A Mine is a Terrible Thing to Waste: Cultural Resources and Vermont's Elizabeth Mine Superfund Cleanup

The Elizabeth Mine

Vermont's

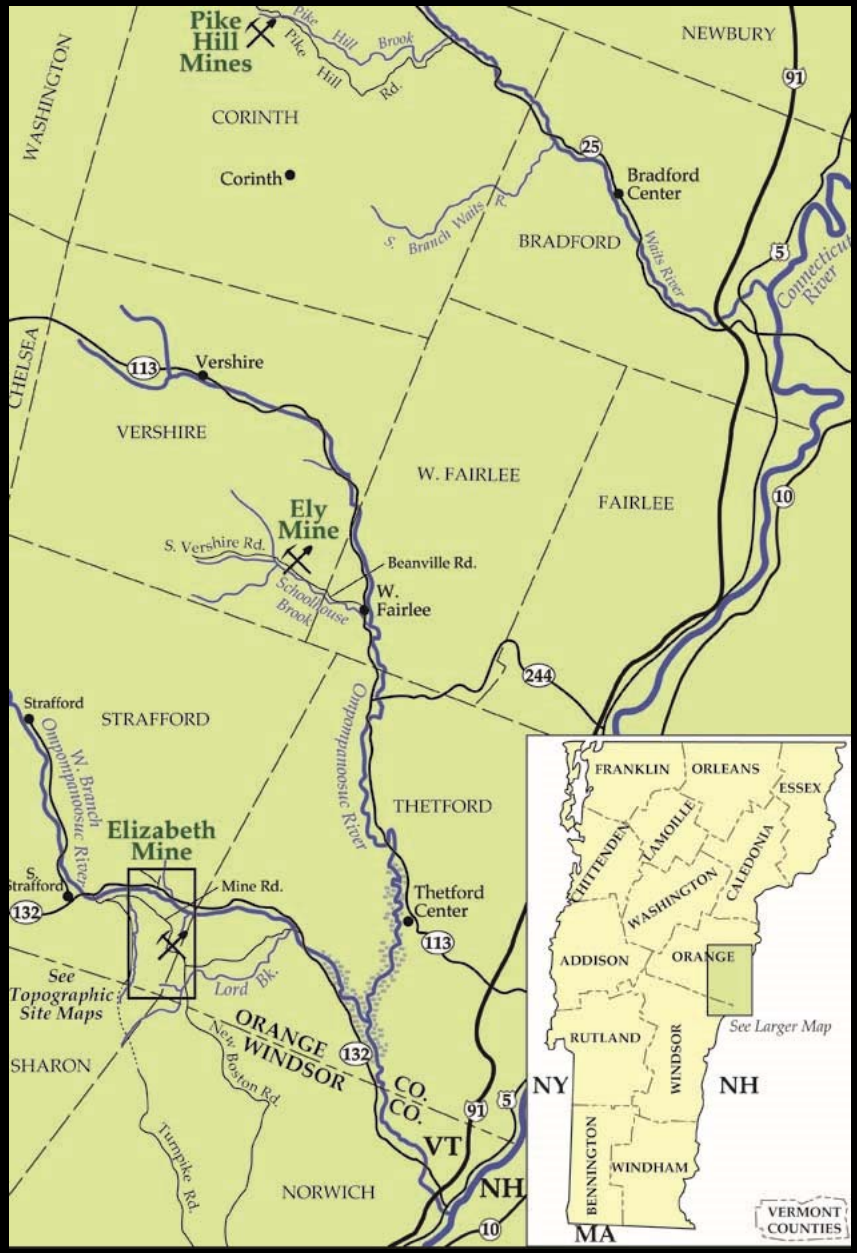
Extractive Industry

Vermont's Orange County "Copper Belt" Mines:

