SULFUR IN THE ORGUEIL CI CHONDRITE.

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Sulfur in CI chondrites occurs in at least 7 reservoirs: (1) Most S is "(Fe,Ni)S" in phyllosilicates, extractable with $(NH_4)_2S_x$ but not easily released as H_2S when treated by HCl. Sulfur in (2) pyrrhotite and (3) pentlandite is released as H_2S when treated with HCl. (4) Sulfur in water soluble sulfates. Minor S is in (5) elemental S, (6) hyposulfites and (7) organic compounds. The distribution of S among these phases changed since the meteorite fell and may affect the determination of total amount of S.

Oxidation of sulfides produces sulfate efflorescence on the outside and salt deposits in phyllosilicate veins of the Orgueil meteorite [1]. If sulfates are terrestrial weathering products, the sulfate content should be a function of the meteorite's residence time on Earth. In 1834, Berzelius describes his sample from the 1806 Alais CI chondrite fall: "*Its color is black with a touch of grey, with dense, fine, white dots or incrustations. This is not reported in the older descriptions; only in the Dictionaire des sciences naturelles, XXX, p. 339, it is noted that this meteorite tends to cover itself with some efflorescence, which the authors give as iron vitriol*." He shows that Fe-sulfate was a misidentification; $FeSO_4$ is never found in any significant quantities in water extracts or in crystalline form. $FeSO_4$ oxidizes to limonite: $FeSO_4{\cdot}7H_2O + 1/4\ O_2 = Fe(OH)SO_4 + 6.5\ H_2O$ and $Fe(OH)SO_4 + 2\ H_2O = Fe(OH)_3 + H_2SO_4$; also providing H_2SO_4 to leach Mg out of phyllosilicates for making the $MgSO_4$ efflorescence.

Three analyses reported ~2 months after the Orgueil fall give S in sulfate form as 1.1±0.3 wt% and total S in all forms as 6.3±0.6 wt % [3-5]. The amount of S in sulfates (~17.5% of all S measured) represents the upper limit to the pre-terrestrial sulfate content in Orgueil. Five recent analyses [6-10] yield 2.4±0.3 wt% S in sulfate form, which is ~45% of all S measured in recent bulk analyses of Orgueil (5.3±0.2% [10-12]). The recent bulk S appears 1 wt% lower than the average of the 3 earlier analyses, which may indicate loss of S through efflorescence formation. In that case, redistribution of S during terrestrial alteration within Orgueil was not isochemical with respect to elemental composition, and use of larger samples, suggested to obtain representative average bulk compositions [13], cannot improve the analytical situation. However, the atomic S/Si ratios (0.40-0.52) in the older analyses are close to the recommended photospheric value of 0.46 [15], which suggests higher absolute element concentrations in the older analyses because of lower H_2O contents of the samples. There is no obvious reason to question that the solar S abundance derived from recent Orgueil analysis is too low.

References: [1] Gounelle, M. & Zolensky, M. 2001 *Meteoritics & Planet. Sci.* 36:1321 [2] Berzelius, J.J. 1834 *Ann. Phys. Chem.* 33:113-148 [3] Pisani, F. 1864 *Comp. Rend. Paris*, 59:132-135 [4] Cloez, S. 1864, *ibid*. 59:37-40, [5] Filhol, E. & Mellies 1864 *Mem. Acad. Imp. Sci*. 6:379-382 [6] DuFresne, E.R. & Anders, E. 1962, *Geochim. Cosmochim. Acta* 26:1085-1114 [7] Bostrom, K. & Fredriksson, K. 1966, *Smithson. Misc. Coll.* 151:1-39 [8] Kaplan, I.R. & Hulston, J.R. 1966 *Geochim. Cosmochim. Acta* 30:479-496 [9] Fredrikson, K. & Kerridge, J.F. 1988 *Meteoritics* 23:35-44 [10] Burgess, R. et al. 1991 *Meteoritics* 26:55-64 [11] Wiik, H.B. 1956 *Geochim. Cosmochim. Acta* 9:279-289 [12] Mason, B. 1962, *Sp. Sci Rev.* 1:621-646 [13] Dreibus, G. et al. 1995 *Meteoritics* 30:439-445 [14] Morlok et al. 2006 *Geochim. Cosmochim. Acta* 70:5371-5394 [15] Lodders, K. 2003 *ApJ*. 591:1220-1246.