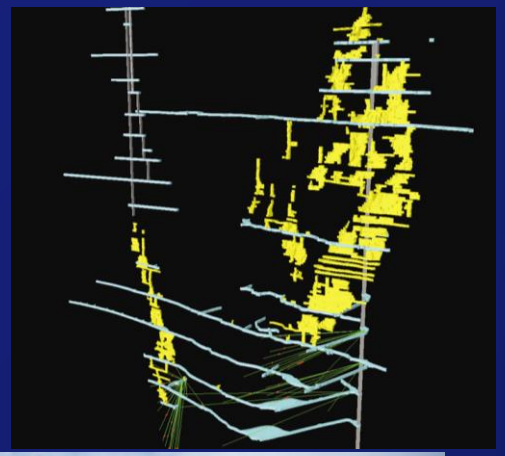


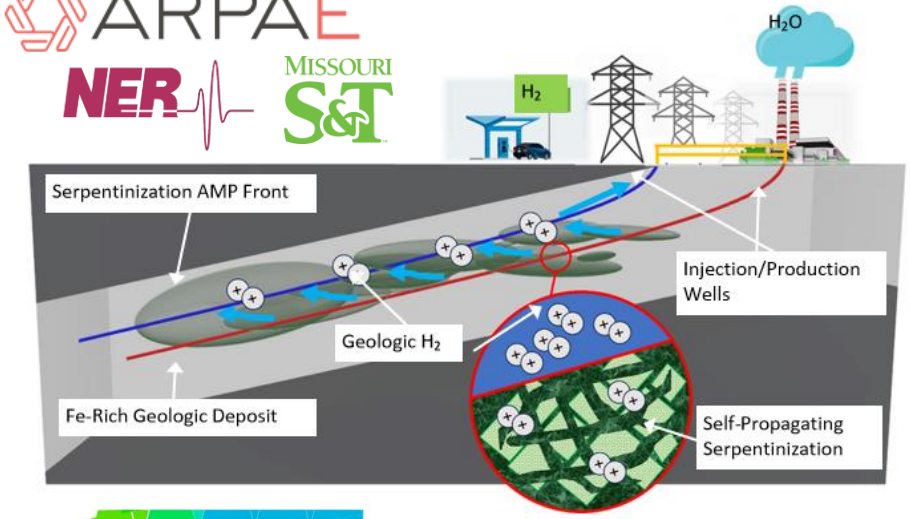
Mines to Megawatts

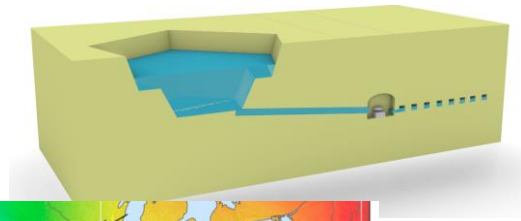
Samuel Nowak, Ph.D.
Co-Founder, OptiRock Group
nowaks@optirockgroup.com
716-418-5600

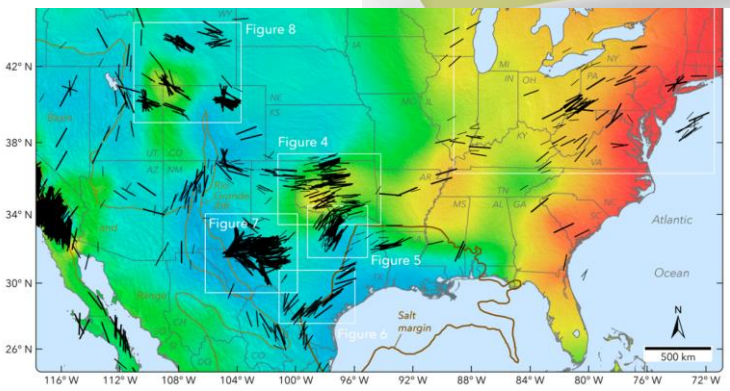
Missouri S&T
August 5th, 2025

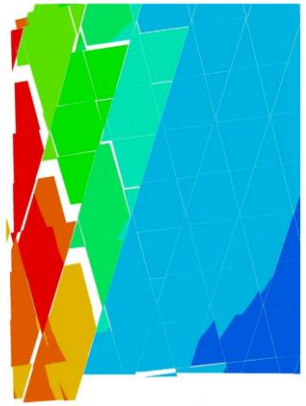
About OptiRock Group

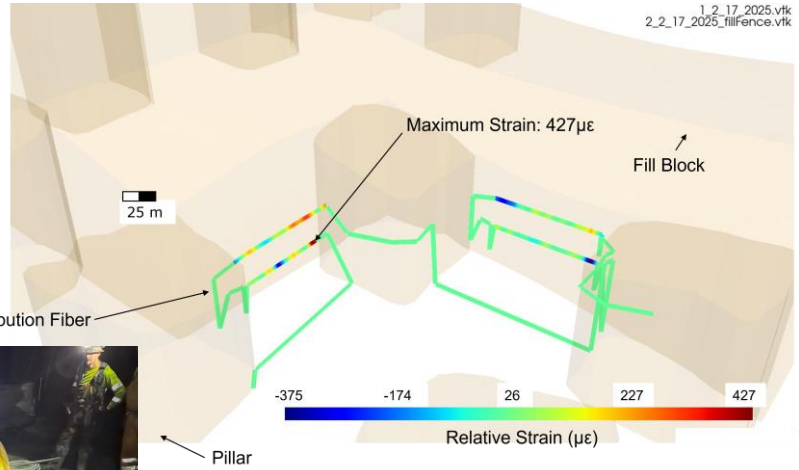
Project Experience

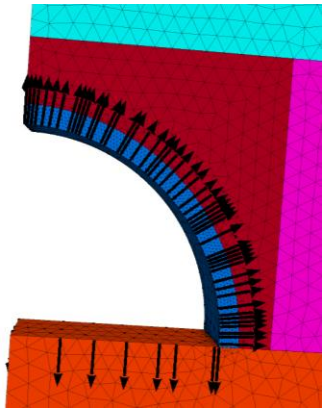


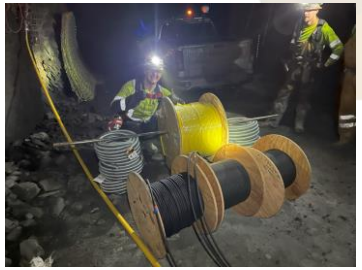






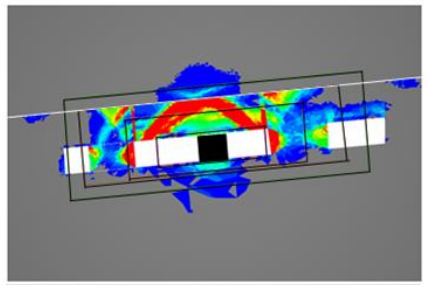


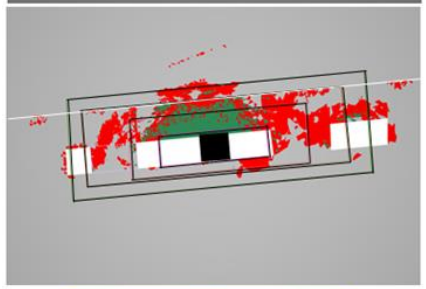


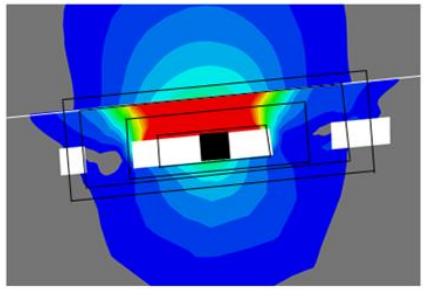


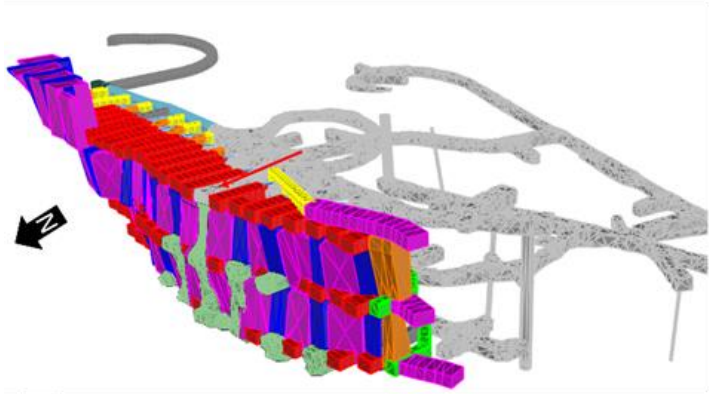
About OptiRock Group

Introduction









Sam Nowak, Ph.D.

- Undergrad in Geology (2017)
- Empire State Mines: Mine Geologist/Engineering
- Missouri S&T: Graduate studies in fiber optic sensing for geomechanical monitoring (2023)
- Co-Founder, OptiRock Group (2022)

Skills and Interests:

- Geomechanics Simulation
- Stress Measurement and Analysis
- Rock Monitoring
- Mine Planning and Mineral/Gas Exploration
- Applications of Underground Space

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Mines to Megawatts

Objectives

Why are we here?

