Coming of age: How digital twin technology is changing the face of mining

A special report based on industry data has gauged the progress and potential of digital twins in mining operations.

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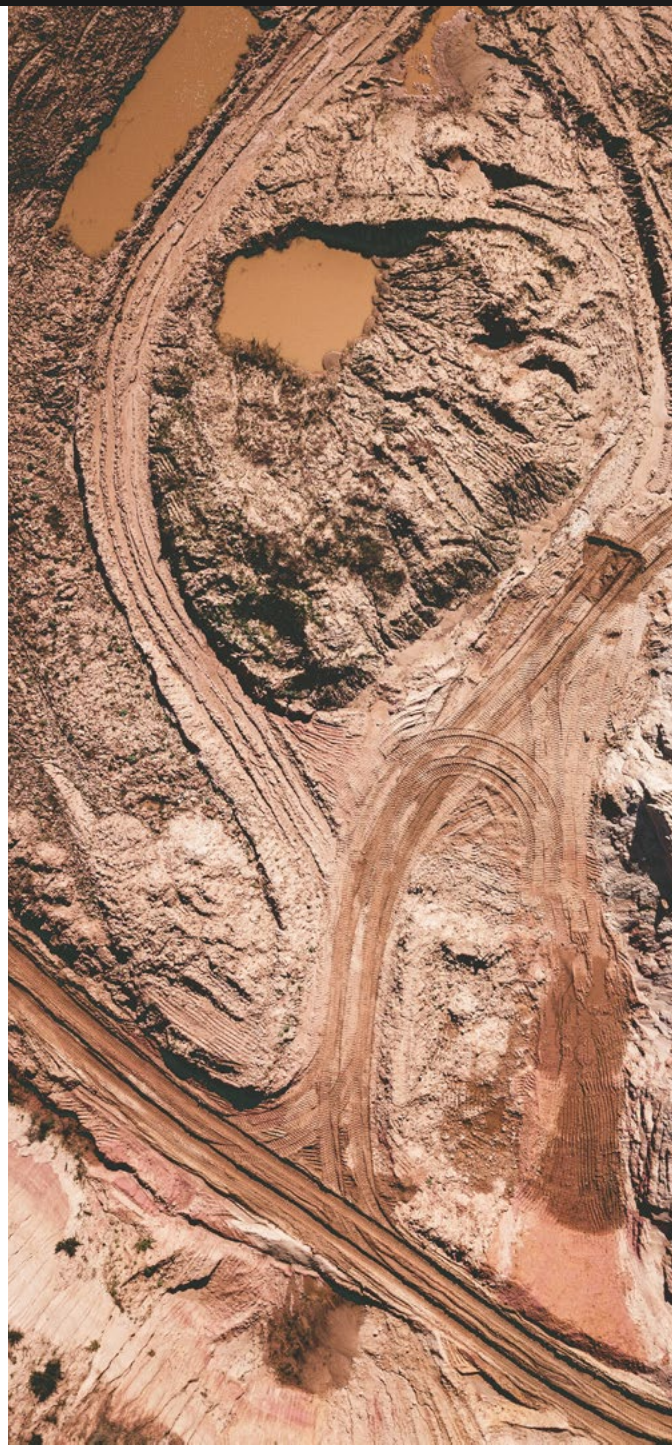


The mining sector at a crossroads

The mining sector faces persistent pressures: enhancing safety, boosting operational efficiency, meeting stringent environmental regulations, and maximizing resource extraction. For years, digital transformation has been promised as a pathway forward, with digital twins emerging as a particularly powerful enabler.

Digital twins are dynamic virtual replicas of physical assets, processes, and entire mine sites.

But are digital twins just a futuristic concept, or are they delivering tangible value today?

To find out, we gathered survey data and insights from mining leaders and industry experts around the globe. The result is a firsthand look at the real-world adoption, challenges, and the perceived value of digital twin technology.

The verdict? Digital twins are coming of age

Our findings reveal that digital twins have moved beyond the pilot stage and are actively being implemented to solve critical mining challenges. While the journey isn't without obstacles, the vast majority of industry leaders recognize the significant potential.

