

Variable Density Charging and other Technologies towards Improved Blasting

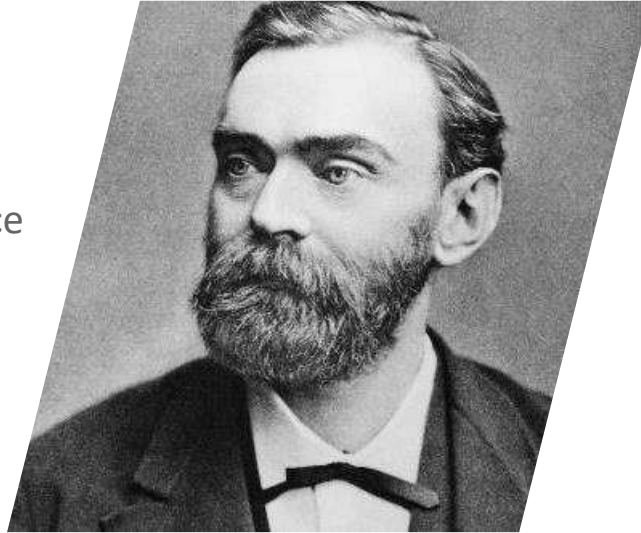
**EXPLOSIVES &
BLASTING WORKSHOP**

South Africa, 2025



Who we are

Alfred Nobel founded the SED *Sociedad Española de la Dinamita, Privilegios A. Nobel* with their head office in Galdácano, Bilbao.



1872

The major Spanish explosive manufacturers merge to create *Unión Española de Explosivos*.



1896

1994

After undergoing a restructuring process, a period of **consolidation and international expansion** begins, extending throughout the five continents

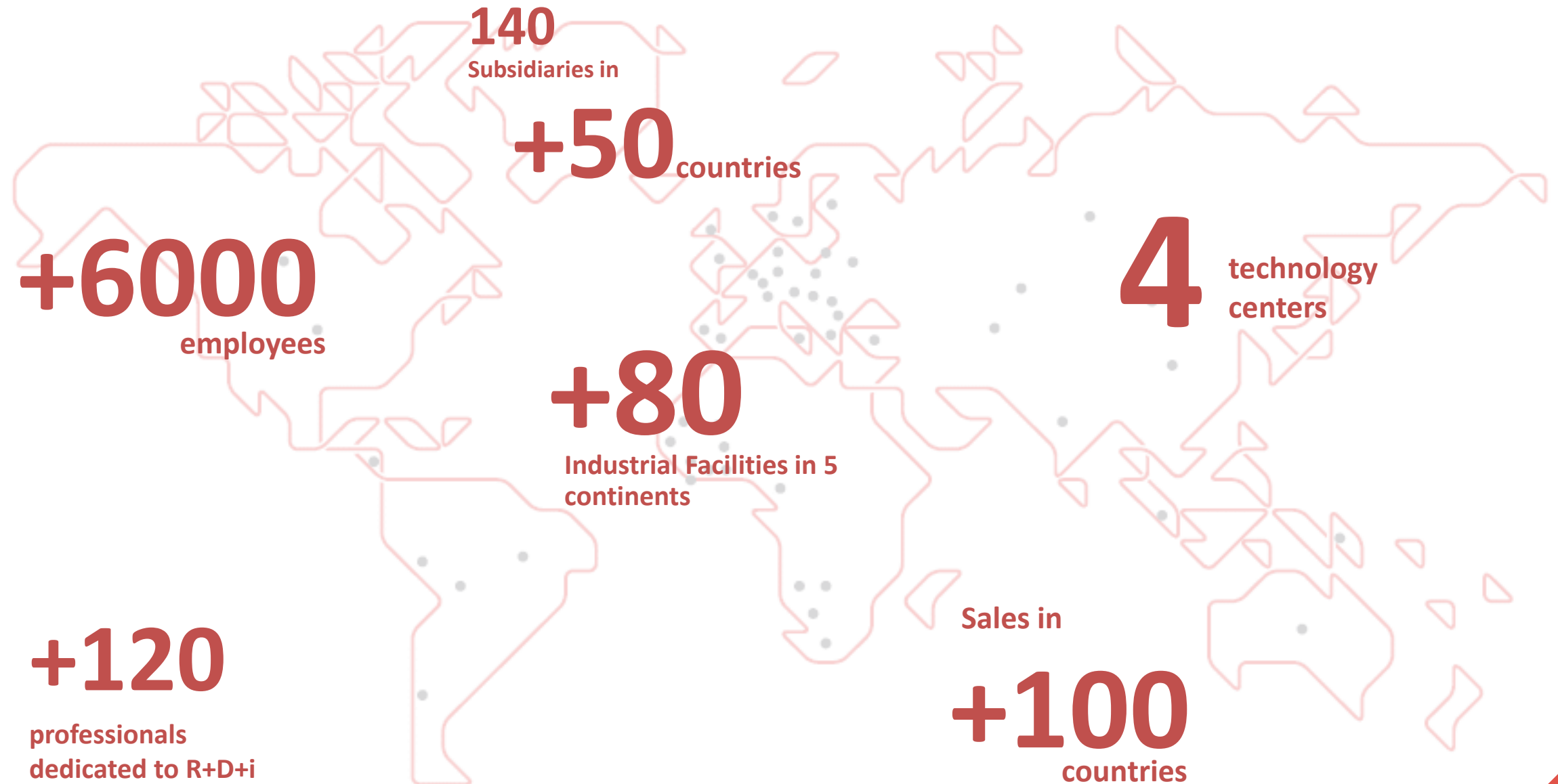
2006

UEE changes its name to

MAXAM

2024

MAXAM now has 140 subsidiaries **operating in over 50 countries** and commercial operations in more than 100.



