

8th September 2021

MLSA

Via Email

Dear Sirs,

A concerned local visitor and a shareholder of Greenland Minerals & Energy

I am a shareholder of Greenland Minerals & Energy (GGG) and former owner of Kvanefjeld. As such I am very familiar with the Kvanefjeld area for over 25 years and have visited it on numerous occasions. As a former owner I have logged many kilometres of core from this deposit. I am also in the unique position of having a complete copy of every scientific article written on the Ilimaussaq intrusion, which number in the thousands. I have read the company's EIA and as someone who has such a keen interest in South Greenland and its people, and as someone who has repeatedly asked the company a series of questions as a shareholder of Greenland Minerals about the EIA, to which I have never received any satisfactory answers. Thus, I have no option but to ask my quite worrying questions in this more formal way. Below is a summary of the major problems I see now giving the company an opportunity to answer. Full back up material is available if required to all questions.

This I have divided up into a number of separate sections.

1. Mullock Dump (Mullock is defined as coarse size waste and low grade ore not put through the plant)

- a. What was the S.G. used for the disposal of material on the mullock dump as it appears to have been assumed to be 2.8 (when it is probably closer to 1.4)? Is this dump large enough to store the mullock, taking into account the much lower S.G. of the loose mullock.?
- b. The potential mullock material based on drill core examined by myself in 2005-07 showed that the main waste is the rock type naujaite. Examination of the core shows that the naujaite does contain thin veins of both mineralised black lujavrite (refer to **Figure 2**) as well as veins of almost pure villiaumite (NaF) – as seen in the photo below of a piece of core which contains one such villiaumite vein in naujaite from the Kvanefjeld area (**Figure 1**).

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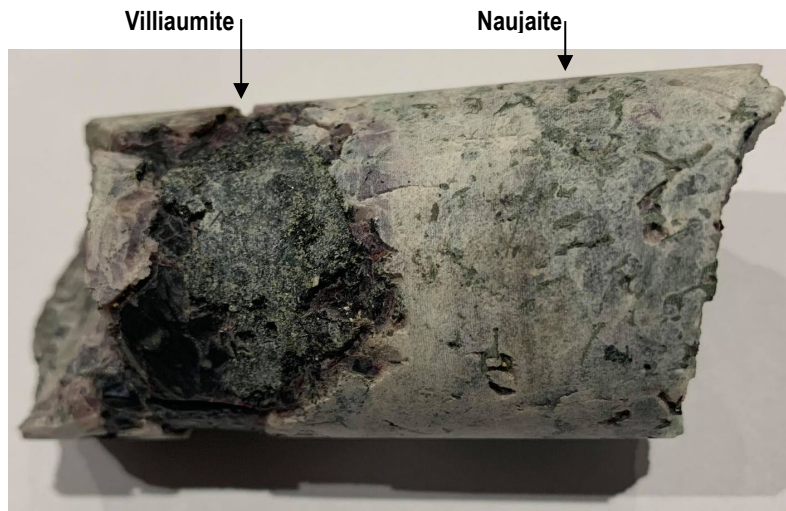


Figure 1 - Vein of villiaumite from Kvanefield

I believe that the mullock dump will contain considerable amounts of fluorine from these sources. I also believe it will contain more thorium, uranium, and soluble phosphate than recorded as it cannot be separated from the mullock. The EIA appears to assume this material will not be present in the dump and the samples appear to be tested on samples of pure naujaite, basalt etc and not a realistic mix.

- c. The EIA appears to infer that none of the uranium enriched black lujavrite ore will make it to the mullock tailings dump. Below is a picture of the cliff face from the fjord (the photo is thus hundreds of metres long and high). In this photo the ore is black while the non-ore is white (here the larger pieces are coloured in yellow to make it clearer). It can be seen that the pieces of the white waste (naujaite) vary from very small to very large and vary greatly in shape. Also present (see yellow circle ore in below picture are narrow veins of black ore within a waste white background). **Can the mining applicant please explain how, when mining say on a 1 or 2m benches it will be possible to get such a clean separation between the 2, especially as when mining dust covers everything? It appears the testing has relied on samples of pure product i.e. all naujaite or all basalt etc and not the mixed ore – waste realistically expected.**