This e-book dives into recent research data to explore:

- The current state of digital twin adoption in mining.
- How digital twins align with key industry priorities.
- The real-world benefits being realized.
- How to get the most value out of your digital twin.

Let's explore how this technology is reshaping the future of mining, backed by insights directly from your peers.

88%

Nearly nine out of 10 (88%) respondents see high or very high value in digital twins for their organization.

46%
High value

42%
Very high

Digital twins gain traction in operations

The concept of digital transformation is well-established in mining, but implementation and results vary.

Survey data shows a sector actively engaged:

64%

of organizations have implemented digital transformation projects and are already seeing results.

30%

are currently implementing these projects.

When focusing specifically on digital twins, the picture shows significant progress, confirming their move into mainstream consideration:

58%

have implemented digital twins in at least one area and are achieving results.

30%

are actively implementing digital twins.

8%

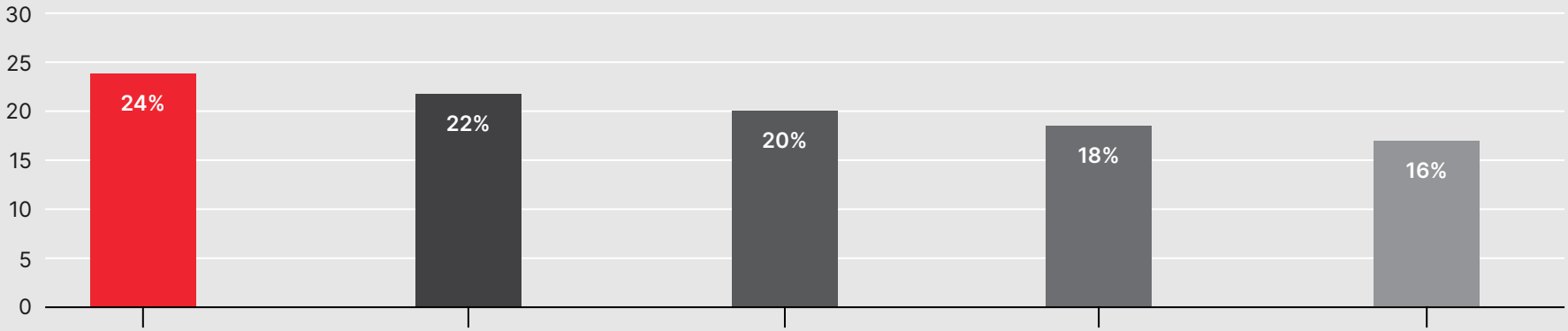
are currently piloting the technology.

This data indicates that nearly 90% of surveyed organizations are either using, implementing, or piloting digital twins. While widespread, mature adoption across all operations is still developing, the technology is clearly proving its worth in targeted applications, moving it firmly into the “coming of age” phase.

Why now? Aligning with mining's core priorities

The growing adoption isn't arbitrary. Digital twins directly address the top strategic priorities identified by mining leaders in our survey.

Top digital transformation priorities in mining:



Improving health and safety: Digital twins allow for remote monitoring, simulation of hazardous scenarios, and predictive maintenance of safety-critical equipment, reducing human exposure to risk.

Improving energy, sustainability, and decarbonization: Simulating operational changes helps optimize energy consumption, model environmental impacts (like water usage or tailings management), and plan decarbonization strategies effectively.

Improving productivity: By identifying bottlenecks, optimizing workflows, and simulating different extraction plans, digital twins drive efficiency gains.

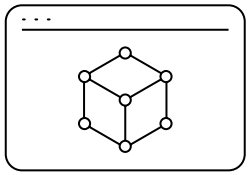
Optimizing equipment utilization and reducing maintenance: Predictive maintenance capabilities, powered by real-time data fed into the digital twin, minimize downtime and extend asset life.

Optimizing planning and design: Digital twins enable better scenario planning for mine expansion, infrastructure development, and operational adjustments.

