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HEAVY METAL POLLUTION FROM MINING IN GREENLAND

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ABSTRACT

Studies on the impact by mining on the environment have been conducted at three mines in Greenland, a lead-zinc mine and a cryolite mine in West Greenland, both in operation, and an abandoned lead-zinc mine in East Greenland. Widespread dispersal of heavy metals from the mining operations have taken place at all three mines, and very high levels of lead and sometimes zinc is found in blue mussels and seaweed in the intertidal zone of the sea. The sources of the polluting metals are somewhat different at the mines. The most important sources seem to be tailings disposal to the sea, airborne spreading of dust containing metals, melting water and precipitation draining piles of concentrate or tailings left on land. Work is being undertaken to reduce the impact at the three mines.

INTRODUCTION

Mining in Greenland started as early as 1851. Since then mining has taken place for copper, graphite, coal, cryolite, lead and zinc. At present two mines are in operation: a lead-zinc mine and a cryolite mine both in West Greenland (see Fig. 1). Furthermore, mineral exploration is taking place in several areas in Greenland.

Environmental studies have been conducted at the two mines still in operation and at an abandoned lead-zinc mine at Mestersvig, East Greenland (see Fig. 1).

THE LEAD-ZINC MINE AT MAARMORILIK

The lead-zinc mine is located in mid West Greenland in the inner part of a large fiord system with large water depths and steep high mountains. The operator of the mine is the Danish company Greenex.

The mine is located c. 600 m above sea level in a mountain called the Black Angel. The mine has an annual production of c. 675 000 tonnes of ore holding c. 3% lead and c. 10% zinc. Crushed ore is brought in cable cars across a fiord to a flotation plant in which lead and zinc