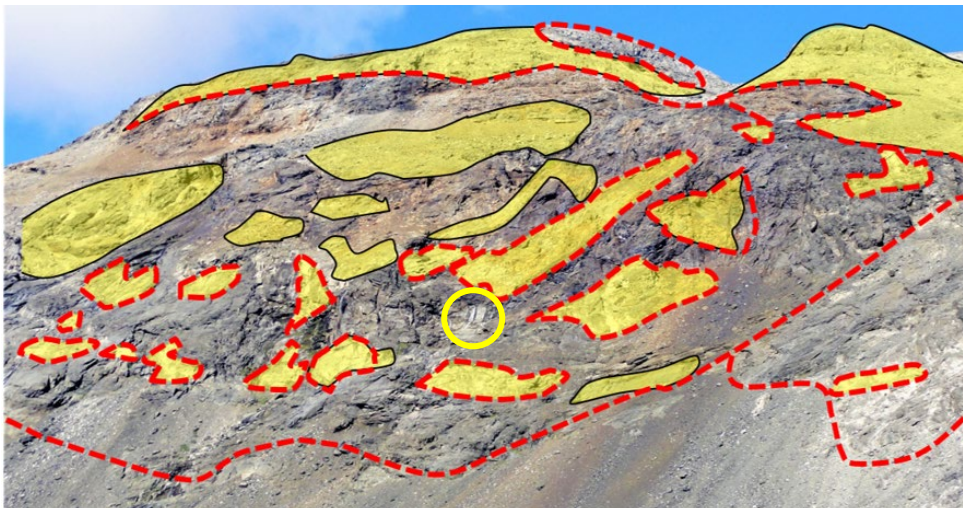


Figure 2 - note in this view the white (larger pieced coloured yellow) is waste - mining to exclude waste will be very difficult to get 100% separation when mining on horizontal benches of say 2m

- d. I believe the mullock dump will contain soluble fluorine and phosphate along with thorium and uranium (with their daughter elements, particularly radon and actinium) the waste will also be extremely alkaline. I feel the measures set out in the EIA do not satisfactorily explain how the company is to overcome these potential environmental problems. Is there a more detailed explanation?

Are there any mitigating factors to stop windblown debris containing the dangerous soluble fluorine or the fertiliser phosphate beyond the area of the dump and particularly impeding on the town of Narsaq?

Can these pollutants be sufficiently contained by the existing dumps when water is added by rain or snow?

2. Physical Tailings Dam (after crushing and separation by floatation)

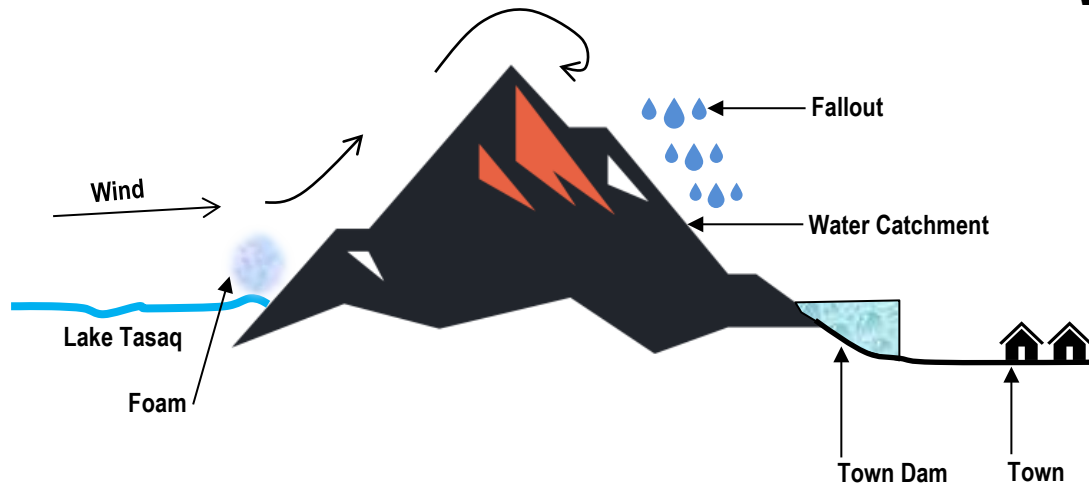
- a. As the fluorine content of the rock is 2-5% with zones as high as 10%, (reference personal logging of the core), but the company has said it only recovers 0.3%, therefore is it a correct assumption that the remainder of the fluorine will remain dissolved in the physical separation lake? Note, some years ago an academic, without looking at the core, suggested that villiaumite will be dissolved from the 1st 50m when actually it has been spotted within 5m of the surface in drill core.