Pike Hill Mines 1846-1919

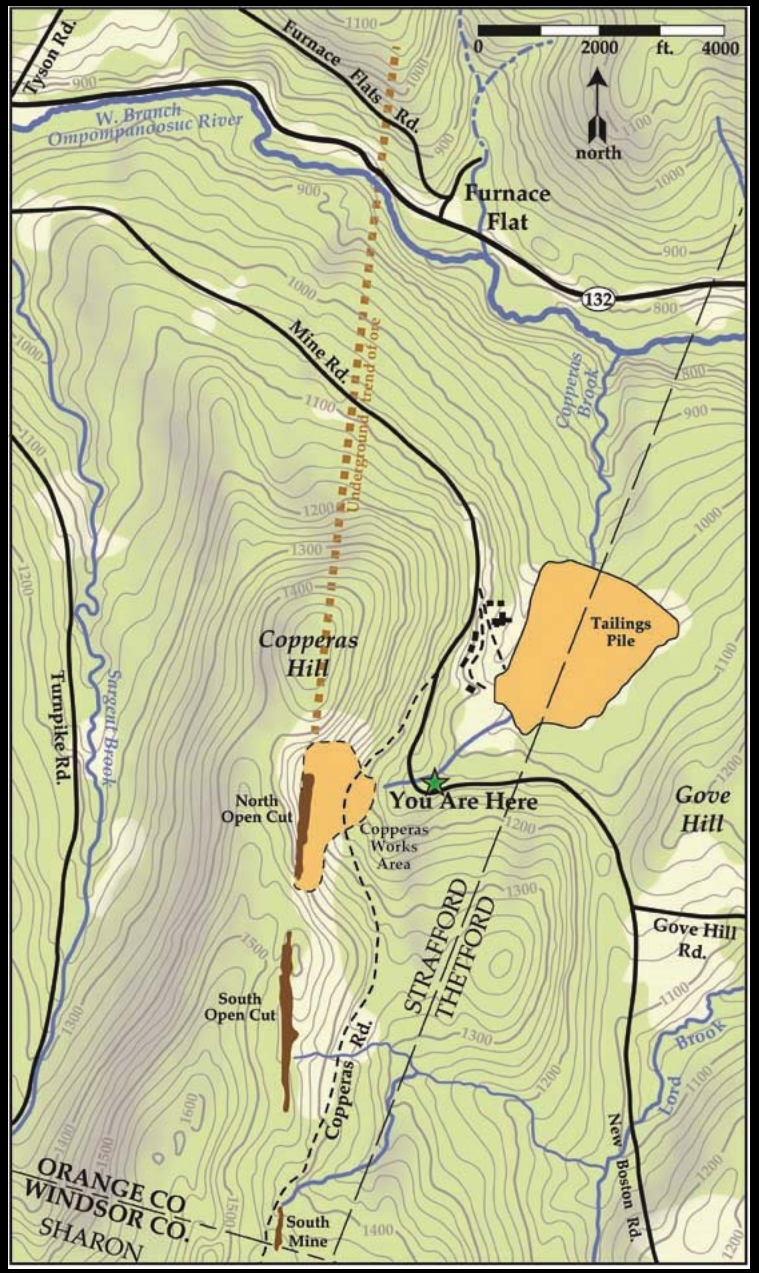
Ely Mine 1853-1918

Elizabeth Mine 1809-1958



The Elizabeth Mine Site

South Strafford, Vermont

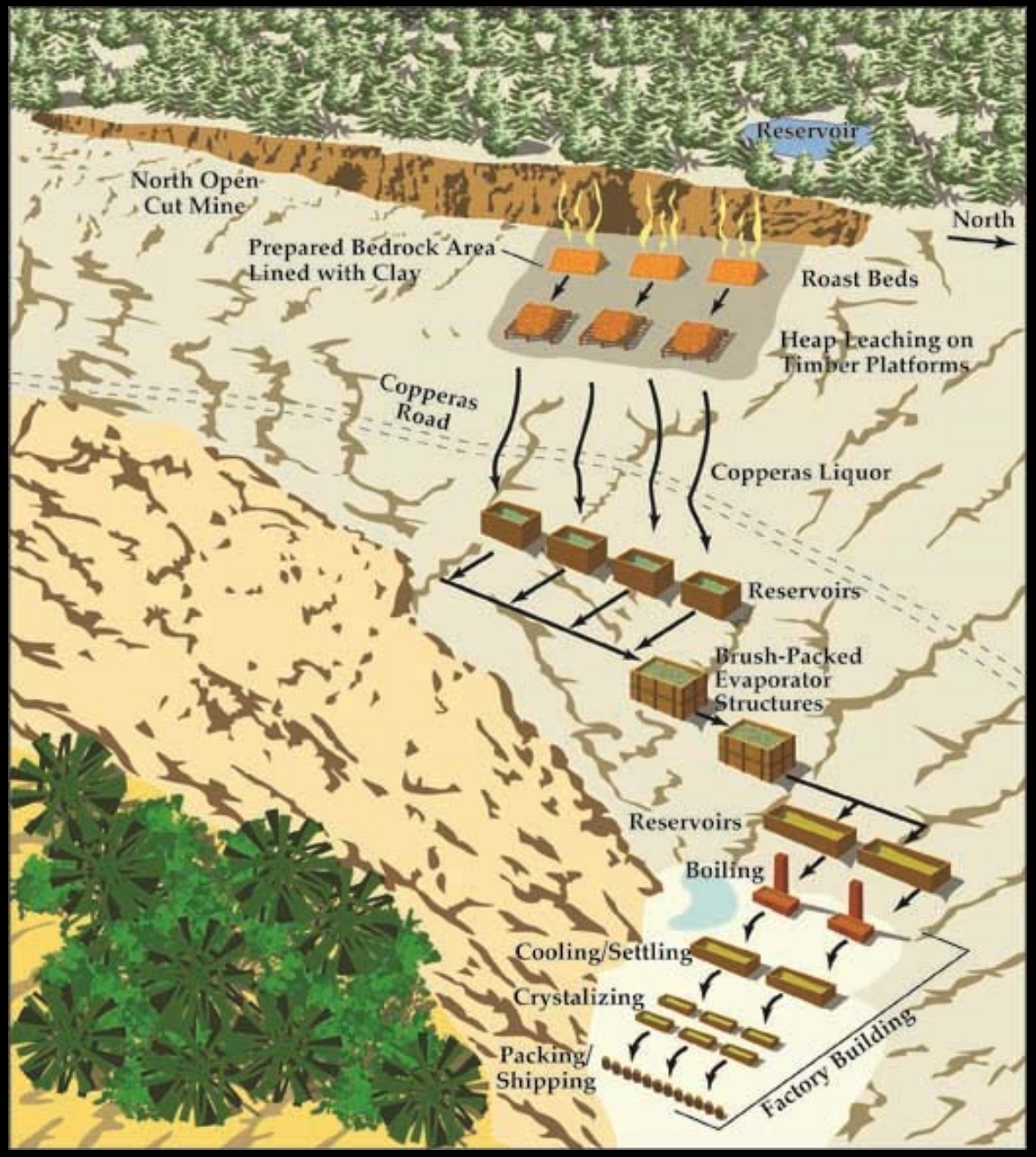


Copperas (Iron Sulfate) Crystals

The Copperas Works

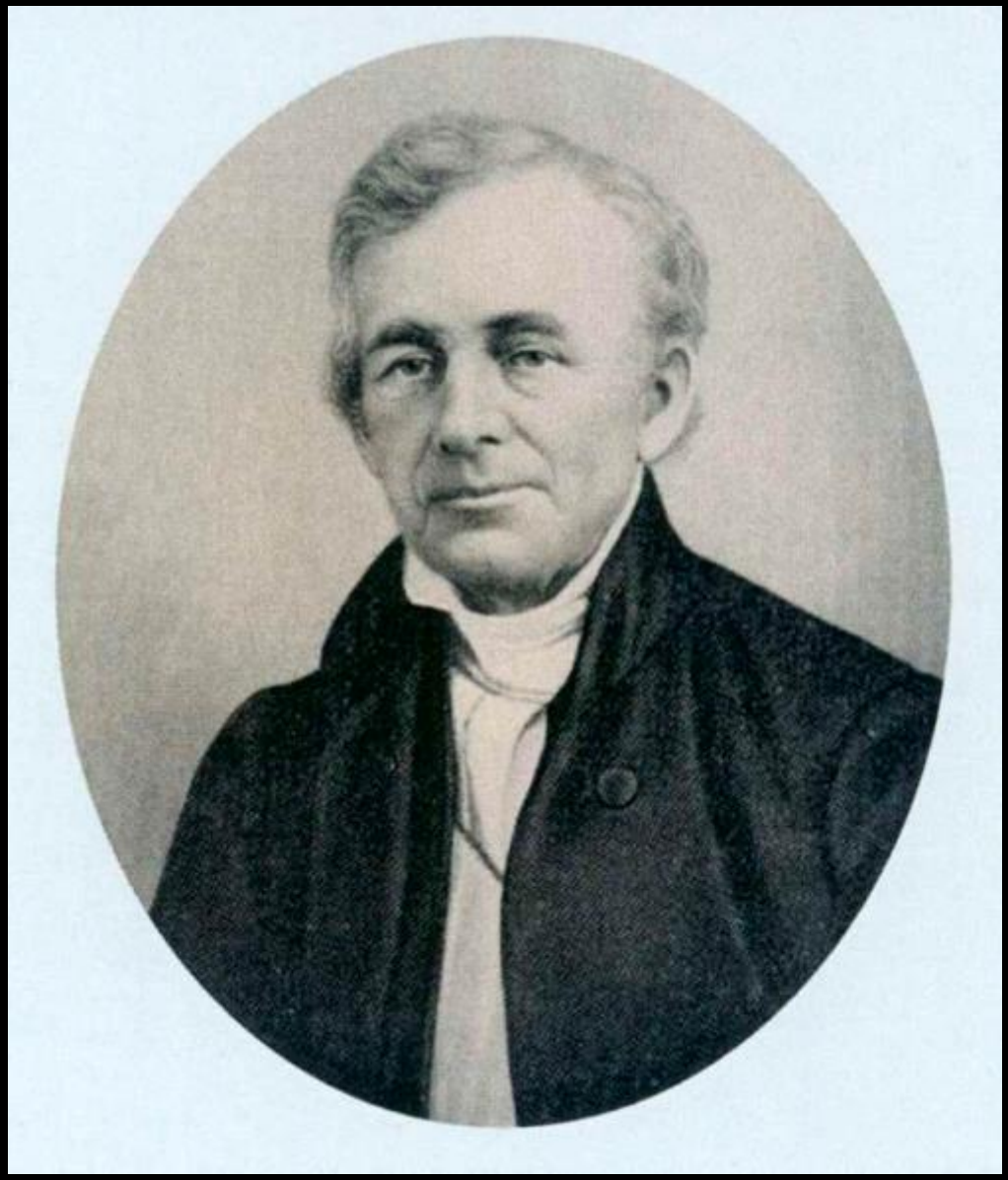
Making Copperas at Copperas Hill

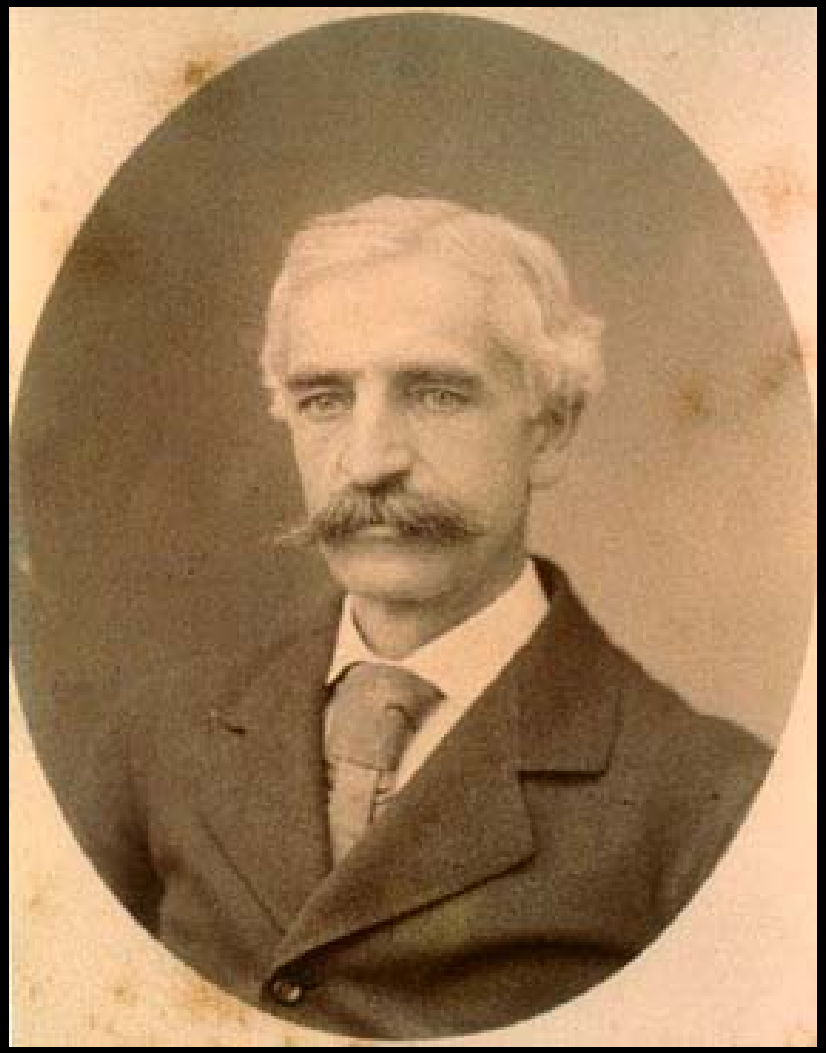
1809-1882



Isaac Tyson, Jr.
1792-1861

