Meteoritics & Planetary Science 37, 619–621 (2002)
Available online at http://www.uark.edu/meteor

From the Editors

Tagish Lake

The history of meteoritics is punctuated by meteorite falls that due to their unusual composition, timing, or locale have catalysed progress in the field. The shower of stones near L'Aigle, France on 1803 April 26, occurring near the height of the debate concerning the origin of "Thunderstones", coupled with the fall's proximity to one of the major centres of that debate (Paris), and its detailed investigation by Jean-Baptiste Biot, was one of the most important events leading to the acceptance of an extraterrestrial origin for meteorites (as previously proposed by Ernst Chladni in 1794) by the scientific community. The large falls of carbonaceous chondrites at Allende, Mexico and Murchison, Australia in 1969 occurred just as labs around the world were gearing up for the return of lunar samples. These falls provided unusual material in quantity to those labs looking for ways to exercise new analytical techniques developed for the lunar samples. These two meteorite falls have stimulated work that has led to significant advances in our understanding of meteorite parent-body processes, nebular cosmochemistry and cosmochronology. More recently, the martian meteorite Allan Hills (ALH) 84001, although a find rather than a fall, has re-ignited the debate over life elsewhere in the solar system, and once again led to a broad revival in research in associated areas.

It is in this context that the fall of an unusual carbonaceous chondrite on Tagish Lake in northern Canada on 2000 January 18 should be viewed. Why is Tagish Lake so special? It does not seem to fit into our existing meteorite taxonomy, having characteristics that set it apart from any other meteorite. On the basis of the elemental composition of Tagish Lake, Friedrich *et al.* (2002) conclude that it is distinct from either the CI or CM chondrites with evidence of little or no thermal metamorphism. Similar conclusions are reached in the geochemical analysis of Mittlefehldt *et al.* (2002), and the mineralogical work described by Zolensky *et al.* (2002). However, Zolensky *et al.* (2002) note that the mineralogy of Tagish Lake is similar to Antarctic micrometeorites, and submillimeter-sized clasts found within howardite–eucrite–diogenite (HED) achondrites, as well as one unusual clast found within the equally unusual Kaidun meteorite. This indicates that Tagish Lake-like compositions are more typical of the extraterrestrial matter colliding with the Earth than macro-meteorite collections suggest. Pizzarello and Huang (2002) argue that the pathways for organic synthesis are quite different in Tagish Lake as compared to CI/CM systematics. In contrast, Grady *et al.* (2002) conclude on the basis of carbon systematics alone that Tagish Lake has greater similarity with the CI chondrites, lending support to a CI2 classification. The pervasive though incomplete aqueous alteration, presence of remnant chondrules, and high carbon and water content of Tagish Lake leave no doubt that it is a type 2 carbonaceous chondrite, but our certainties end there. Its precise taxonomic placement will not be resolved until additional work is accomplished on this enigmatic meteorite, or, more probably, until additional equally primitive meteorite samples are recovered.

The opportunity to better understand early solar system organic chemistry processes using Tagish Lake seems promising. Indeed, the relatively high carbon and water content of this meteorite, the lack of evidence for high-temperature alteration, the record levels of preserved interstellar materials as reported by Grady *et al.* (2002), low bulk density (1.6 g cm^{-3}), and extreme porosity (40%) are all consistent with a primitive body whose origin is farther from the Sun than any other meteorite. Tagish Lake has been identified as spectroscopically similar to D-class asteroids (Hiroi *et al.*, 2001). Perhaps Tagish Lake is our first sample from the primitive P and D asteroids of the outer belt; if so, the low amino acid concentration found by Kminek *et al.* (2002) suggests that we may have to reevaluate the canonical wisdom concerning the organic content of these bodies.

That Tagish Lake is in our collections at all appears to be the result of the confluence of an unlikely set of circumstances. The large initial mass of the meteoroid (~60 tonnes), its low entry angle and low entry velocity (resulting in lower peak ram pressures), and its fall in winter on a frozen lake surface where it was not exposed to liquid water until the spring melt, all contributed to unusually favourable (if brief) recovery circumstances for Tagish Lake. Most extraordinary of all is the manner in which material was first collected. Local resident Jim Brook came upon fragments of Tagish Lake on the ice of Taku Arm of Tagish Lake only a week after it fell. He had the awareness to not touch any of the specimens, wrapped them in plastic bags and kept them frozen. In all some four dozen specimens totalling ~870 g were collected in this way and most remain frozen. This makes Tagish Lake among the most pristine of recovered meteorites, a remarkable circumstance for such an unusual meteorite that may benefit so much from cold storage. The spring melt afforded another opportunity to recover 5 to 10 kg of specimens that had been water saturated, and to map out a strewn field at least 16 km long.

