JAROSITE DETECTION IN EVAPORITIC SHORELINE CRUST FROM A SMALL LAKE ON THE MARGIN OF THE GREENLAND ICE SHEET. P. D. Cavanagh[1] and L. M. Pratt[1], [1]Indiana University, 1001 East 10th Street, Bloomington, IN 47405 (pdcavana@indiana.edu).

Introduction: Low-temperature geochemical processes, crystalline bedrock, and continuous permafrost in southwestern Greenland serve as a useful analogue for modern Mars and provide insight into freeze/thaw processes in lakes on early Mars. During summer field campaigns in 2014 and 2015, sediment and rock samples were collected from the watershed of a small lake (Triangle lake: **N67° 04.695' W50° 20.287'**) perched on a terrace above the Watson River near an active lobe of Greenland Ice Sheet known as the Russell Glacier (Fig. 1). A stratigraphic section with about 5 meters of thinly interbedded feldspar-rich quartzites and amphibolites is exposed at the south end of the lake. One amphibolite sample was analyzed using X-ray diffraction (XRD). Visual inspection with a hand lens and XRD data were the basis for determining that pyrrhotite was present in the sample and likely contributing to elevated contents of sulfur in the surrounding area. XRD results from evaporitic shoreline deposits on the margin of Triangle lake indicate the presence of Fe-sulfates.

The evaporitic deposits are evident in concentric bands around Triangle lake except for a portion of the shoreline buried by an encroaching dune. Patches of yellow, black, and white minerals were sampled from the evaporitic crust adjacent to damp sand on the shoreline. Each of the three samples was analyzed for mineralogy using XRD.

Unexpected high levels of the Fe-sulfate jarosite, $(K,Na)Fe_3(SO_4)_2(OH)_6$, were detected in the yellow crust in addition to common evaporate minerals. Questions related to the formation of jarosite on Mars have reemerged following the detection of jarosite by CheMin at Gale Crater [1] and an earlier discovery by the Mars Exploration Rovers [2]. Low temperature Earth analogues such as Greenland provide accessible environments in which to study the formation of jarosite and related evaporate minerals and the ability of these minerals to shed light on potential paleoclimates of early Mars.

Methods: XRD analysis was done on whole-crust samples prepared by freeze drying and powdering in a corundum mortar and pestle. XRD measurements were performed using a Bruker D8 X-ray diffractometer, measuring from 2-70° 2θ at 2 sec./step (step size=0.02° 2θ). The XRD data were analyzed using Bruker EVA software for mineral identification and Bruker TOPAS software [3] to determine quantitative abundance information using Rietveld refinement.

During the 2015 field campaign, water samples were also collected from Triangle lake. Ion chromatography was performed using an ICS-2000.

Results: *Bedrock mineralogy*. The metasedimentary bedrock consists of variably feldspar-rich quartzites with interbeds of friable amphibolites. Analysis of the weathered amphibolite by XRD (Table 1) reveals a mineralogy consisting largely of hornblende (~74%), followed by minor amounts of pyroxene, feldspars, phyllosilicates (chlorite and muscovite), and trace amounts of sulfide. Pyrrhotite ($Fe_{1-x}S$) (x=0-0.2) was detected in trace amounts and is consistent with an observed mineral having a granular habit, metallic bronze luster, and magnetic properties.

