Mining Wastes Overview

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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)

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Types of Mine Waste

Type	Physical Characteristics	Problems
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

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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)

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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*)

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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***)

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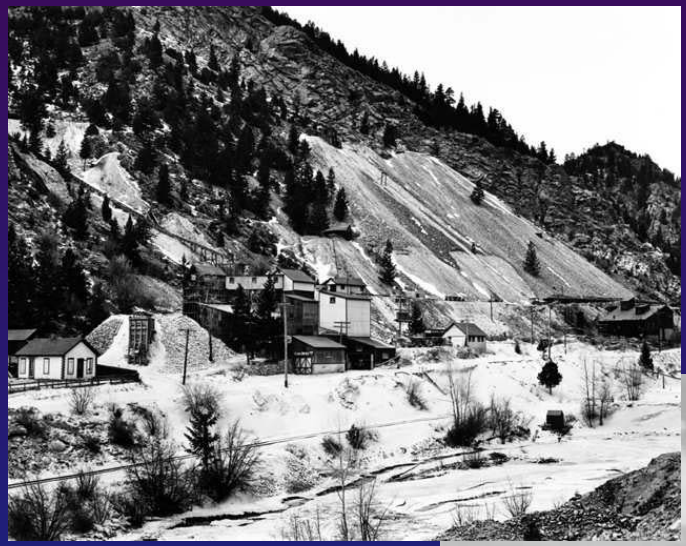
Placement of Historical Mining Wastes

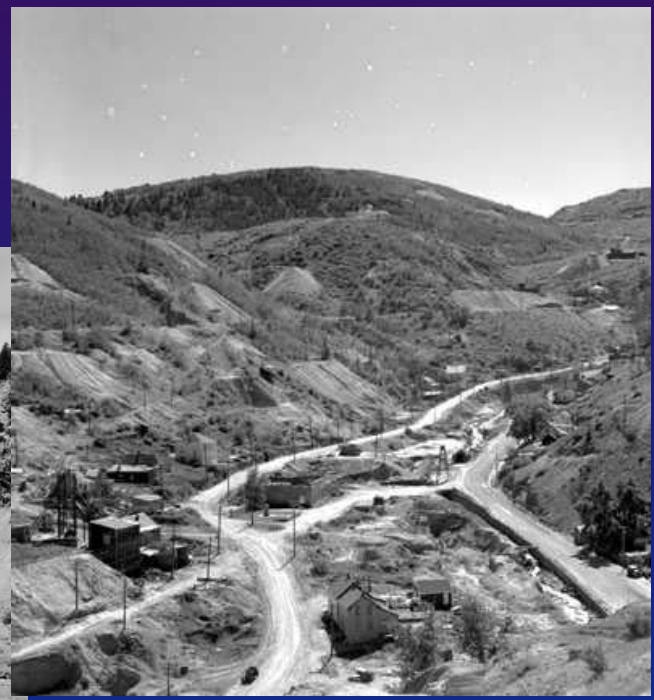
Often adjacent to or in stream channels



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*)

Often on steep slopes



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

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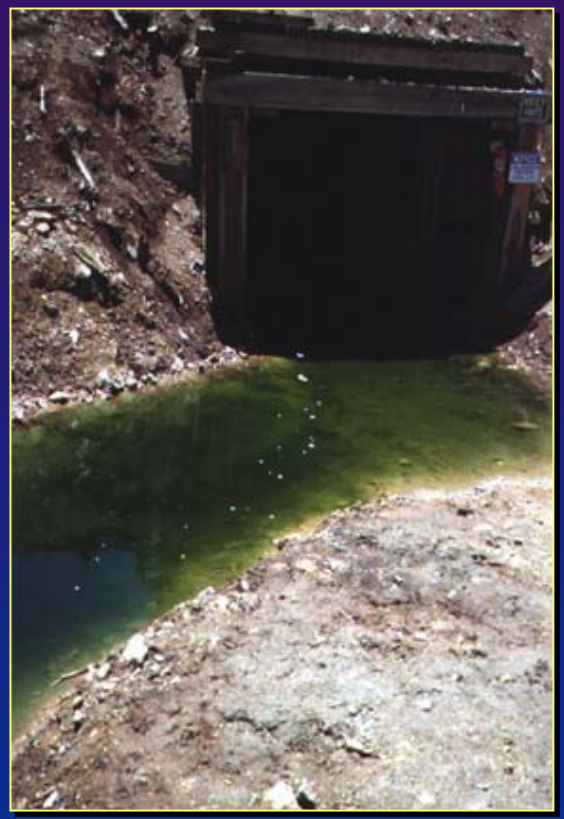
Placement of Historical Mining Wastes