Teck

BHP



BARRICK



RioTinto

IAMGOLD[®]
CORPORATION

GLENCORE



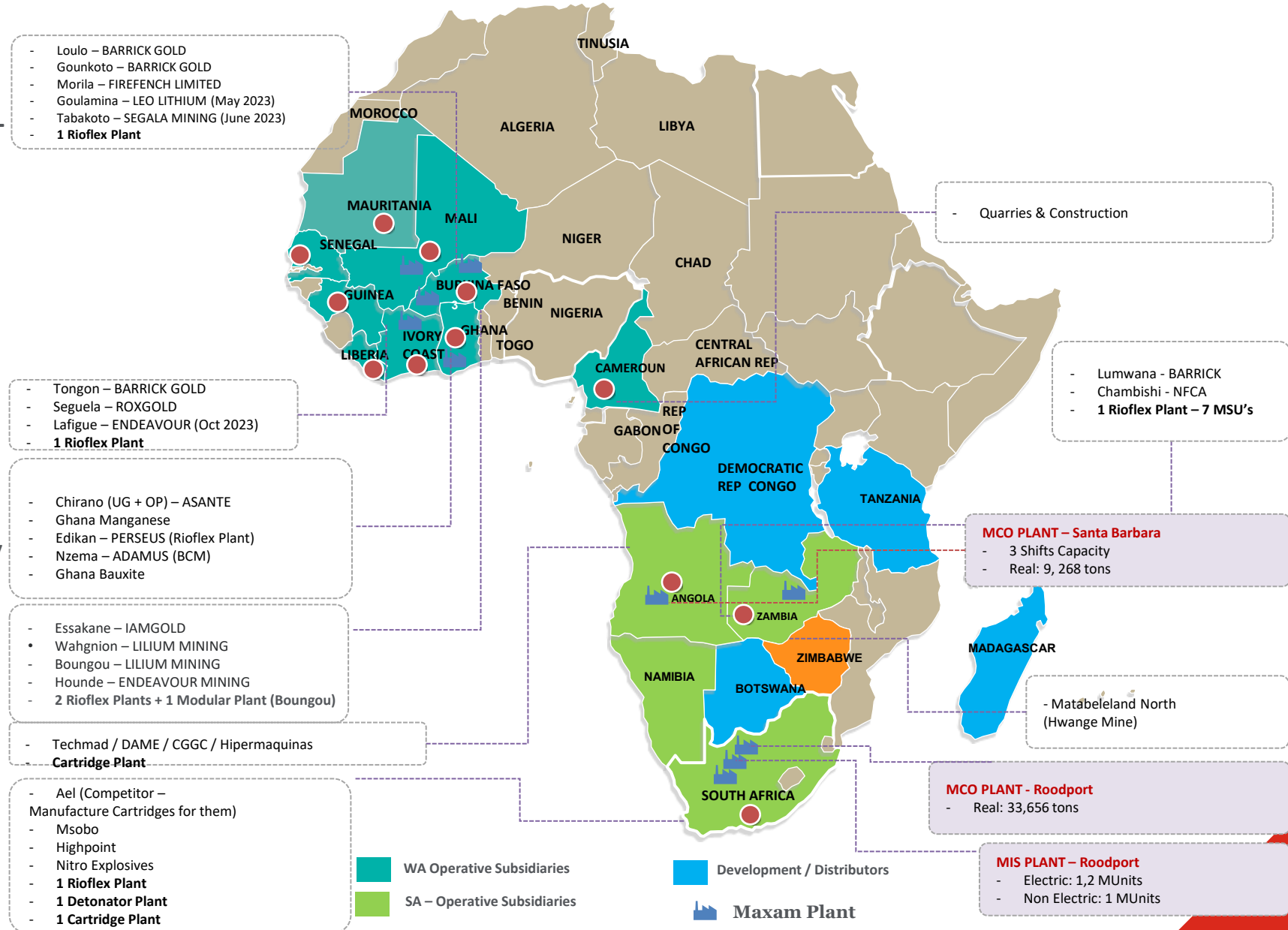
Terrafame

Regional Footprint

MAXAM

A global Blasting Solution provider –
Leader in WA

- **People:** More than 700 talented and committed people
- **18 mining operations** under contract in West Africa
- **11 Manufacturing plant in the Region :** Rioflex, high energy and premium, Watergel explosives
- **More than 40 operative MSUs:** to supply all our mining operations in the Region with back up
- **Reliable supply:** thanks to our regional and worldwide footprint
- **FQML is a strategic customer** for MAXAM to explore possibilities for partnership & generate added value.

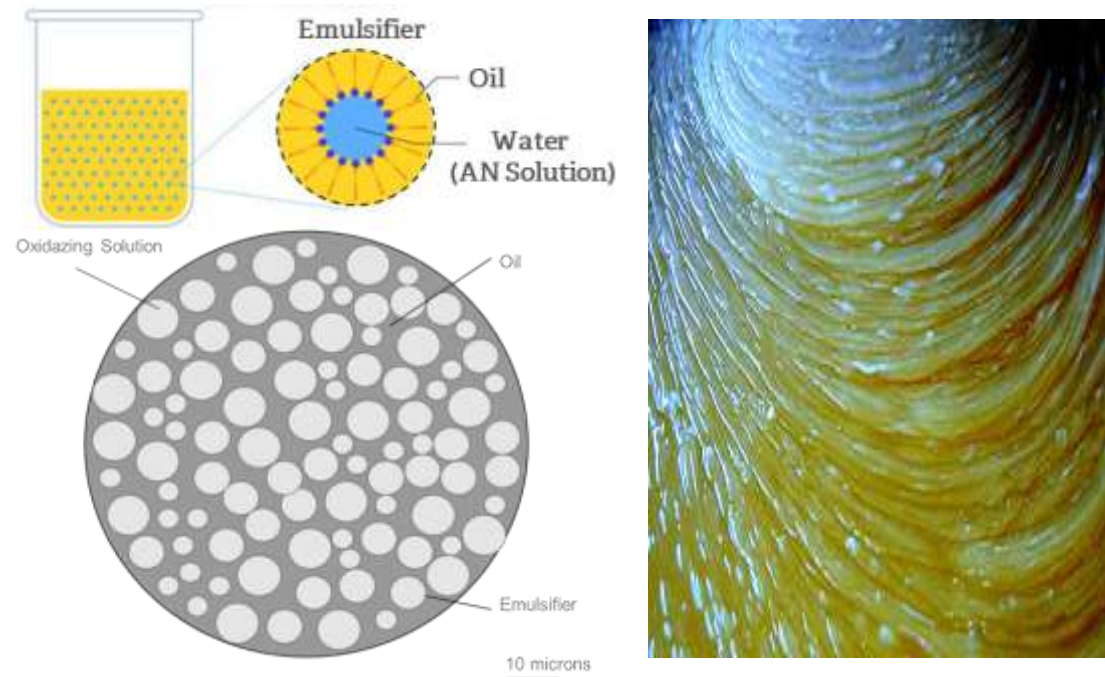


X RIOFLEX: Special Applications

RIOFLEX Overview | Introduction

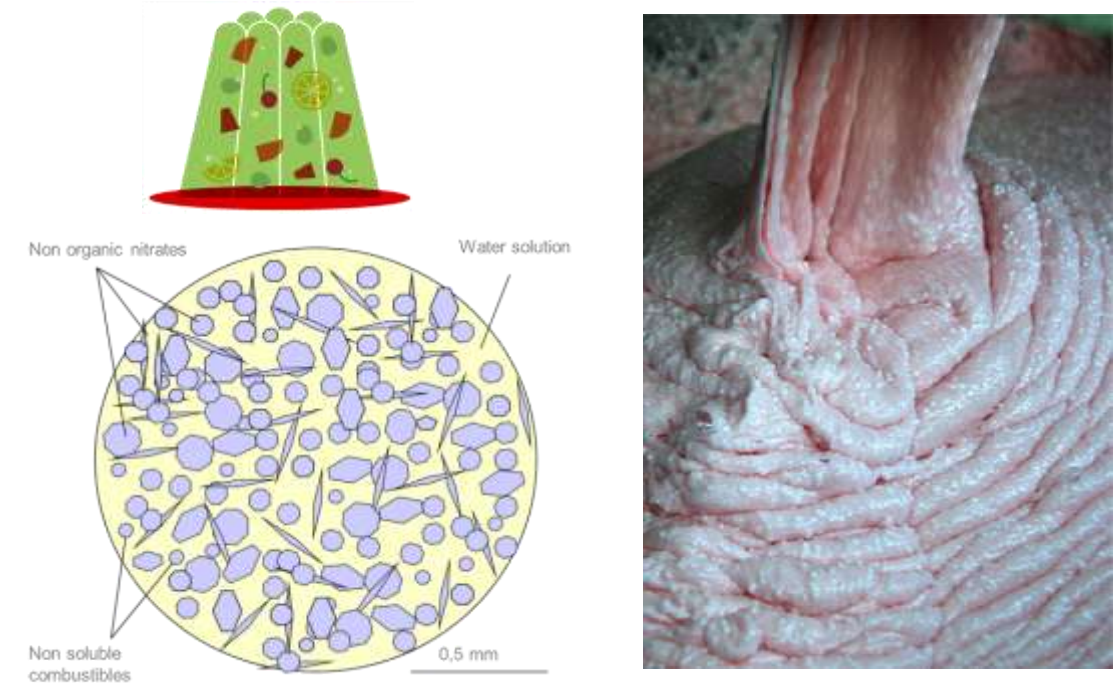
Different families of Explosives:

