Industry process chemicals and discharge to the arctic environment

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Mining project in the planning phase

Most of the mines in Greenland will be **closely connected to the coastal waters**

Disposal of tailings close to the coastline or in the dam

Discharges of wastewater into the marine environment directly or indirectly via rivers.

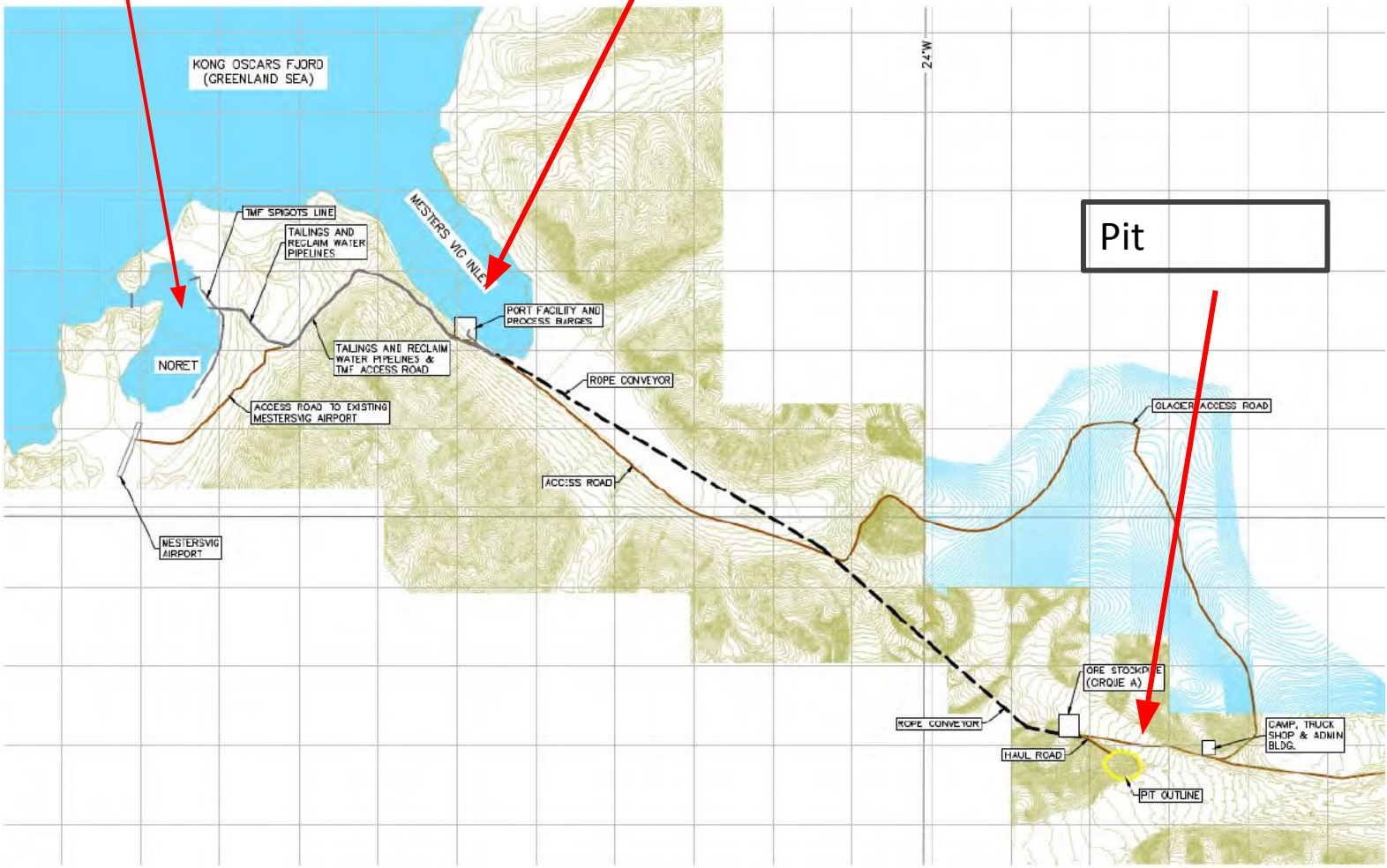
Processing of the ore on barges in a bay

Disposal of tailings in an inlet cut off with a semipermeable dam.