Chalcopyrite from Elizabeth Mine



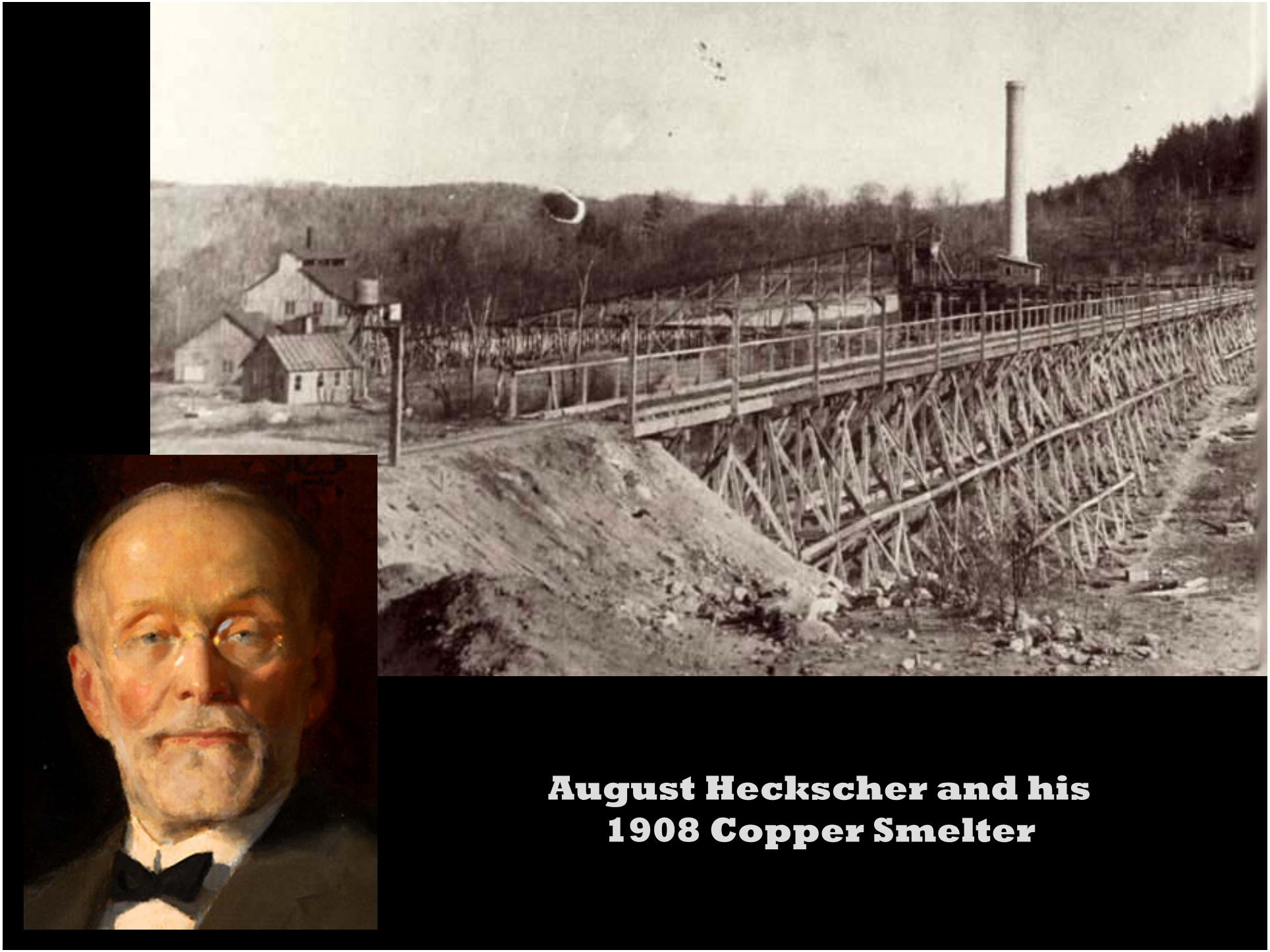


James Tyson
1832-1900

Elizabeth Tyson
1828-1888

Tyson No.1 Shaft, 1880s

Tyson Smelter, about 1902



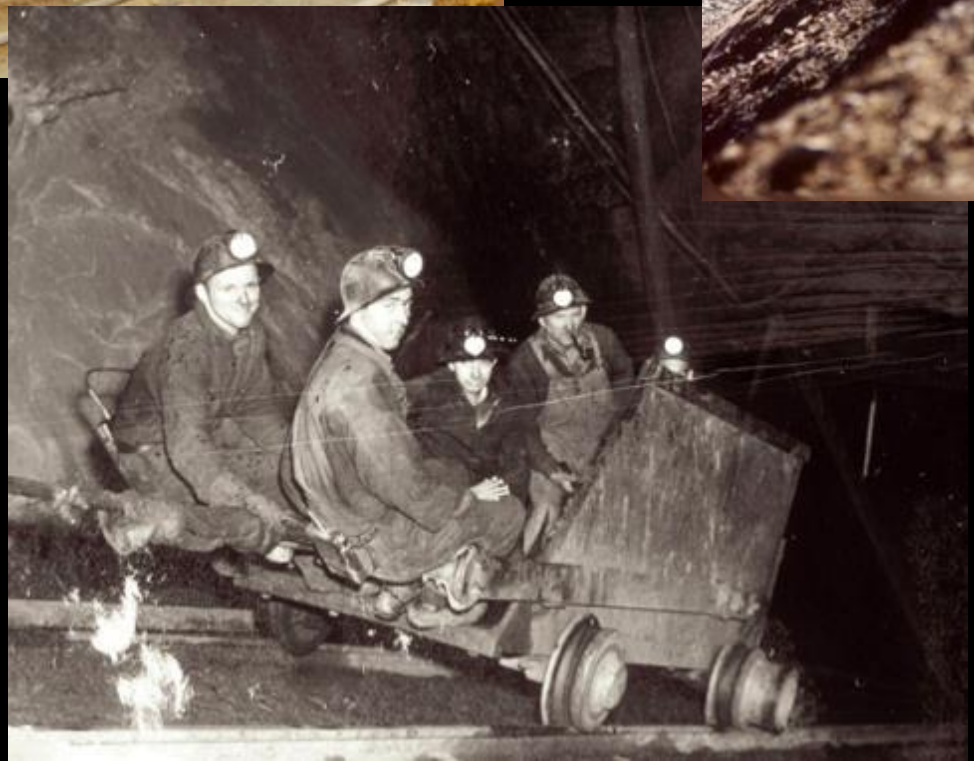
August Heckscher and his 1908 Copper Smelter

Elizabeth Miners, World War II

1942 Ore Concentration Mill

Miners Posing Underground

1950s Operations



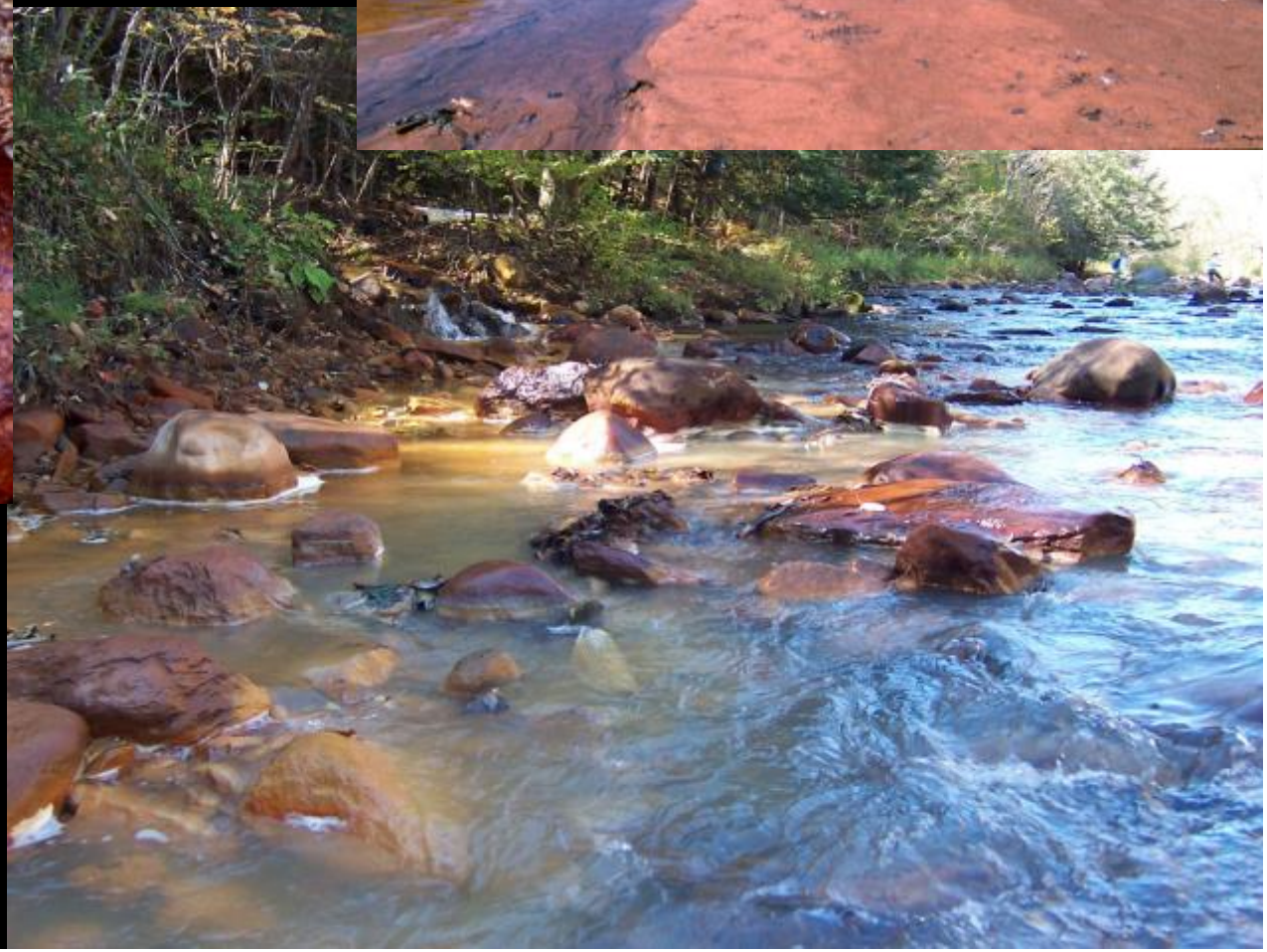