The clear alignment between digital twin capabilities and these fundamental business drivers explains the technology's increasing momentum within the sector.

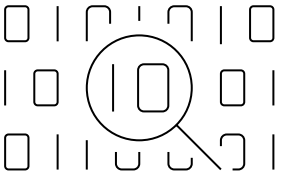
Seeing around corners: The power of the virtual replica

At its core, a digital twin provides a dynamic, data-rich virtual environment that mirrors physical reality. This unlocks powerful capabilities:



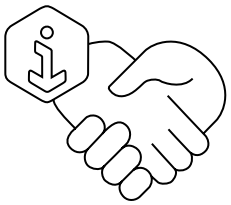
Simulation and optimization: Test process changes, new equipment configurations, or different operational plans in a risk-free virtual space before committing resources in the physical world. This capability allows for incremental improvements and confident decision-making.

Benefit: Cost-effective experimentation, faster optimization cycles.



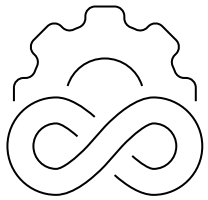
Predictive insights: Integrate real-time data from IoT sensors, equipment telemetry, and other systems to monitor asset health, predict potential failures (e.g., equipment breakdown, slope instability), and anticipate operational bottlenecks.

Benefit: Reduced downtime, enhanced safety, proactive maintenance.



Enhanced collaboration and visualization: Provide a common operating picture for dispersed teams, such as geologists, engineers, operations, and maintenance. Complex data becomes intuitive and actionable through 3D visualization.

Benefit: Improved communication, faster problem-solving, better cross-functional alignment.



Lifecycle management: Maintain a living record of an asset or site, from design and construction through operation and eventual closure, supporting better long-term planning and regulatory compliance.

Benefit: Improved asset knowledge, streamlined compliance, better long-term strategic planning.

The verdict is in: Digital twins deliver value

The data speaks clearly—digital twin technology has firmly arrived in the mining sector. It's no longer a niche experiment but a strategic capability that addresses the industry's most pressing needs.

Survey data confirms:

- **Strong adoption:** A majority of organizations are implementing digital twins and seeing results.
- **Clear priorities:** Digital twins address top goals like safety, sustainability, and productivity.
- **High perceived value:** An overwhelming **88%** of leaders recognize their high or very high potential value.

While challenges related to integration, skills, and investment remain, the pathway forward involves strategic planning, focused pilot projects, and crucially, effective partnerships. The prevalence of collaborative approaches highlighted in our research underscores the importance of leveraging external expertise alongside internal capabilities.

As digital twin technology matures, organizations that proactively embrace it stand to gain a significant competitive advantage. They will be better equipped to:

- Operate more safely and sustainably.
- Optimize resource extraction and processing.
- Improve asset reliability and reduce costs.
- Make faster, data-driven decisions.
- Attract and retain talent in an increasingly digital world.

The question is no longer if digital twins will reshape mining, but how quickly your organization will harness their power. The "coming of age" is happening now.

What’s next: Extracting more value from your digital twin

While digital twins are already delivering measurable benefits across mining operations, the most progressive organizations are taking them a step further—by integrating real-time IoT sensor data and automated condition monitoring systems.

This integration transforms a digital twin from a static or periodically updated model into a living, evergreen version. As a result, your digital twin can evolve alongside your operation, enabling smarter, faster, and more proactive decision-making.

A regular digital twin typically represents a snapshot in time—it’s valuable for planning, design, and periodic analysis, but its insights can quickly become outdated between data updates.

An evergreen digital twin, continuously fed by real-time data from IoT sensors and connected systems, stays in sync with the actual state of your mine or infrastructure asset. That live connection unlocks major operational advantages.

The value of real-time data: Why it matters

In the mining sector, condition monitoring has rapidly advanced, with automation through internet-connected sensors now becoming the standard. Among mine owners, 72% of monitoring data is already collected through automated means, a figure expected to climb to 80% within the next two years.