Emulsion: metastable state



Explosive emulsions are water-in-oil type emulsions

Suspensions (RIOFLEX) are in thermal equilibrium



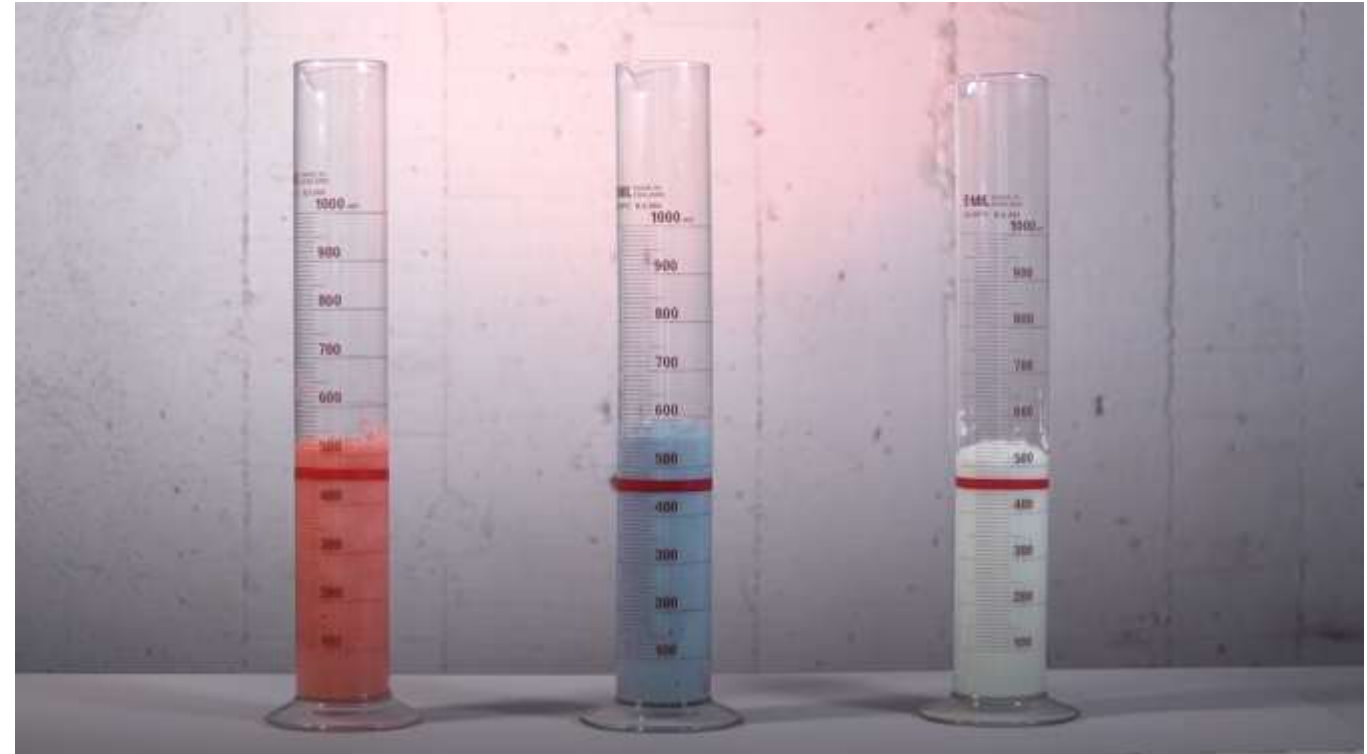
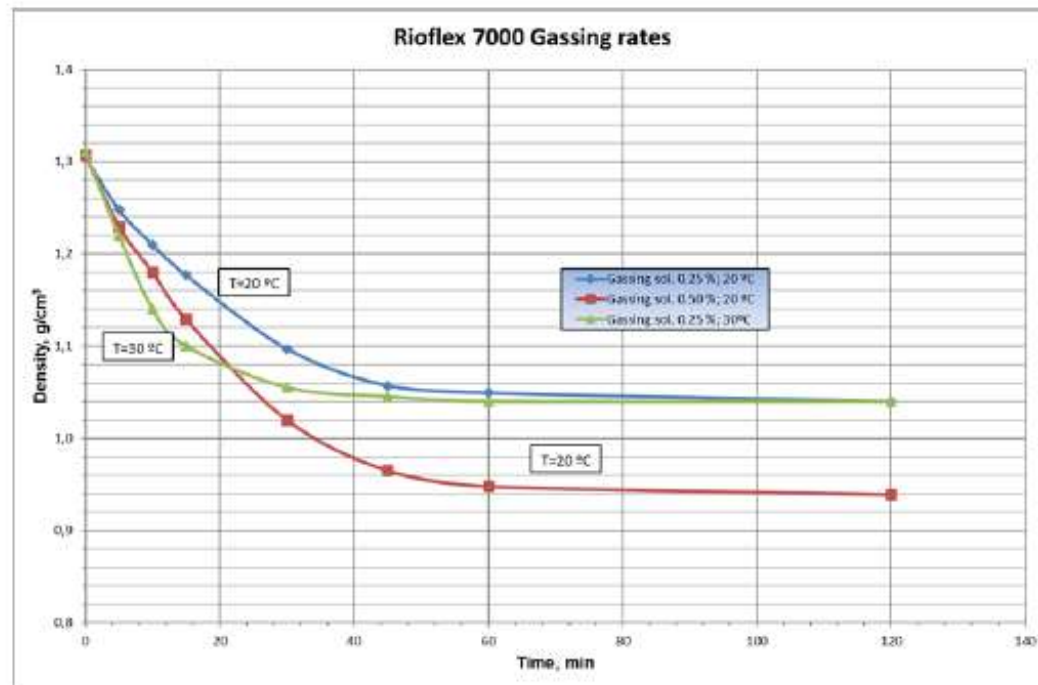
Very fine crystals of ammonium nitrate in a thickened aqueous solution of ammonium nitrate.

RIOFLEX Overview | Flexibility in Gassing

Chemical Gassing: RIOFLEX GX

Chemical reaction of NaNO_2 .
Same than emulsions.

Waiting time to load the stemming.
Less accurate control of stemming height



Rioflex GX is has higher range of
densities than emulsions

RIOFLEX Overview | Flexibility in Gassing

Mechanical Gassing: RIOFLEX MX

Rioflex not only can be chemically gassed it can also be mechanically gassed.

This kind of gasification allows for quality control before product delivery, controlling the precise density and the stemming height.

By reducing the dilution and flyrock events, more control and increased safety is achieved.

