MERCURY CONTAMINATION OF STREAM SEDIMENT IN NORTH GEORGIA FROM FORMER GOLD MINES IN THE DAHLONEGA GOLD BELT

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REFERENCE: Proceedings of the 1995 Georgia Water Resources Conference, held April 11 and 12, 1995, at The University of Georgia, Kathryn J. Hatcher, Editor, Carl Vinson Institute of Government, The University of Georgia, Athens, Georgia.

Abstract. Floodplain sediments downstream from 19th century gold mining sites were studied to determine if mining activities released toxic metals into streams. Mercury was found to be the only significant mining pollutant, and it results from the use of mercury to amalgamate and recover gold from stamp mills and sluices. Sediment-bound mercury in mining-related sediment ranges from 0.01 to 10.0 mg/kg, whereas natural background concentrations range from 0.01 to 0.06 mg/kg. Mercury content decreases with increasing distance from former mines, and only the sites in very close proximity to mines contain "hazardous" levels of mercury in sediments. Limited data indicate that some mercury is released to stream water in the mining district.

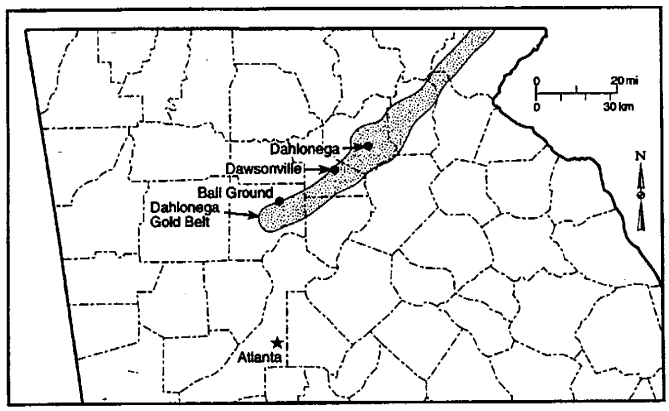

Figure 1. Map of the Dahlonega Gold Belt and locations referenced in the text.

INTRODUCTION

The objective of this research was to assess the magnitude and spatial distribution of trace metals in floodplain sediments associated with former gold mining activity in the Dahlonega Gold Belt of north Georgia. Sediments can store and release toxic metals in aquatic systems and are considered as potential non-point source contaminants in watersheds. In north Georgia extensive gold mining occurred from 1829 until about 1940 (Pardee and Park, 1948; German, 1985), and much mine-waste is currently stored as floodplain sediment near the former mines. Several hazardous trace metals, including arsenic (As), copper (Cu), lead (Pb), and zinc (Zn), were associated with the gold ore within accessory minerals, and it was initially thought that these metals would be present as contaminants in floodplain sediments. However, mercury (Hg) was found to be the only significant contaminant, and the focus of this research was devoted primarily to mercury contamination. Mercury does not occur naturally at elevated levels in north Georgia bedrock, but it was used to amalgamate and recover gold from sluices and milling operations (Yeates et al., 1896). In fact, an 1885 United States Census report states that up to 38% of mercury used in gold mining in the U.S. escaped directly into the nearest stream (U.S. Census Office, 1885).

Study Areas

Three floodplain segments within the Dahlonega Gold Belt, representing intensive, moderate, and isolated gold mining activity, were chosen for study (Figure 1). The intensively mined area included the Yahoola Creek-Chestatee River watershed immediately south and east of Dahlonega, Georgia along a 20 km long stream segment that terminates in Lake Sidney Lanier. The moderately mined area included the upper Etowah River southwest of Dahlonega along a 12 km stream segment immediately west of Auraria and downstream to Georgia Highway 136. The isolated mining area, a floodplain downstream of a single gold mine (Franklin-Creighton Mine), is located along 10 km of the middle Etowah River near Ball Ground between the Forsyth/Cherokee County line and Georgia Highway 372 . Sample site locations and complete data sets are reported in Leigh (1994a, 1994b).

