

CARBONACEOUS COMPONENTS IN ORDINARY CHONDRITES; IMPLICATIONS FOR METAMORPHISM VS. HETEROGENEOUS ACCRETION.

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The low temperature post accretionary history of the CM and CI chondrites (1) has led to the preservation of organic material within them (*e.g.* 2). Based on the comparison of N isotope release profiles obtained by stepped combustion of HF/HCl residues, Alexander *et al.* (3) concluded that an organic material, similar to that in CM and CIs, is also present in Semarkona (LL3.0). Evidence for similar 'organic' components have been found in HF/HCl residues prepared from 4 other UOCs; Bishunpur, Krymka, Inman and Tieschitz (Chainpur is currently under study). In all 5 UOCs the dominant 'organic' component has a uniform composition of $\delta^{13}\text{C}$ of between -19 and -17‰, which is very similar to the CM and CI organics. The uniform isotopic composition of 'organic' carbon in these chondrites suggests they may have formed from similar carbon reservoirs. However, N and H (4) isotopes preclude such a simple explanation. In addition to C δ , at least 3 distinct N-bearing components are required to explain the complex release profiles exhibited by the UOC 'organics' (table). In Semarkona and Inman, for instance the major release of nitrogen (N) is relatively light, with much heavier N given off at temperatures above and below, perhaps because the major release is superimposed on a broad heavy N release. However, Bishunpur, Krymka and Tieschitz do not have a release of heavy N at temperatures below the major release. CM and CI chondrites show a similar variety of N release profiles but the apparent shifts between the major release and the minor, heavier releases on either side are much more subdued than in the UOCs.

The organics in the carbonaceous chondrites (CC) are thought to have formed by Fisher-Tropsch (FT) synthesis (2). While this may be correct for the bulk of the low temperature material in the chondrites it is difficult to see how such a mechanism could produce the large fractionations in H and N observed. Therefore, at least some part of the organics must have formed by another mechanism that was able to fractionate H and N but not C. Ion-molecule reactions at low-temperatures is one possibility. Another, though probably related mechanism, is suggested by the experiments of Greenberg (5).

Carbonaceous chondrites are a prolific source of high temperature, isotopically anomalous components. ^{13}C -enriched components, present at the ppm level or less, are found in the UOCs studied (table) but seem to be distinct from their counter parts in the CCs. Isotopically unusual N does appear to be associated with some of these components. However, the amounts of N released are very small which may account for some of the variation observed. HF-HCl residues of much larger samples of Tieschitz and Inman are being prepared so that some of these components may be better characterised.

It has been known for some time that the abundance of bulk carbon and C δ decreases with increasing petrologic type in the UOCs (6,7), the major change occurring at about the type 3-4 transition. Two possible explanations have been suggested. The first is that the temperature of accretion changed as accretion proceeded (*e.g.* 8). The variations in temperature are modest (100K) and are unlikely to have effected C δ but would have altered the stability of the organics forming in the nebula. Alternatively the material being accreted may have changed. The second possibility is that the carbonaceous phases were destroyed during progressive metamorphism either by thermal degradation or oxidation by Fe-oxides. To examine the effects of thermal degradation we have carried out pyrolysis experiments of 3-4 weeks duration on HF/HCl residues of Cold Bokkvelde at various temperatures. These experiments suggest that the maximum weight loss of the organics that can be expected is 30 to 50wt%. C δ was not effected. To test the oxidation hypothesis is more problematic. The most likely source of oxygen would have been Fe-oxides such as magnetite. From thermodynamic calculations it is expected that both the organics (9) and C δ would have undergone oxidation during metamorphism but it is not clear whether kinetic constraints would allow for significant reaction. From stepwise combustion experiments of HF/HCl residues UOCs it is possible to extract the rate constants of oxidation, where $K = B e^{-A/RT}$ and $B = B' \cdot p(\text{O}_2)/R$ (R being the initial radius of the particles combusting). However, it can not be ruled out that a different reaction mechanism operated at the very much lower oxygen pressures expected in the OCs or that some minerals will not have catalysed the reactions.

Other sources of error include: estimated $p(O_2)$ during the experiment; clumping of particles in the residues will tend to produce grains that are much larger than in the meteorites; and alteration of the 'organics' during the very harsh chemical processing of the residues. The errors in $\ln(B)$ and A obtained by experiment are about 10%, but as a result of the numerous other sources of error listed above the calculated value of the rate constants, particularly B , may be orders of magnitude too low. The results of calculations, using the experimentally derived constants, for an 85km asteroid, with a thermal history similar to the model of Miyamoto (10), are shown in fig 1 and 2 (curves marked 1). To illustrate the effect of errors in B , curves for various multiples of B have also been included. The striking and rather surprising difference in the behaviour of the organics and $C\delta$ result from the very large value of B for $C\delta$ (due to its extremely fine grainsize). The results indicate that oxidative metamorphism may be able to explain the distribution of $C\delta$. The same is true for the organics but only if the value of B has been significantly under estimated. This approach holds some promise in resolving what is an important debate but major obstacles must be overcome before it can be used with any confidence. (1) Bunch and Chang (1980) G.C.A. 44, 17. (2) Hayatsu and Anders (1981) Topics in current chemistry 99,1. (3) Alexander *et al.*, (1988) Lun. Plan. Sci. XIX, 5. (4) Yang and Epstein (1983) G.C.A. 47, 2199. (5) Greenberg (1986) Asteroids, Comets and Meteors II, 221. (6) Grady *et al.*, (1982) J.G.R. 87 suppl., A289. (7) Alearts *et al.*, (1979) G.C.A. 43, 1399. (8) Laui *et al.*, (1973) G.C.A. 37, 329. (9) Sugiura *et al.*, (1984) J.G.R. 89 suppl., B641. (10) Miyamoto *et al.*, (1982) Proc. L. P. Sci. Conf. 12B, 1145.

	'ORGANICS'				HIGH T. COMPONENT					
	Maj. peak		Maj. peak							
	$d^{15}N$	$^{\circ}C$	$d^{15}N$	$^{\circ}C$	$d^{15}N$	$^{\circ}C$	$d^{13}C$	$d^{15}N$	$^{\circ}C$	
Semarkona	+195	275	+7.3	390	+178	490	+130	+100	850	
Inman	+256	390	+134	440	+120	575	+153	+28	1100	
Bishunpur	-21	B	-40	450	+90	500	+599	-133	900	
Krymka	-2	360	-41	470	+88	490	+584	+30	850	
Tieschitz		B	-20	490	+31	600	+111	+104	900	

B= broad release.

The isotopic composition and temperature of the major organic release and the ^{15}N maxima on either side in 5 UOCs, as well as the C- and N-isotopic composition of a high T component(s).