Disposal of tailings in an inlet cut off with a semipermeable dam

Processing on barges in a bay and discharges of wastewater to the bay

Pit



Process Chemicals in Mining Project

- Chemicals added during **processing and enrichment of metals and minerals**
- The **needs of chemicals vary a lot from project to project,** depending on the mineralogy and elements extracted
- In terms of **environmental protection**, the use and fate of the chemicals used in mining projects are subjects that require attention!

Main types of chemicals used in the mining industry

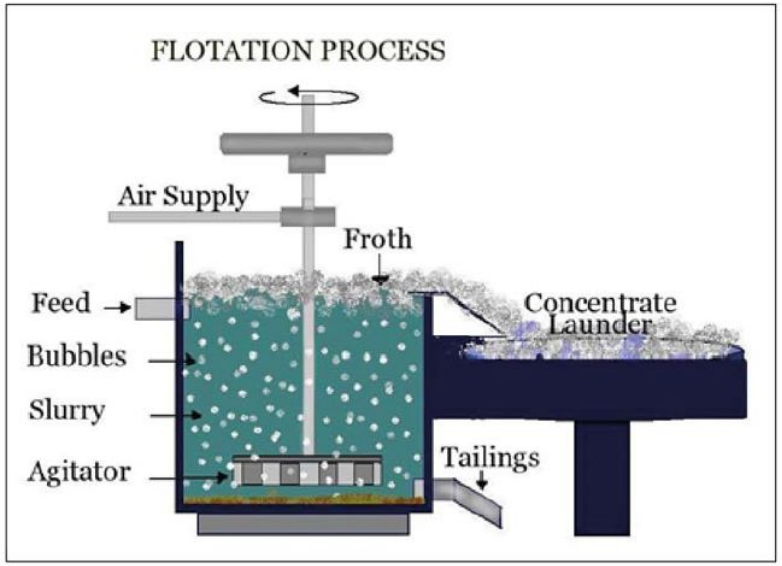
Flotation chemicals

Flotation chemicals are **necessary for enrichment of ore and minerals**

- Skimmers (allows simple formation of air bubbles)
- Collectors (adsorbs to the surface and makes hydrophilic particles hydrophobic)
- Regulatory substances (added to achieve full effect of skimmers and collectors)

Flocculation chemicals

Flocculation chemicals are used to recover water and to **reduce the water content in the tailings and increase flocculation of the fine fraction.**



Fate of the chemicals

Flotations Chemicals

- **Organic flotation chemicals** will mainly be skimmed off and follow the mineral
- **Inorganic flotation** chemicals will mainly follow the tailings.
- As a result, the organic flotation chemicals will **in principle not be discharged** to the recipient by wastewater or tailings.
- **However, as it is common practice to add an excess volume of flotation chemicals**, some of these will be discharged with the wastewater and tailings.

Flocculation Chemicals

- Flocculation chemicals are used by the mining industry to **increase sedimentation of fine-particulate material**. They are used for tailings in order to **recover fresh water** during the enrichment process.
- Flocculation of the fine fraction may be **related to wastewater or tailing.**

Example of products that a mining company recently like to use in a mining project in Greenland (>25 different products)

Reagent Function	Used for	Purpose	Annual consumption Tonnes
Zetag 8140 * Concentrator Flocculant	Zinc flotation	Thickener flocculant for zinc sulphide concentrate - to promote particle sedimentation to enable recovery of zinc product from process.	1.2 - 3.0
SNF FO4800H Concentrator Flocculant	REMC flotation	Thickener flocculant for REMC - to promote particle sedimentation to enable recovery of REMC from process.	150 - 400
Magnafloc 155 Refinery Flocculant (Anonic)	Impurity removal - Refinery	Thickener flocculant for anionic impurities - to promote particle sedimentation to enable removal of impurities in the refinery circuit.	75 - 180
Magnfloc 430 * Refinery Flocculant (Cationic)	Impurity removal and product recovery - Refinery	Thickener flocculant for cationic impurities and cationic products - to promote particle sedimentation to enable removal of impurities, and recovery of products in the refinery circuit.	20 - 60
RM1250 * Refinery Coagulant	Silica agglomeration	Thickener agglomerate for silica impurities - to promote agglomeration of fine silica particles to enable their removal from uranium product liquor.	60 - 160
Sodium iso-butyl xanthate (SIBX) Flotation Collector	Zinc flotation	To float the zinc sulphides, thereby separating these from the ore.	125 - 320
Copper sulphate ($CuSO_4.5H_2O$) Flotation Activator	Zinc flotation	To activate the surface of the zinc sulphide particles thereby improving the efficiency of their flotation.	25 - 60
Aero 6494 Flotation Collector	REMC flotation	To float the RE-bearing minerals, thereby separating these from the non-value mineral tailings.	1,000 - 2,700