Rioflex MX is delivered at final density

Range of densities:

Rioflex 7000 pumped: 0.9 -1.35 g/cm³

Rioflex 5000 (Heavy ANFO auger): 0.7-1.3 g/cm³



RIOFLEX Overview | Flexibility in Gassing Instantaneous sensitization by CAS

MAXAM latest Patent on sensitization with compressed air:

- Available for pumped and augered products
- Widest range of densities
- Change density instantaneously (meter by meter)
- Delivered at final density and instantaneous crosslinking

RIOFLEX SMART



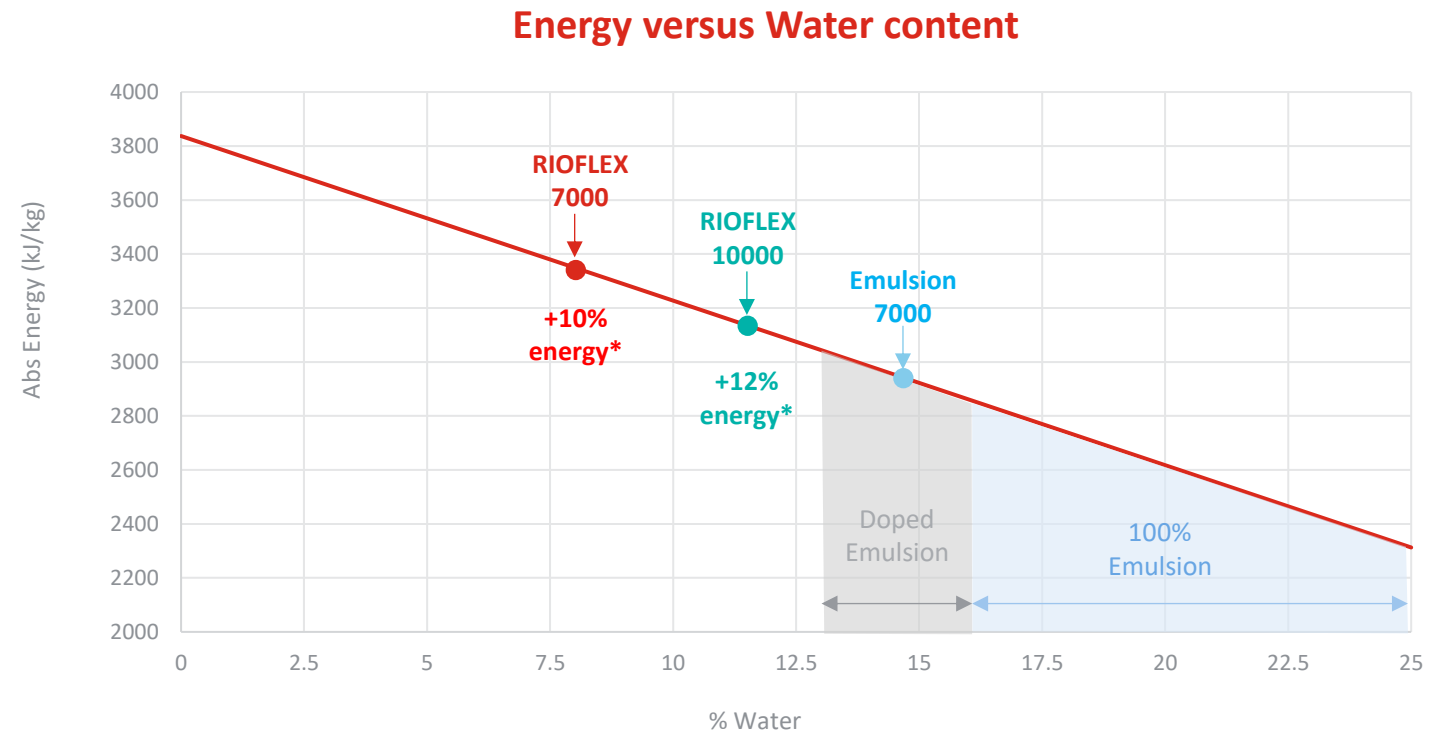
RIOFLEX SMART
Selective Loading

RIOFLEX Overview | Energy Output

Approximate calculation of Heat of Explosion for water-based explosives

For thermochemical calculations, the difference of an emulsion and ANFO is the water content

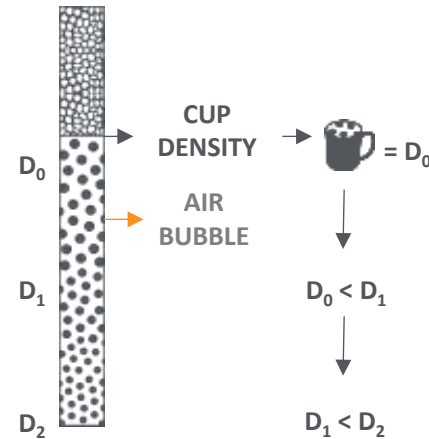
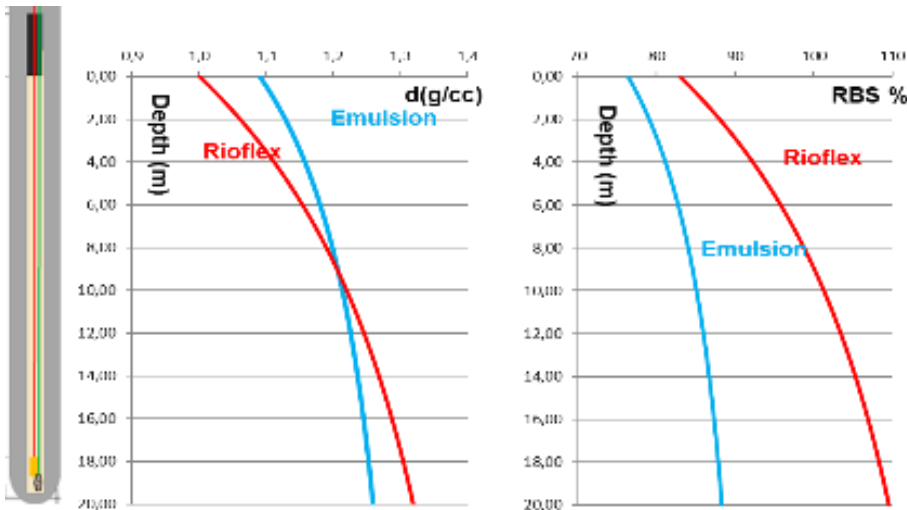
RWS	% Water	Abs Energy (kJ/kg)	Examples
100	0	3837	
92	5	3532	
87	8	3349	RIOFLEX 7000
84	10	3227	
82	11.4	3140	RIOFLEX 10000
79	13	3044	Doped Emulsion
78	14	2983	
76	15	2922	
75	16	2861	
73	17	2801	100% Emulsion
71	18	2740	
70	19	2679	
68	20	2618	
67	21	2557	
65	22	2496	
63	23	2435	
62	24	2374	
60	25	2313	



*in comparison with the standard emulsion 7000.

RIOFLEX Overview | Better energy distribution in the hole

- **Rioflex** matrix density: 1.5 g/cm^3
- **Emulsion** matrix density: 1.3 g/cm^3



RIOFLEX INTRINSIC VALUE

✗ Limit density

RIOFLEX BENEFITS

✗ More energy at the bottom

CUSTOMER BENEFIT

- ✗ Drilling cost reduction (€/T)
- ✗ Mining equipment maintenance (€/Unit)
- ✗ Better Floor level
- ✗ Loading and hauling cost reduction (€/T)

More energy at the bottom

Rioflex limit density is higher than an emulsion, allowing more energy at the bottom.

RIOFLEX Overview | Cross-Link

Rioflex is cross-linked; a viscous liquid which solidifies in the hole.

The application of the product is robust, avoiding product migration through cracks in the rock and stemming dilution.

This way MAXAM avoids uncontrolled blasts, minimizes flyrocks, and reduces post-blast fumes and waste generation.

All in all, operations health and safety is visibly improved.

