USGS
science for a changing world

Mining Wastes Overview

Sharon F. Diehl and Kathleen S. Smith

Billings Symposium / ASMR Annual Meeting

Assessing the Toxicity Potential
of Mine-Waste Piles Workshop

June 1, 2003

U.S. Department of the Interior
U.S. Geological Survey

Types of Mining

- Hard-rock (metallic) mines
- Coal mines (includes coalbed methane)
- Industrial minerals (non-metallic)
- Petroleum (oil and gas)

USGS

Types of Mine Waste

Rock waste	Igneous, metamorphic, sedimentary; very coarse fragments, unprocessed heterogeneous	High permeability, acidic leachate
Tailings	Silt size, processed	Wind erosion before consolidation, acidic leachate
Coal waste	Sedimentary Rock, interbedded coal, processed	Acidic leachate
Radioactive/ Uranium waste	Processed	Low-level radiation, radon

USGS

Hard-Rock versus Coal Mining

Greater amount of rock waste	Lesser amount of rock waste
Complex mineralogy, geology, and alteration halos	Less diverse mineralogy, simple stratigraphy
A variety of mining methods (e.g. underground, open-pit, placer, solution)	Underground and (or) open-pit (strip mines)

USGS

Composition of Historical Mining Wastes

Related to:

- **Geology**
- **Mining methods**
- **Milling and smelting technology**
- **Market demand**
  - **WWII vs. Great Depression**
- **Governmental policy**

Stamp mill in Colorado

(photo from the William L. Fick Colorado Mining Collection, Western History/Genealogy Dept., Denver Public Library)

USGS

Segregation of Historical Mining Wastes

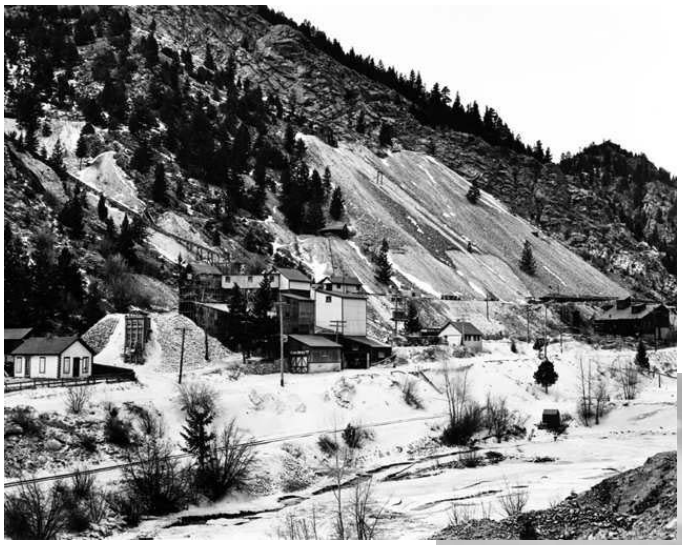
Early miners segregated mined materials

Ibex #4 ore bin in Idaho Park near Leadville, Colorado
(*photo from the Western History/Genealogy Dept., Denver Public Library*)

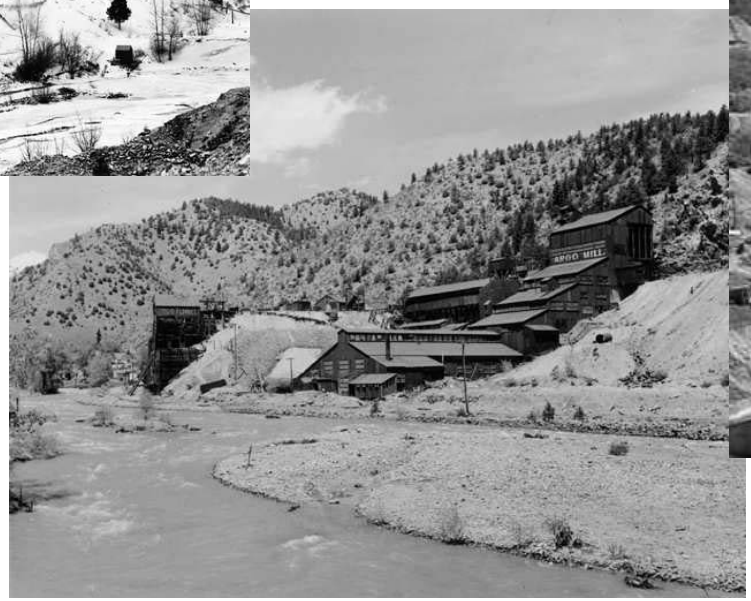
Placement of Historical Mining Wastes

Often adjacent to or in stream channels

Often on steep slopes



Alma Lincoln mine, Colorado
(*photo from the William L. Fick Colorado Mining Collection, Western History/Genealogy Dept., Denver Public Library*)



