MINING SECTOR

Maximize Operational Efficiency and Safety Through Advanced Subsurface Intelligence

Leveraging the latest generation of NMR geophysical systems engineered by Vista Clara, COLUMBIA Technologies delivers proven, advanced subsurface characterization solu tions to optimize your mining operations— from exploration through closure, enabling informed decisions, reducing operational risks, and achieving sustainable mining practices with confidence.

Why NMR for Mining? Meeting Critical Industry Challenges

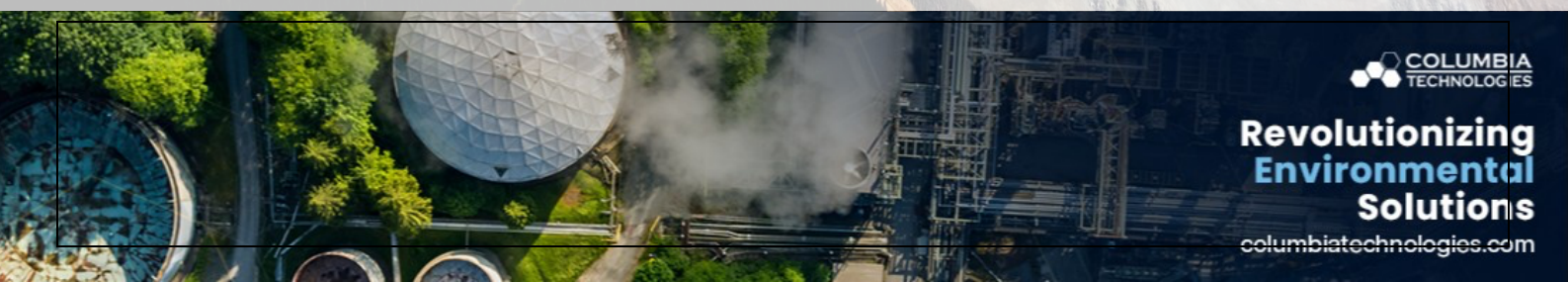
The global mining sector faces unprecedented pressures: maximizing resource recovery, managing water efficiently, ensuring slope stability, meeting stringent environmental standards, and optimizing capital deployment.

Traditional hydrogeological characterization methods often fall short in providing the real-time, high-resolution data needed for modern mining operations.

Your challenges:

- Locate and characterize water resources for process and operational water
- Dewater pit walls and underground workings safely and cost-effectively
- Prevent slope instabilities caused by groundwater
- Optimize tailings dam design and monitor stability
- Minimize environmental impact and demonstrate compliance
- Manage water balance throughout the mine life cycle
- Characterize resources for solution mining and in-situ recovery

Our solution: NMR technology provides the subsurface hydrogeological intelligence you need to address these challenges with confidence and precision.



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COLUMBIA TECHNOLOGIES

MAGNETIC RESONANCE GEOPHYSICS
MINING APLICATIONS

The NMR Advantage:

Direct Measurement of Critical Parameters

Nuclear Magnetic Resonance directly detects hydrogen in subsurface water molecules, delivering quantitative measurements that traditional geophysical and hydrogeological methods cannot match.

What Makes NMR Different?

Direct water measurement – No interpretation or guesswork; NMR measures volumetric water content, total porosity (if fully saturated) and relative pore size distribution directly.

Distinguishes mobile vs. bound water – Provides continuous, real-time measurements to calculate hydraulic conductivity, transmissivity, and specific yield on-site.

High-resolution continuous profiling – Characterize aquifers and aquitards before and during operations

Non-invasive characterization – Minimal site disturbance for environmental and operational assessments

Flexible deployment options – Surface systems (GMR), Javelin borehole logging tools (2" to 18" diameter wells), and Dart direct push tools for any project scale

Lithology-independent porosity – Accurate measurements unaffected by clay content or mineralogy

