Transfer of sediment-associated metals downstream of abandoned and active mining sites in the Quesnel River catchment, British Columbia

MARCEL VAN DER PERK[1], MARLOES L.H.M. VAN LIPZIG[1], GOSRO KARIMLOU[1], PHILIP N. OWENS[2] & ELLEN L. PETTICREW[2]

[1]Department of Physical Geography, Utrecht University, P.O. Box 80115, 3508 TC Utrecht, The Netherlands; e-mail: m.vanderperk@geo.uu.nl

[2]University of Northern British Columbia, 3333 University Way, Prince George, British Columbia, Canada, V2N 4Z9

Universiteit Utrecht

1. Introduction

Metal mining may have considerable impact on downstream water and sediment composition. The rate and extent that metals move downstream determine the magnitude and time scale of downstream sediment contamination. Conversely, the downstream metal content of sediments provide important clues of sediment transfer.

To examine the downstream transfer of sediment-associated metals, samples of bed sediments and suspended sediments were collected from small streams draining an abandoned hydraulic gold mine (sample location P1; Fig. 1; Fig. 2a-b) and an active open cast copper mine (locations H1, H2, and D1; Fig. 2c) in the Quesnel River catchment, BC, Canada. In addition, sediment from a control site with no apparent upstream contaminant sources was sampled (location C1).

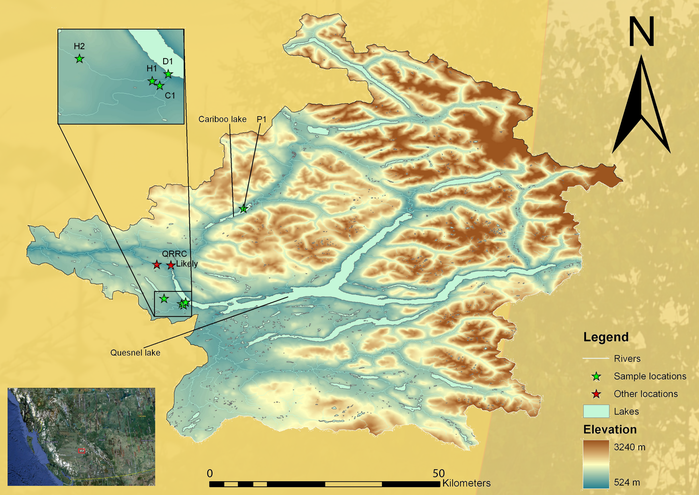

Fig. 1 Location of the sample locations

a. *b.* *c.*

Fig. 2 a. Active copper mine; b. abandoned gold mine; c. Sample location P1 (downstream abandoned gold mine)

2. Sediment sampling and analysis

The samples included bulk suspended sediment samples collected using a time-integrated suspended sediment sampler (Fig. 3a) (n = 5), bulk bed sediment samples collected using the resuspension method (Fig.3b) (n = 24), and depth profile samples (n = 49). The samples were sieved through a 63 µm mesh sieve and the fraction <63 µm was analysed for metal content by ICP-MS after aqua regia digestion.

a. *b.*

Fig. 3 a. Time-integrated suspended sediment sampler; b. Bed sediment sampling using the resuspension method

3. Statistical analysis

Local background concentrations were estimated by means of linear regression of the metal concentrations on the aluminium content of the control site samples and the deeper, uncontaminated depth profile samples (n = 29). Metal enrichment ratios (ER) were then calculated by dividing the actual metal concentration by the regression prediction of the background metal concentration.

4. Background concentrations and enrichment ratios

Table 1 and Fig. 4 show the results from the regression analysis. Table 2 shows the ERs in bed sediment and suspended sediment

The bed sediment and suspended sediment in the stream draining the active copper mine are enriched in Se, Mn, Cu, and Hg, whereas the sediments in the stream draining the abandoned gold mine are enriched in Pb and Ni.

Table 1 Regression parameters of relation between background metal concentrations and Al content

	Intercept (mg kg^{-1})	Slope (mg kg^{-1} %$^{-1}$)	R^2
Se	-0.6	1.12	0.449
Mn	-502	796.2	0.111
Cu	-16.8	38.7	0.695
Hg	-0.03	0.07	0.410
Pb	-4.3	9.1	0.583
Ni	-8.5	26.2	0.786

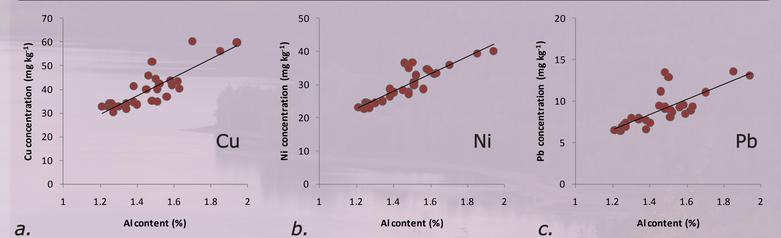

Fig. 4 Relations between background metal concentrations and Al content

Table 2 Enrichment ratios (ERs) in bed sediment and suspended sediment at the various sample locations

	Control site	Downstream active copper mine				Downstream abandoned gold mine	
Location	C1	H1		H2		P1	
	BS	BS	SS	BS	SS	BS	SS
n	9	6	2	3	1	7	2
Se	1.2	4.2	8.9	1.8	3.8	2.2	2.6
Mn	1.7	2.8	5.7	1.1	5.3	0.9	8.9
Cu	1.0	2.0	2.6	1.4	2.2	3.8	2.6
Hg	1.1	1.6	2.2	1.3	1.6	0.4	0.3
Pb	1.0	0.7	0.8	0.6	0.7	15.9	7.7
Ni	1.1	0.8	0.9	0.6	0.7	2.8	2.9

6. Discussion and Conclusions

In the stream draining the active copper mine, the ERs for the suspended sediments are larger than those for the bed sediments. This suggests that in this stream, the metal enrichment in the bed sediments will likely increase in the future due to continued supply and deposition of metal-enriched sediment.

In contrast, the ERs for the suspended sediments are smaller than the ERs for the bed sediments in the stream draining the abandoned gold mine. This would imply that in this stream, the transfer of metal enriched sediments from upstream sources has declined and that the metal enrichment is likely to decrease over time.