In MAXAM we synthesize our own Xlinkers:

Different Xlinking rates: **Slow or Fast Crosslink**



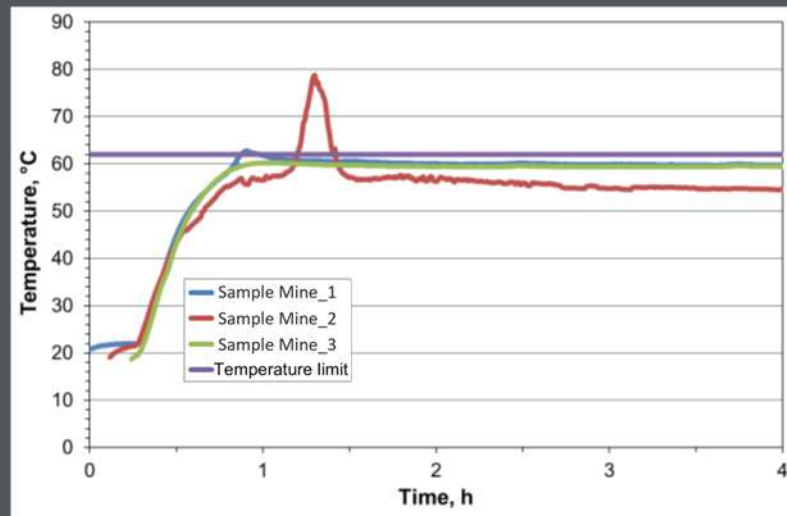
RIOFLEX Overview | Reactive Ground

RIOFLEX is intrinsically inhibited

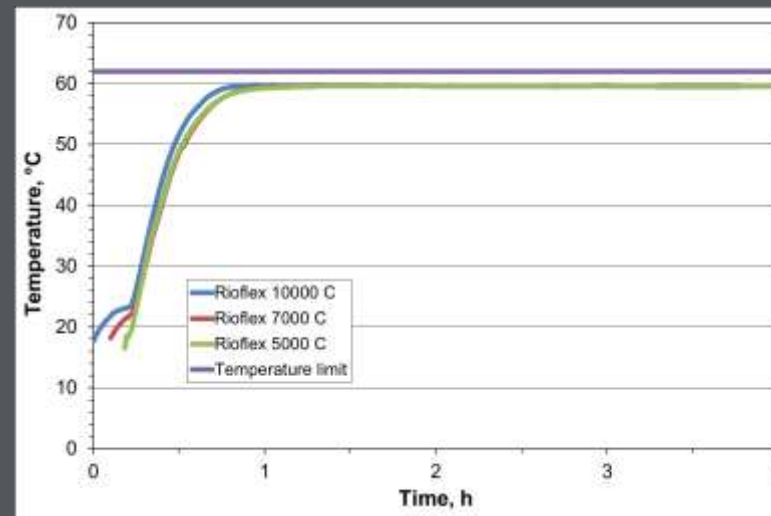
While emulsions require different formulations for reactive ground, hexamine nitrate based **RIOFLEX is inhibited**, not needing to add additives like Urea in the emulsions that reduce the energy of the explosive when used in reactive grounds.

Case Study: Reactive Ground Study in an Open Pit Copper Mine (2017)

An earlier study carried out by MAXAM's R&D department in 2017 to determine the inhibition degree of RIOFLEX 10000 c, RIOFLEX 7000 c and RIOFLEX 5000 c with the reactive ground samples from an Copper mine in Zambia.



Different reactive samples with AN; Samples 2 & 3 react exceeding the Temperature Limit



The most reactive (sample 2) with RIOFLEX blends not reacting and not exceeding the Temperature Limit

All the RIOFLEX samples were inhibited enough for the maximum recommended sleeping time (7 days), as no temperature increase above the temperature limit, or any sign of reaction was observed during the duration of the test (32 days).

RIOFLEX Overview | Properties

	Physical (EMUNEX)	Chemical Gassing (RIOMEX) (RIOFLEX GX)	Mechanical Gassing: Natural Air Catching (RIOFLEX MX)	Mechanical Gassing: CAS (RIOFLEX Smart)
Density distribution	Ideal	Gradient	Gradient	Gradient
Stemming control	Final density	Waiting time	Final Density	Final density



RIOFLEX Overview | Energy Output

The most **energetic, robust and flexible** bulk explosive technology



Flexible Density 0.60-
1.35 g/cm³

Higher Energy
RBS 73-222%

Selective Energy &
Loading

Single Matrix

Mechanical & Chemical
Sensitization

Crosslinking - Cracks
Migration

Energy Profile inside the
borehole

Wall Damage control

Reactive Ground
Inhibited



X-ENERGY | RIOFLEX Smart

X-ENERGY
maxAM



RIOFLEX SMART

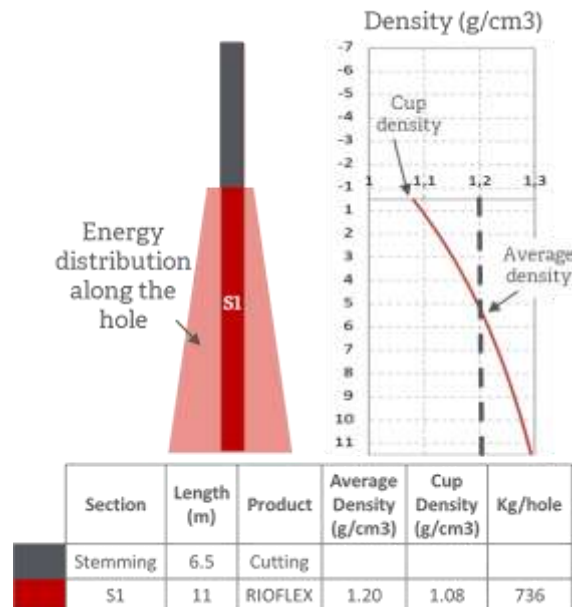


X-ENERGY | Selective Loading - Adaptation of the Explosive's density

Equalizing the Energy Distribution along the borehole through dual density

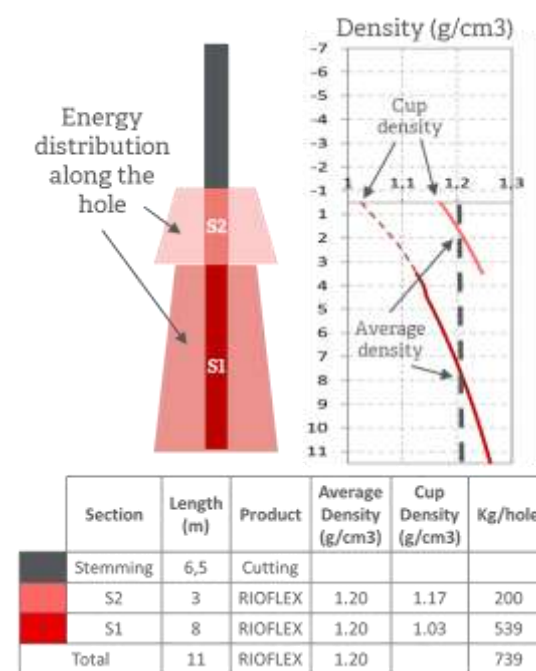
RIOFLEX

Zone 1: Baseline (single density)