METHODS

Floodplain sites were sampled at 0.5 to 5 km intervals in the downstream direction from the most intensively mined parts of the watersheds in order to identify distance-decay patterns in the dispersal of trace metals. Each site was sampled as a vertical profile of riverbank samples at 25 cm intervals down to the maximum possible depth, typically 2-4 m. Prehistoric (Holocene) stratigraphic units were distinguished from historic units by the presence of a buried soil, whereas laminated/stratified and massive/unweathered sedimentary structures characterized historical sediment. Background levels of metals were determined from prehistoric alluvium and

unmined upland soils.

Laboratory procedures include multi-element, arsenic, gold, and mercury determinations. Extractable multi-element determinations were done by digesting 0.5 g samples in a nitric-hydrochloric acid mix (1:1) for 4 hours and measuring concentrations with an inductively coupled plasma generator (ICP) at the University of Georgia Chemical Analysis Laboratory. Total arsenic, gold, and mercury concentrations were measured on the less-than 0.177 mm fraction (<80 mesh) by a professional geochemical exploration laboratory (Skyline Labs, Inc.). Leigh (1994a and 1994b) showed that Hg concentrations in the <0.177 mm fraction provide an accurate estimate of total Hg in the whole sample. In addition to sediment analyses, a limited number of water and sediment elutriate samples were analyzed for Hg by cold vapor atomic absorption to evaluate the release of mercury from sediment into surface waters.

RESULTS

Sediment

Results indicate that Hg is the only significant trace metal contaminant resulting from former mining activities and that all other metals are essentially at natural background levels. The most severe mercury contamination is restricted to the immediate vicinity (within 5-10 km) of mines near Dahlonega along Yahoola Creek, and other study sites contain only isolated instances of significant mercury contamination (Figures 2a, b, c). The distance-decay pattern of mercury within the Yahoola Creek-Chestatee River segment suggests that much of the mercury from mine-waste was not transported more than 5 or 10 km downstream from the mines, or that it became significantly diluted with uncontaminated sediment in the downstream direction. A study by Williams (1994) suggests that at least three dams were in place on Yahoola Creek during the period of mining, and those dams probably prevented much of the mercury from being transported farther downstream.

Unlike the other mining-related metals (As, Cu, Fe, Pb, Zn), the mercury in historical sediment exceeds background levels and sediment quality guidelines. Mercury concentrations are one to two orders of magnitude (10X-100X) above background, especially in the Yahoola Creek and Chestatee River study area (Figure 2a). The background concentration of Hg is 0.04 ± 0.02 mg/kg and sediment quality guidelines for mercury typically range between 0.1 and 1.0 mg/kg of Hg (Baudo and Muntau, 1990; Giesy and Hoke, 1992). The maximum Hg concentration measured in floodplain sediments is 10.0 mg/kg at the Battle Branch Mine just west of Auraria on the Etowah River (Figure 2b), but Hg concentrations above 1.0 mg/kg are more common along Yahoola Creek east of Dahlonega (Figure 2a). Channel bed sediments were also measured and were found to contain a maximum of 12.0 mg/kg of Hg in the heart of the mining district of Yahoola Creek, but most other channel sediments contained less than 0.1 mg/kg of Hg.

