during metamorphism. With the exception of highly volatile Br, our data show no significant differences among petrographic types of L and LL chondrites. There is also no significant difference among H-group types 4–6. Our set of H-related type-3 chondrites includes Dhajala and Sharps which show no significant compositional differences from H4–6 chondrites, and Bremervörde and Tieschitz, which have siderophile abundances intermediate between H and L levels. The kamacite Co content and O-isotope composition of Tieschitz show it to be more closely related to L than H, and the O-isotope composition of Bremervörde is also L-like. It seems probable that these latter meteorites are rare representatives of nebular materials intermediate in properties between H and L, and did not originate on either of these parent bodies. Our data also show that Albareto, Bjurböle, Cynthiana and Qidong have olivine and kamacite compositions and siderophile abundances between the upper L and lower LL limits.

Siderophile abundances in the L3 falls Hedjaz and Khohar and LL3 falls Bishunpur, Manych, Ngawi and Semarkona fall within the ranges defined by the type 4–6 members of the respective groups. We conclude that nebular accretion processes were the same for all types of each ordinary chondrite group. This is comforting, since even if mechanical processes late in nebular history led to a gradual fractionation in planetesimal compositions, asteroids appear to have accreted somewhat later by the accumulation of planetesimals and smaller asteroids. This process would have led to the incorporation of such fractionated bodies at all levels in asteroid-size parent bodies. If degree of metamorphism was directly related to the radial depth within the asteroidal parent body, the early- and late-formed planetesimals should occur at all depths and show all degrees of metamorphism.

Different Interplanetary Source Regions of Antarctic and Non-Antarctic H-Chondrites? The Noble Gas Record. H. W. Weber, L. Schultz and F. Begemann. Max-Blanck-Institut für Chemie, D-6500 Mainz, FRG.

On the basis of differences in the concentrations of some trace elements it has been suggested that Antarctic and non-Antarctic chondrites have different parent populations (1, 2, 3), a proposition which is being debated, however (4, 5).

Non-Antarctic H-group chondrites have a cosmic-ray exposure age distribution which is characterized by a peak at about 8 Ma. This peak, between nominal ages of 6 Ma and 10 Ma, contains about 45% of all H-chondrites and is interpreted as caused by a major collisional event, which spalled these meteorites off their parent body 8 Ma ago. If Antarctic H-chondrites came from a different source population they might have a different exposure age distribution as well which, in particular, might not show the pronounced 8 Ma peak.



We have measured the concentration and isotopic composition of He, Ne, and Ar in 31 H-chondrites found on the Allan Hills ice fields. Exposure ages were calculated from cosmogenic ^{21}Ne, using the procedures given in (6). The results are shown in the figure together with the exposure age distribution of non-Antarctic meteorites as calculated by the same procedure from literature data. Note, that for such a comparison, possible uncertainties in the absolute values of the production rates are irrelevant.

There is no obvious difference between the two distributions. The 8 ± 2 Ma peak contains 14 out of 31 cases (=45%), which is in perfect agreement with the result for the non-Antarctic suite of samples. According to mineralogical evidence (metamorphic grade classification) as well as radiogenic and solar wind noble gas data, at least 9 out of the 14 samples in the 8 Ma peak are independent falls, which gives a minimum percentage of 35% (9 out of 26) belonging to this exposure age peak. We conclude that the exposure age distribution does not corroborate the contention of an origin from different parent bodies of Antarctic and non-Antarctic H-chondrites. A similar conclusion, based on 9 Yamato H-chondrites, has been arrived at by Takaoka *et al.* (7). Of course, the possibility cannot be excluded that the 8 Ma event was not restricted to a single parent body. In this case one would have to explain, however, why only H-chondrite parent bodies should have been affected and why it does not show up for L-chondrites. References: (1) Dennison J. E. *et al.* (1986) *Nature* **319**, 390. (2) Ligner D. W. *et al.* (1987) *Geochim. Cosmochim. Acta* **51**, 727. (3) Dennison J. E. *et al.* (1987) *Geochim. Cosmochim. Acta* **51**, 741. (4) Wetherill G. W. (1986) *Nature* **319**, 357. (5) Cashore J. *et al.* (1988) *Lunar Planet. Sci.* **19**, 168. (6) K. Nishiizumi *et al.* (1980) *Earth Planet. Sci. Lett.* **50.** 156. (7) N. Takaoka *et al. (1981) Mem. Natl. Inst. Polar Res.* (Tokyo) **20,** 264.

Macrochondrules in Ordinary Chondrites: Constraints on Chondrule Forming Processes. M. K. Weisberg,[1,2] M. Prinz[2] and C. E. Nehru.[1,2] [1]Brooklyn College (CUNY), Brooklyn, NY 11201. [2]Amer. Museum Nat. Hist., NY, NY 10024 USA.