

The AI-Ready Mine: A Field Guide to **12 AI Use Cases** Transforming Mining

From exploration to processing to safety; where artificial intelligence is already changing drill-hit rates, downtime, recovery, and workplace risk across the mining value chain.

12

AI USE CASES

04

VALUE-CHAIN STAGES

08

DELIVERY SERVICES

FOREWORD

Why we're publishing this now

Last week, Idea Theorem sat down with the Hon. Stephen Lecce, Ontario's Minister of Energy and Mines, and David Smith, MPP and Parliamentary Assistant to the Minister, at the Ministry of Energy and Mines. The conversation centred on one question: how can AI and technology help modernize the mining sector; from exploration and predictive maintenance to safety monitoring; and what role can technology partnerships play as Ontario builds out its critical minerals and energy future?



We are the technology partner that enables the mining sector.

Idea Theorem, on the role of technology partnerships in Ontario's critical minerals strategy

THE OPPORTUNITY

Exploration success rates are declining industry-wide, unplanned downtime still eats into Tier-1 output, and safety incidents remain costly in every sense. AI is now mature enough to move the needle on all three; with results operators are already publishing.

WHAT'S INSIDE

This guide walks through twelve high-leverage AI use cases across four stages of the mining value chain, the documented impact behind each one, and the services Idea Theorem uses to deliver them; from readiness assessment to production deployment.

IDEA THEOREM AT THE TABLE

Representing Idea Theorem in conversation with Ontario's Ministry of Energy and Mines on AI, technology partnerships, and the province's critical minerals and energy strategy.

01

Exploration & Mineral Discovery; closing the decline in success rates

02

Operations & Automation; documented gains at Tier-1 sites

03

Processing & Recovery; where every % point is revenue

04

Safety, ESG & Workforce; continuous evidence, not periodic



Exploration & Mineral Discovery

Where AI is closing the decline in exploration success rates.



USE CASE 01

Mineral target prediction

WHAT IT DOES

ML models trained on geophysical surveys, satellite imagery, and historical drill data identify high-prospectivity zones; turning manual interpretation into repeatable science.

Up to 10x improvement in drill-hit rates on isolated targets.



USE CASE 02

Subsurface modelling

WHAT IT DOES

Deep learning fuses gravity, magnetic, seismic, and EM data into 3D subsurface representations, surfacing mineralization signatures hidden in conventional interpretation.

Faster, more confident drill planning; reduced exploratory drilling and land disturbance.



USE CASE 03

Resource estimation

WHAT IT DOES

Ensemble models predict deposit size, grade, and continuity from sparse drill data; quantifying uncertainty so capital goes to the most promising targets first.

Better-targeted programs; lower exploration cost per discovered tonne.

10x

Drill-hit rate uplift on isolated targets

3D

Subsurface models replacing manual interpretation



Operations & Automation

Where AI is already delivering documented production gains at Tier-1 sites.



USE CASE 01

Autonomous fleet management

WHAT IT DOES

Multi-agent AI coordinates haul trucks, drills, and loaders in real time; optimizing routing, speed, load balancing, and fuel consumption across the pit.

15% lower haul costs and a 30% productivity gain reported by Tier-1 operators.



USE CASE 02

Predictive maintenance

WHAT IT DOES

Sensor-stream ML on vibration, temperature, and acoustic data detects component degradation weeks before failure; moving from reactive repair to prescriptive intervention.

20–30% reduction in unplanned downtime across Tier-1 assets.



USE CASE 03

Energy & emissions optimization

WHAT IT DOES

AI tunes power use across crushers, mills, ventilation, and pumps in response to load and ore variability, reducing kWh per tonne and emissions intensity.

Lower energy cost per tonne; measurable progress on operational emissions targets.

30%

Productivity gain from autonomous fleet coordination

20–30%

Less unplanned downtime across Tier-1 assets



Processing & Recovery

Where small gains compound - every percentage point of recovery translates directly to revenue.



USE CASE 01

AI-driven ore sorting

WHAT IT DOES

Computer vision and spectral imaging classify ore by grade and composition on conveyor belts, diverting waste rock before it consumes downstream processing capacity.

15–20% improvement in resource recovery rates reported across operations.



USE CASE 02

Flotation & recovery control

WHAT IT DOES

Predictive models adjust reagent dosing, pH, airflow, and froth conditions in real time as ore characteristics shift, stabilizing recovery despite feed variability.

Higher recovery, lower reagent use; +90,000 t/yr copper at Freeport with no new capex.



USE CASE 03

Throughput optimization

WHAT IT DOES

End-to-end models simulate the full processing line; crushing, grinding, flotation, dewatering; and recommend setpoint changes that maximize throughput.

Increased asset utilization without capital expansion; smoother production planning.

15–20%

Improvement in resource recovery rates

+90,000 t

Extra copper per year at Freeport, no new capex



Safety, ESG & Workforce

Where AI shifts compliance from periodic reporting to continuous evidence - and supports the people doing the work.



USE CASE 01

Hazard & PPE detection

WHAT IT DOES

Computer vision on site cameras detects PPE compliance, exclusion-zone breaches, vehicle proximity risks, and unsafe behaviour in real time; issuing alerts before incidents occur.

Projected ~30% reduction in workplace incidents across industry adopters.



USE CASE 02

Tailings & ESG monitoring

WHAT IT DOES

Continuous AI surveillance of tailings dam stability, water discharge, emissions, and surrounding biodiversity using satellite, drone, sensor, and IoT data streams.

Earlier risk detection; compliance becomes evidence-based and continuous, not periodic.



USE CASE 03

GenAI operator copilots

WHAT IT DOES

Conversational AI trained on equipment manuals, maintenance procedures, SOPs, and incident reports lets field technicians query in natural language.

Faster troubleshooting, less downtime, lower onboarding cost for new operators.

30%

Fewer workplace incidents projected across adopters

24/7

Continuous tailings and ESG surveillance

What Idea Theorem Brings to the Table

A full AI agency stack from opportunity identification to production deployment proven across regulated industries.

01

AI Readiness Assessment

Evaluate data maturity, capability, and opportunity gaps; the starting point for any AI program.

05

Predictive Analytics

Operational decision support from sensor, geological, and process data: equipment health, recovery, throughput.

02

Theorem Foresight

Identify the highest-leverage AI opportunities for a specific operational context, as a prioritized portfolio.

06

AI-Driven Workflows

Wire AI into day-to-day operations; from alerts and recommendations to autonomous coordination.

03

Theorem Atlas AI

Define the AI vision and roadmap; sequencing, dependencies, governance, and investment plan.

07

Theorem Engage AI

Conversational AI for field operators, maintenance, and internal knowledge copilots.

04

Custom AI Solutions

Build and deploy models that solve the specific operational problem; exploration, predictive, optimization.

08

Cloud & Engineering

Production-grade deployment on Azure, AWS, GCP; data platforms, MLOps, and systems integration.



LET'S BUILD IT TOGETHER

From slide to **site**; let's put AI to work in your operation.

Government sets the agenda for Ontario's critical minerals and energy future. We're the technology partner that turns it into deployed systems; fewer unplanned shutdowns, safer sites, and more tonnes recovered from the ore you've already mined.

[Talk to Idea Theorem →](#)

01

Start with an AI Readiness Assessment to find your highest-leverage opportunity.

02

Sequence a roadmap with Theorem Atlas AI governance and investment included.

03

Deploy production-grade AI with our Cloud & Engineering team.