Flotation Tailings Pile and Disposal Launders

Mid-1950s:

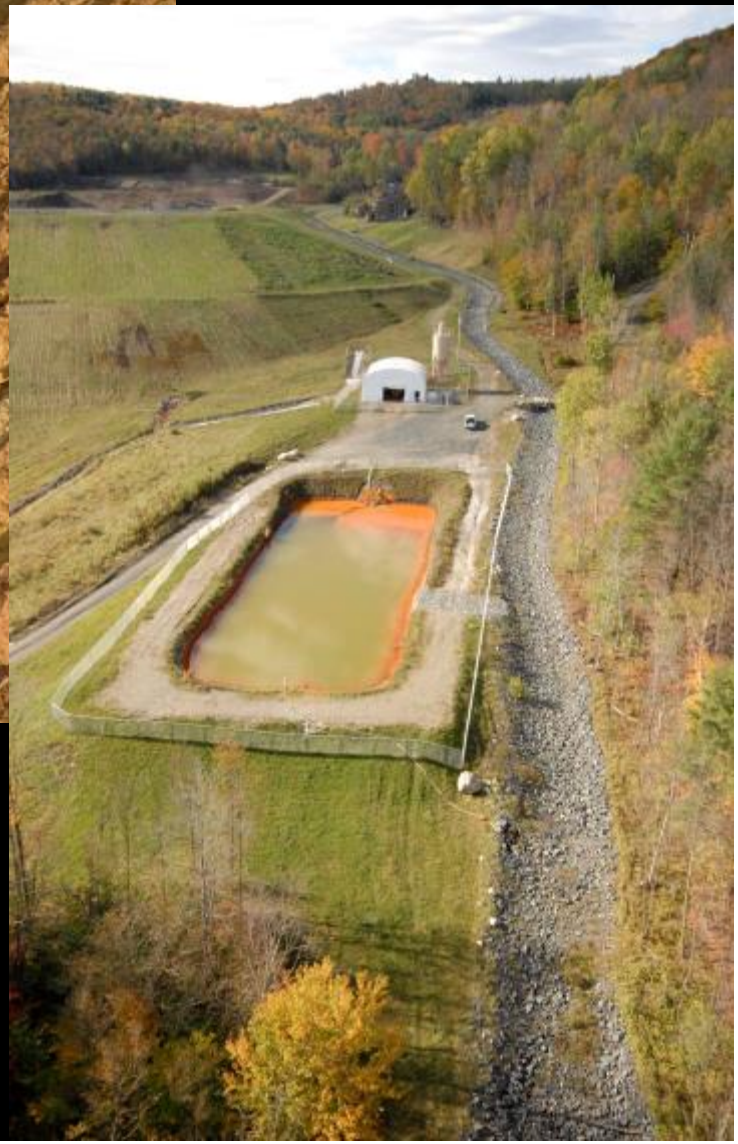
“Boom to Bust”

Copperas Works Roast Beds and Heap Leach Piles

Lower Copperas Factory Foundation, Mine Road



Acid Mine Drainage and Ompompanoosuc River



RECLAMATION: Tailings Grading; Leachate Treatment Plant and Diversion Channel

Mine Waste Removal

Waste Cover Construction

EPA CERCLA

TCRA

EMCAG, SHS, Etc.