- **Outline a case for the use of nuclear power for mining operations**
- **Discuss the potential for underground siting of nuclear reactors within mine facilities**
- **Connect industry leaders and experts across multiple domains**
  - Nuclear, Mining, Regulatory, Governmental, Academia
- **Gain insights to identify next steps**

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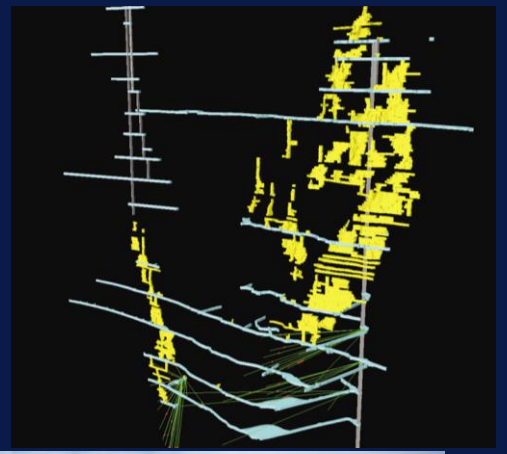
Mines to Megawatts

Outline

- Global Trends in Mining
- Economic Considerations
- Attractive Site Attributes
- Sustainable Development
- A Diversified Grid
- Closing Remarks



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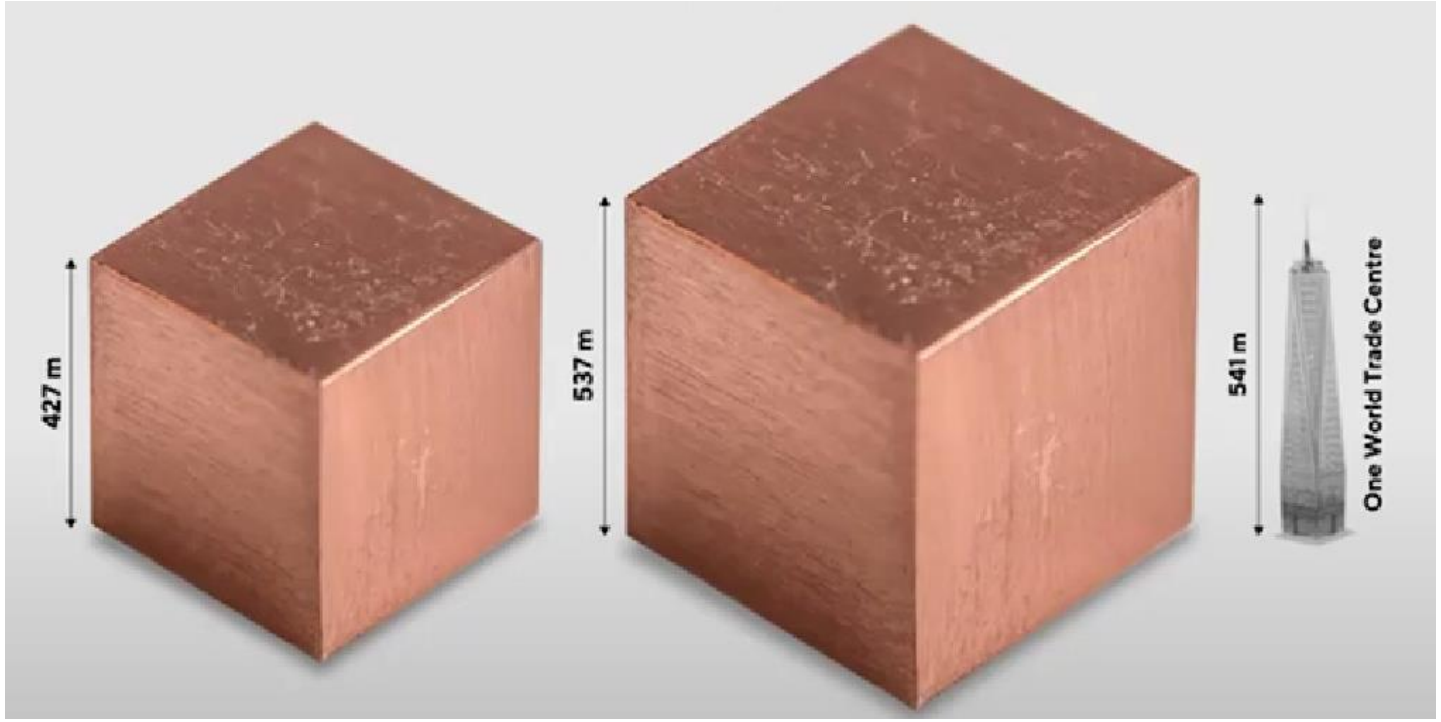
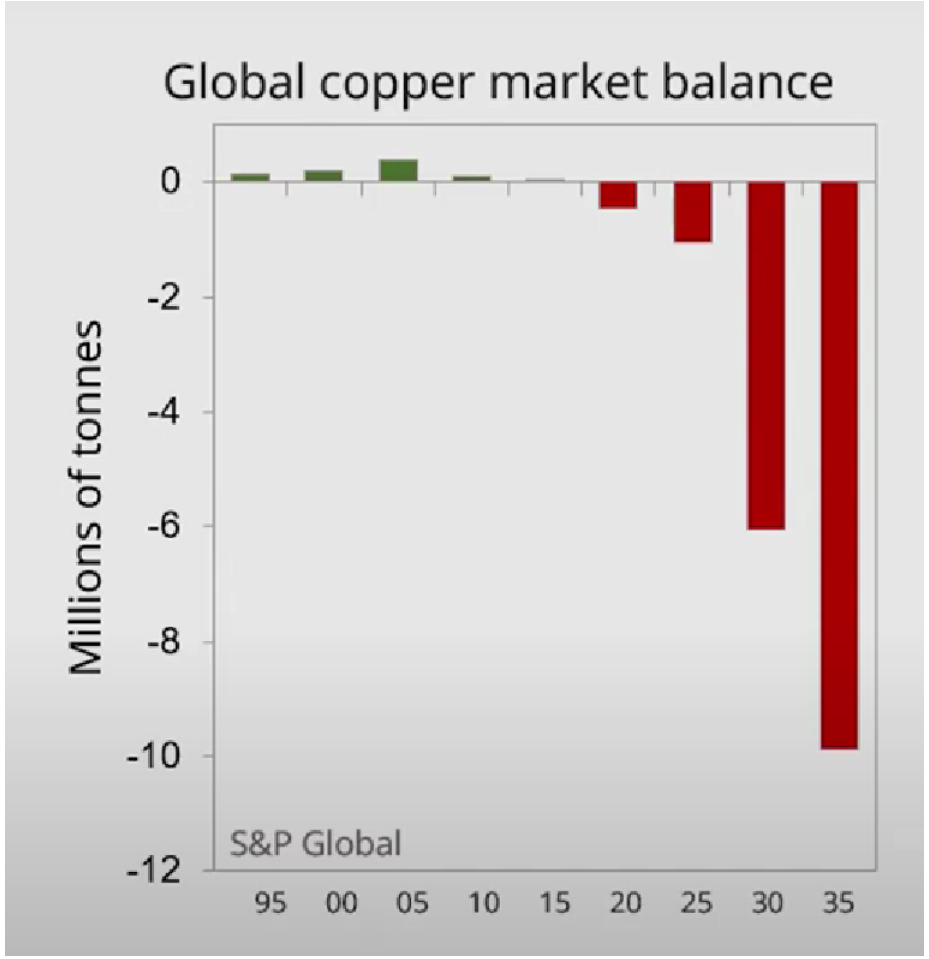
The Need for New Sources of Energy in Mining

Higher Demands Than Ever Before



All copper which has been produced in human history:700 Million Tons

New copper required to reach net-zero by 2050: 1.4 Billion Tons



Wicks, D. (2025, April). *Abysmal: The Outlook for Critical Minerals for Energy Dominance* [Slide show]. https://www.chemeng.ucla.edu/special-seminar-on-arpa-e-the-outlook-for-critical-minerals-for-energy-dominance-by-douglas-wicks/

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The Need for New Sources of Energy in Mining

Global Trends in Mining

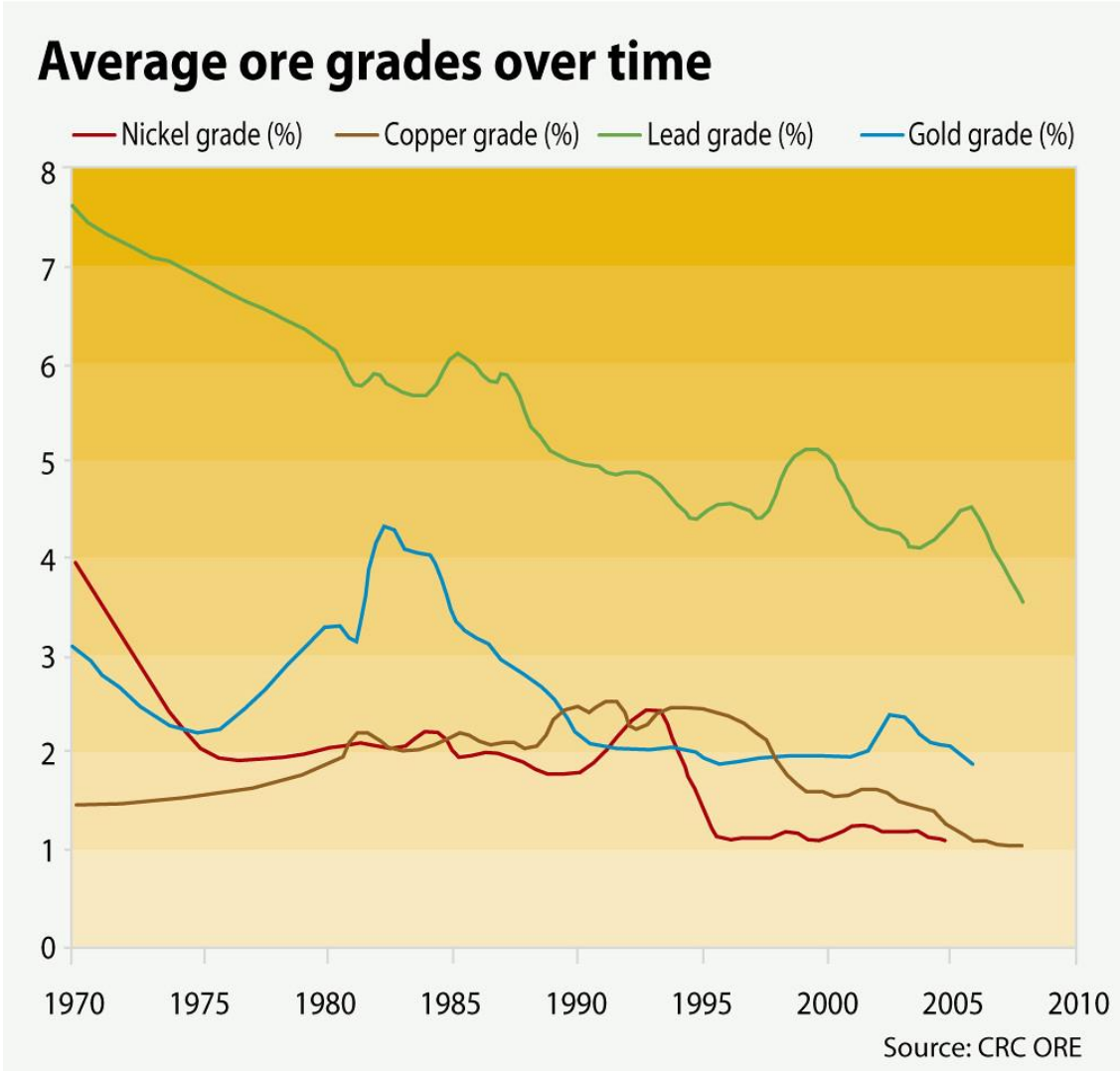
Deeper Deposits

Lower Ore Grades

Increased Demand for Exotic Commodities (REE, Critical Minerals, Battery Metals)

Result:

- Larger quantities of rock to transport and process
- Larger amounts of energy used per unit of commodity produced
- Lower profit margins for mine operators
- Demand for new mine infrastructure (shafts, process circuits)



Mudd, G.M., et al., *Quantifying the recoverable resources of by-product metals: The case of cobalt.* Ore Geology Reviews, 2013. **55**: p. 87-98.

