ANOMALOUS ^{53}Cr AND ^{54}Cr AND NEARLY NORMAL Ni IN DIFFERENTIAL DISSOLUTION STEPS OF MURCHISON.

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Introduction: We report the Cr isotope compositions of differential dissolution steps (leachates) of Murchison, as a companion report to the results on the partial dissolution residues of Orgueil and Murchison in [1, 2]. We also present preliminary results on Ni measurements on the first two Murchison leachates. There has been extensive Cr isotope work on leachates of carbonaceous chondrites, starting with the pioneering work of Rotaru et al. [3]. These workers also reported briefly that they investigated the neutron-rich isotopes of other Fe-peak elements (Ti, Fe, Ni, Zn) for the leachates with the higher ^{54}Cr effects but found only a hint of very small excesses for ^{66}Zn. The Cr work has been extended by additional measurements by other groups [4, 5]. This is the first attempt to follow up for Ni, on the brief report and negative findings in [3]. The leachates are the supernates of differential dissolution steps, starting with weak acids and then proceeding to stronger acids, which attack more aggressively most phases except possibly large refractory oxides and spinels. The partial dissolution techniques used in different studies have been similar, but with

some important differences. The dissolution steps (see Table 1) for samples in this work were described in Reisberg et al. [6], in connection with Os isotope measurements.

Results: The dissolution steps in this study and in [6] are listed in Table 1. The leaching techniques used by [3] and [5], for Murchison, which are very similar to each other, are listed in Table 2. Cr and Ni results are listed respectively in Tables 3 and 4. The ε^{54}Cr and ε^{53}Cr results are plotted in Fig. 1 and Fig. 2 (top portions) for our work and in Fig. 1 and 2 (bottom, for ease in comparing), for the work on Murchison from [3, 5]. The general patterns for ε^{54}Cr include deficits for ^{54}Cr in the acetic acid and nitric acid leachates, with significant excesses in ^{54}Cr appearing with the first use of HCl and then HCl+HF, and gradually decreasing as the acids used are heated. The effects for ε^{53}Cr are significantly smaller and range from +0.4 εu to -1.0 εu for our work and from +1.0 εu to -0.5 εu for the work by [3] and [5, 7]. The observed range of effects for ε^{53}Cr may reflect a combination of general
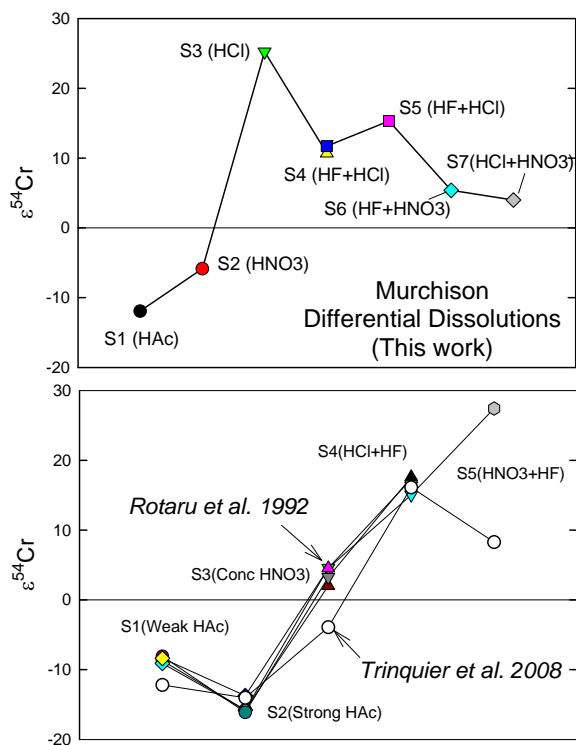
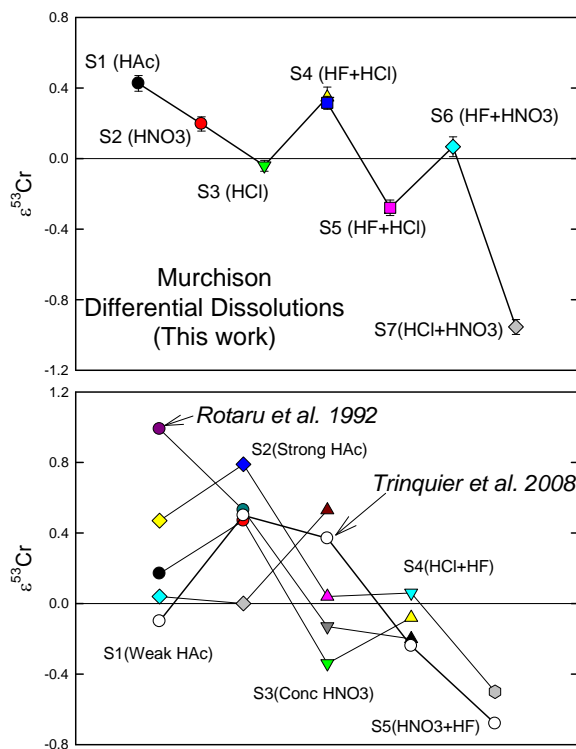Figure 1. ε^{54}Cr in differential dissolution steps of the Murchison meteorite.

