A NEW CARBON-RICH PHASE ("COPS") IN ANTARCTIC MICRO-METEORITES. C.Engrand, M.Maurette (C.S.N.S.M., Bat.108, 91405-Orsay, France), G.Kurat, F.Brandstatter (Naturhistorisches Museum, A-1014, Wien, Austria), M.Perreau (Laboratoire d'Etudes des Microstructures, ONERA, BP 72, 92322-Chatillon, France).

The contemporary flux of micrometeorites with sizes > 50 μm reaching the Earth's surface each year (about 20,000 tons/a, see [1], is much larger than the value of ≈100 tons/a, reported for conventional meteorites up to masses of ≈10,000 tons [2]. Moreover, on the average, Antarctic micrometeorites contain at least as much carbon as does Orgueil, the most C-rich meteorite [3,4]. Micrometeorites are thus responsible for most of the carbon accreted by the Earth. In this paper we report SEM observations of a new C-rich "dirty magnetite" phase observed as tiny inclusions in both melted and unmelted micrometeorites. This phase, which is enriched in C, O, P, S, Fe, frequently shows Ni contents in excess of 0.2%, strongly suggestive of an "extraterrestrial" origin. We also discovered this "COPS" phase in the fusion crust of Murchison. It appears likely that COPS is a product of meteoroid reprocessing during frictional heating in the Earth's atmosphere and/or its fast "weathering" in the upper atmosphere. Upon "catalyzed" hydrolysis this phase might have facilitated the functioning of micrometeorites as "micro-chondritic-reactors" for the synthesis of prebiotic molecules on the early Earth.

This COPS phase has been observed in about 1/3 of all types of chondritic micrometeorites investigated so far. This is illustrated by a selection of EDS spectra shown in Figure 1, derived from a "melted" "barred" cosmic spherule (1a), a scorian type micrometeorite (1b), a crystalline (1c) and a fine grained phyllosilicate-dominated (1d) micrometeorites. The corresponding polished sections of these grains (Fig.2a-2d) indicate that COPS appears mostly as inclusions concentrated in isolated voids and/or cavities. The EDS spectra reported in Figure 1e illustrates our discovery of similar COPS inclusions in cavities of the fusion crust of the Murchison CM chondrite (13 inclusions with sizes < 10 μm observed on 2.5×10^{-3} cm^2).

COPS was never observed before in conventional meteorites and IDPs. It differs from the hydrous iron oxisulfate (tochilinite) reported from primitive meteorites [5]. It shows a clear association of phosphorus and sulfur, and also frequently contains a richer variety of minor elements, including K, Ca, Cr, Ni, Cu, Zn. These COPS inclusions are not an artefact of our polishing technique (based on an all diamond powder procedure) as they are observed either in a given object before and after polishing (see the chondritic cosmic sphere reported in Fig.2e and 2a, respectively), or in micrometer-size crushed grains [4]. It is also unlikely that COPS be related to terrestrial weathering effective during the trapping of AMMs in Antarctica blue ice or their recovery from melted ice water [6]. Indeed they are found in the fusion crust of Murchison, a meteorite collected very soon after fall in an Australian "hot" desert. We thoroughly searched for COPS in a large number of terrestrial grains, including particles of dark rust. Only the grain reported in fig.2f did show a COPS looking phase without Ni (see EDS spectra in Fig.1f). We have to definitively assess wheter this peculiar grain is an extraterrestrial particle.

The high concentrations of Ni generally observed in COPS inclusions are strongly suggestive of their extraterrestrial origin. However, in the Murchison meteorite, they have only been found in the meteorite fusion crust, yet. This suggests that such inclusions result from the remobilization of some progenitor extraterrestrial component during either frictional heating in the Earth's atmosphere, or a fast "weathering" in the upper layers of the atmosphere. The habit of the beautiful COPS "nugget" in a chondritic cosmic sphere (see arrows in Fig 2e and Fig.2a), looks very similar to that of Fe/Ni metal and/or magnetite nuggets frequently observed in similar types of spheres, and which have been attributed to the seggregation of a metal bead from a melted chondritic droplet. Such similarities would rather support a frictional heating reprocessing of some unknown precursor material of COPS. But we cannot definitively rule out that most of the "dirty magnetite" COPS inclusions, as well as the ultrathin coating of magnetite observed around AMMs, might result from some poorly understood atmospheric "weathering" process [7].

Perreau et al [4] from their observation of μm-size crushed grains with an analytical TEM estimate that COPS represents about ≈5% of the total amount of C-rich material trapped in micrometeorites. This "minor" phase might be an interesting tracer of atmospheric processes, which can be hopefully monitored in the distant past looking at micrometeorites of different terrestrial ages. But COPS inclusions could have also been involved in the synthesis of prebiotic molecules on the early Earth, through a process of "catalyzed hydrolysis", effective within individual micrometeorites, which could have functioned as "micro-chondritic chemical reactors" [9].