Mining leaders understand the stakes: real-time data isn't a luxury, it's a necessity for safety, operational resilience, and risk mitigation.

According to our latest Condition Monitoring Report:

82%

of mine owners report they can execute projects more cost-effectively through automated condition monitoring.

76%

say it has enabled them to expand into new markets.

45%

say that automated condition monitoring has allowed them to complete more projects annually.

36%

say they have been able to unlock recurring revenue.

These benefits go beyond operational uptime. In an increasingly regulated industry, real-time monitoring supports compliance, improves public reporting, and demonstrates operational transparency to stakeholders.

How automated monitoring and digital twins work together

While automated condition monitoring has been widely adopted in mining, its full potential is realized when combined with digital twins.

Here's how they work in tandem:

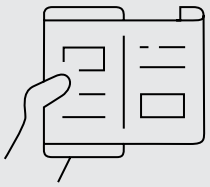
- IoT sensors deployed across mine infrastructure continuously capture operational and environmental data.
- This data streams into automated condition monitoring platforms, which process and flag anomalies in real time.
- The data feeds directly into the digital twin, updating the virtual model with the current state of the physical asset or site.
- Mine managers and engineers use the digital twin to visualize asset health, simulate interventions, and plan responses collaboratively.
- Predictive analytics inform operational decisions, maintenance schedules, and risk mitigation strategies.

The result: A smarter, safer, and more responsive mining operation.

From static model to evergreen decision-making tool

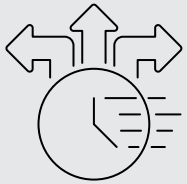
A digital twin connected to live, sensor-based monitoring data becomes an active operational resource—not just for planning, but for real-time decision support.

The benefits of an evergreen digital twin include:



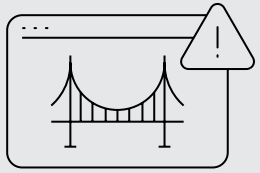
Current, real-time insights

Immediate awareness of changing conditions and risks

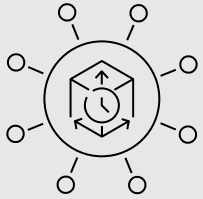


Faster, more informed operational decisions

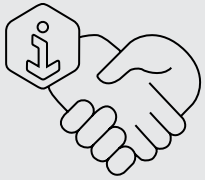
Proactive, predictive maintenance instead of reactive fixes



