IMPACT OF TOXIC METALS FROM THE CARIBOU GOLD MINING AREAS IN NOVA SCOTIA, CANADA.

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ABSTRACT

The Caribou gold mining areas in Nova Scotia, Canada were in full production from 1869 to 1927. Abandoned waste rocks and fine-grain tailings from Hg-amalgamation processes were weathered into Long Lake, part of the Moose River system. Metal burdens in tailings, stream sediments, lake sediments, fish, as well as biological community structure above and below the processing site were investigated. Surface tailings were found to contain > 5000, 0.1-0.6.5, 0.7-2.0, 1600-1900, 60-140 and 0.03-0.56 *m*g/g for As, Cd, Hg, Ni, Pb and Tl respectively. Air-surface exchange from tailings (preliminary results, 24 hr. cycle) exhibit Hg-flux rates 20 to >100 times from those of natural soils. Additional data on Cd, Cu, Mn, V, Zn, surface tailing Hg-exchange with the atmosphere as well as biological community structure is included in the poster.

INTRODUCTION

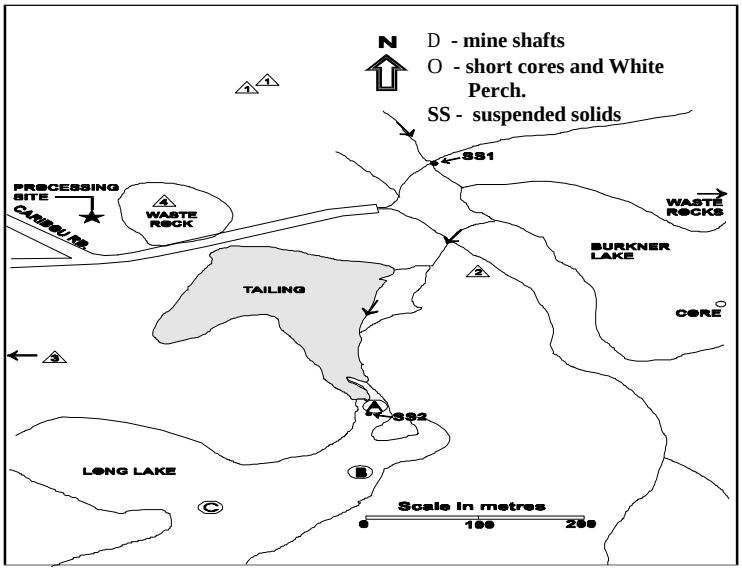
The use of Hg in amalgamation processes and abandoned mine tailings become a significant source of Hg and other pollutant metals to the environment (Lacerda, 1996; Wayne, 1996) . From 1860 to 1960, the Caribou gold mining district was the fourth highest producing site in Nova Scotia. 185,640 tons of ore were processed yielding 91,358 oz. of gold (NSDNR; Editors, 1945-Moose River ores included). There was continuous activity from 1869 to 1927 where stamp-crushing and Hg-amalgamation was the major gold and silver recovery technique, some cyanide leaching was introduced into the process starting in the early 1900's, mainly for the reworking of old tailings (Roach, 1935). At least six mining operations were in the immediate area (fig. 1), and several underground mine shafts were within 2 km of the mill. The abandoned fine grain tailings can be found immediately south of the mill spreading to a tailing fields of approximately 40,000 m^2. Subsequent weathering had carried some of the tailings into Long lake, part of the Moose River system. To complicate matters, the area bedrock has very low buffering capacity (stream waters pH of 4 to 5; alkalinity <2 to 3) to the acid produced from the sulfide minerals exposed, including the many waste-rock piles left over from relic mining operations. This study reports on the distribution, enrichment and the impact of selected metals: As, Cd, Hg, Ni, Pb and Tl from the tailing field to the receiving lakes and streams as well as possible impact to the fish population.

METHODS

The Caribou Gold district is located in Halifax County, approximately 65 km North-West of Dartmouth, Nova Scotia. Area bedrock consist of quartzite, pyrite, arsenopyrite and other sulphur bearing minerals, some of which are enriched with natural Hg in the range of 0.1-200 *m*g/g (EPS report). Abandoned mine shafts belonging to several mining concerns can be found within 2 km of the processing site (fig.

1), waste rocks piles littered the immediately areas of the mill and close to the mine shafts located at the east end of Buckner lake(BL).

Methods used in the recovery of suspended solids in stream waters, lake waters, stream and lake sediments, sediment cores and mine tailing cores were described in detail from an earlier study (Wong, 1999), sampling locations are shown in figure 1. Gill nets were used to collect White Perch at Long lake(LL) and Angevine lake(AL), a control lake located East of Amherst in Cumberland County. Burkner lake (BL) is upstream of LL and relatively unaffected by the abandoned tailing at the sampling site. Freeze-dried particulate samples were extracted with HNO_3-H_2O_2 in a Milestone high temperature and pressure microwave system. Extraction efficiencies were determined by the use of NIST standard reference Buffalo River sediment. Mercury was determined by the cold vapor method; As, Cd, Ni, Pb and Tl were determined by ICP-MS.



RESULTS AND DISCUSSION

The weathering of exposed surfaces from waste rock and tailing in the Caribou areas are further complicated by the effects of acid mine drainage. Metals are being leached from natural surfaces as well as from metals discharged during the milling and extraction processes. Mercury loss was estimated as 0.1 oz. per ton of ore (Henderson, 1935) and the loss of Ni-Fe-Cr alloy from the metal die and shoe from the ore crushers were 0.13-0.14 pounds per ton of ore (Henderson, 1935) . From a total of 185640 tons of ore processed (NSDNR), we estimated a production loss of 526 kg of Hg and 11,000 kg of the alloy. From metal levels in tailing cores, the residual metal burden in the abandoned tailing is listed in table 1.