NTCRA

SECTION 106 NHPA

VT DHP (SHPO)

CRM

NRHP DOE

MOA

MITIGATION

MITIGATION:

-DOCUMENTATION
-ARCHAEOLOGY
-PRESERVATION
-EDUCATION

DOCUMENTATION:

Historic American Engineering Record (HAER):

Narrative History Report

HISTORIC AMERICAN ENGINEERING RECORD

Elizabeth Mine

HAER No. VT-35

Location: Mine Road, 1-3/4 miles southeast of the intersection of Vermont Route 132 and Mine Road in the village of South Strafford, Orange County, Vermont

USGS South Strafford Quadrangle, Universal Transverse Mercator Coordinates: 18.714570.4855625

Dates of Construction: 1942–1958

Engineer, etc.: Galigher Company, Salt Lake City, Utah ca. 1943 (buildings)

Present Owner (s): Privately owned (withheld by request)

Present Use: Closed (1958)

Significance: The Elizabeth Mine is one of three copper mines that operated in Orange County, Vermont, in the nineteenth and twentieth centuries. The Elizabeth Mine operated almost continuously from 1809 to 1958. Of the three mines, it produced the highest tonnage of copper, and left the largest and most complex mining landscape. Beginning in 1809 the mine was an important domestic producer of copperas (iron sulfate), and copper was smelted in several brief campaigns between 1830 and 1919. The mine was most productive between 1943 and 1958 when it was revived using modern ore processing technology. Between 1946 and 1956 the Elizabeth Mine was at times among the top 25 copper producers in the U.S. Total copper output for the mine is estimated at more than 100 million lb. The site includes historic mining resources including a regionally unique cluster of World War II-era hard rock metal mining and ore processing buildings and associated man-made landscape features including tailings and waste rock piles, all evidence of historically significant industrial activity.

Historian: Matthew A. Kierstead, November 2003

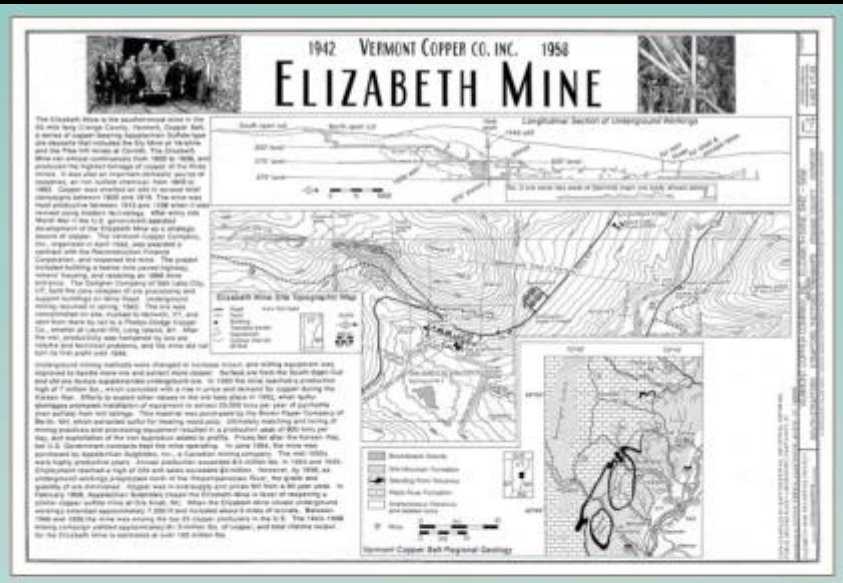
Project Information: The Elizabeth Mine has been identified as source of water contamination in the West Branch of the Ompompanoosuc River, a tributary of the Connecticut River. The U.S. Environmental Protection Agency listed the Elizabeth Mine site on the National Priority List ("Superfund") on June 14, 2001. The site was subsequently determined eligible for listing in the National Register of Historic Places. This Historic American Engineering Record documentation of the World War II to 1958 period historic architectural, engineering and landscape resources at the Elizabeth Mine was completed during spring and summer 2003 by PAL, Inc. of Pawtucket, RI for the U.S. Army Corps of Engineers in partial fulfillment of a Memorandum of Agreement stipulating mitigation of potential cleanup impacts to historic resources under Section 106 of the National Historic Preservation Act.

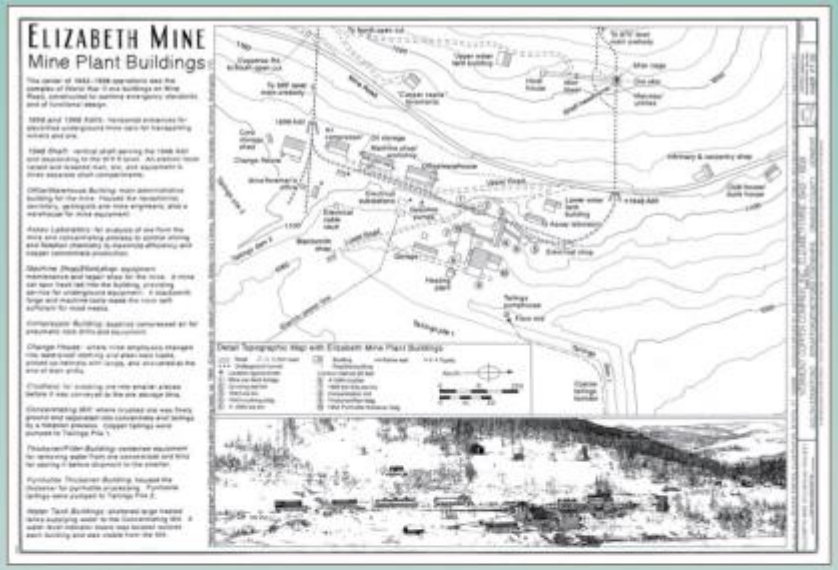
DOCUMENTATION:

HAER:

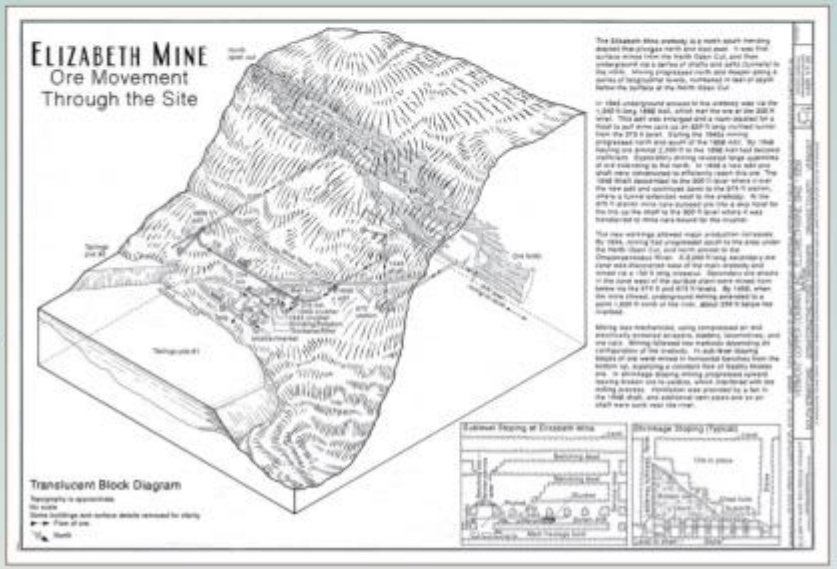
Large-Format Archival Photographs

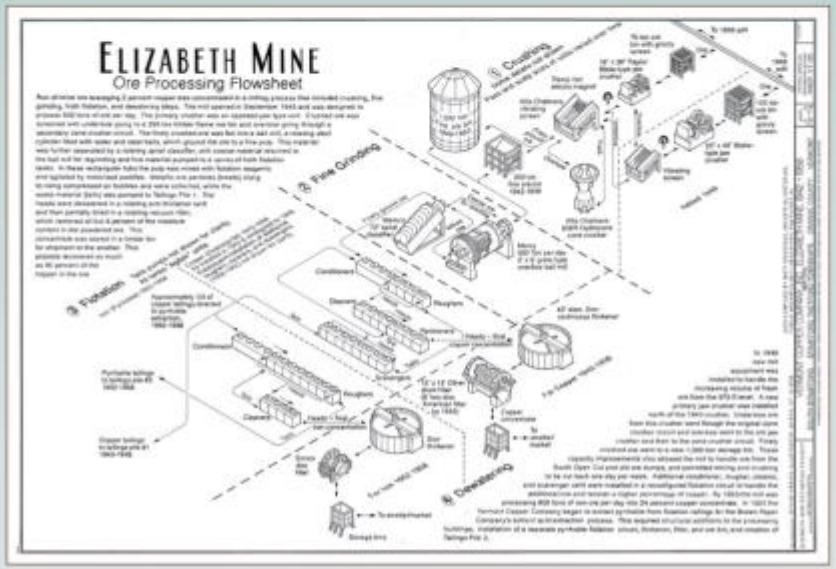
DOCUMENTATION: HAER: *Drawings*



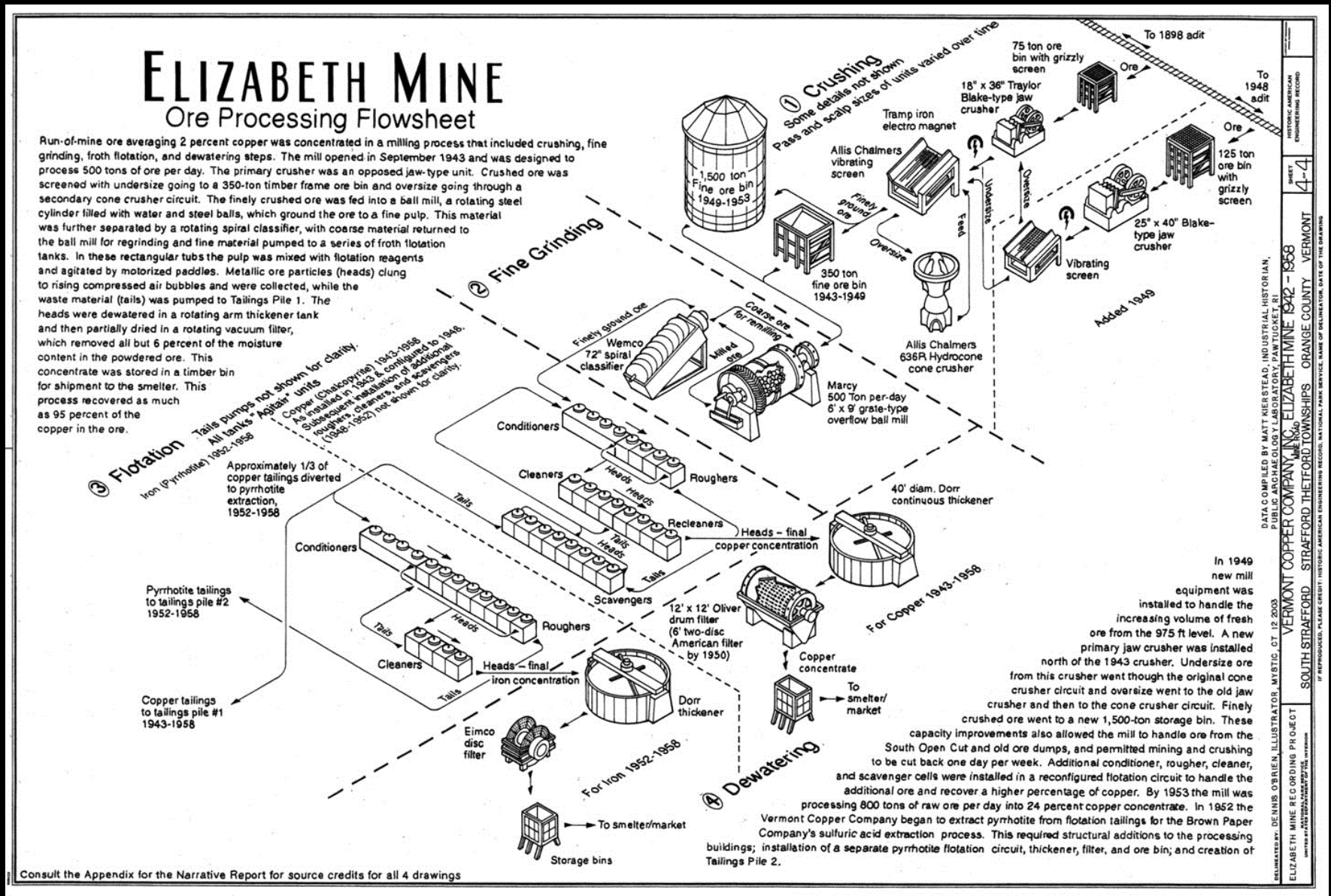


Drawings by Dennis O'Brien Maps & Wayfinding





HAER: Process Drawing



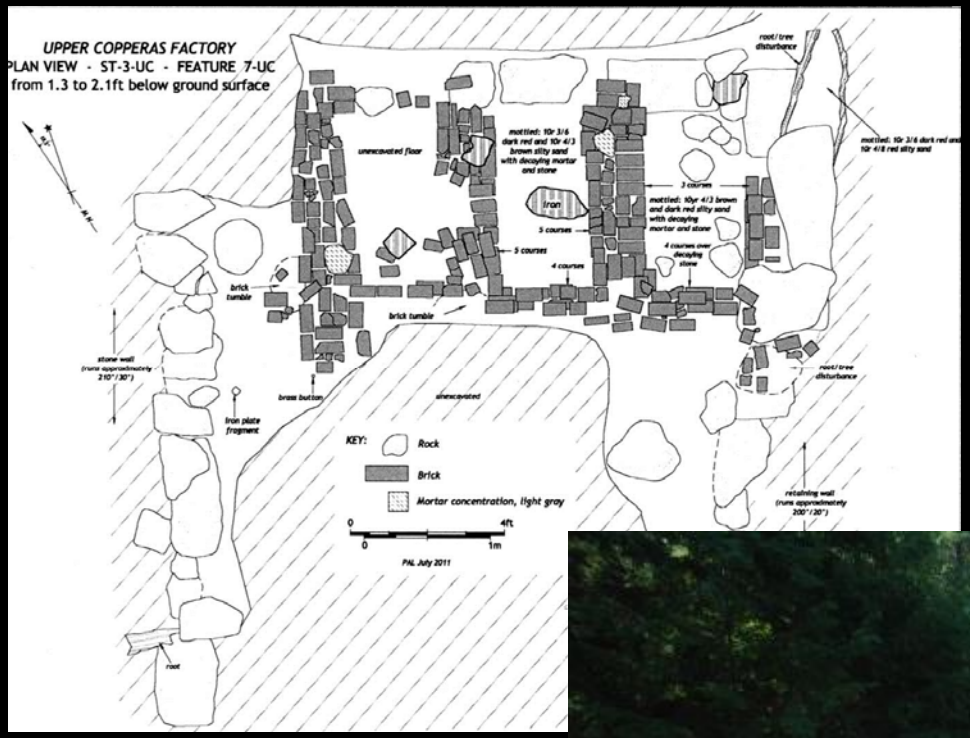
MITIGATION:

ARCHAEOLOGY

Data Recovery

Copperas Factory:

BOILER

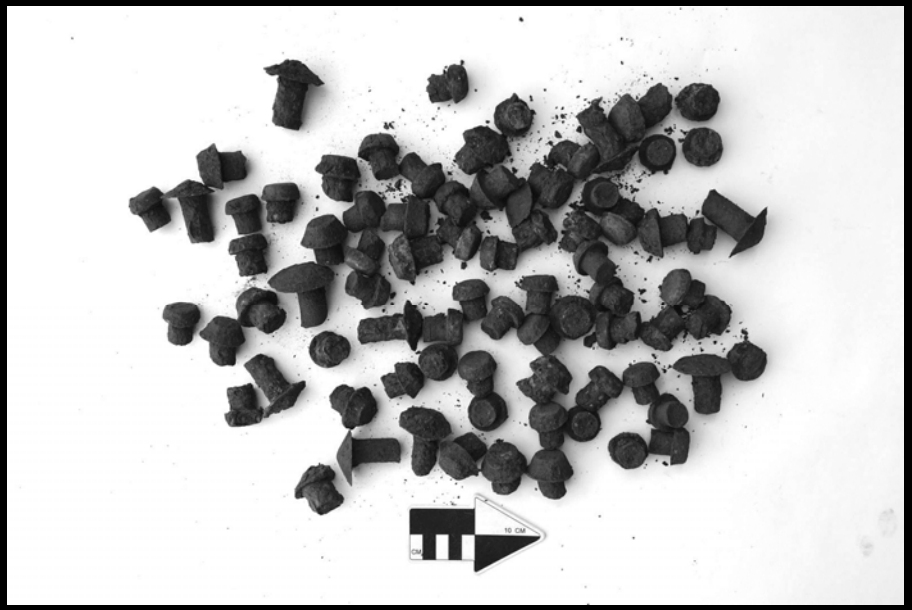


Copperas Factory: COOLER

Copperas Factory: CRYSTALLIZER

Copperas Factory:

ARTIFACTS



MITIGATION:

PRESERVATION

Copperas Factory Foundations

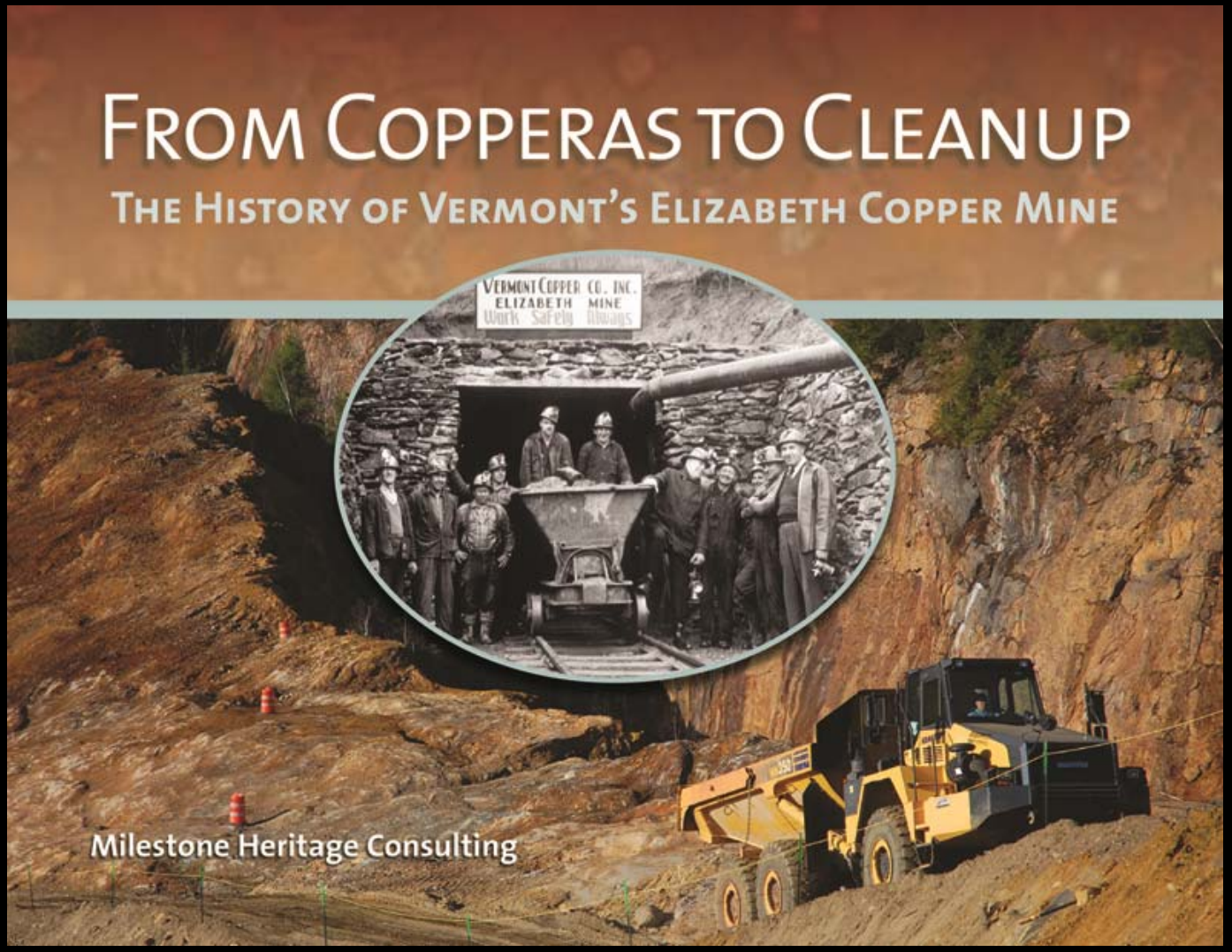
MITIGATION:

PRESERVATION

Ore Concentration Mill Foundations

MITIGATION: EDUCATION

Popular Report



MITIGATION: EDUCATION

Elizabeth Mine

You are standing at the center of the Elizabeth Copper Mine site, a scene of widespread industrial activity from 1809 to 1958. The mine was the largest producer of the chemical "copperas" in the United States in the mid-nineteenth century. Modernized for World War II production, it became one of the top 20 American copper ore producers of the 1950s. A century and a half of mining left behind a dramatic landscape that contaminated part of the Connecticut River watershed. The U.S. Environmental Protection Agency declared the Elizabeth Mine a "Superfund" site in 2001, and the EPA's cleanup actions have dramatically improved the ecological health of the impacted streams and rivers.