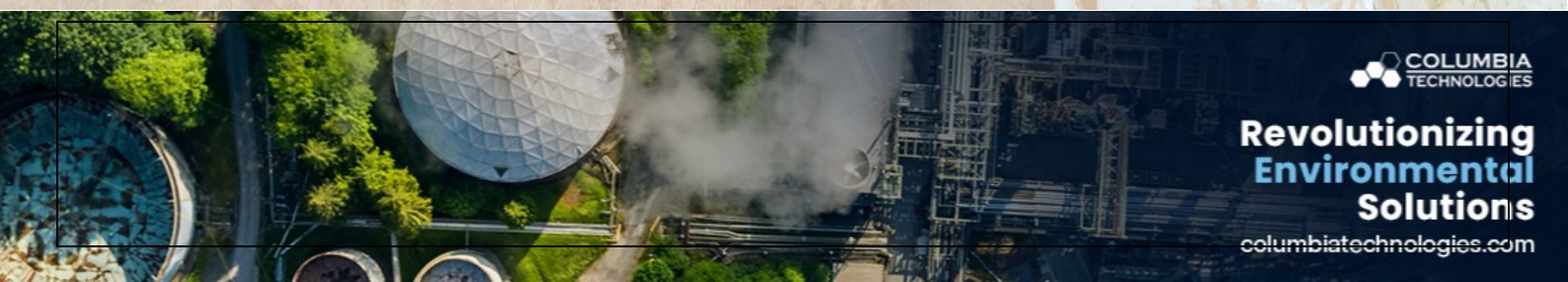
From shallow overburden to deep bedrock aquifers, from exploration through closure, NMR delivers the subsurface data that drives operational excellence and risk reduction.

What Can NMR Do for Your Mining Operation?

EXPLORATION & RESOURCE DEFINITION

Conventional Mining:

- Identify and characterize water-bearing zones to avoid during excavation
- Map aquifer boundaries and hydraulic properties for mine planning
- Optimize exploration drilling programs with targeted hydrogeological data
- Reduce drilling risk and exploratory costs



Solution Mining (ISR, Heap Leach, In-Situ Recovery):

- Characterize target aquifer permeability and porosity for resource modeling
- Confirm presence of confining aquitards above and below mining zones
- Quantify pore volume for leach solution calculations
- Assess feasibility of in-situ recovery operations
- Map preferential flow pathways for solution distribution
- Direct detection of lithium, potassium, and other elements in brines (via specialized NMR nuclei)

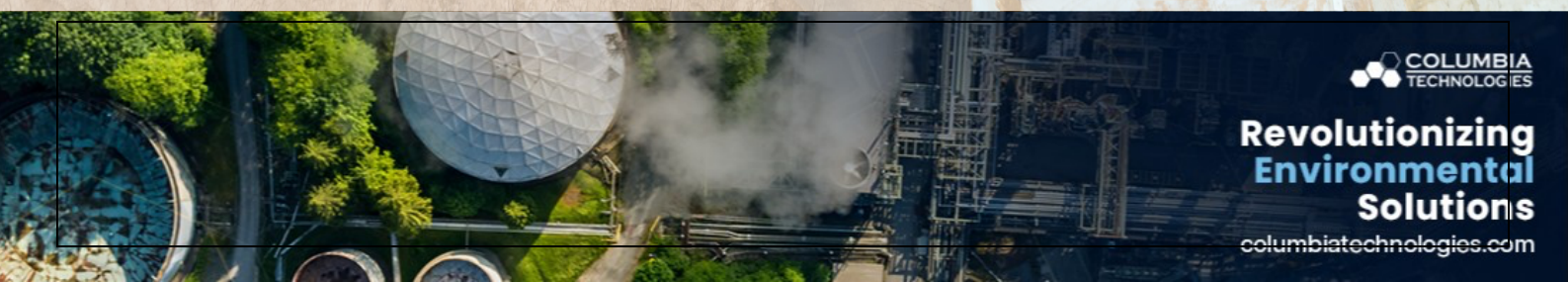
MINE DEWATERING & WATER MANAGEMENT

Optimize Dewatering Programs:

- Identify high-permeability zones requiring focused dewatering
- Map aquitards that may compartmentalize aquifer systems
- Calculate specific yield to predict dewatering volumes
- Design efficient well field layouts based on transmissivity data
- Monitor dewatering effectiveness through time-lapse measurements

Water Resource Development:

- Locate high-yield aquifer zones for process and potable water supply
- Optimize production well screen placement in highest permeability zones
- Support water rights applications with defensible hydrogeological data
- Integrate surface and groundwater resource planning



