MAXIMIZING THROUGHPUT IN MINING OPERATIONS

BRAINCUBE FOR MINING COMMINUTION THROUGHPUT OPTIMIZATION

Mining operations generate enormous amounts of operational data, from sensors, control systems, and historians embedded across circuits. Yet even with this data in place, many teams still struggle to translate variability into consistent, repeatable performance.

The challenge isn't data availability; it's the ability to act on operations in real time as production dynamics shift.

Mining is inherently unstable: ore characteristics vary, equipment wears, operating modes shift, and teams rotate. Performance doesn't come from following a static "model." It comes from continuous adjustment, especially as constraints tighten.

Think of it like a Formula 1 race: when conditions are perfect, the best driver can drive the ideal line. But when the surface changes (rain, dirt, grip loss), you win by constantly adjusting to stay on the optimal line.

Mining is similar. Those who adapt fastest consistently outperform.

Comminution throughput sits at the center of mining economics. Small shifts in feed characteristics, operating conditions, and constraints influence output, energy intensity, recovery, and wear.

Without live guidance, teams are forced into reactive mode, adjusting after losses appear, rather than preventing them.

WHY PERFORMANCE STILL DRIFTS IN MINING OPERATIONS

Mining productivity rarely fails all at once. It erodes gradually, driven by fluctuations that compound across shifts, assets, and daily decisions.

Ore characteristics change. Feed blends drift. Equipment wears. Operators rotate. Control strategies that worked yesterday lose effectiveness today. This is not an exception. It's the normal state of mining.

Too often variability is treated as noise instead of reality.

How variability turns into lost performance

When variability is not actively managed, it shows up in familiar ways.

In comminution circuits, fluctuations typically follow a pattern:

- Throughput that rises and falls unexpectedly
- Energy per tonne creeping upward
- Growing recirculation loads
- Accelerated liner wear
- More frequent operator intervention just to keep the circuit under control

These symptoms are visible, but rarely driven by a single variable.

Material properties, operating ranges, upstream conditions, and equipment state all interact at once. Teams respond by making local adjustments based on experience and intuition. But when decisions are made in isolation, the circuit can remain unstable, even as people work harder to control it.

Performance targets don't stay fixed

It's tempting to look for the "right" settings when conditions are stable. The best configuration across the comminution circuit. The ideal comminution throughput target. The optimal energy balance. In practice, those targets are constantly shifting.

As material properties and production environments change, the balance between throughput, energy, recovery, and wear changes with them. A setting that performed well on one shift can quietly drift outside the target range on the next.

Productivity is not about finding a perfect state. It is about staying aligned as that state moves.

Where performance gaps emerge

This is where performance begins to drift. Teams often have strong data and deep expertise, but the circuit moves faster than human consistency can sustain.

The gap is not visibility. It is the ability to:

- Identify what is truly driving performance right now
- Separate what is controllable in the current climate from what is not
- Support fast adjustments that keep production aligned with the ideal zone as conditions evolve

Without that support, instability keeps winning. Decisions lag behind conditions, and small deviations quietly compound into lost tonnes, higher energy use, and unnecessary wear.

TOO OFTEN VARIABILITY IS TREATED AS NOISE INSTEAD OF REALITY.

Why real-time adjustment wins

In an inherently unstable environment, performance comes from continuous adjustment, not periodic correction.

High-performing operations recognize change early, understand which levers matter under current conditions, and adjust before fluctuations turn into loss.

They don't wait for reports to confirm a problem. They act while there's still time to stay on target.

This is the shift from reactive control to active guidance.

Instead of asking what went wrong after the fact, the focus becomes:

1. What is changing right now?
2. How is that affecting the operating window?
3. What adjustment keeps us closest to optimal under these conditions?

This is the foundation of continuous optimization. Not eliminating fluctuations, but helping teams respond consistently as they unfold.

THIS IS THE SHIFT FROM REACTIVE CONTROL TO ACTIVE GUIDANCE.

From chasing averages to managing movement

Optimizing around averages hides the instability that drives losses in mining.