The Elizabeth Mine was a source of metallic, sulfur-bearing minerals. The iron-, copper-, and sulfur-bearing "sulfide" ore minerals mined here were deposited on the ancient seafloor around 400 million years ago and later included in the formation of Vermont's Green Mountains. Sulfide ores and mining waste exposed to air and water can create acid water and metals contamination.

Copper is an important metal with a long history of mining in the U.S. Copper has been used by humans for thousands of years. Its malleability, strength, and corrosion resistance make it ideal for weapons, containers, coins, statues, musical instruments, and plumbing. Copper is also highly conductive, and by 1900 it was in great demand for electrical and communications uses. Most of the copper used in America during the colonial period was imported. The U.S. copper industry emerged in the 1840s, and Michigan and Vermont became important Civil War–era contributors. Later in the nineteenth century the industry expanded in the Rocky Mountains and the American Southwest, where copper is now mined in huge open pits.

Vermont once hosted New England's most productive copper mines. Orange County's historic "Copper Belt" includes the Elizabeth Mine, the Ely Mine in Vershire, and the Pike Hill mines in Corinth. These mines operated on and off, based on demand for copper for the American Industrial Revolution, the Civil War, two World Wars, and the Korean War. Together they produced almost 150 million pounds of copper, almost 100 million pounds of which came from the Elizabeth Mine. These mines were "boom and bust" industries where natural resources were exploited and the resulting landscapes abandoned. After the Elizabeth Mine closed in 1958, waste contaminated the water in Copperas Brook, Lord Brook, and the West Branch of the Ompompanoosuc River, tributaries of the Connecticut River, for over forty years.

Elizabeth Mine pollution was addressed through environmental cleanup. Public concern over pollution led to the environmental movement of the late 1960s. The U.S. Environmental Protection Agency was established in 1970, and in 1980 Congress passed the Comprehensive Environmental Response, Compensation, and Liability Act, or "Superfund," which allows the EPA to provide funding or take enforcement actions to clean up sites that could harm people or the environment. The EPA's Elizabeth Mine cleanup project greatly reduced acid and metals releases, leading to dramatic recovery of downstream water quality. Mining also left archaeological sites, buildings, and industrial landscapes, and the EPA addressed cleanup impacts to those historical resources through archaeology, documentation, and public education.

Sample of dark sparitic copper sulfide ore mined underground at the Elizabeth Mine. Source: U.S. Environmental Protection Agency.

Aerial view of partially overgrown Elizabeth Mine copper ore mill tailings pile looking southeast, 2008. Source: Stratford Historical Society

Ocean to Mountain: Elizabeth Mine Ore

The remarkable expanse of exposed bedrock on Copperas Hill is the result of historic industrial activity and recent environmental cleanup. Between 1809 and 1882, copperas miners dug iron sulfide ore from an open trench at the top of the slope, roasted it in heaps, and leached it with water to make weak copperas "liquor." Miners removed the soil, plugged cracks in the rock with clay, and cut trenches, turning the hillside into a giant funnel directing the copperas liquor to the factories at the bottom of the hill. Later, multiple phases of copper mining left more waste on top of the copperas ore piles. The U.S. Environmental Protection Agency identified the colorful eroded waste as a major source of acid mine drainage and metal contamination. In 2010, the EPA removed the waste and relocated it for onsite disposal, exposing the bedrock once again. The bare rock contains crystals of minerals characteristic of metamorphosed seafloor rocks, including large garnets and amphiboles.

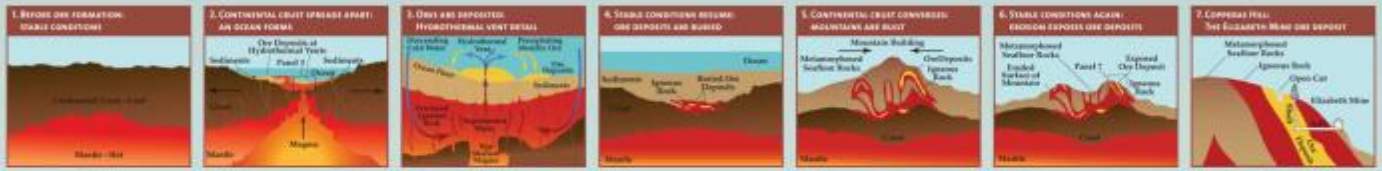
The Elizabeth Mine is located in the Gile Mountain Formation, which is a geologic unit within Vermont's eastern Green Mountains, a part of the Appalachian Mountains. The Appalachians, stretching from Alabama to eastern Canada, were formed by a series of orogenies—mountain-b and 260 million years ag eroded to their present h building stones, metals,

Weathered dark copperas ore in piles from roasting and heap leaching and lighter copper mining waste rock on Copperas Hill before the cleanup, 2008. Source: U.S. Environmental Protection Agency.

by shallow magma, resulting in submarine hot springs. These types of sulfide ores form worldwide and were also mined in the eastern United States at locations including Ducktown, Tennessee; Ore Knob, North Carolina; Great Gossan Lead, Virginia; Rowe, Massachusetts; and Blue Hill, Maine. Sulfide ores can contain copper, lead, zinc, and other metals, although only copper was produced at the Elizabeth Mine. Sulfide ore mine waste exposed to weathering has potential to create acid water and metals contamination.

Elizabeth Mine Ore Formation

Formation of seafloor sulfide ore deposits of the type including the Elizabeth deposit



Silurian Period and earlier; approximately 430 million years ago and older. Conditions are stable, with thick continental crust riding on the hot mantle. (Illustrations are schematic and different scales.)

Early Devonian Period; approximately 415 million years ago. Molten rock rises up through the mantle into the crust. The crust splits, thins, and pulls apart. Seawater fills the resulting basin. Volcanic rocks spread out onto the seafloor. The volcanic heat and seawater begin to interact to form metallic sulfide ore deposits at hydrothermal vents. Continental rocks erode and bury the seafloor rocks in sediments.

Early Devonian Period; approximately 415 million years ago. Cold seawater descends through seafloor cracks under great pressure. Water is superheated by hot rocks, leaching out metals and sulfur. Hot, metal-laden water rises through cracks back into the ocean. Metals precipitate from cooling water and are deposited on the seafloor to form metallic sulfide ore deposits.

Early Devonian Period; approximately 415 to 400 million years ago. Magmatic and volcanic activity ends. Hydrothermal venting and ore formation stop. Sediments continue to bury the ore deposits on seafloor.

Early Devonian Period; approximately 400 million years ago. The split continental crust drifts back together. Crust, including igneous and sedimentary rocks and ore deposits, thickens as opposing plates collide, forming mountains. The collision deforms the rocks from their original horizontal configuration into the tilted positions that we see today. Crustal thickening caused the rocks to undergo physical and mineralogical changes due to heat and pressure, a process that geologists call metamorphism.

Early Devonian Period to present; approximately 400 million years ago to today. Millions of years of erosion wear down the mountains and expose the metamorphic rocks containing the ore deposits. In Vermont, erosion of the Green Mountains exposes the Orange County copper ore deposits exploited by the Elizabeth Mine.

East-west section through Copperas Hill, looking north, present conditions. Steeply dipping sulfide ore deposit shown in yellow is oriented parallel to uplifted metamorphosed seafloor host rock beds. The surface open cut, underground vertical shaft and horizontal "adit" (tunnel) show ways miners typically accessed ore for mining. An actual secured adit and shaft are visible from Copperas Road where it crosses the hillside.

Interpretive Panels

Copperas Works

Tailings Pile

Q&A

MILESTONE HERITAGE CONSULTING