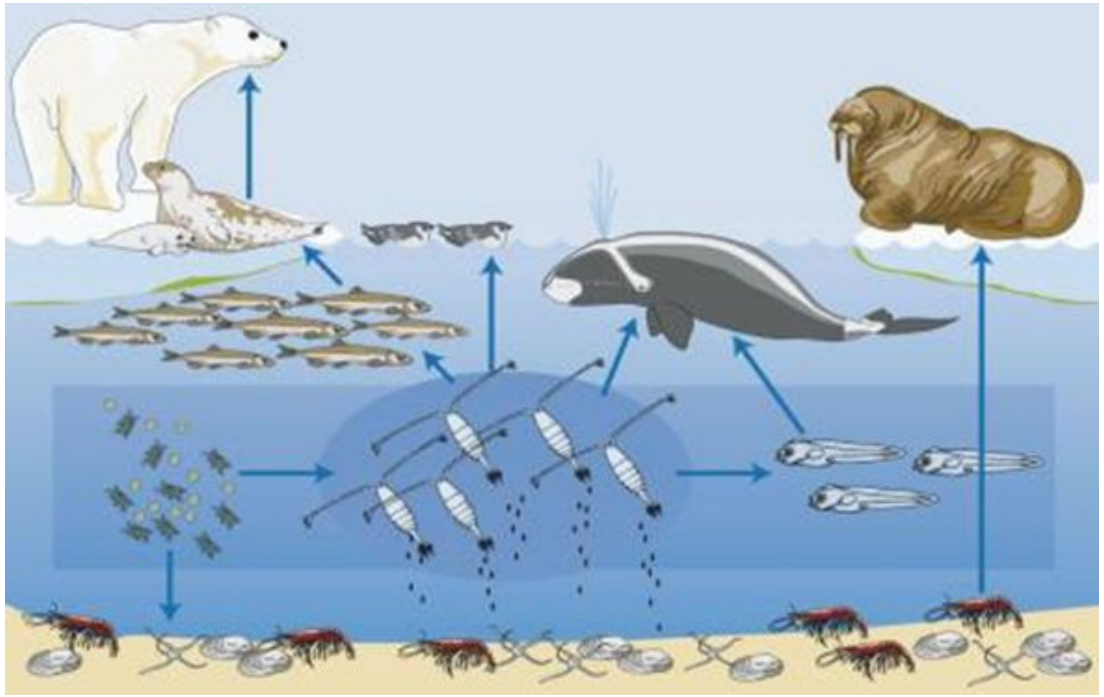
Reagent Function	Used for	Purpose	Annual consumption Tonnes
Sodium Silicate Flotation Depressant	Zinc and REMC flotation	Depressant - prevents the flotation of the non-value mineral tailings.	2,300 - 5,800
Polyfroth W22C Flotation Frother	Zinc and REMC flotation	To reduce the bubble size and increase froth stability in the flotation process.	110 - 280
Sodium Carbonate	REE product precipitation	To precipitate REE intermediate products from process liquors in the refinery circuit.	12,000 - 30,000
Sulphur	Sulphuric acid (H_2SO_4) production	To produce sulphuric acid, used to leach REEs and uranium from the REMC in the refinery circuit.	16,000 - 41,000
Sodium Chloride	Hydrochloric acid (HCl) and caustic soda (NaOH) production	To produce hydrochloric acid and caustic soda, used to respectively to leach REEs and to raise pH of process liquors (for product precipitation and impurity removal) in the refinery circuit.	35,000 - 87,000
Limestone	Impurity removal	To raise pH of process liquors in the refinery circuit.	30,000 - 77,000
Caustic Flake (NaOH)	Product precipitation and impurity removal	To precipitate cerium product, and to raise pH of process liquors in the refinery circuit.	1,400 - 5,000
Calcium Chloride	Water treatment	To precipitate fluoride from the treated water placement stream entering Nordre Sermilik.	6,900 - 17,500
Pyrolusite	REE leaching	To oxidise REE species during acid leaching process to improve REE recovery.	300 - 750
Haematite	REE leaching	To precipitate phosphate species during acid leaching process to improve REE recovery.	0 - 15,000
Hydrogen Peroxide	Product precipitation and Impurity removal	To precipitate uranium oxide, and to precipitate impurities from refinery process liquors.	125 - 300