Automated alerts for safety and performance issues

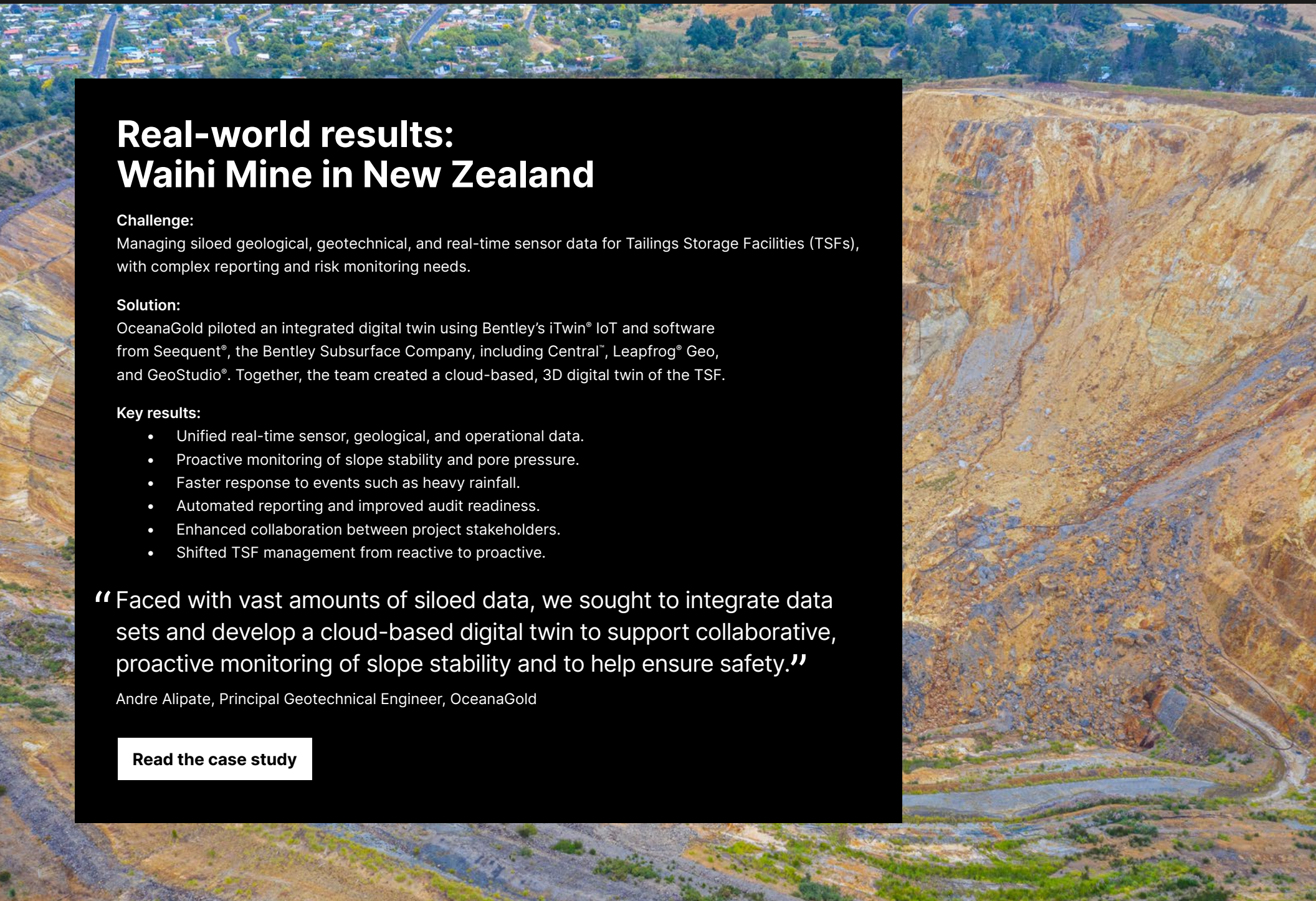


Time-stamped operational history for compliance, ESG, and audit readiness



Better collaboration with a shared, live view of asset health for dispersed teams

Bottom line: A regular digital twin is a valuable planning tool—but an evergreen digital twin becomes a live operational command center.



Real-world results: Waihi Mine in New Zealand

Challenge:
Managing siloed geological, geotechnical, and real-time sensor data for Tailings Storage Facilities (TSFs), with complex reporting and risk monitoring needs.

Solution:
OceanaGold piloted an integrated digital twin using Bentley's iTwin® IoT and software from Seequent®, the Bentley Subsurface Company, including Central™, Leapfrog® Geo, and GeoStudio®. Together, the team created a cloud-based, 3D digital twin of the TSF.

Key results:

- Unified real-time sensor, geological, and operational data.
- Proactive monitoring of slope stability and pore pressure.
- Faster response to events such as heavy rainfall.
- Automated reporting and improved audit readiness.
- Enhanced collaboration between project stakeholders.
- Shifted TSF management from reactive to proactive.

> "Faced with vast amounts of siloed data, we sought to integrate data sets and develop a cloud-based digital twin to support collaborative, proactive monitoring of slope stability and to help ensure safety."