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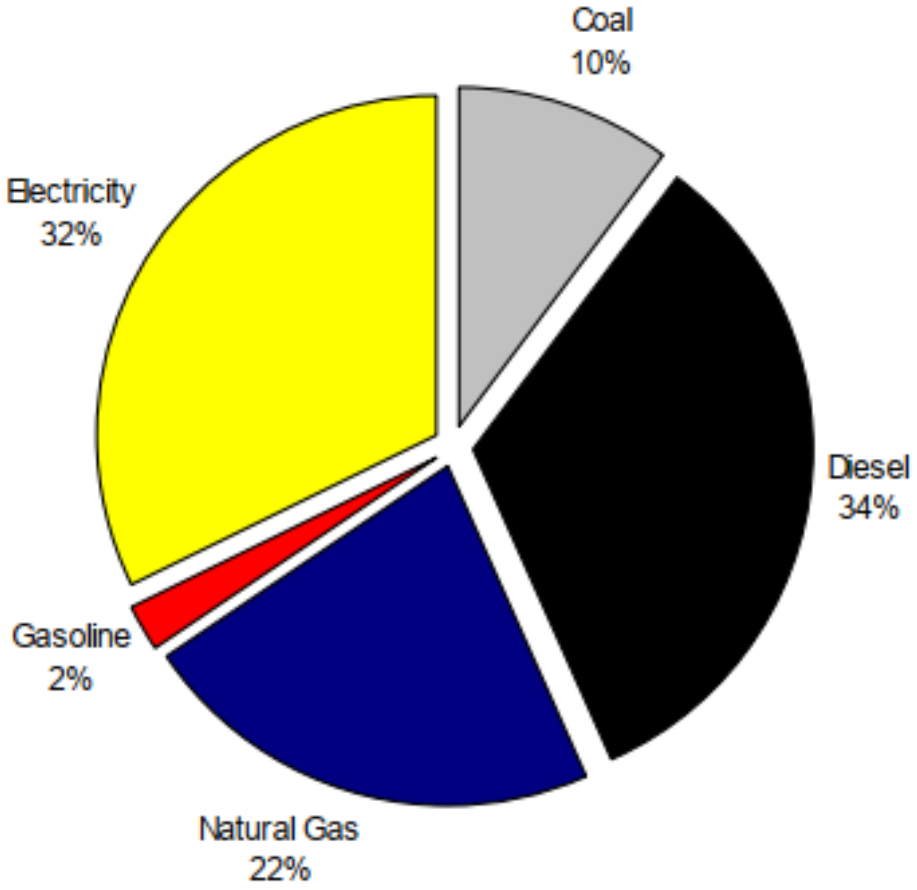
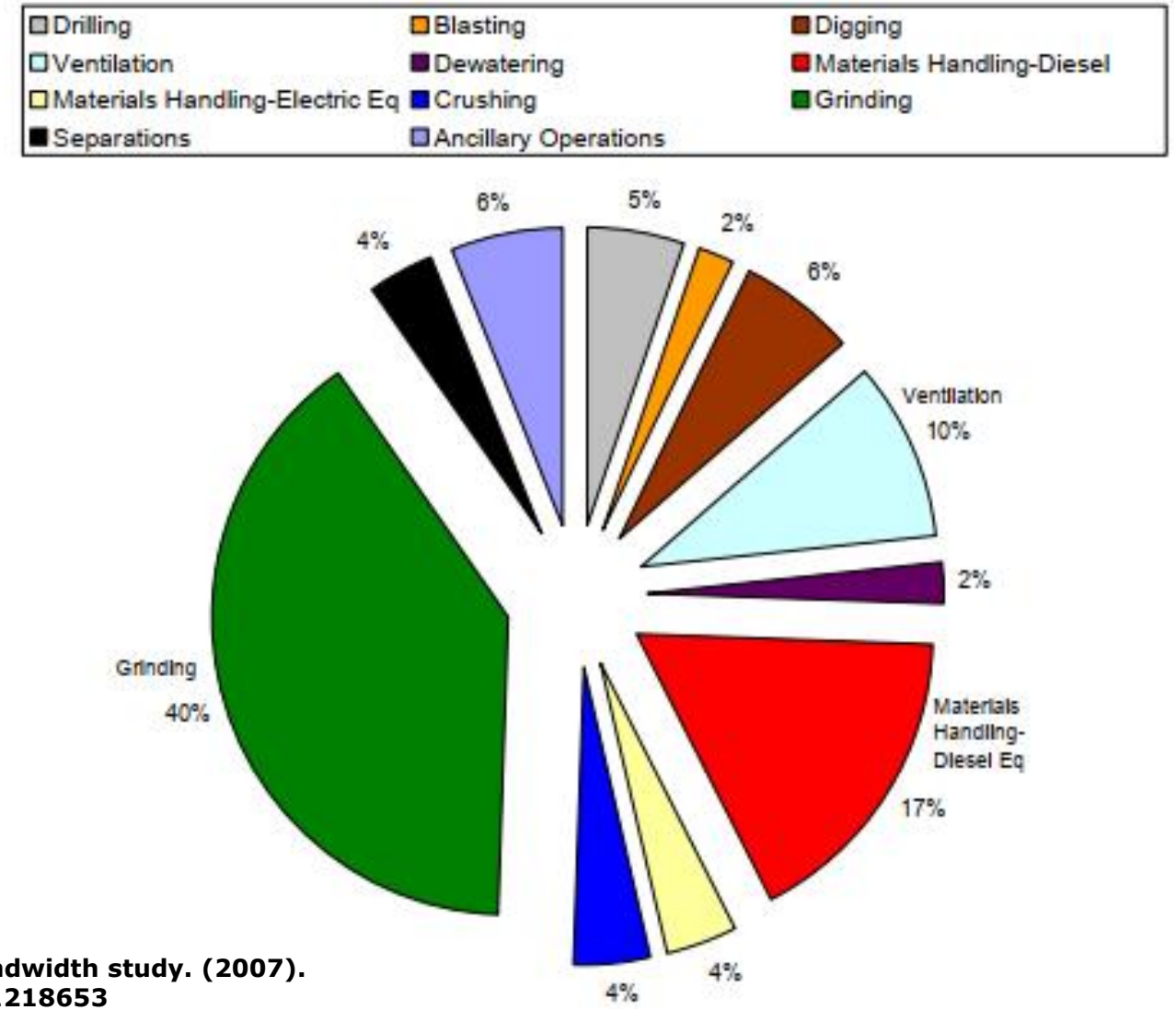
Energy Consumption in Mining

600 Trillion BTU/Year





Mining industry energy bandwidth study. (2007). https://doi.org/10.2172/1218653

The Need for New Sources of Energy in Mining

Energy Usage from a Mine in the United States

- **3.4 MW needed for processing broken ore**
- **2.9 MW needed per mining operations (4 Mines)**
- **=15 MW total**
- **Subject to peak hours pricing**
  - Avoid critical operations during peak hours
    - Skipping ore, crushing
  - A dedicated source of energy could play a role in this mine's decision making

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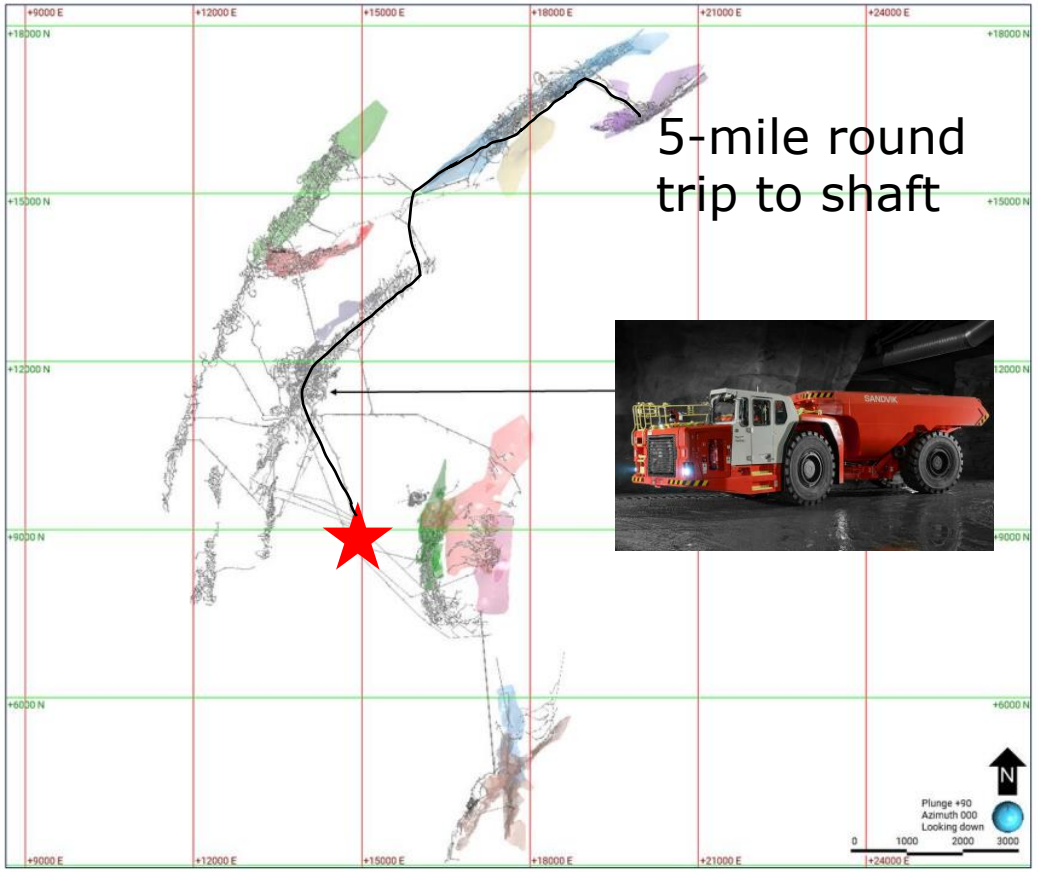
The Need for New Sources of Energy in Mining