GEOTECHNICAL & SLOPE STABILITY

Pit Wall & Underground Stability:

- Identify water-saturated zones that may contribute to slope instability
- Map perched water tables and confined aquifers in pit walls
- Monitor moisture content changes in waste rock and pit slopes
- Support depressurization programs with high-resolution permeability profiles
- Characterize drainage effectiveness in real-time

Foundation & Infrastructure:

- Assess soil moisture and bearing capacity for infrastructure siting
- Characterize foundation conditions for heavy equipment and structures
- Support tailings dam and waste rock facility design

TAILINGS MANAGEMENT & DAM SAFETY

Tailings Characterization:

- Monitor settling characteristics and consolidation in real-time
- Differentiate mobile vs. bound water content in tailings
- Track pore water pressure conditions non-invasively
- Assess effectiveness of flocculants and coagulants
- Predict tailings pond lifetime and capacity

Dam Stability Monitoring:

- Detect seepage pathways and phreatic surface location
- Monitor saturation conditions in dam embankments
- Identify potential instability zones before failure
- Support ongoing dam safety compliance programs

ENVIRONMENTAL COMPLIANCE & MONITORING

Baseline & Impact Assessment:

- Establish pre-mining groundwater conditions
- Demonstrate non-impact zones for stakeholder confidence
- Monitor aquifer recovery during and post-closure
- Track contaminant migration potential through hydraulic parameter mapping

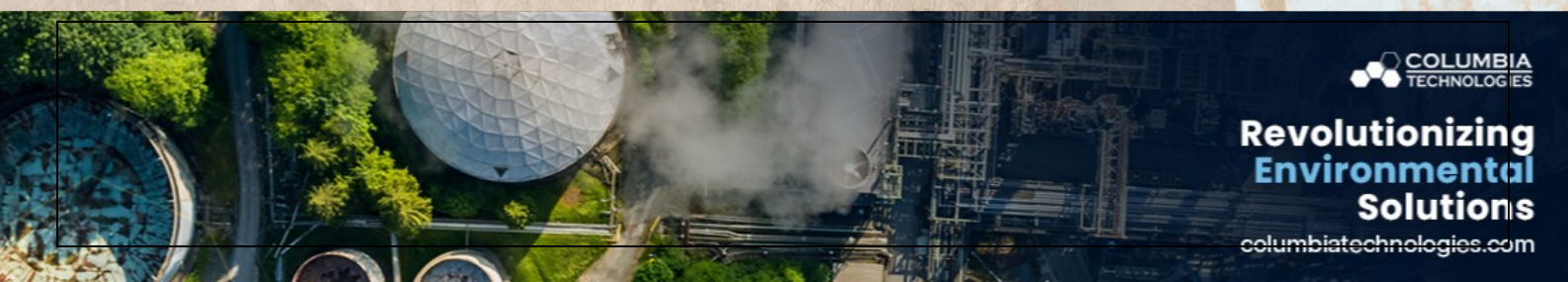
Closure & Reclamation:

- Verify effectiveness of pit lake or backfill saturation programs
- Monitor revegetation soil moisture conditions
- Support long-term closure water management plans
- Demonstrate achievement of closure objectives

NMR Technology: "Water You Can Measure"

Unlike resistivity, electromagnetic, and seismic methods that *infer* hydrogeological properties from indirect measurements, NMR directly detects and quantifies water, providing:

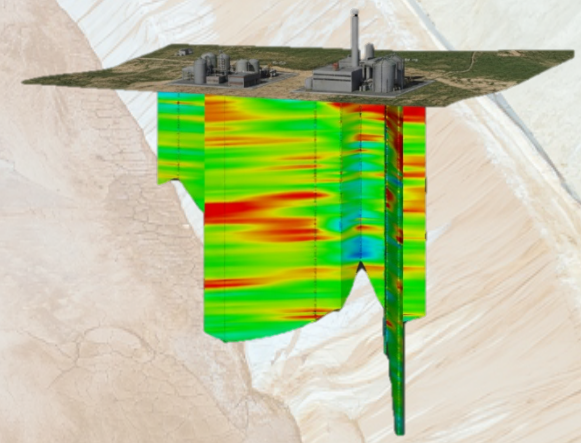
- **Total porosity** – lithology-independent measurement of all water in the formation
- **Effective porosity** – mobile water available for drainage or production
- **Bound water** – water held in clays and capillaries (non-drainable)
- **Pore size distribution** – indicates permeability and drainage characteristics
- **Hydraulic conductivity** – estimated using multiple empirical methods (SDR, Timur-Coates, Sum of Echoes)
- **Transmissivity** – quantifies horizontal water transmission capacity
- **Specific yield** – predicts drainable water volume for dewatering calculations