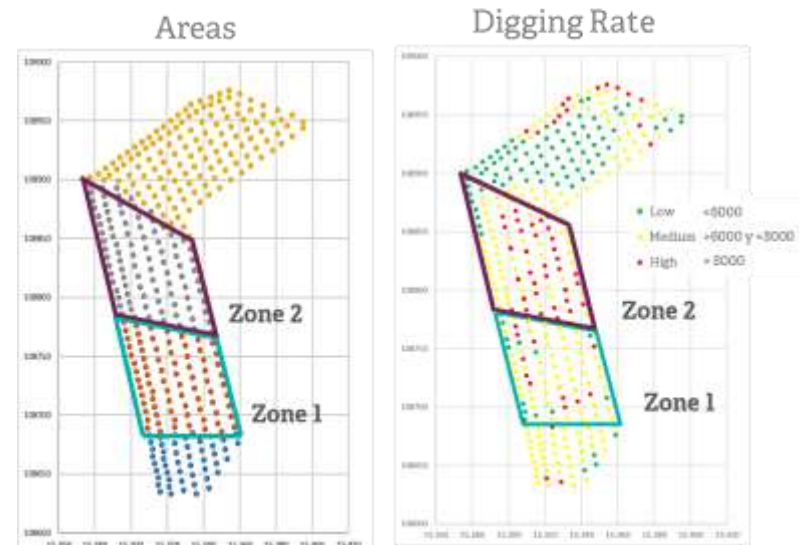
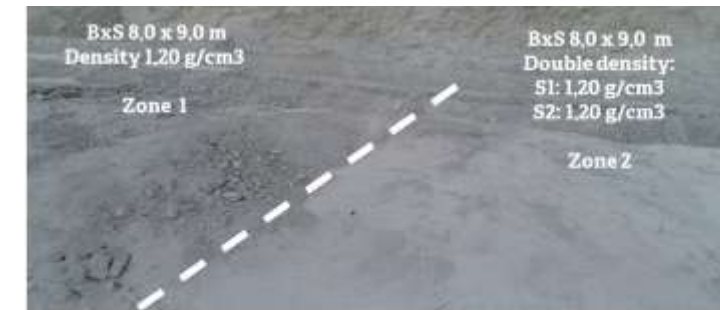


Smart RIOFLEX

Zone 2: Blast with dual density



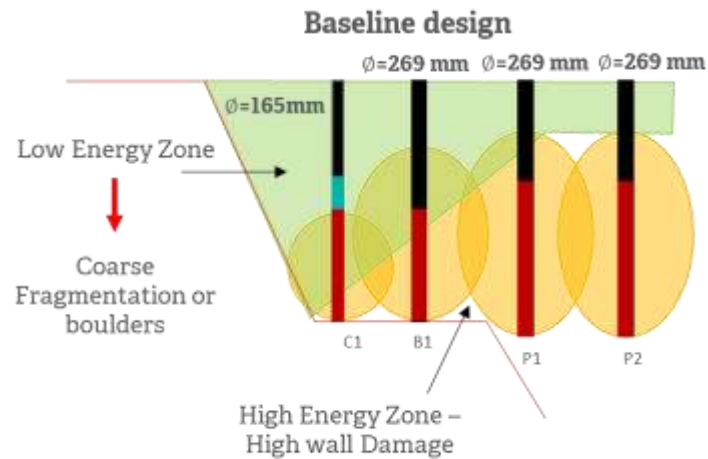
Improvement in the upper fragmentation zone (stemming zone) without increasing the total explosive amount in the hole, leading to digging improvements.



X-ENERGY | Selective Loading - Adaptation of the Explosive's density

Reducing wall damage and improving slope stability lowering density

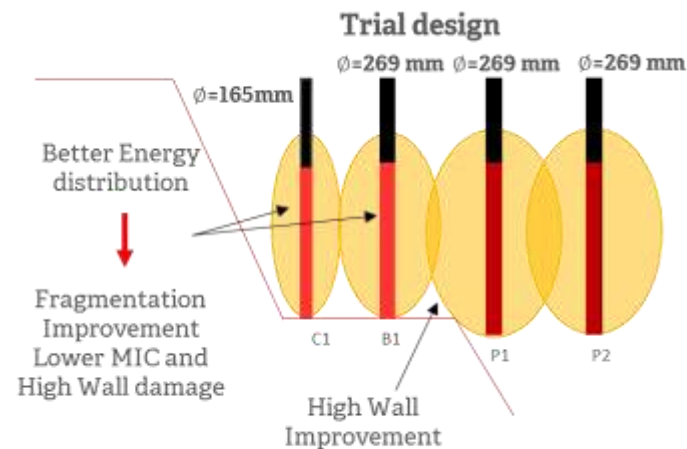
RIOFLEX



Contour holes: Previous design

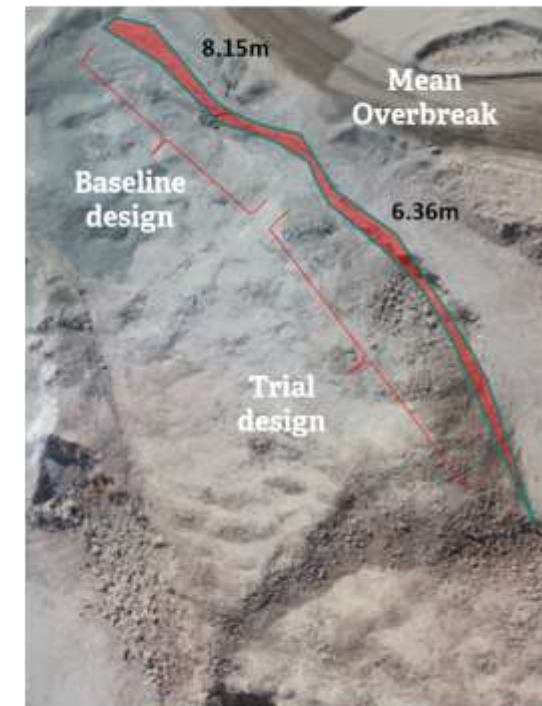
Section	Length (m)	Product	Density (g/cm ³)
Stemming	6	Cutting	-
Air Deck	2	Air	-
S1	8.5	RIOFLEX	1.20

