

Iron Mining on Pilot Knob Peak

A Tale of 5 Tramways

Based on historical research conducted by Jon Bergenthal
with LiDAR interpretation and mapping by Dr. Russell Myers

30 August 2022

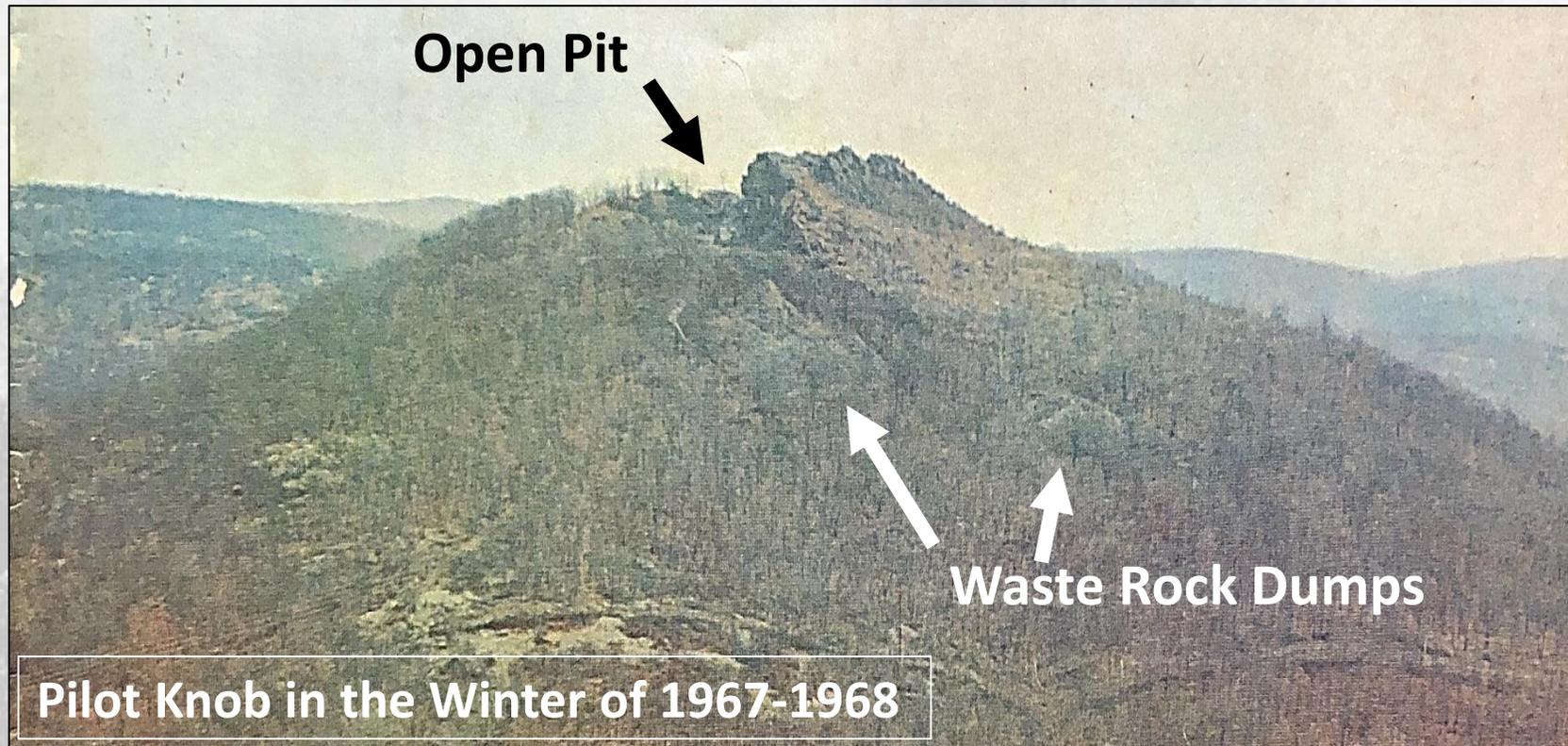
Ozark Regional Library, Ironton, Missouri

The Unwritten History of Pilot Knob's Peak

Seeing through dense jungle cover, LiDAR has revealed lost Mayan cities and outposts...

...more modestly at Pilot Knob...

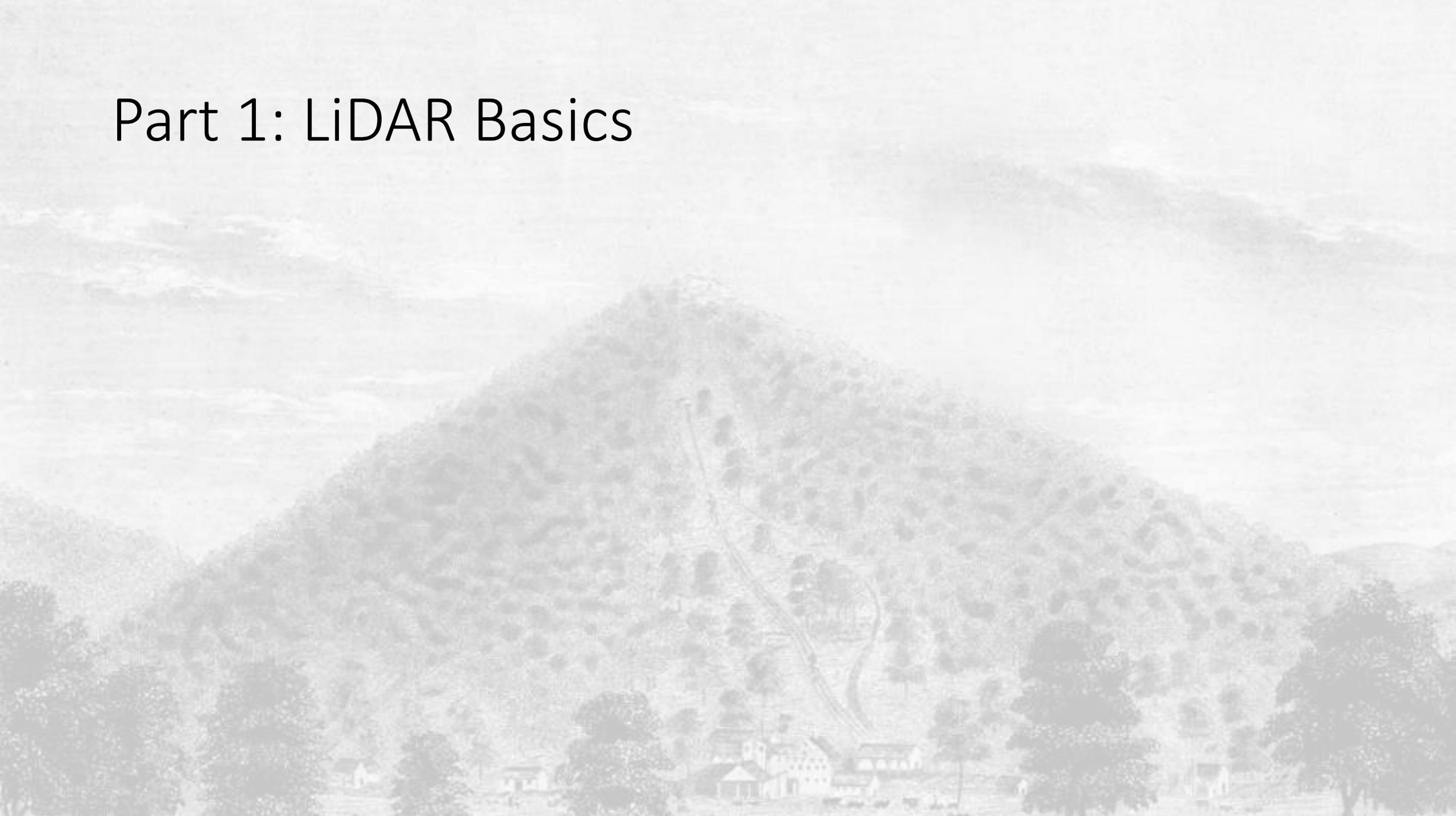
....historical data together with LiDAR-mapped features tell a previously unwritten story.



Presentation Overview

1. LiDAR Basics
2. Pilot Knob Pellet Company
3. Historical Information
4. LiDAR Interpretation

Part 1: LiDAR Basics

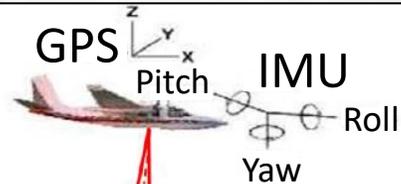


LiDAR: Light Detection and Ranging

- 1: Laser pulse (parallel, in-phase, monochromatic light)
- 2: Measure time and intensity of reflections
- 3: Calculate reflection distance from time
- 4: Calculate reflection point X,Y,Z from GPS + Beam Direction

Scanning Rate:
150,000 pulses per second
Unspeakable volumes of data!

Beam Sweep LiDAR Scanning



Full Sweep Angle

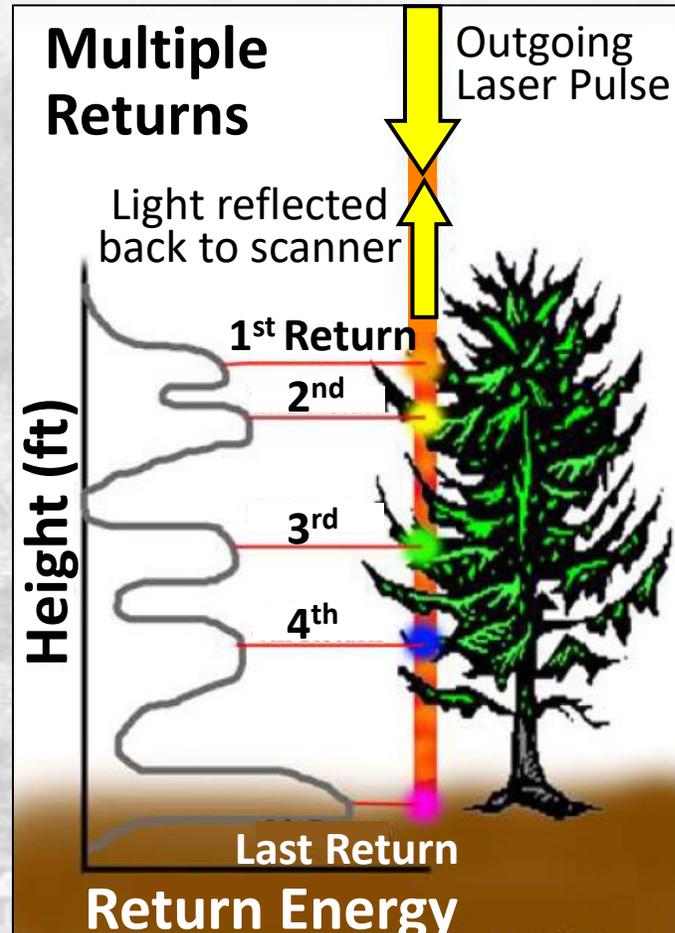
Single Laser Shot

GPS Base Station



IMU = Inertial Measurement Unit

Multiple Returns



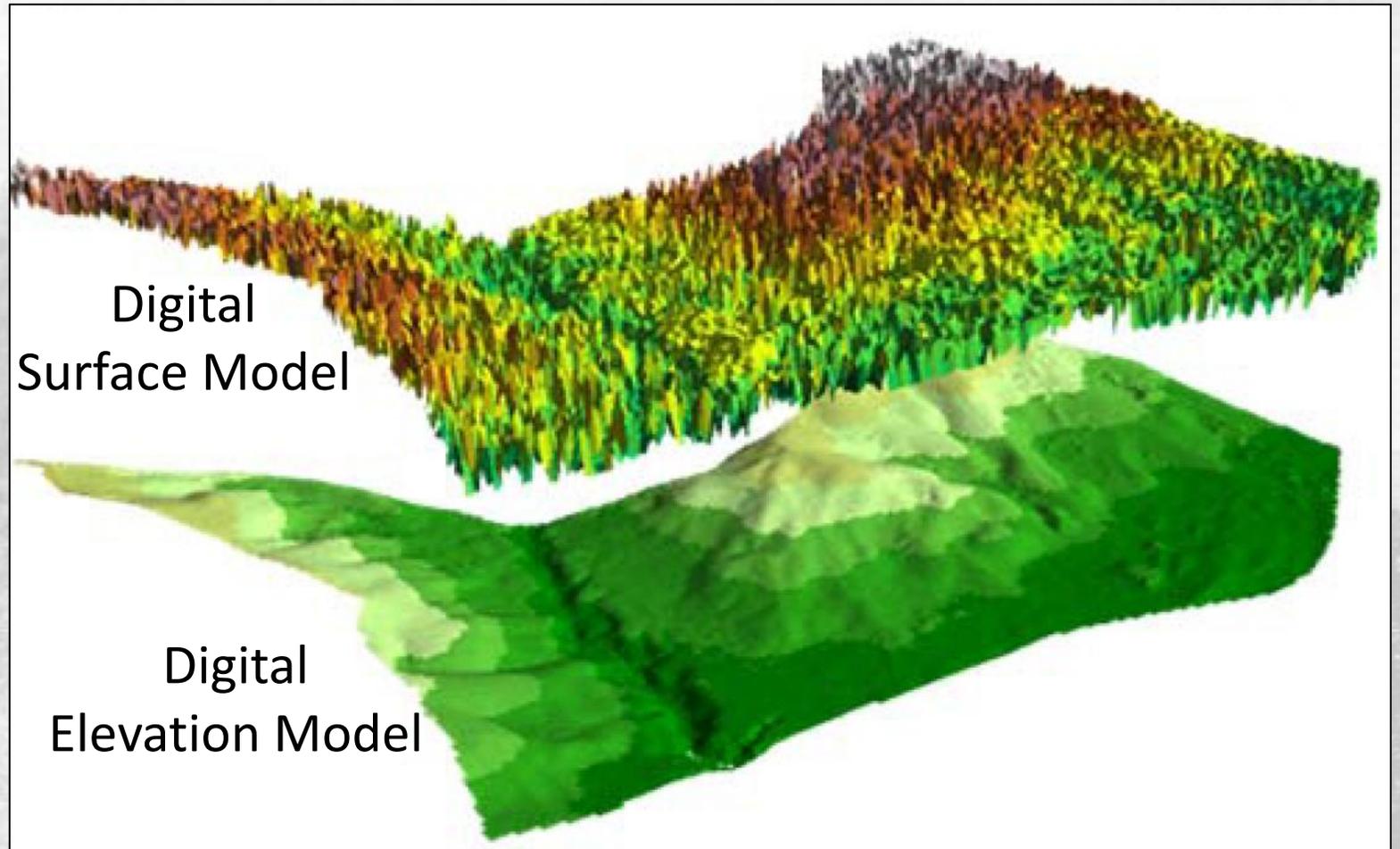
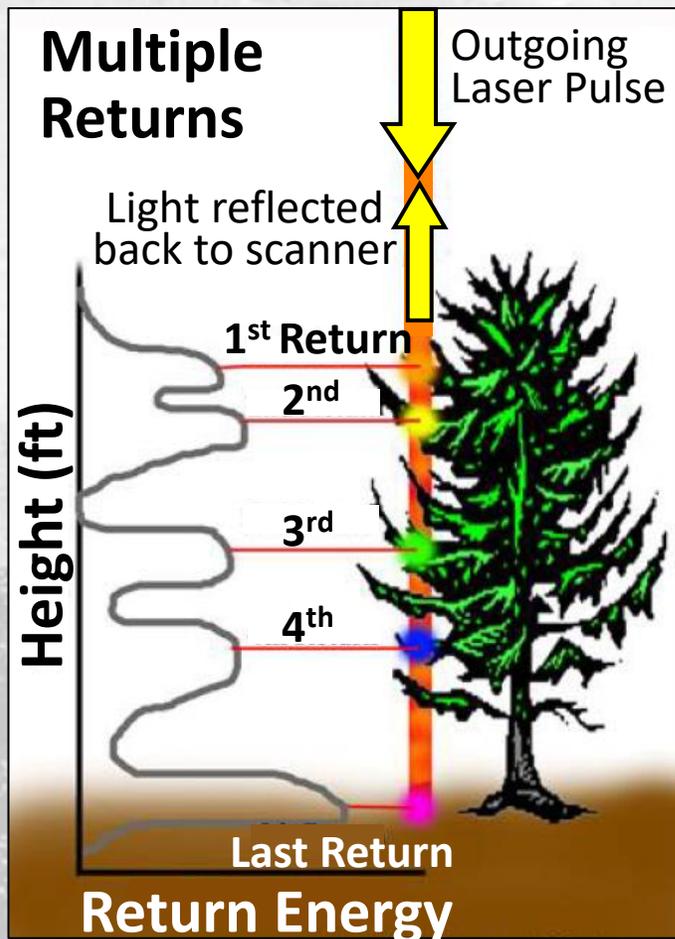
3D Point Cloud Of Reflections



LiDAR-Derived Digital Elevation Model (DEM)

First Return => Digital Surface Model

Last Return => Bare Earth Digital Elevation Model

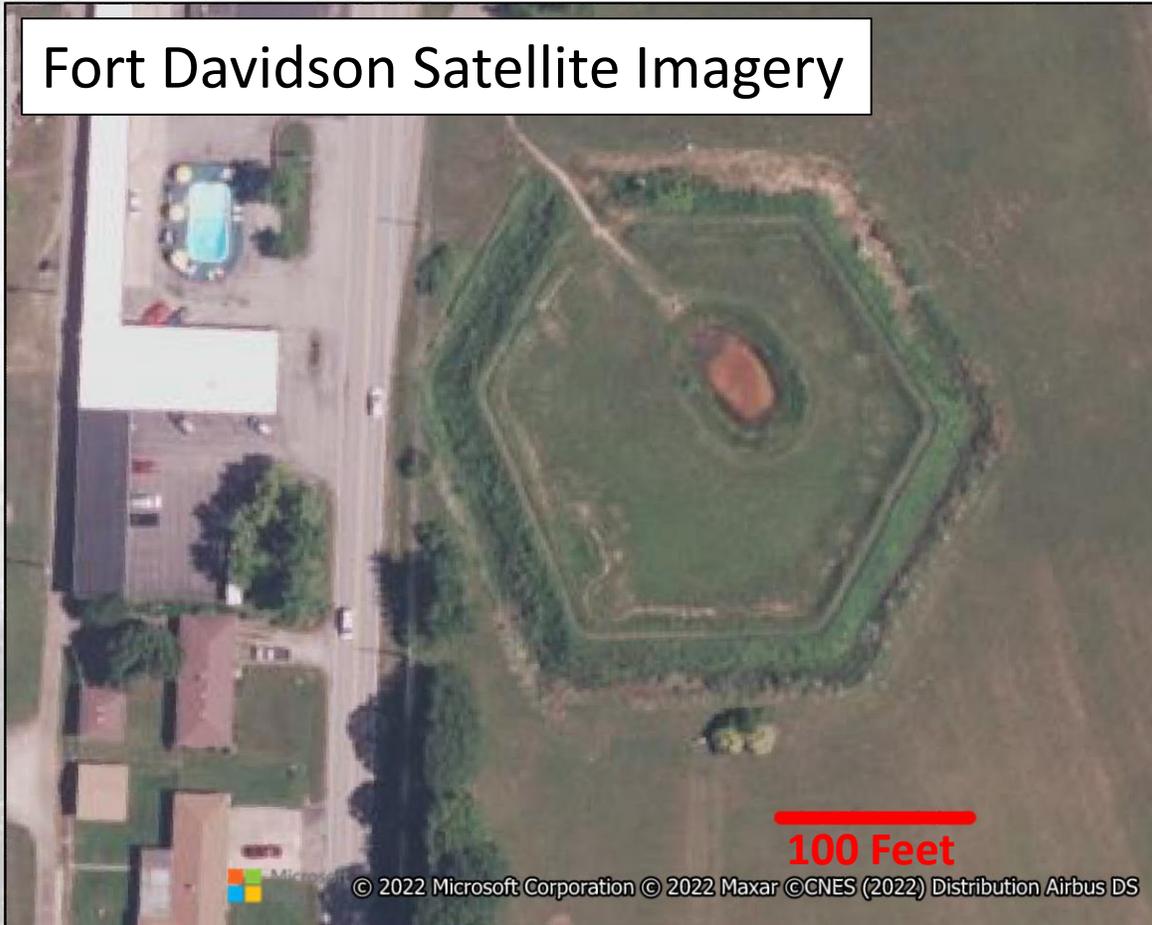


USGS LiDAR-based 1-meter Digital Elevation Model (DEM)

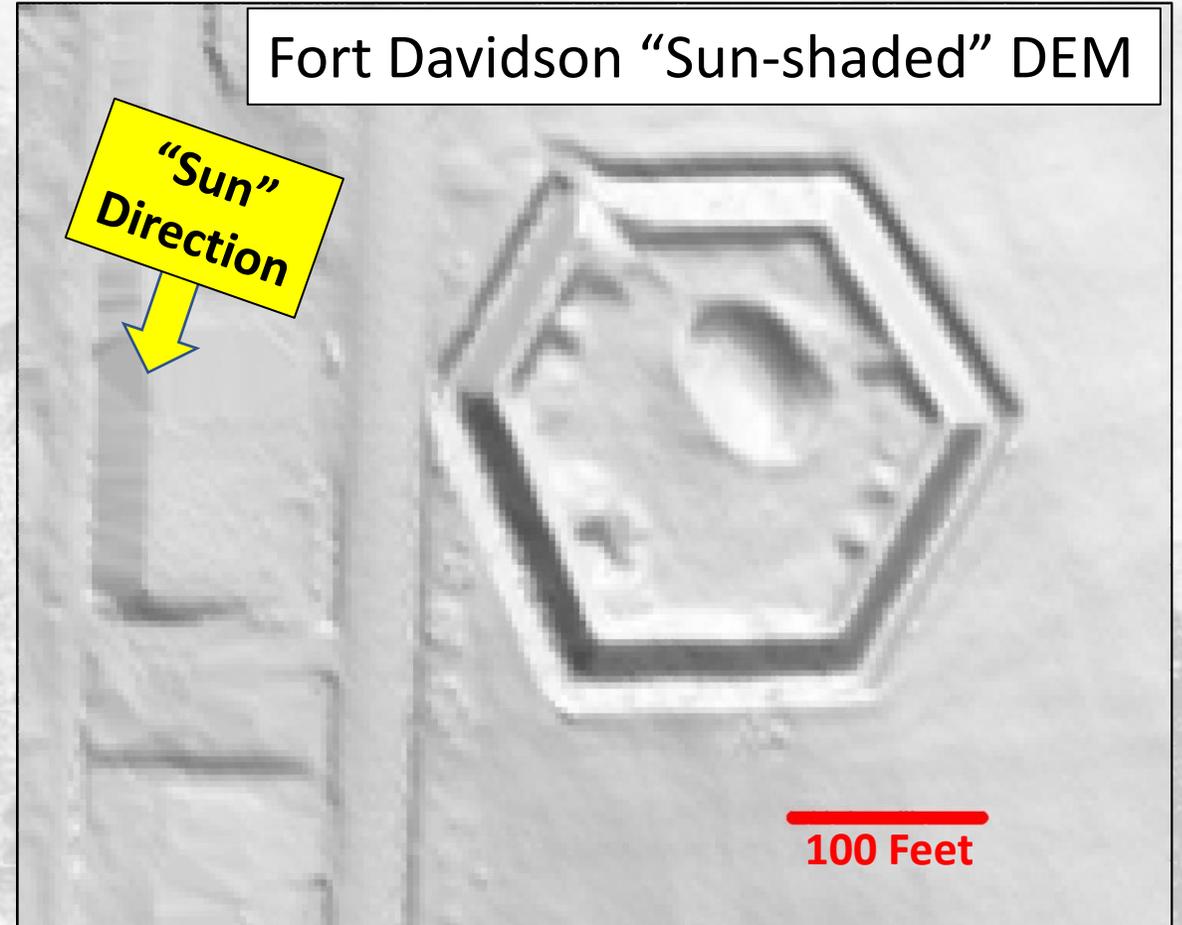
LiDAR survey designed to support 1-foot topographic contours
Horizontal resolution: 3 feet (1 meter)
Vertical resolution: 8 inches

Sun-shade Mathematical Processing:
Slopes facing the “sun” are illuminated
Slopes facing away are in shadow

Fort Davidson Satellite Imagery



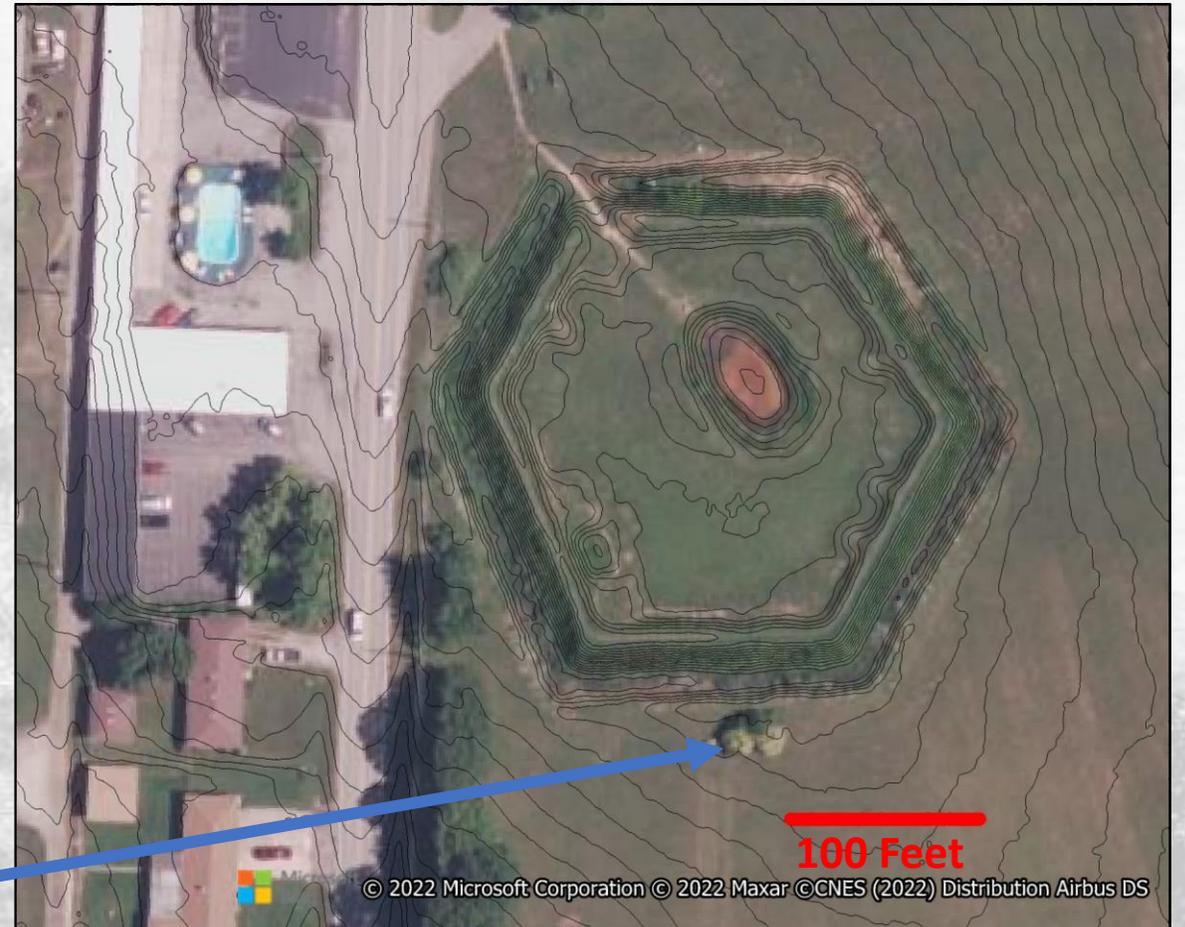
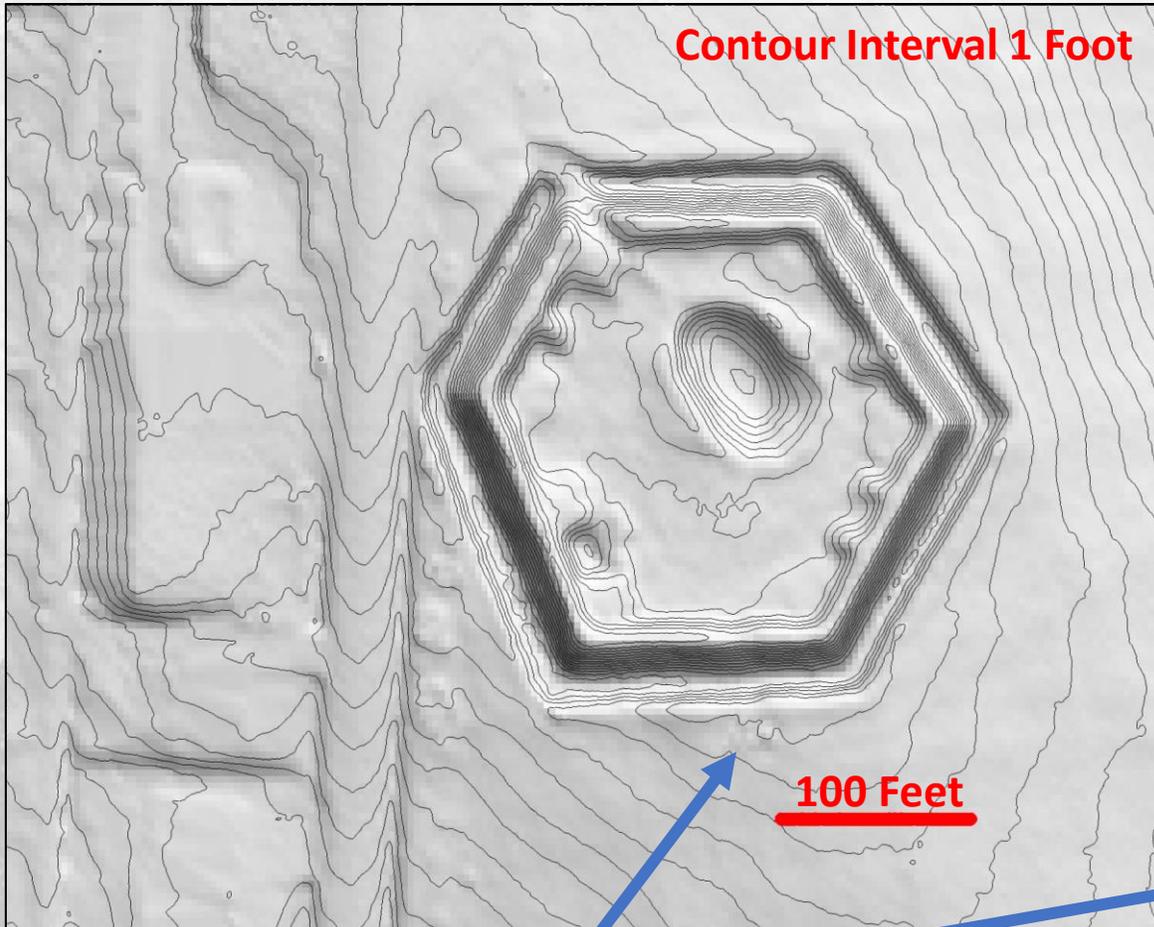
Fort Davidson “Sun-shaded” DEM



Data free from USGS Website

The Power of 1-Foot Topographic Contours

Examples: Explosion crater is just over 6 feet deep
From inside the fort the walls are just over 4 feet high. Keep your head down!