Effluent from draining adits frequently flows over or into waste piles



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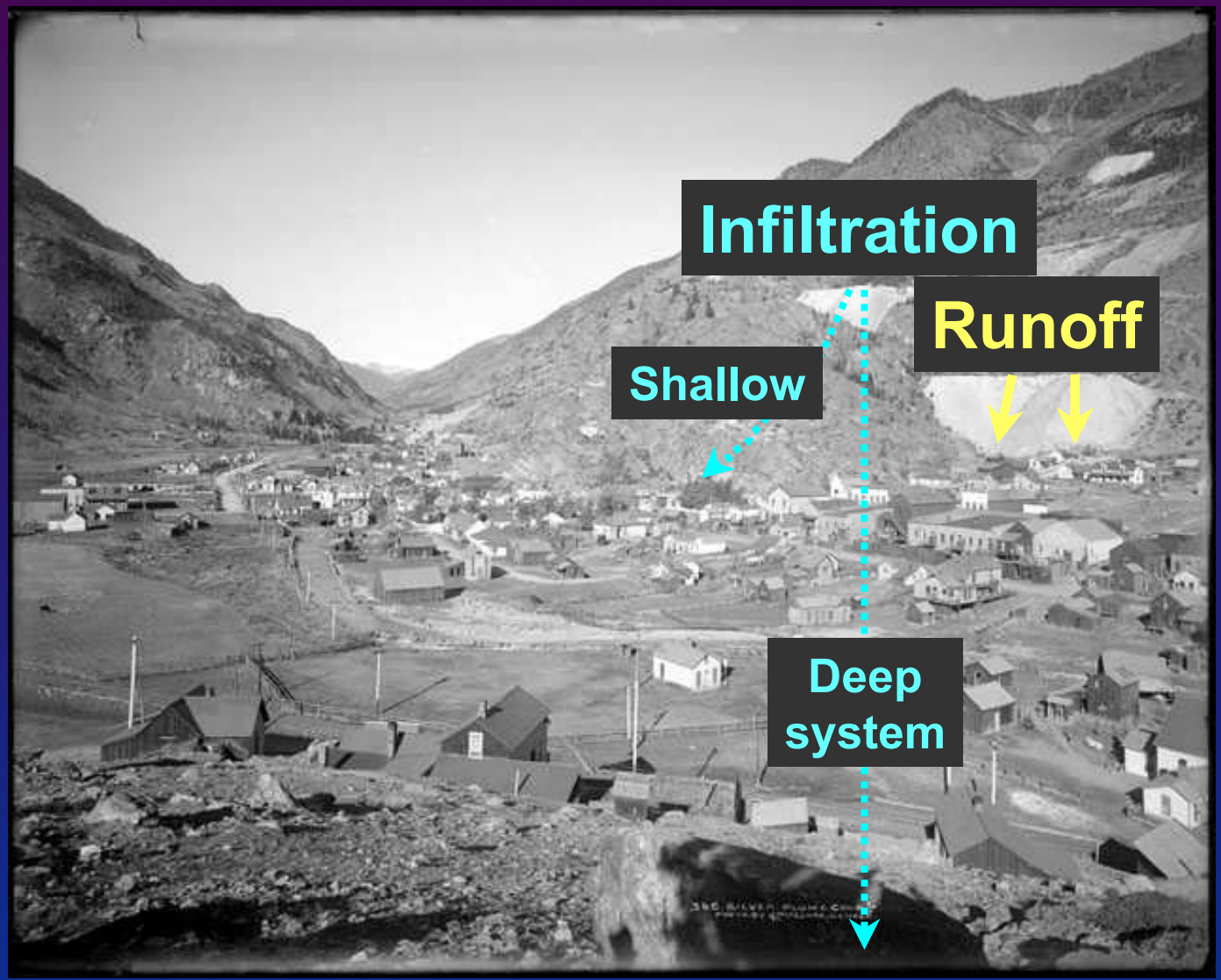
Mining Wastes and Regional Hydrology



