chemical composition data. This work is supported by Research Fellowships of the Japan Society for the Promotion of Science for Young Scientists.

References: [1] Mason B. et al. (1992) *Antarc. Meteorite Newsletter, 15(2),* 30. [2] Mason B. and Marlow R. (1992) *Antarc. Meteorite Newsletter, 15(1),* 16. [3] Davis A. M. et al. (1993) *LPS XXIV,* 375–376. [4] Mittlefehldt D. W. (1993) *Meteoritics, 28,* 401–402. [5] Hervey R. P. (1993) *Meteoritics, 28,* 360. [6] Eugster O. (1988) *GCA, 52,* 1649–1662. [7] Marti K. and Graf T.(1992) *Annu. Rev. Earth Planet. Sci., 20,* 221–243. [8] Marti K. (1967) *EPSL, 2,* 193–196. [9] Mittlefehldt D. W., personal communication. [10] Miura Y. et al. (1993) *GCA, 57,* 1857–1866. [11] Hagee B. et al. (1990) *GCA, 54,* 2847–2858.

RAMAN CHARACTERIZATION OF GRAPHITE INCLUSIONS IN THE METAL OF THE BISHUNPUR CHONDRITE. S. Mostefaoui[1] and C. Perron[2], [1]Muséum National d'Histoire Naturelle, 75005 Paris, France, [2]Institut d'Astrophysique Spatiale (CNRS), 91405 Orsay, France.

In the course of a study of Fe-Ni metal composition in chondrites, we found abundant graphite inclusions in the metal of Bishunpur (L3.1) and other primitive ordinary chondrites [1]. In addition, the metal composition in Bishunpur showed evidence that these graphite inclusions are remains of C that served to reduce Cr, P, and Si into Fe-Ni during chondrule formation. To help determine the origin of this graphite, we tried to characterize it via Raman microprobe analysis, at LASIR-CNRS, Thiais.

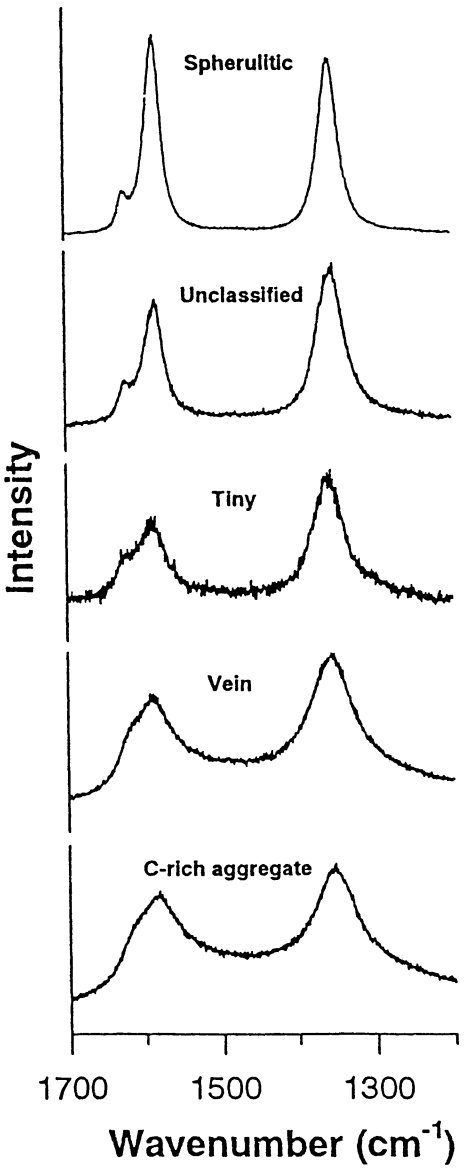

Fig. 1.

