ANOMALOUS ^{54}Cr AND ^{53}Cr IN BULK ACID RESIDUES FROM ORGUEIL AND MURCHISON.

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Introduction: Correlated isotope anomalies have been determined for neutron rich isotopes of Fe-peak nuclei in CAI. After the first identification of isotope anomalies for Ca in FUN inclusions [1] and of endemic anomalies for Ti in FUN and typical CAI [2], and of ubiquitous Ti anomalies in typical CAI [3], attention shifted to Cr. The first clear evidence of endemic isotope effects for ^{54}Cr in typical CAI and of evidence for the ^{53}Mn-^{53}Cr system [4] was followed by endemic ^{54}Cr effects in typical CAI and large effects for ^{54}Cr (both positive and negative) and ^{53}Cr in FUN inclusions [5, 6] and by discoveries of effects in ^{58}Fe and in ^{66}Zn also in FUN inclusions [7, 8]. These measurements, especially in FUN inclusions, identified the presence of correlated excesses and deficits in the neutron-rich isotopes ^{48}Ca, ^{50}Ti, ^{54}Cr, ^{58}Fe, and ^{66}Zn, attributable to neutron-rich equilibrium nucleosynthesis components [9]. Following these measurements on bulk CAI, the presence of very large ^{54}Cr effects in leachates of carbonaceous chondrite (CC) matrices was identified [10]. This pioneering work was followed by extensive measurements on Cr in leachates of CC, and especially of Orgueil and Murchison [11, 12], in an effort to characterize the carrier minerals for the large ^{54}Cr effects. While the extensive Cr data on the leachates identified the presence of large effects, the carrier has not been identified. In addition, because of the emphasis on the leacheates, the attendant residues have not received attention or have yielded almost normal ^{54}Cr compositions. In particular, identical aliquots A and B of a non-magnetic residue were obtained after acetic, nitric, and mild HCl leaching [11]. Essentially normal Cr was found in residue B, while rresidue A was then subjected to stronger leaching by 6N HCl at 80°C and yielded a leachate with a large ^{54}Cr excess [11]. In a separate study, after dissolution of CC [13] the small residues were attacked in Teflon bombs and yielded ^{54}Cr effects of 13 εu for Ivuna (CI) and 5 εu for Murchison. The assumption has been that only a small fraction of Cr in the CC matrix contains anomalous ^{54}Cr that is released partially by sequential, leaching/partial dissolution techniques, while bulk residues average a diverse grain population and yield essentially normal Cr isotopic compositions. In this work, we have analyzed aliquots of bulk leaching residues from Orgueil and Murchison (cf. [14]).

Analytical Results and Discussion: The residues were obtained after leaching with acetic and nitric acids. Prior published studies indicated that these leachates show typically deficits in ^{54}Cr, while subsequent leachates with HCl yield large ^{54}Cr excesses. Since the purpose of [14] was to identify the carrier phases of the large ^{54}Cr effects, the residues were leached only with acetic and nitric acids and not HCl.

We have analyzed fine-grained residues, separated by size: a) colloidal; b) <0.2 μm; c) 0.2-0.8 μm and d) >0.8 μm. The residues were dissolved in Teflon bombs in $HF+HNO_3$, at 180°C. The chemical separation included anion and cation exchange and a complete separation of interfering species. The Cr isotope results are presented in Table 1 and Fig. 1a, b. We present ε^{54}Cr and ε^{53}Cr data (parts in 10^4) normalized to ^{50}Cr/^{52}Cr= 0.0518595.

The residues, separated by size, for Orgueil and Murchison show similar patterns: large positive effects for ε^{54}Cr and well resolved small negative effects for ε^{53}Cr. Using the silica gel-boric acid technique for running Cr, we obtain a relatively narrow range of 3‰ for the raw, directly measured ^{50}Cr/^{52}Cr, at the beginning of Cr runs for the terrestrial standard and for the Orgueil and Murchison residues. This indicates the absence of large effects in ^{50}Cr/^{52}Cr. Hence, the dominant isotope anomaly for Cr resides in ^{54}Cr, independently of the correction for isotope fractionation. A more precise constraint on ^{50}Cr/^{52}Cr may be obtainable by ICP-MS.

These results are the first to indicate that bulk residues contain large ^{54}Cr/^{52}Cr effects, as opposed to large effects being exhibited only by preferential leaching of the carriers of the ^{54}Cr anomalies. The values measured in these residues approach those measured in HCl leacheates [10-12] both for Orgueil and

Table 1. ^{53}Cr and ^{54}Cr in bulk acid residues from Orgueil and Murchison

Sample	ε^{53}Cr	± error	ε^{54}Cr	± error
Orgueil				
Colloidal	-2.17	0.04	170.3	0.11
<0.2 μm	-0.66	0.05	38.60	0.12
0.2-0.8 μm	-0.98	0.02	11.90	0.19
>0.8 μm	-0.44	0.05	9.84	0.12
Murchison				
Colloidal	-1.76	0.06	148.0	0.17
<0.2 μm	-0.43	0.08	83.8	0.18
0.2-0.8 μm	-0.06	0.07	6.78	0.17
>0.8 μm	0.02	0.03	4.96	0.08

for Murchison. To the extent that the colloidal materials shows the largest ^{54}Cr enrichments, it may be reasonable to conclude that the finest grained, colloidal components are characterized by the largest effects. This confirms the conclusion [15] that the carrier of ^{54}Cr anomalies is smaller than 0.2 μm.