Silver Plume, Colorado

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

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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*)

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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

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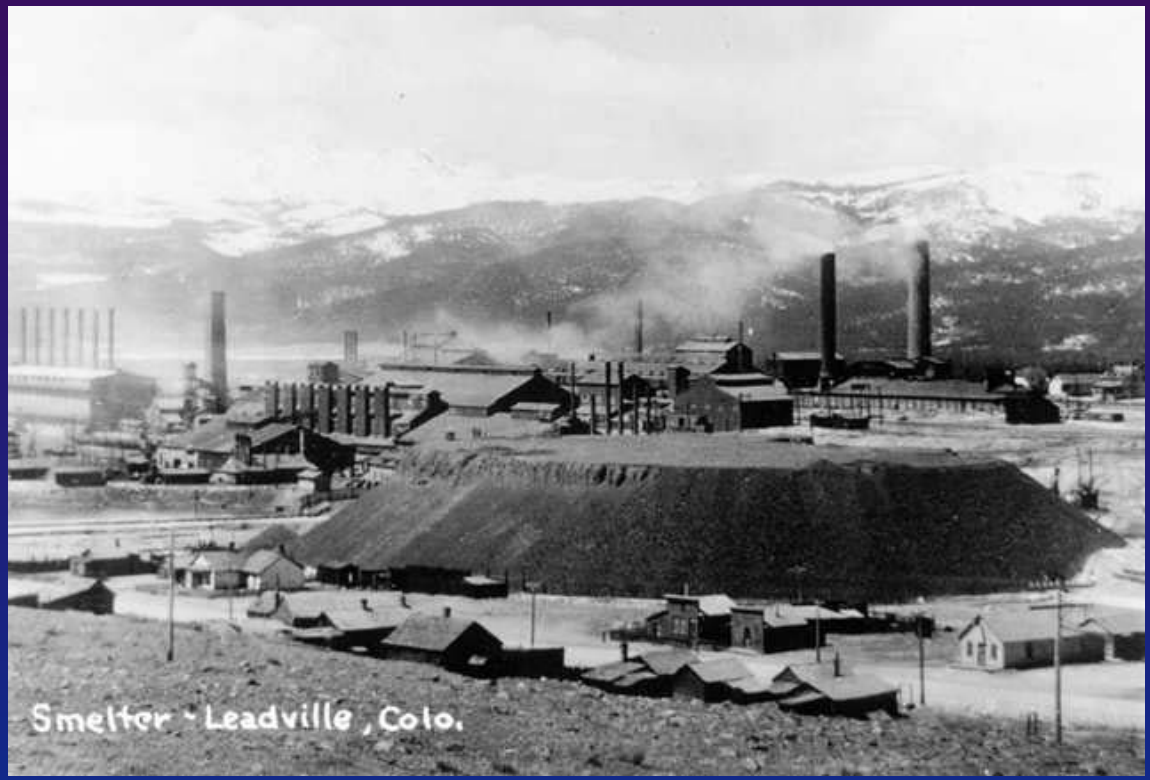
Mining Wastes and Airborne Transport