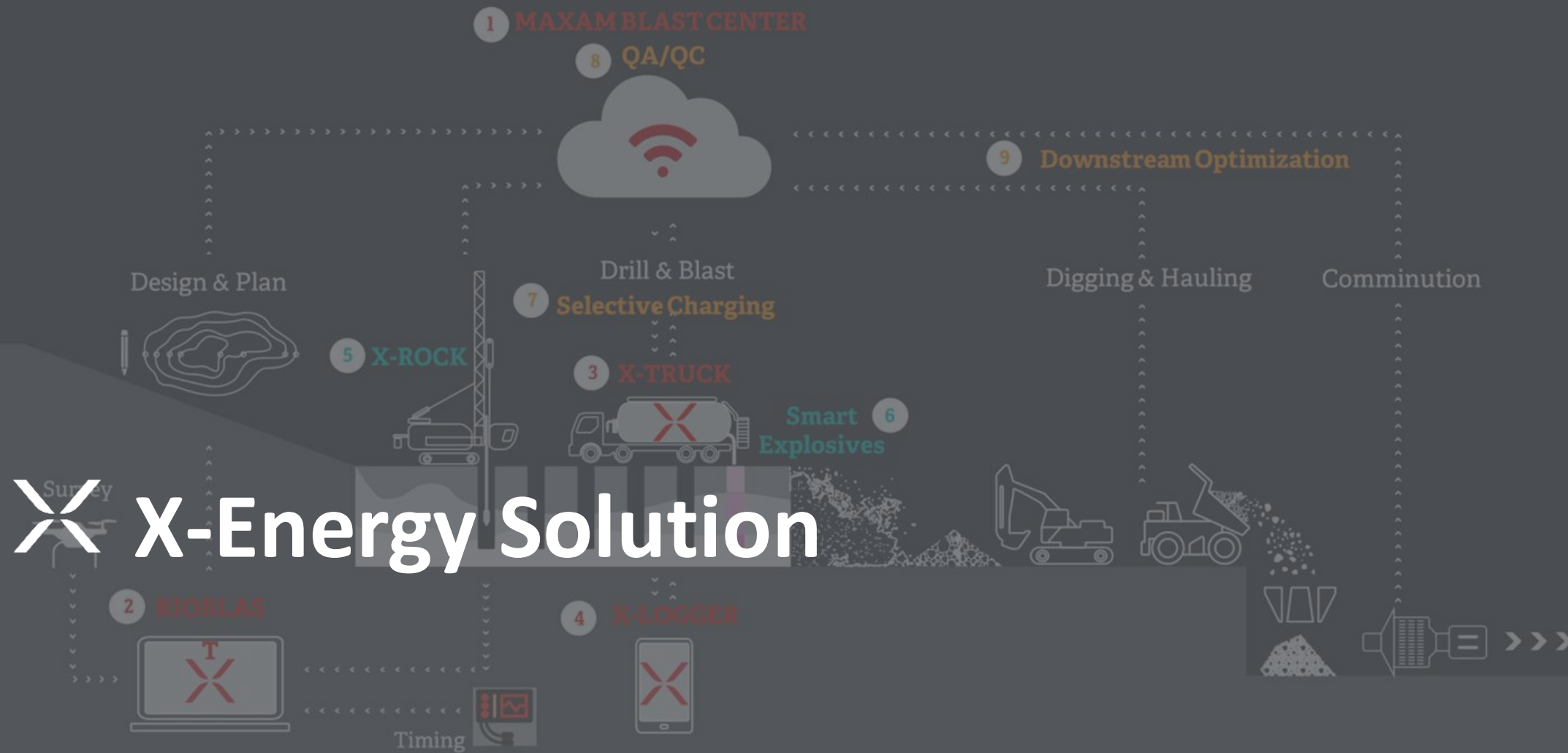
Smart RIOFLEX



Contour holes: Trial

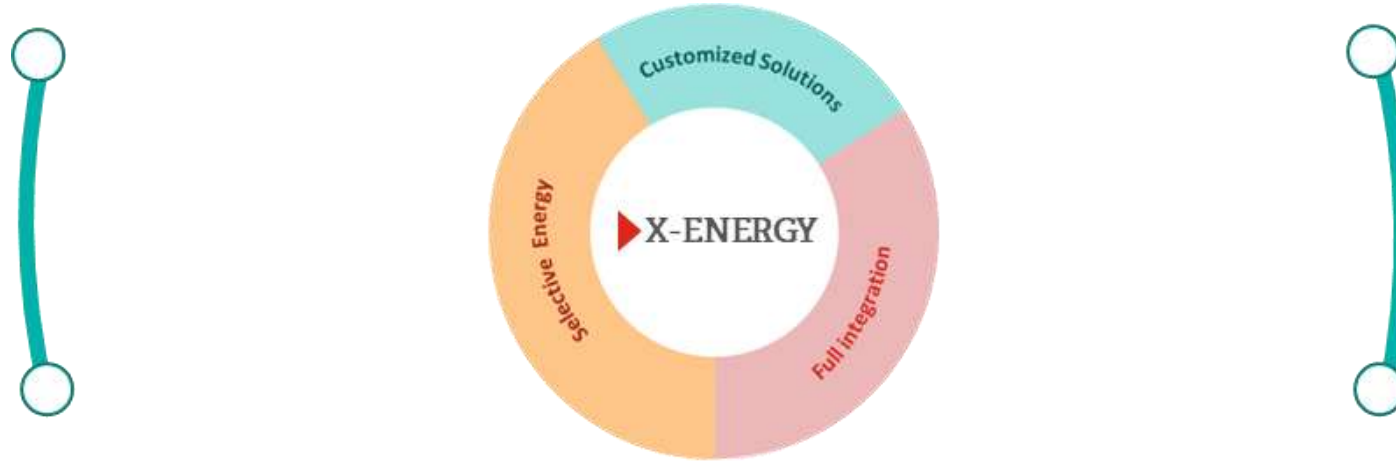
Section	Length (m)	Product	Density (g/cm ³)
Stemming	6.5	Cutting	-
S1	10	RIOFLEX	1.05





X-ENERGY Solution

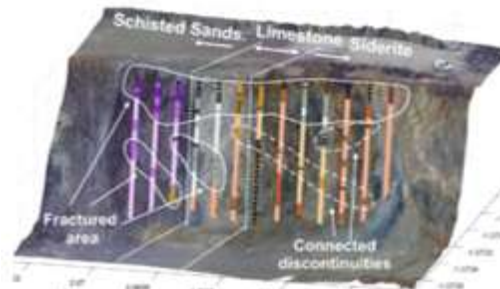
Integration of selective energy application in a fully digitalized mining cycle.



Main components:



