CHONDRITE CHRONOLOGY BY INITIAL $^{87}Sr/^{86}Sr$ IN PHOSPHATE?; F. A. Podosek and J. C. Brannon; McDonnell Center for the Space Sciences, Washington University, St. Louis, MO 63130-4899.

There is little doubt that ordinary chondrite materials formed at very nearly the same time as any of the oldest known materials in the solar system, e.g. CAIs. Nevertheless, ordinary chondrites also experienced a subsequent history, recorded by several different chronometric systems, frequently spanning several times 10^7 to more than 10^8 years. In most cases these times presumably represent metamorphism in a parent-body environment. It has proven difficult however, to construct specific thermal histories for which different chronometric schemes applied to the same meteorite yield consistent results or results which correlate with metamorphic grade. It is not yet clear whether this implies chaotic thermal histories, with different chronometers "closing" at different stages in these histories, or whether interpretations of geochronological data must be reevaluated.

Although phosphates are only accessory minerals in ordinary chondrites they have considerable weight in assessing chondrite chronology. They are major hosts for rare earth and actinide elements, and thus important for the U-Pb and Sm-Nd methods, and also for those based on ^{244}Pu. While phosphates are not major hosts for Sr, typically they are severalfold enriched (relative to whole rock composition) in Sr and depleted in Rb. They thus have low Rb/Sr ratios, permitting precise determination of initial $^{87}Sr/^{86}Sr$ ratios which can be interpreted chronologically with a resolution finer than that of absolute Rb-Sr ages [1]. The objective of the present study is to expand the data base for initial $^{87}Sr/^{86}Sr$ in chondritic phosphates and, where possible, compare chronological interpretations of initial Sr with those of other chronometric systems.

Phosphate-enriched samples (prepared by P. Pellas) were washed in water and methanol, then etched in dilute HNO_3, to remove any superficial contamination (cf. [2]), then dissolved in 0.5 NHCl. Rb and Sr were purified by standard ion exchange chromotography. Isotopic analyses were performed on a VG354 mass spectrometer using a Daly detector operated in pulse-counting mode. New data for chondritic phosphates are set out in Table 1. The isotopic data for Ankober and Mt. Browne are relatively imprecise because only very small samples were available, but they are consistent with the data from other chondrites. The results for Forest Vale are noteworthy in that they indicate significantly lower Rb/Sr and $^{87}Sr/^{86}Sr$ than previously observed in chondritic phosphates. Our results for Guarena phosphate (Table 1) indicate significantly higher $^{87}Sr/^{86}Sr$ and Rb/Sr than the Guarena phosphate results of Wasserburg *et al.* [1], but the initial $^{87}Sr/^{86}Sr$ ratios for the two analyses are compatible within errors.

All available data for Rb-Sr analyses of chondritic phosphates are displayed in Figure 1. It is clear that chondrite phosphates typically have initial $^{87}Sr/^{86}Sr$ ratios which are distinctly elevated (by 10 to 20 ε-units) relative to early solar system marker values such as ALL [4], BABI [5] or the best-fit whole rock chondrite isochron initial value (.69885 ± 10) reported by Minster *et al.* [6]; indeed only St. Severin (and possibly Mt. Browne) are compatible with such values.

Assuming that phosphate Sr started with unradiogenic composition such as those cited above, evolution to the elevated "initial" values present at isotopic closure of the phosphates requires time. Calculation of such a "formation interval" requires a model assumption for the Rb/Sr ratio in the growth environment; for scale, for a representative whole-rock chondrite $^{87}Sr/^{86}Sr = 0.75$, $^{87}Sr/^{86}Sr$ evolves at the rate 0.15 ε-unit/Ma.

Such times are not implausible per se, and it is encouraging that recently reported [7] U-Pb ages for chondritic phosphates indicate the same time scale, but the data base is yet too small to permit useful case-by-case comparisons of initial Sr and U-Pb ages of phosphates. Initial Sr intervals do not agree with whole-rock I-Xe ages in general (which indicate an overall timescale severalfold shorter, requiring Xe closure at a higher temperature than Sr closure), nor do they suggest consistent qualitative trends in case-by-case comparison. Initial Sr elevations do not obviously correlate with metamorphic grade or with chemical class (although LLs are distinctly under represented). Alternatives to these simple chronological interpretations should thus be considered seriously.