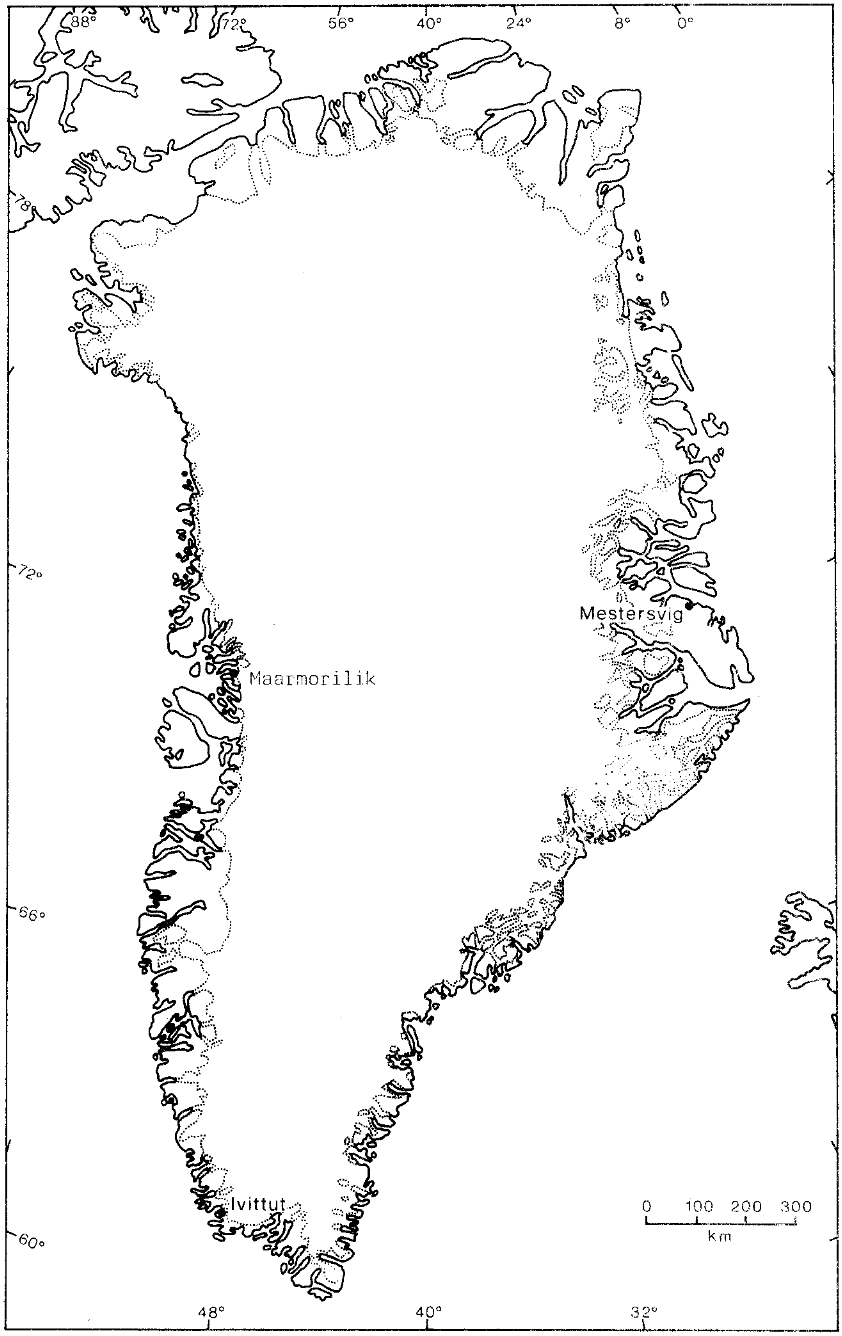

Fig. 1. Location of three mines in Greenland.

concentrates are produced (c. 25 000 tonnes of lead concentrate and c. 120 000 tonnes of zinc concentrate per year). Tailings from the plant are discharged into a small sill fiord where tailing solids accumulate (c. 530 000 tonnes per year).

The mine started its production in 1973. Since then environmental studies have been carried out regularly, and as these have demonstrated a widespread heavy metal pollution much effort has been put into identifying pollutant sources and into reducing the pollution from these.

Pollutant sources

The massive sulphide ore is hosted in a light coloured marble. The ore is mainly composed of pyrite, sphalerite and galena. The main pollutants are lead, zinc, and cadmium, but copper, arsenic, mercury, and silver pose a pollution potential. The composition of the ore and the tailings is shown in Table 1.

Table 1. Composition (tonnes) of ore and tailings 1984.
Total production = 675 000 tonnes of ore.

	ore	tailings
Pb	2.96%	0.15%
Zn	10.44%	0.26%
Fe	12.91%	15.1%
Cu	333 ppm	113 ppm
Cd	521 ppm	17 ppm
As	94 ppm	71 ppm
Ag	21 ppm	2.4 ppm
Hg	14 ppm	0.4 ppm

Tailings are discharged into a small fiord (Affarlikassaa), and solids settle here as a sill at a mouth of the fiord prevents tailings from flowing into the adjacent larger fiord (Qaamarujuk), see Figure 2. However, a small but significant part of lead, zinc and cadmium in the tailings dissolves in the fiord and is transported from the sea floor to the upper water masses and from there into the larger fiord. The amount of dissolved zinc, lead, and cadmium in the two fiords is shown in Figure 3. The mechanism causing the solution of heavy metals is not fully understood, but small amounts of zinc, lead and cadmium carbonate in the ore are possible sources. Figure 3 shows that a significant reduction in the amount of heavy metals in the fiords has taken place since 1978. This has been achieved partly by increasing the flotation efficiency thus leaving less metal in the tailing and partly by a chemical treatment of the tailing with lime, aluminum sulphate and a flocculant.

The tailings discharge is by far the most important source of heavy metal pollution. But three other sources are also important, as metals from these enter the upper water column directly. One source is metal holding particles being washed into the sea from waste rock left on slopes of the Black Angel mountain. The amount of pollutants entering the sea from this source cannot be quantified, but it is known to be important at least locally, since the highest levels of lead, zinc, and cadmium in blue mussels and seaweed is found below a waste dump.

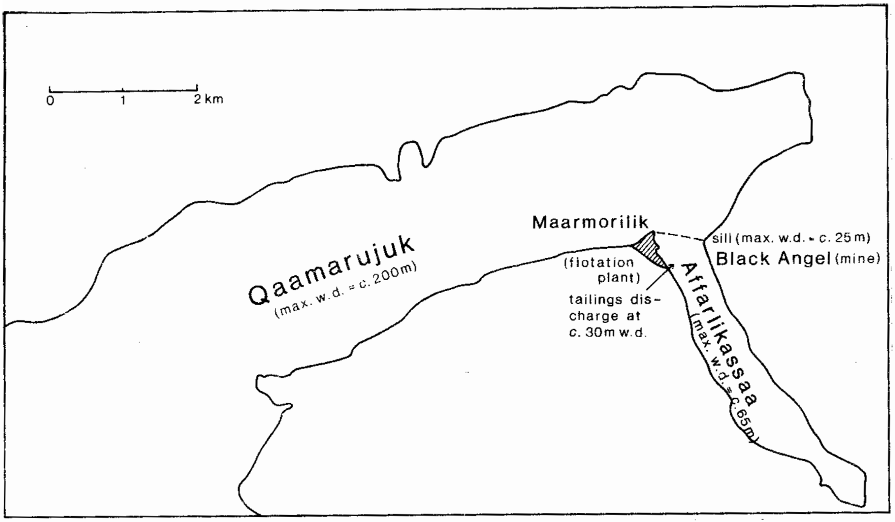

Fig. 2. Map of Maarmorilik area. (w. d. = water depth)