We note that the large excesses in ^{54}Cr are accompanied by small deficits in ^{53}Cr. In Fig. 2, we show this apparent correlation for these residues. The correlation slopes for the fine-grained residues are -93.0 and -78.9 for Orgueil and Murchison. We note that the values for the FUN inclusions EK-1-4-1 and C-1 do nor fall on the correlations for the CC residues. We also note that ε^{53}Cr and ε^{54}Cr correlations have been observed for whole rock CC measurements with slopes of 6.6±1.8 [16] and a slightly lower slope by [13]. Based on the large differences of slopes for CC whole rock and residue data, it is unclear how to interpret the apparent correlations, especially when the FUN inclusions do not fit either correlation. We conclude that there are multiple Cr components with positive and negative ^{54}Cr and ^{53}Cr effects, reflecting nucleosynthetic processes and an initial ^{53}Cr/^{52}Cr for the solar system lower than the terrestrial value.

Identifying the carrier of the ^{54}Cr anomalies remains a puzzle. Isolation of presolar material from meteorites, in the laboratory, has traditionally proceeded by digesting most of the meteorite to isolate chemically resistant phases. The carrier grains for ^{54}Cr do not share these characteristics, since they are readily attacked by HCl as dilute as 6N. Yet, this carrier must show some resistance, since it is the finest colloidal materials, found in the most aqueously altered meteorites, which contain the largest ^{54}Cr anomalies. It is for instance unlikely that <200 nm silicate grains survived quantitatively such aqueous alteration unless they were enclosed in protective organic material. The present work establishes that large ^{54}Cr effects are a characteristic of bulk residues and, hence, potentially not so elusive.

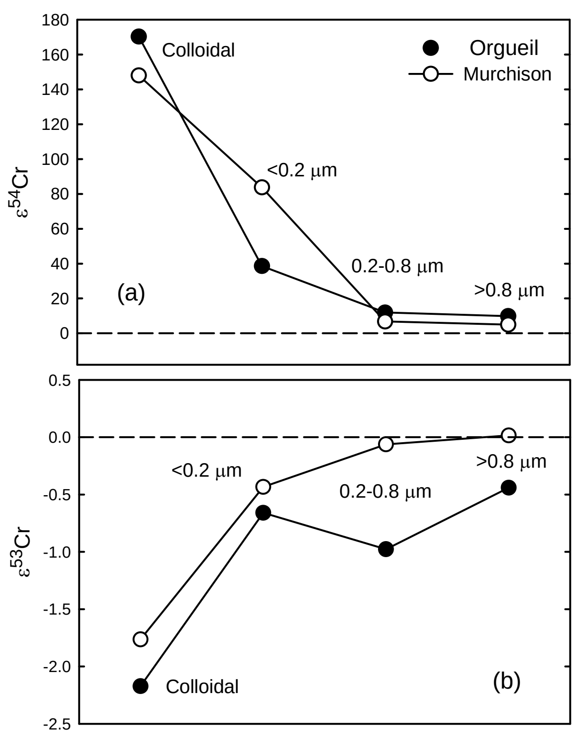

Figure 1. ε^{54}Cr (Fig. 1a) and ε^{53}Cr (Fig. 1b) in acid residues of Orgueil and Murchison.

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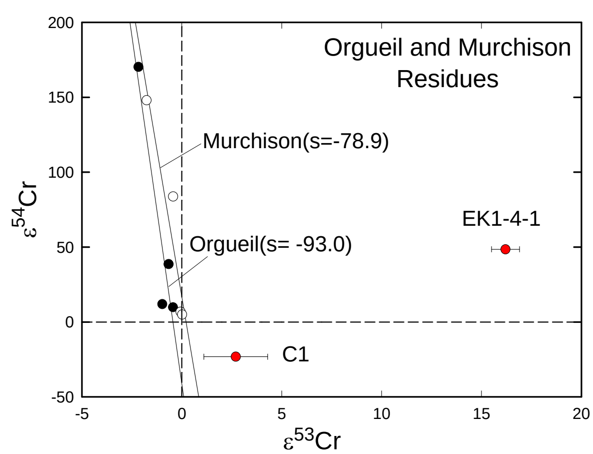

Figure 2. ε^{53}Cr-ε^{54}Cr apparent correlation in acid residues from the Orgueil and Murchison meteorites and in FUN CAI.