CHROMIUM-54 CARRIERS IN A TAGISH LAKE RESIDUE: A NANOSIMS STUDY. E. Jacquet[1], M. Petitat[2], S. Mostefaoui[2], M. Gounelle[2,3], J.-L. Birck[4], T. H. Luu[4,5]. [1]Canadian Institute for Theoretical Astrophysics, University of Toronto, 60 St George Street, Toronto, ON, M5S 3H8, Canada (ejacquet@cita.utoronto.ca). [2]Laboratoire de Minéralogie et de Cosmochimie du Muséum, CNRS & MNHN, 57 rue Cuvier, 75005 Paris, France. [3]Institut Universitaire de France, Maison des Universités, 103 boulevard Saint-Michel, 75005 Paris, France. [4]Laboratoire de Géochimie et Cosmochimie, Institut de Physique du Globe de Paris, Sorbonne Paris Cité, 1 rue Jussieu 75238 Paris cedex 05, France. [5]Centre de Recherches Pétrographiques et Géochimiques (CRPG)-Nancy Université-CNRS, UPR 2300, 15 rue Notre-Dame des Pauvres, Boîte Postale 20, 54501 Vandoeuvre-lès-Nancy, France.

Introduction: Notwithstanding decay products of short-lived radionuclides or disk processes e.g. for oxygen [1], isotopic anomalies in meteoritic material [2] point to incomplete homogenization of nucleosynthetic components [3]. Such is in particular the case of ^{54}Cr, for which variations have been evidenced from refractory inclusion [4] or whole-rock analyses [5-11], with carbonaceous chondrites having ^{54}Cr/^{52}Cr ratios higher by up to 2 parts per 10,000 than enstatite and ordinary chondrites [7]. Identification of the carrier of ^{54}Cr would shed light on its astrophysical source, and hence the stellar environment of solar system formation, as well as the origin of chondrite groups [3].

Early sequential dissolution experiments obtained the largest anomalies (at the percent level) for leachates resulting from addition of hot hydrochloric acid (e.g. [5], [11]), while subsequent dissolutions in hot hydrofluoric+nitric acid yielded smaller ^{54}Cr excesses. NanoSIMS imaging of Orgueil (CI1) fractions treated by acetic+nitric acids and sodium hydroxide, dominated by spinels, by [12] enabled detection of 2 nanoparticles with ^{54}Cr/^{52}Cr > 3.6 x and 1.3 x the solar value. [13] found 10 grains, most likely spinels too, in CsF/HCl residues of Orgueil with up to 2.5 x solar ratios, likely lower limits due to beam overlap with isotopically solar grains, as confirmed by [14-15]. Both studies concluded that these were presolar grains synthesized in type II supernovae. Unequivocal recognition of the presumed spinel grains of [12] as responsible for the ^{54}Cr anomalies of chondrites is hampered, besides low statistics, by the fact that spinel would not be expected to be dissolved by HCl [6] although experiments by [12] suggest otherwise for the smallest grains; the residues of [13], on the other hand, are posterior to HCl treatment, making correspondence with the high anomalies of HCl leachates ambiguous.

In this study, in the hope of securing identification of the carriers of ^{54}Cr, we have turned our attention to Tagish Lake (C2) whose HCl leachates are the ^{54}Cr-richest measured for any meteorite [11]. We have imaged samples of the residue #3 of [11], that is, the one *prior* to HCl treatment, after the (non-anomalous) majority of Cr has been removed by acetic and nitric acids, but with silicates still extant.

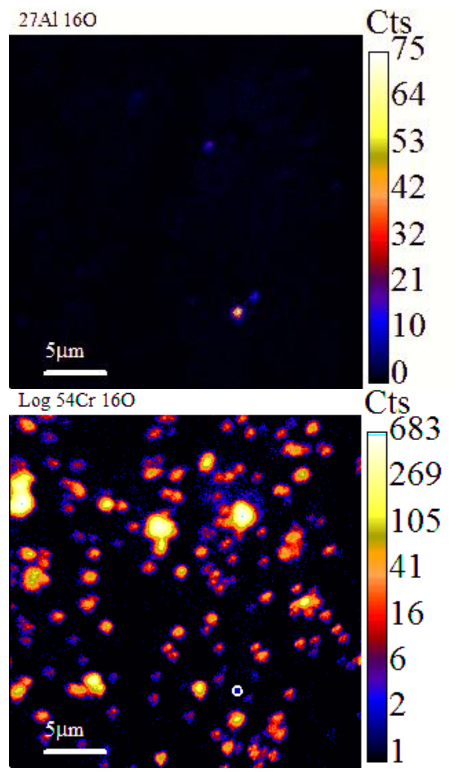

Figure 1: *30x30 µm^2 image where the ^{54}Cr-richest grain was found (the brightest one in the AlO$^-$ map and circled in the ^{54}CrO$^-$ + ^{54}FeO$^-$ one, where most of the hotspots are ^{54}Fe hotspots).*