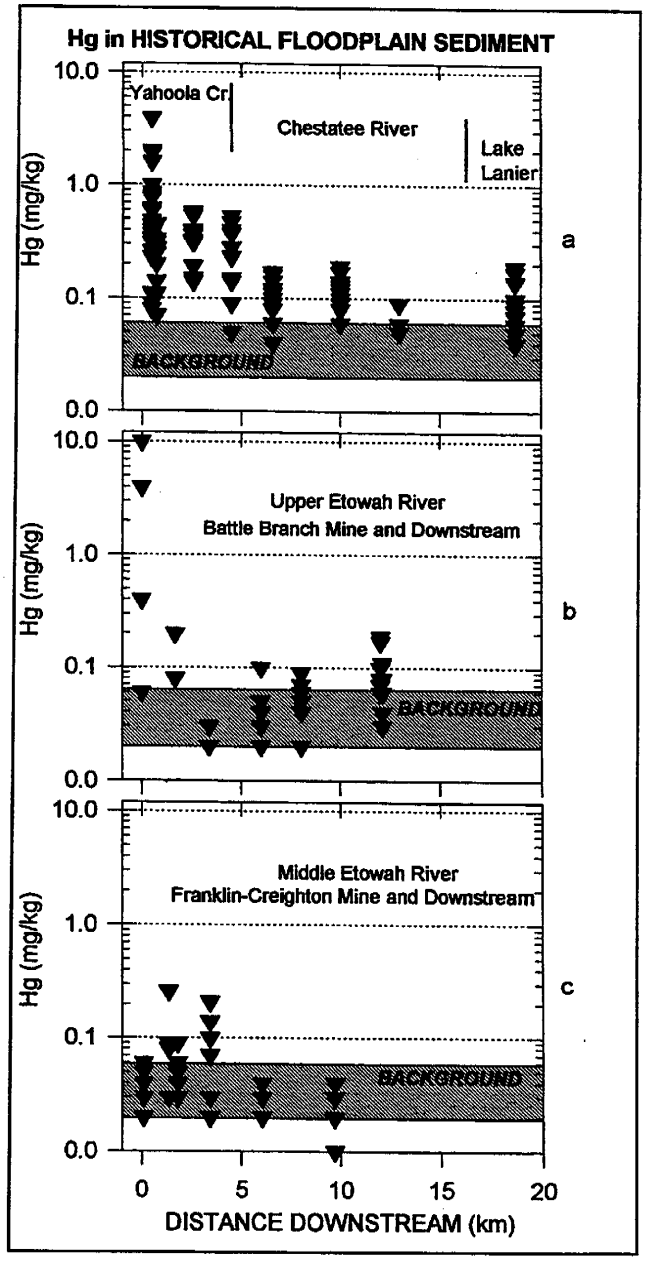

Figure 2. Distance-decay plots of mercury (Hg) in historical sediment in each of the studied stream segments. Zero on the x-axis marks the approximate location of the most intense mining along each stream segment. Many of the plotted points represent multiple samples at the same concentration.

Water

Nine surface-water samples in the Yahoola Creek and Chestatee River were measured for Hg, and five of these contained elevated mercury levels, with Hg concentrations ranging from <0.6 μg/L to 1.5 μg/L. Five other samples of

water extracted as sediment elutriate samples yielded mercury concentrations ranging from <0.1 μg/L to 2.0 μg/L with only the sediment samples with more than 0.85 mg/kg of Hg releasing measurable concentrations of Hg into the water.

Finally, soft tissue from a composite sample of freshwater mussels (*Corbicula Fluminia*) collected on the Chestatee River at the Highway 400 bridge yielded 0.7 mg/kg of Hg, indicating that those organisms are accumulating mercury.

CONCLUSIONS

Mercury-contaminated sediments observed in this study exceed standards and guidelines established by other State and Federal agencies (Giesy and Hoke, 1990) and probably pose a risk to aquatic and terrestrial organisms affected by the most contaminated sediment. However, additional research will be needed to fully understand the environmental impact of the mercury-contaminated sediment. The mercury stored in floodplain sediments serves as a nonpoint source of mercury that can be remobilized by channel bank erosion, dissolved by groundwater and surface water, and continuously cycled through the ecosystem.

This study identifies mercury contamination resulting from former mining activity and focuses on mercury stored in sediment, but leaves many research questions. Future research needs include mercury speciation studies and detailed bioassessment studies to understand more about the environmental hazard posed by the contaminated sites. Also, assessment of the magnitude and spacial extent of mercury contamination from isolated former gold mines elsewhere is needed.

Finally, gold mining of the type described in this study occurred in many places on the southern Piedmont from Alabama to Virginia (Pardee and Park, 1948). Thus, it is likely that mining-related mercury-contaminated sediments exist in may watersheds in the Southeast. In fact, grab samples collected on floodplains near Gold Hill, North Carolina showed elevated levels of mercury similar those of this study.

ACKNOWLEDGMENTS

Partial funding for this research was provided by the U.S. Geological Survey through the Georgia Water Resources Program at the Georgia Institute of Technology's Environmental Resources Center on project #14-08-0001-G2013-(04). I thank Steve Williams for field and laboratory assistance, and the landowners who provided access to their property.

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