(*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

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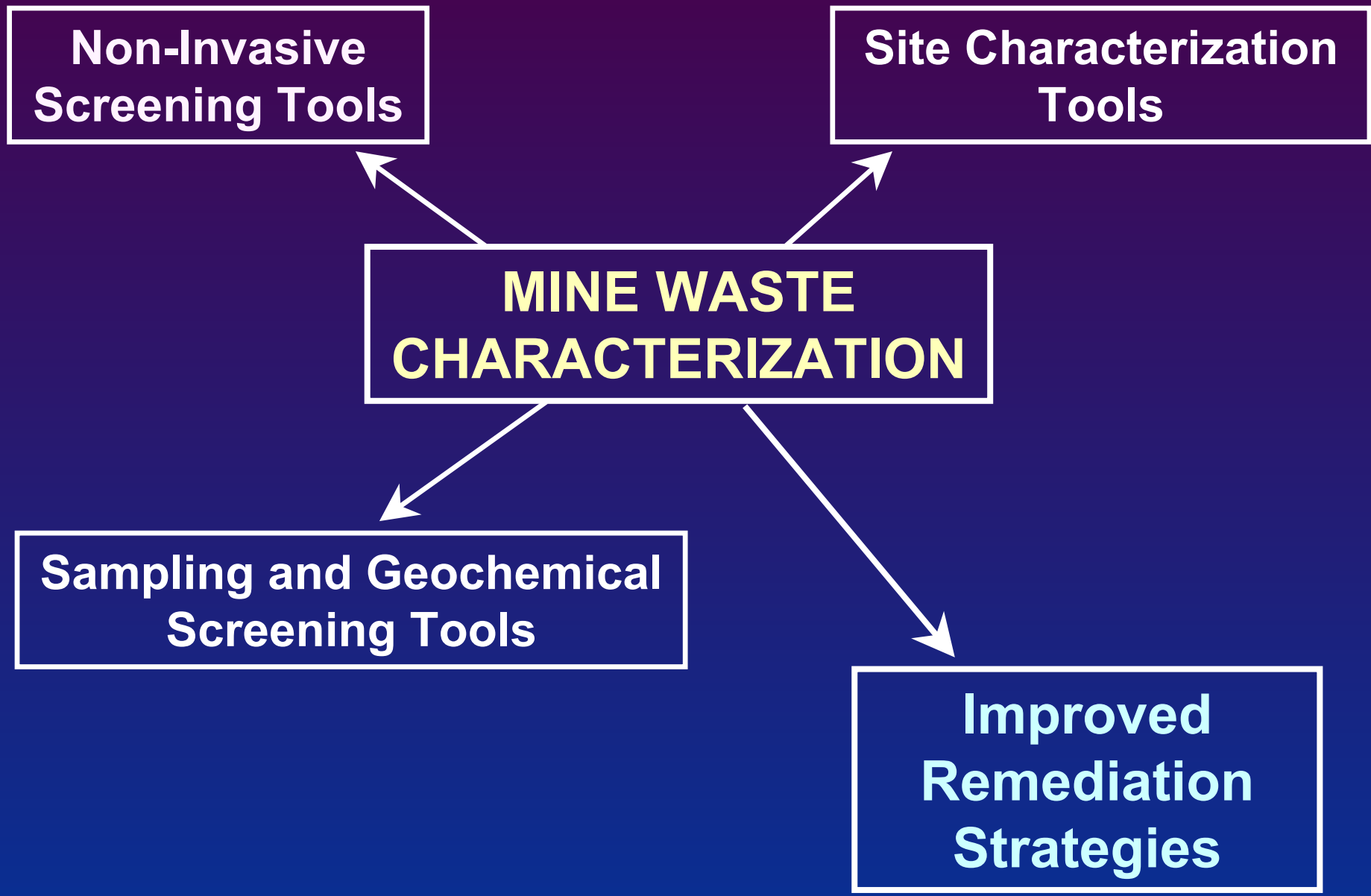
Non-Invasive Screening Tools
Site Characterization Tools
MINE WASTE CHARACTERIZATION
Sampling and Geochemical Screening Tools
Improved Remediation Strategies

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Non-Invasive Screening Tools