An Illustrative Example



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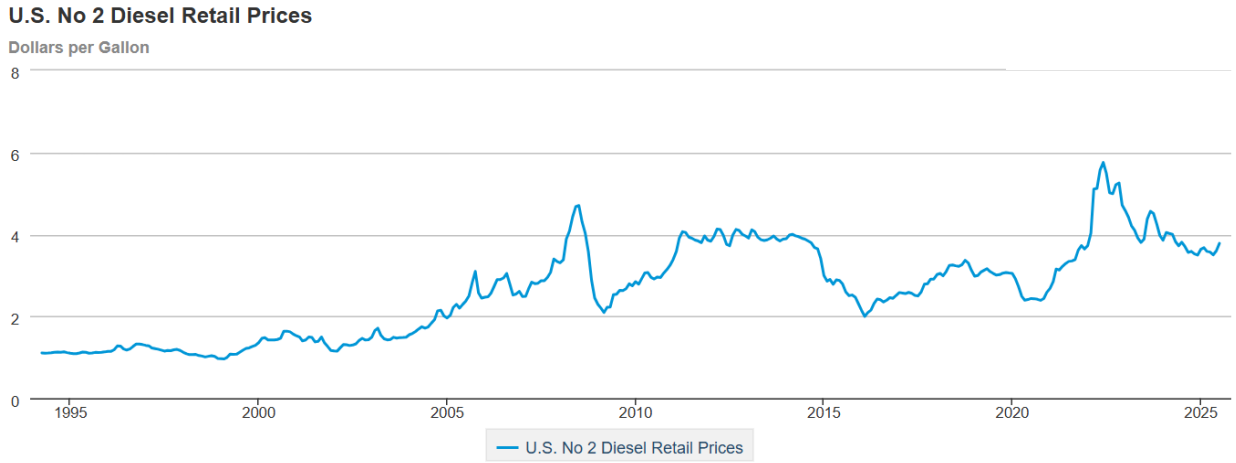
Global Trends in Mining

Fluctuations in Consumables and Commodities



https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EMD_EPD2D_PTE_NUS_DPG&f=M

The Need for New Sources of Energy in Mining

Electrification of Material Handling

Electric Haul Truck

Conveyor

Railveyor

The Need for New Sources of Energy in Mining

Remote Mining Operations

- **Heavily reliant on diesel generators**
- Can hamper growth of operation
- High transport costs for diesel
- **Efforts to transition to renewables or low carbon solutions**
  - Diavek Diamond Mine is an example of transition from several million liters of diesel/ year to a wind-diesel-solar hybrid system

https://www.e-mj.com/features/mine-power-options/#:~:text=Aggreko%20provided%20E&MJ%20with%20details,secure%20its%20utility%20grid%20connection.

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Mines to Megawatts

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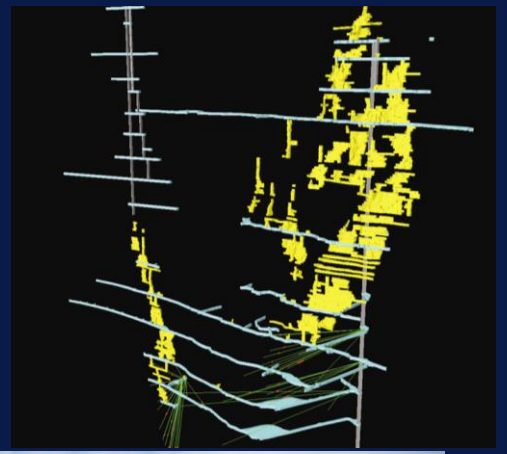

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Nuclear Power at Mine Sites

Comparison of Permitting Processes

- Comprehensive EIA/EIS
- Public Comment Period
- Multi-Agency Oversight (Local, State, Federal)
- Health and Safety Regulations and Inspections
- Reclamation/Decommissioning Plans Required
- Must manage hazardous materials

- Much longer permitting process
- Heavy details required on the reactor itself
- Storage of reactor waste is extremely complex
- Overall higher bar to meet

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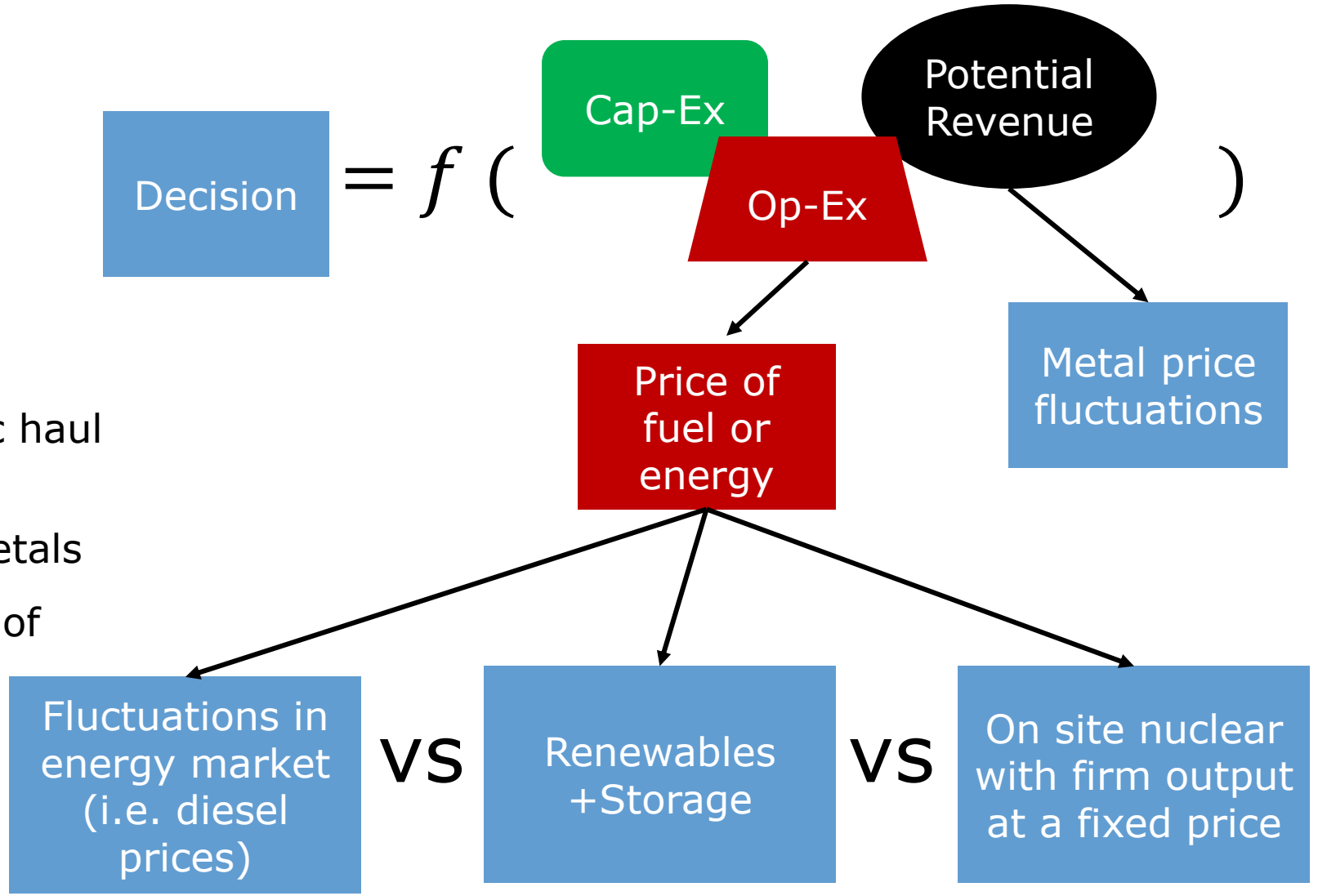
Economic Considerations

Potential for Nuclear Energy to Impact Major Mine Economic Decisions

- **New infrastructure requires intense capital investment**
  - New shafts/portals
  - Push Backs
  - Material Transport
    - Railveyor, Conveyor, Electric haul trucks
  - Processing circuits for new metals
  - Exploration and development of new deposits



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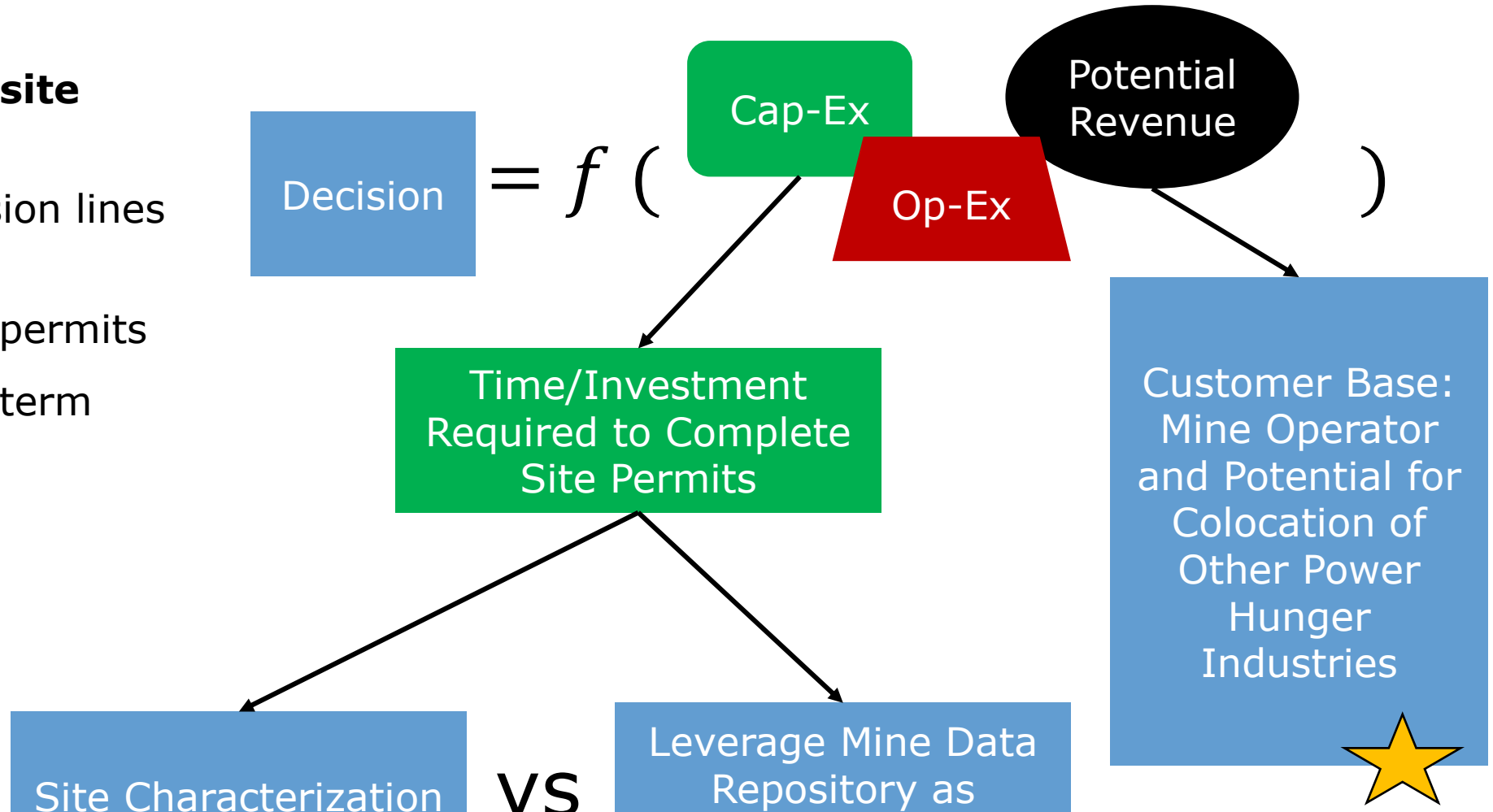
Economic Considerations

