Chemical Composition of a Unique Carbonaceous Chondrite Meteorite: Tagish Lake

G. J. Flynn (SUNY, Plattsburgh), A. Lanzirotti and S. R. Sutton (U. of Chicago)

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Introduction: On January 18th, 2000, after the observation of a brilliant fireball over the Yukon Territory and northern British Columbia, several dozen fragments of a meteorite were recovered from Tagish Lake in British Columbia. Additional fragments of this meteorite were recovered from the ice covered lake and from the adjacent land over the next several months. Meteorites are classified on the basis of their mineralogy and their chemical composition. The high abundance of hydrated minerals in the Tagish Lake meteorite suggests a similarity to either the CI1 or the CM2 meteorite classes. The presence of chondrules and Ca-Al-rich inclusions excludes Tagish Lake from the CI1 class. However, the carbon and volatile element contents of the Tagish Lake meteorite are significantly higher than that of the CM2 meteorites, suggesting a similarity to the volatile-rich CI chondrites (Brown et al., 2000). Brown et al. (2000) classified Tagish Lake as a CI2, a previously unknown type of meteorite.

Methods and Materials: We separated a chip, measuring ~1 mm x 1 mm x 0.5 mm in size, from an ~30 mg sample of the Tagish Lake meteorite and performed x-ray fluorescence composition measurements using the X-Ray Microprobe at X26A. The analysis beam was ~15 x 15 micrometers in size, penetrating the sample at a 45° angle. The escape depth of the fluorescence x-rays limited our analysis volume to ~10^{-8} cm^3 (a mass of ~$3x10^{-8}$ grams). Because of the small analysis volume, we performed 14 individual analyses of different spots on the chip as well as 3 spots on another chip, measuring about 200 micrometers across, that was taken from the same 30 mg fragment. We obtained element/Fe ratios for Ca, Cr, Mn, Ni, Cu, Zn, Ga, Ge, As, Se, and Br, that were converted to element abundances using the 19.3% Fe content of Tagish Lake determined by Brown et al. (2000).

Results: The averages of the 14 spot analyses of the 1 mm x 1 mm x 0.5 mm chip and the 3 spot analyses of an ~200 micrometer chip are given in Table 1. The average abundances of the moderately volatile elements (Cu, Zn, Ga, Ge, As, Se and Br) in the 1 mm x 1 mm x 0.5 mm chip agree to within ~10% with the values reported by Brown et al. (2000) on a larger Tagish Lake sample. These abundances are between the mean CM2 and the mean CI1 compositions. For example, Zn is present at about 250 ppm in Tagish Lake compared to 315 ppm in the CI1 chondrites and 180 ppm in the CM2 chondrites. However, Cr, Mn, and Ni are all higher by 25 to 30% in this Tagish Lake sample than in the one analyzed by Brown et al. (2000).

Table 1: Chemical Composition of the Tagish Lake Meteorite

Sample	Ca (%)	Cr (ppm)	Mn (ppm)	Fe (%)	Ni (%)	Cu (ppm)	Zn (ppm)	Ga (ppm)	Ge (ppm)	As (ppm)	Se (ppm)	Br (ppm)
Bulk*	0.99	2840	1450	19.3	1.16	116	253	8.4	30	1.74	14.3	2.8
SXRF Avg. 14	0.7	3550	2000	19.3**	1.45	126	240	7	27	<3***	16	~2
SXRF Avg. 3		3000	1700	19.3**	1.6	130	290	8	35	<3***	25	~2

*from Brown et al. (2000) ** Fe fixed at 19.3% in SXRF data reduction ***As includes a contribution from Pb

Element abundance patterns can be used to monitor the degree of terrestrial alteration or contamination of meteorites. This is particularly important in the case of the Tagish Lake meteorite because CI and CM carbonaceous chondrites are rather porous, and some fragments were recovered months after the fall and after exposure to water from the melting snow. Chondritic micrometeorites and some meteorites that have been exposed to water are depleted in S, Ni, and Se, reflecting the aqueous removal of sulfates. Many meteorites show evidence of terrestrial contamination by elevated levels of Pb or halogens (such as Br). The ~30 mg sample of Tagish Lake has a Se content comparable to the larger sample analyzed by Brown et al. (2000) and shows no evidence for elevated levels of Pb (which has an L-line near the As K-line) or Br (see Table 1).

Our measurements also provide the opportunity to assess the heterogenity of the Tagish Lake meteorite. The individual spot analyses show variations from the mean of no more than a factor of three, quite a bit smaller than the range we measured for ~10^{-8} cm^3 fragments from the CM2 meteorite Murchison, but comparable to the range we measured for ~10^{-8} cm^3 fragments of the CI1 meteorite Alais. This low degree of heterogenity indicates that, within this sample, the mean grain size is significantly smaller than the ~10^{-8} cm^3 analysis volume.

Conclusions: The element abundances in these two small chips taken from an ~30 mg fragment of the Tagish Lake meteorite are consistent with the composition of a larger sample of Tagish Lake analyzed by Brown et al. (2000) indicating a low level of compositional heterogenity among different pieces of this meteorite. The volatile element abundances are between those of the CI1 and CM2 meteorites, indicating that Tagish Lake is a new type of carbonaceous chondrite meteorite. The Se and Br contents, and the absence of detectable Pb, suggest this ~30 mg sample of the Tagish Lake meteorite has experienced no more terrestrial alteration or contamination than the larger sample analyzed by Brown et al. (2000).

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References: P. G. Brown et al., The Fall, Recovery, Orbit, and Composition of the Tagish Lake Meteorite: A New Type of Carbonaceous Chondrite, Science, 290, 320-325, 2000.