Table 1.
Metal levels and estimated total burden in tailing field, Caribou, Nova Scotia.

	As	Cd	Hg	Ni	Pb
Background *m*g/g	20-500	0.001-0.070	0.02-0.05	20-25	<0.1-1.5
mean values *m*g/g (n=6)	50830	0.43	2.15	1270	97
Metal burden($x10^3$ Kg)[a]	9436	0.080	0.4	236	18

[a] estimated from total ore processed 1862-1960 = 188620x 10^3 Kg

A roughly estimated Hg-loss deficit of 120 kg (Hg loss - calculated burden) can be attributed partly to losses to the atmosphere during the ore extraction process and the continuous loss (exchange) during the last 150 years bearing in mind that natural Hg and other metals are being continuously leached from

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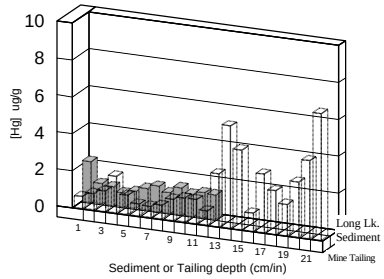

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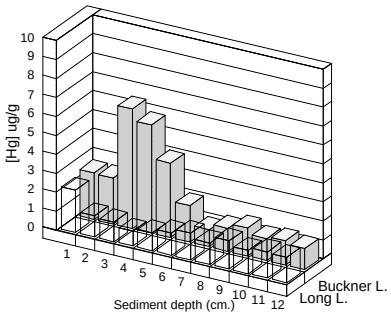

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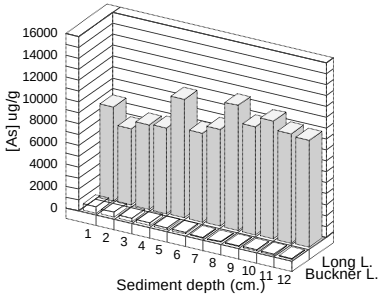

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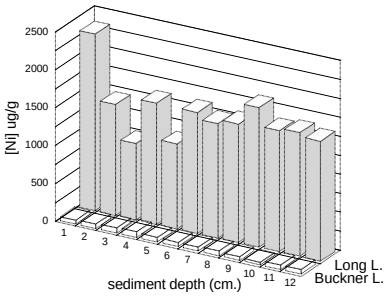

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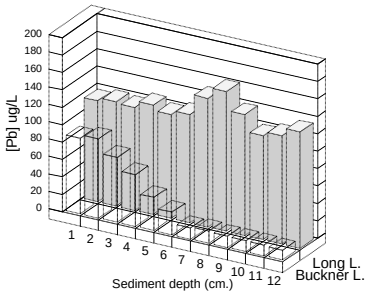

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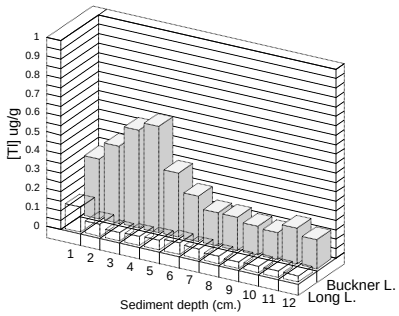

Fig 2. (a) Profile of mercury in tailing core and LL sediment. (b) - (f) Profiles of mercury, arsenic, nickel, lead and thallium in surface sediments, station A - Long lake and Burkner lake.

the exposed surfaces. Indeed, Beauchamp etal (this proceeding) reported an average Hg upflux of 258 ng m^2 day $^{-1}$ at this Caribou site, a 200-fold increase from background values of < 1.0 ng m^2 day $^{-1}$ in Nova Scotia. Surface sediment from short cores taken close to the LL connecting stream in-flow (stn. A) indicated that long lake sediments in the area are highly influenced by the continuous deposition of mine tailings into the lake (fig. 2a,b) The increase of Hg content at deeper tailing horizons may not indicate Hg loss at the surface tailings but rather the matrix of the ore process at the time.

Metal profiles from BL showed a relatively undisturbed depositional history and that the surface 0-6 cm of sediment represents the regional anthropogenic input. Long lake sediments, however, were highly mixed with the tailings. Metal contents for surface sediments from both lakes (fig. 2c,d,e,f) highlighted the enrichment of As, Pb and Ni from the tailings to the sediments in LL. Under the influence of the tailings, residual Tl and Hg in the surface sediments "appears" to be less for LL, however, we must also take into account that LL sediments were 5 to 6 times heavier (quartz grains) than those of BL sediments. The residual metal content as represented in the figures were estimated to be approximately five times higher for LL when normalized with their respective values in specific gravity.

Mercury levels in whole White Perch were found to be three times higher under the influence of the Caribou mine tailing (Table 2). Fork length to body weigh ratios were 4.1 and 2.9 for LL and AL White Perch respectively. Under similar conditions, we may infer that Hg and other metal species at Caribou may inhibit the normal rate of increase in body mass of the fish population (Biney, 1991).

Table 2.
Mercury levels, length and weigh of White Perch from Long and Angevine lakes

mean values	Long lake (Caribou)	Angevine lake (Control)
[Hg] μg/g	0.62(1.01-0.22)	0.23(0.16-0.31)
Fork length(mm.)/ body weigh(g.)	4.12(138.8/33.7)	2.93(147.6/50.3)

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