

Water geochemistry of cryoconites in Eqip Sermia Glacier, Greenland: preliminary data

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Abstract

Current climate warming is accelerating mass loss from most of the arctic glaciers. The Greenland Ice Sheet (GrIS) has also experienced dramatic ice melt in recent years (Koenig et al., 2016) with an increase in crevices that serve as conduits (called moulins) that transport meltwater rapidly into the glacier (Figure 1, down). Water, flowing through these moulins down to the bottom of the ice sheet

and towards the sea, can modify the primary geochemical signature of precipitation. Moreover, a certain part of the glacial surface is dispersed by cryoconite holes, near-vertical tubes formed as consequence of melting induced by solar heating of dark debris (Cook et al., 2016) (Figure 1, up). Cryoconite hole may contribute to the glacial runoff on ablating ice surface (Fountain et al., 2008).

Although a big effort has been done from the scientific community in order to interpret the sedimentary records of past extreme events in arctic areas, rather little is known about the geochemistry of glacial meltwater input into the oceans.

For this reason, it is of interest to measure the concentration of elements accumulate in the unmelted ice body and on the meltwater within cryoconite holes flowing into the moulins. In this study the preliminary data about the major element compositions and the heavy metals level of ice and meltwater collected on Eqip Sermia Glacier (Greenland) are examined.

Eqip Sermia Glacier is located close to Disko Bugt, in the central-western coast of Greenland, and represents the link between GrIS and its largest ice-free expanse proglacial area (Figure 2). During GRAAL II expedition (Greenland Research Animal and Algae) organized by SpéléIce Association in summer 2010 (Romeo et al, 2014), samples for geochemical analysis were collected in a region situated at 967 m asl, tens of kilometres from the glacial margin of the southern lobe (69°36 N - 49°47 W). Sampling took place within cryoconite holes (C4G) and inside the Fossil Moulin (C3G) at 15 m below the glacier surface (Figure 2).



Figure 1: Cryoconite holes (up) and Fossil Moulin (down) in the Eqip Sermia Glacier (photos Alessio Romeo).

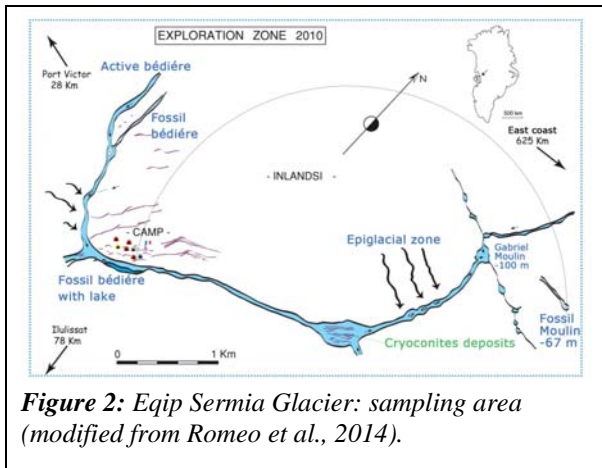


Figure 2: *Eqip Sermia Glacier: sampling area (modified from Romeo et al., 2014).*

Cryoconite water and unmelted, relatively-old ice from the cave wall were stored in pre-cleaned polyethylene plastic bottles in the dark at 5 °C and analysed after filtering through 0.4 µm pore-size in the laboratory. Major ions were measured with ion chromatograph while heavy metals were determined through ICPMS at the Chelab (Treviso, Italy).

These preliminary results show that unmelted old ice has a high salinity and solute concentration respect to cryoconite water which is exceptional much lower. The Total Dissolved Solid (TDS) values are 9 mg/L and 1 mg/L in ice and cryoconite water, respectively. In this poorly

buffered system, pH values are around 6.7 in the cryoconites hole and 6.4 in the ice.

Figure 3 (up) compares the concentrations of major species in glacier ice and cryoconites hole. The general scheme of elements in decreasing order of their concentration for the cryoconite sample was $Cl^+ > Na^+ > SO_4^- > K^+ > Ca^+$ while for ice was $Cl^- > Na^+ > K^+ > HCO_3^- > Ca^+$.

Similarity in trends in the two sample types confirms that the environment indeed contains these elements in that order of abundance, exception for sulphate that was detected only in cryoconite hole suggesting that oxidation and/or dissolution of trace sulphides and sulphates in dust is important supply water within the holes.

The chemical composition of the dust also impacts on bicarbonate concentration. As its composition is mainly silicate, consisting of high abundance of quartz particles with almost the same proportion of albite and hornblende (Sanna & Romeo, 2015), its weathering provide irrelevant quantity of bicarbonate.