In Bishunpur, the generally small sizes of graphite inclusions (≤1 μm, which we call tiny graphite) make it difficult to obtain a detailed structural description using optical microscopy. When sufficiently large, we identified them as generally spherulitic [2]. Graphite can fill veins along grain boundaries, at kamacite-taenite or kamacite-kamacite interfaces. Other morphologies, which we did not classify, are also more rarely present. A large graphite-patch (so-called "C-rich aggregate" [3]) was also found in the matrix of Bishunpur.

The Raman spectra show that all the analyzed graphite in Bishunpur is poorly crystalline, as attested by the prominent peak at 1355 cm^{-1} (Fig.1 and [4]). To check the effect of polishing, we compared spectra from polished sections with spectra from nonpolished graphite (obtained by dissolution of metal grains). This showed the effect of polishing is important for well-crystallized graphite as in Canyon Diablo, but negligible for poorly crystallized graphite as in Bishunpur. The crystallite sizes L_a, calculated from the intensity ratio of the peaks at 1680 and 1355 cm^{-1} according to the calibration of [4], range from ≤20 Å for vein graphite and the "C-rich aggregate," to ~50 Å for the less-disordered spherulitic graphite. Only the spherulitic and the unclassified graphites have mean crystallite sizes >30 Å, a value indicative of an early stage of crystalline growth [5]. Preliminary data obtained for five other type 3 chondrites (Semarkona, Tieschitz, Kohar, Mezo-Madaras, and Massenya) are similar to those for Bishunpur.

The graphite inclusions in Bishunpur may be formed, like Cr-, P-, and Si-based inclusions [6], by exsolution during metamorphism: either by direct precipitation or by decomposition of carbides. This appears a likely process in particular for the tiny and the vein graphite. However, Raman spectra of *vein* graphite are different from those of the other inclusions, but very similar to that of the "C-rich aggregate." It may thus be formed by conversion of preexisting carbonaceous matter during metamorphism [3]. The presence of different graphite structures with different crystalline stages within the same metal grain indicates that metamorphism may not be solely responsible for the formation of graphite in metal. Ion probe isotopic analysis is necessary to obtain more information. It is presently under way.

References: [1] Mostefaoui S. and Perron C. (1994) *LPS XXV,* 945–946. [2] El-Goresy A. (1965) *GCA, 29,* 1131–1151. [3] Brearley A. (1990) *GCA, 54,* 831–850. [4] Tuinstra F. and Koenig J. L. (1970) *J. Chem. Phys., 53,* 1126–1130; Wopenka B. and Pasteris J. D. (1993) *Am. Mineral., 78,* 533–557. [5] Rouzaud J. N. et al. (1983) *Thin Solid Films, 105,* 75–96. [6] Zanda B. et al. (1994) *Science, 265,* 1846–1849.

CARBON IN METAL OF PRIMITIVE ORDINARY CHONDRITES. S. Mostefaoui[1,2], C. Perron[1,2], M. Chaussidon[3], P. Hanon[3], and F. Robert[1], [1]Muséum National d'Histoire Naturelle, 75005 Paris, France, [2]Institut d'Astrophysique Spatiale (CNRS), 91405 Orsay, France, [3]Centre de Recherches Pétrographiques et Géochimiques (CNRS), 54501 Vandoeuvre-lès-Nancy, France.

Abundant graphite inclusions have recently been found in Fe-Ni metal grains of the Bishunpur (L3.1) chondrite [1]. Their presence in metal is correlated with the concentrations of minor elements (Co, Cr), which has been interpreted as evidence that C played a role in redox processes during chondrule formation [2]. The origin of these inclusions is not clear. In a companion paper [3] their characterization has been attempted by Raman spectrometry. Here we try to (1) ascertain whether they are related to the rest of the C in the chondrite and (2) determine the C content of metal grains.