As this lake will also have small amounts of soap waste (from the floatation) one would expect this lake, when the strong foehn wind which blows from the east to produce vast amounts of fluorine enriched froth (also known as aerosol), which may blow down wind over the Narsaq water supply water catchment and town site.

This aerosol type of spreading of salts is well known world wide with salt for example spreading many tens of kilometres downwind from the ocean. Why would a similar spreading of deadly sodium fluoride not occur, especially as the formation of such aerosol is favoured by the presence of soaps and strong winds.

The foehn wind blows from the east, the town of Narsaq lies in the foot of the mountain at the western end of Lake Tasaq in the direct path. In 2007 I was at the top of the mountain in a foehn wind to witness this first hand:

- i. The wind was blowing up the slope at tremendous speed and strength; and
- ii. Behind the hill in the lee indicted anything carried up by the wind was being preferentially dropped in the lee of the mountain, over the town, its water supply, and the water supply catchment i.e.:

E**W**

- b. I draw attention to other major fluorine poisoning episodes:
- i. Hooper Bay in Alaska where 261 people got sick (or died) due to 100 ppm instead of 1ppm being put into the town water supply (refer to Appendix 1);
 - ii. Lake volcanic eruption in 1783-84 where 80% of sheep and 50% of the population of Iceland died due to soluble and solid fluorine poisoning on grass, in water etc; and
 - iii. A number of other eruptions have resulted in soluble fluorine on vegetation at Mt Hekla 1970, Lonquimay Chile 1995, Nyamuragira Congo 1795, Mt Ruapehu New Zealand 2002.

Although not of volcanic eruption, here the result would be similar with potential for large areas to be covered with deadly soluble fluorine derived from froth formed in the lake and transported by the wind as froth.

- c. Similar concerns exist for the soluble phosphate from this deposit which could cause algae blooms in the fjord.
- d. The EIA reports discusses the extremely unlikely effect of a dam failure and how much the resultant slime will affect the valley, town etc. However, it does not go into the likely effects of the millions of tons of soluble fluorine and phosphate on the marine life and in particular its effect on the local industries such as fishing and farming. With a potential several million tons of soluble fluorine and somewhat smaller amounts of soluble phosphate, I would have expected comments on this potential major pollutant in the report (2-5% NaF less the 0.3% recovered. That is potential for 1.7-4.7 million tons of sodium fluoride into the ocean rapidly where it would have to be watered down to about 10 ppm to be safe, which is potentially many hundreds of km² of ocean polluted.

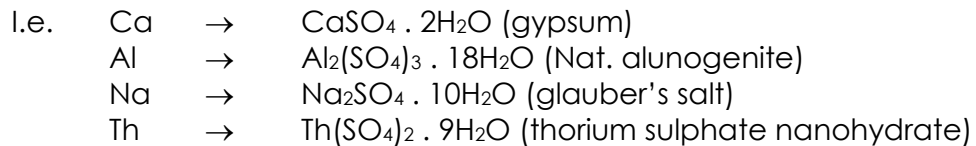
I am considerably concerned on the data presented on physical separation dam, particularly with the pollution by fluorine and phosphate both of which can cause considerable environmental damage, although in an opposite ways (fluorine kills, phosphate kills by causing an algae bloom and taking oxygen out of the water).

The question due to dam failure that has not be considered is the effect of large volumes of soluble fluorine (and to a lesser extent) phosphate into the marine environment.

3. Chemical Dam

The chemical dam presents some more of my major concerns.

- a. Is this dam large enough to store all the waste, taking into account the great increase in volume due to the possible formation of water crystallisation that can occur with sulphate salts?



There appears to be no comment as to exactly which chemical is formed in the dump and if sulphates then what is the exact amount of the water crystallisation that would be expected in these solids.

At the large lake Baotou in China, it is believed the large lake (refer to **Figure 3** below) is caused by large volumes of sulphate solids with associated water crystallisation.