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One possible alternative is suggested by the association of phosphate grains with metal/sulfide assemblages and the view that most of the phosphate is formed during metamorphism by oxidation and exsolution of P [8]. Any Sr originally associated with metal/sulfide might then be disproportionately represented in phosphates, i.e. the usually assumed whole-rock Rb/Sr environment may be inappropriate for evaluating the evolution of phosphate Sr. The relevant question is then how much Rb and Sr are associated with metal or sulfide before metamorphism. In a first approach to this question we have analyzed a high-purity sample of Dhajala metal prepared by C. Perron and P. Pellas. Preliminary results indicate a nontrivial Sr concentration (whether actually in metal or in some associated phase), enough to make a significant contribution to phosphate Sr, with an Rb/Sr ratio lower than for typical chondrites but nevertheless having initial $^{87}Sr/^{86}Sr$ higher than BABI and in the same general range as phosphates in metamorphosed chondrites. The significance of such results is unclear but it may turn out that the systematics of phosphate Sr is influenced by that of Sr associated with metal.

REFERENCES: [1] Wasserburg *et al.* (1969) EPSL **7**, 33; [2] Brannon *et al.* (1988) Proc. 18th LPSC, 555; [3] Manhes *et al.* (1978) EPSL **39**, 14; [4] Gray *et al.* (1973) Icarus **20**, 213; [5] Papanastassiou and Wasserburg (1969) EPSL **5**, 361; [6] Minster *et al.* (1982) Nature **300**, 414; [7] Gopel *et al.* (1989) 52nd Met. Soc. Abstracts. 71: [8] Murrell and Burnett (1983) GCA **47**, 1999.

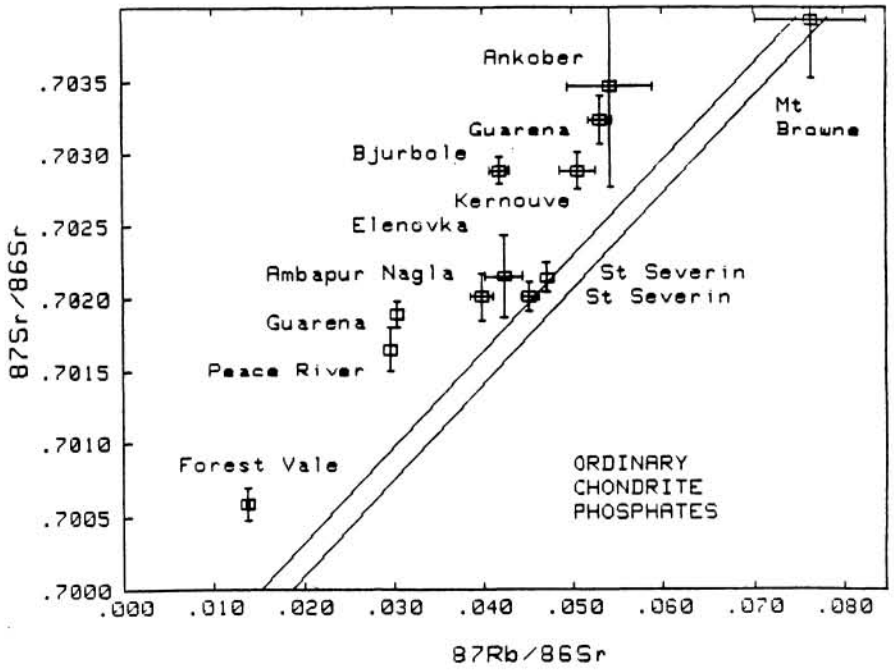

Table 1. Rb-Sr analyses of ordinary chondrite phosphates

Sample	Class	[Rb] ppm	[Sr] ppm	$\frac{^{87}Rb}{^{86}Sr}$	$\left[\frac{^{87}Sr}{^{86}Sr}\right]^{a}$	$\left[\frac{^{87}Sr}{^{86}Sr}\right]_{I}^{a,b}$
Forest Vale	H4	0.44	93.3	.0137 ± 2	.70058 ± 11	.69966 ± 11
Mt. Brown	H6	0.60	22.5	.0764 ± 62	.70392 ± 40	.69881 ± 57
Ankober	H4	0.37	19.7	.0541 ± 47	.70346 ± 70	.69984 ± 77
Guarena	H6	1.25	68.0	.0531 ± 12	.70323 ± 17	.69973 ± 18
Kernouve	H6	0.96	54.7	.0505 ± 20	.70288 ± 13	.69955 ± 18

(a) Adjusted to .71014 for NBS-987.
(b) Corrected for *in situ* decay in 4.55 Ga.

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