Sustained productivity comes from managing movement:

01

Staying within the right performance ranges as material changes

02

Adjusting setpoints before instability escalates

03

Balancing trade-offs dynamically, not statically

In comminution, where upstream volatility meets downstream impact, the ability to adapt as changes occur becomes a decisive advantage.

COMMINUTION THROUGHPUT: WHERE REAL-TIME OPTIMIZATION DRIVES PRODUCTIVITY

Mining operations like yours face many interconnected challenges: variability, cost pressure, energy intensity, asset wear, and quality risk. What ties them together is the need to make the right adjustments as conditions change.

That challenge shows up most clearly in comminution throughput.

Where do you start?

In many mining environments, the most effective starting point is the comminution circuit (crushing and grinding together) because it most directly shapes how much material can move through the plant and how efficiently downstream processes can perform.

Comminution is often where inconsistency first appears and where its impact is felt fastest across the rest of the flowsheet.

Why comminution is the leverage point

Comminution plays a central role in mining economics because it determines how much stable throughput the circuit can sustain, which in turn drives:

- Tonnes processed per hour
- Downstream recovery stability
- Energy intensity per tonne
- Equipment wear and maintenance exposure
- Overall plant predictability

That means even small improvements in comminution throughput can create outsized value.

At the same time, comminution is not constrained by one static factor. It is constrained by the plant's ability to operate consistently near its best operating window as conditions change. Feed characteristics change. Equipment wears. Circulating loads fluctuate. Operator response varies by shift.

Performance depends on how well the operation adapts as those conditions evolve.

Maximize stable comminution throughput under operating variability

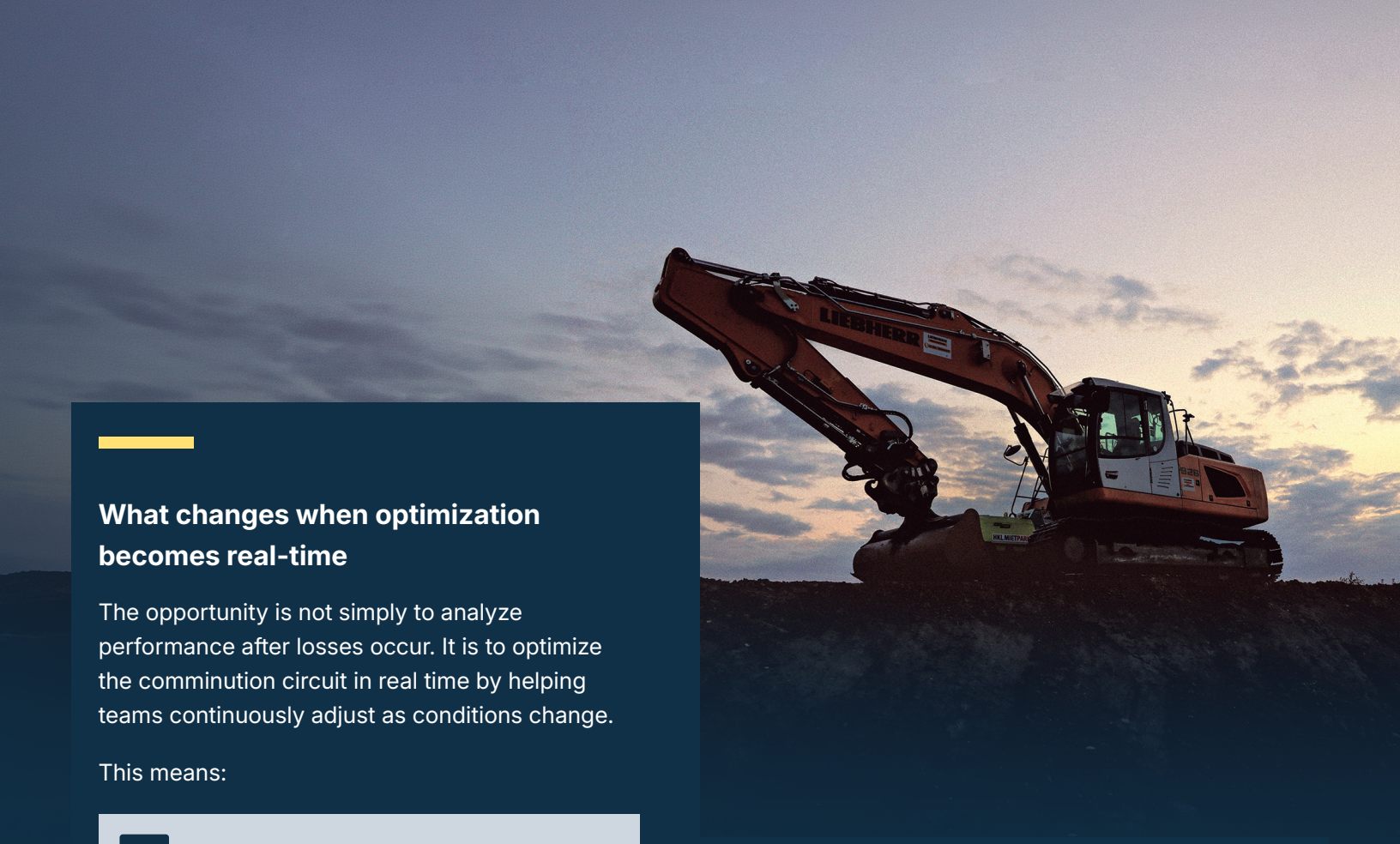
Comminution performance is shaped by a combination of changing conditions and interacting variables, including:

- Feed fragmentation and hardness
- Moisture and blend composition
- Liner condition and wear
- Circulating load and water balance
- Operating mode, control behavior, and operator response
- Each variable matters, but not in the same way all the time

This creates the central operational challenge: the "best operating window" moves. Running at fixed targets forces teams to choose between risk and lost throughput.

Because crushing is the first stage of comminution, variability introduced here does not stay isolated. Instability at the crusher propagates downstream, affecting grinding stability, energy use, recovery, material handling, and maintenance planning.

As comminution throughput fluctuates, teams are pushed into reactive adjustments just to keep the circuit under control.



What changes when optimization becomes real-time

The opportunity is not simply to analyze performance after losses occur. It is to optimize the comminution circuit in real time by helping teams continuously adjust as conditions change.

This means:

01

Identifying which variables truly impact comminution throughput in the current context

02

Separating what is controllable from what is not under current conditions

03

Translating that understanding into live guidance on what to adjust now

This is where real-time process optimization comes into play.

Braincube continuously analyzes production data to understand how the comminution circuit is behaving and guides teams on what to adjust to sustain higher, more stable throughput. The focus is not on rebuilding fragile models or chasing perfect setpoints, but on sustaining higher, more stable comminution throughput under variability.

What teams see when comminution throughput is optimized in real time

Mining teams applying this approach commonly see:

- Higher and more consistent comminution throughput
- Fewer interventions and unplanned slowdowns
- Reduced process variability
- Better energy efficiency per tonne
- Improved wear predictability and maintenance planning

The gains do not come from a single “best setpoint.” They come from keeping the comminution circuit functioning closer to its stable throughput zone as conditions change.

Comminution is where variability first constrains performance. It is also where live operational guidance delivers fast, resilient, and scalable impact without major capital investment.

REAL-TIME PROCESS OPTIMIZATION FOR VARIABLE OPERATIONS

Braincube enables real-time guidance by turning production data into clear, actionable direction for the comminution circuit. This helps teams sustain higher, more stable comminution throughput across shifting conditions.

Braincube supports this approach through three core capabilities.

01 02 03

Identify what truly drives performance

Industrial processes generate thousands of signals, but only a small number explain most performance variation in a given operating context.

Braincube identifies the variables that matter most to comminution throughput, stability, and energy efficiency, and how their influence changes as process dynamics evolve.

This gives teams clarity on what is shaping performance right now, rather than what appears important in hindsight.

