THE ORGANIC COMPOSITION OF A CR2 CHONDRITE: DIFFERENCES AND SIMILARITIES WITH THE MIGHEI-TYPE METEORITES.

S. Pizzarello[1] and L. A. J. Garvie[2]. [1]Arizona State University, Dpt. of Chemistry & Biochemistry, Tempe, AZ 85287-1604, pizzar@asu.edu. [2]School of Earth and Space Exploration, Arizona State University, Tempe, Arizona 85287-1404, lgarvie@asu.edu

Introduction: The soluble organic material found in carbonaceous meteorites has provided the only analytical reference so far to interpret the chemical evolution of the biogenic elements in a planetary setting. The most extensively analyzed of these meteorites have been the CM2 chondrites, predominantly the Murchison meteorite because of its recent fall and large availability. Recently, several stones belonging to the CR group have been found and geochemical data show them to be primitive in composition and level of alteration [1]. Therefore, it is possible that their organic composition may provide new details on the abiotic chemistry of carbon. We report here on analyses of the water and solvent extracts of the GRA95229 (CR2) meteorite.

Methods: The powder from a 0.45 g fragment was extracted in water at 100°C for 20 h. The extract was decanted and the powder set aside and dried in a desiccator. 2/3 of the water extract, pH 7.25, was applied directly to a cation exchange column (AG-W50, H^+). Both H_2O (pH 3.1) and NH_4OH eluates were collected [2]. The remaining 1/3 of the extract was dried, hydrolyzed with 6N HCl for 24 h, desalted, and fractionated on a C_{18} Supelcosil column [2]. Dried powders were extracted with DCM:methanol (9:1, v:v). Both extracts were analyzed by GC-MS, employing columns with a chiral phase (CP-Chirasil-Dex, Crompack) for the water extract and a DB-17 (J&W Sc.) for hydrocarbons.

Water-soluble compounds: Amino acids are the largest component of the GRA95229 water-extract analyzed so far (carboxylic acids and amines have not yet been analyzed) and their amount totals well over one micromole per gram of meteorite, i.e., approximately double that found in the Murchison meteorite [3]. In spite of the many similarities of content, most of the species found in Murchison are seen here also, this CR2 amino acids' distribution and relative abundances do not replicate closely those found in CM chondrites. As sample amounts listed in Table 1 show, the linear amino acids are more abundant than the branched species of this meteorite and the comparable amino acids of the Murchison or Murray meteorites, the abundance of all amino acids declines much more rapidly with increasing carbon chain length than seen in CMs, and hydrolysis of the extract yielded little or no additional α-branched species. In addition, pyridine carboxylic acids, seen in the Murchison, Murray, and TL meteorites[3], were not detected.

The most intriguing analytical finding for the CR2 is the chiral distribution of its amino acids. They appear to have suffered minimal contamination and protein equivalents such as alanine, valine, leucine, aspartic and glutamic acids are found racemic. However, also isovaline, the most abundant chiral amino acid in the Murchison and Murray meteorites with enantiomeric excesses (ee) of up to 15%, is here nearly racemic (L-ee = 1.6-3.0 %).

Table 1. Amounts of the major amino acids in the GRA 95229 water extract before and after hydrolysis.

Amino acid (a.)	Concentration (Unhyd. nmol/g)	Concentration (Hyd. nmol/g)
Linear α-amino a.		
Glycine	160	234
Alanine	668	823
2-aminobutyric a.	70	82
Branched α-amino a.		
2-aminoisobutyric a.	258	316
isovaline	79	78
2-methylnorvaline	6.5	6
Non–α-amino a.		
3-aminobutyric a.	27.5	37
4-aminobutyric a.	8.5	56.5
5-aminovaleric a.	2	10.5

Most surprisingly, the diasteromeric pair of isoleucine (ile) and *allo*isoleucine (*allo*)(6C stereoisomers with two chiral centers) show in this meteorite the same relative abundance (*allo*/ile ≈ 2) and D-*allo*, L-ile ee as seen in Murchison Fig.1).

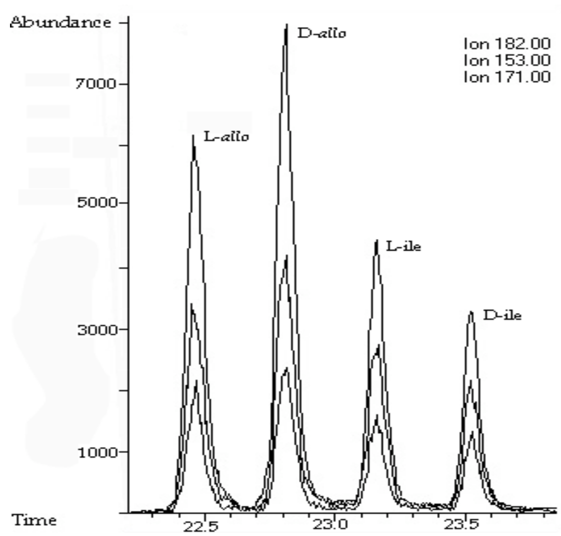

Figure 1. Allo&ile enantiomers in the GRA 95229

These ee had been attributed to contamination for CMs [2] but are difficult to explain on the same basis for this CR2, in view of the lack of comparable L-ee in all of its other protein amino acids. Also the alternative possibility that protein contaminants were completely racemized by terrestrial exposure would not be consistent with the *allo*/ile ratio found, which in such cases should reach values nearing 0.8 [4], leaving the finding as yet unexplained.

