

**Rb-Sr SYSTEMATICS IN CHONDRITIC METAL;** F. A. Podosek<sup>1</sup>, J. C. Brannon<sup>1</sup>, C. Perron<sup>2</sup>, and P. Pellas<sup>2</sup>; <sup>1</sup>McDonnell Center for the Space Sciences, Washington University, St. Louis, MO 63130, USA; <sup>2</sup>Laboratoire de Mineralogie du Museum, 75005 Paris, France.

The metal phase of chondritic meteorites experienced a different pre-accretionary history than the silicates. In some relatively little-metamorphosed chondrites the metal contains inclusions of silica, chromite and phosphate [1], evidently formed from Si, Cr and P (originally dissolved in the metal phase) by oxidation and exsolution in a parent body environment. Chondritic metal and/or its associated phases are also the host of an unusual Xe component, termed FVM-Xe [2] (for Forest Vale metal).

We have performed Rb-Sr analyses of purified metal separates from three ordinary chondrites, Dhajala (H3), Forest Vale (H4) and Estacado (H6), in order to investigate whether this isotopic system might provide chronological constraints on the history of chondritic metal. Also, phosphates are important phases for a number of chronometric methodologies applicable to the histories of chondrites, including that based on initial  $^{87}\text{Sr}/^{86}\text{Sr}$  [3-5]. Chronological interpretation of initial  $^{87}\text{Sr}/^{86}\text{Sr}$  requires a model for the environment from which phosphates obtained their Sr; if phosphate Sr is derived from a local environment not typical of the whole-rock reservoir usually assumed in initial Sr studies, the physical and probably genetic association of phosphates with metal-sulfide assemblages [1,6] suggests that the metal might provide the appropriate local environment.

We analyzed bulk samples of purified metal prepared as in previous studies. In order to provide some information on the phases contributing Rb and Sr, samples were treated sequentially with different reagents (washing in methanol and water, etching in HCl or HF, dissolution in 6NHCl) and aliquots of the solutions were spiked for K + Ca and Rb + Sr. As observed visually, some but only little of the metal dissolved in the etch steps: most (>99%) did not dissolve until the final 6NHCl step. Isotopic analyses were performed on the Washington University VG354 thermal emission mass spectrometer, K and Ca by Faraday detector and Rb and Sr by pulse-counting Daly detector. Results are given in Table 1 and illustrated in Figure 1. Observed quantities are low and in some cases not significantly different from blank levels, but are well above analytical blanks in several fractions.

As expected, concentrations of lithophile elements (Table 1) in these metal-enriched samples are low compared to whole-rock values, and metal and associated phases as sampled in this study provide only a small part of the whole-rock inventory; for Dhajala, for example, ~ 10% "metal" at 0.3 ppm Sr accounts for only 0.03 ppm Sr in the whole rock, i.e. 0.3% of a representative 10 ppm Sr in chondrites. Sr in phosphates separated from bulk chondrites is only about 4% of the whole rock inventory (assuming ~ 0.5% phosphate at ~ 70 ppm Sr), however; "metal" (including "associated phases") as observed in Dhajala and Forest Vale could thus account for a small but nontrivial (of order 10%) fraction of the Sr typically found in chondritic phosphates. Given that most of the metal does not dissolve until the final 6NHCl step, it is evident that most of the Sr observed in these samples is not actually in the metal phase. Even in this step the Sr likely resides in phases enclosed by the metal rather than the metal itself. The Sr/Ca ratios in these final fractions are comparable to those in bulk-sample phosphates [5]; Sr/Ca ratios in the earlier fractions are higher.

It is hazardous to try to infer trends from only three samples, but these results are at least consistent with the expectation that any of these normally lithophile elements originally in or associated with metal would become less abundant with progressively greater degree of metamorphism. The Rb/Sr ratio in the Dhajala and Forest Vale samples is less than in most whole rock chondrites ( $^{87}\text{Rb}/^{86}\text{Sr} \sim 0.75$ ): it may be significant that this ratio increases with increasing degree of metamorphism.