Not 100% Perfect...

...but 20x better than 20 foot contour on 1:24000 topo quads!

Pilot Knob Sun-shaded 1-meter Digital Elevation Model

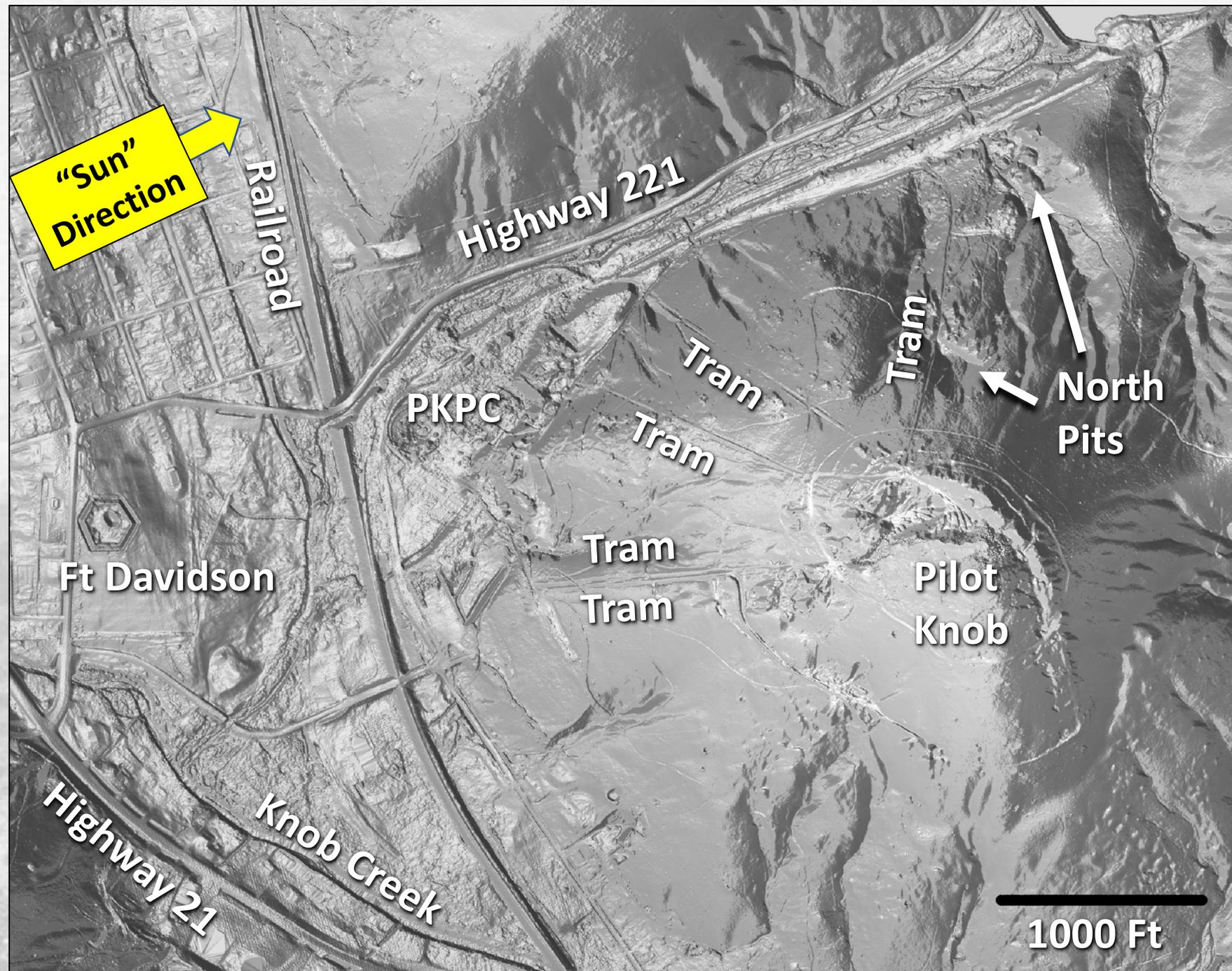
Streets, Highways, Railroads

Pilot Knob

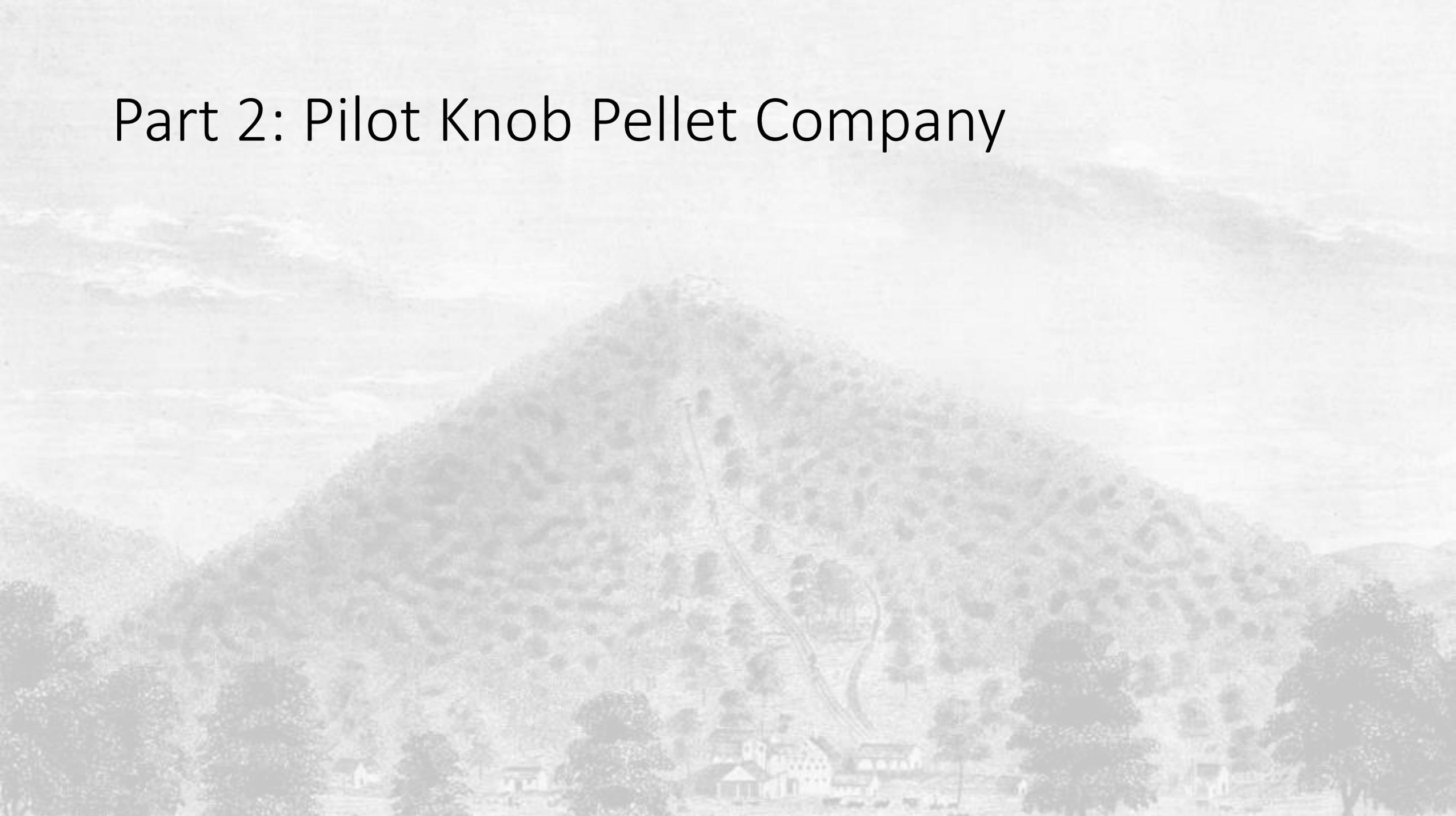
Upper Mine Features

- Disturbance around peak
- Pits on north side of hill
- Surprise?
 - 5 Access Developments

Older features like
tramways overprinted by
Pilot Knob Pellet Company
(PKPC) Facilities

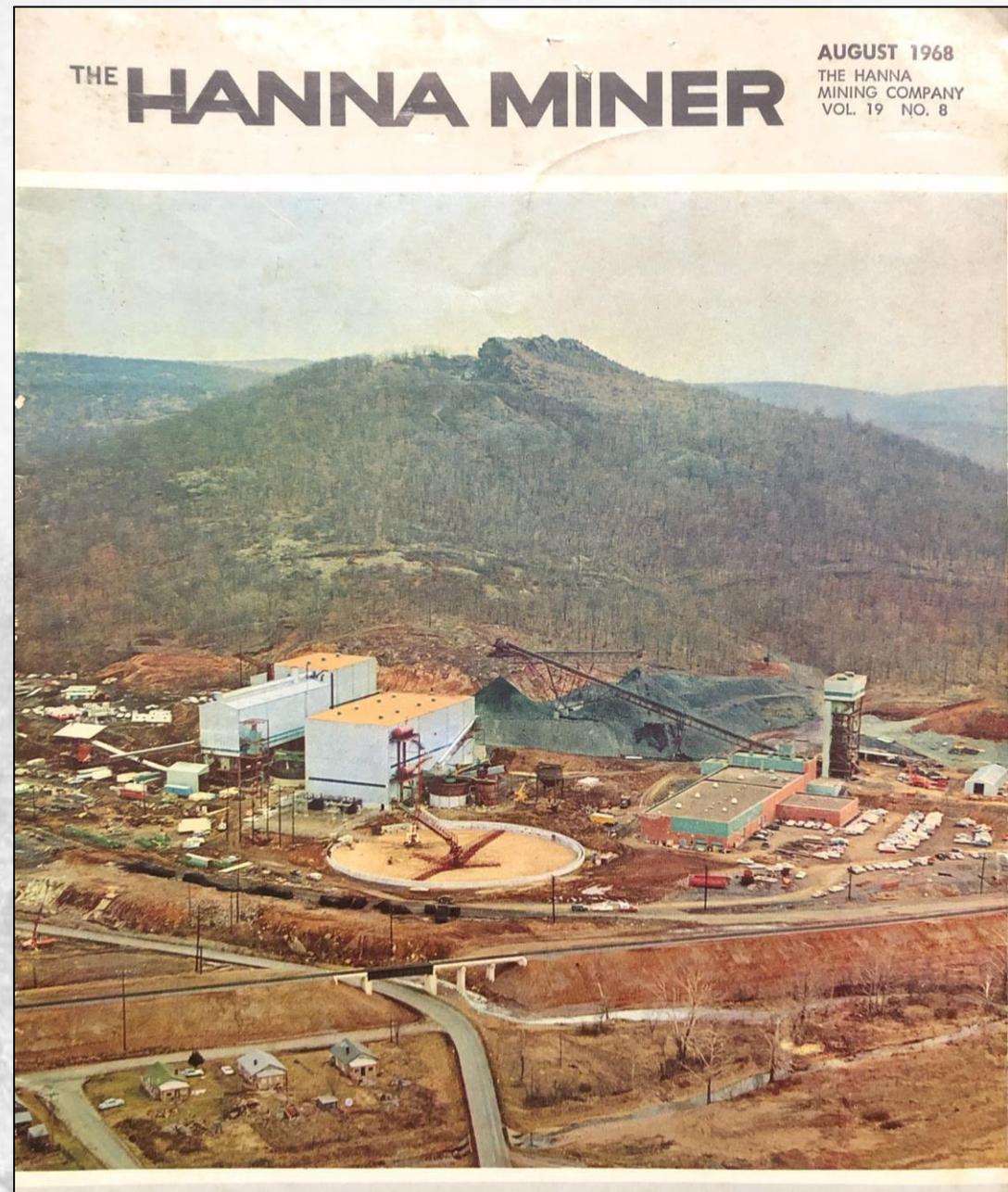


Part 2: Pilot Knob Pellet Company



Pilot Knob Pellet Company

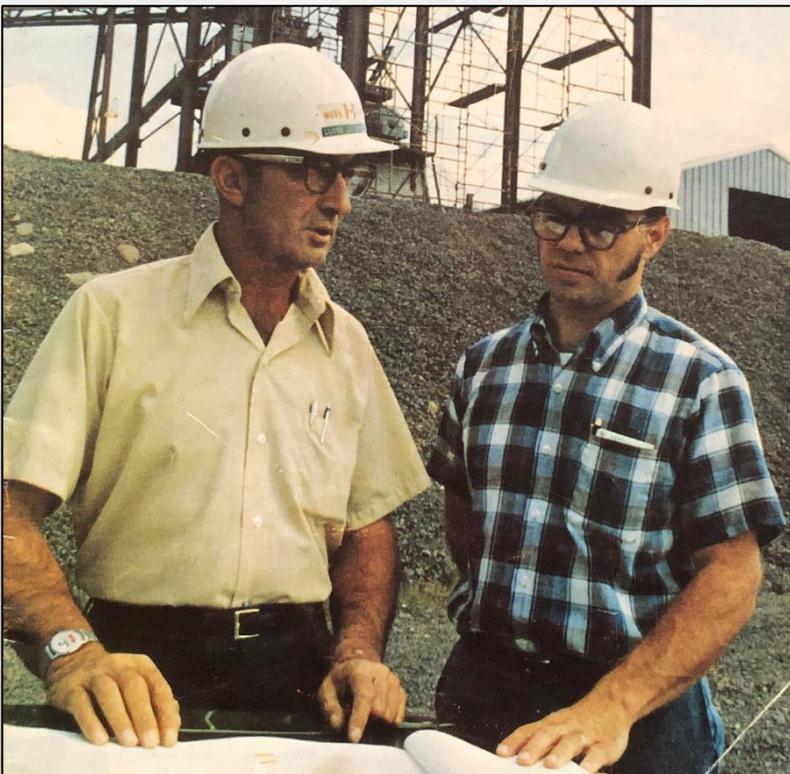
Hanna Mining Ore Body Exploration in 1950s-60s
Mid 1960s Construction – JV with Granite City Steel
First Pellet Shipment June 29th, 1968
Operations ceased in November 21st, 1980



Hematite Pellets for
Blast Furnace Feed

Lloyd Erpenbach (left)
Director of Planning
and Technical Services
with George Newell,
Metallurgical Engineer

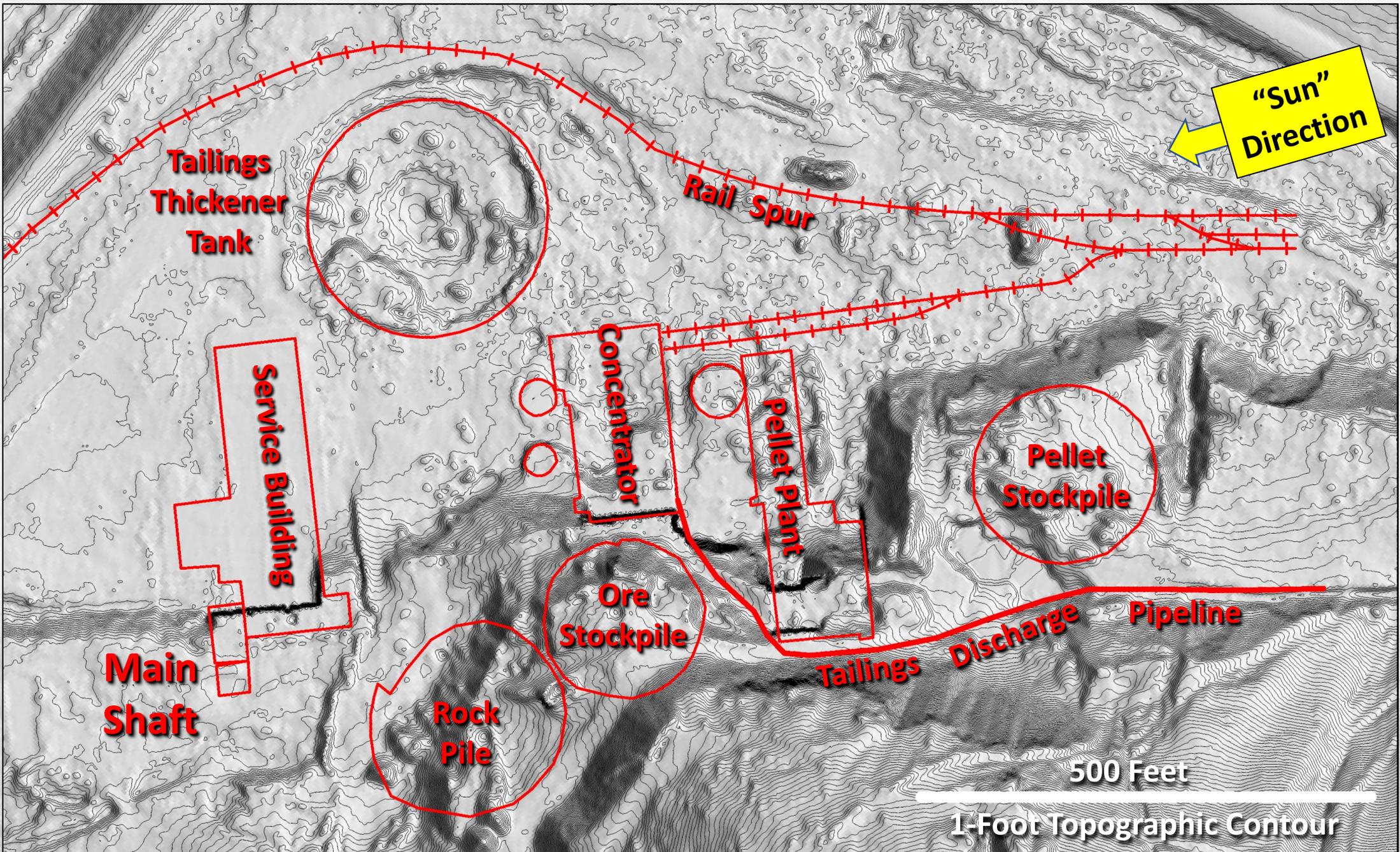
20th Century Overprint on 19th Century Works



1967 Pilot Knob Pellet Company in Construction



DEM View

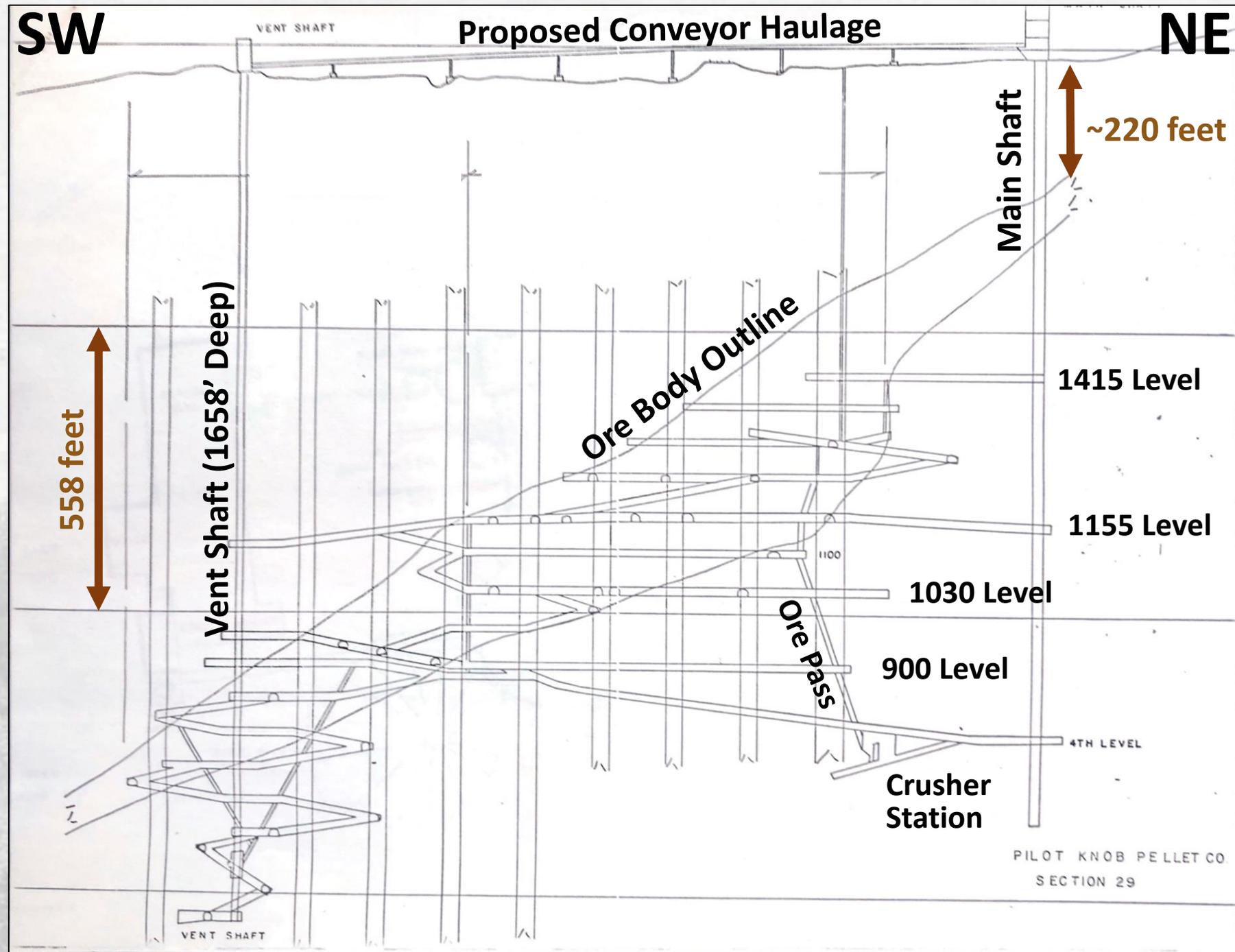


Plant layout georeferenced from undated drawing in Hanna Mining information folder at Iron County Historical Society

PKPC Underground Workings

Undated Cross-section

- Dipping Sheet Ore Body
- Mined on Multiple Levels and Sublevels
- Mined rock crushed underground



PKPC Underground Workings at Closure

Selected Level Plans

1500 Level is shallowest level

450 Level is deepest level

(1880' feet below surface, -950' AMSL)

Solid polygons in Levels 960-1500 indicate the orebody was stoped out.

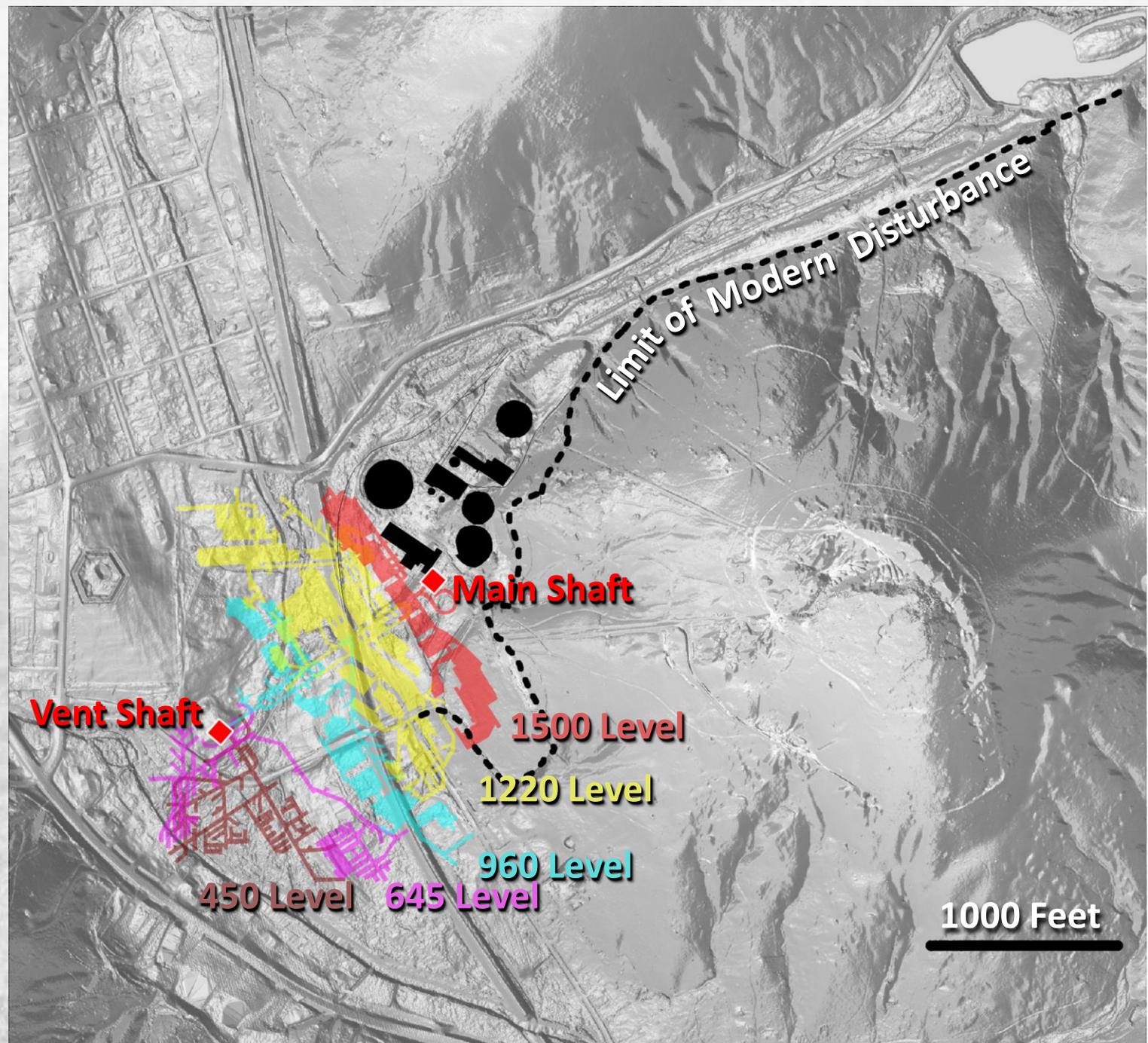
Skeletal forms of levels 450 and 645 indicate that this was development work.

Workings extend almost to Highway 21 between the bank and Shepherd Mtn Inn.

