^{54}Cr ANOMALIES IN THE TAGISH LAKE AND ORGUEIL CARBONACEOUS CHONDRITES. J.-L. Birck[1], M. Petitat[2], T. H. Luu[1], M. Gounelle[2]. [1] Laboratoire de Géochimie et Cosmochimie IPG, 4 Place Jussieu 75252, Paris Cedex 05, France; [2] Département d'Histoire de la Terre, Laboratoire d'Étude de la Matière Extraterrestre, Muséum National d'Histoire Naturelle, 57 rue Cuvier 75005 Paris, France. (birck@ipgp.jussieu.fr; petitat@mnhn.fr).

Introduction: Early solar materials bear a variety of isotopic anomalies that reflect compositional differences deriving from distinct stellar nucleosynthetic processes. As shown in previous studies [i.e. 1,2,3], the stepwise dissolution with increasing acid strengths of bulk rock carbonaceous chondrites liberates Cr with both excesses and deficits in ^{53}Cr and ^{54}Cr. The magnitude of the ^{54}Cr variations decreases in the sequence CI>CR>CM>CV>CO>CK and correlates with the degree of metamorphism of each carbonaceous chondrite class [3]. The Orgueil CI chondrite presents the highest ^{54}Cr anomalies ever measured in major mineral fractions, consistent with this meteorite being chemically the most pristine [4]. The Tagish Lake meteorite is classified as an anomalous CI2 chondrite [5] and presents H [6], O [7] and C [8] isotopic compositions intermediate between CI and CM2 carbonaceous chondrites. Tagish Lake may have originated from a D-type asteroid or cometary parent body, coming from beyond the asteroid belt and harbouring the most pristine matter than any other known meteorite [9,10]. The goal of this study is to extend the survey of meteorites exhibiting Cr anomalies to Tagish Lake. A sample of Orgueil has been measured in parallel for comparison with earlier studies.

Experimental methods: The stepwise dissolution of 0.32g of Orgueil (Org) and 0.29g of Tagish Lake (TL) followed the previously established procedure described in [1]. During the first 2 leaching steps sulfates, carbonates, sulfides, and other easily soluble minerals, were dissolved in dilute acetic acid. Their dissolution was then completed in step 3 by using dilute HNO_3. During step 4 silicates were disintegrated (HCL + HF conc.). Finally, refractory minerals such as spinel were attacked in step 5 (HNO_3 + HF conc.). Additionally, a whole rock sample (0.05g) of Tagish Lake was digested in boiling mixtures of concentrated HF + HNO_3 acids to investigate its bulk Cr isotopic composition. The chemical separation of Cr and the TIMS measurements were described in Trinquier et al [11]. After normalization to the terrestrial ^{52}Cr/^{50}Cr ratio, typical precisions obtained for Cr isotopic measurements are at the 10 ppm and 20 ppm level for the ^{53}Cr/^{52}Cr and ^{54}Cr/^{52}Cr ratios respectively. All data are expressed in $\delta^{53,54}$Cr values, which is the relative deviation of the ^{53,54}Cr/^{52}Cr ratio from the terrestrial standard value expressed in one per 10000. Fe isobaric interference on ^{54}Cr was monitored on ^{56}Fe. Procedural blanks ca 0.2ng for Cr have negligible implication on the final results.

Results: Chromium isotopic results for the Orgueil and the Tagish Lake meteorites are detailed in table 1. No isotopic data were measured for leach 1. Cr and Mn in Orgueil and Tagish Lake are mainly concentrated in the most easily dissolved fractions.

Anomalies in ^{54}Cr: Each dissolved fraction represents different mineral types from the same meteorite and is anomalous relative to the terrestrial (solar) composition. The most easily dissolved fractions show a deficit ranging from -6 for Orgueil to -16 for Tagish Lake. In contrast, the more chemically resistant fractions host excesses rising up to 79 for Orgueil and 139 for Tagish Lake.

Anomalies in ^{53}Cr: The amplitude of the variation is two orders of magnitude smaller than for ^{54}Cr. Excesses in ^{53}Cr are concentrated in the chemically less resistant fractions, where Mn and Cr are abundant.

Whole rock: The ε^{53}Cr value measured for the whole rock of Tagish Lake is higher than the one determined for Orgueil. On the contrary, the ε^{54}Cr is higher in Orgueil than in Tagish Lake.

Meteorite	Leach	ε^{53}Cr	ε^{54}Cr
Orgueil (CI1)	2	1.00±0.15	-6.08±0.12
	3	0.04±0.12	-6.78±0.24
	4	-0.62±0.63	79.25±1.81
	5	-0.84±0.11	18.25±0.28
	wr	0.25±0.03	1.56±0.06
Tagish Lake (CI2)	2	1.28±0.26	-16.14±0.47
	3	0.43±0.10	-8.03±0.16
	4	-1.45±0.13	139.01±0.85
	5	-1.00±0.17	13.80±0.21
	wr	0.55±0.20	0.94±0.32

Table1. Results from this study. Error bars are 2σ; wr= whole rock. wr for Orgueil from [3].