Argo mill, Idaho Springs, Colorado
(*photo from the William L. Fick Colorado Mining Collection, Western History/Genealogy Dept., Denver Public Library*)

Gregory Gulch, Colorado
(*photo by Donald Campbell Kemp, Western History/Genealogy Dept., Denver Public Library*)

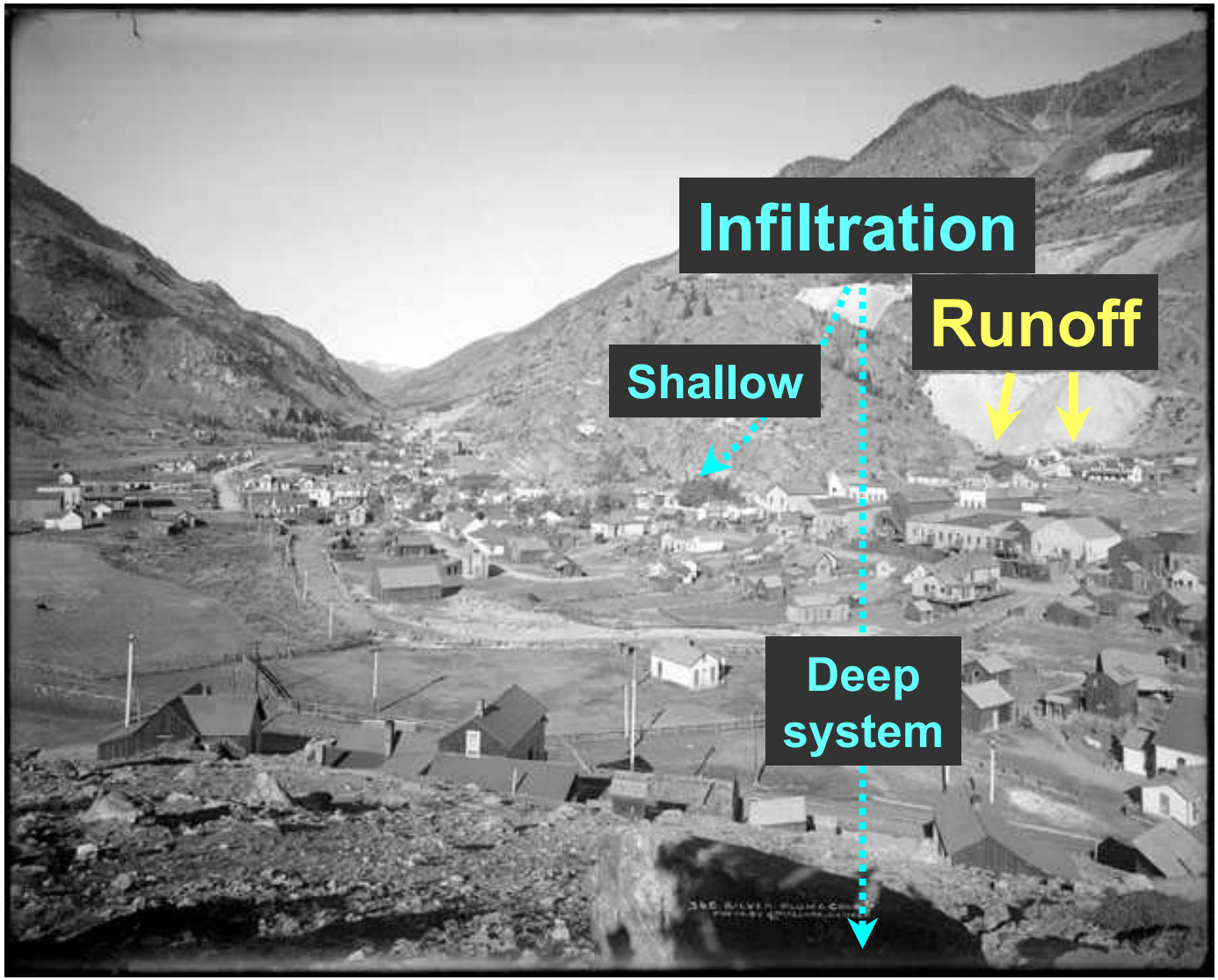
USGS

Placement of Historical Mining Wastes

Effluent from draining adits frequently flows over or into waste piles

USGS

Mining Wastes and Regional Hydrology



Silver Plume, Colorado

(photo from the L.C. McClure collection, Western History/Genealogy Dept., Denver Public Library)

USGS

Mining Wastes and Regional Hydrology

Mine workings often alter the regional hydrology

Silver Queen mine, California

(*photo from the Western History/Genealogy Dept., Denver Public Library*)