Potential for Existing Mine Sites to Impact Nuclear Siting Considerations

- **Decision on where to site nuclear reactors**
  - Proximity to transmission lines and customers
  - Ability to gain project permits
  - Ability to ensure long-term customer base



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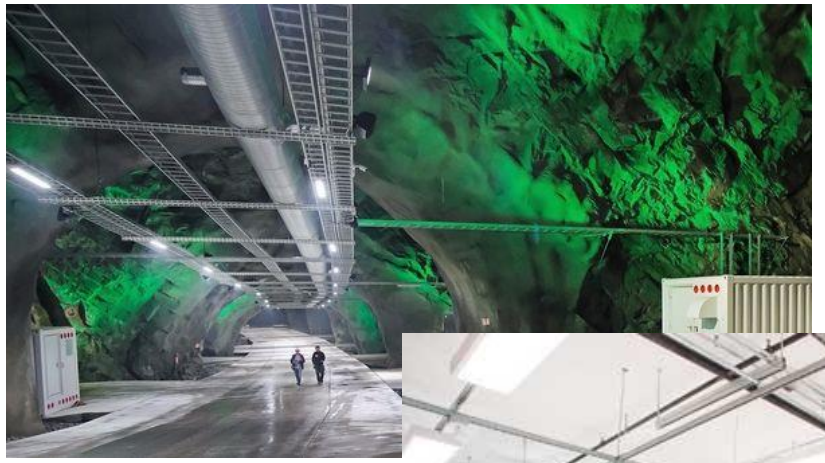
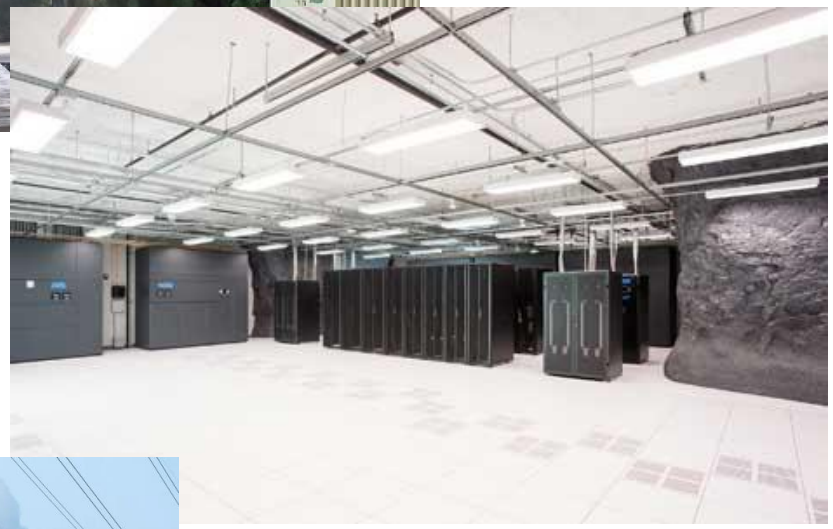
Economic Considerations

Colocation Potential for Data Centers

- Opportunities to pair nuclear power with other power-hungry critical infrastructure
- Data Centers require 10-50 MW
- Hyperscale AI Data Centers require up to 300 MW
- Scales of power requirements may not be possible for renewables
  - Evidence of need for nuclear power in Microsoft's Re-opening of the 3 Mile Island Power Plant





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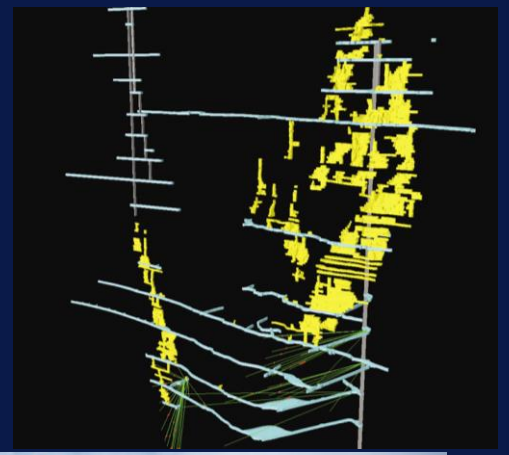

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Colocation of Underground Nuclear and Data Centers

Thermal Management

- Shallow mine excavations remain close to 50°C
- Natural or engineered ventilation networks
- Flooded mine areas could be accessed for use as heat sinks
- Large open spaces underground allow for dissipation of heat into unused workings

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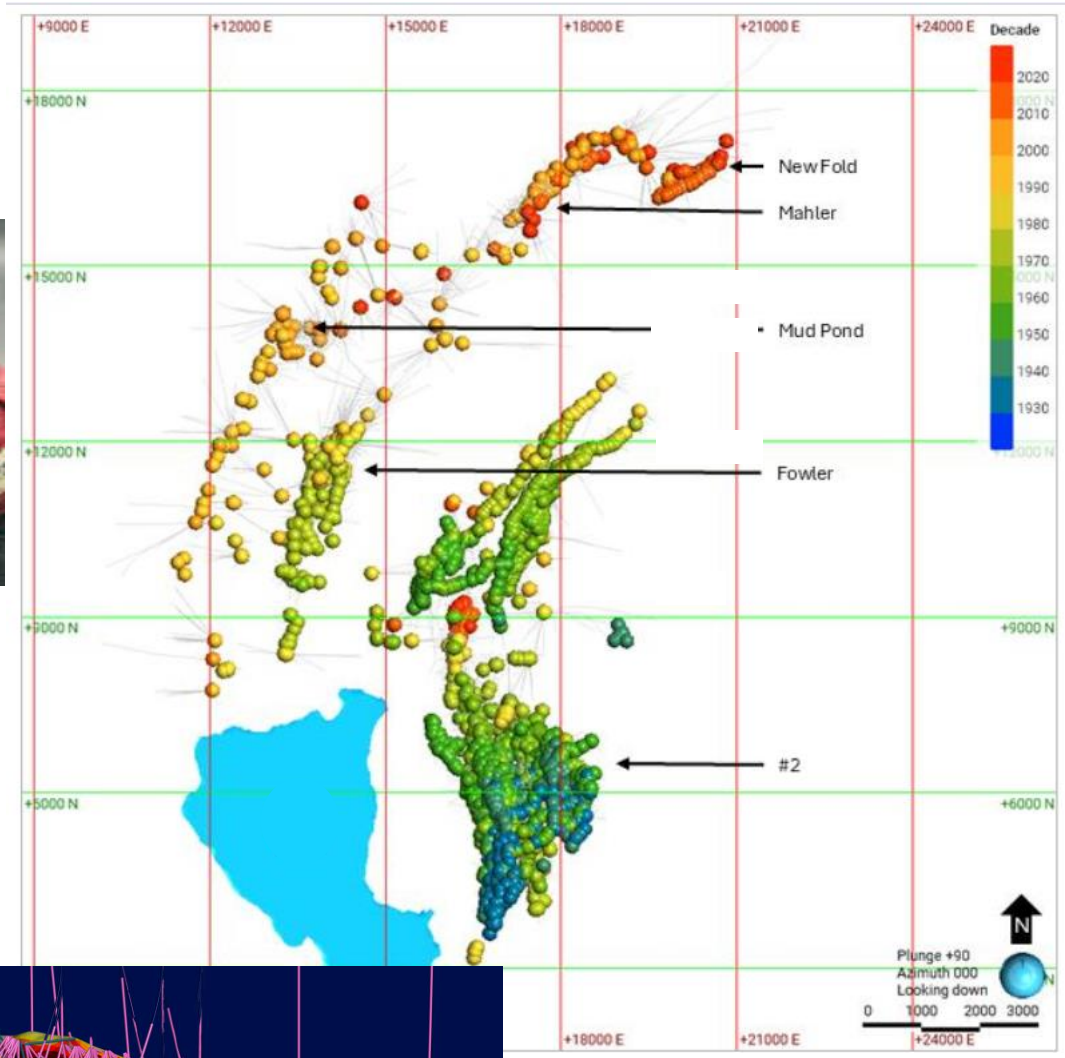
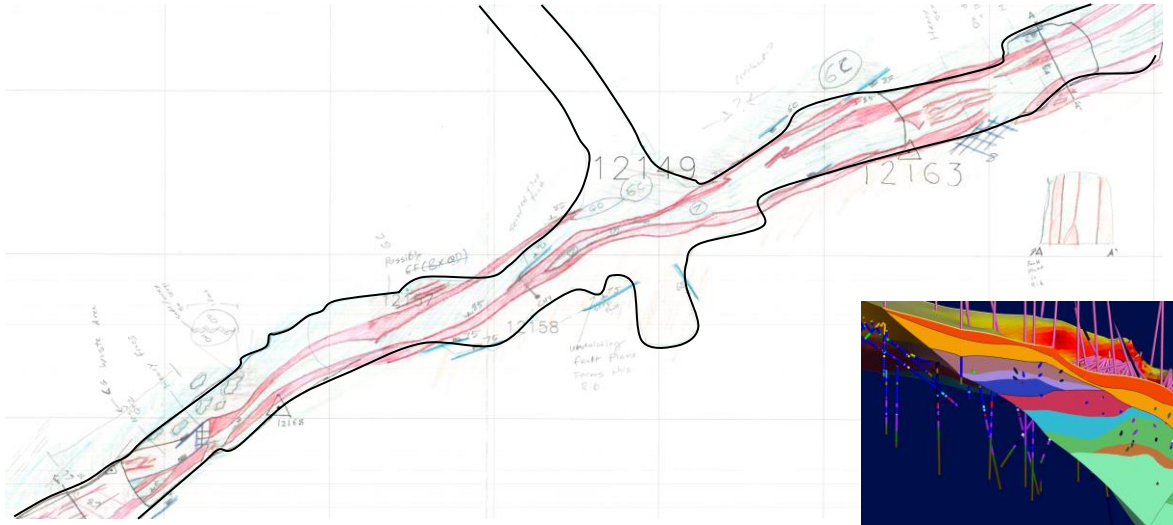
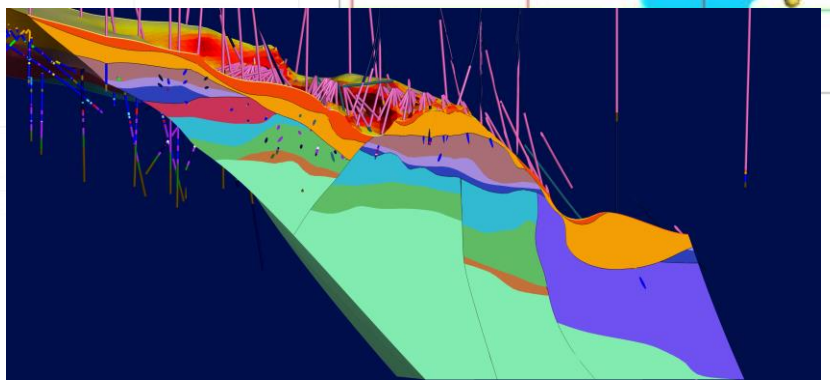
Mines to Megawatts