Discussion:

Excess of ^{54}Cr in the bulk samples of carbonaceous chondrites: Figure 1 illustrates the ε^{54}Cr heterogeneity among sequentially dissolved fractions of bulk rock carbonaceous chondrites measured in this study and in Murchison and Allende [3] for comparison. The pattern of isotopic data for Orgueil is similar to the one obtained by [1,2,3]. The first two leaching steps exhibit deficits in ^{54}Cr. The highest ^{54}Cr excesses are produced in step 4. With a ε^{54}Cr ≈ 80, the present value falls within the range of values measured for Orgueil so far. Tagish Lake has several striking differences relative to the systematics of carbonaceous

chondrites. For the major mineral containing Cr, it displays both the highest excess and deficit in ^{54}Cr. The general trend from C1 to C4 is a decrease in the isotopic difference between step 2 and Step 4. Taking only this observation, Tagish Lake would be significantly more primitive than the C1s (Orgueil here as an example). More precisely it displays the highest deficit which is generally found in dissolution step 2 and for which surprisingly the highest values are found in C2s and not in C1s. Tagish Lake also displays the highest excesses in step 4 from all groups of C meteorites. With the exception of a magnetite enriched fraction from Orgueil [2], this is the highest ^{54}Cr excess observed in one of the major mineral fraction of a meteorite.

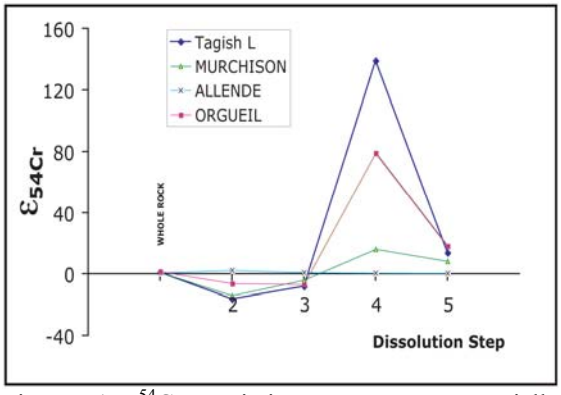

Figure 1. ^{54}Cr variations among sequentially dissolved fractions of bulk rock carbonaceous chondrites. Data at 1 are whole rock data.

Excess of ^{53}Cr in the bulk samples of carbonaceous chondrites: Figure 2 illustrates the ε^{53}Cr variations for the same 4 meteorites. Aside from leach 4, Tagish Lake and Orgueil exhibit identical ε^{53}Cr values within uncertainties which differ significantly from the one measured in Murchison and Allende. The ^{53}Cr and ^{54}Cr anomalies are anti-correlated (comparison of Fig. 1 with Fig. 2).

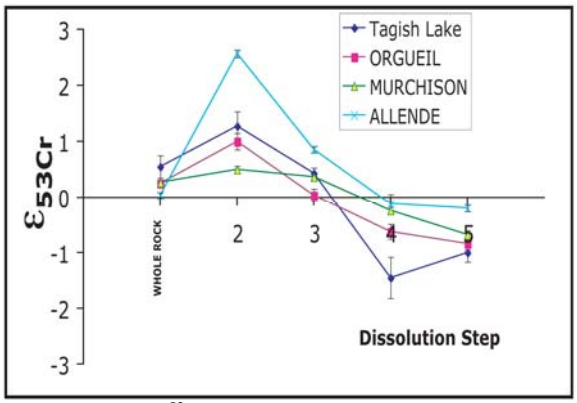

Figure 2. ^{53}Cr variations among sequentially dissolved fractions of bulk rock carbonaceous chondrites measured in this study and in [3]. Data at 1 are whole rock data.

The dissolution of carbonates, sulfates and sulfides during the first 2 leaching steps produce the highest ^{53}Cr excesses (Allende>Tagish Lake, Orgueil>Murchison), whereas the disintegration of the silicate portion in step 4 generates ^{53}Cr deficits (Tagish Lake>Orgueil>Murchison>Allende). The secondary minerals, i.e. carbonates, sulfates, precipitated as a result of extensive aqueous alteration on the respective parent body of Orgueil and Tagish Lake, during which the the Mn-Cr system may have been mobilized. No correlation is observed between the ^{55}Mn/^{52}Cr ratio and the ε^{53}Cr value measured for each dissolved fraction. This suggests that the ^{53}Cr excesses are not linked to the radioactive decay of ^{53}Mn or if they are related to ^{53}Mn decay the system is strongly disturbed.

Whole rock: The ^{54}Cr anomaly determined for the Tagish Lake whole rock is within error equal to the one of Murchison. In contrast, the ^{53}Cr anomaly measured in the Tagish Lake whole rock is the highest so far, being a factor 2 higher than the one obtained in the Murchison and Orgueil meteorites. The ^{55}Mn/^{52}Cr ratio in the present data set is twice as high as in [12]. Thus, on the bulk rock carbonaceous chondrite correlation line from [13], our Tagish Lake value plots the highest but on it.

Conclusion: The ^{54}Cr excesses reported in this study for Orgueil are within the range of already published values. However, we report the highest ^{54}Cr excess so far for the silicate fraction of Tagish Lake. The high excess measured for Tagish Lake reinforces the fact that Tagish Lake is made up of very pristine material (the most pristine of all according to this study) and strengthens suggestions that Tagish Lake may have originated from a comet or a type-D asteroid in a cold region beyond the asteroid belt, where its components could have conserved their pristine signatures. The magnitude of ^{54}Cr variation decreases now in the following sequence: Tagish Lake, Orgueil (CI1), Murchison (CM2) and Allende (CV2). Finally, these large excesses make from Tagish Lake a major target for deciphering the carrier phase of the ^{54}Cr anomaly.

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