S-PROCESS MATERIAL IN MURCHISON: SR AND MORE ON BA;

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Primitive meteorites contain phases (SiC;[1]) that carry traces of elements which are enriched in s-process products. These were first identified in the noble gases Xe and Kr [2,3], but we have recently also demonstrated the presence of associated s-process Ba [4] in an $HF/HCl/Cr_2O_7^{2-}/HClO_4/H_3PO_4$-treated residue from the Murchison meteorite. In two coarse-grained fractions, R1CPD and R1CPF, enrichments in s-only $^{134,136}Ba$ relative to p-only $^{130,132}Ba$ of ≈ 40 % were observed [5].

One of the residue fractions (R1CPD, [5]) has now been investigated for its Sr isotopic composition by multi-collector thermal ionization mass spectrometry using direct loading with H_3PO_4 and Si-gel. Abundance ratios relative to s-only ^{86}Sr are shown in Fig.1 as deviations in o/oo from normal ([6]; except for $^{87}Sr/^{86}Sr$, where the ALL value of 0.69877 [7] has been used). Relative to s-only $^{86,87}Sr$ and s-dominated ^{88}Sr there is a clear deficiency at p-only ^{84}Sr of (-113 ± 16) o/oo. $^{88}Sr/^{86}Sr$ (8.389 ± .011) and $^{87}Sr/^{86}Sr$ (0.700 ± .004) are very close to the normals; due to interferences from ^{87}Rb and a molecular interference (probably CaAlO with the main peak at mass 83) the existence of minor components with different ^{87}Sr cannot be excluded, however.

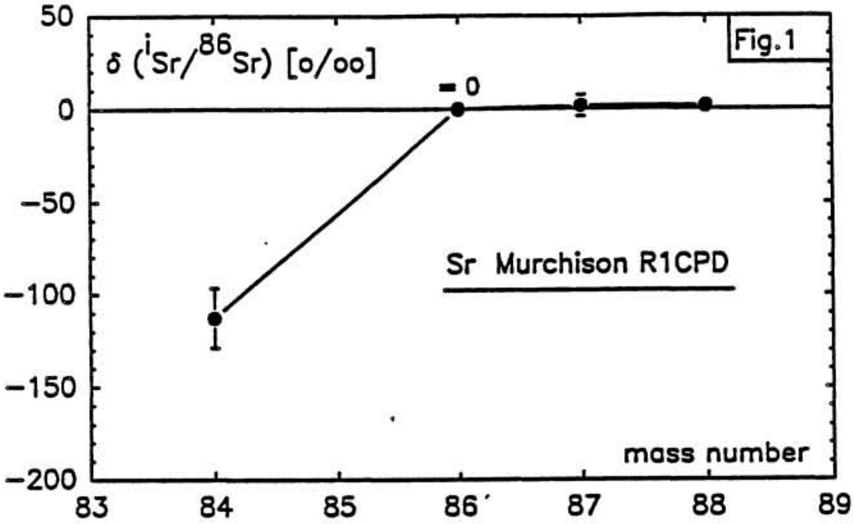

Fig.1

The inferred composition of s-Sr obtained from extrapolating to $^{84}Sr = 0$ is $^{86}Sr/^{87}Sr/^{88}Sr = \equiv 1/0.710(+0.050,-0.035)/8.50(+0.14,-0.12)$, indistinguishable from the abundance ratios in normal Sr (except for ^{84}Sr). The ratio $(^{87}Sr/^{86}Sr)_s$ derived here is at the upper end of, but compatible with, what has been predicted for s-process Sr [9]. A complication is the lack of information on the exact composition of the 'normal' component which, by mixing with s-Sr, yields the composition observed in R1CPD. The value of 0.710 given above uses the ALL value [7]; using a different composition such as 0.707 (for a solar Rb/Sr ratio; [8]) results in $(^{87}Sr/^{86}Sr)_s = 0.64$, also in agreement with results of calculations for the s-sprocess. Due to its low neutron capture cross section [9] the abundance of ^{88}Sr is sensitive to the total neutron exposure in the s-process. The ratio $^{88}Sr/^{86}Sr = 8.50$ obtained here is clearly lower than the value 12.3 implied from the a simple σN = const.-approximation, not taking into account branching at ^{85}Kr. In this approach one calculates an effective mean neutron exposure $\tau_0 = 0.33\ mb^{-1}$, much higher than the 0.18 mb^{-1} implied from $^{138}Ba/^{136}Ba$ [5], but similar to the value of 0.30 mb^{-1} for the main component of the 'solar s-process' [9]. This agreement is probably fortuitous, however, since branching at ^{85}Kr has been observed in s-Kr [10] and will result in a partial bypass of ^{86,87}Sr and an enhanced ^{88}Sr/^{86}Sr ratio.