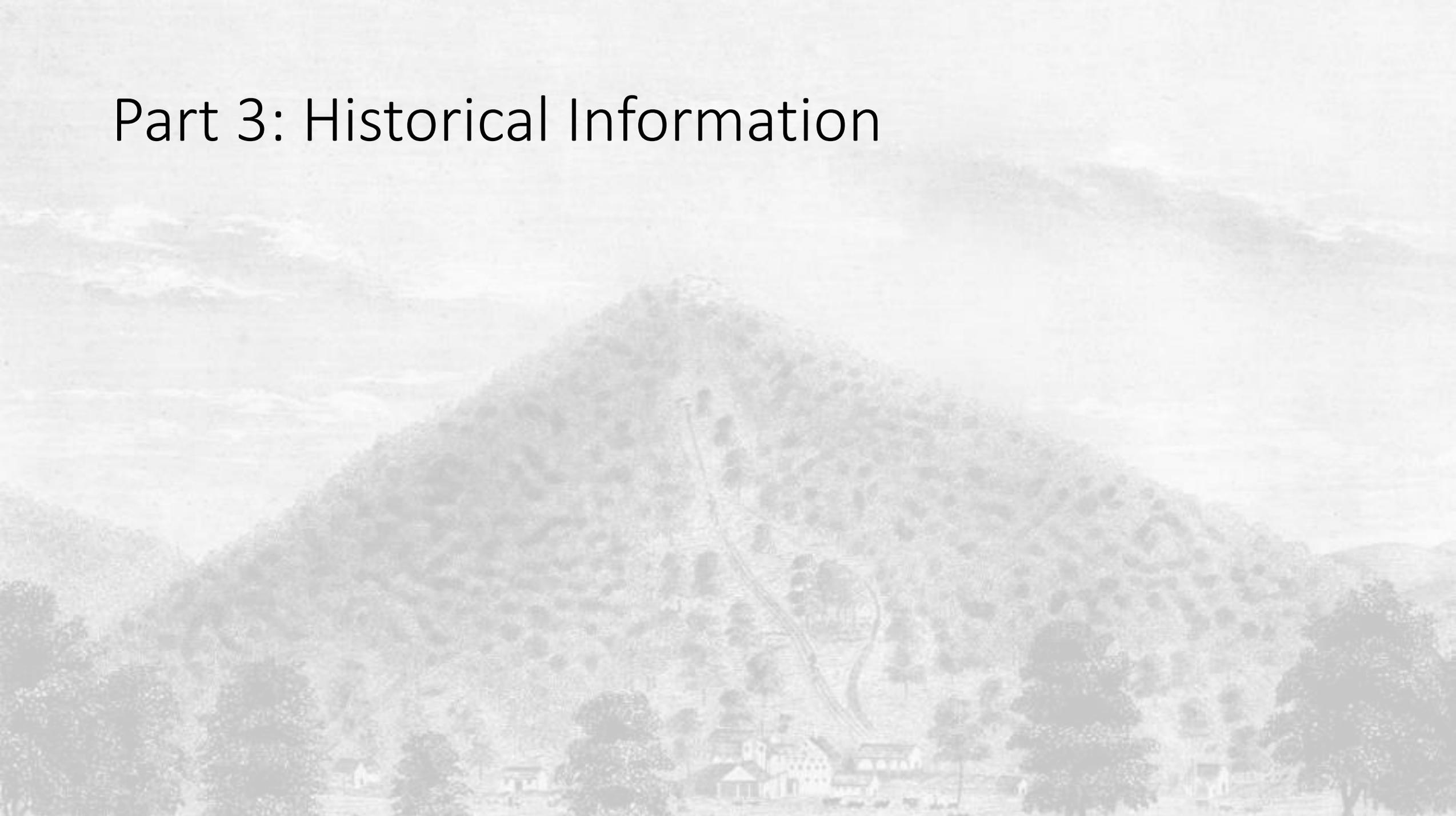
Objective of Exercise:

Define Limit of Modern Disturbance

Peak mine was not overprinted!



Part 3: Historical Information



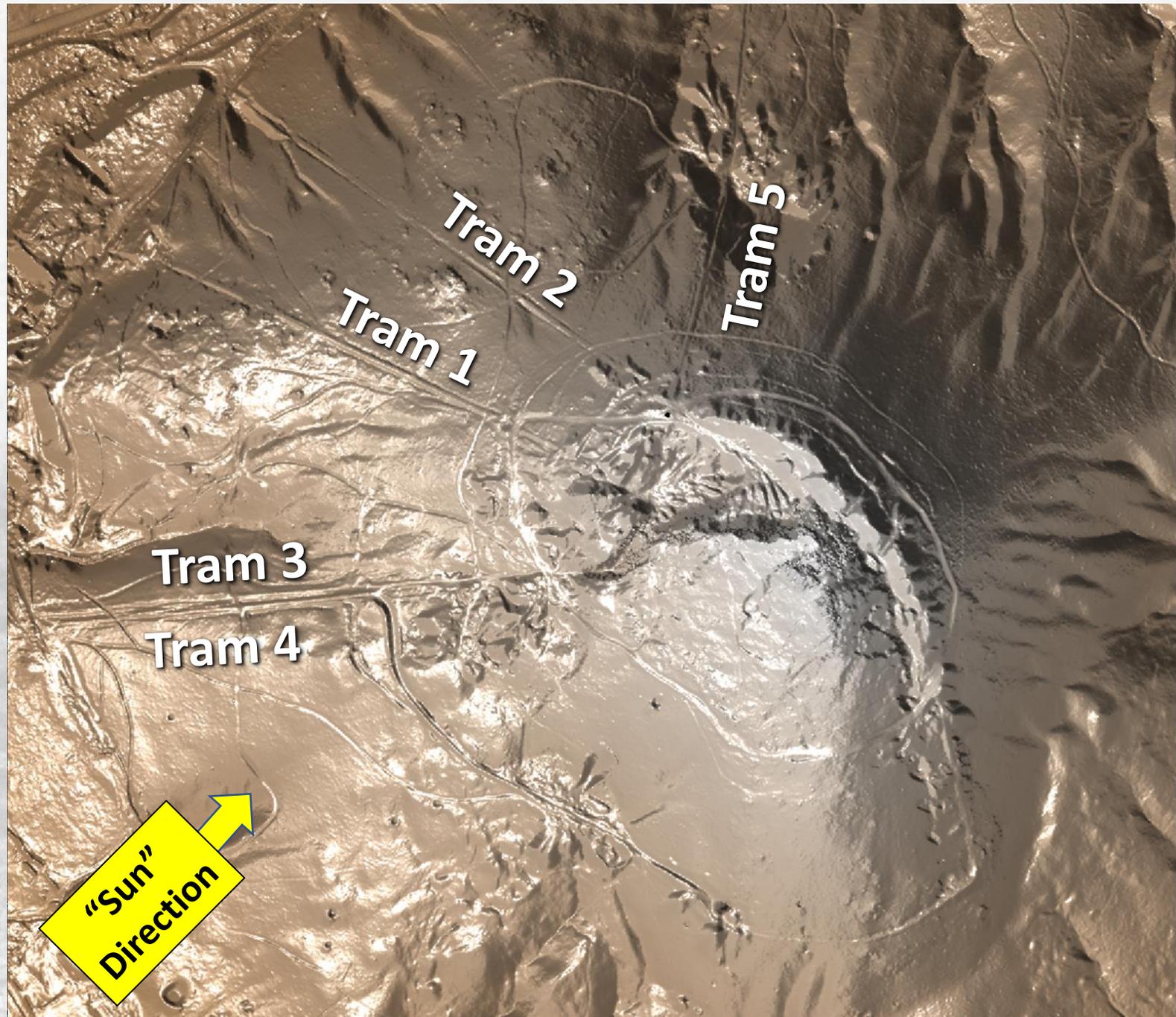
Pilot Knob Peak

A Tale of 5 Tramways

- Steep, constant-grade railroad tracks to haul ore and supplies from and to the mine.
- **Expensive and labor intensive to build**
- Therefore....

Each tramway represents a significant new phase of mine development.

When and Why?



Pilot Knob Peak Capitalization Phases

Phase 1: Startup 1848-1854

1848: First blast furnace built and mining begins
7-8 tons/day of pig iron

Phase 2: Expansion 1855-1862

1855: Second blast furnace constructed
Adds 12 tons/day of pig iron capacity
1858: Railroad comes to Pilot Knob

Hiatus: 1862 - Closure due to lack of *accessible* ore. 1864 - Confederates burn furnaces

Phase 3: Reconstruction 1865-1880

1865: Both furnaces restarted
Between 1866 and 1869 increase from 6.6K to 38K tons/year of ore
1873: approx. 46,000 tons of ore mined

Phase 4: Modernization 1880-1890

1880: Construction of modern blast furnace
1887: 200,000 tons of ore mined

Hiatus: 1890 - Closure due to lack of ore. Corporate bankruptcy

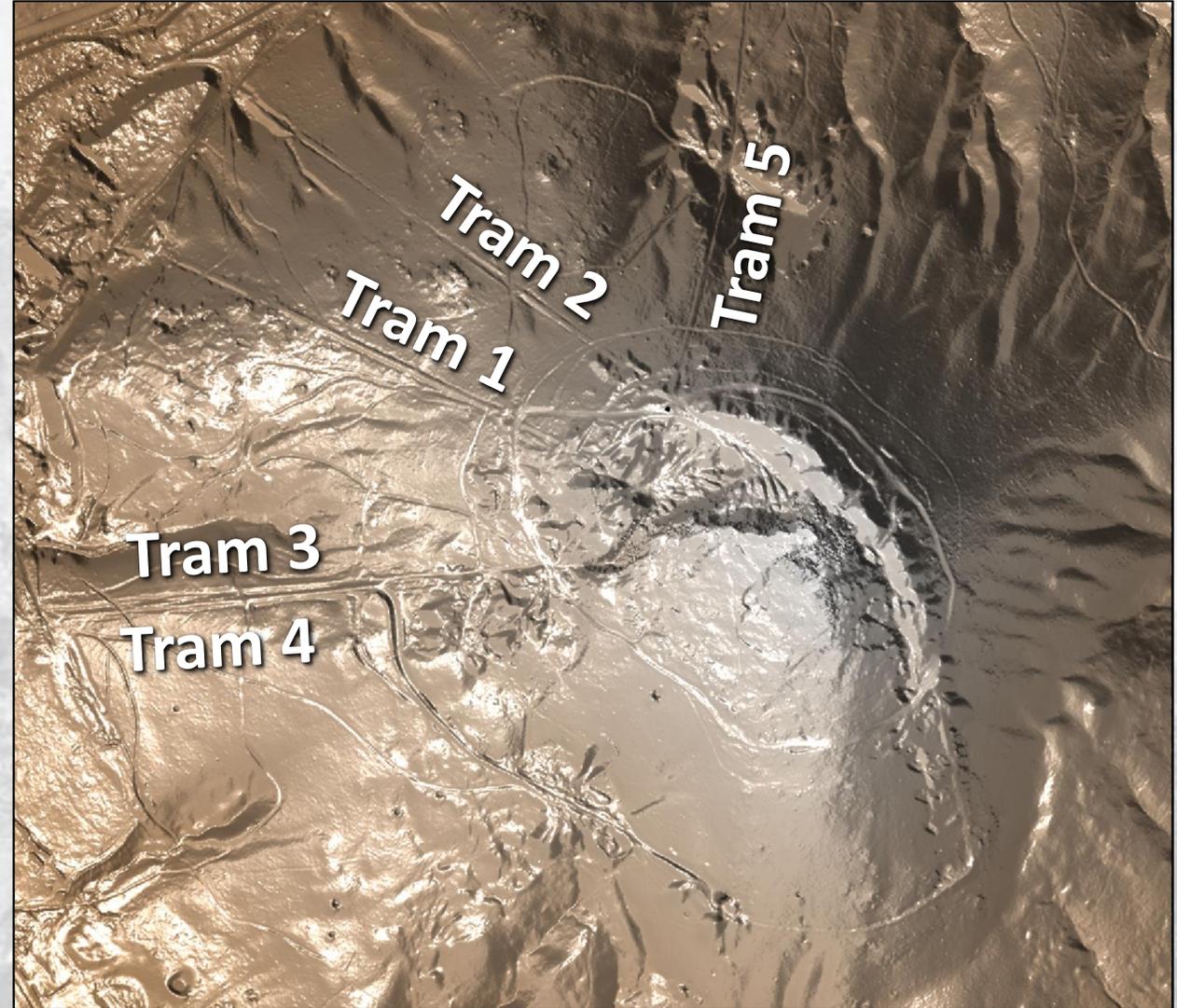
Phase 5: Floundering 1892-1920

1892-1900: Prospecting conglomerate ores
1910-1912: Conglomerate Mining
1916-1920: Upper mine opened briefly

5 Phases
5 Trams
Good Start!

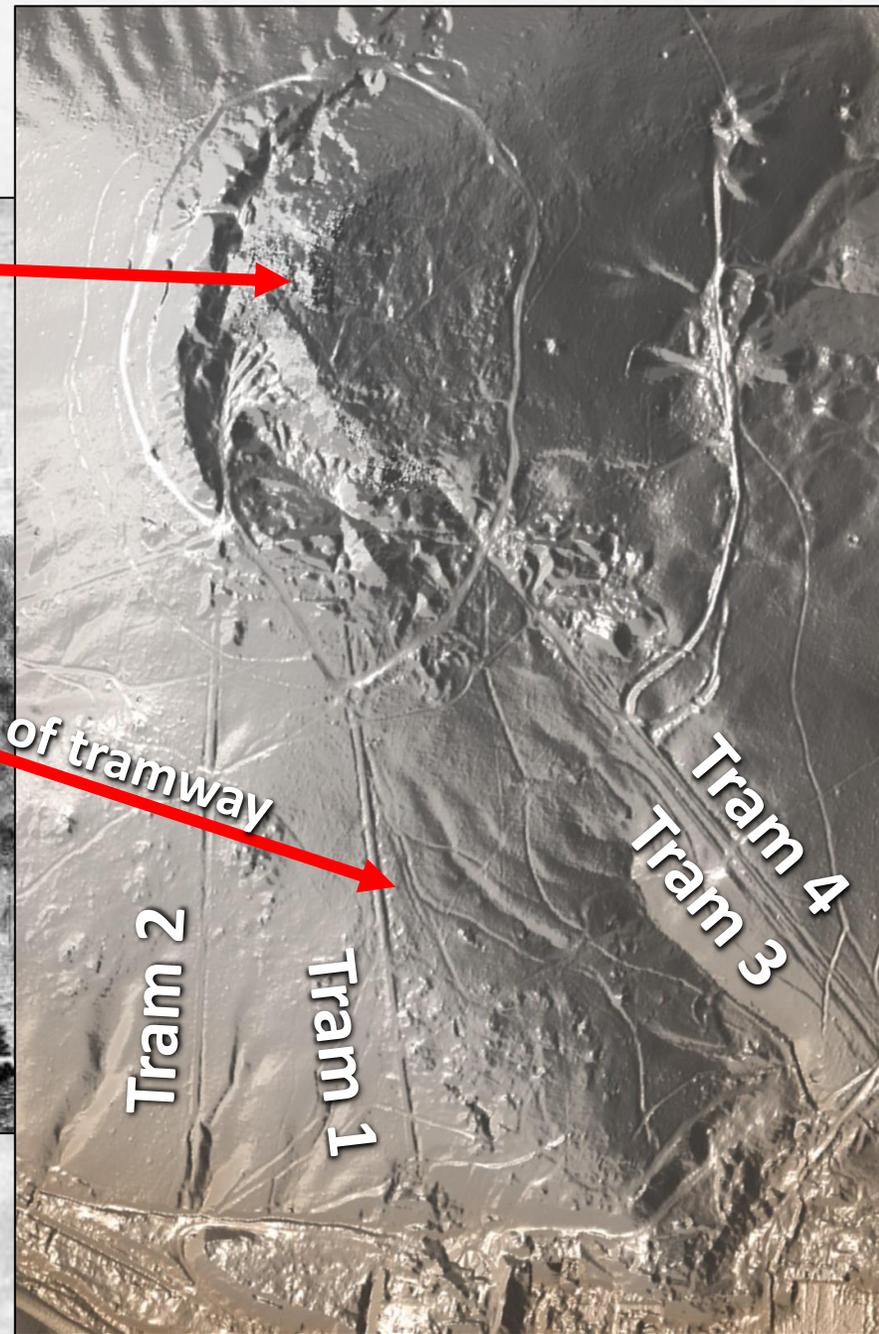
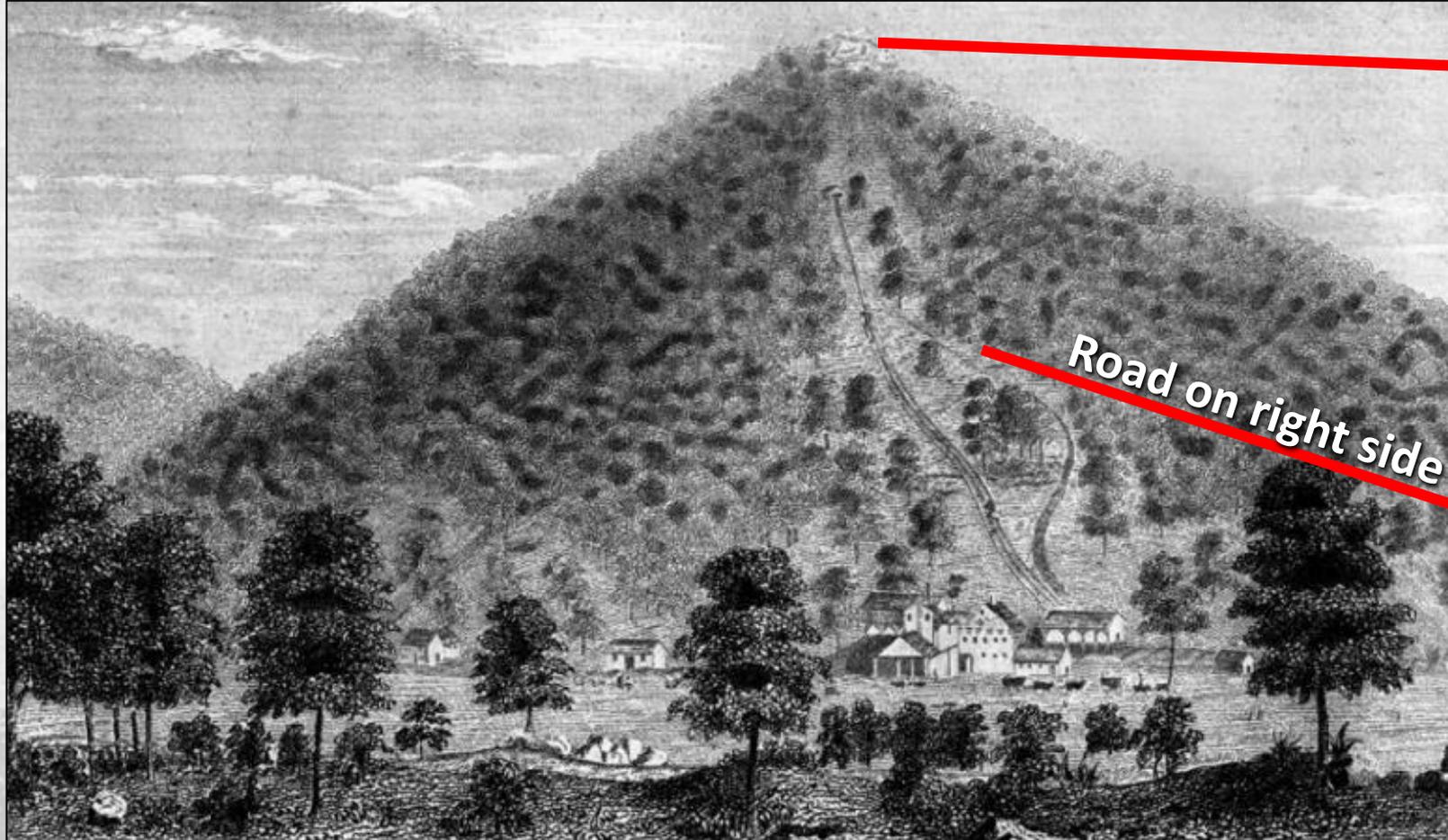
When and why were these trams built?

Enter:
Detective Jon Bergenthal
with the historical facts....



Drawing from 1855 Report

From: 1st and 2nd Annual Reports, Geological Survey Missouri, 1855



Tram 1 Conclusions:
When: Prior to 1855 = Startup - Phase 1
Why: Deliver ore to Furnace

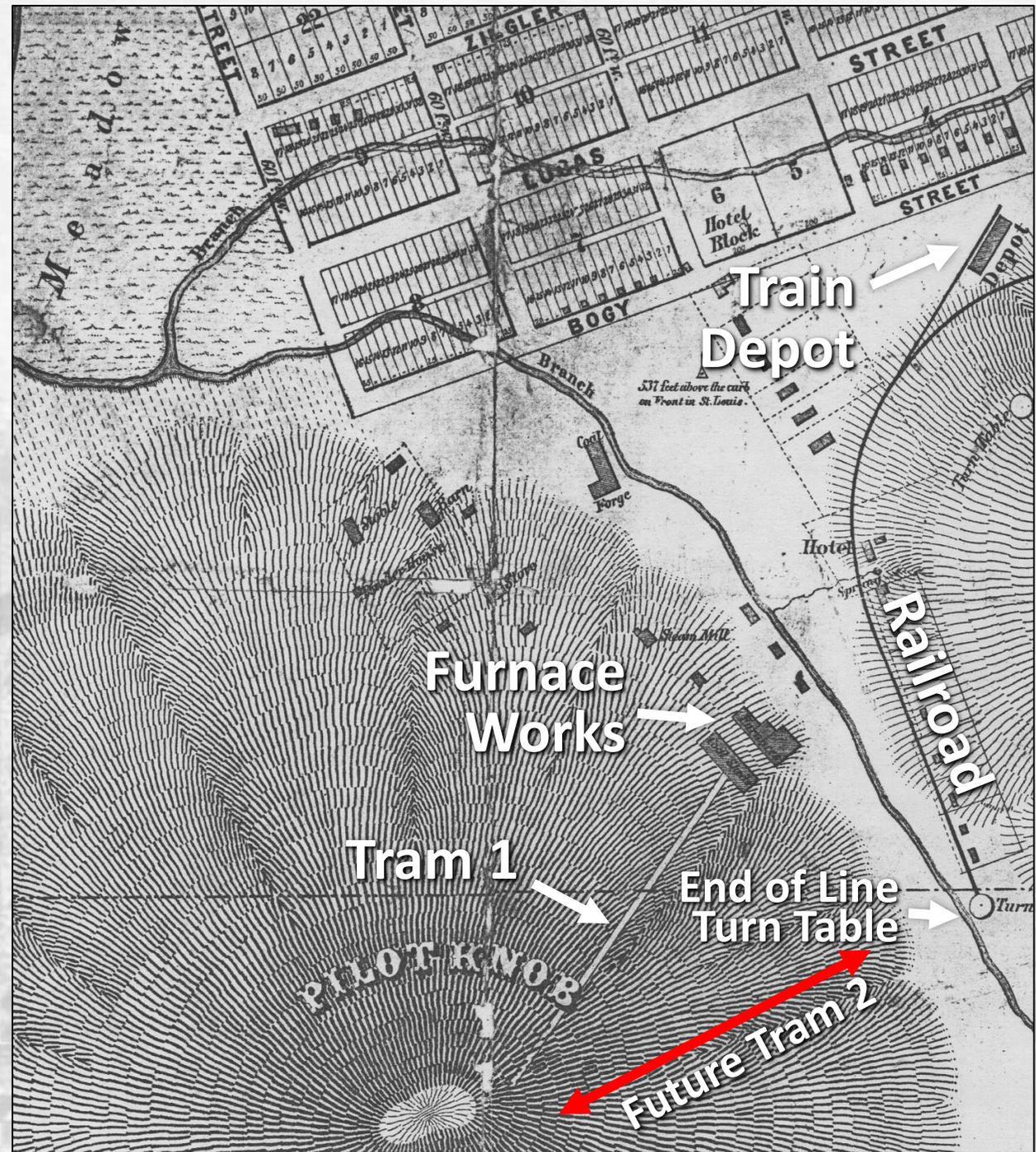
Pilot Knob Map from 1858 Train Line Poster

St Louis & Iron Mountain Rail Road line to Pilot Knob completed in 1858 and they were promoting tourism.



Implications:

- Only Tram 1 when map was drawn
- End of railway at future Tram 2 terminus



Newspaper Article

Daily Missouri Republic
August 17, 1859

Travelogue by "CURTIUS" on a visit to the top of Pilot Knob and the Arcadia Valley.

"CURTIUS" reported that

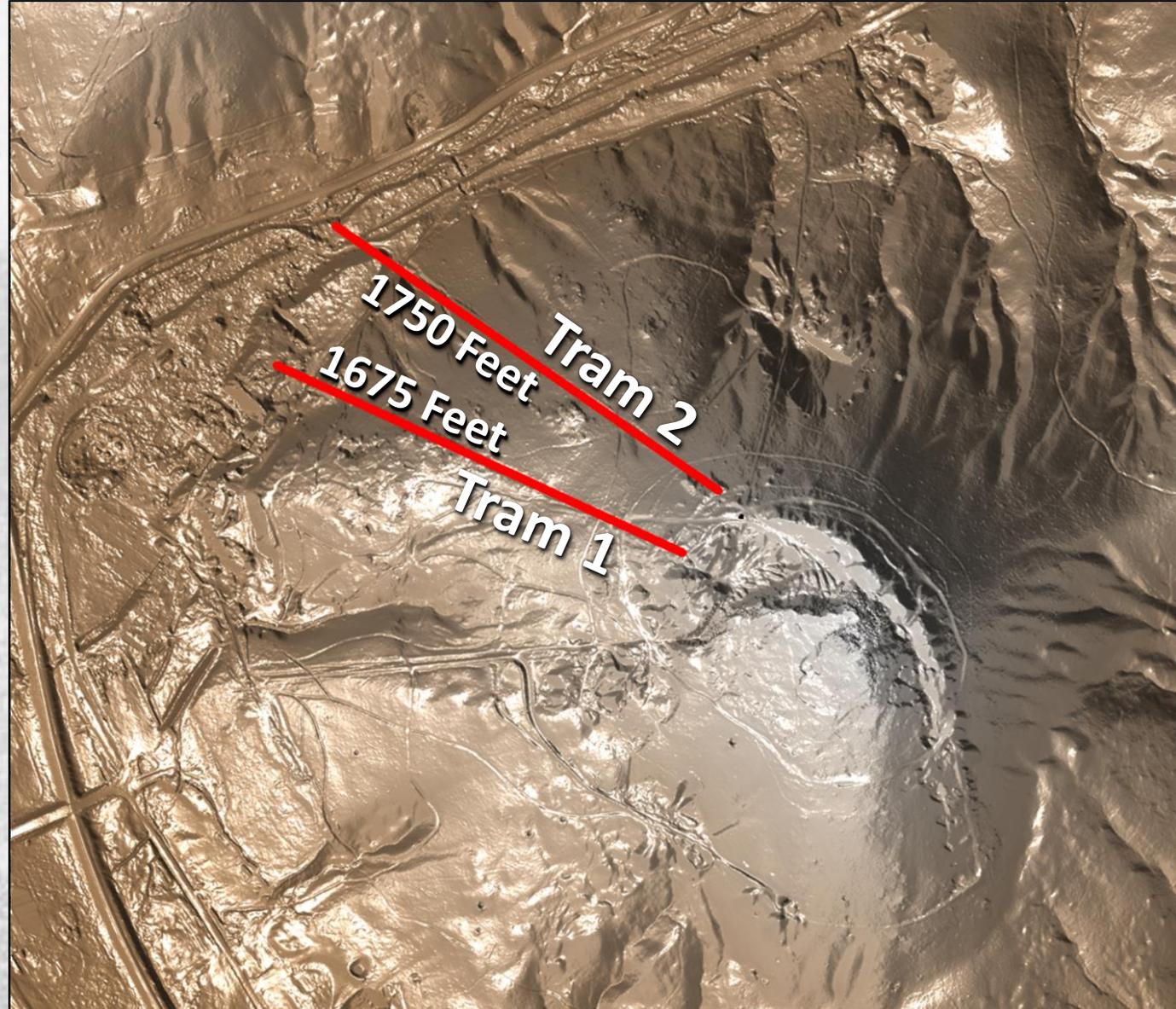
Main Tram ran 1675 feet from "quarry" to a terrace above the blast furnace.

Second tram for direct shipping ore by train ran 1750 feet to railroad level.

Tram 2 Conclusions:

When: 1858-1859 – Expansion - Phase 2

Why: Deliver ore to new railroad link



Washington County Journal June 20, 1867, p. 2

“The Pilot Knob Iron Company has a number of men at work opening a mine on Pilot Knob mountain, on the south side, and is constructing a railway from the mine to the foot of the mountain. The railroad will be extended so as to load the cars with the ore as it is brought down the mountain.