Better Data → Better Modeling → More Sustainable Solutions

NMR data provides the high-resolution input parameters needed for accurate groundwater flow models, geotechnical stability analyses, and environmental impact predictions. This leads to:

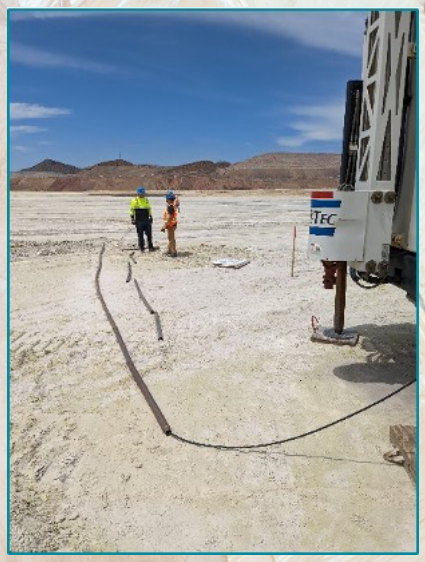
- Reduced uncertainty in mine planning
- Optimized capital and operating expenditures
- Minimized environmental footprint
- Enhanced regulatory compliance
- Improved stakeholder relationships



NMR Applications Across the Mining Life Cycle

EXPLORATION STAGE

- Preliminary hydrogeological characterization
- Resource definition for solution mining
- Baseline environmental conditions
- Water supply identification



FEASIBILITY & PERMITTING

- Detailed aquifer characterization
- Predictive dewatering modeling
- Environmental impact assessment support
- Stakeholder engagement data

CONSTRUCTION & DEVELOPMENT

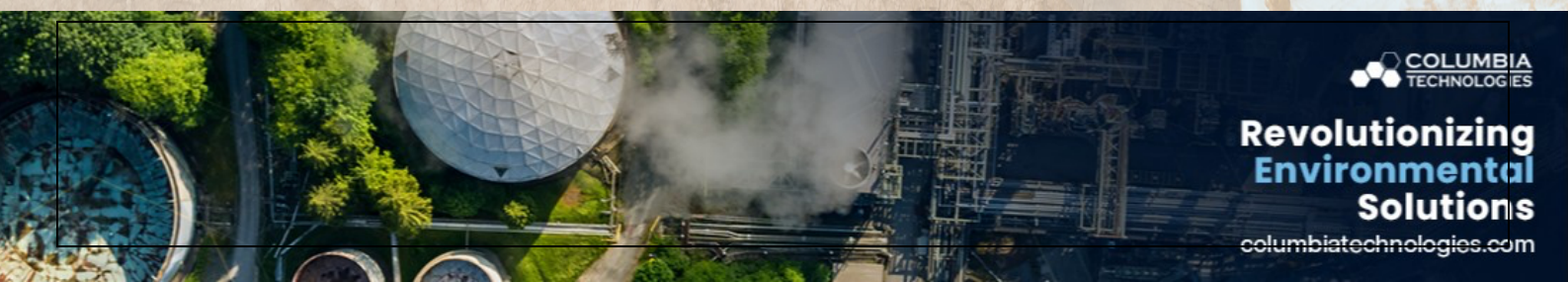
- Dewatering system optimization
- Foundation characterization
- Slope stability monitoring initiation
- Water management infrastructure siting

OPERATIONS

- Continuous dewatering performance monitoring
- Solution mining optimization (ISR, heap leach)
- Tailings management and dam safety
- Process water supply management
- Environmental compliance monitoring

CLOSURE & POST-CLOSURE

- Pit lake filling and aquifer recovery monitoring
- Long-term environmental monitoring
- Reclamation effectiveness verification
- Water quality trend assessment