Separate what can be controlled from what cannot

Mining and manufacturing performance is shaped by both controllable levers and uncontrollable factors, such as raw material variability or upstream disturbances.

Braincube distinguishes between these effects as operations unfold, helping teams focus adjustments on what can realistically influence comminution throughput under current conditions. This prevents overcorrection, reduces unnecessary intervention, and helps teams respond proportionally to change.

Deliver live recommendations on what to adjust now

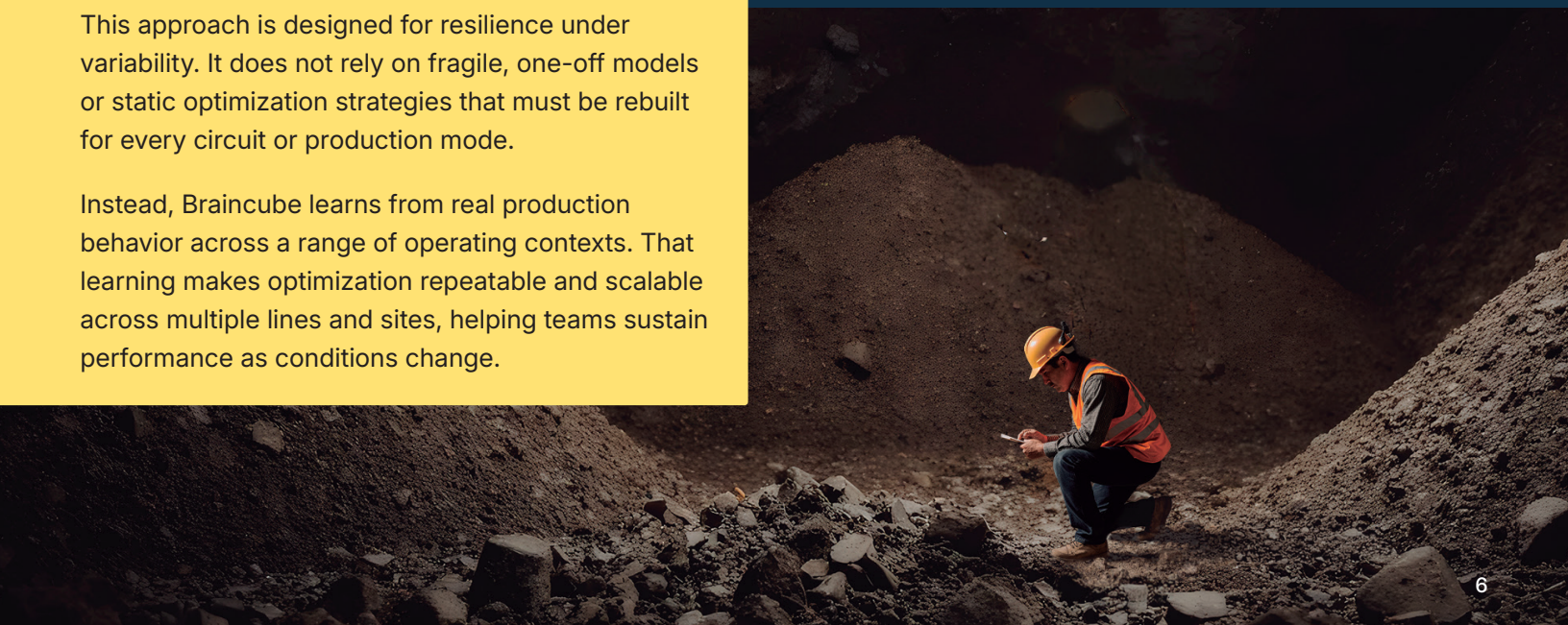
Braincube converts analytical understanding into actionable guidance by delivering real-time recommendations on what to adjust. Where relevant, this guidance is reflected in APC targets and rules to support operators and engineers as conditions evolve.