USGS

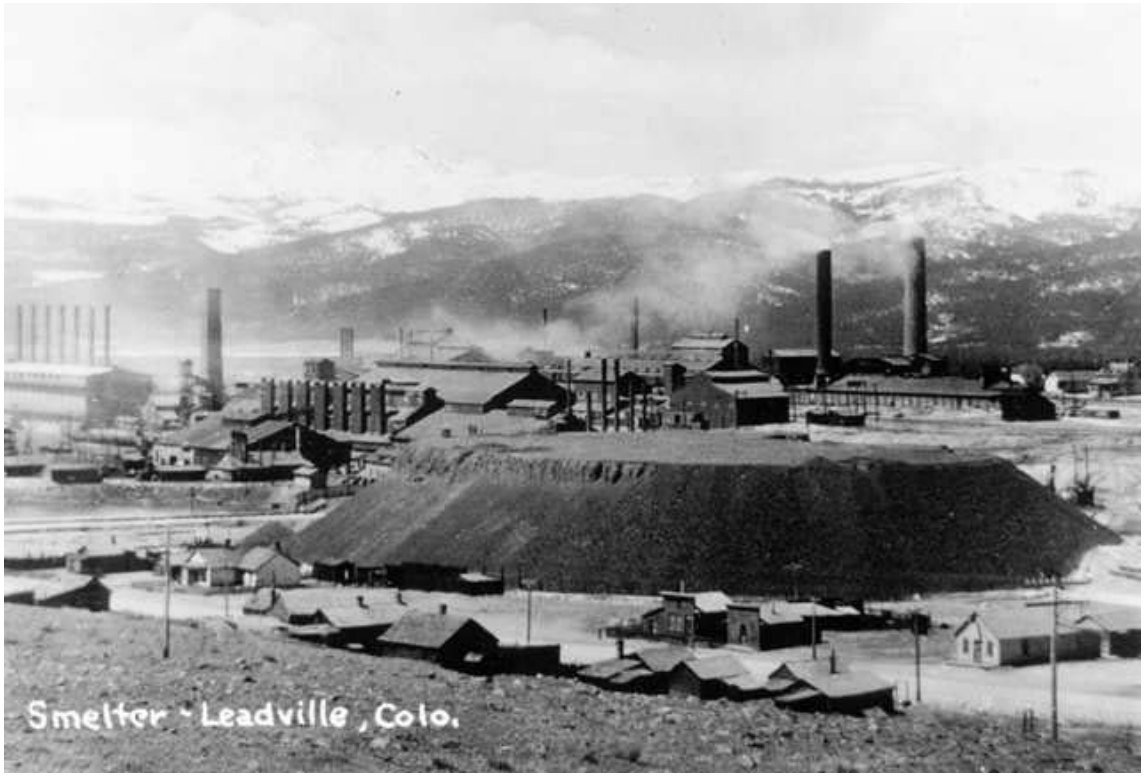
Tracer Injections

- Determine how much metal enters a stream
  - Mass loading (concentration x discharge)
- Determine how much metal stays in a stream
- Provide accurate discharge measurements
  - Difficult to obtain in mountain streams
- Differentiate between multiple sources
- Monitor effectiveness of remediation efforts
- Usually combined with synoptic sampling
  - Collection of samples from many locations during a short period of time, typically a few hours

See USGS Fact Sheet FS–245–96

USGS

Mining Wastes and Airborne Transport



(*photo from the Western History/Genealogy Dept., Denver Public Library*)

Mining wastes are often near former smelting operations

Fine-grained material from mining wastes can be transported by wind

USGS

Non-Invasive
Screening Tools

MINE WASTE CHARACTERIZATION

Improved
Remediation
Strategies

USGS

Non-Invasive Screening Tools

- Physical Characterization
- Geological Characterization
- Imaging Spectroscopy
- Geophysical Methods