Reagent Function	Used for	Purpose	Annual consumption Tonnes
Lime	Impurity removal	To raise pH of process liquors in the refinery circuit.	3,800 - 9,500
Barium Chloride	Impurity removal	To precipitate impurities from refinery process liquors.	1,800 - 4,500
Sodium Hydrosulphide	Impurity removal	To precipitate impurities from refinery process liquors.	60 - 200
Alamine 336 * SX Extractant	Uranium SX	To extract uranium species from process liquors in the refinery circuit, thereby removing these from impurities and enabling production of pure uranium oxide.	2.5 - 10
Isodecanol * SX Phase Modifier	Uranium SX	To improve the solubility of the extractant in the organic diluent, thereby ensuring effective removal of uranium from the liquor phase.	1.0 - 5.0
PC-88A or Ionquest 801 * SX Extractant	REE SX	To extract REE species from process liquors in the refinery circuit, thereby removing these from impurities and enabling production of pure REE products.	70 - 175
Shellsol D70 * SX Diluent	REE SX	To provide the organic phase needed to carry the extractant, thereby ensuring effective removal of REEs from the liquor phase.	160 - 500
Uranium iX Resin CleanTeQ R603B	Impurity removal	To remove uranium impurities from the REE process liquor stream in the refinery circuit.	0.1 – 1.0
Accepta 2827/2302 Cooling Water Biocide	Cooling water treatment	To prevent the growth and build-up of microbiological organisms in the cooling water system, thereby ensuring optimum performance of process plant cooling systems.	140 - 500
Accepta 2319 Cooling Water Inhibitor	Cooling water treatment	To prevent the formation of rust in equipment associated with the cooling water system, thereby ensuring optimum performance of process plant cooling systems.	5 -30

Arctic Environment and Ecosystems

- Results from monitoring and research have shown that the **arctic ecosystems are very sensitive** to pollution with chemicals, oil substances, etc.
- **Slow degradation** of chemicals due the low temperatures and low concentrations of nutrients in arctic waters
- **Arctic organisms have a very high content of fat** for insulation against the cold climate and long winter periods without food.
- **High risk of bioaccumulation of lipophilic chemicals (substance with high affinity for fat) in arctic organism**
- Slow growth cause **long recovery time**

Arctic ecosystems are characterized by **simple food chains and a high content of fat**



Environmental Concern in relation to use of chemicals in mining

Concerns

Significant volumes of chemicals, in particular flotation chemicals, are used and it is therefore important to ensure these are:

- Biodegradable
- Not toxic (acute or chronic)
- Do not bioaccumulate in organisms

Protection of the environment

Use chemicals with

- low toxicity
- low potential for bioaccumulation
- easily degradable in nature

Minimize the release and discharge of chemicals to the environment

All use of chemicals **should be approved by authorities** before use

Recommendation

- Classification of chemicals provides **important information on hazard properties**
- All use of chemicals **should be approved by authorities** before use
- **We recommend to use OSPAR classification** to chemicals as also used for offshore oil and gas extraction
- **Replace environmentally hazardous product/chemicals** with less hazardous should be sought
- **If needed tests** should be performed under arctic conditions and with arctic organisms.
- All substances in products should be evaluated

High Arctic Copepod

Lipid sac up to 40% of the body weight

*The relative **larger size, longer life and larger lipid sac** of the high Arctic Copepod are generally **assumed** **to be adaption to the strong seasonality of the high Arctic***

Thanks for your attention!