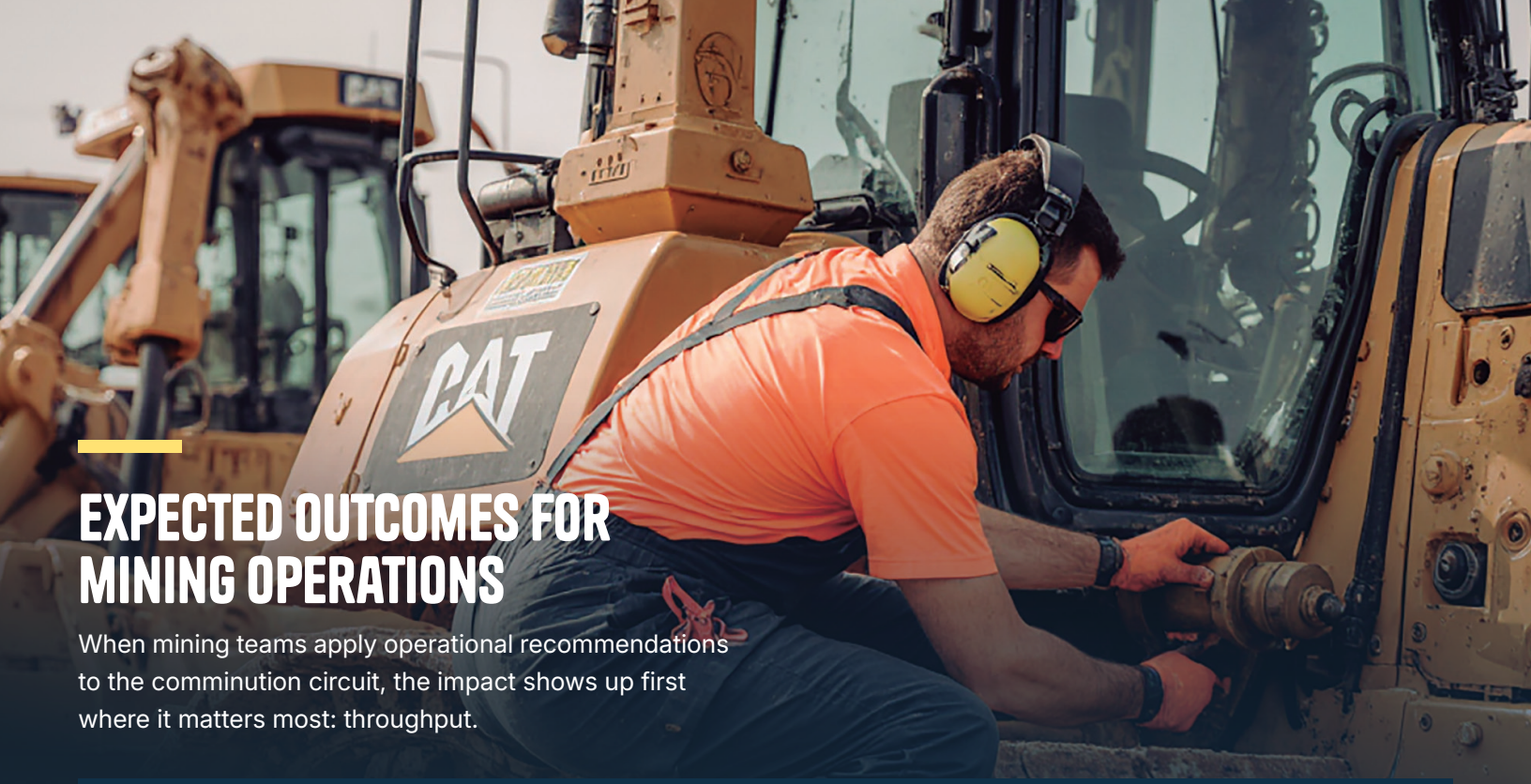
Teams receive timely, context-aware guidance that helps maintain stability and keep the comminution circuit operating within its ideal window.

A scalable approach to resilient operations

This approach is designed for resilience under variability. It does not rely on fragile, one-off models or static optimization strategies that must be rebuilt for every circuit or production mode.

Instead, Braincube learns from real production behavior across a range of operating contexts. That learning makes optimization repeatable and scalable across multiple lines and sites, helping teams sustain performance as conditions change.





