THE METEORITE CONCENTRATION MECHANISM AT ALLAN HILLS, ANTARCTICA

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During the 1978-79 austral summer season a 15 kilometer long triangulation survey network was established at the Allan Hills for the study of ice ablation and movement as related to meteorite finds. The triangulation chain is composed of 20 stations extending from the Allan Hills westward. This network was resurveyed the following Antarctic summer and preliminary ablation measurements indicate that the ice surface is wearing away at an average rate of 5 centimeters per year. The yearly vertical movement (upwelling) of the ice in the area of highest meteorite concentration approximately balances this yearly erosion rate. The horizontal vectors show dissimilar directional movement at three different locations along the network, which suggests that the region of stagnant ice where meteorites have been found is a localized effect. The crevasse patterns and the horizontal vectors at the westernmost stations of the network show that the surface flow of the ice sheet is generally toward the northeast. The ice surface flow direction becomes more easterly at the stations situated closer to the Allan Hills where the surface exhibits a step-like topography. The yearly movement of the ice surface ranges along the network from over 2 meters on the west to less than 20 centimeters on the east. Although the mechanism of meteorite transport and concentration is imperfectly understood, it appears that the Allan Hills ice field serves as a small but effective collection basin for a limited part of the East Antarctic ice sheet.

THE MURCHISON BLUE ANGEL INCLUSION: ITS MINERALOGY AND PETROLOGY

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Hibonite-bearing inclusions found in CV and CM chondrites are thought to contain some of the earliest phases condensed from the solar nebula. A well preserved inclusion of this type, found by R. Becker, has been isolated from the Murchison CM chondrite for extensive analysis. This inclusion, dubbed "Blue Angel" for its light blue color, is ~ 1 mm in diameter. It is comprised of four crudely concentric zones: (1) a dark gray inner *core* of large subhedral to euhedral hexagonal plates of hibonite with trace poikilitic perovskites and occasional large pore spaces; (2) an intermediate very porous *blue zone* composed of finely crystalline, euhedral, hexagonal plates and prismatic needles of hibonite with trace perovskite and very minor traces of spinel (calcite appears between many of the hibonite crystals as a cement); (3) an outer *white zone* composed primarily of calcite which is cross-cut with numerous very fine (< 1 μm) veins of silicates and which contains randomly oriented, fine-grained assemblages of subhedral to euhedral spinel, perovskite, hibonite, and minor diopside; and (4) a discontinuous *rim* zone containing an inner rim of massive anhedral to subhedral spinel with poikilitic perovskite and rare hibonite, and a very thin (< 5 μm) outer rim of aluminous pyroxene.

Vanadium is present in substantial abundance in the core and blue zone hibonites which have virtually identical chemistry (Table 1, #1). Vanadium is present in significantly lesser amounts in the white zone and rim hibonites and spinels (Table 1, #2-3). Iron and chromium are in low concentration, but clearly present in both hibonites and spinels in this inclusion.

Table 1
Average (± 1σ) analyses of Blue Angel hibonites and spinels

#	MgO	CaO	FeO	Al_2O_3	Cr_2O_3	V_2O_3	SiO_2	TiO_2
1	2.01 ± .26	8.40 ± .18	.01 ± .03	83.87 ± 1.54	.06 ± .05	1.08 ± .19	.19 ± .09	4.11 ± .62
2	3.02 ± .53	8.31 ± .33	.16 ± .24	82.87 ± 2.09	.03 ± .04	.24 ± .21	.33 ± .16	5.11 ± .86
3	28.52 ± .41	.07 ± .11	.24 ± .13	71.19 ± 1.14	.14 ± .12	.17 ± .10	.07 ± .06	.17 ± .07

1. hibonite from zones 1 & 2, n = 49.
2. hibonites from zones 3 & 4, n = 18.
3. spinels from zones 3 & 4, n = 20.