Figure 2. ε^{53}Cr in differential dissolution steps of the Murchison meteorite.

nucleosynthetic isotope anomalies and of radiogenic effects from ^{53}Mn. The effects in these dissolution steps are compatible with the range of measured values and of extrapolated initial values for ^{53}Cr/^{52}Cr for typical Allende CAI. For ε^{54}Cr, the effects observed here and in the earlier work for Murchison leachates are generally reproducible but smaller than the effects we are reporting in the companion abstract for residues [1]. For Murchison, mild leachates (acetic and nitric acids) expose components with deficits in ε^{54}Cr while more aggressive leaching, starting with HCl shows large excesses in ε^{54}Cr. These excesses are, however, significantly smaller than the effects observed in residues obtained after only mild leaching of Murchison with acetic and nitric acids [1].

Nickel results: The results for Ni on steps S1 and S2 are given in Table 4. Ratios are calculated relative to ^{58}Ni and normalized to ^{62}Ni/^{58}Ni = 0.05338858. We list deviations from normal Ni, in parts in 10^4. The values for ^{64}Ni are preliminary, because of small corrections (10.6 and 7.6 εu for S1 and S2, respectively) for ^{64}Zn interference, based on the ion intensity at mass 66. We anticipate that, with an additional chemical separation, the Zn mass interference will become negligible. Mass interferences, including for ^{64}Ni, are absent for the analyses of Ni standards.

The Ni isotope composition for S1 is normal within uncertainties (2σ). For S2, ε^{60}Ni shows a significant deficit, ε^{61}Ni shows a possible deficit, and ε^{64}Ni shows a small but significant excess (6σ). It is clear that potential effects for Ni are absent (in S1) or much smaller than observed for ^{54}Cr. Furthermore, a hint of an excess in ^{64}Ni is observed in S2 as compared to the larger deficits for ^{54}Cr in S1 and S2. We note that almost all the Ni is leached out in steps S1 and S2. Hence, the results on Ni isotopes in S1 and S2 may reflect bulk measurements, with deamplified effects, since steps 3 and beyond contain only a few hundred nanograms of Ni. We will pursue Ni isotope measurements on leachates S3-S7.

Conclusions: Results on Cr on differential dissolution steps confirm earlier work on similar partial dissolution procedures. Hence, the chemical characteristics and chemical reactivity of the carrier(s) of the ^{54}Cr effects are reproducible, even if the nature of the carriers remains elusive. The positive and negative ^{54}Cr effects could reflect contributions of grains from diverse stellar sources or diverse zones from individual stars. This suggests preservation of grain condensates and their physical associations prior to incorporation in the solar system and further survival of the grains and physical associations, after incorporation in the solar system bodies. One should also keep in mind the pos-

sibility that the ^{54}Cr-rich grains were added to the solar nebula with an initial isotope composition depleted in ^{54}Cr. The results on Ni in the same partial dissolution steps suggest that Ni is not trapped in retentive phases but is extracted with relatively mild chemical attack (acetic and nitric acids).

Table 1. Differential dissolution steps of Murchison (Reisberg et al., 2009 [6] and this work)

Step 1) 50 mL acetic acid+50 mL H$_2$O, 1 day, 20 °C

Step 2) 25 mL HNO$_3$+50 mL H$_2$O, 5 days, 20 °C

Step 3) 30 mL HCl+35 mL H$_2$O, 1 day, 75 °C

Step 4) 30 mL HF+15 mL HCl+15 mL H$_2$O, 1 day, 75 °C

Step 5) 10 mL HF+10 mL HCl, 3 days, 150 °C
Step 6) 5 mL HNO$_3$+5 mL HF, 15 hours, 120 °C (applied to 0.117 g of Step 5 residue)
Step 7) 0.5 ml HCl+0.5 ml HNO$_3$, 3 days, high P-T Teflon capsule (applied to Step 6 residue)

Table 2. Leach procedures reported by Rotaru et al. (1992) [3]

Step 1) Acetic acid, 2.5%, 30 min, 20°C

Step 2) Acetic acid, 50%, 24 h, 20 °C

Step 3) Nitric acid, 25%, 7 days, 20 °C

Step 4) HCl (6N)+HF(27N), 1/1, 4days, 100 °C

Step 5) HBr (9N)+ HF(27N), 95/5, 10 days, 150 °C

Table 3. Cr isotopic compositions in samples of Murchison

Name	ε^{53}Cr	± error	ε^{54}Cr	±error
S1	0.43	0.04	-11.92	0.10
S2	0.20	0.04	-5.85	0.09
S3	-0.04	0.03	25.24	0.07
S4#1	0.35	0.06	10.69	0.13
S4#2	0.32	0.04	11.72	0.09
S5	-0.28	0.04	15.31	0.11
S6	0.07	0.06	5.39	0.14
S7	-0.96	0.04	3.98	0.11

Table 4. Ni isotopic compositions in samples of Murchison

	ε^{60}Ni	±	ε^{61}Ni	±	ε^{64}Ni[1]	±
S1	0.00	0.10	0.72	0.57	1.00	0.88
S2	-0.35	0.07	-0.79	0.34	1.66	0.53

1. Corrected for ^{64}Zn, assuming ions at mass 66 are all ^{66}Zn. Ni data normalized to ^{62}Ni/^{58}Ni =0.05338858.

References: [1] Chen J. C. *et al.* (2010) *LPSC 41*, Abstract # 2005. [2] Dauphas N. *et al.* (2010) *LPSC 41*, Abstract # 1073. [3] Rotaru M. *et al.* (1992) *Nature 358*, 465-470. [4] Podosek F. A. *et al.* (1997) *Meteor. Planet. Sci. 32*, 617-627. [5] Trinquier A. *et al.* (2007) *Ap. J. 655*, 1179-1185. [6] Reisberg L. *et al.* (2009) *EPSL 277*, 334-344. [7] Trinquier A. *et al.* (2008) GCA 72, 5146-5163.