Commodity-Specific Applications

BASE & PRECIOUS METALS

- Dewatering optimization for open pit and underground operations
- Tailings consolidation monitoring
- Acid rock drainage pathway characterization

COAL

- Mine water management and methane drainage
- Overburden and spoil pile moisture monitoring
- Slurry impoundment characterization

INDUSTRIAL MINERALS

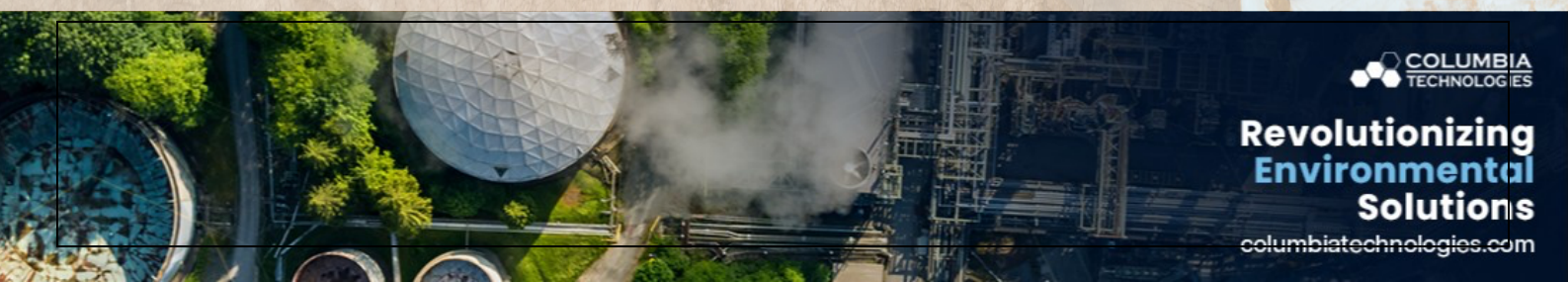
- Solution mining resource assessment (potash, trona)
- Cavity and brine characterization
- Aquifer protection and monitoring

LITHIUM, COPPER & URANIUM (ISR)

- Target aquifer permeability and porosity mapping
- Confining layer verification
- Leach solution distribution optimization
- Production zone monitoring
- Quantitative lithium content determination in brines (^{7}Li NMR)

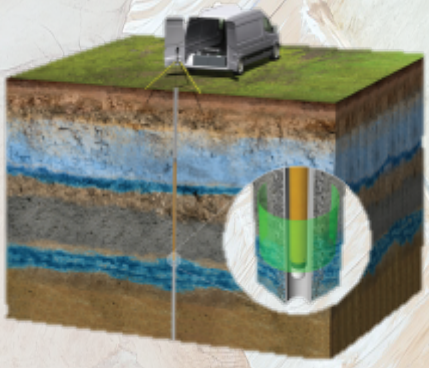
IRON ORE & PHOSPHATE

- Dewatering of high-grade zones
- Slurry pipeline routing optimization
- Beneficiation water management



Integration with Your Existing Programs

Vista Clara's NMR technology seamlessly complements and enhances conventional exploration and monitoring methods



- **Drilling programs** – provides continuous high-resolution data between core samples
- **Geophysical surveys** – adds direct quantitative measurements to indirect geophysical interpretations
- **Pump testing** – extends point measurements to continuous profiles; reduces testing requirements
- **Hydrochemistry** – identifies sampling intervals and characterizes flow zones
- **Piezometer monitoring** – provides formation property context for pressure measurements
- **Geotechnical testing** – bridges the gap between lab-scale and field-scale measurements