Graphite has been occasionally observed in the metal of ordinary chondrites (OC) [4], but no systematic search has apparently been conducted. We surveyed the metal of a number of chondrites and found graphite in 10 OCs, all of type 3 (Bishunpur, Inman, Kohar, Manych, Massenya, Mezo-Madaras, Moorabie, Ngawi, Semarkona, and Tieschitz) and in Kainsaz (CO3). We have quantified the abundance of graphite-bearing metal by the number of metal grains with visible graphite inclusions (regardless of the

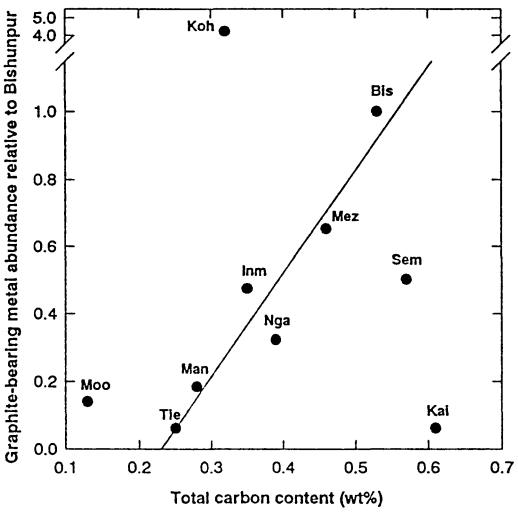

Fig. 1.

size of the grains and of the inclusions) per square centimeter of polished surface, normalized to the metal abundance of the chondrite, taken from [4]. Figure 1 shows the values obtained, normalized to Bishunpur, plotted as a function of total C content, taken from [5] and references therein, for 10 chondrites (the total C content of the eleventh, Massenya, is unknown). The line is a regression through six points. Four points have not been taken into account because (1) Kainsaz, a carbonaceous chondrite, may not follow the OC trend; (2) Semarkona metal contains abundant carbides [6], which may result in a lower graphite abundance; and (3) Kohar and Moorabie, whose graphite is essentially in veins extending into silicates, show abundant signs of shock effects (the link between graphite and shock is not clear, but there is some evidence of concentration of carbonaceous matter in shock veins [7]). If the correlation shown in Fig. 1 is real, it is a strong argument in favor of a common origin for graphite inclusions in metal and the bulk of C.

Preliminary values of C concentration have been obtained with the ion probe at Nancy for seven metal grains in Bishunpur. They range from ~0.1 wt% C for kamacite in reduced chondrules (FeO-poor silicates, Cr-rich metal) and Cr-rich nonchondrule metal, to ~0.3 wt% C for kamacite in oxidized chondrules (FeO-rich silicates, Cr-poor metal) and Cr-poor, graphite-bearing, nonchondrule metal. These results confirm that C is present in chondrules, and qualitatively agree with the conclusions of [2] that C was the reducing agent responsible for incorporation of Cr, P, and Si in metal during chondrule formation. These data—the very first on the C content of OC metal—need to be confirmed and extended. Work is now in progress in that direction.

References: [1] Mostefaoui S. and Perron C. (1994) *LPS XXV*, 945. [2] Mostefaoui S. and Perron C. (1994) *Meteoritics, 29*, 506. [3] Mostefaoui S. and Perron C., this volume. [4] Ramdohr P. (1973) *The Opaque Minerals in Stony Meteorites*, Elsevier; McKinley S. G. et al. (1981) *Proc. LPS 12B*, 1039. [5] Jarosewich E. (1990) *Meteoritics, 25*, 323. [6] Taylor G. J. et al. (1981) *LPS XII*, 1076. [7] Semenenko V. P. and Golovko N. V. (1994) *GCA, 58*, 1525.

LIGHT NOBLE GAS ABUNDANCES IN THE SOLAR WIND TRAPPED BY CHONDRITIC METAL.

Ch. Murer, H. Baur, and R. Wieler, ETH Zürich, Isotope Geology, NO C61,CH-8092 Zürich, Switzerland.