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

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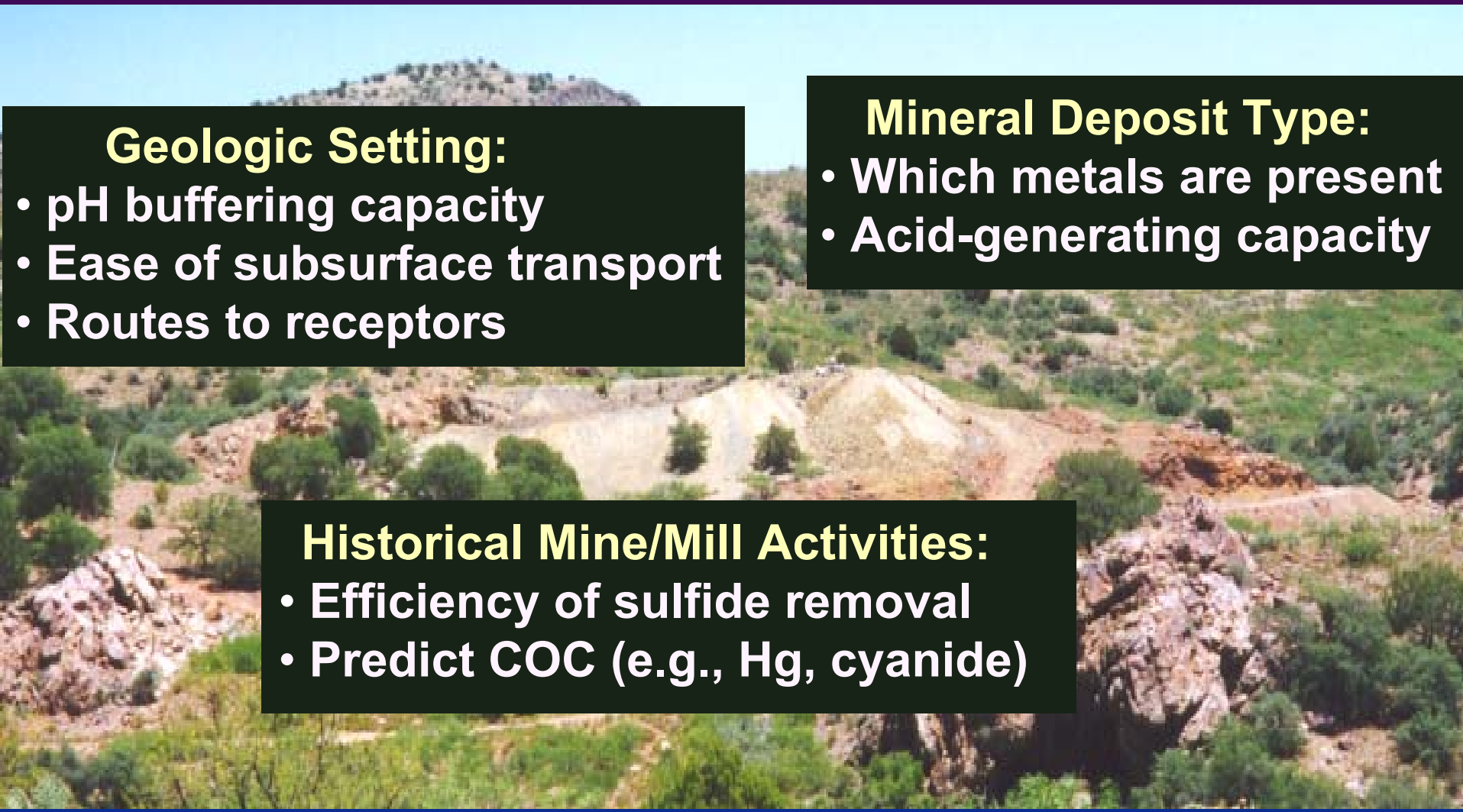
Geological Characterization



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)

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Sampling and Geochemical Screening Tools

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

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Site Characterization Tools

- Mineralogy
- Weathering Sequences
- Metal Partitioning
- Sulfur Speciation

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Mineralogical Characterization

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

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Potential Environmental Impact of Mine Waste

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

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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

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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

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