The acidic portion of the extract showed another noticeable difference with previously analyzed meteorites [5] in the markedly lower abundance of dicarboxylic acids, which in the CR2 present with only up to C_8 chain lengths and a lower number of isomers.

Solvent soluble compounds: In contrast to the abundance of individual compounds found in the water extract of this CR2, hydrocarbons appear to be present in far lower amount. The chromatogram is dominated by numerous, unresolved, trace amounts of branched and cyclic (and/or olefinic) aliphatic species; the saturated compounds predominate in the first part of the chromatogram (at lower molecular weight) while the cyclic/unsaturated do so in the later part. Linear hydrocarbons with C_{14}, C_{15}, and C_{16} chain lengths were observed, but appear to decline to a small C_{17} peak and are not seen at higher molecular weight. It is possible that smaller straight-chain hydrocarbons were present in the extract but evaporated upon drying.

Individual PAHs were observed, the most abundant are naphthalene, phenanthrene, fluoranthene, and pyrene, present in about equal amounts (~15 nmol/g). Acenaphthene and biphenyl are approximately 1/3 less abundant and anthracene is 1/10 the amount of phenanthrene. Some branched forms of the above compounds as well as higher PAHs such as perylene and benzopyrene are also observed in very low abundance. O-, and N-containing PAHs were searched for but not found. Because of the baseline distribution of many small peaks, the attribution of a precise amount for hydrocarbon in the meteorite is not possible. Based on the chromatographic area, hydrocarbons appear to be at least ten times less abundant than amino acids.

The acid residue of the CR2 was analyzed by transmission and scanning electron microscopy (TEM and SEM). Solid and hollow (Fig. 2) nanoglobules are abundant and there is a higher abundance of hollow carbonaceous nanoglobules in the CR2 compared to the IOM of the CM2 meteorites [6]. Electron diffraction patterns of the globules show they are poorly ordered and have therefore not been significantly heated.

The soluble organic compounds found in the GRA95229 seem to support the general interpretation given for these compounds' formation in other carbonaceous chondrites, i.e., that their synthetic processes were most likely multiple and distinct [3]. For the amino acids in particular, the large isotopic differences between subgroups indicated a closer relation to interstellar chemistry for some of the compounds than for others.

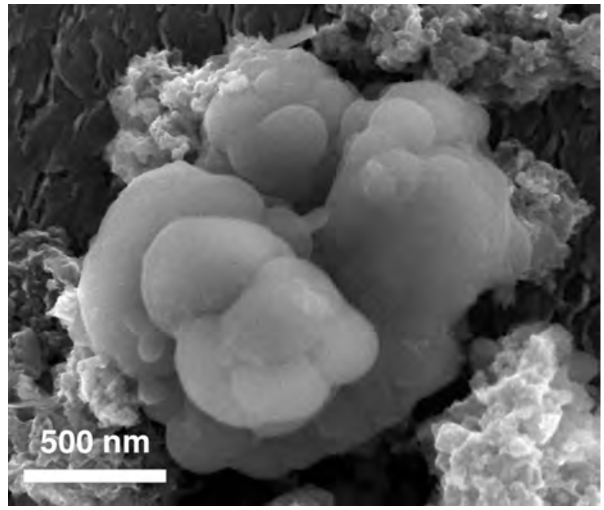

Figure 2. SEM image, SE mode, of a large hollow, compound nanoglobule from the acid residue of the CR2.

The linear α-amino acids found in large abundance in the CR2 are believed to have formed via a Strecker-like reaction during the parent body aqueous phase [3]. Had these non-stereospecific syntheses been predominant in the GRA95229 it would explain the low chiral asymmetry of its isovaline, which in Murchison displayed a high δD value (+3600‰), suggestive of a more direct interstellar lineage and, possibly, exposure to processes responsible for its ee.

Because the abundances found for the diasteromeric pairs of isoleucine/*allo* isoleucine enantiomers show that they had brief or no water exposure, it is plausible that these and other branched amino acids found in low abundance in this meteorite could be the result of distinct incorporation processes. Similar explanations may be needed to justify the presence of a large suite of amino acids in such an oxidized meteorite, in fact, the absence of the compounds in Tagish Lake was interpreted as being the possible consequence of oxidative stages in the meteorite parent body [3]. Compound specific isotopic analyses are planned and should be most helpful.

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