New data obtained on other size fractions from the same residue indicate the existence of variations in the abundance of ^{134}Ba that may be indicative of the effects of branching at ^{134}Cs ($T_{1/2\text{-terr}}$=2.06a). The effect is most pronounced in Murchison R1CPK5 with a nominal size range 0.3-1μ. In Fig.2 the means of 10 consecutive measurements each initially follow a mass fractionation trend. The offset from the line through the origin (normal) is consistent with the addition of ≈ 1-2 permil of s-Ba with a composition like that derived from R1CPF. Blocks 10-17, however, veer off towards lower ^{134}Ba, before returning to the original trend towards the end of the run. For the bypassing of ^{134}Ba to become important, a low temperature for the s-process seems to be required [11] just as a temperature lower than what is commonly assumed for the s-process follows from the composition of s-Kr in Murchison [10].

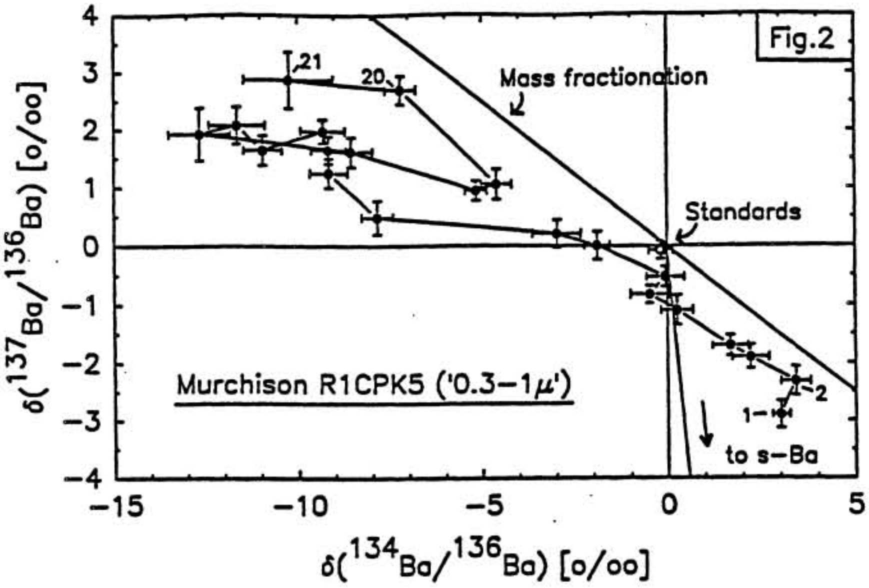
Fig.2

References: [1] Tang M. and Anders E. (1988) GCA 52, 1235. [2] Srinivasan B. and Anders E. (1978) Science 201, 51. [3] Alaerts L. et al. (1980) GCA 44, 189. [4] Ott U. et al. (1989) Meteoritics 24, in press. [5] Ott U. and Begemann F. (1990) Ap. J. (Letters), in press. [6] Patchett P.J. (1980) Nature 283, 438. [7] Gray C.M. et al. (1973) Icarus 20, 213. [8] Anders E. and Grevesse N. (1989) GCA 53, 197. [9] Käppeler F. et al. (1989) Rep. Prog. Phys. 52, 945. [10] Ott U. et al. (1988) Nature 332, 700. [11] Takahashi K. and Yokoi K. (1987) Atomic Data Nucl. Data Tables 36, 375.