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Magnitude and extent of the impact of a small-scale gold-mine on the geochemistry of stream bed and floodplain sediments in the Horsefly catchment, British Columbia, Canada

Marcel van der Perk (1), Marjolein F.A. Vogels (1), Deirdre E. Clark (1), Philip N. Owens (2), and Ellen L. Petticrew (2)

(1) Utrecht University, Department of Physical Geography, Utrecht, Netherlands (m.vanderperk@geo.uu.nl), (2) University of Northern British Columbia, Prince George, British Columbia, Canada

Mining represents a major source of metal contamination for fluvial systems worldwide. Monitoring and understanding the effects on downstream water and sediment quality is essential for effective management of active and abandoned mine sites. This study aims to determine the downstream effects of the abandoned, small-scale hydraulic Black Creek gold mine on the geochemistry of fine (<63 μm) stream bed and floodplain sediments of the Horsefly River system (British Columbia, Canada), which is part of the Quesnel watershed. The Black Creek mine was intermittently active from 1930 to 2001. Samples of channel bed sediments were collected from the 2 km long Black Creek and the Horsefly River into which the creek drains. Furthermore, three $\sim$0.7 m sediment cores were retrieved from the Horsefly River floodplain: one core about 1 km upstream from the mouth of Black Creek, one core about 2 km downstream from the mouth of Black Creek, and one core about 55 km downstream in the Horsefly River delta in Quesnel Lake. The cores were sampled at 1 cm intervals. Concentrations of As, Cd, Cu, Se, and Zn in the fine (<63 μm) particle size fraction of the samples were determined by aqua regia digestion followed by ICP optical emission spectrometry or ICP mass spectrometry. Age-depth models for the cores were constructed using excess Pb-210 and Cs-137 activity concentration profiles. The results from the floodplain cores show that As concentrations just downstream of Black Creek peaked at more than twice the baseline concentration shortly after the beginning of the mining activities, but quickly returned to values close to the baseline concentration. Since the early 20th century, the sediment in the three cores showed elevated Se concentrations. Since approximately the 1950s the cores just upstream and downstream from Black Creek also contain slightly elevated Zn and Cd concentrations. Because the Se, Zn, and Cd concentrations are also elevated in the core upstream from Black Creek, these contaminants are likely derived from upstream mine sources. The stream bed sediment samples show local increases in As concentrations along the Black Creek up to more than three times the baseline concentration, but the As concentration in the stream bed sediments of the Horsefly River are close to the baseline. The stream bed sediments of the Horsefly River contain slightly higher Zn (up to 1.3 times the baseline value) and Cd (up to twice the baseline value) concentrations than the baseline level, which is in line with the results from the floodplain cores. The results show that the Black Creek mine caused local As contamination of the Horsefly River floodplain during the first years of operation, but at present the contamination is contained in the Black Creek. No further recent mining effects of the Black Creek mine were observed along the Horsefly River, likely due to the mine's inactive status and small size. Nevertheless, we identified continued elevated concentrations of Se, Zn, and Cd, which are likely derived from historic upstream mining activities.