EXPECTED OUTCOMES FOR MINING OPERATIONS

When mining teams apply operational recommendations to the comminution circuit, the impact shows up first where it matters most: throughput.

On a typical comminution line, teams can achieve additional throughput of up to

+50 t/h

Across different sites and production environments, this is often reflected as an average increase of **+2% to +5%**, depending on circuit design and material characteristics.

These gains come from keeping the comminution circuit performing within its best throughput zone as operating dynamics shift, reducing the small, compounding losses that occur when performance drifts out of alignment.

What improves as throughput stabilizes

As you hold throughput steady, a small set of reinforcing operational improvements tends to follow:

- Greater stability across crushing and grinding, making the circuit easier to control
- Improved energy efficiency per tonne, as the process runs more steadily
- More predictable equipment wear, with fewer unplanned interventions

These effects aren't separate initiatives. They emerge as a result of stabilizing the comminution circuit and sustaining higher throughput under real-world conditions.

How this translates to business impact

At the business level, this shows up as:

- More reliable asset utilization
- Fewer downstream disruptions
- Productivity gains that arrive faster and hold more consistently

In mining environments, these results come from consistent decision-making and action at the comminution circuit level, rather than pushing assets harder or relying on fixed targets that don't hold as production realities shift.

**Results vary by site; impacts shown are based on observed deployments and depend on circuit configuration and material variability.*

FROM GUIDANCE TO RESULTS: HOW MINING TEAMS SCALE PERFORMANCE IMPROVEMENTS

Sustainable productivity gains in mining don't come from big-bang transformations. They come from starting with a high-impact process, proving value quickly, and scaling what works, without disrupting operations.

Start where leverage is highest

Mining teams typically begin with a clearly defined, high-impact process: the comminution circuit. Improvements in comminution throughput create significant economic impact, with stability and energy efficiency improving as downstream outcomes. Starting at the comminution constraint allows teams to focus effort, build confidence, and demonstrate results quickly.

This mirrors how mining teams already work: stabilize the comminution constraint, reduce sources of variability, then extend what works across the value chain.

From first results to scalable performance

While each site is different, successful rollouts follow a consistent progression:

1. Connect to existing production data
2. Identify the key drivers shaping comminution throughput in real-world environments
3. Translate that understanding into operational recommendations
4. Replicate proven production practices across similar assets and sites

This progression allows teams to move from early learning to repeatable performance gains without overwhelming people or processes.

Data readiness is about action, not perfection

Most operations already have the data required to start. What matters is whether teams trust it enough to act. In practice, readiness means reliable historian data, a clear link to comminution throughput, and enough history to reflect how the circuit behaves.

Gaps are typically addressed alongside value delivery, not as a prerequisite.

Scaling inside existing operations and ecosystems

Braincube builds on existing production data and systems to deliver operational recommendations, helping teams adjust faster and more consistently as production dynamics shift. This approach scales across assets and sites without replacing core systems and works in both direct and partner-supported deployments.

FINAL THOUGHTS: SUSTAINING THROUGHPUT WHERE VARIABILITY LIVES

Mining performance is not limited by a lack of data or expertise. It is limited by how consistently operations stay aligned as conditions shift.

Over time, small deviations compound, eroding throughput and increasing operational friction.

This is why comminution is the first place to look. As the point where upstream change meets downstream impact, the comminution circuit offers the fastest path to stabilizing throughput and improving overall plant performance. Sustaining results here depends on timely, practical guidance that reflects how the circuit is actually running, not how it was expected to run.

By supporting consistent adjustments at the circuit level, mining teams can sustain higher throughput, improve stability, and recover value that is often lost to day-to-day performance drift, without major capital investment or operational risk.

Braincube for Mining delivers live operational guidance designed for this reality, helping teams achieve results quickly and scale performance across sites.

BRAIN CUBE

To learn more or request a demonstration, contact your Braincube partner/reseller, or email **sales@braincube.com,** and we'll connect you with the right local contact.

Learn More