The white zone and rim hibonites are chemically distinct from those found in the blue zone and core. The average Al/Mg atomic ratio is 33.4 ± 4.7 (1σ) for blue zone and core hibonites and 22.4 ± 4.8 for the white zone and rim. The average Mg/Ti ratio is 1 for blue zone and core hibonites and somewhat greater than 1 for the white zone and rim, reflecting coupled substitution of Mg and Ti for Al. The hibonites in all zones are very stoichiometric, closely corresponding to the formula Ca (Al, V, Cr, Fe, Mg, Ti, So)$_1$2O$_{19}$.

There is evidence of fracturing of a portion of the rim during incorporation of the inclusion into the meteorite. In one portion, there is a sharp contact between the matrix and calcite from the white zone. Textural arguments indicate that calcite thoroughly impregnated the outside portions of the inclusion and penetrated even into the core. This penetration appears to have taken place after the inclusion was formed, but prior to its incorporation into the meteorite in its current position. Some of the silicate veining in the outer zone is inferred to have occurred after emplacement. This inclusion's mineralogy shows that the complex mineral alteration and crystallization typical of carbonaceous chondrites must be considered even in studying the meteorites' earliest high temperature inclusions.

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EXPERIMENTAL BOUNDARIES ON THERMAL HISTORY OF REFRACTORY MINERALS IN CARBONACEOUS METEORITES

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Speculation about the thermal evolution of primordial condensates including "condensation temperatures" has been based on observed phase relationships in meteorites coupled with hypotheses about the thermal state of the source cloud from which the solids formed. Since the outcome of such considerations is critically dependent on assumptions concerning temperature and pressure, and since these are *a priori* unknown, the conclusions remain hypothetical. Interdiffusion between coexisting solids provides a basis for realistic evaluation of thermal exposure and is particularly sensitive in the temperature region down to about one half of the melting temperature. Simple diffusion couples such as pure platinum in nickel iron, discovered and measured by El Goresy *et al.* (1978) have been selected by Arrhenius and Raub (1978) for consideration of thermal exposure during and after formation. This choice avoids the uncertainties associated with the interpretation of more complex platinum metal alloy couples also found in carbonaceous meteorites (Wark, 1979; Arrhenius, 1978).

The well-known phase relationships and diffusion kinetics in the systems Fe-Pt and Ni-Pt can be applied to the system Pt-($Fe_{0.4}Ni_{0.6}$), observed in carbonaceous meteorites. However Larimer (1979) has proposed that unknown phases may occur in the ternary system, which would extensively slow down intermetallic diffusion so as to invalidate the conclusions from the experimental data quoted above. Although there is no evident basis for such an assumption, an experimental study was undertaken of the diffusion of Pt into $Fe_{0.4}Ni_{0.6}$ at a series of temperatures, and the diffusion coefficient determined as a function of composition in the diffusion path. The diffusion coefficients thus measured in this ternary system at 1100 °K range from $4.6 \cdot 10^{-6}$ cm^2/day at 5% Pt to $7 \cdot 10^{-6}$ at 10% Pt, in concord with earlier published data for the binary system at the same temperature.

Oxide diffusion barriers, which have also been invoked as retardants are thermodynamically excluded in this system at temperatures as high as 1600 °K and at the gas compositions generally assumed. Measurement of diffusion of metals through iron oxide films (Cabrera, 1980) demonstrated them to be ineffective as diffusion barriers at the thickness involved (unobservable by EMX and SEM).

Diffusion measurements in platinum-nickel iron couples overgrown with refractory silicates in carbonaceous meteorites appear at the present time to provide the only existing observational evidence for the actual upper limits of formation temperatures for these refractory minerals. The temperature at growth of the melilite and spinel crystals containing the metal couples could accordingly not have exceeded 1000 °K; however, the kinetic temperature of the source medium could, in radiation equilibrium with such grains, be an order of magnitude higher (De and Arrhenius, 1978).

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