Site Characterization

- Massive amounts of geologic data collected *after* permits are issued
- Cores, Geotech maps
- Experience with large excavations







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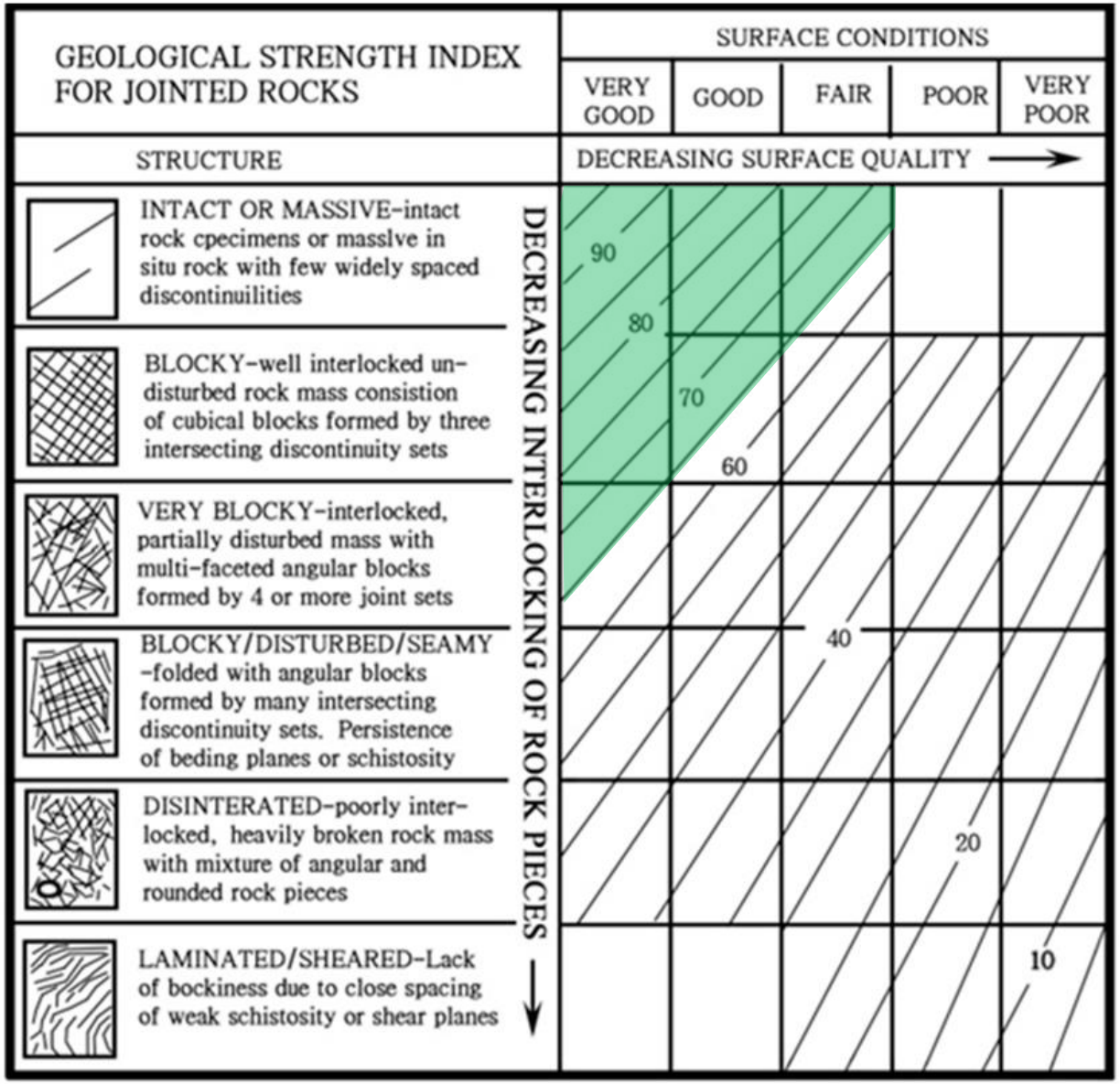
Mines to Megawatts

Targeting High Quality Rock Mass

Long-term stability for underground excavations



Range of Rock Mass Values Suitable for Underground Development

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Mines to Megawatts

Ground Control

Underground development becomes costly when reality challenges our assumptions

- Insufficient site characterization
- Inability to physically test the system prior to construction
- Developing in mines leverages the collective experience of the workforce, and alleviates these issues
  - Monitoring, rock support selection, identification of maximum stable spans, lifespan of excavations, in-situ stresses

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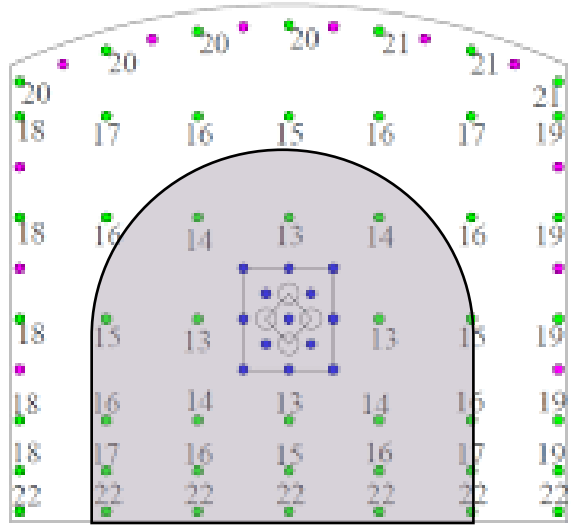
Mines to Megawatts

New Underground Development

- **Many examples of underground facilities and research laboratories utilizing existing underground mines**
- **New development in existing mines could leverage the existing excavations**
  - Widening an existing excavation is much more cost effective than creating a new one
    - Lengthiest portion of face drilling is already complete
    - Advance rates could be double to triple depending on the size of the excavations

https://ctif.org/associate-member/hagerbach-underground-research-laboratory



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Environmental Monitoring

- **Mines have robust environmental monitoring programs already in place**
  - Water quality
  - Water accounting
  - Air quality/ monitoring
  - Dust control
  - Erosion Control
  - Remediation/Reclamation activities

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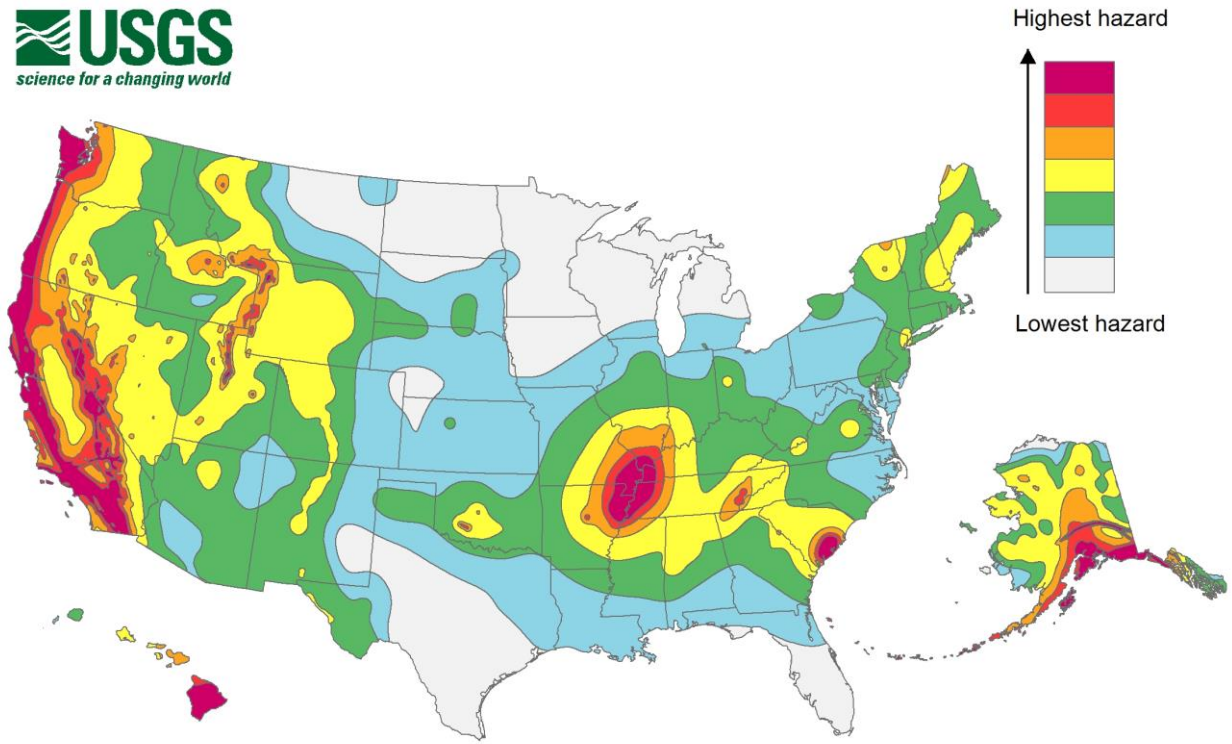
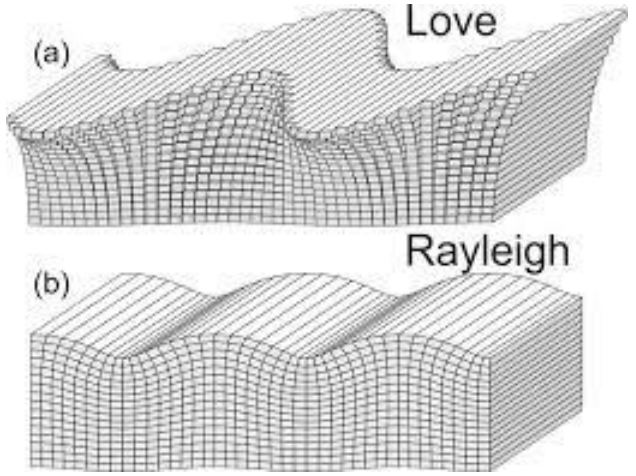
Seismic Hazards