USGS

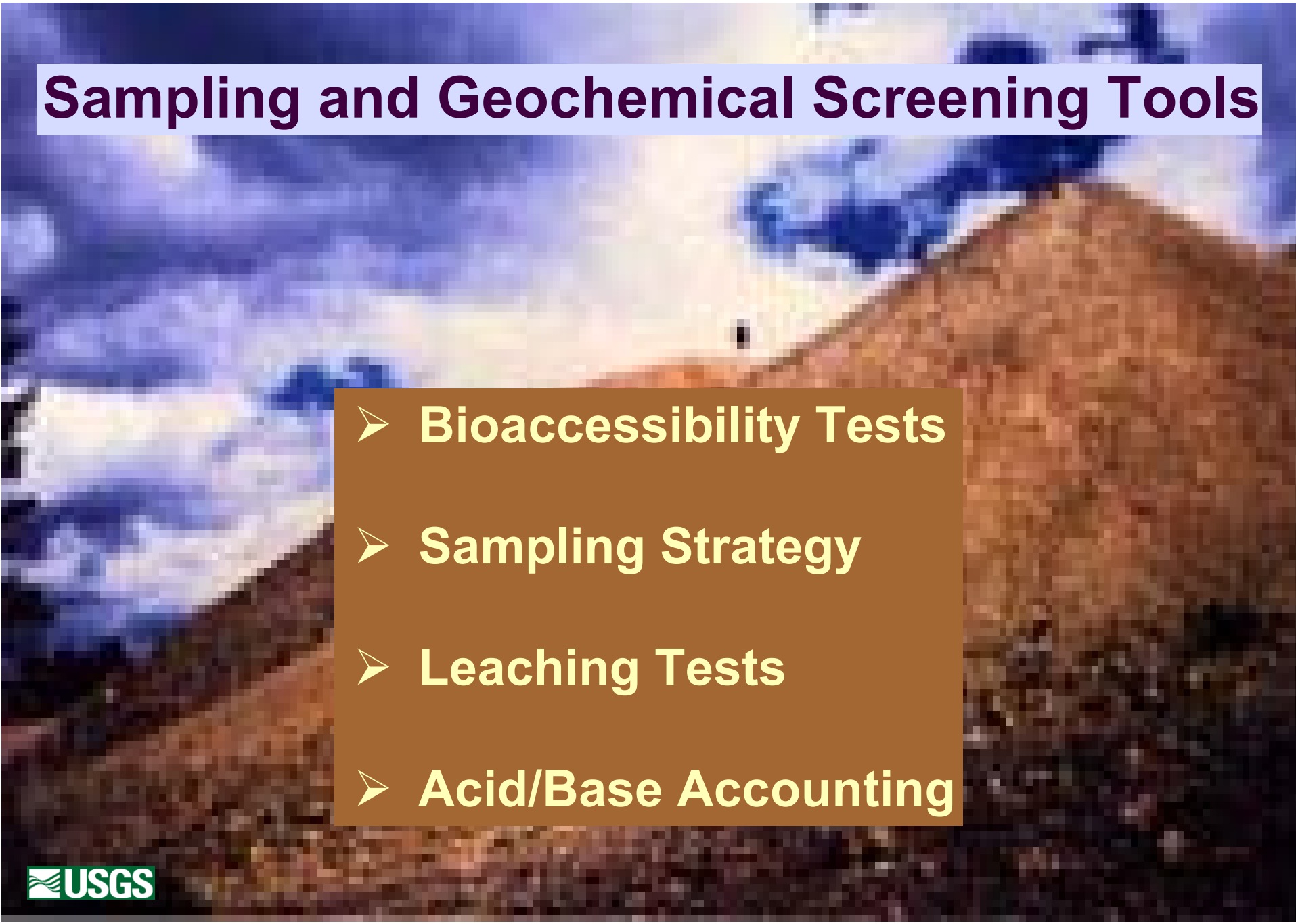
Geological Characterization

Geologic Setting:
- pH buffering capacity
- Ease of subsurface transport
- Routes to receptors

Mineral Deposit Type:
- Which metals are present
- Acid-generating capacity

Historical Mine/Mill Activities:
- Efficiency of sulfide removal
- Predict COC (e.g., Hg, cyanide)

Sampling and Geochemical Screening Tools



- Bioaccessibility Tests
- Sampling Strategy
- Leaching Tests
- Acid/Base Accounting

USGS

Site Characterization Tools

- Mineralogy
- Weathering Sequences
- Metal Partitioning
- Sulfur Speciation

USGS

Elemental Residence Phases
(from mineral separates, 4 Colorado mine-waste sites)

Jarosite [$KFe_3(SO4)_2(OH)_6$]	Pb, Ag, Cu, Bi
Pyrite [FeS_2]	Cu, Bi, Ag, As
Sphalerite [ZnS]	Cd, Cu, Mn, Ag
Galena [PbS]	Ag, Bi
Anglesite [$PbSO_4$]	Zn, Cd, Bi, Cu

- Degraded water quality
- Decreased species diversity
- Decreased population level
- Kill zones around waste piles
- Visual impact; esthetics

USGS

Potential Environmental Impact

A complex function of:

- Geology
- Geochemical and biogeochemical processes
- Climate
- Topography
- The mining and mineral processing methods used
- Age of wastes and reclamation history

USGS

Types of Mineral Deposits

- Conceptual models (geoenvironmental models) have been developed to predict drainage quality and potential environmental impacts
- Geoenvironmental models of mineral deposits describe pertinent earth science and engineering information about the environmental characteristics of geologically similar mineral deposits:
  - prior to mining (= Baseline conditions)
  - resulting from mining and mineral processing

USGS