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

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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

Beams Sweep
LIDAR Scanning

GPS
IMU
Full Sweep Angle

GPS Base Station

Single Laser Shot

IMU = Inertial Measurement Unit

3D Point Cloud Of Reflections

Multiple Returns

Outgoing Laser Pulse

Light reflected back to scanner

1st Return

2nd Return

3rd Return

4th Return

Last Return

Return Energy

Height (ft)

Scanning Rate:
150,000 pulses per second
Unspeakable volumes of data!
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
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....
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
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
“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.
1873 View (Phase 3)

3 tramways operating

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

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

**Critical spatial information!**
1888 Map Georeferenced

Tunnel No. 2 = Devil’s Icebox

Tunnel No. 3

Tunnel No. 4

Collapse Features

Good Match!

Ore Edge

Good Match
Desperate for Ore!

Map from Crane (1912)

Status
Circa 1890

End of Mine
Pillar Robbing

Roof fallen in

Sept. 1889

Tunnel 2
Feb. 1888

Tunnel 3

Simpson Shaft

Showing method of working mine and subsequent removal of pillars.
Roof Support after Pillar Robbing

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

Phase 5: Floundering (1892-1920)

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

Early focus on conglomerate ores

- 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
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.


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

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
Basic Elements of a Mine Site: Tunnel 3 Example

**Mine Excavation** – Cutting into the surface

- **Crest** – Top of cut edge
- **Toe** – Bottom of cut edge
- **Bench** – Level working area

**Mine Dump** – Waste rock disposal pile

**Fill** – Waste rock used for construction

**Transport:** Hachured away from road bed

**Natural Slope**

**Solid Rock**

**2-foot Contour**

**Angle of Repose**

**Waste Rock**

**Solid Rock**
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

Tramway Line Fill and Cut

200 Feet
2-foot Topographic Contours

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

- **Conglomerate**
- **Ore Beds**
- **Purple Rhyolite**
- **Lower Red Rhyolite**

Pit Shape controlled by distribution of Ore Beds
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.

- Tunnel 1 Entrance in Middle of Lower Bench?
- Railroads run over dumps?
- Good Location Rail in Cut
- Cut made after Upper Bench Mining
- Good Location Funicular runs to exit cut
- Tunnel 2 Entrance in Devil’s Ice Box
- 2 Foot Contours
- 200 Feet
- Earliest mining history when Trams 1 and 2 were in use has been overprinted by later mining.
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

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

Undated photo courtesy of Iron County Historical Society
Mining Phase 2: Upper Bench (1855-1862)

Tram 2 Operational in 1859
Upper Bench Developed

View of Upper Bench Looking Southeast

Undated photo courtesy of Iron County Historical Society

Imagined Rail configuration
Stage 2 Upper Bench Mining (Post 1859?)

Undated photo courtesy of Iron County Historical Society

A not a hole
40 Foot Deep Hole
Multiple Dumps
Multiple Rail Lines
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

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

Legend:
- Upper Red Rhyolite
- Conglomerate
- Ore Beds
- Purple Rhyolite
- Lower Red Rhyolite
Mining Phase 3: Underground + Upper Bench

- 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.

Photos Courtesy of Iron County Historical Society
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!