Figure 3 - Lake Baotou in China

If these are the chemicals formed in this process, as for the thorium compound is it all soluble, so presumably some other thorium salt will be created prior to dumping as thorium sulphate is partially soluble. This is not stated in the EIA.

- b. This dam will contain, I presume, all the thorium and about half the uranium from the breakup of the mineral steenstrupine (the uranium can no longer be sold, so I presume it ends up in this dam)? What will be the new levels of radioactives in the dam? Considering the thorium levels are higher at the start of the mining program. What sort of variation in radioactives will there be through the dump and over time? World practices suggest a 130 ppm total radioactives for a dump. Initially at about 1300 ppm thorium (later dropping to about 500 pm) and perhaps 200 ppm uranium, plus radon, and other daughter products. This will clearly exceed these limits, although the possible great volume of water crystallisation will enormously lower these values. Again there are no notes on this in the EIA and I presume these must be in the non-disclosed notes?

With the thorium in particular higher in the beginning, it is clear it will be gradually buried by less radioactive material. Although the question of what actual compounds form there will be in the lake needs to be further explained if as suggested they occur in a soluble form, this is not explained

- c. There is a statement that 6m of water is needed to keep the radioactive radon from getting out into the environment, is there any testing to prove this 6m of water will contain the radon gas, either by the company or others?
- d. An Italian environmentalist stated at the last EURARE meeting that the levels of actinium (a radioactive daughter product) in the Kvanefjeld deposit was 8-12 times above acceptable limits. Although this contaminant would be possibly expected to go out with the concentrate, has any work been undertaken on the flow diagram of this radioactive metal? And if so, why has it not been reported.

4. The Plant

Much of the plant working diagrams are very much simplified and stylised, although this may have been explained as a need to keep security over the process (although in a process largely developed by the EU in their EURARE program and as such the data is open to all anyway). This has made an assessment of the plant environmental characteristics difficult.

There are however several points of issue that arise, just from studying these limited documentations.

- a. I assume that the thallium goes out with the zinc, only a few refineries in China (and at a great expense to the miner) will touch thallium enriched zinc. Is thallium going to be a problem either in tailing or reduced sales prices of the zinc? Thallium is the second most poisonous metal and is often called the 'poisoners poison' as it is so difficult to detect.
- b. Due to the taking of non-representative bulk samples and the fact the minerals like dorfmanite could be unevenly spread, does this soluble Na_3PO_4 have any effect on the recovery of steenstrupine? What bulk testing has been done to see the effect of saturated phosphate enriched water has on the recovery of steenstrupine and particularly the grade of the final concentrate during the floatation process. Clearly there is a need for further testing with a representative sample or at least using a saturated solution of phosphate to see what, if any the effects are, both commercially and particularly environmentally.
- c. The recycling of the water from the tailings pond to the plant has a risk of being super saturated with both fluorine and/ or phosphate – which may cause the precipitation of fluoro-apatite rather than fluorite. What bulk testing has been carried out for this eventually (a fluoro apatite may not be saleable)? In fact, has any testing been carried out on the formation of the calcium fluoride as this bulk testing is not mentioned?
- d. Both sulphuric acid and sodium hydroxide freezes at about 10°C – the freezing of such chemicals contributed to the failure of the rare earths Mountain Pass mine. What procedures are in place for this likelihood as a frozen water pipe once put Mountain pass out of production for nearly 3 months.
- e. Sodium sulphate has a great variation in solubility between the temperature of 0° and 20°C – has this been taken into account especially in the piping where a change in temperature can cause a blockage if the pipe is cooled and sodium sulphate is deposited out. Does this variation in solubility have any effect on the tailings dump stability?
- f. Is it correct that the actinium will go out with the lanthanum concentrate and that little will go to the tailings dam and are there any limits for actinium from the Chinese and shipping people?
- g. It is clear the poor recovery of the heavy rare earths along with other potential by-products such as zirconium, tantalum, niobium is due to the presence of these metals preferentially in other rare earth silicate minerals such as eudialyte. Does the company have any intentions of reworking the physical testing dump to recover these lost heavy rare earths? At one AGM of Greenland Minerals the then Chairman stated they were examining this possibility.