Methods: Aliquots of Tagish Lake residue #3 of [11] pressed against gold foils were analyzed using the NanoSIMS 50 of the Muséum National d'Histoire Naturelle of Paris. A Cs$^+$ beam of 22.5 pA was rastered over 40 x 40 µm^2 or 30 x 30 µm^2 areas ("survey") of the sample (e.g. Fig. 1). Measurement time was 500 µs per pixel (with typically 256 x 256 pixels per image) and typically 20 planes were acquired per area. Use of Cs$^+$ enhances spatial resolution compared to O$^-$ beams used by [12-13] (see also [14-15]). The measured secondary ions were ^{18}O$^-$, ^{28}Si$^-$, ^{27}AlO$^-$, ^{52}CrO$^-$, ^{56}FeO$^-$, ^{26}MgO$^-$, ^{54}CrO$^-$ + ^{54}FeO$^-$, necessitating a second magnetic field for the latter two. The data were analyzed using the L'Image software (L. Nittler) and interference of $^{54}FeO^-$ with $^{54}CrO^-$ was corrected by assuming a terrestrial $^{54}Fe/^{56}Fe$ ratio (0.0637). The validity of the correction was checked for Charoy magnetite, pure chromium standards as well as chromite from the Estacado H6 chondrite. Candidate grains were reanalyzed with a 0.9 pA Cs^+ beam typically rastered over 5 x 5 μm^2 areas ("verification") around them to confirm potential nonsolar $^{54}Cr/^{52}Cr$ ratios.

Results: A total surface of 163,500 μm^2 has been scanned so far. 4 grains with corrected $^{54}Cr/^{52}Cr$ excesses up to 5 times the solar values were identified while a 5th grain shows a deficit with a corrected $^{54}Cr/^{52}Cr$ ratio of 1/4 the solar value (see Table 1).

It is conceivable that some of these apparent ^{54}Cr anomalies actually hide ^{54}Fe excesses given not insignificant $^{56}FeO^-/^{52}CrO^-$ ratios in some cases, but overall consistency of survey and verification with different resolution and thus contamination of adjacent Fe suggest nonsolar Fe isotopic composition is a minor issue. Theoretically, supersolar $^{54}Fe/^{56}Fe$ ratios, which may be expected in type Ia supernovae [16] (while subsolar ratios would prevail in type II supernovae [17]) would be accompanied by ^{54}Cr excesses [16] anyway.

As to the nature of these grains, the two ^{54}Cr-richest ones show relatively high AlO^- counts and, from relative sensitivity factors derived from the Estacado chromite, are consistent with spinels *sensu lato* with a significant chromite component for the richest one. The other grains are dominated by Cr and could be magnesiochromite ($MgCr_2O_4$) or eskolaite (Cr_2O_3). More work beyond these tentative considerations is needed.

Discussion: Our data from Tagish Lake are provisionally in agreement with previous work on Orgueil in ascribing ^{54}Cr anomalies to presolar oxide grains, likely spinels. Indeed, while the anomalies reported do not exceed a factor of a few over solar, in contrast to the order-of-magnitude anomalies seen in the Orgueil CsF/HCl residue of [14-15], the relative abundance (> 10^{-5} the surface) is sufficient, given the 1-2 order-of-magnitude Cr enhancement of the grains over the whole rock, to explain the part per 10,000 effects in bulk chondrites if these presolar carriers were distributed heterogeneously in the disk. It is interesting to note that the proportion of X grains among SiC grains, which are believed to be of type II supernova origin [18], is higher in carbonaceous chondrites than in enstatite chondrites (1 % vs. 0.1 %; [18]), the same order than that of bulk $^{54}Cr/^{52}Cr$ ratios.

This suggests the existence of an heterogeneously distributed supernova ejecta component in the protoplanetary disk, perhaps due to inhomogeneity in the parental cloud infalling onto the protostellar disk, if late injection into the disk is ruled out by overprediction of ^{60}Fe relative to meteoritic evidence [19-21]. Homogenization in the disk may have been prevented by low turbulence levels (such as may account for the distinctive chondrule population in the different chondrite groups [22]), e.g. owing to the presence of a dead zone spanning the planet-forming regions [23-24].

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Table 1: *List of presolar grains encountered in this study (for reference, solar $^{54}Cr/^{52}Cr$ is 0.0282; errors are one standard deviation).*

Grain	$^{54}Cr/^{52}Cr$ (survey)	$^{54}Cr/^{52}Cr$ (verification)	$^{56}FeO^-/^{52}CrO^-$	$^{52}CrO^-/^{27}AlO^-$
3b_3_3	0.15 ± 0.02	0.14 ± 0.04	2	0.013
1_3_5	0.101 ± 0.007	0.077 ± 0.005	0.015	0.06
13_13_1	0.069 ± 0.012	0.048 ± 0.010	0.8	177
1_3_2	0.043 ± 0.003	0.042 ± 0.008	0.25	2.9
12_2_1	0.010 ± 0.002	0.007 ± 0.001	0.3	7