The heavy solar noble gases Ar-Xe are retained elementally unfractionated relative to the incoming solar corpuscular radiation in lunar soils, as is shown by the flat profiles of Ar/Kr and Kr/Xe throughout closed-system stepped etch extractions [1,2]. In contrast, He/Ar and Ne/Ar reach present-day solar wind (SW) values only toward the end of the runs, indicating that the well-known fractionating losses of solar He and Ne from lunar

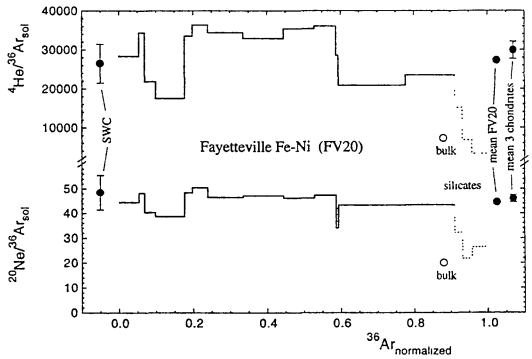

Fig. 1.

samples affect the shallowly sited SW component, but not the more deeply implanted solar energetic particles (SEP).

Rather flat He/Ar and Ne/Ar profiles were previously observed in stepped etchings of metallic Fe-Ni from solar-gas-rich meteorites [3–5], suggesting that Fe-Ni retains unfractionated He, Ne, and Ar from SW and SEP. Most runs showed some variation in elemental ratios, possibly due to (1) experiment-induced fractionation, (2) the different penetration depths of the various gases [4], or (3) variable elemental abundances in SW and SEP. The results of a repeat run on an Fe-Ni separate from the H chondrite Fayetteville are shown in Fig. 1. The $^{20}Ne/^{36}Ar$ ratio is essentially flat and most values fall in the range of 48.5 ± 7 of the modern SW [6]. The low values in the last three steps are presumably due to fractionated solar noble gases released from silicate impurities by Cu-Cl in these final ~10-day extractions, since the lowest value is close to that in bulk samples. We thus cannot confirm a real variation of Ne/Ar with grain depth. The He/Ar pattern is similar to Ne/Ar except that the values of individual steps scatter considerably more.

Flat profiles as in Fig. 1 strongly suggest that the average ratios deduced from meteoritic Fe-Ni (in some cases slightly corrected for, e.g., contributions from silicates) yield good estimates of the relative light noble gas abundances in SW and SEP trapped by chondritic regoliths. Table 1 shows best values deduced from three chondrites (two runs each). These values differ by less than about 15% from those reported for present-day SW and for solar gases in Acfer 111 metal [4]. Remarkable is the good agreement of Ne/Ar deduced from meteorites with the SWC ratio, since the derivation of the latter value involved an about 40% correction for solar ^{36}Ar released from lunar soil and retrapped into the Al foils.

References: [1] Wieler R. et al. (1993) *LPS XXIV*, 1519. [2] Wieler R. and Baur H. (1995) *Astrophys. J.*, in press. [3] Murer Ch. et al. (1994) *Meteoritics, 29*, 506. [4] Pedroni A. and Begemann F. (1994) *Meteoritics, 29*, 632. [5] Murer Ch. (1995) Ph.D. thesis, ETH Zürich, #10964. [6] Cerutti H. (1974) Ph.D. thesis, Univ. Bern.

TABLE 1. Helium, Ne, and Ar abundances in solar wind reservoirs.

	$^4He/^{36}Ar$	$^{20}Ne/^{36}Ar$
Fayetteville, Acfer 111, Noblesville* (Fe-Ni separates)	29,900 ±2,200	46.0 ±1.5
Acfer 111 (Fe-Ni)†	25,100	41
Recent solar wind (SWC)‡	26,500 ±5,000	48.5 ±7.0

* This volume and [3,5]. Errors represent the standard deviation of the mean values of six closed-system etch runs.

† Pedroni and Begemann [4], closed-system etch run.

‡ Apollo Solar Wind Composition Experiment [6], mean of Al and Pt foils, Al values corrected for retrapped ^{36}Ar.