Of the data obtained in these analyses, only the 6NHCl dissolution fraction of Forest Vale (and, within rather broad error limits, the Estacado etch fraction) is consistent with normal bulk chondrite Sr evolution, i.e. lies on the bulk chondrite isochron [7]. All the other data lie to the upper left of the chondrite isochron, i.e. they indicate the presence of more radiogenic initial  $^{87}\text{Sr}/^{86}\text{Sr}$  than has been found in carbonaceous chondrites and igneous achondrites and inferred for bulk chondrites [7]. Barring isotopic heterogeneities, metal-associated Sr thus appears to indicate a history involving higher Rb/Sr ratio than

now characterizes these samples; since parent body history apparently involves loss rather than gain of Sr, this history is presumably pre-accretionary.

Qualitatively, metal-associated Sr is like that in phosphates in the sense of high initial  $^{87}\text{Sr}/^{86}\text{Sr}$ . Quantitatively, observed Sr levels in these metal samples are inadequate to account for Sr in bulk-sample phosphates. Pre-metamorphic metal may have had higher levels of associated Sr, however, and the sample preparation process is likely to have removed some metal-associated Sr. It is thus possible that bulk-sample phosphate Sr actually reflects the history of chondritic metal more sensitively than it does the whole rock.

References: [1] Perron *et al.* (1990) 53rd Met. Soc. (Perth) abstracts, p.129; [2] Marti *et al.* (1989) *Z. Naturforsch.* 44a, 963; [3] Wasserburg *et al.* (1969) *EPSL* 7, 33; [4] Brannon *et al.* (1988) *Proc. 18th LPSC*, 555; [5] Podosek and Brannon (1991), *Meteoritics*, submitted; [6] Murrell and Burnett (1983) *GCA* 47, 1999; [7] Minster *et al.* (1982) *Nature* 300, 414.

Figure 1: Rb-Sr isochron diagram for chondritic metal fractions (from Table 1), shown on different scales in (a) and (b); the solid line is the whole-rock chondrite isochron [7].

Sample Fraction	[K] ppm	[Ca] ppm	[Rb] ppb	[Sr] ppb	$^{87}\text{Rb}/^{86}\text{Sr}^{(d)}$	$^{87}\text{Sr}/^{86}\text{Sr}^{(d,e)}$
Dhajala (209 mg)						
Wash			0.4	26	$0.0489 \pm 12$	$0.7084 \pm 2$
HCl etch	0.7 <sup>(b)</sup>	81	0.6	207	$0.0079 \pm 3$	$0.7087 \pm 1$
HCl dissolution	1.3	248	6.3	82	$0.222 \pm 3$	$0.7149 \pm 3$
Forest Vale (37 mg)						
Wash	<0.4 <sup>(c)</sup>	7 <sup>(b)</sup>	0.3 <sup>(b)</sup>	11	$0.076 \pm 0.08$	$0.7085 \pm 10$
HF etch	1.2 <sup>(b)</sup>	30	2.6	118	$0.0648 \pm 0.005$	$0.7107 \pm 5$
HCl etch	<0.2 <sup>(c)</sup>	14	0.2 <sup>(b)</sup>	9	$0.073 \pm 0.11$	$0.7152 \pm 11$
HCl dissolution		107	9.4	56	$0.478 \pm 0.04$	$0.7306 \pm 2$
Estacado (92 mg)						
Wash	<0.1 <sup>(c)</sup>	<1 <sup>(c)</sup>	<0.1 <sup>(c)</sup>	<1 <sup>(c)</sup>		
HCl etch	<0.1 <sup>(c)</sup>	<1 <sup>(c)</sup>	0.1 <sup>(b)</sup>	1 <sup>(b)</sup>	$0.40 \pm 10$	$0.7254 \pm 17$
HCl dissolution	<0.1 <sup>(c)</sup>	2 <sup>(b)</sup>	1.2	3	$1.05 \pm 0.4$	$0.7768 \pm 8$

(a) Elemental concentrations obtained by isotope dilution, stated in terms of total sample weight.

(b) Nominal blank is more than 10% (but less than 50%) of total quantity measured.

(c) Nominal blank is more than 50% of total quantity measured; stated upper limit in concentration is amount observed divided by effective sample weight.

(d) Two-sigma errors.

(e) Adjusted to 0.71014 for NBS-987.