- h. The presence of soluble fluorine at any stage when the feed becomes acid will cause the formation of the highly corrosive hydro-fluoric acid. What safety provisions have been made for any features of pipes etc to leak or collapse due to the effect of HF. At any stage during this complex process is the feed likely to be made acidic to say aid floatation which could then form highly corrosive hydro-fluoric acid?
- i. As the waste is finely ground, plus the material which has variable solubility, this consultant is not confident that the amount of water expected to be recycled will be possible. Are other reserves of water available? Finely ground material is also notoriously difficult to get to settle out so that water can be returned. Have there been any settling tests on finely crushed waste from the plant to confirm the amount to be recycled is possible?

5. The Pit

Reading the EIA it leads to a number of questions which may have been answered elsewhere in submitted documents, including:

- a. The level of radon increases dramatically with depth. As radon is heavier in air it will accumulate at the base of the pit, will this radon be flushed out and if so where will it spread to? Is this increased radon a hazard to workers in the pit?
- b. Soluble fluorine will accumulate in the pit or mine water, is this water to be retreated or expelled into the ocean?
- c. Blasting will produce NaF in dust – only small amounts are needed to cause death. Are the workers to wear masks while working?

Conclusion

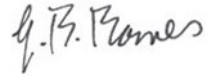
The above means that in my opinion much more has not been explained in their EIA. In my opinion the EIA needs to be expanded to cover these points.

- 1. Non-representative bulk sample (the rain had taken out the fluorine and phosphate) which could result in extreme bias through all subsequent testing. A satisfactory representative sample or samples probably taken from the adit need to be retaken and tested.
- 2. Fluorine – fluorine poisoning is possible in:
 - a. The pit as dust or in the mine water
 - b. The plant in solution or from burst pipes
 - c. In dust or dissolved in water from the mullock dump
 - d. As aerosol derived from the physical separation dumps lake
 - e. From Narsaq main drinking water supply
 - f. Major contamination of the ocean if the dam wall breaks
 - g. Not saleable as CaF due to PO₄ contamination

3. Phosphate soluble:
 - a. Promotes growth in waters of streams, lakes, and the ocean, choking off life. There appears to be no testing as to the effect of soluble phosphates on the local environment. The Russians testing on similar ore found over 40 soluble and semi-soluble minerals, mostly phosphates (they drilled with kerosene and constructed an adit to find them as an academic exercise).
 - b. Potential for major reduction in the efficiency of recovery of the steenstrupine which has, it appears, never been tested.
4. The heavy rare earths are preferentially in the silicate minerals and not the phosphate minerals (and only the phosphate minerals can be floated). Does the company have any intention to recycle the wastes at a later date to recover the more expensive heavy rare earths (they also don't recover the zirconium, tantalum, niobium etc)?
5. Sulphuric acid, sodium hydroxide, water and a number of other fluids will freeze in these arctic conditions. What has been done to overcome this?
6. Sodium sulphate – the potential waste sodium sulphate has an enormous difference in solubility between 0°C and 20°C. Has this been taken into account in the plant and the stability of the chemical dump.
7. Thallium – is known to exist, will presumably go out with the zinc where it will be a penalty. Has the economics and environmental of this dangerous metal been explained? Also is its trajectory through the plant known? Evidence also suggests this element is rare, but when found can be very common.
8. Thorium – If in the chemical lake, at what grade and in what chemical form if as a sulphate, is it soluble? Can its final chemical status be better explained?
9. Uranium – under this existing scheme about half the uranium is not recovered as it is not in a phosphate mineral and this ends up in the physical dump. Now the rest cannot be sold, where is it to be dumped and in what form?
10. Radon – This radioactive gas appears to increase greatly with depth (personal observations) thus:
 - a. What are the new levels of radon exposure from the mullock dump, now knowing a considerable amount of ore will be put there?
 - b. What is the radon output from the physical dump?
 - c. What is the radon output from the chemical dump? Actually the radon from the chemical dump can also come from the decay of thorium (which is often called thoron, which is an isotope of radon).
 - d. Knowing the radon increases with depth, what is the likely exposure to miners in the pit?
11. Actinium – insufficient data.

In conclusion, I personally favour uranium mining, but not when the wastes from this mine are particularly very dangerous and in my opinion are not adequately explained. I think the EIA needs to be expanded to cover aspects such as detailed in this summary.

Kind Regards

A handwritten signature in black ink that reads "G. B. Barnes". The signature is written in a cursive style with a large initial 'G' and 'B'.

Gregory Bennett Barnes