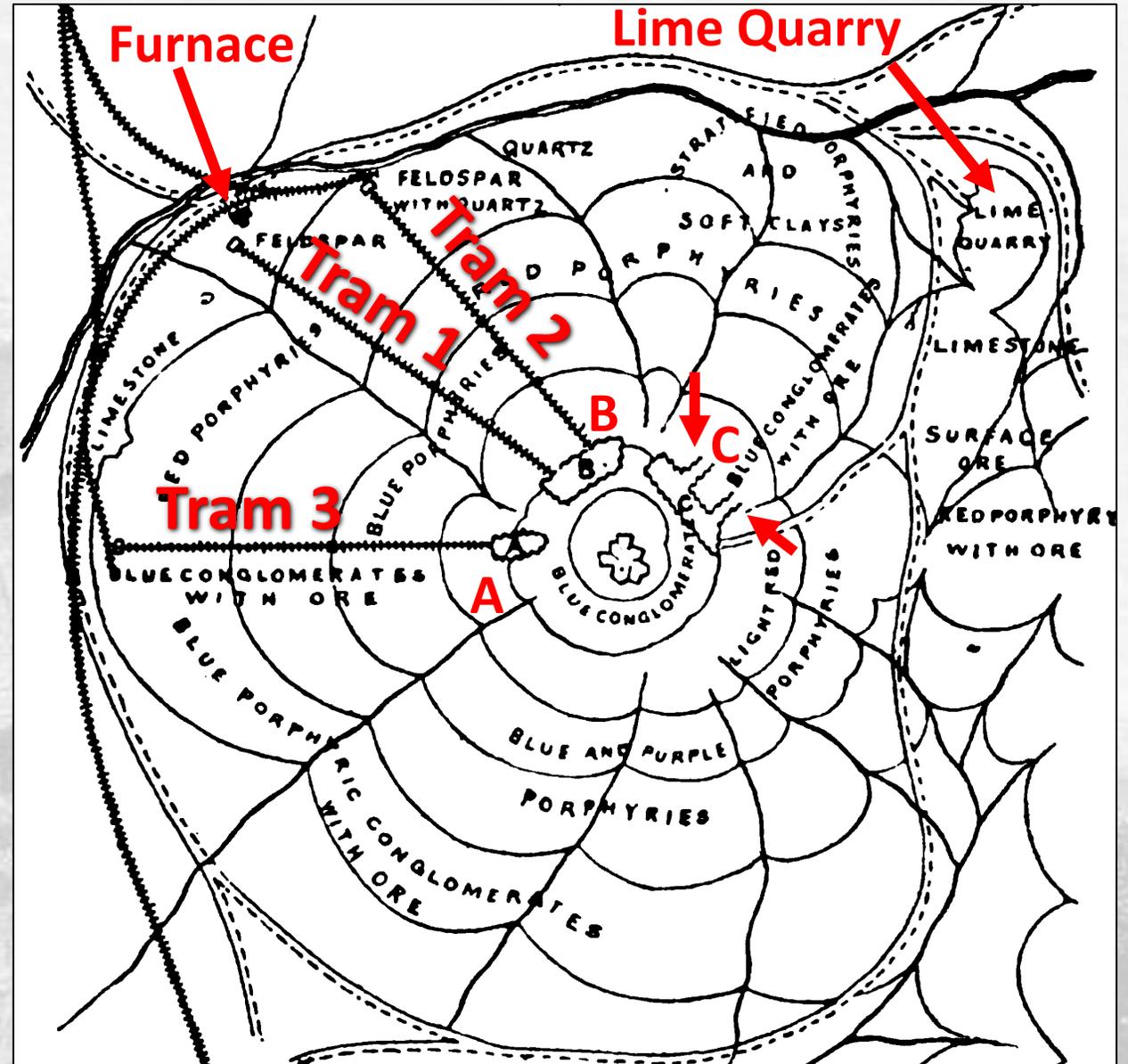
Tram 3 Conclusions:

When: 1867 - Reconstruction – Phase 3

Why: Increase ore production

Note: Map suggests all three trams were operating in 1872.

Pilot Knob in 1872 Report



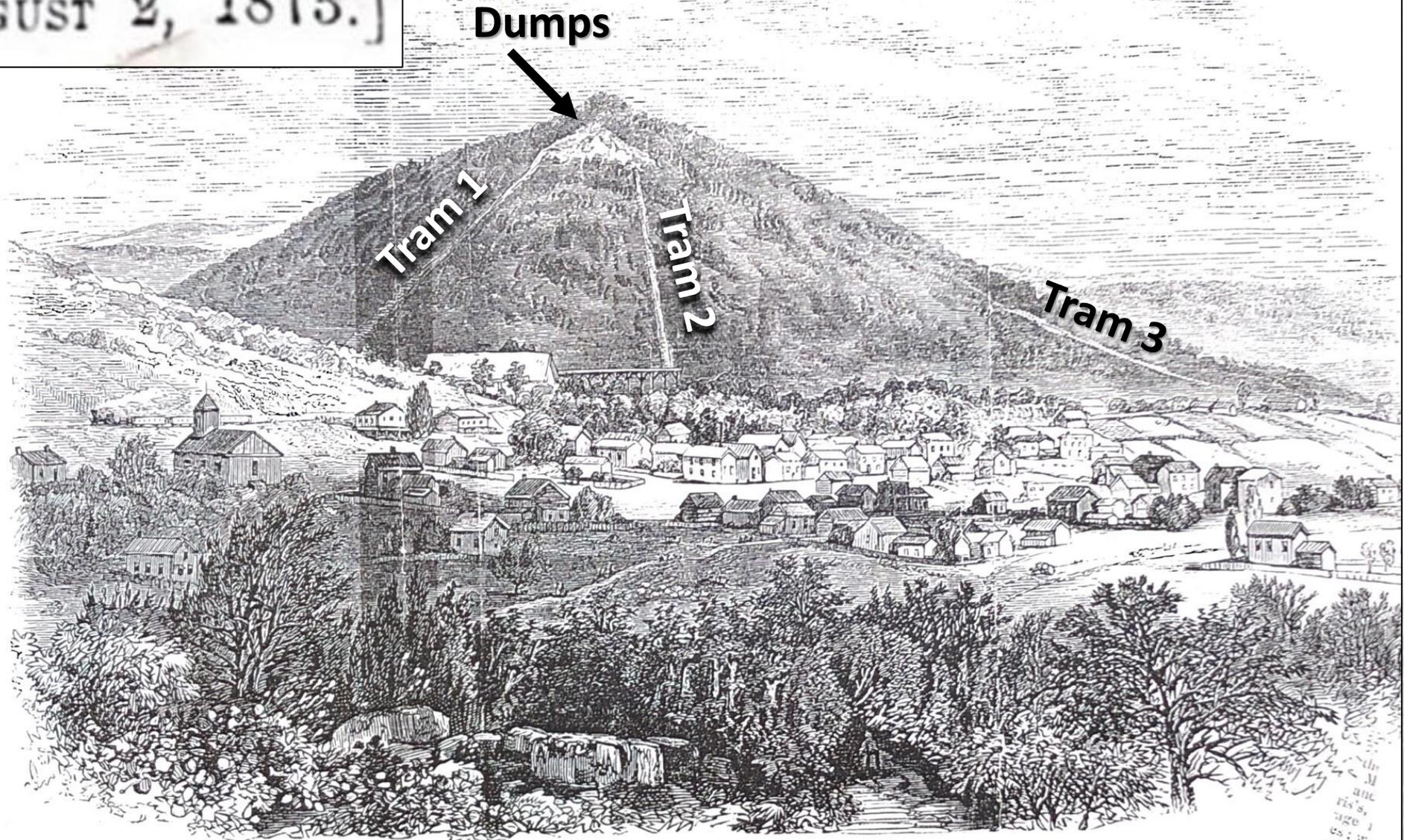
Map from Pumpelly (1872) page 110

August 2, 1873.]

AUGUST 2, 1873.]

1873 View (Phase 3)

3 tramways operating



From photocopy of original paper held by the Iron County Historical Society.

MISSOURI.—THE GREAT IRON REGION—PILOT KNOB MOUNTAIN AND THE CITY OF IRONTON.—FROM A SKETCH BY JAMES E. TAYLOR.

Iron County Register, September 25, 1879, p. 3

“The Pilot Knob Iron Company is building an additional tramway on the west side of the Knob, and about forty feet south of the one now in operation. Both tramways will be necessary for the proposed increased shipment of ore. Increased activity is noticed in the vicinity, and the tenements are being rapidly filled with workmen and their families.”

Iron County Register, August 19, 1880, p. 5

“A man named Frank MacNally was killed last Monday morning on the tramway leading from the mines on Pilot Knob to the foot of that mountain. He was engaged in building the new track, just east of the old, and had started across the old track, with a tie across his shoulder.”

Tram 4 Conclusions:

When: 1879-80 - Modernization – Phase 4

Why: Increase ore production

Conclusions

Phase 1: Startup - 1848-1854

Tram 1 was operational in 1855 which means that it must have been constructed earlier.

Phase 2: Expansion - 1855-1862

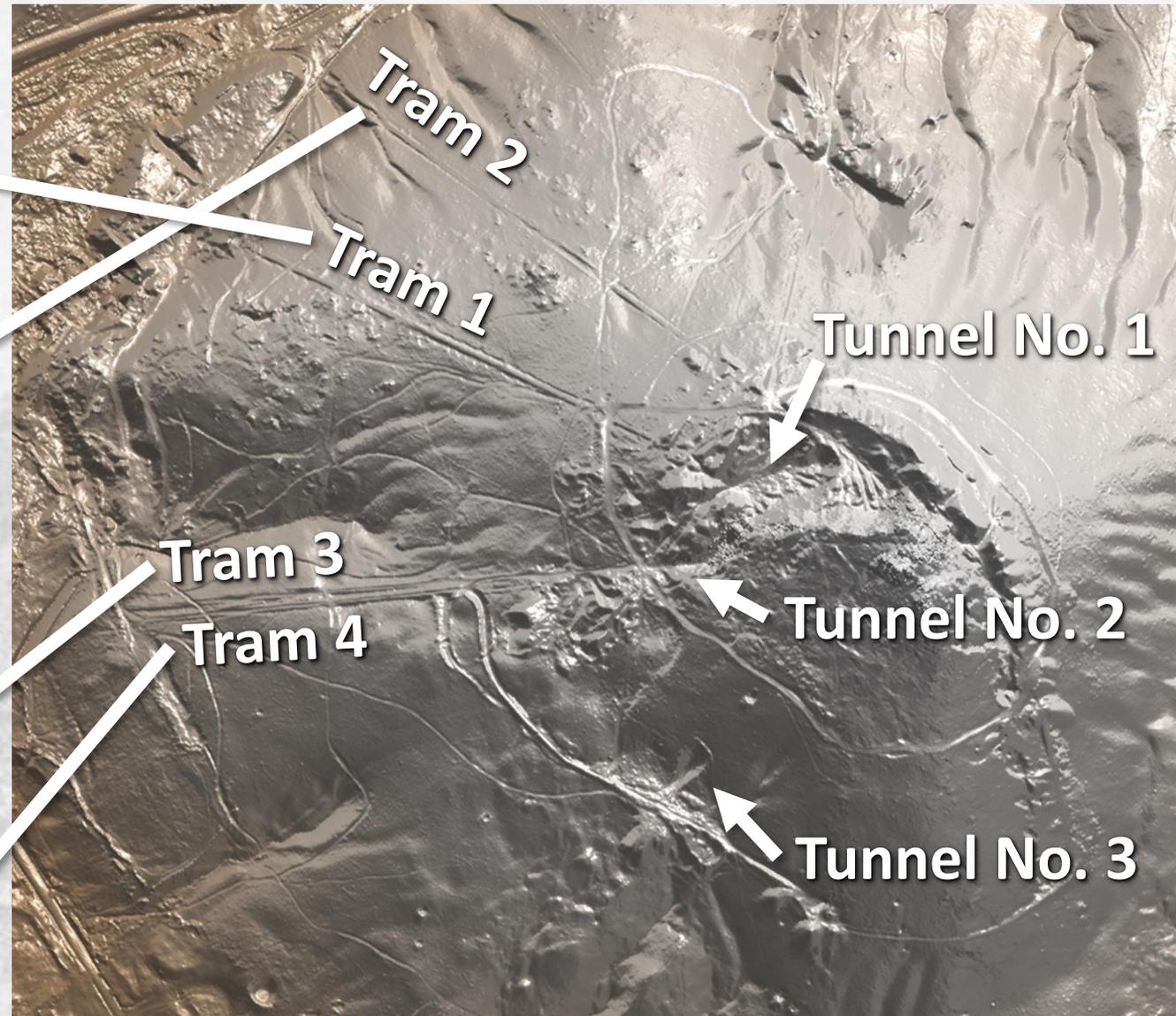
Operational in 1859. Built for direct ship ore after rail link to St Louis was complete.

Phase 3: Reconstruction - 1865-1880

Tram 3 construction in 1867 to access new underground ore from Tunnel 2.

Phase 4: Modernization - 1880-1890

Tram 4 constructed in 1879-1880 to support increased demand for ore.



1890: End of an Era – Company Declares Bankruptcy

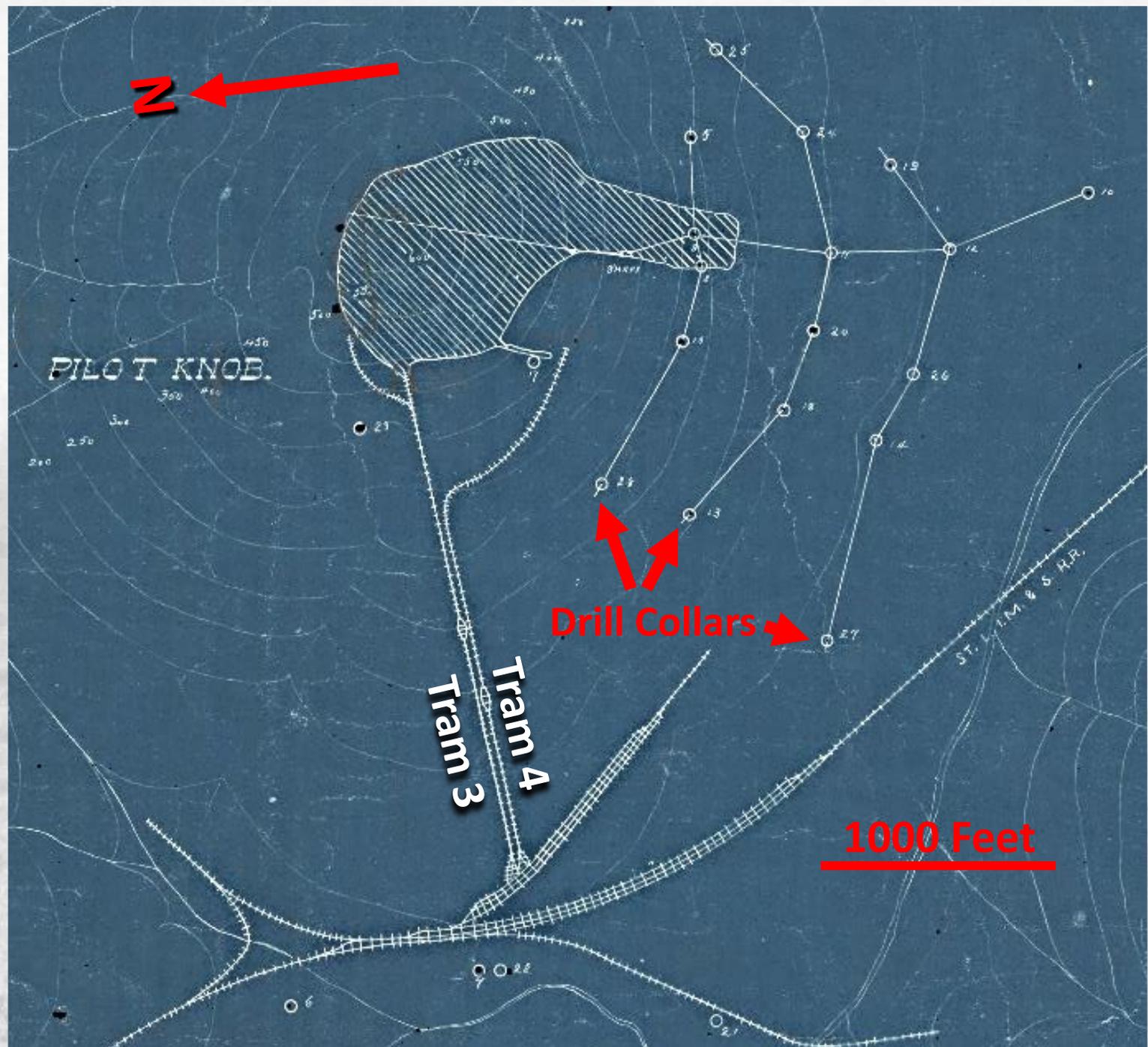
“Map 220” showing Pilot Knob 1888 Exploration Drilling

Ore was running out!

Drill holes sited by Professor W Potter of St Louis showed only low grade material down dip.

Map shows that Trams 1 and 2 were no longer an active part of the mining operation

Blueprint shows specific details of tram and rail layout.



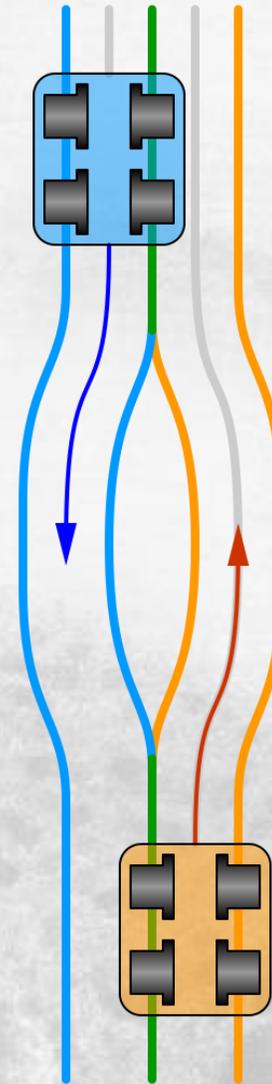
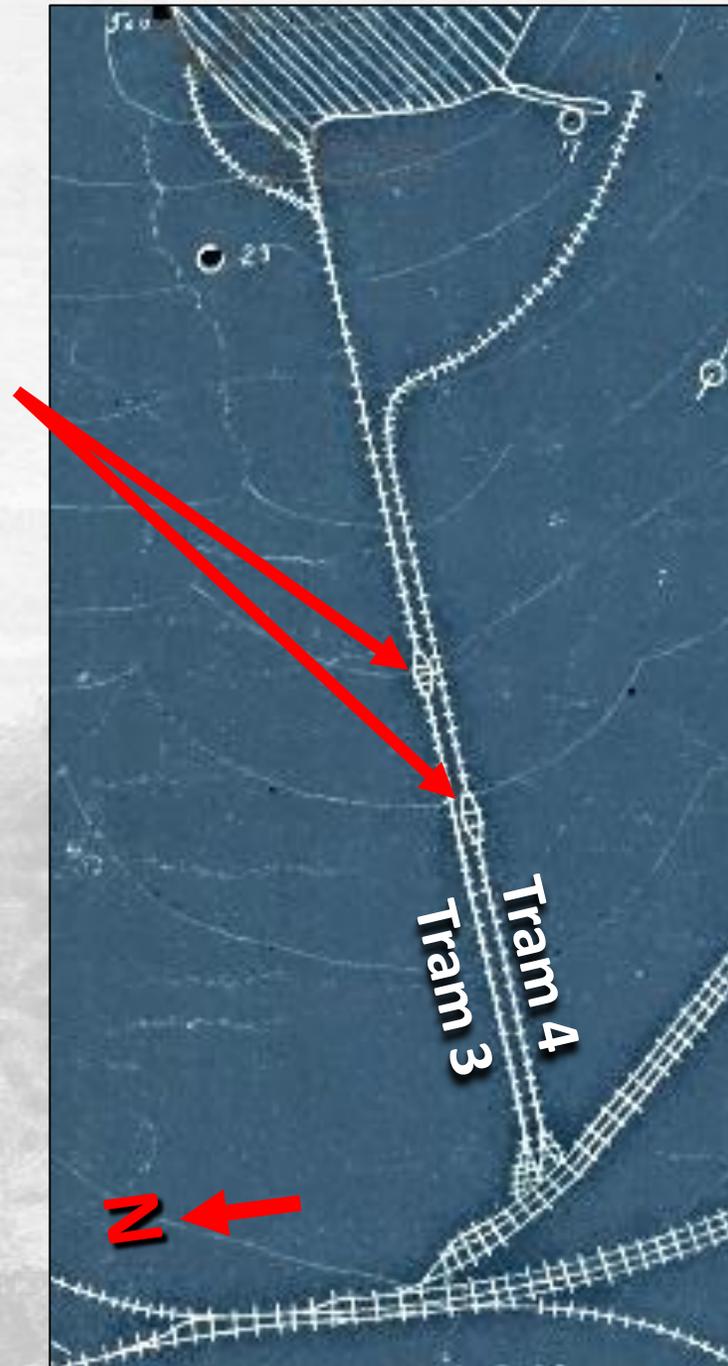
Trams 3 and 4 1888 Detail

Passing loops indicated on each tram line indicate that these were **Funiculars**.

What is a Funicular?

Cable rail system where cars are attached to either end of a cable so that one car goes up while the other goes down.

Cars must pass each other at the halfway point.



A 3-rail Funicular is cheaper than building two parallel rails for each car and requires no special equipment or switches at the passing loop.

3-rail passing loop

By Cmglee at English Wikipedia, CC BY 3.0,
<https://commons.wikimedia.org/w/index.php?curid=10546565>

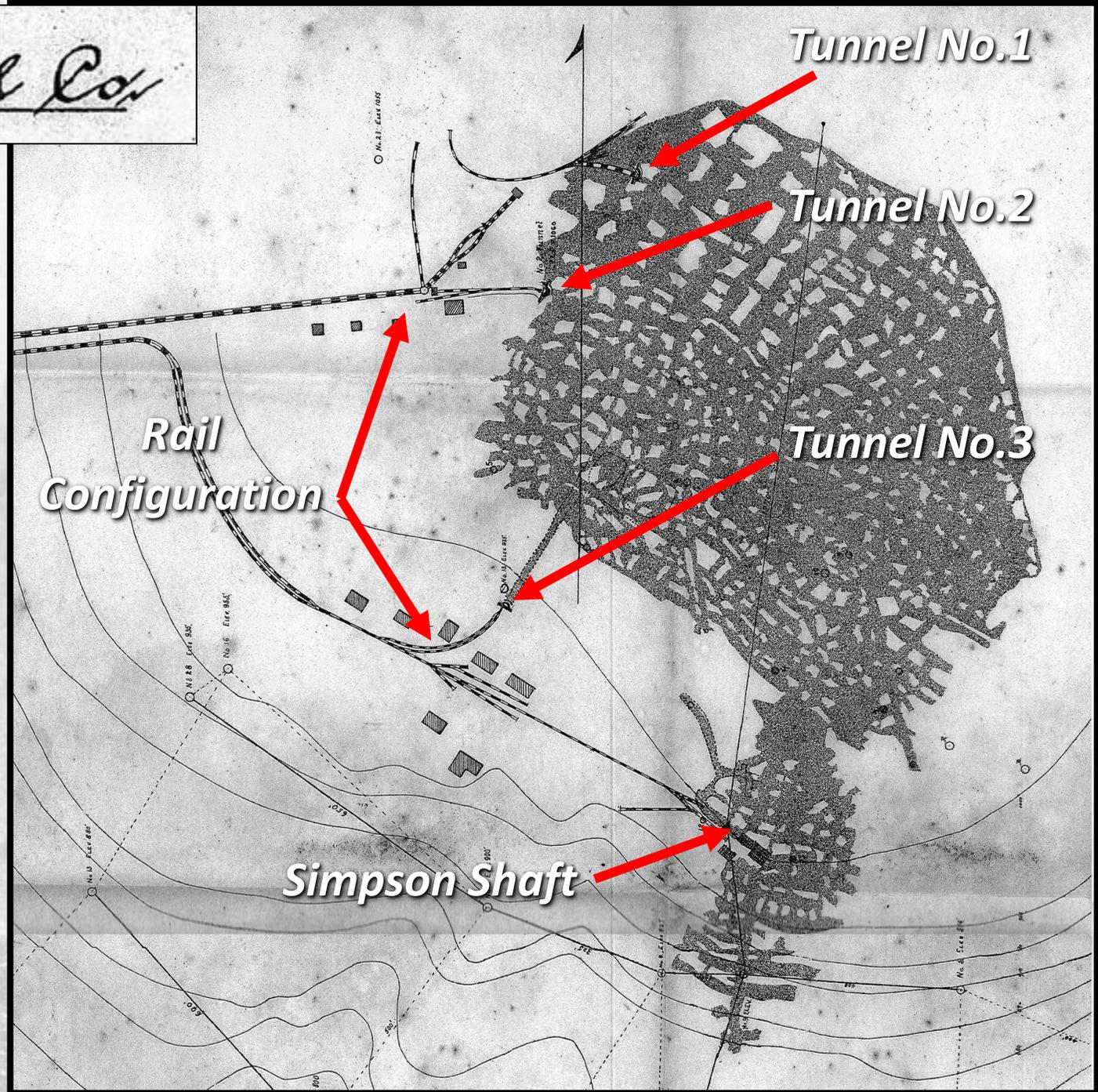
St Louis Ore and Steel Co.