- Underground structures suffer appreciably less damage during seismic events than those on the surface
- Benefit increases with depth
- No surface waves
- No soils
- Damage to portals or surface infrastructure should be the main focus
  - Could be hardened in seismic prone areas





Hashash, Y. M., Hook, J. J., Schmidt, B., & Yao, J. I. C. (2001). Seismic design and analysis of underground structures. *Tunnelling and underground space technology*, *16*(4), 247-293.

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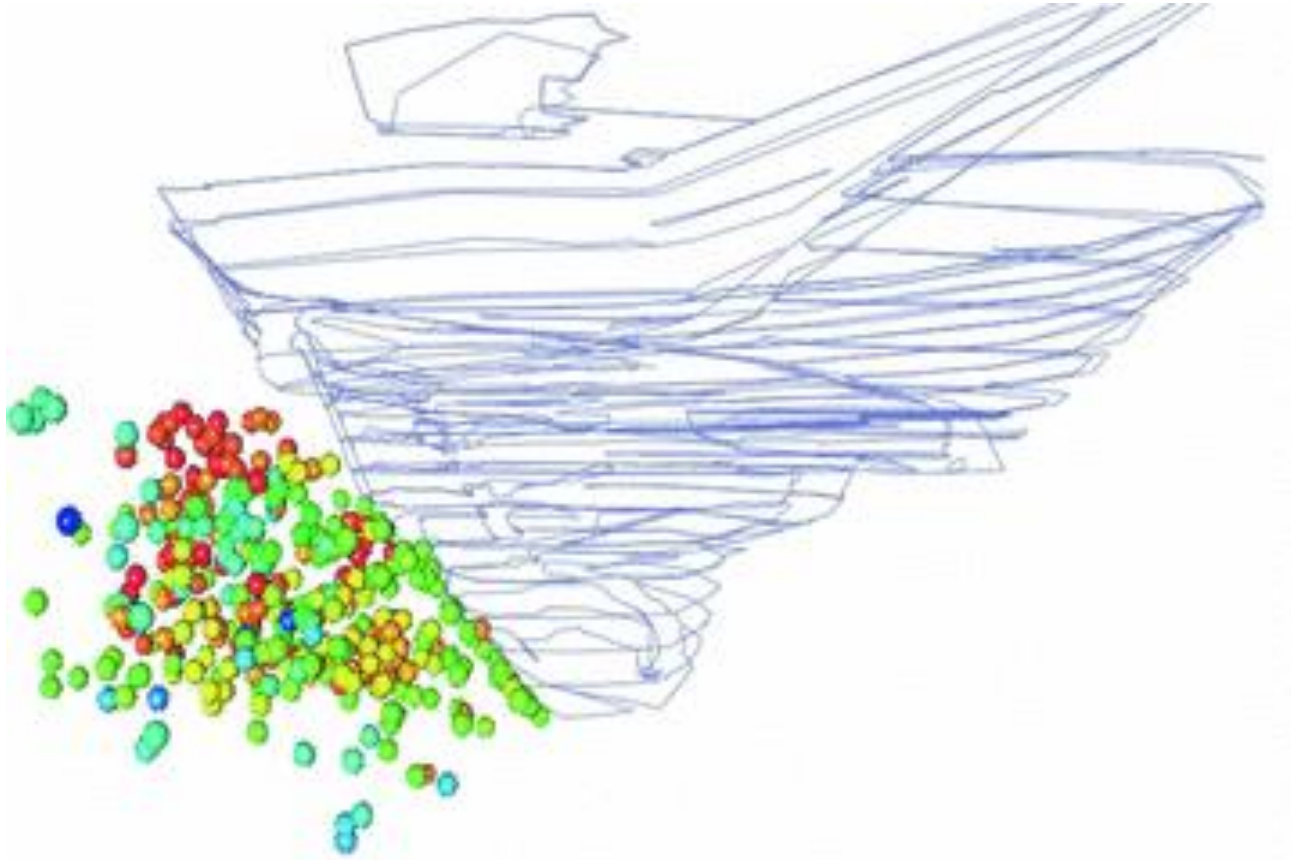
Mine Seismicity Monitoring

- Most modern mines are actively monitoring micro-seismic events 24/7
- Advanced monitoring systems are already in place
- Rigorous TARPs have already been developed, tested, and iterated over a lengthy period of time and experience



https://www.researchgate.net/figure/Example-of-microseismic-monitoring-of-an-open-pit-mine-Lynch-2007_fig19_283246322

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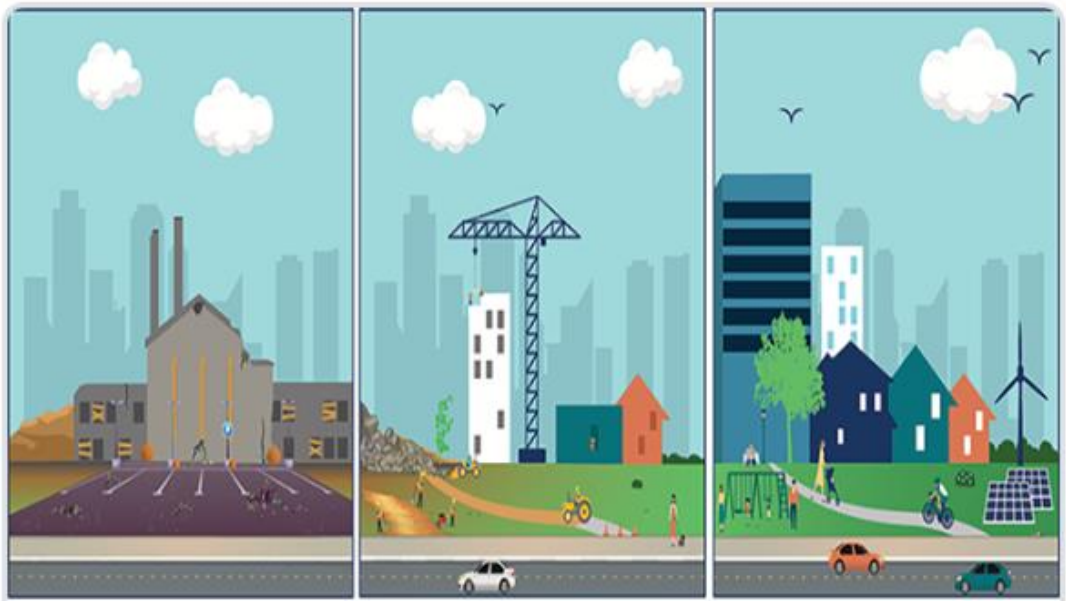
Mines to Megawatts

The Brownfield Advantage

- **Mine sites are considered a brownfield**
  - Large existing industrial footprint that has been in place for a long period of time
  - A pre-existing contaminated site
  - Also a brownfield in skilled labor and industrially focused community
- **Siting a nuclear reactor on brownfield sites will be streamlined in terms of public perception**
- **EPA Brownfields Program**
  - Provides assistance to developers working to revitalize aging industrial sites

EPA United States Environmental Protection Agency



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Mines to Megawatts

On Site Waste Storage

- **Riskiest component of the waste storage cycle is transportation**
- **Transportation could be eliminated with on site waste storage**
  - Competent rock
  - Pre-existing access to deep underground areas
- **Ability to maintain the excavation is seen as a positive**
  - Allows for monitoring of the deposited waste
  - Allows for the potential of removal should a better solution be found in the future

https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-waste/storage-and-disposal-of-radioactive-waste

Mines to Megawatts

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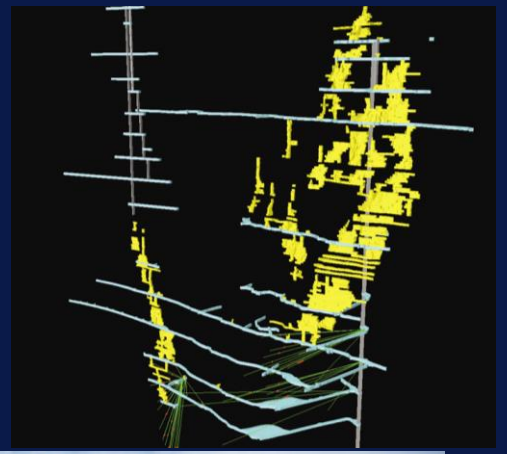

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Mines to Megawatts

Sustainable Development

- Mining damages the environment and can present challenges to local communities
- Mine operators are looking for ways to make their operations safer, cleaner, and to benefit their communities more
- Nuclear power could transform mine sites from power consumers to power producers
- Enable job stability long after mining is complete