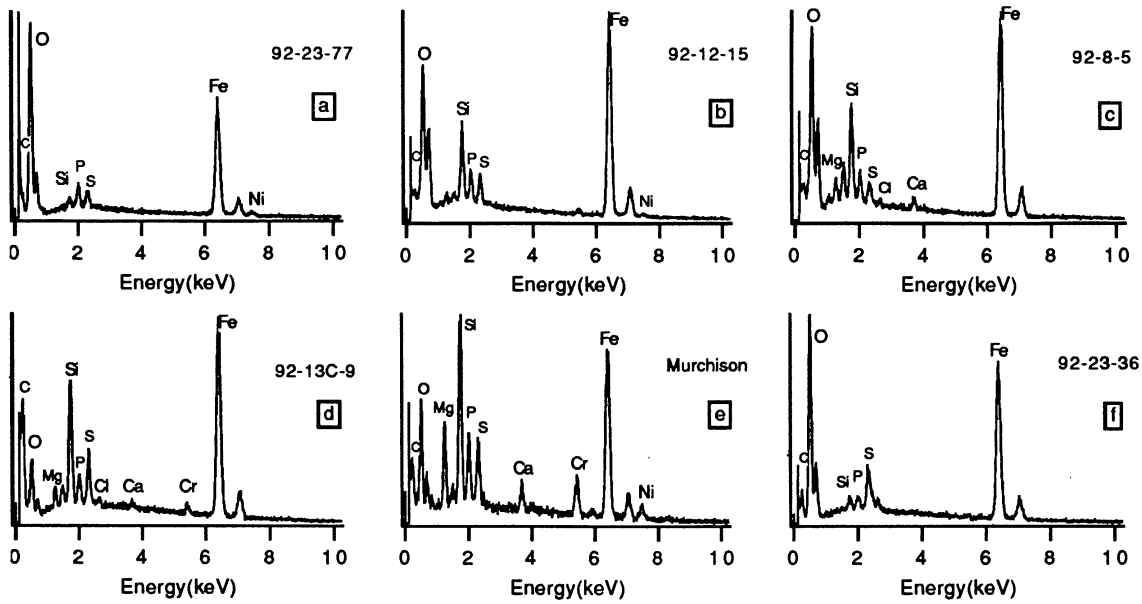

Figure 1

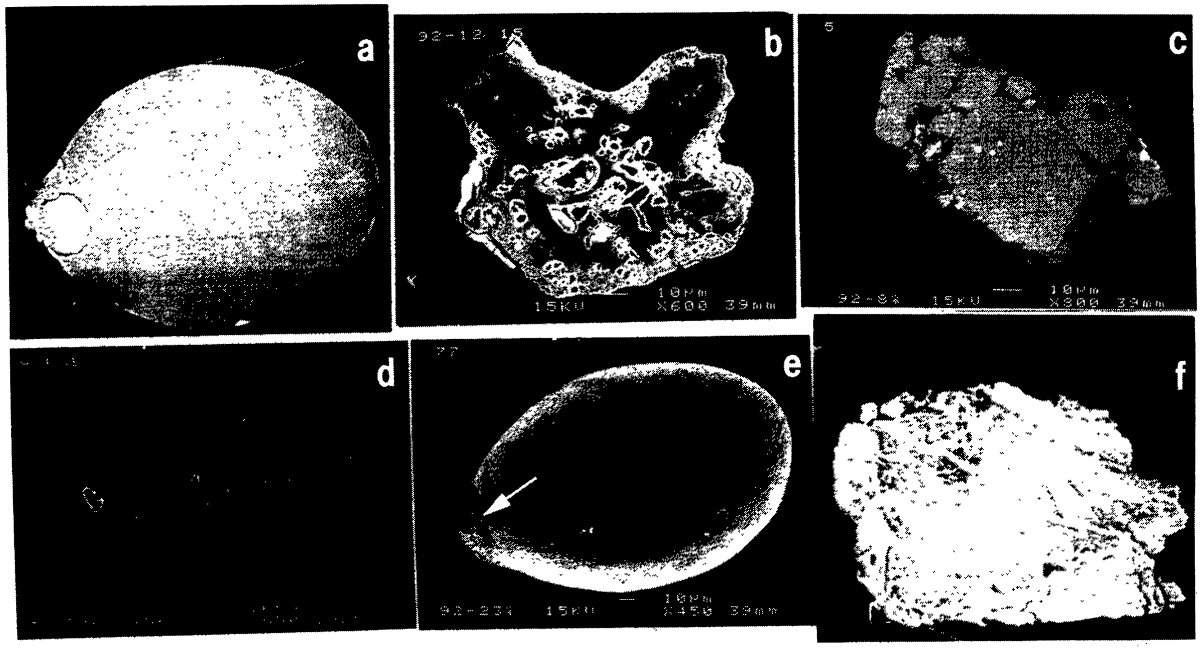

Figure 2

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