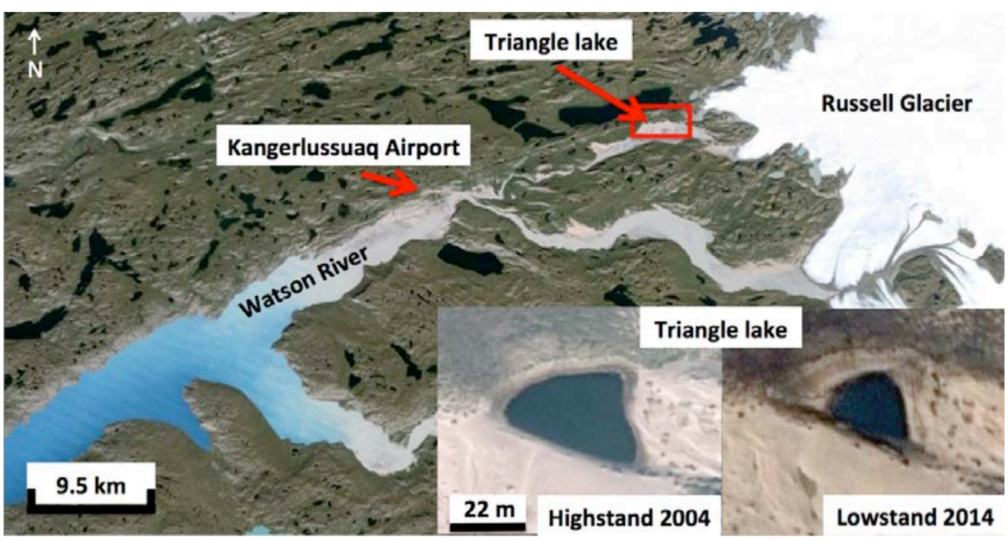

Figure 1. Study site located west of the Russell Glacier. Paired inserts depicts the location of Triangle lake and the encroaching dune on the southwest shoreline. Evaporitic shoreline crusts are visible as concentric bands on two sides of Triangle lake in the image from the 2014 lowstand.

Phase	Wt%	Error
Hornblende	73.5	1.7
Chlorite	9.4	1.4
Augite	6.0	0.6
Orthoclase	2.9	0.7
Albite	2.4	0.9
Hematite	2.4	0.5
Muscovite	1.3	0.6
Pyrrhotite	1.3	0.3
Quartz*	0.8	0.3
Sum	100.0	

Table 1. Crystalline mineralogy of amphibolite sequence in metasedimentary bedrock. (* - At or near detection limit)

Triangle lake. Triangle lake water samples from 2015 had a sulfate concentration of 518 mg/L. Additionally, fluoride and chloride concentration were measured at 0.17 mg/L and 13.4 mg/L, respectively. Other common anions were not present above detection limits. Measured pH was approximately 4. XRD analysis of the yellow crust from Triangle lake (Table 2) shows ~12% jarosite, in addition to trace amounts of ferrihydrite (~0.1%).

Phase	Wt%	Error
Quartz	30.4	2.5
Gypsum	23.6	6.1
Plagioclase	19.2	1.8
Jarosite	11.8	1.0
Microcline	8.3	0.9
Muscovite	2.4	0.6
Diopside	2.2	0.4
Hornblende	2.1	0.5
Ferrihydrite*	0.1	0.1
Sum	100	

Table 2. Crystalline mineralogy of Triangle lake yellow mineralized crust sample. (* - At or near detection limit)

Discussion: The region near Triangle lake receives less than ~360 mm annual precipitation [4] and is underlain by continuous permafrost that has an estimated thickness of 127 +/- 31 meters with seasonal active layer extending down to 0.15 to 5 meters [5]. The presence of permafrost limits the interaction of near-surface weathered deposits with groundwater sources. Thus, small perennial lakes represent a prime location to study local weathering processes related to exposed bedrock. We propose that the source of iron and sulfur contributing to the precipitation of jarosite in the evaporitic crust at Triangle lake results from oxidation of pyrrhotite detected in an adjacent outcrop of metasedimentary rock.

Jarosite on Earth. Jarosite is commonly known to occur in many different environments on Earth, including weathered gossan deposits in Canada and Greenland [6, 7], near-surface playa deposits in acid-saline lake settings such as those found in Australia [8], and acid mine-drainage locations like the Rio Tinto River [9, 10]. In all of these environments, there is a common theme of proximity to or discharge from a pyrite-bearing ore deposit. The mineralized crust at Triangle lake has no groundwater inflow and is mildly acidic compared to other reported sites of jarosite precipitation.

Conclusions: The detection of jarosite confirms that there is an active weathering process providing local sources of sulfur for lakes and ponds isolated by permafrost. Oxidation of pyrrhotite, subsequent leaching of sulfate and H^+ are inferred to cause an unusually low pH in Triangle lake. Nearby lakes sampled during field campaigns are near-neutral pH or slightly alkaline but Triangle lake has a pH of ~4, consistent with the upper stability limit for the formation of jarosite [11]. Future work will include sequential sulfur extraction of the samples collected from the evaporitic crusts and the adjacent exposure of metasedimentary strata. Additionally, thin sections made from the bedrock will be analyzed using SEM and microprobe techniques.

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