*Map of the
Pilot Knob Mine,*

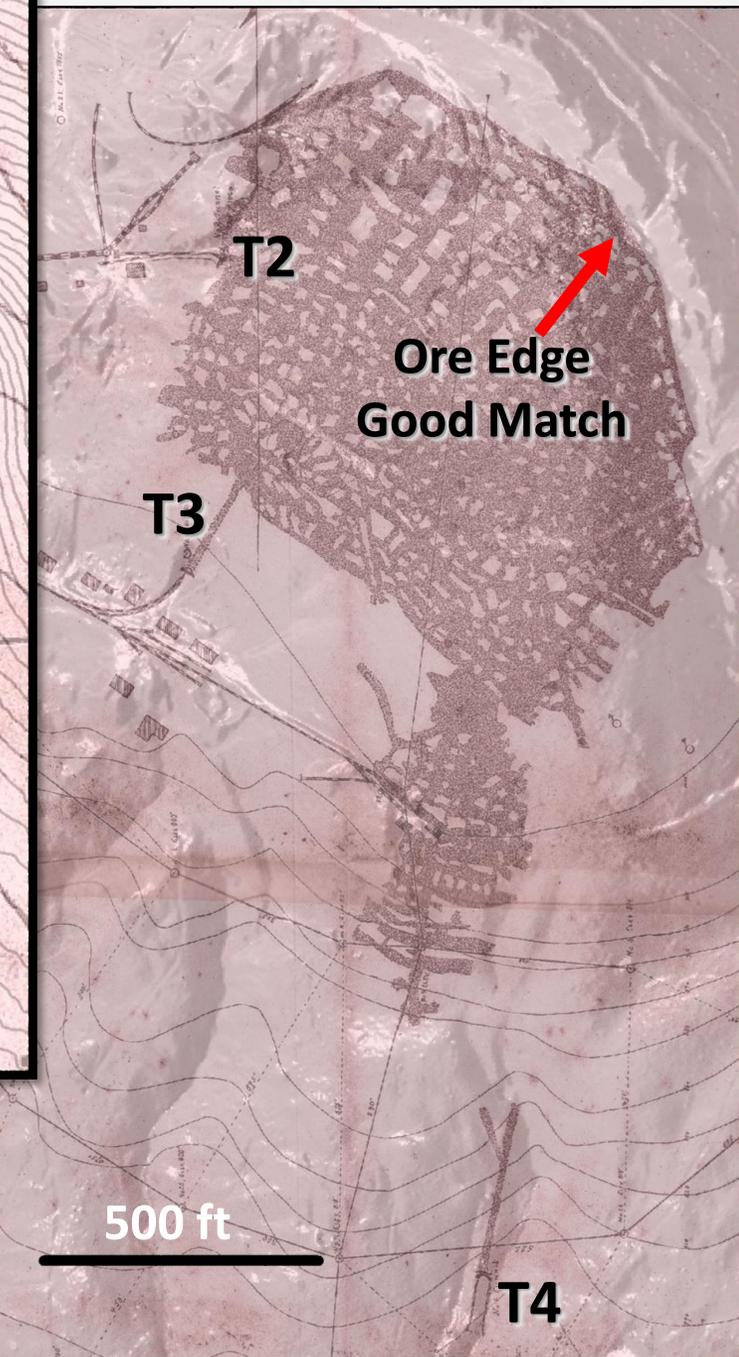
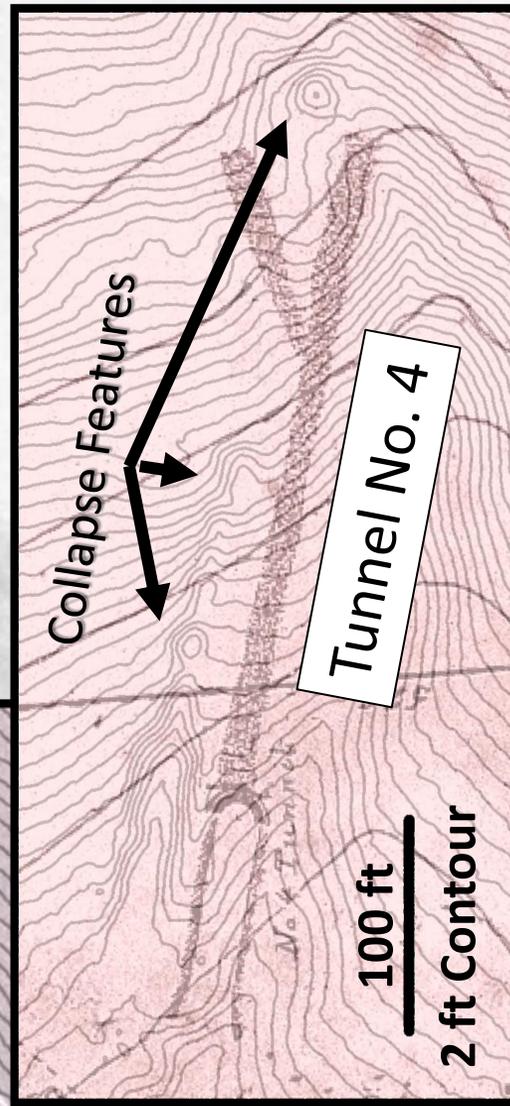
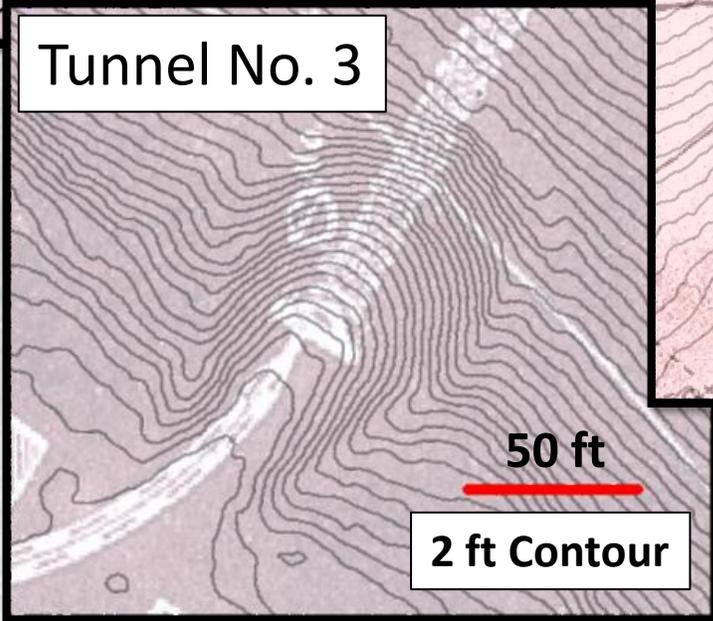
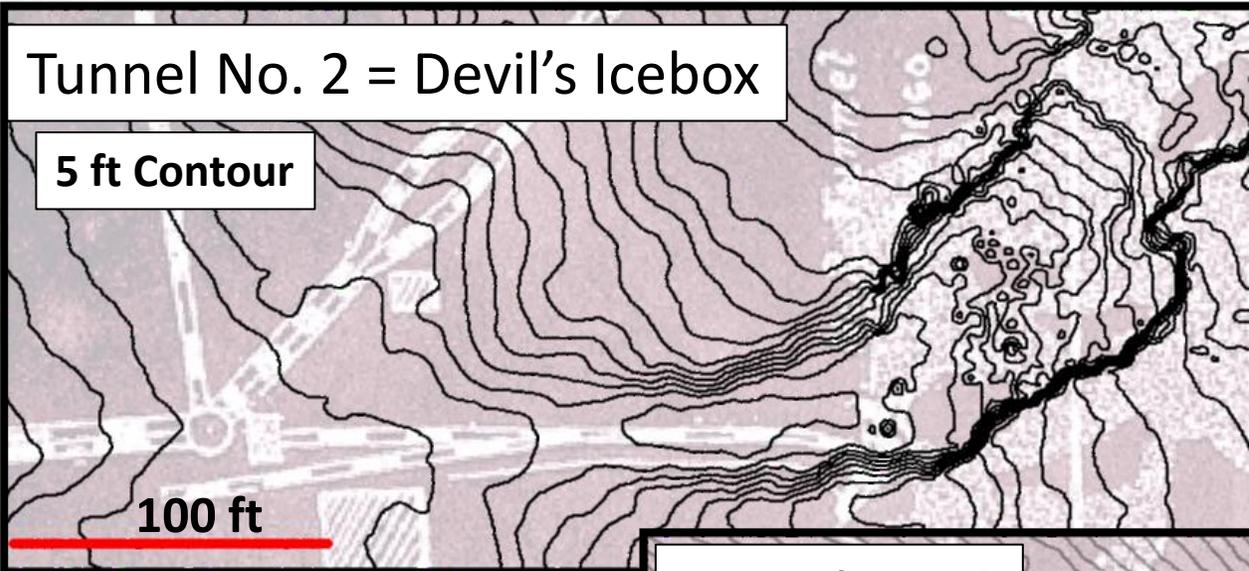
February, 1888.

Map shows the location of tunnels and railroads as well as underground mine workings and exploration drill holes.

Critical spatial information!



1888 Map Georeferenced



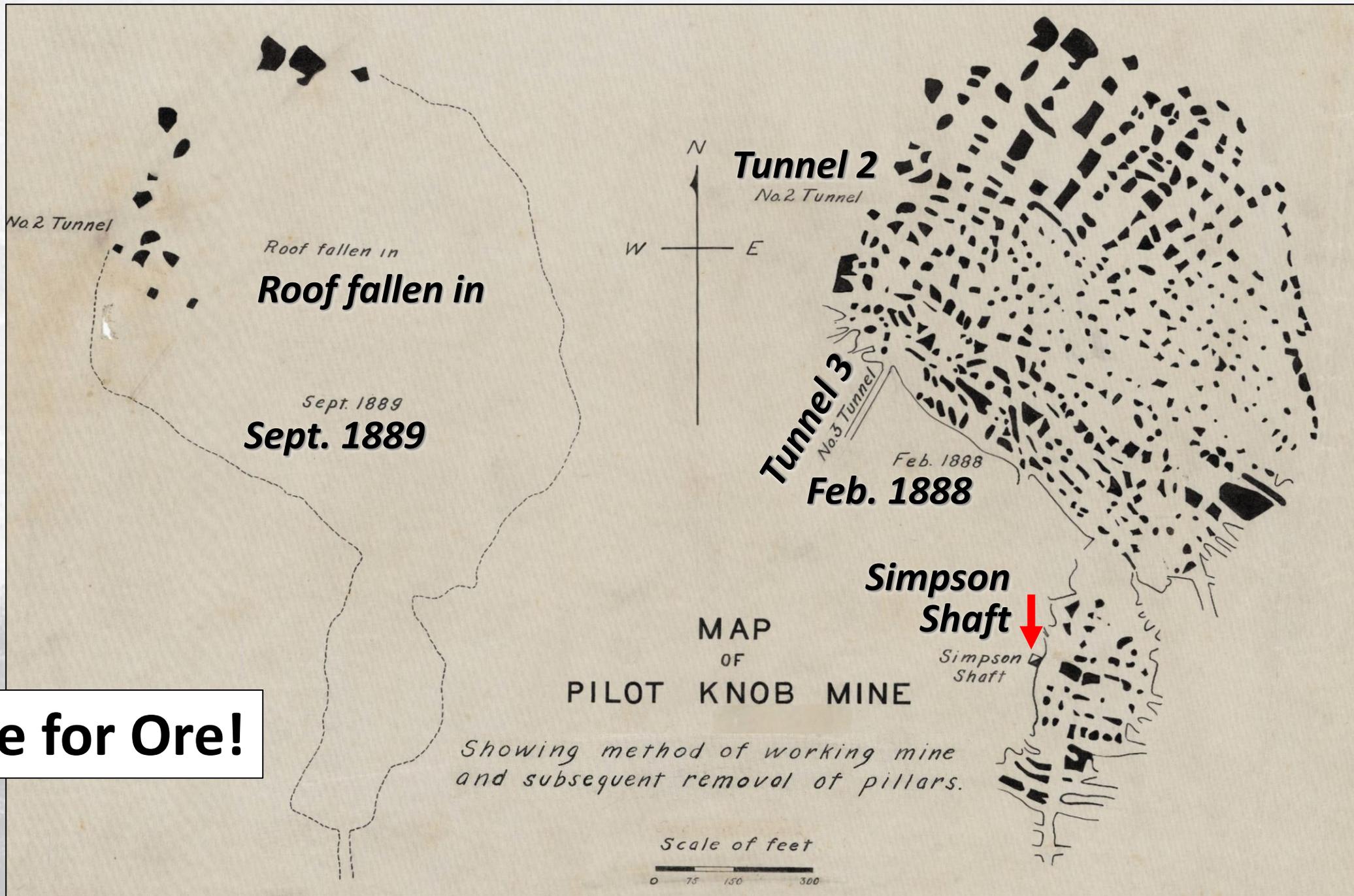
Good Match!

Map from Crane (1912)

Status
Circa 1890

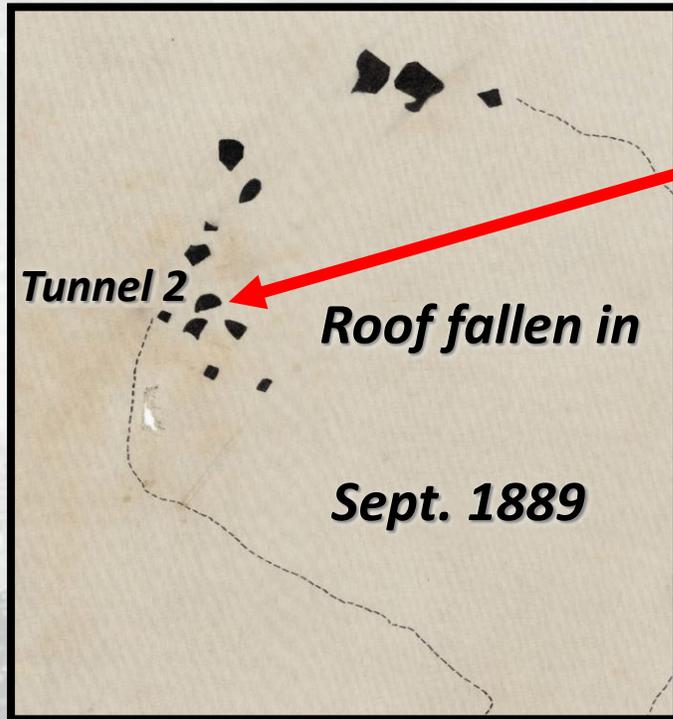
End of Mine
Pillar Robbing

Desperate for Ore!



Roof Support after Pillar Robbing

Tree trunks, or “Stulls” were used to support the roof as pillars were robbed



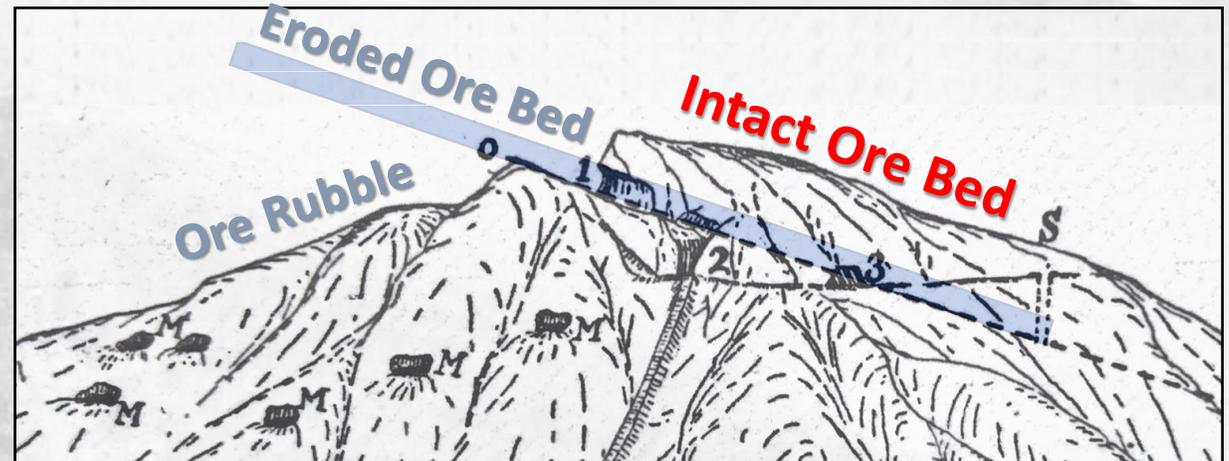
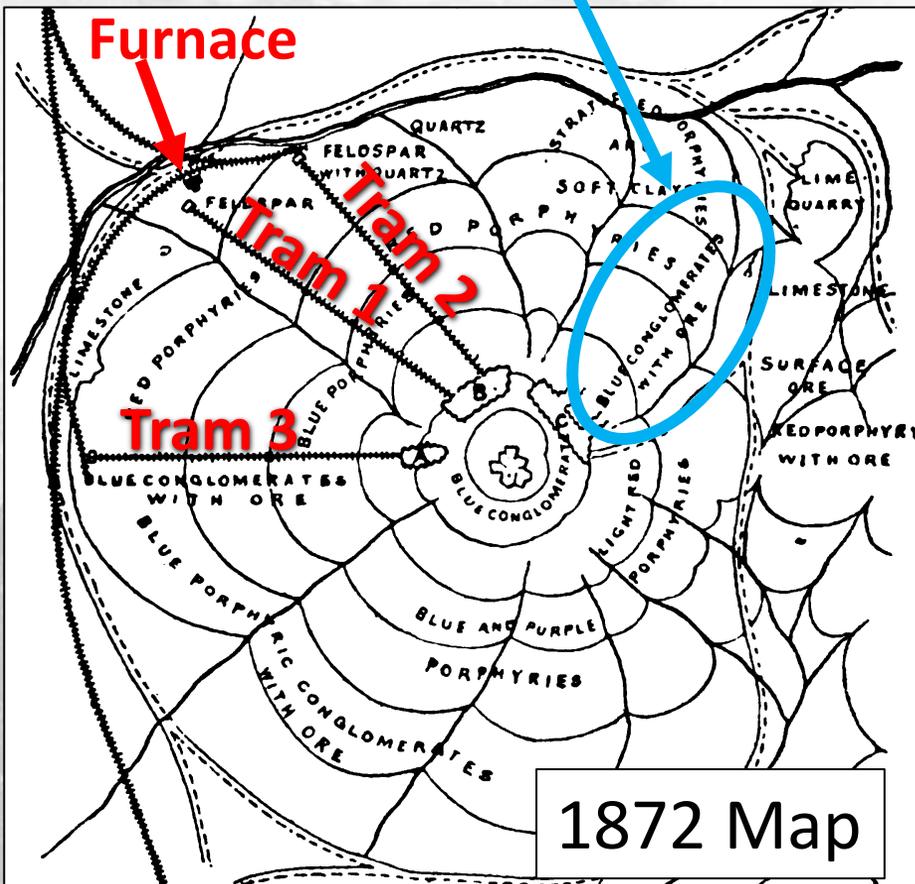
Lower Mine near Tunnel 2, February 22, 1958. Photo by Richard F. Myers. From Elliot and Kennedy (2008).

Phase 5: Floundering (1892-1920)

St Louis Ore and Steel Company bankruptcy ➡ 1892 - Big Muddy Coal and Iron Company

Early focus on conglomerate ores

Blue Conglomerates with Ore

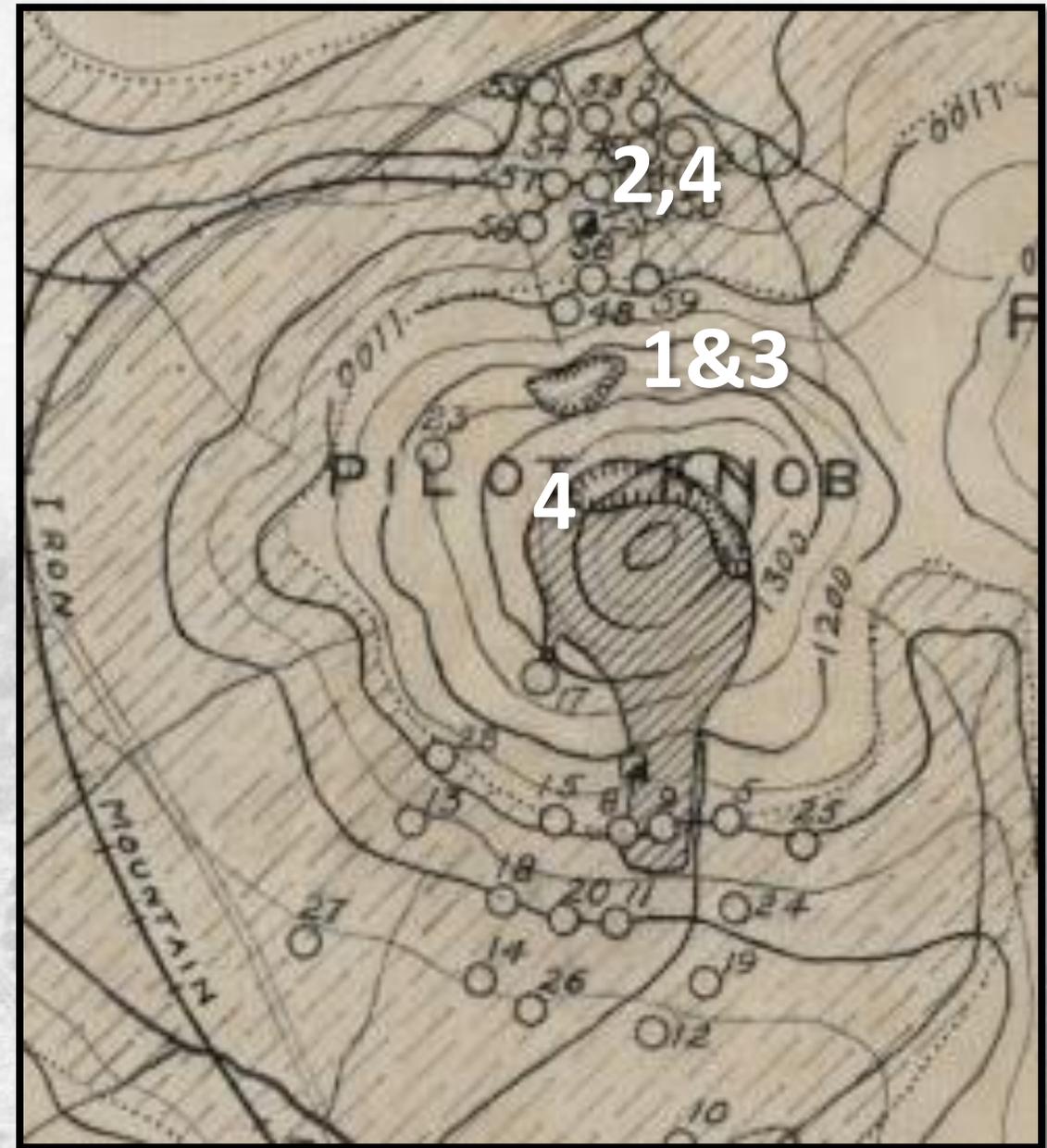


- Like gold, iron ore is heavy so it sinks to the bottom and is concentrated as the hill erodes away and rubble moves down slope.
- Conglomerate ore formed prior to deposition of Cambrian dolomite
- **Up to 200 feet thick in places**

Big Muddy Flounderings

1. 1892-1893: Small amounts of conglomerate ore are mined in the summers
2. 1899 - 1900: Work begins on a shaft east of furnace. Target is conglomerate ore. Planned depth 300 feet. June 30, 1900 depth is 130 feet.
3. 1910 – 1912: Leased mineral rights to Puxico Iron Company who reopened the conglomerate ore pit and operated it in 1911 and 1912.
4. 1916-1919: Active exploration on Pilot Knob. New rail put in on north side of hill. Conglomerate shaft reopened.

1920: Big Muddy changes name to Pilot Knob Ore Company and starts selling trap rock.



Map from Crane (1912)

Puxico Pit 1911

Millions of years of weathering dissolved silica and improved the grade of the iron ore but made it friable.

As a result iron ore pieces had to be handpicked from conglomerate.

Not surprisingly, one man was killed by a collapse in this pit.

Photo from Crane (1912)

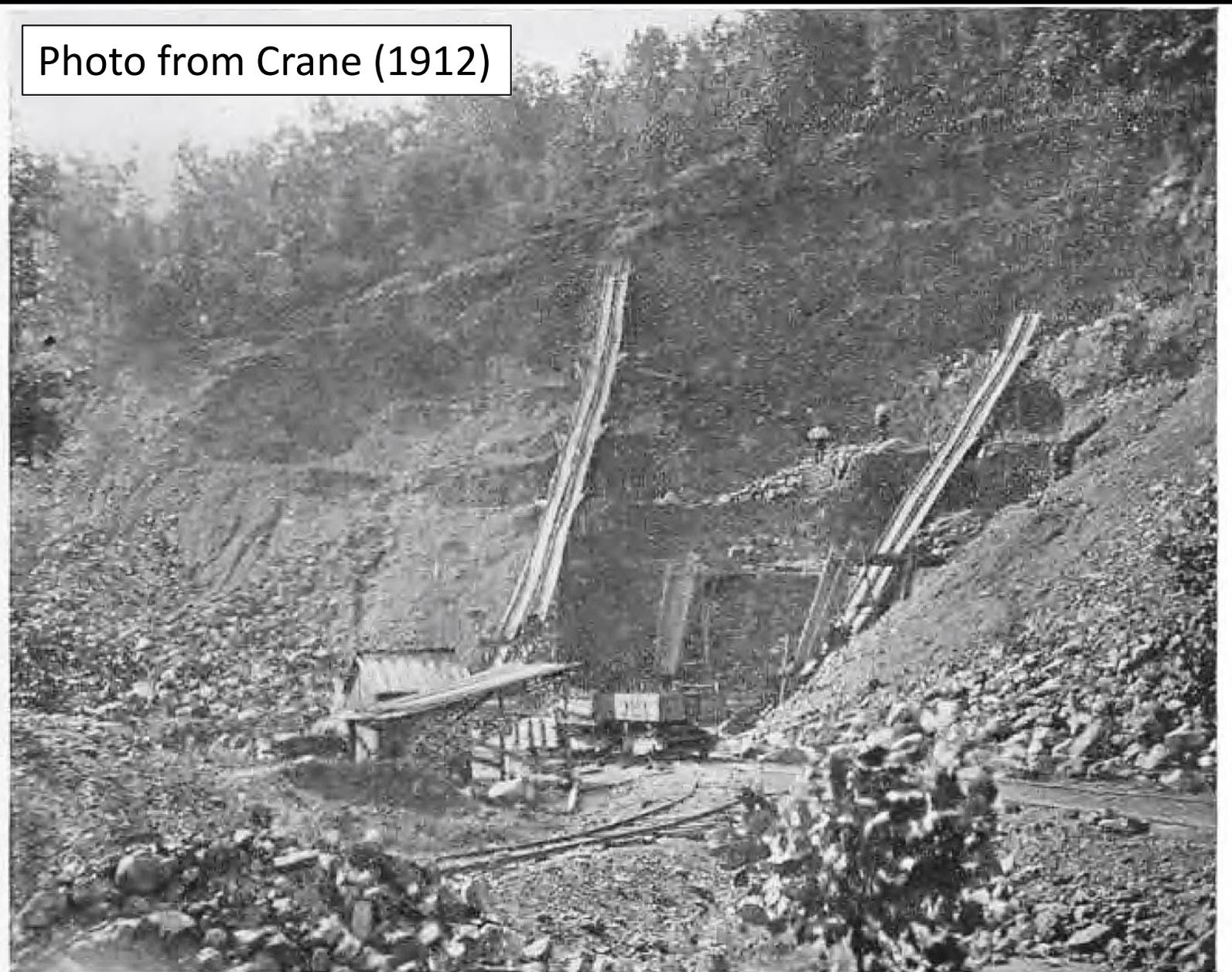


Fig. 2. VIEW OF THE SOFT CONGLOMERATE ORE CUT ON THE NORTH SLOPE OF PILOT KNOB.

Upper Pilot Knob Reopening

Photo location unknown but
caved opening suggests
Tunnel 1 or Tunnel 2.

Clearly had rail equipment
operating at this time.

Pilot Knob mining scene

Pictured above is an early mining scene at Pilot Knob Mountain, taken **Spring 1919**. From left to right: Frank Tyndall, Pearl Mayberry, George Tripp, Hermann Amelung, Hank Hart, Chris Amelung, Johnnie Filpo, Noah Thurman, George Sogn, Henry Weher, Andrew Yates, Brad Mayberry, Hollie Hart, Isa Barnes and Ross Parton. List of names supplied by Donnie Tyndall, son of Frank Tyndall in picture. Photo given to the Iron County Historical Society by Hardy Studio of Ironton. (The mule's name is Toby.)