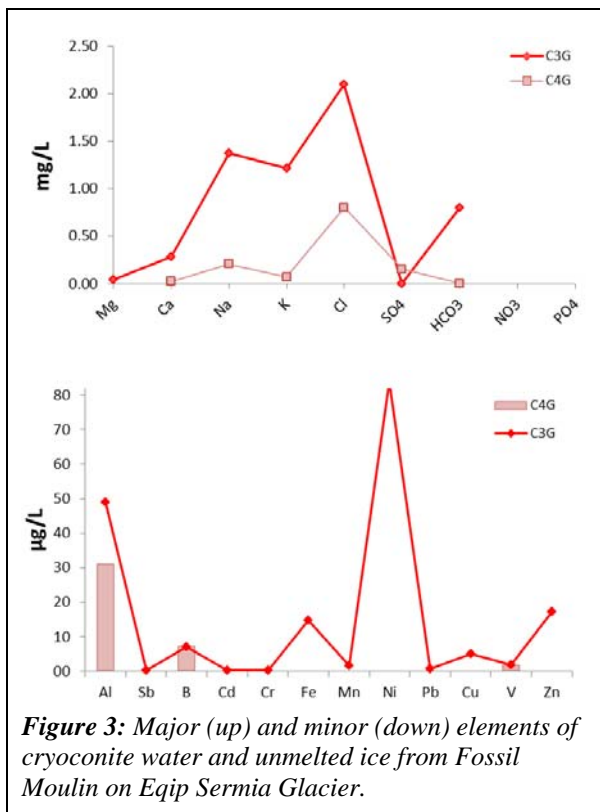
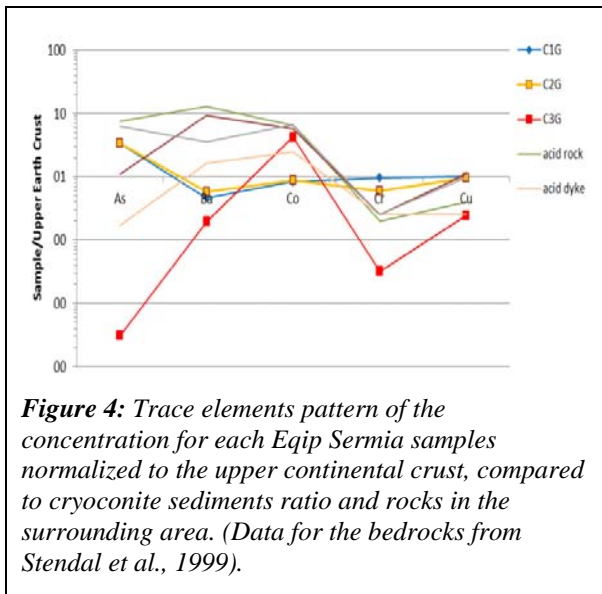


Figure 3: *Major (up) and minor (down) elements of cryoconite water and unmelted ice from Fossil Moulin on Eqip Sermia Glacier.*

The $Ca^+ : Cl^-$ equivalent ratio of 0.238 in Fossil Moulin ice (greater than seawater ratio of 0.038) also suggests significant terrestrial input of terrestrial particles to the surface of Eqip Sermia Glacier at the time of deposition. The 0.049 value in cryoconite water is close to snow ratio of 0.20. Moreover the nitrate is under detection limit likely because lost to post depositional diffusion in the ice and/or by biological uptake and autotrophic organisms living in the cryoconite holes.

Amongst the minor species analysed, aluminium has relative high concentration in both samples (Figure 3, down) followed by boron and vanadium. The trace elements pattern of unmelted ice shows a high pick for nickel and a slight enrichment for zinc, copper and iron. Figure 4 reports the trace elements pattern of unmelted ice normalized to the averaged upper continental crust (Taylor & McLennan, 1995) compared to the cryoconite sediments collected in the neighbouring area (Sanna & Romeo, 2015).



Enrichment in cobalt and depletion in arsenic, chromium, copper and barium denotes a local source probably related to the nearby altered rocks outcropping along the coast.

As suggested from this initial study, cryoconites contain the primary solutes derived directly from snow and dust, and they are flushed as they coalesce with dilute supraglacial streams during summer melt while the glacier accumulates heavy metals that can be released during melting.

Further work will be required to correctly interpret the geochemical input recorded in the ocean of extreme warm events that inject large quantity of meltwater.

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