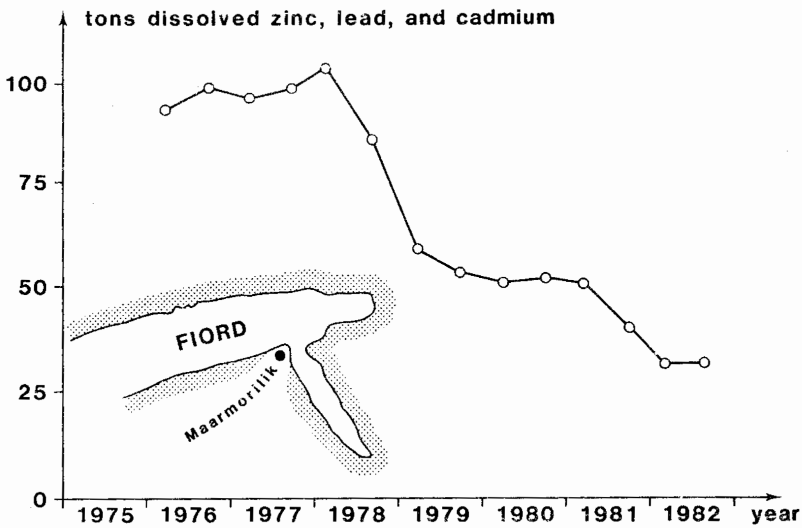

Fig. 3. Amount of dissolved heavy metals in the two fiords at Maarmorilik.

A second source until 1985 has been dust from the ore crusher in the mine. 4.2 tonnes of zinc and 1.2 tonnes of lead per year have been estimated to spread from this source. This probably has been the main cause of increased deposition of heavy metals on land to long distances from the mine, as has been demonstrated in a study of metal uptake by lichens (Pilegaard, 1983). Dust from the ore crusher may also have been an important source of heavy metals in seaweed and blue mussel of the intertidal zone, as significant amounts of metals deposited on land may have been washed into the sea by rain and melted snow, then exposing the biota of the intertidal zone.

A third source is fresh water entering the mine. This has not been a problem until 1984, when a drift in the mine hit fresh water in the rock formation. Since then c. 10 m^3 per minute has been entering the mine. The source of the water is the inland ice sheet which covers the rock formation, and the water flow is only partly controllable. On entering the mine the water is not polluted, but on its way through the mine the water flushes metal containing particles which eventually leave the mine via the slopes of the Black Angel mountain, from where at least some finally reach the sea. The amounts are estimated to be:

zinc:	2-10 kg per day
lead:	1-5 kg per day
cadmium:	0.01-0.05 kg per day

Work is now being undertaken to minimize these amounts by building sumps where particles will settle and by pumping the water through pipelines where possible to avoid resuspension of particles from car and truck traffic.

Environmental impact

Biota in the fiords are most affected by lead. The most severe impact is found in blue mussels and seaweed of the intertidal zone, see Figure 4, which shows that a large area is affected. Lead levels are so high that it has been recommended not to collect blue mussels for consumption within c. 35 km from the mine. Elevated levels of lead have also been found in the heads and shells of shrimp, in the liver and bone of two fish species, and in liver and kidney of some seabirds, but not in meat from fish and birds, and not in blubber, meat, liver, and kidney from seals. Zinc levels are elevated in seaweed and blue mussels, whereas cadmium only is elevated in blue mussels and only within a very small area.

THE CRYOLITE MINE AT IVITTUT

The mine is an open pit mine located in Arsuk Fiord in South Greenland, see Figure 1 and Figure 5. Mining started in 1854. The mine is operated by the Danish company Kryolitselskabet Øresund. The cryolite was located in an ore body c. 115 x 50 metres in plan and c. 70 metres deep. The main part of the cryolite body consisted of siderite-cryolite rock, i.e. cryolite with about 20% siderite and 1-2% quartz and sulphides. The formation was very close to and partly in the fiord. A dam had to be built towards the fiord to prevent sea water from filling the pit.

At Ivittut the ore has only been handled mechanically and has been