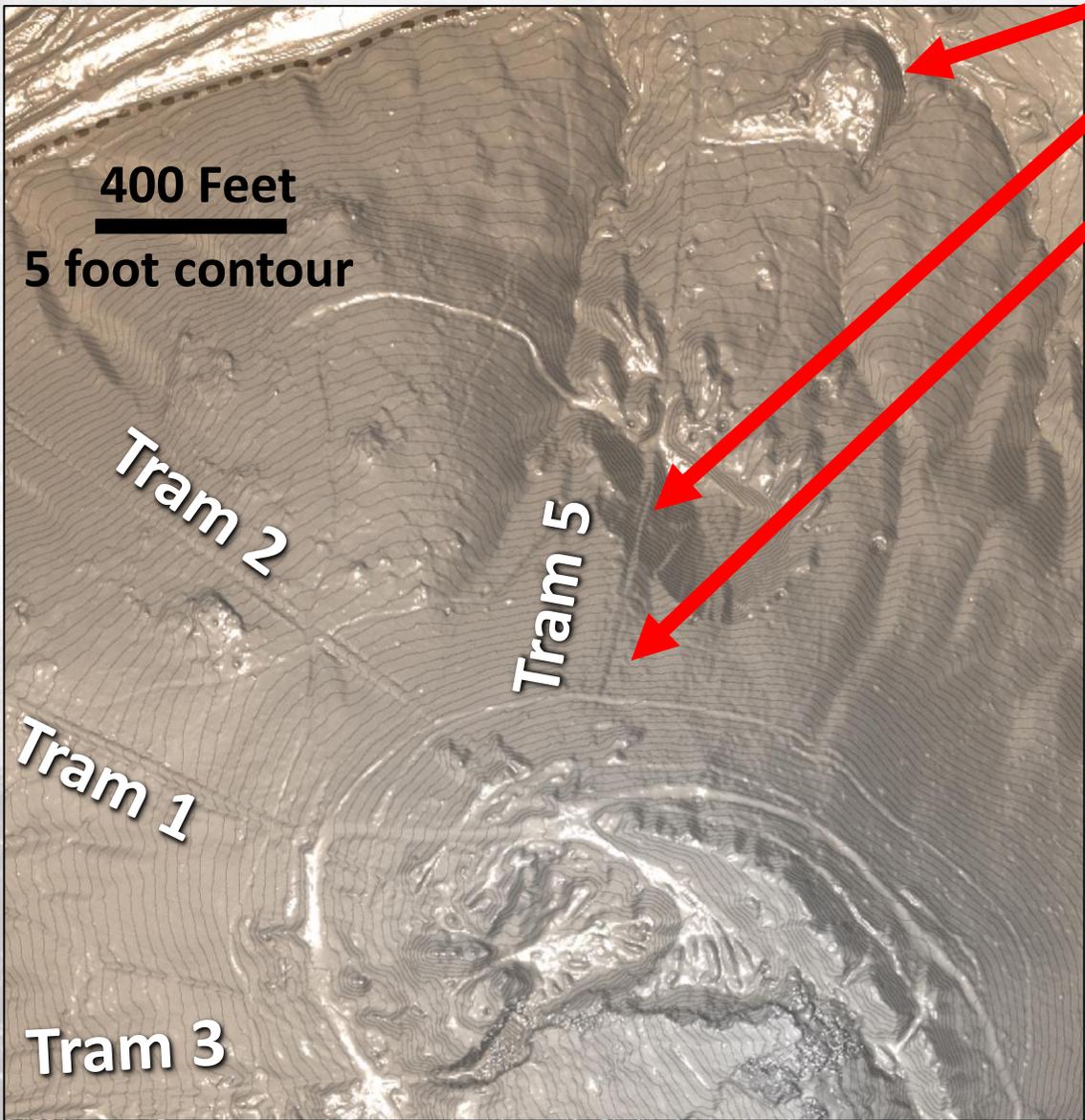
Spring 1919



Caption: The Mountain Echo, 5/4/1994

Photo courtesy of the Iron County Historical Society

Post 1912 Age of Tram 5

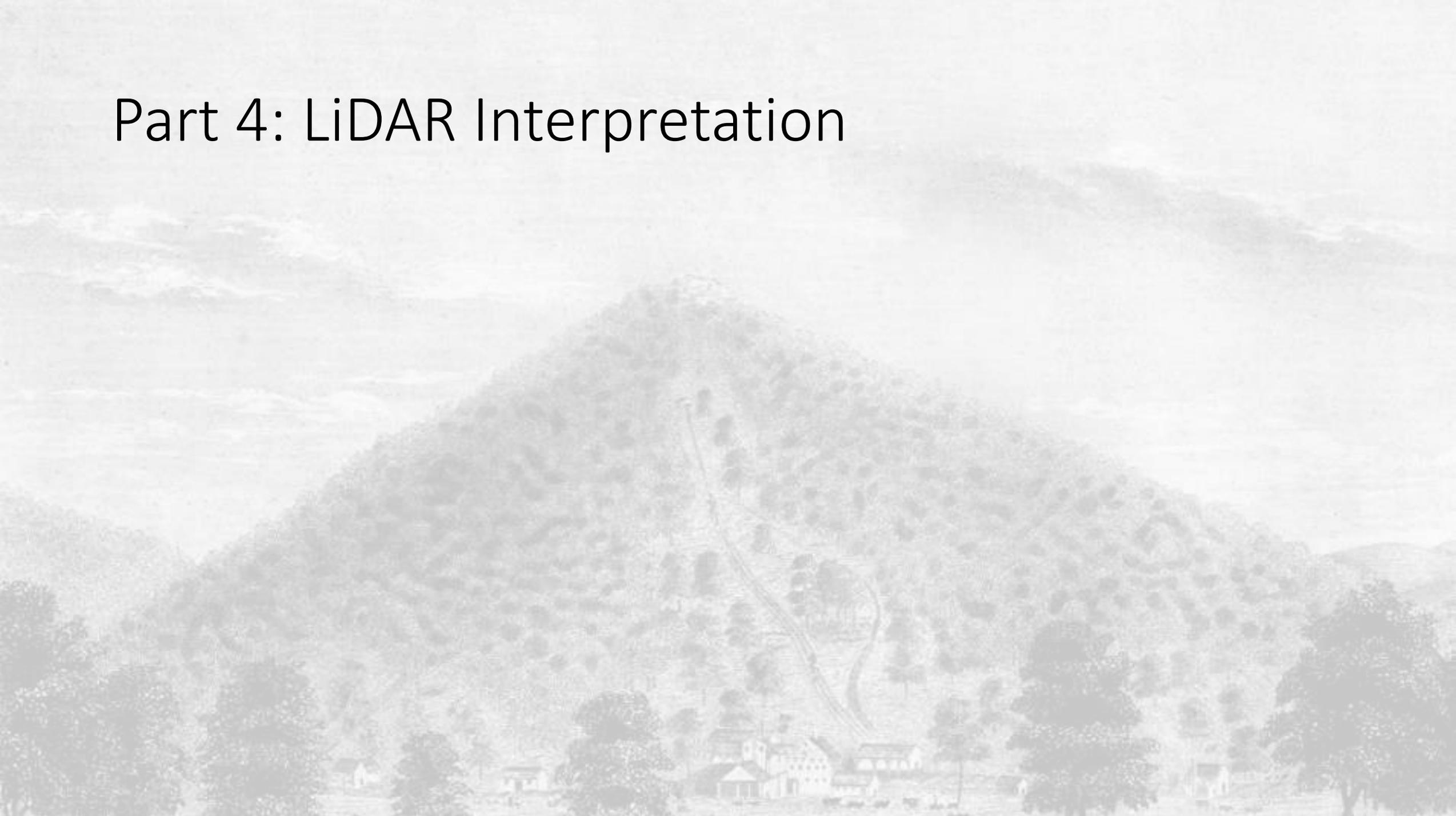


- Big Muddy Shaft Working Area**
- Tram 5 Superimposed on 1912 Puxico Pit Wall**
- Tram 5 Raised Roadbed**



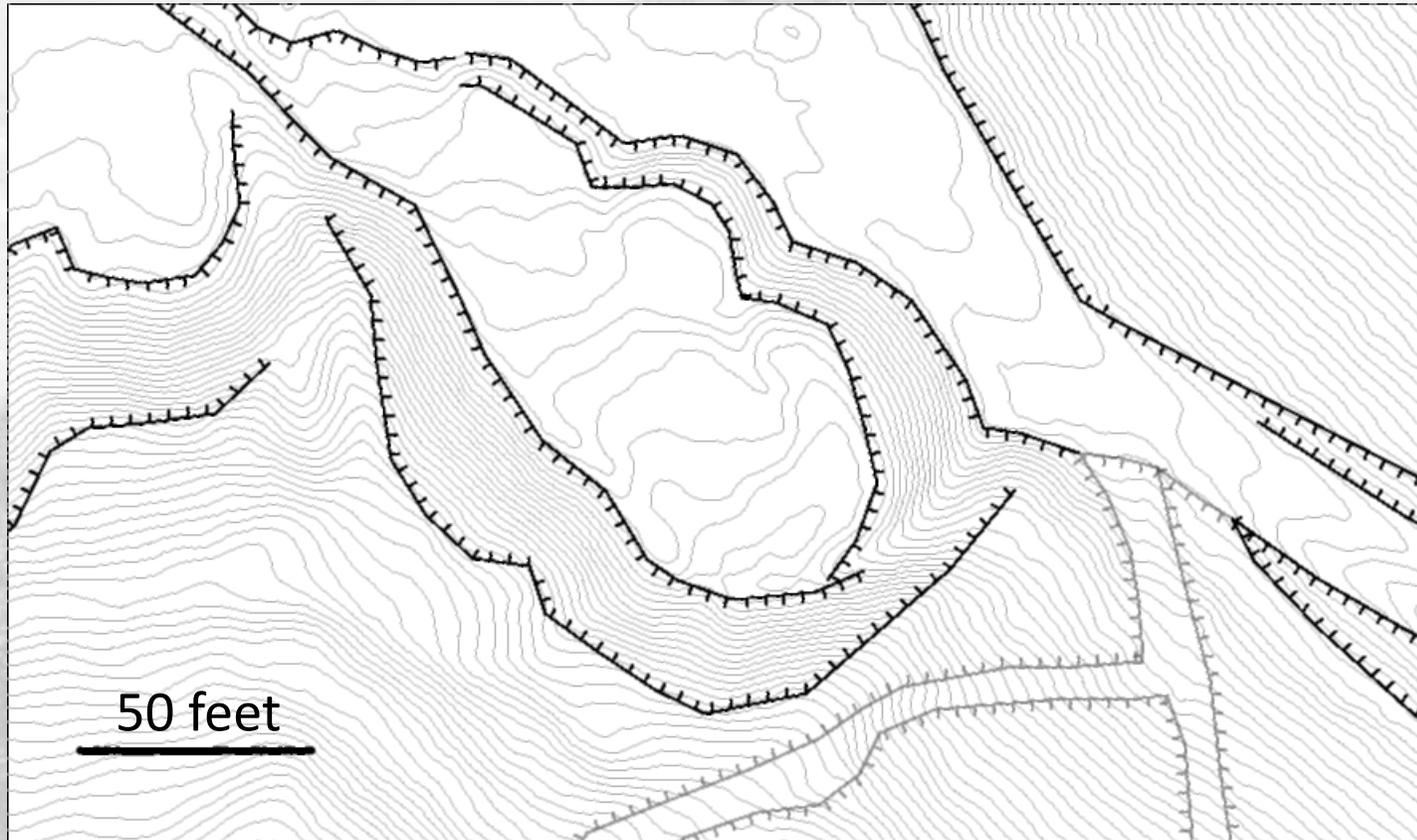
Missouri Geological Survey Archive photo which reportedly shows men at work on Pilot Knob In the early 1900's.

Part 4: LiDAR Interpretation



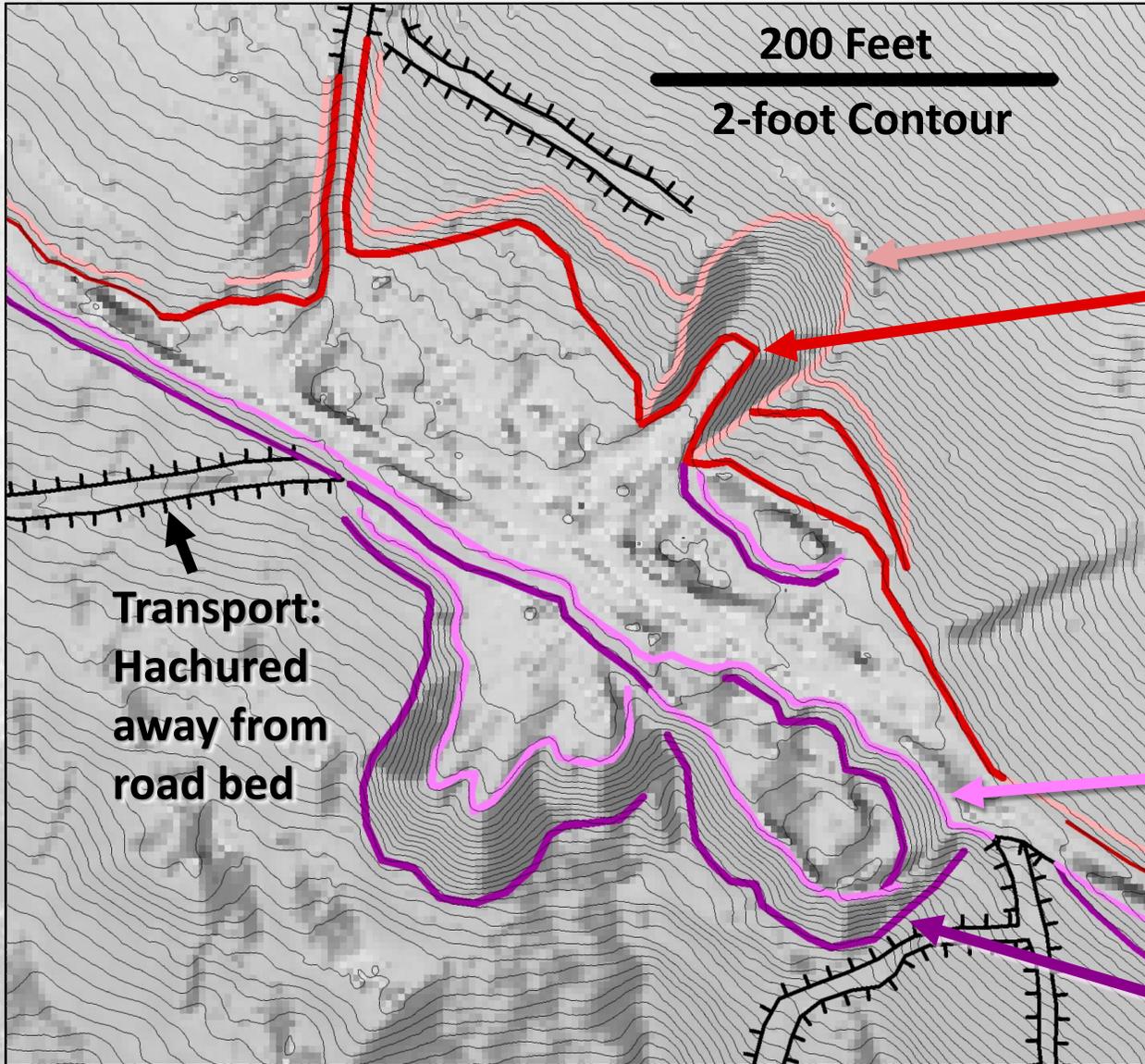
LiDAR Interpretation Method

1. Process data to produce 1-, 2- and 5-foot topographic contours
2. Interpret and digitize boundaries at consistent scale of 1:500
3. Field validate questionable features
4. Finalize interpretation

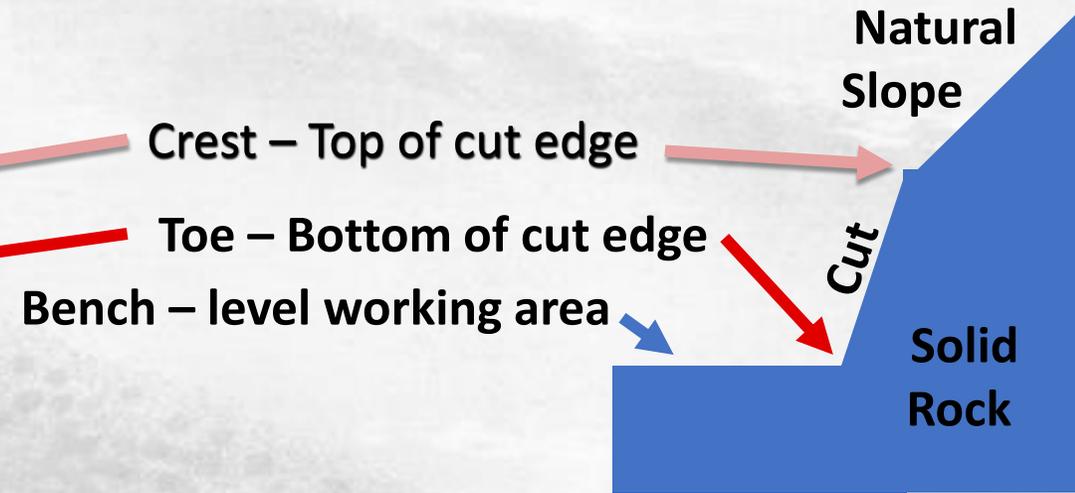


	PK_BenchToe
	PK_BenchCrest
	PK_DumpCrest
	PK_DumpToe
	PK_TramCut_Crest
	PK_TramCut_Toe
	PK_TramFill_Toe
	PK_TramFill_Crest
	PK_RoadFill_Crest
	PK_RoadFill_Toe
	PK_RoadCut_Toe
	PK_RoadCut_Top
	PK_RoadEdge_Lower
	PK_RoadEdge_Upper

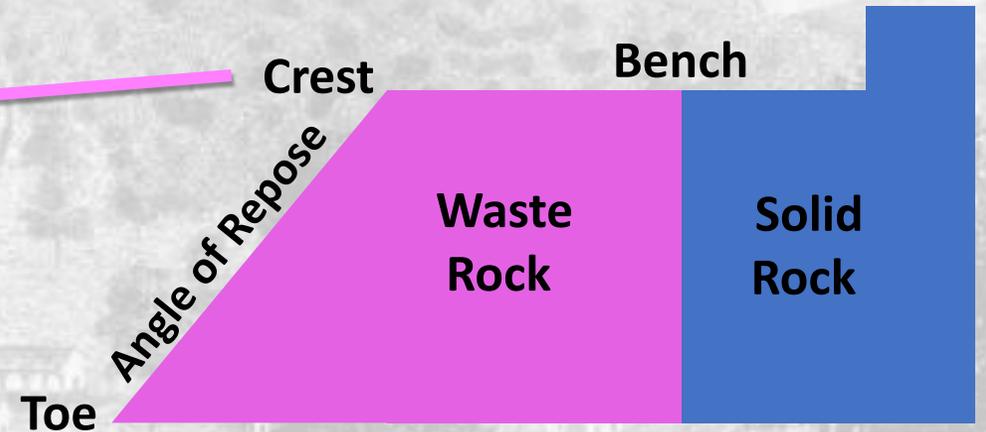
Basic Elements of a Mine Site: Tunnel 3 Example



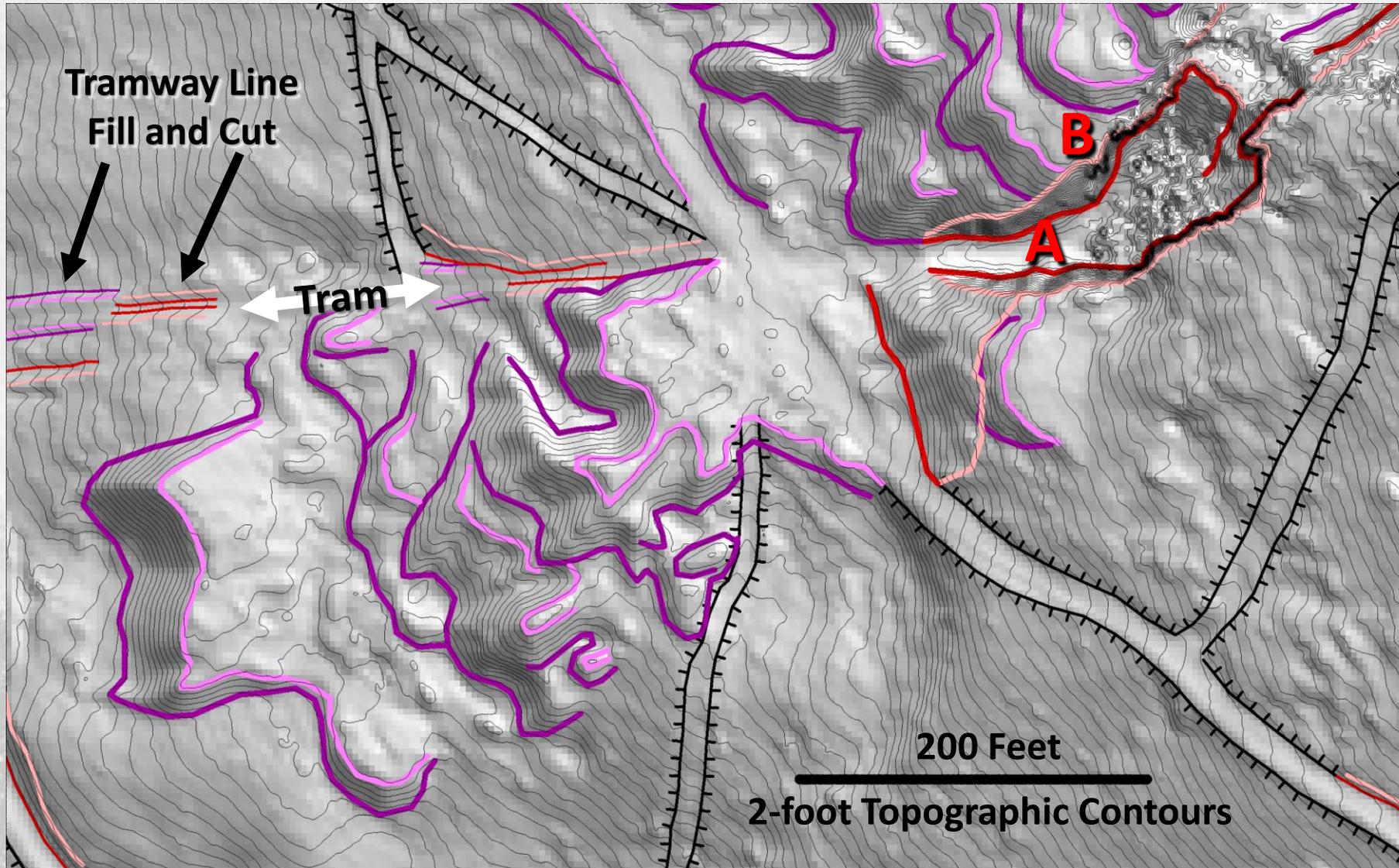
Mine Excavation – Cutting into the surface



Mine Dump – waste rock disposal pile
Fill – waste rock used for construction



Tunnel No. 2: Head of Tram 3 – Devil's Icebox



Deep mine cut at
Tunnel 2 entrance
(Devil's Icebox)

A 1294' Elevation

B 1350' Elevation

Complex pattern of
waste dumps below
Tunnel 2

— Cut Crest

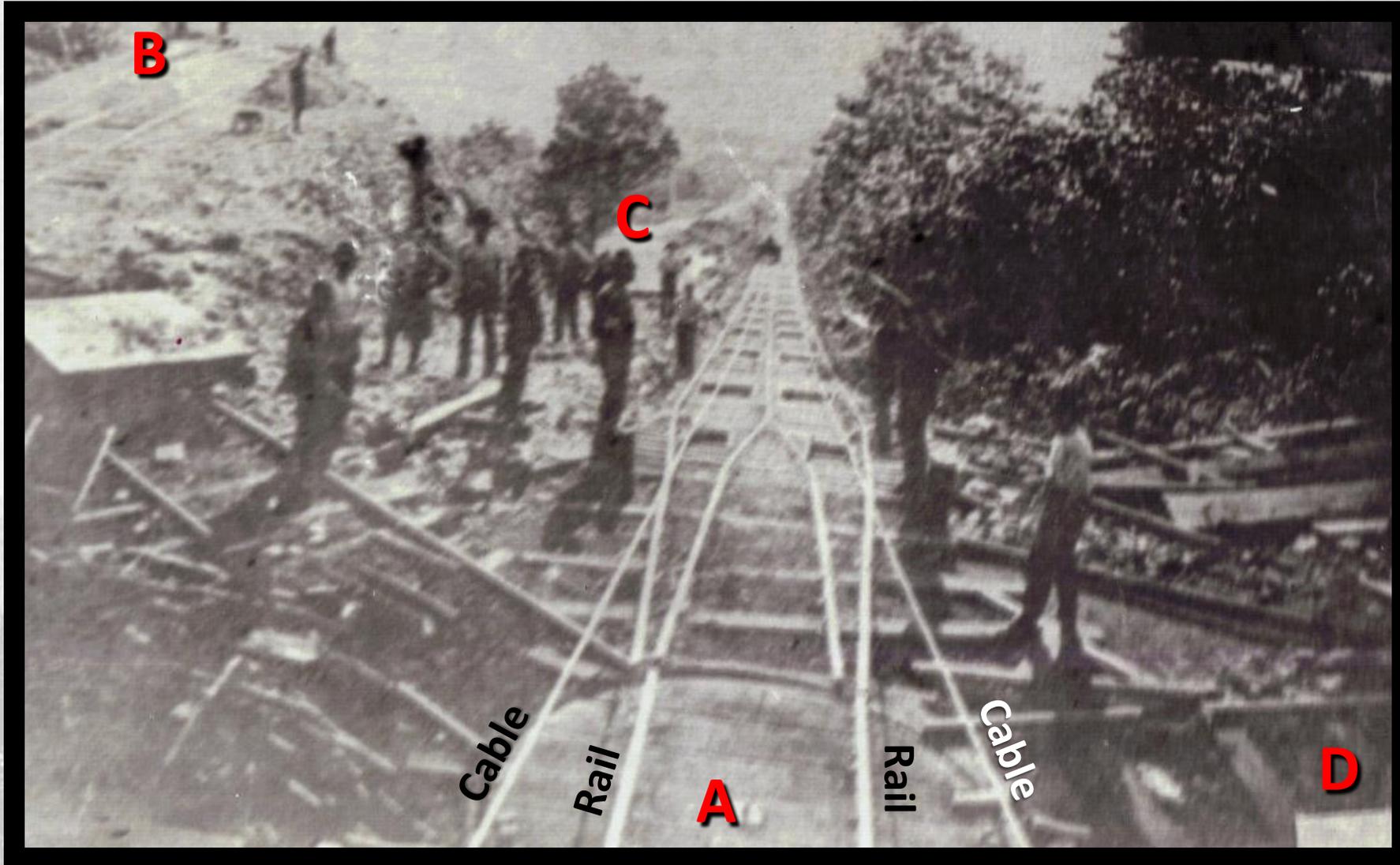
— Cut Toe

— Dump Crest

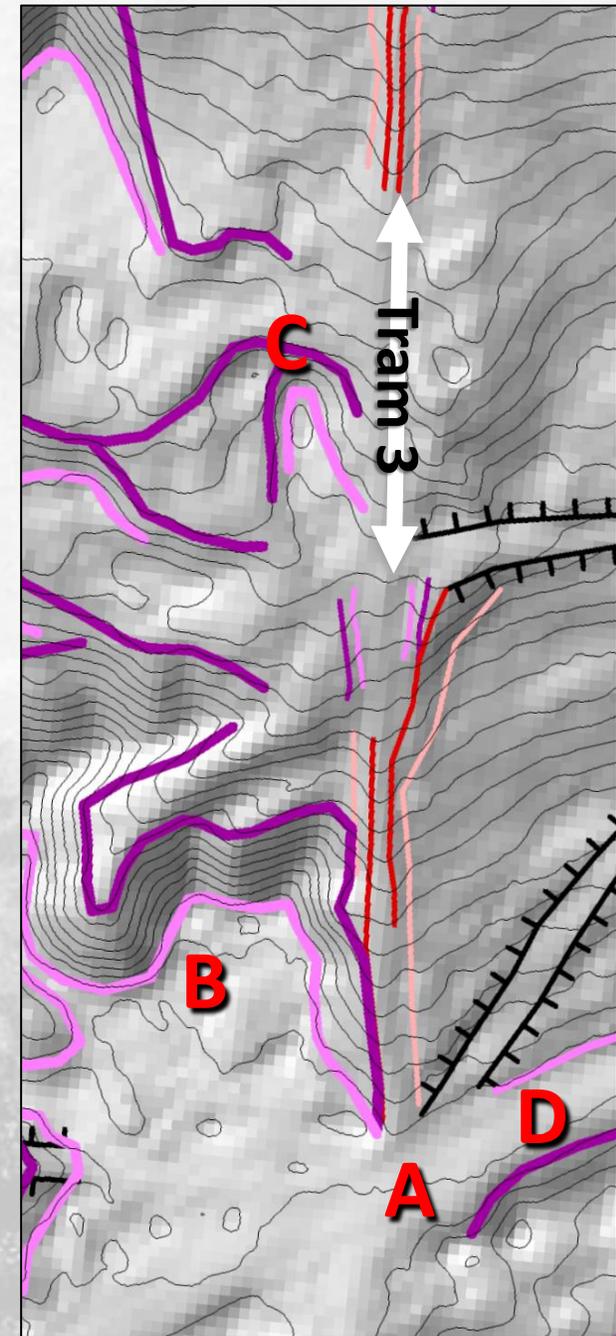
— Dump Toe

View from the top of Tram 3

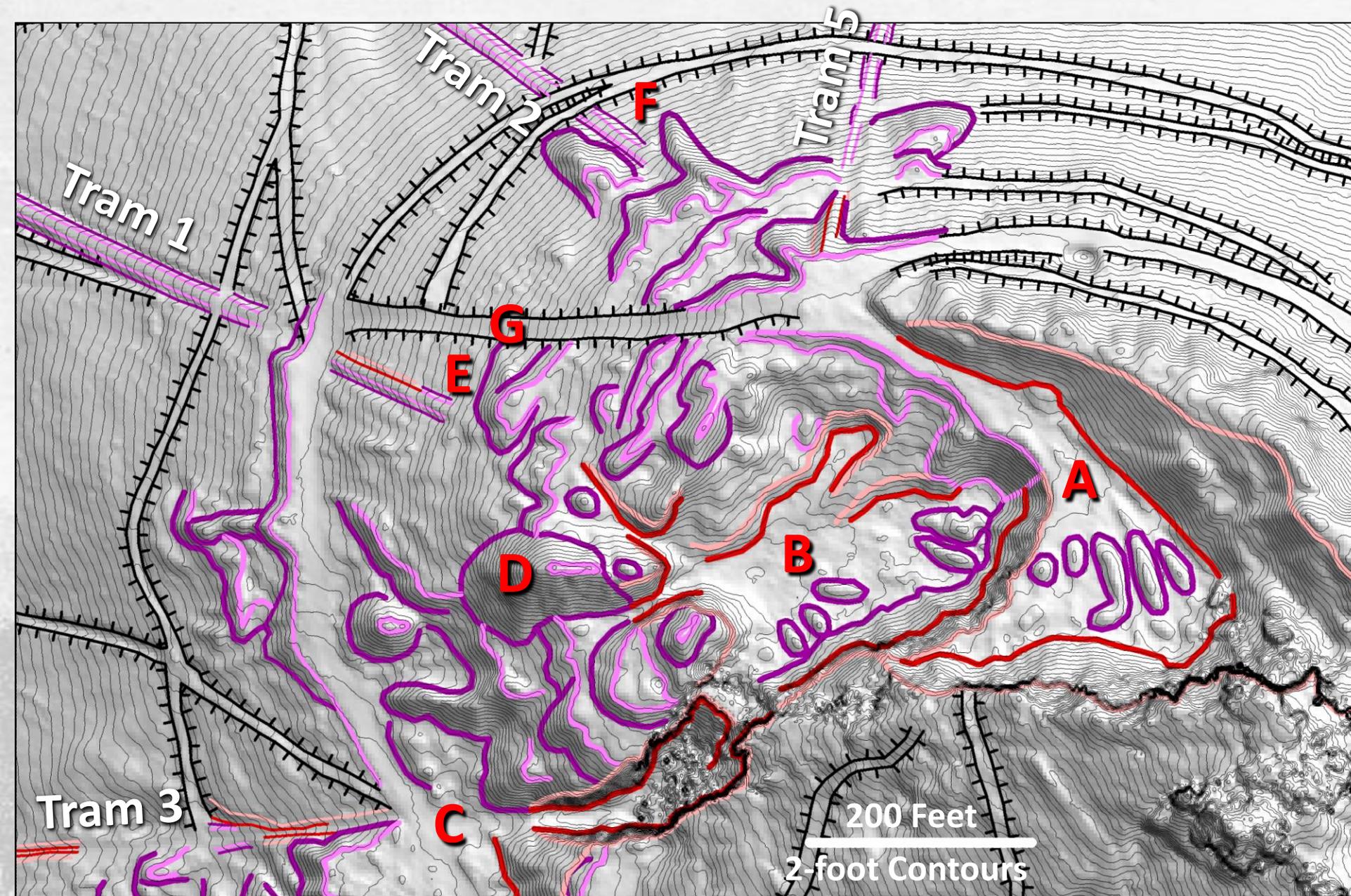
3-Rail Funicular with Turn Table at Top to Redirect Cars



