Environmental Geology Class Notes
April 15, 2004 - OSU Seminar – Paul Ashley

"Orogenic Antimony-Gold Deposits and Environmental Consequences of Their Exploitation – An Antipodean View"

I. Introduction

Orogenic Antimony (Sb) and Gold (Au) – elemental / mineral deposits associated with mountain-building / tectonics

Mesothermal deposits formed at mid to shallow crustal depths
Orogenic gold deposits – formed in collisional mountain zones – e.g. Alps of New Zealand
Primary deposits Similar to Mother Lode gold deposits of California / Sierra Nevada
Secondary deposits – weathering – regolith – placer deposits

Geologic occurrence

- fault –hosted veins; orogenic fluids percolating along faults / fractures
- accounts for 35-40% of world gold production
- there is no documented relationship between these types of accumulations and intrusive igneous activity

II. Mineralogy / Geochemistry

Associations: Gold (Au) – Arsenic (As) – W and Au-Sb Low amounts of base metals: Cu,Pb, Zn

Mineralogy: pyrite, arsenopyrite; gold with quartz-calcite vein associations; associated with hydrothermal alteration zones

III. Mining of Ores

- associated with impoundments / dams, waste dumps, spoil piles, Cyanide (CN) processing to leach /remove gold from ores
- Acid mine drainage – self-regulated / neutralized because of calcite (alkaline mineral) association, AMD not prevalent problem in these types of deposits
- Sb-Au deposits / ore forming environment: temp = 100-250 deg. C, pressure < 2 kilobars, hydrothermal processes associated with fluid boiling / reaction with wall rock
- Quartz-stibnite (Sb_2S_3) association, pyrite-carbonate association, sericite alteration common

IV. Antimony (Sb) Geochemistry

-atomic no. = 51, at. Wt. = 122

- natural crustal (background) concentration = 0.2 ppm (relatively rare element); for comparison other natural concentrations: U = 2-3 ppm, Sn (tin) = 2-3 ppm, Cu (copper) = 20 ppm

- Sb common ionic state = Sb^{+3} and Sb^{+5}
- Sb commonly associated with As, heavy metal, toxic metals
- Sb environment: becomes concentrated up to 50-100 ppm around hot springs, fumaroles, sulfide ore deposits / fumaroles, black smokers, coal-black shale

Antimony uses: fire retardant in plastics, rubber, paper; used as alloy in metals, semi-conductors

- worldwide production = 60,000 tons/yr, china is primary producer

V. **Environmental Dispersion**

- weathering from bedrock rock, mining/smelting, urban runoff
-As used as pesticide / pre WWII, As associated with Sb
-Sb contamination resides as residue in stream sediments (fine clays and organics)

- mobility of Sb – pH dependent: mobilized in either acidic or alkaline environments

- Drinking water standards – allowable limits of concentrations

	Sb	As
Drinking Water	6 ppb	10 ppb
Fresh Water	6 ppb	<50 ppb
Sediments	2-25 ppm	20-70 ppm

Sb and As – toxic in water, bioaccumulates in food chain, As is a proxy for phosphorous and works it's way into cell structure

VI. **Case Study: Hillgrove Mine, Australia (East Coast)**

- largest Sb accumulation in Australia, > 60,000 tons produced since 1877
- environmental concerns: mine tailings, several million tons on landscape
- one of the largest Sb contamination sites worldwide
- related: CN (cyanide) treatment of ores, open tailing piles, stream sediments
- tailings dam, contaminated water
- Tailings concentrations: Sb 0.5%, As 0.2%, No AMD at site (self neutralized)

Watershed perspective: mine site lies in McCleay River System, drainage area = 11,500 sq. km

Contamination zone in channel extends 300 km downstream from mine/tailings site; also contamination found in channels and in side tributaries

Sb attached to clays and fine organic particles

All contamination above drinking water standards

Contamination Issues:

Contaminated sediment / water quality
-plant uptake of Sb/As from sediments
-bioaccumulation of Sb/As in food chain from cattle grazing on plants
- plant concentrations up to several 100's ppm
- floodplain and agricultural contamination in lower end of watershed
- nearshore / ocean contamination at mouth of river (oyster beds)

Problem with Sb – difficult to remediate, general lack of toxicology / health-effect data.

VII **Conclusion:**

Sb contamination in case study has implications for North America / similar mining sites around world

- Sb is a relatively obscure element, not much known about toxicology
- Sb is highly soluble and mobile
- Sb forms part of sediment contamination, bioaccumulates via plants
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- ANTIMONY KILLS – BETTER HIRE A GEOLOGIST TO CHECK OUT YOUR BACKYARD TODAY!