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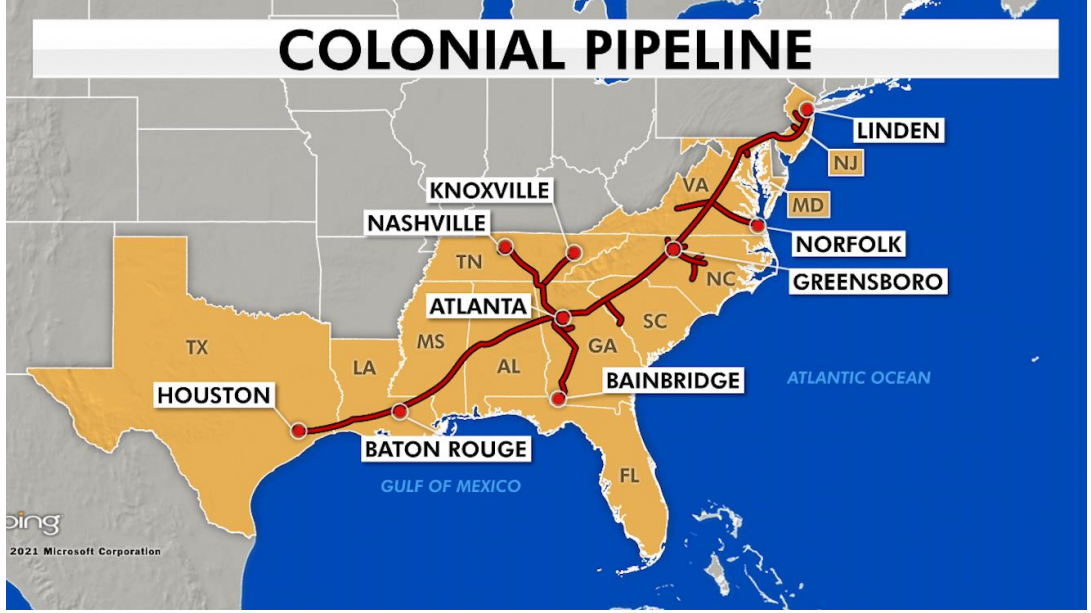
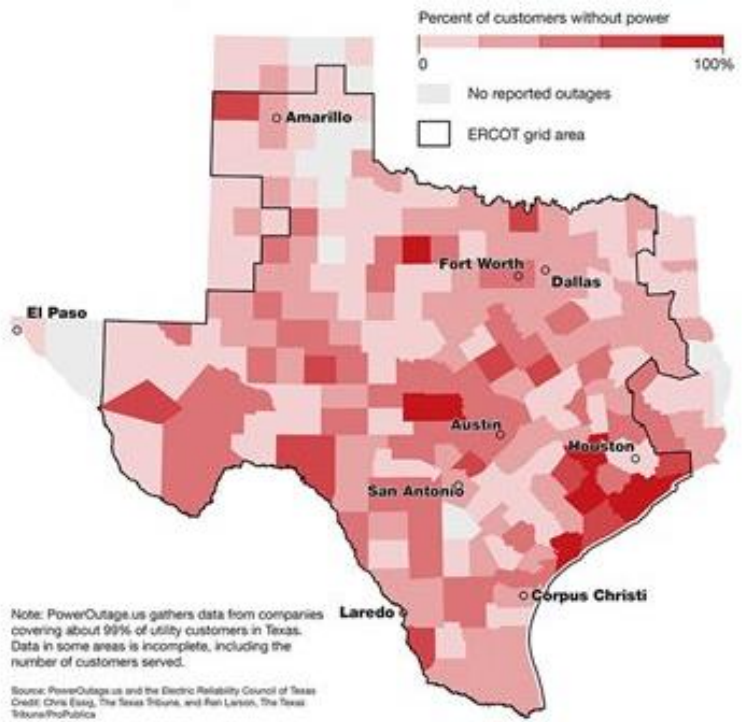
Mines to Megawatts

A Fragile Grid

- **A clear need exists to harden portions of our electrical and critical infrastructure network**
  - EMP
  - Severe Weather
  - Deliberate Attacks
  - A growing reliance on electricity and data in normal society
- **Underground nuclear and data centers address this**





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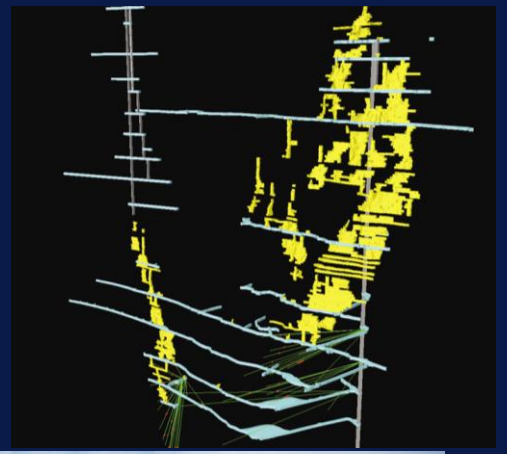

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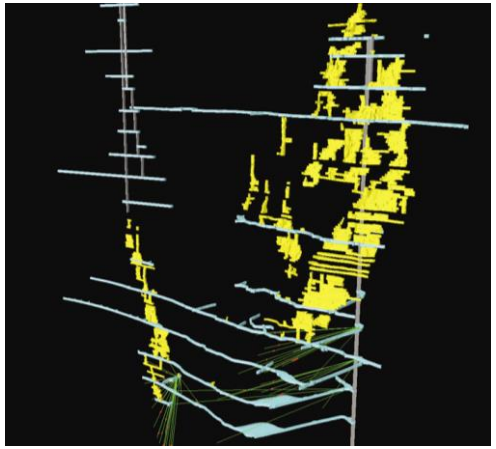
Mines to Megawatts

Closing

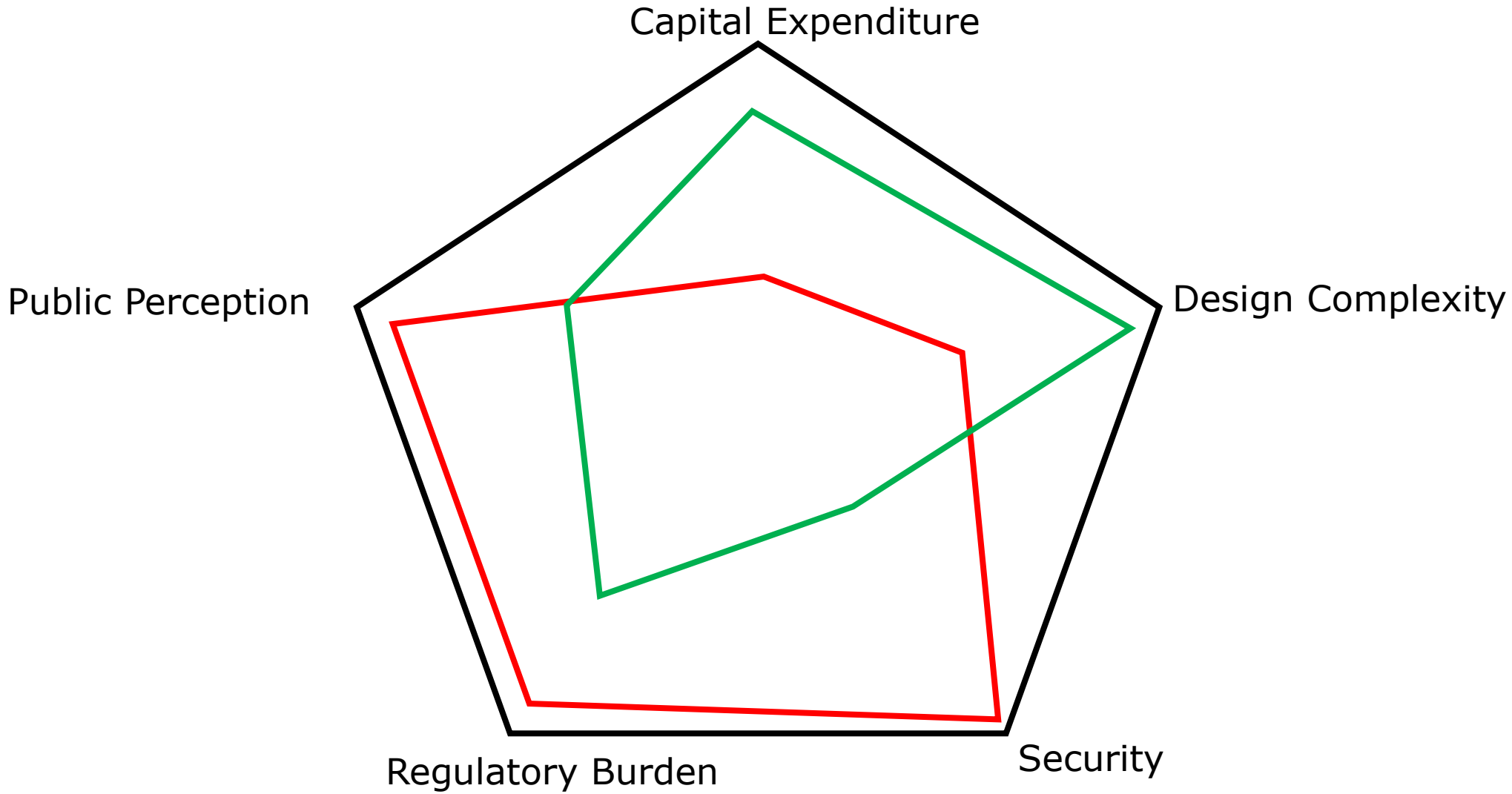
- Mining and Nuclear Development have many similarities which could streamline the permitting process
- A clear advantage exists toward both sectors for colocation in terms of reduction of cap-ex and op-ex
- Society would benefit from a diversified power and data network which can weather extreme events
- Clear advantages exist for everyone to revitalize existing industrial sites



OptiRock GROUP

Mines to Megawatts

Closing



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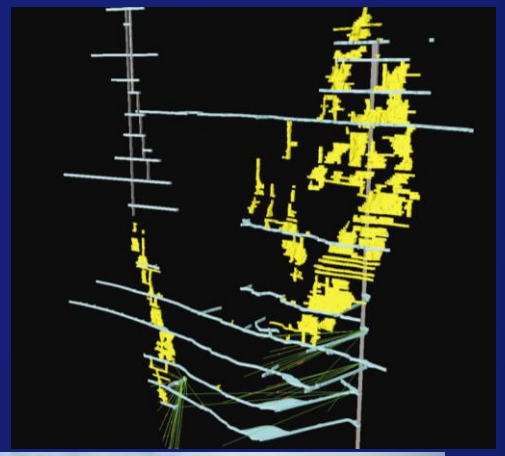

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