RIOFLEX SMART



X-4TRAITS



SELECTIVE LOADING



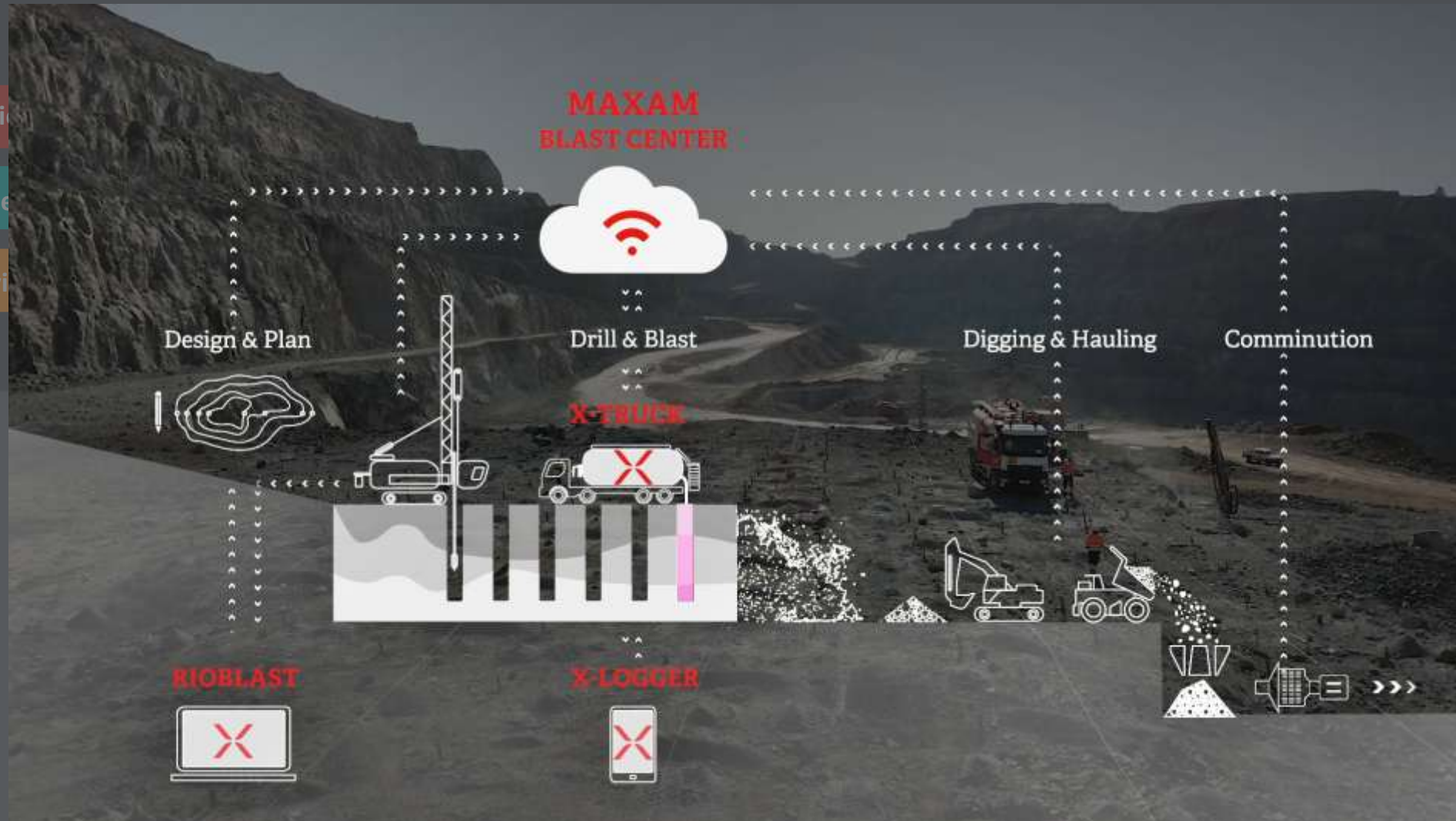
DIGITALIZATION

maxam

X Digitalization



X-ENERGY | Digital Tools



X-ENERGY | Digital Tools



MAXAM BLAST CENTER



Cloud-based management center that enables digitization, traceability and analysis of the D&B process



X-TRUCK



It is the new generation of fully digitized MSUs connected with 5G network.



X-LOGGER



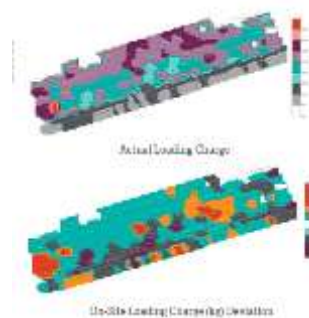
Portable device for field use



RIOBLAST



Blasting design and simulation software



Integrates fleet management.
Receiving data from the D&B process.
Analysis, management of D&B process data
Monitoring the progress of the D&B process
Create custom reports.
Integrates data with customer systems.



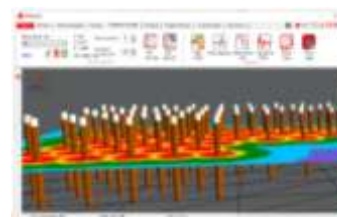
Automate loading process without human interaction.
Perform selective explosive charge.
Synchronize charging data in real time.
Remote access to check truck status.
GPS connectivity.
Perform predictive maintenance.



Perform drilling audit:

- Short/long wells
- Water level
- Deviation in X,Y.

Real-time drilling progress tracking | Explosive loading data analysis
| Off-line operation | Adaptable to the needs of the operation |
Easy to implement and intuitive



User-friendly interface
Built-in 3D design environment
Multi-density loading possibilities
Electronic timing design
Advanced simulation modules
Integration with BLAST CENTER

X X-4Traits and Selective Loading

X-ENERGY | X-4Traits - Automatic rock characterization from drilling data

Digitaliza

New Technolog

Customized Ser



X-ENERGY | Selective Loading - **Adaptation of the Explosive's density**



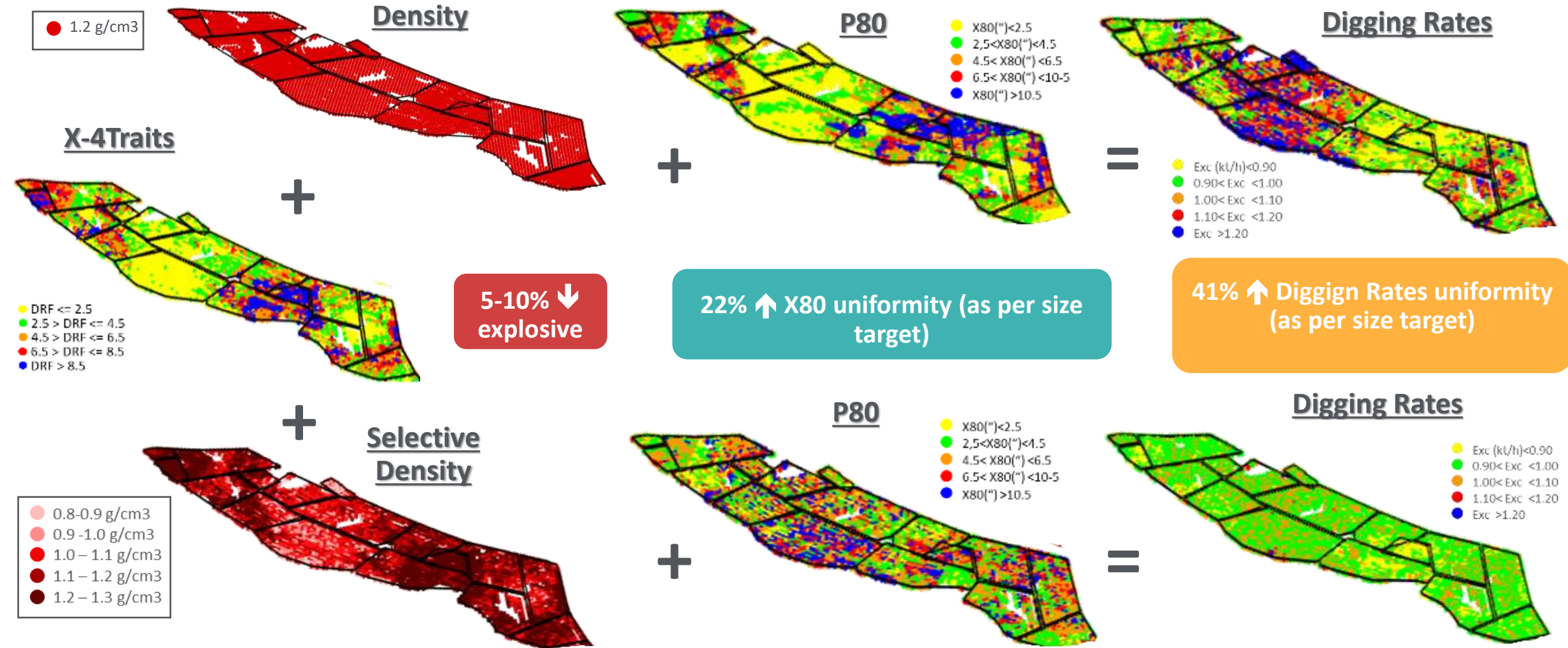
Digitaliza

New Technolog

Customized Ser

X-ENERGY | Selective Loading - Adaptation of the Explosive's density

Density distribution along of the blast based on rock properties



X-ENERGY & X2Mill Solutions | Selective Loading application in a fully digitalized mine cycle

Main Benefits

✕ Sustainable long-term optimization program



... by aligning the selective application of the explosive's energy with a consistent digital integration, which is key for mining long-term objectives and optimization.

✕ Optimized rock fragmentation and heave



... by matching the explosive's density to the actual rock conditions, via X-4Traits and RIOFLEX Smart, to optimize balance between shock and heave energies.

✕ Improved wall control and slope stability



... by using lower explosive's density and energy, optimized blast design and timing, to minimize wall damage and back break.

✕ Downstream savings in comminution



... by optimizing ore fragmentation according to the specific comminution requirements, both plant energy and throughput can be improved.

✕ Enhance mining productivity



... by improving instantaneous digging rates due to better fragmentation size distribution and muckpile shape.

✕ Full digitalized process and integration



... by deploying a reliable digitalization strategy, both safety and QA/QC initiatives improves, a part of being key for D&B optimization



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