Also of notable significance, the fireball of the Tagish Lake fall was well-documented instrumentally allowing determination of its pre-fall orbit, the first for a carbonaceous chondrite, and the fifth for any meteorite. Analysis of the satellite recorded light curve of the fireball's terminal disruptions has established limits on the physical characteristics of the pre-atmospheric meteoroid, revealing a high-porosity, low-density, low-strength object (Brown *et al.*, 2002). The Tagish Lake meteoroid bridges the fireball-derived strength characteristics of carbonaceous chondrites at their weakest and cometary bodies at their strongest. This multi-sensor examination of the Tagish Lake fall emphasizes the powerful contribution that fireball data offers to address the physical properties of small asteroidal and cometary bodies.

The Tagish Lake fall allowed recovery of the physically weakest meteorite known to date. Its recovery suggests that from time to time, on intervals of years to decades, the meteoritical community will have the opportunity to recover analogous unusual weak material, possibly including the stronger fraction of cometary material such as devolatised crusts. Reflecting the prodigious number of meteorite recoveries from Antarctica, Campins and Swindle (1998) suggest that the burgeoning Antarctic collections might some day include cometary meteorites. However, the weathering behaviour of Tagish Lake indicates that this is unlikely. When exposed to water these porous phyllosilicate-rich meteorites rapidly disaggregate. Two decades of experiments (*e.g.*, Folco *et al.*, 2002) have shown that much larger and denser meteorites are transported by the katabatic winds of the ice cap. Disaggregated, porous meteorite fragments are probably rapidly removed by the wind in Antarctica. This effect is demonstrated by the dearth of CI chondrites recovered from Antarctica relative to the proportions of other types of recovered meteorites (including CM chondrites) as compared to the population statistics established by falls. Thus, this type and any other similar or weaker/more porous meteorite types are probably rapidly destroyed by disaggregation and wind transport when exposed on the Antarctic ice cap.

Our best opportunity for recovery of fragile meteorites of asteroidal or cometary origin is through fresh falls. In Canada an opportunity somewhat analogous to Tagish Lake occurred with the fall of the Revelstoke CI chondrite on 1965 March 31. Sometime during the middle of April, two trappers, Elmer Coats and Alfred Daniels, found several pieces of already disaggregated CI chondrite in snow-covered ice across a distance of ~800 m (Folinsbee *et al.*, 1967). The significance of this discovery was not immediately appreciated by concerned investigators, so that the chance to recover CI material from a fall probably larger than Tagish Lake was missed. In Canada a federal government sponsored group charged with investigating fireballs has existed since 1960; it is currently called the Meteorites and Impacts Advisory Committee to the Canadian Space Agency. This group was originally constituted in part to preserve a corporate memory of how to investigate fireballs to take advantage of these somewhat rare and episodic events; this maintenance of awareness was at least partly responsible for the efforts (that turned out to be very fruitful) to recover meteorites during the spring melt at Tagish Lake. However, despite this corporate awareness, finding funding for the field investigation was still more difficult than it might have been.

The international meteoritical community has a challenge in creating a pool of experienced fireball investigators and a funding mechanism to support field efforts to exploit the opportunities created by fresh meteorite falls. Investigation of fireballs to locate meteorites is something of a lost art amongst many meteoriticists. This challenge is complicated by the national boundaries that cross our meteorite collecting surface, but may be within the capabilities of the Meteoritical Society. The theory applied to modelling the light curve of Tagish Lake (Brown *et al.*, 2002) offers the prospect of our being able to assess (and prioritize) all the satellite-observed, large fireballs for falls of low-velocity, high-porosity, weak material of greatest research value. However, another recent discovery, that of halite in two fresh ordinary chondrite falls (*e.g.*, Rubin *et al.*, 2002) suggests that all fresh falls deserve attention.

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