Undated photo courtesy of Iron County Historical Society



Pilot Knob Upper Pit

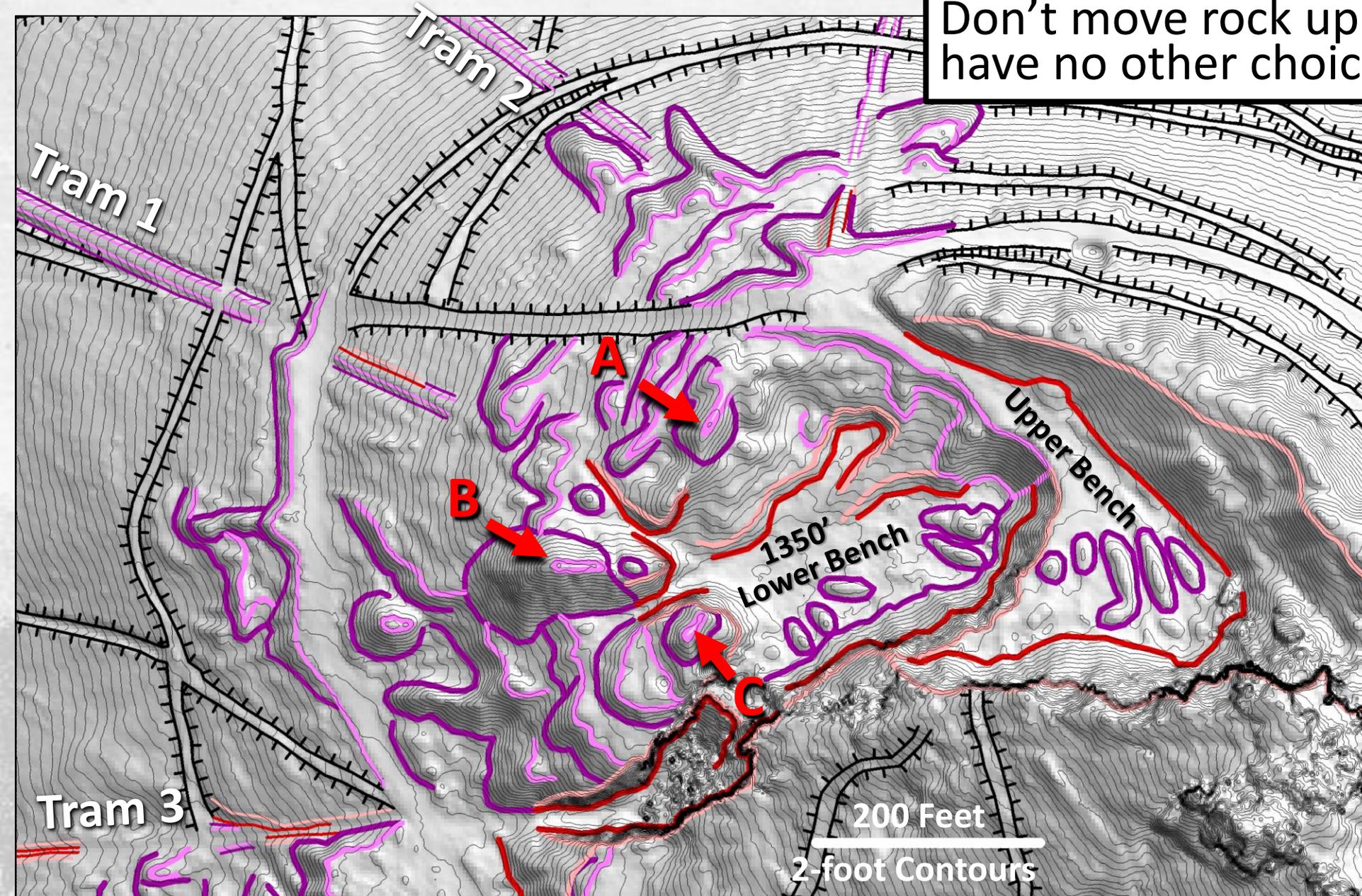


- A** Upper Bench
1390' Elevation
- B** Lower Bench
1350' Elevation
- C** Tunnel No. 2
1290' Elevation
- D** Largest Dump
1377' Top Elev.
54' Tall
- E** Tram 1 Head
Covered by dump
- F** Tram 2 Head
Covered by dump
- G** 1987 Road cut to
put in refuge
fence

Upper Bench Dumps

Mining Rule No. 1:

Don't move rock uphill unless you have no other choice!



**Upper Bench
Elevation = 1390'**

A - Crest 1390'

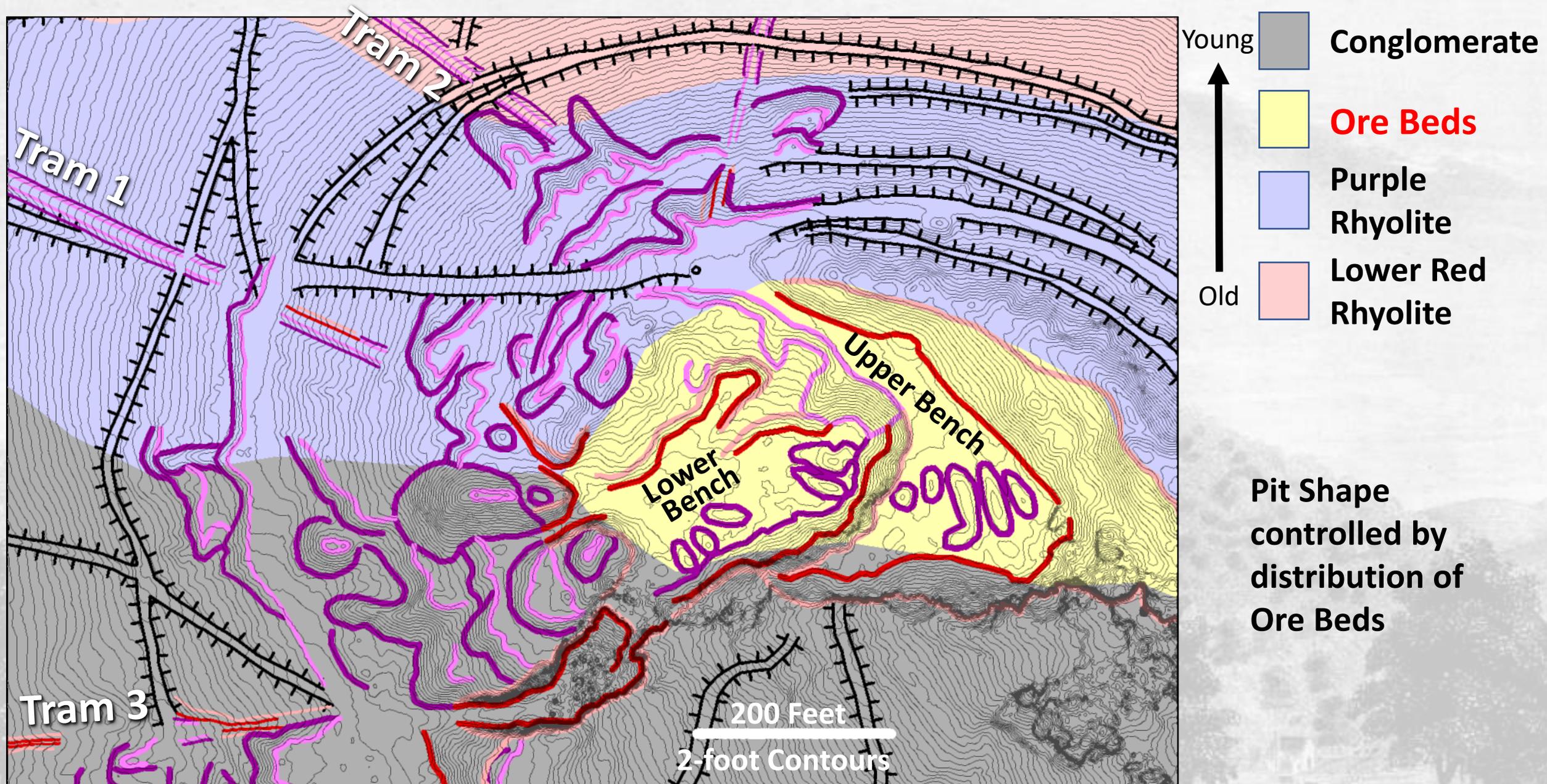
B - Crest 1377'

C - Crest 1381'

Implication:

**Upper Bench
originally extended
over much of
Lower Bench**

Pilot Knob Upper Pit Geology

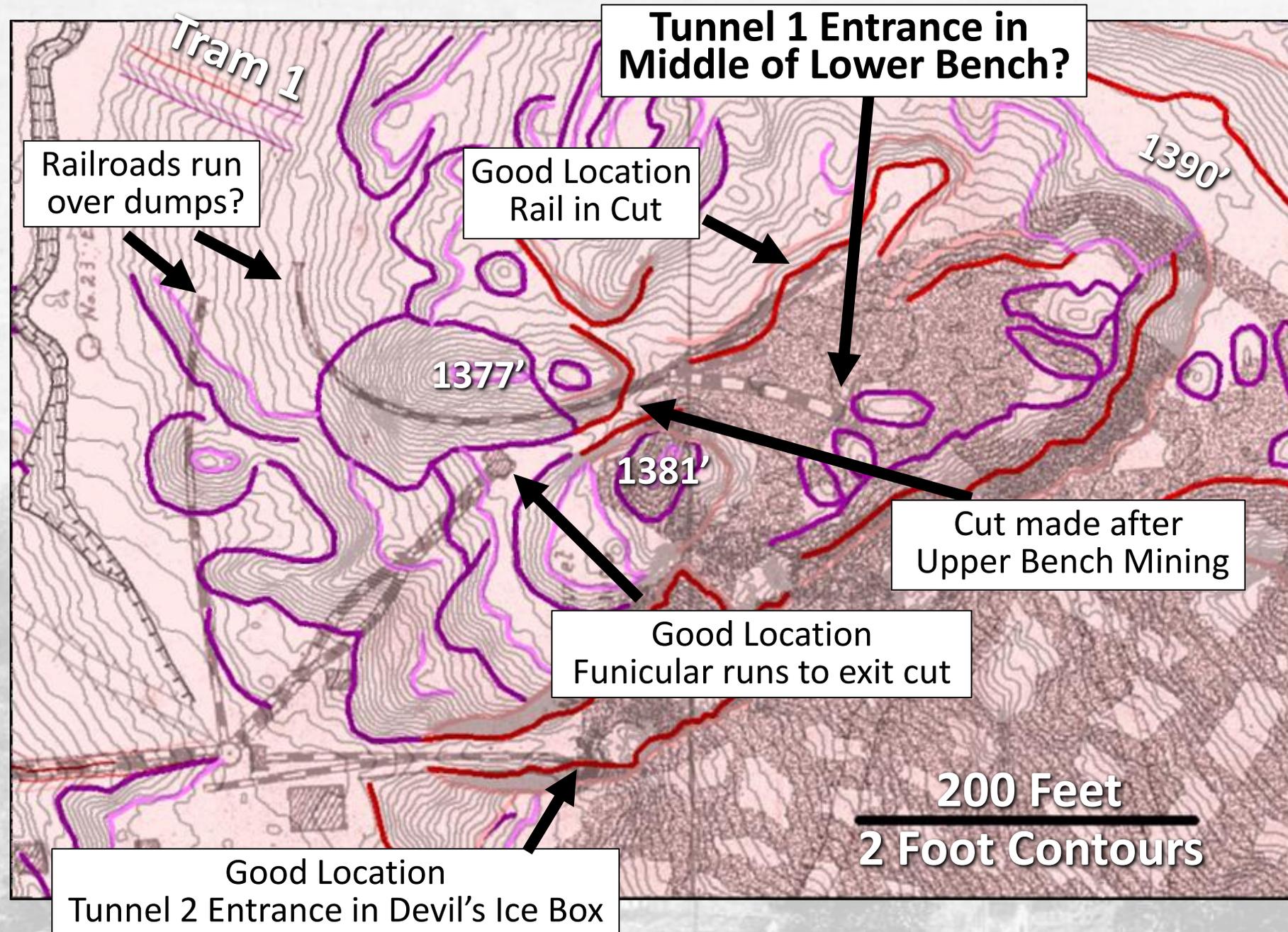


Feb. 1888 Map Conundrum

Overprinting
vs.
Drafting Errors

Earliest mining history
when Trams 1 and 2
were in use has been
overprinted by later
mining.

**Location of Tunnel 1
may imply that the
Lower Bench was
finished during the
desperate post-Feb
1888 pillar robbing
period.**

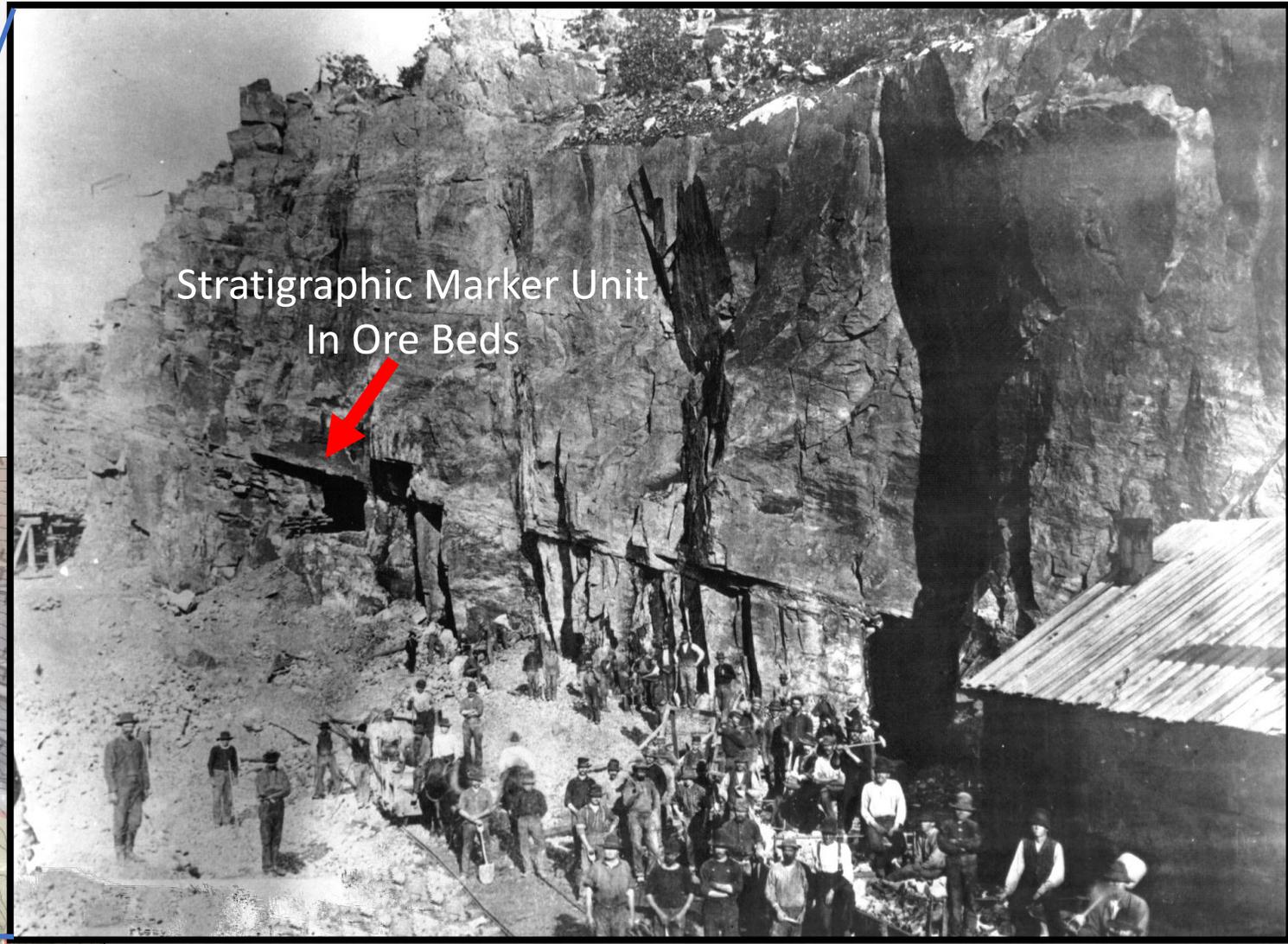
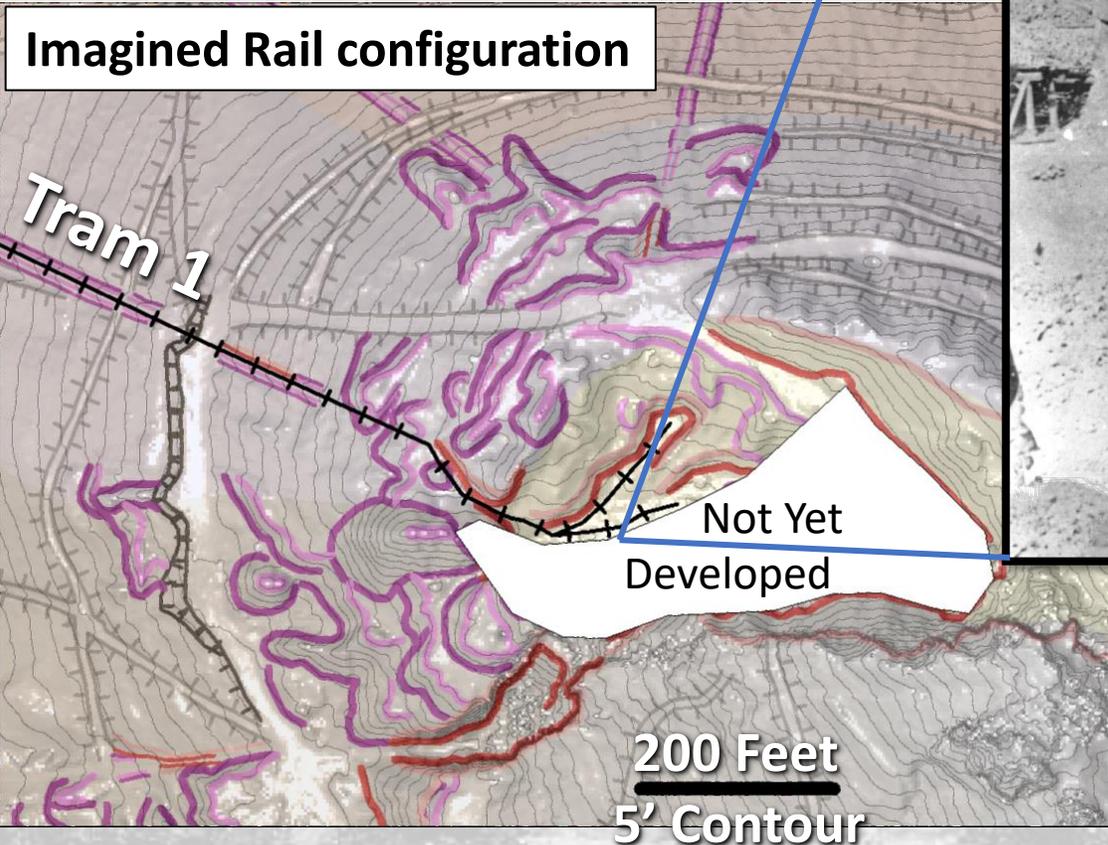


Mining Phase 1: Lower Bench (1848-1855)

Based on written accounts:

Slot cut from Tram 1 to enter mine
Mainly Lower Bench low strip ore

Imagined Rail configuration



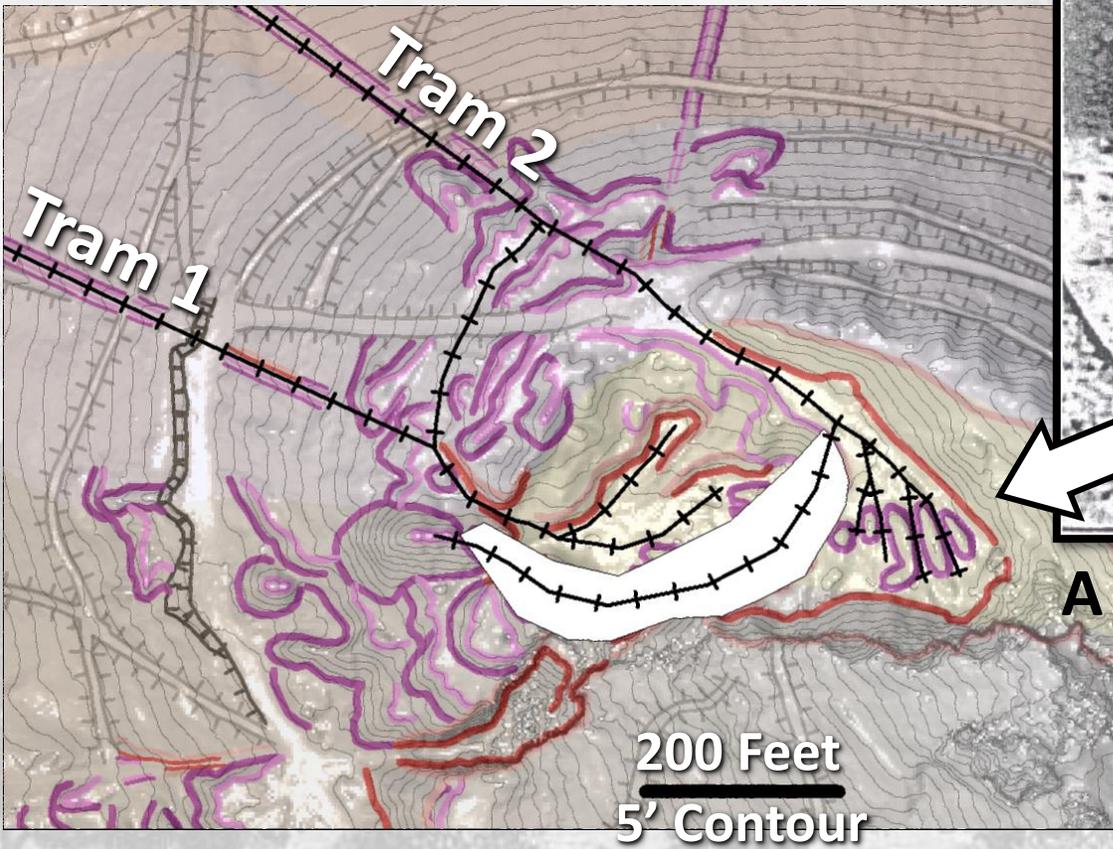
Undated photo courtesy of Iron County Historical Society

Cut height approx. 45 feet based on height of men
Elevations: Upper bench 1390'; Lower Bench 1350'

Mining Phase 2: Upper Bench (1855-1862)

Tram 2 Operational in 1859
Upper Bench Developed

Imagined Rail configuration



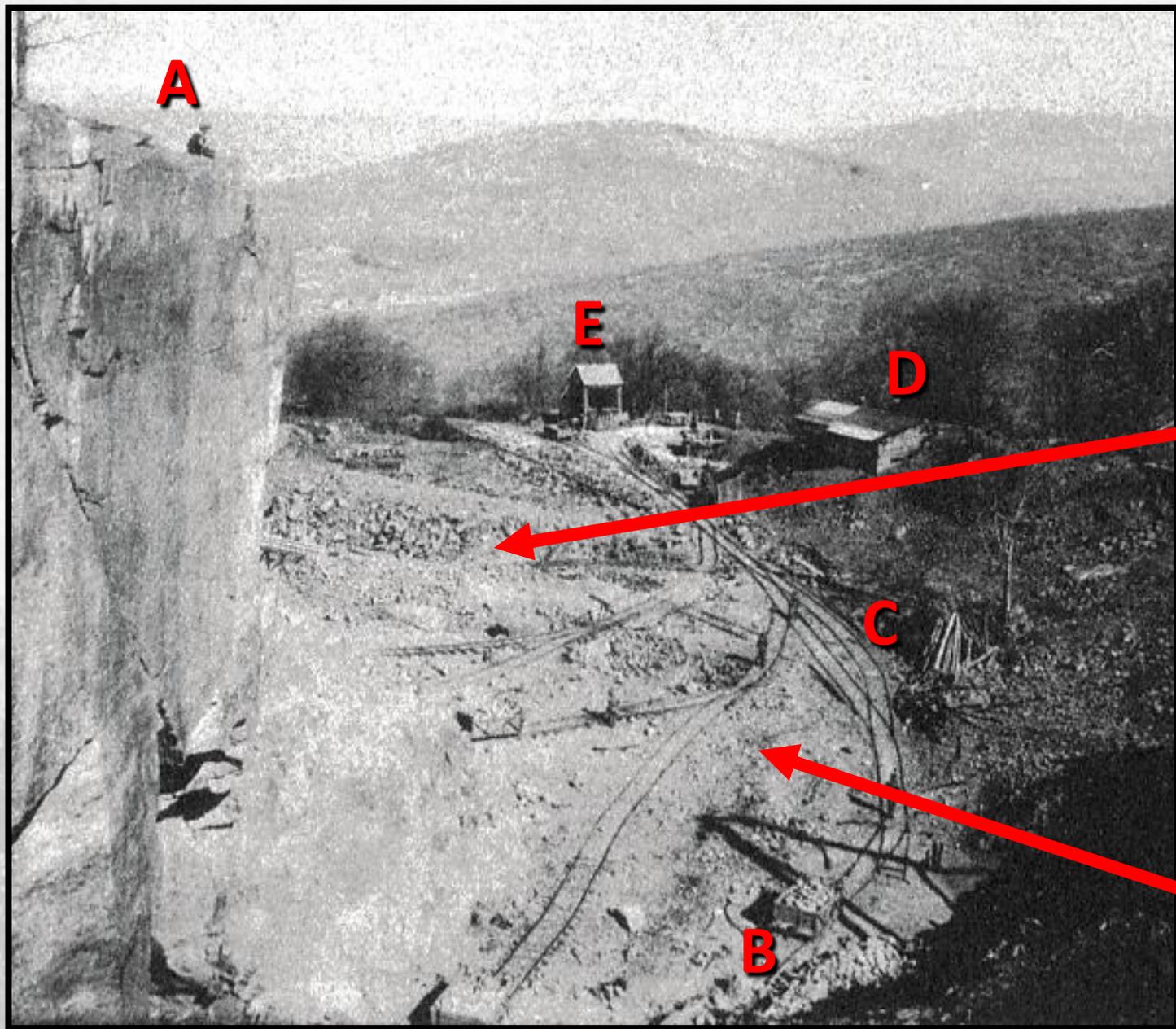
View of Upper Bench Looking Southeast



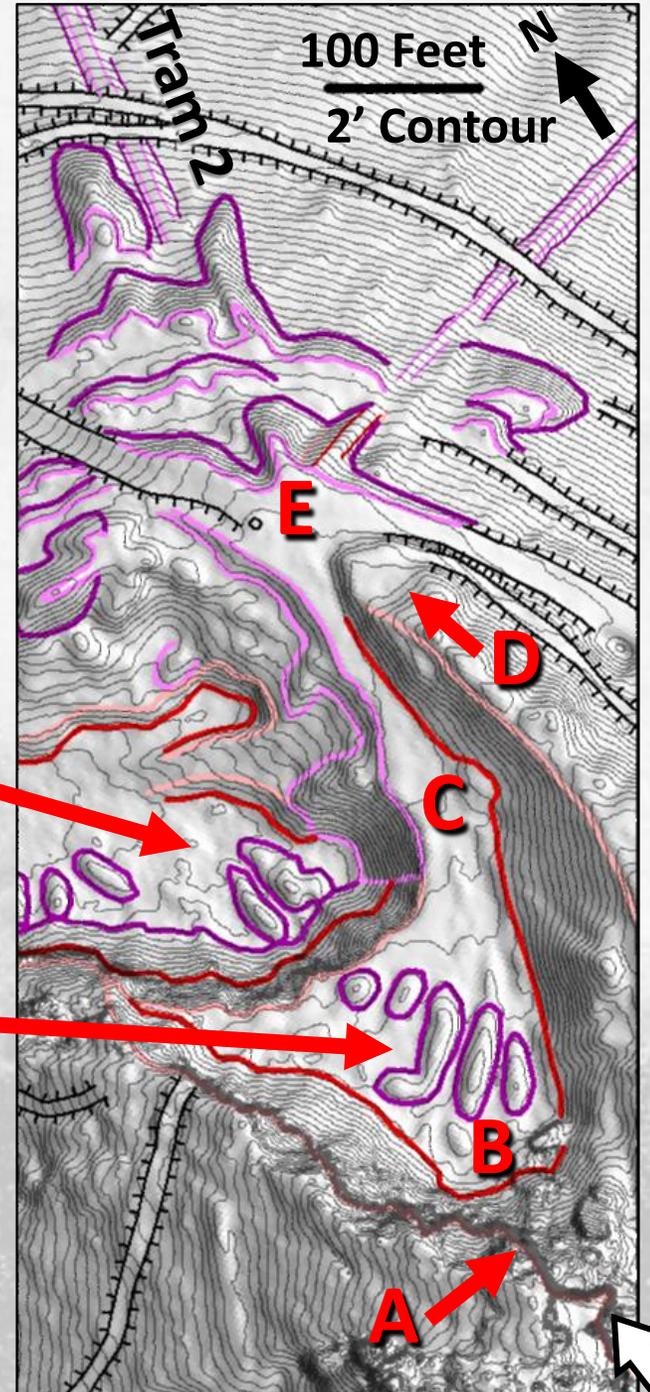
Undated photo courtesy of Iron County Historical Society

Stage 2 Upper Bench Mining (Post 1859?)