Andre Alipate, Principal Geotechnical Engineer, OceanaGold

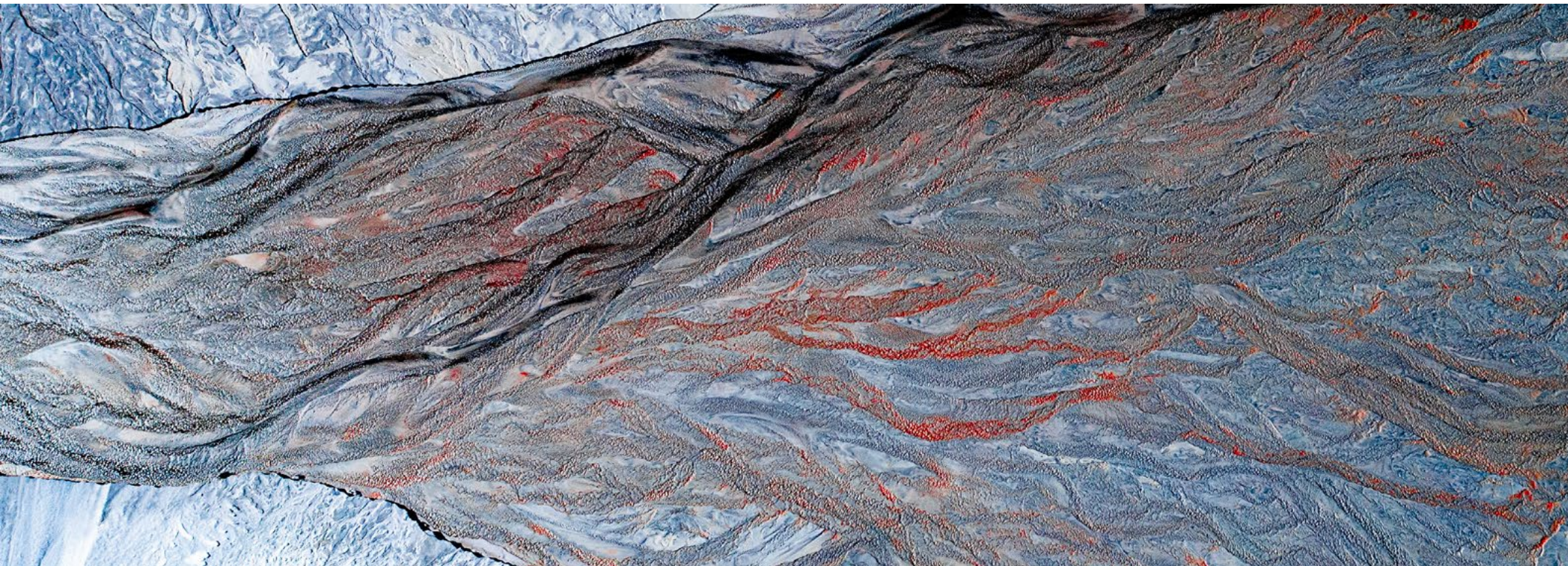
Read the case study

Key takeaway: Real-time data turns digital twins into operational engines

Mining companies aren't just adopting digital twins—they're enhancing them through real-time data integration. The combination of automated condition monitoring and digital twins is giving operators the insight they need to optimize safety, efficiency, and long-term asset performance.

As this technology matures, organizations that integrate real-time IoT data into their digital twins will gain a clear competitive edge in operational resilience, ESG reporting, and business agility.

About the research data: The insights and data points shared throughout this e-book are based on two primary research sources. The first, Use of Digital Twins in Mining Operations, is a global survey conducted by Mining Magazine and Australia's Mining Monthly, capturing perspectives from senior mining operations leaders on the adoption and impact of digital twin technology. The second, the 2024 Condition Monitoring in Mining Report, is a global survey commissioned by Bentley Systems, gathering insights from mining industry experts on the current state and future of condition monitoring practices. Together, these reports provide a comprehensive view of how mining organizations worldwide are advancing digital transformation, improving operational efficiency, and managing the health of their assets.



Ready to create an evergreen digital twin for your mine site?

Bentley offers industry-leading digital twin and IoT condition monitoring solutions tailored for mining.

Discover how a connected, evergreen digital twin can help you:

- Improve safety and risk management.
- Optimize mine planning and operations.
- Enhance asset reliability and performance.
- Support sustainability and ESG initiatives.

Learn more about iTwin IoT