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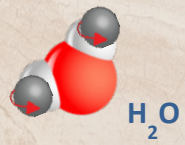
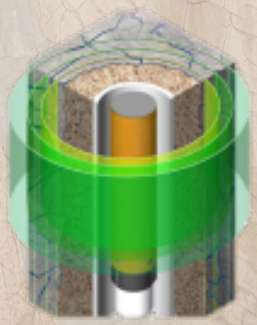
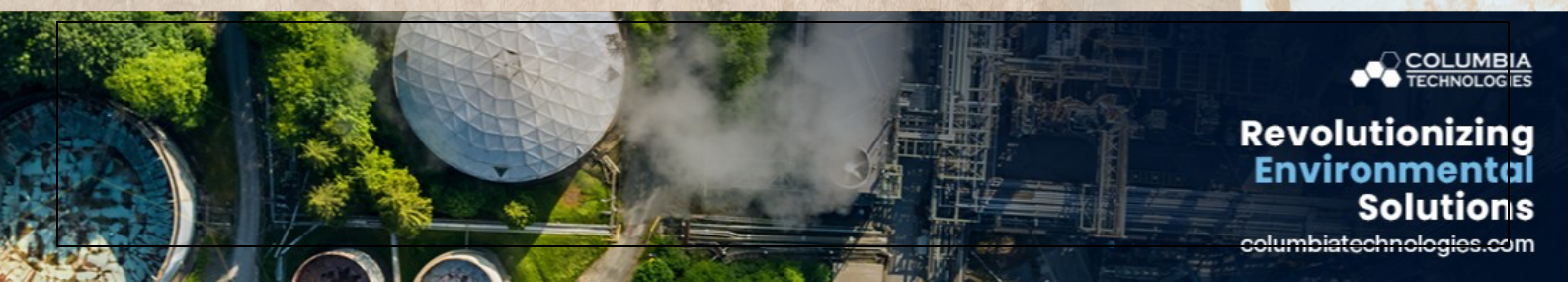


Our commitment:

- Collaborative project execution with your technical teams
- Transparent data interpretation and reporting
- Solutions aligned with international mining standards and best practices
- Technology transfer and training for ongoing monitoring programs





Proven Technology, Real Results

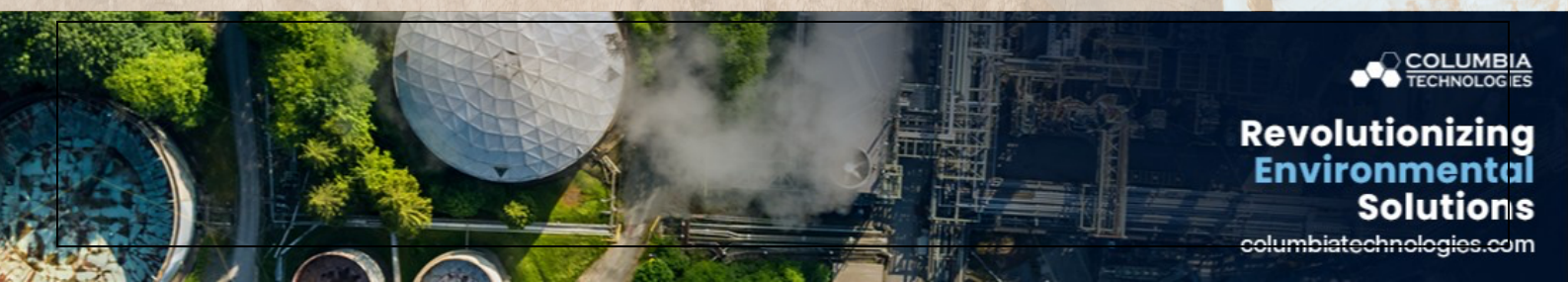
NMR has been successfully deployed in mining operations worldwide:

- **Australia**: In-situ uranium mining aquifer characterization (Alligator Energy, Samphire Project)
- **Canada**: Oil sands tailings settling optimization
- **United States**: Lithium brine exploration and resource definition (Clayton Valley, Nevada)
- **South America**: Copper solution mining and heap leach operations
- **Global**: Hundreds of mine sites for dewatering optimization and slope stability monitoring Case studies demonstrate:
- Up to 50% reduction in dewatering costs through targeted well placement
- Real-time tailings management reducing storage requirements
- Slope stability improvements through enhanced drainage characterization
- Faster permitting through superior baseline characterization
- Increased resource recovery in solution mining operations

Ready to Optimize Your Mining Operation?

Whether you're exploring a new deposit, optimizing dewatering, managing tailings, ensuring slope stability, or demonstrating environmental compliance, Columbia Technologies and Vista Clara provide the subsurface intelligence that transforms uncertainty into operational

excellence.



Let's discuss how NMR can strengthen your next project.

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Vista Clara Inc. supplies the NMR instrumentation and technical support for these applications. Columbia Technologies serves as consultant and representative and service provider in Brazil and Latin America.