Undated photo courtesy of Iron County Historical Society



Not a Hole
40 Foot Deep Hole
Multiple Dumps
Multiple Rail Lines



Exploration

1862 Closure

No more accessible ore!

1865 Reconstruction

Need to go underground

- The decision to begin underground mining was based on solid prospecting that had been done to follow the Ore Beds around the east side of the hill.
- Exact timing unknown

Young



Old



Upper Red Rhyolite



Conglomerate



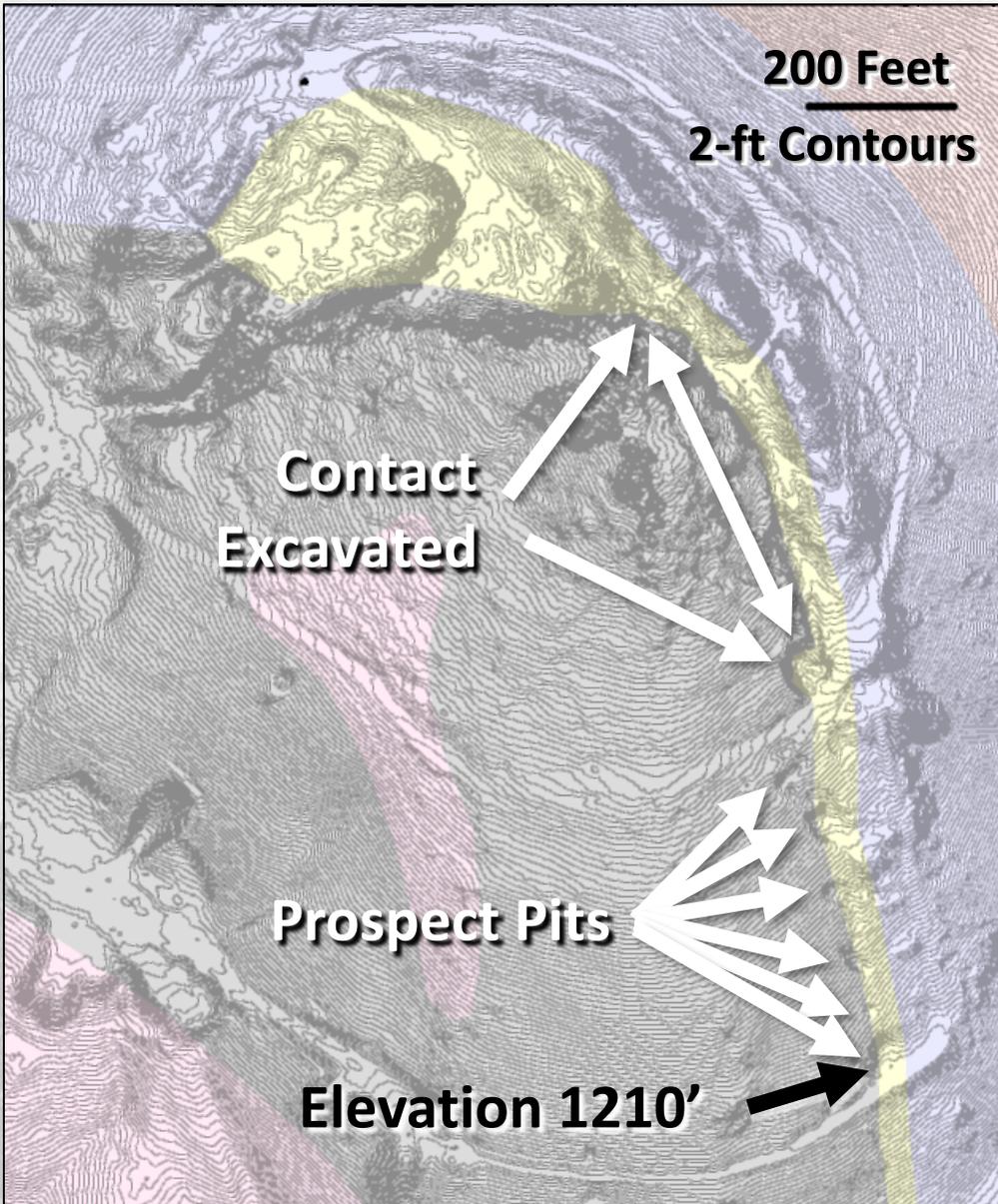
Ore Beds



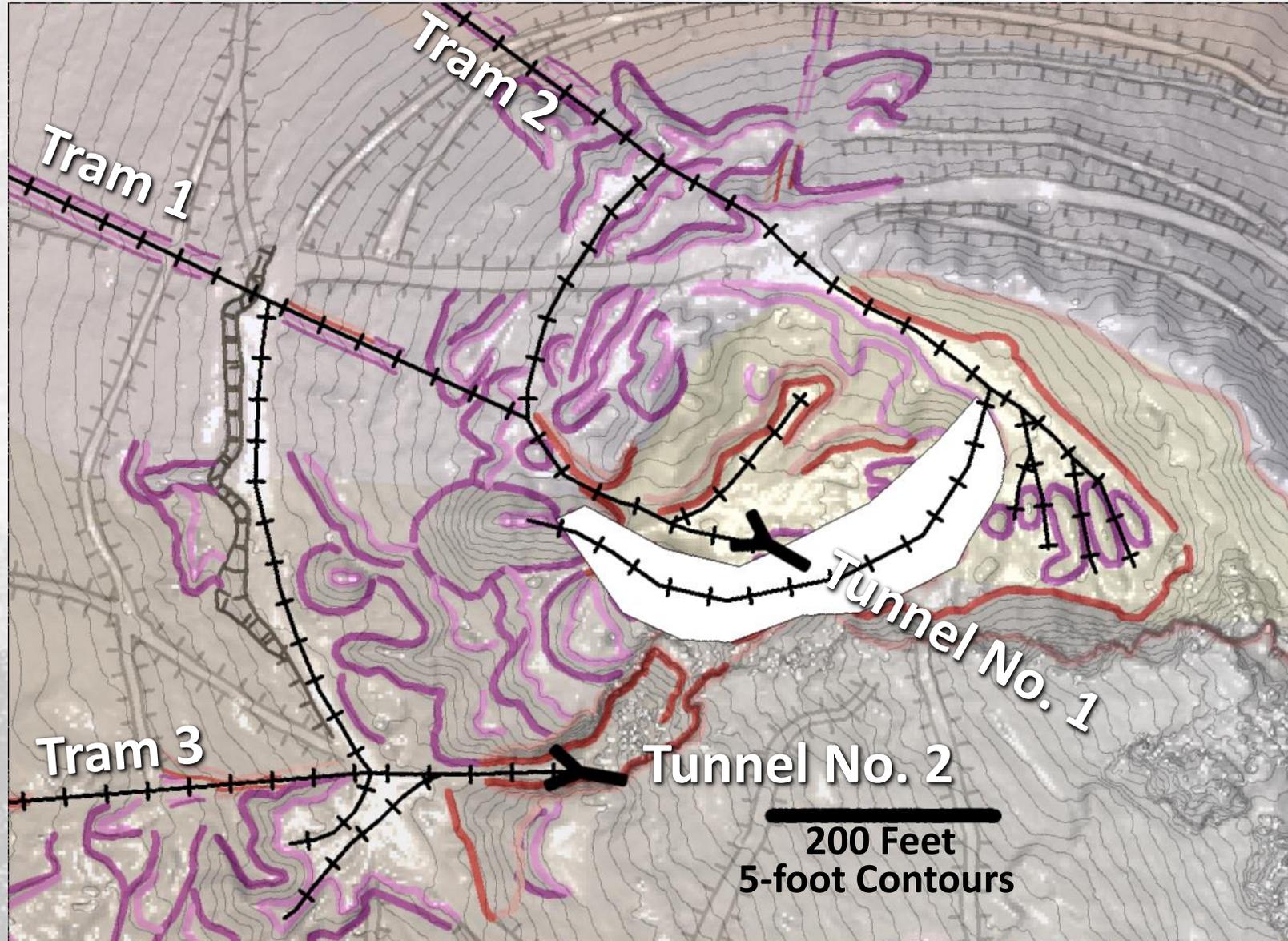
Purple Rhyolite



Lower Red Rhyolite



Mining Phase 3: Underground + Upper Bench



Imagined 1872 Configuration

- Based on Nason's 1872 map Trams 1, 2 and 3 were all operational for a time.
- Tunnels 1 and 2 initiated

Tunnel 2

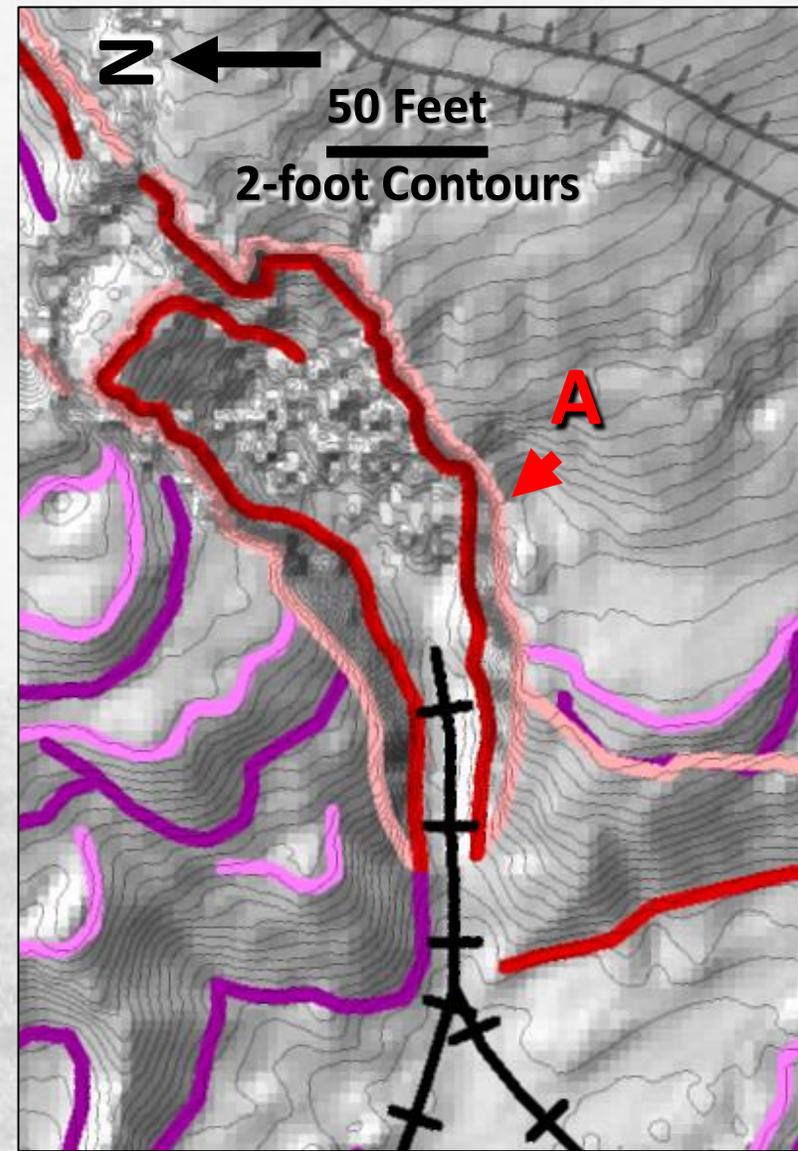
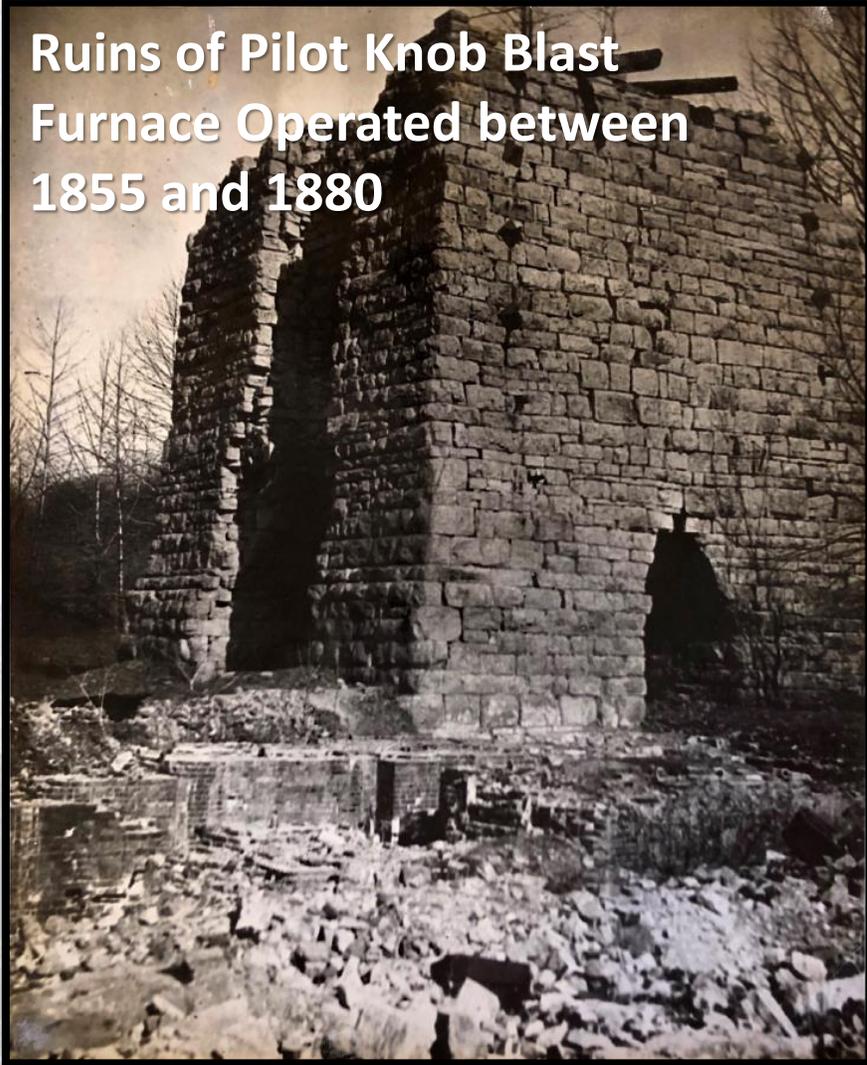


Photo Courtesy of Iron County Historical Society

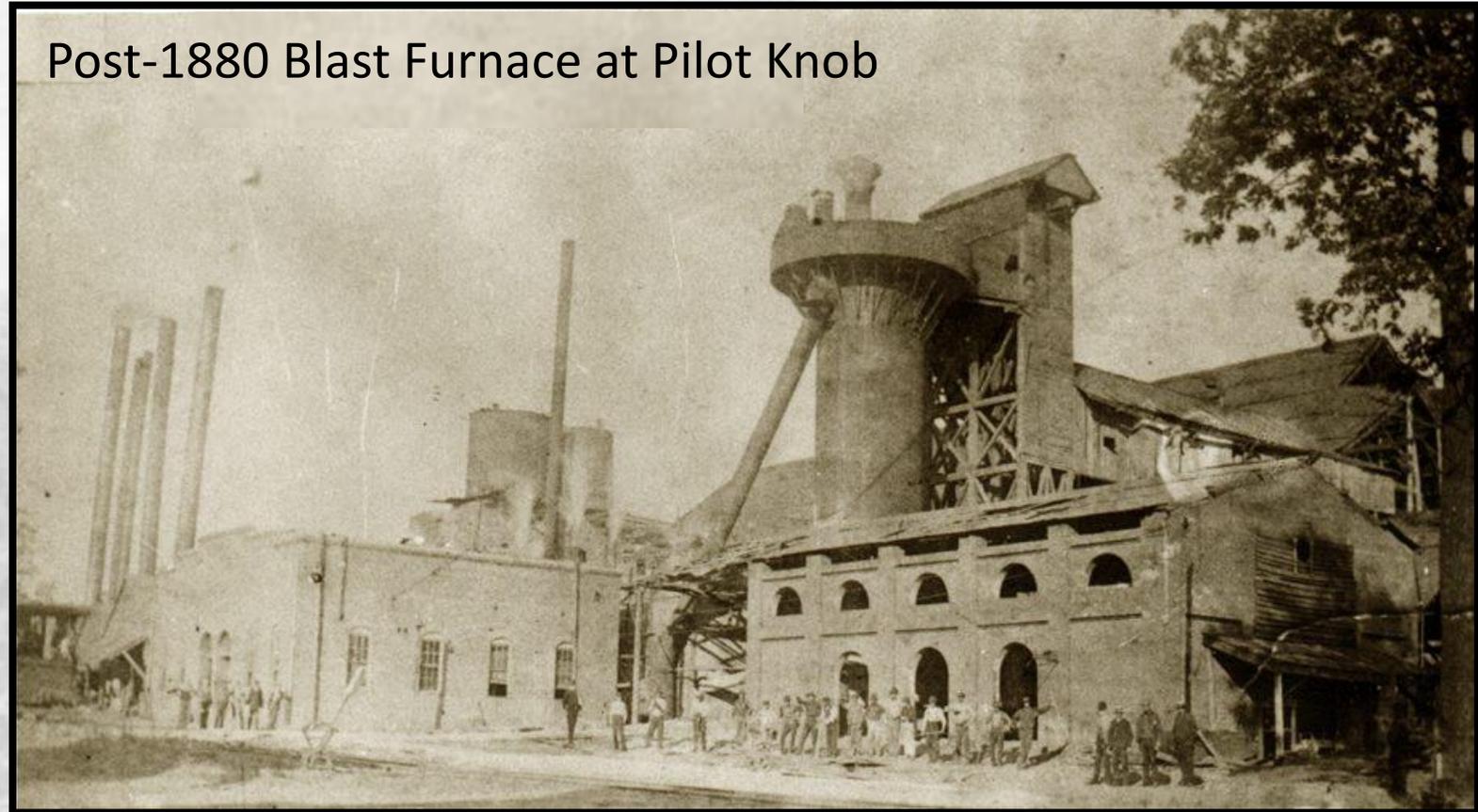
1880 Capitalization: Change from Artisanal to Industrial

Need to increase mine production to keep up!

**Ruins of Pilot Knob Blast
Furnace Operated between
1855 and 1880**



Post-1880 Blast Furnace at Pilot Knob

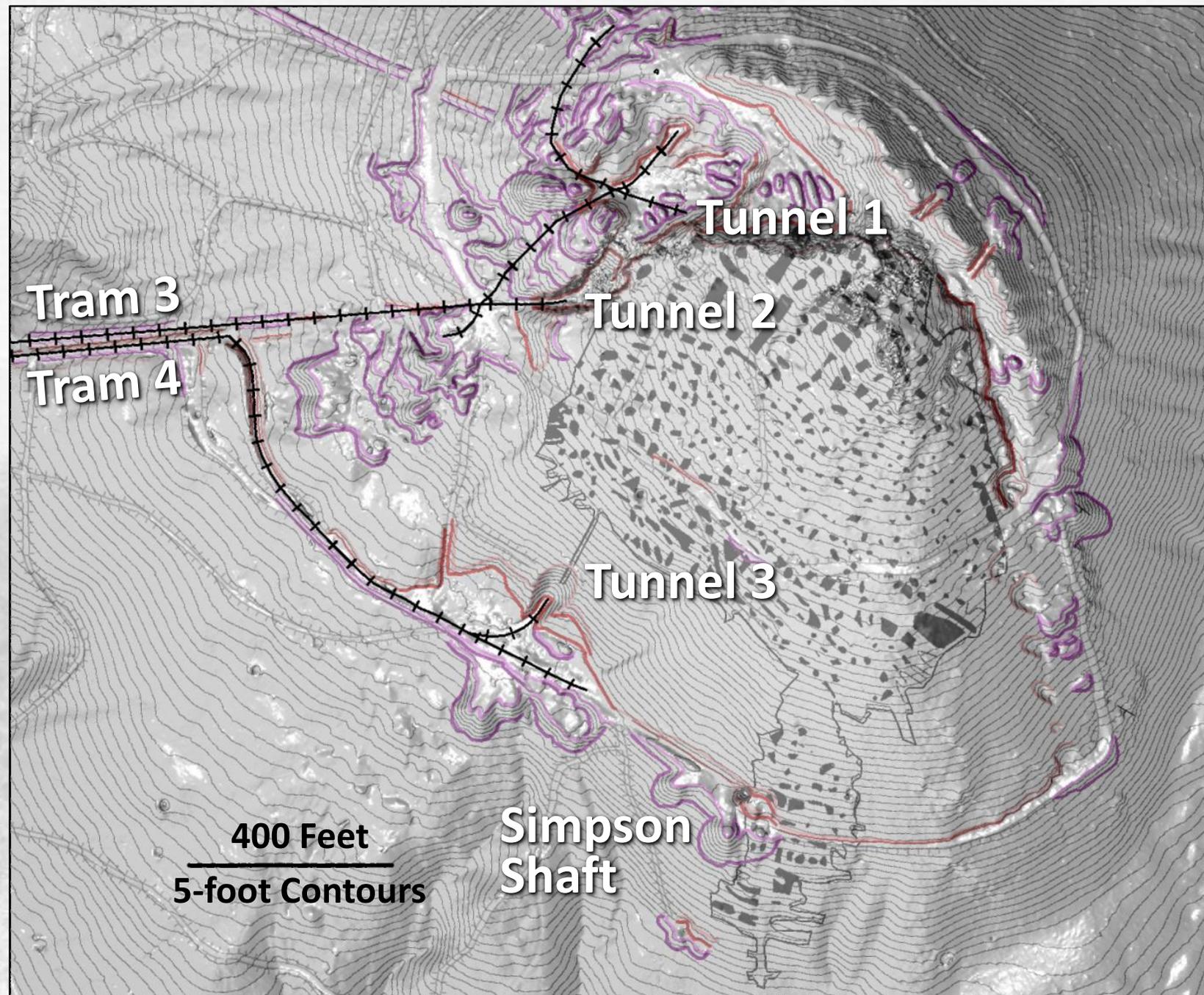


PILOT KNOB FURNACE IN BOOM MINING DAYS OF LAST CENTURY
Picture courtesy of Mrs. Savannah Whitworth Peck.

Mining Phase 4: Tunnel 3 On Line

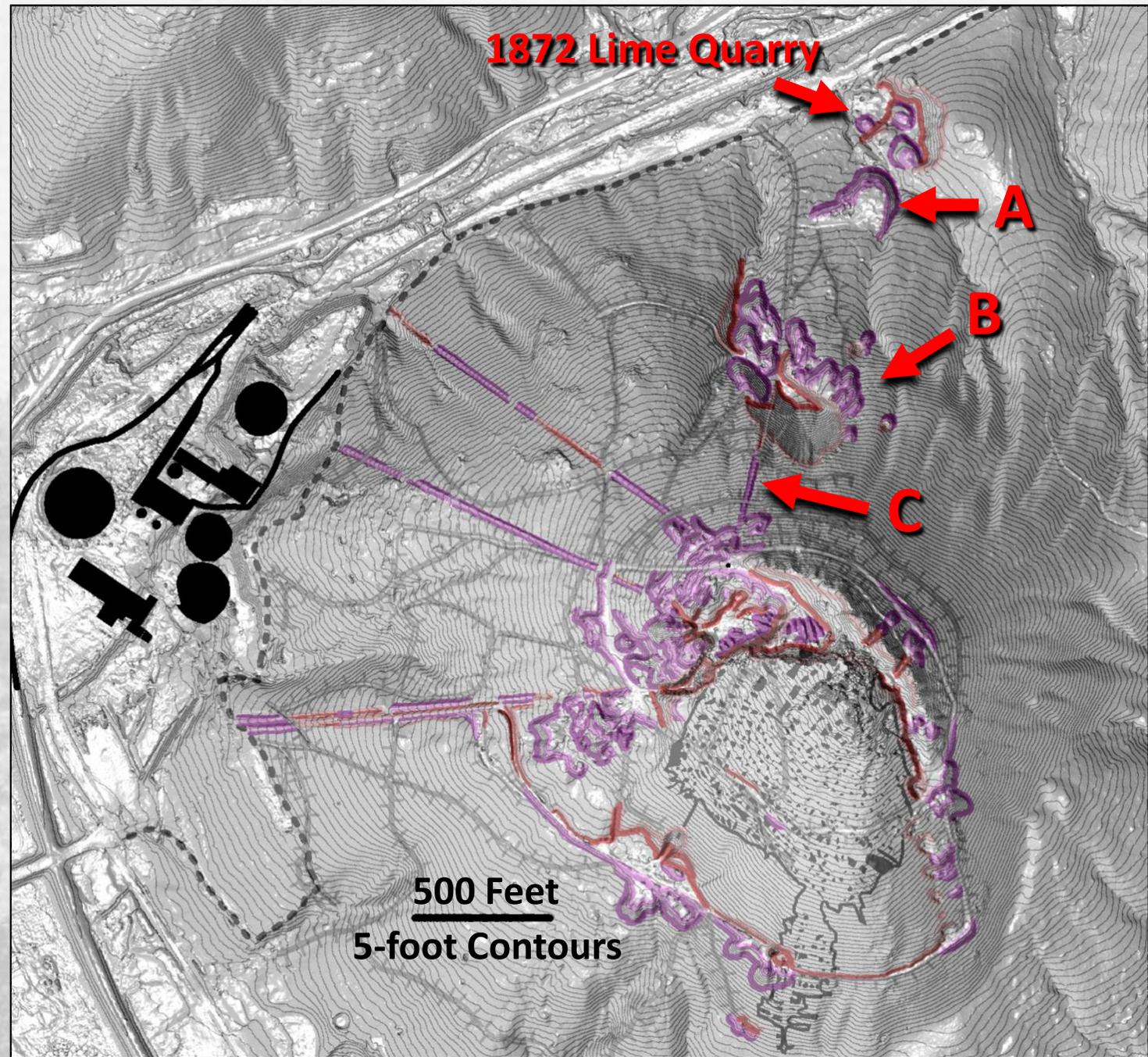
~1880 to 1889

- Tunnel 3 serviced by Tram 4
- Production continues from Tunnels 1 and 2 using Tram 3
- Trams 1 and 2 abandoned
- Production peaks in 1887 with 200,000 tons, 12% of the 1.6 million tons produced
- Pillar-robbing and clean up begin after February 1888
- Lower Bench in Upper Pit is extended post Feb. 1888



Mining Phase 5: Floundering 1892-1920

- A** 1989-1900 Shaft Platform
- B** Open pit mine created by Puxico Iron Company in 1911-1912
- C** Elevated tram bed to access peak during 1916-1920 exploration



Pilot Knob: A Tale of 5 Trams

All this forgotten history
brought to life by LiDAR

Imagine what else is
waiting to be discovered!

