

# Nouveaux développements dans le domaine de l'instrumentation nucléaire pour améliorer l'extraction et la récupération de l'Uranium

*Journées Uranium, Orsay le 20/01/2022*

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## 1. Orano Mining

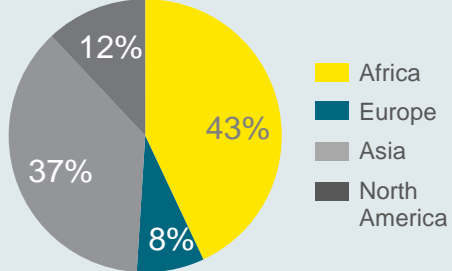
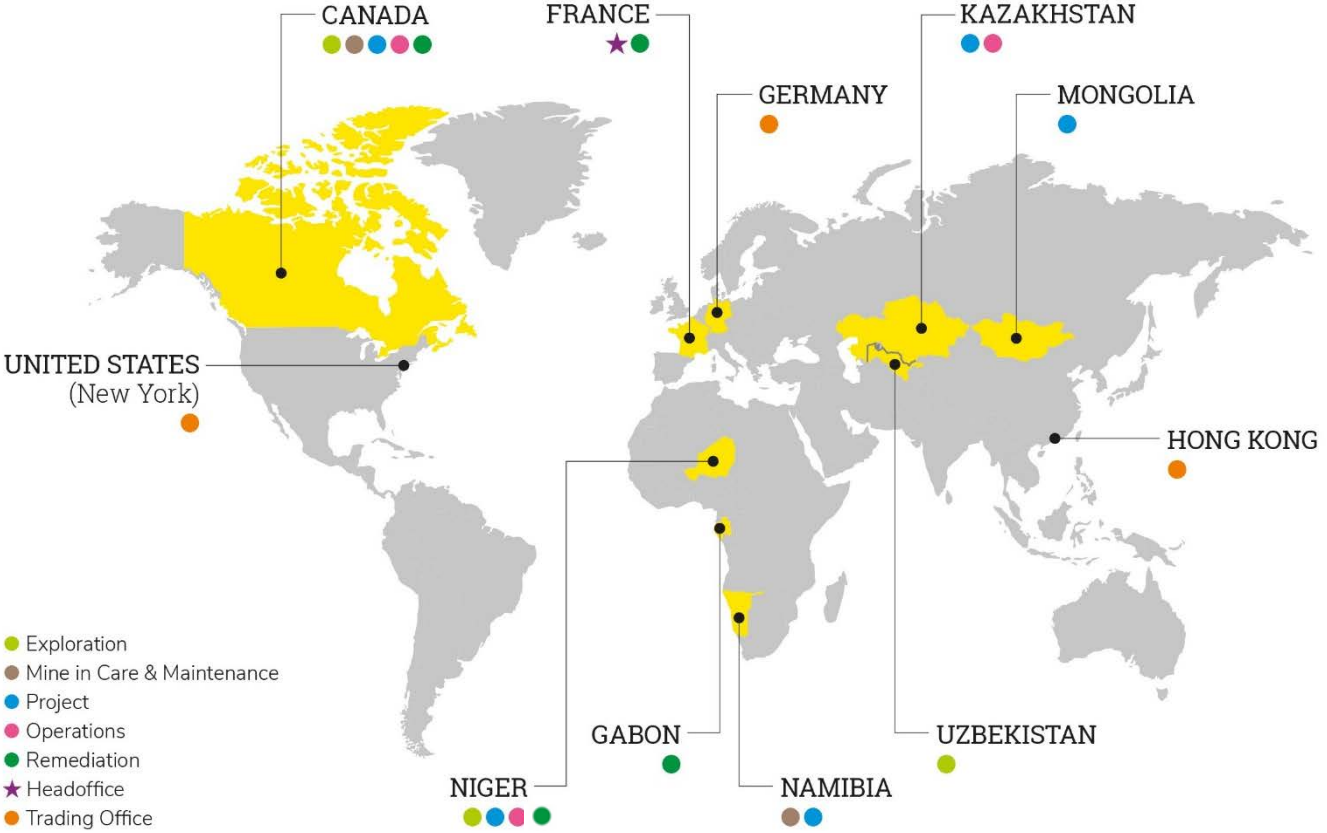
- General presentation
- R&D Overview

## 2. Needs in nuclear measurement in U mine

- Global overview along the mining process
- Examples : In diagraphy, mining extraction, process control

## 3. Conclusions

# AN INTERNATIONAL PRESENCE



**3445**

**EMPLOYEES**

98% LOCAL RECRUITEMENT










**OUR COMMITMENT TO COMMUNITIES**

MAINTAIN A HIGH LEVEL OF LOCAL RECRUITEMENT (MINIMUM 95%)

# R&D: Portfolio mapping

## Contributing to the Mining BU Strategy

- Profitability of our operations and projects
- Access to new resources
- Responsible Mining Player

	SHORT TERM INNOVATIONS	PRODUCTION SUSTAINING AND DEFENSIVE R&D	NEW MEANS AND NEW TOOLS	NEW RESOURCES
<b>DIGITAL MINE</b>	<p>Connected geologist Drones</p> 	<p><b>ISR</b></p> <p>Geological modeling Instrumentation</p>	<p><b>GEO</b></p> <p>Geochemistry Geophysics, Geostatistical</p>	<p>Geology Metallogeny: Roll fronts, Athabasca</p>
<b>MINES</b>	<p>Digital Mine</p> 	<p>ISR reactive transport</p> 	<p><b>SABRE</b></p> <p>SABRE</p> 	
<b>TREATMENT PROCESSES</b>	<p>Process data analysis Laboratory analysis</p> 	<p><b>TREATMENT</b></p> <p>Process Upgrade Membrane technics</p> 	<p>Pulsed columns New solvent</p>	<ul style="list-style-type: none"> <li>- Support to Orano MED</li> <li>- U from Phosphate</li> <li>- V by products</li> </ul> 
<b>ENVIRONMENT</b>	<p><b>ENVIRONMENT</b></p> <p>In situ XRF probe, DGT biodisponibility Membrane technics</p>	<p>Natural attenuation ISR</p> <ul style="list-style-type: none"> <li>- Support to management of french closed mines</li> <li>- Tailings and effluents in Niger</li> </ul>	<ul style="list-style-type: none"> <li>- Reactional mechanisms (sorption..)</li> <li>- Piston corer</li> <li>- Modelling</li> <li>- Effluents treatment</li> </ul>	

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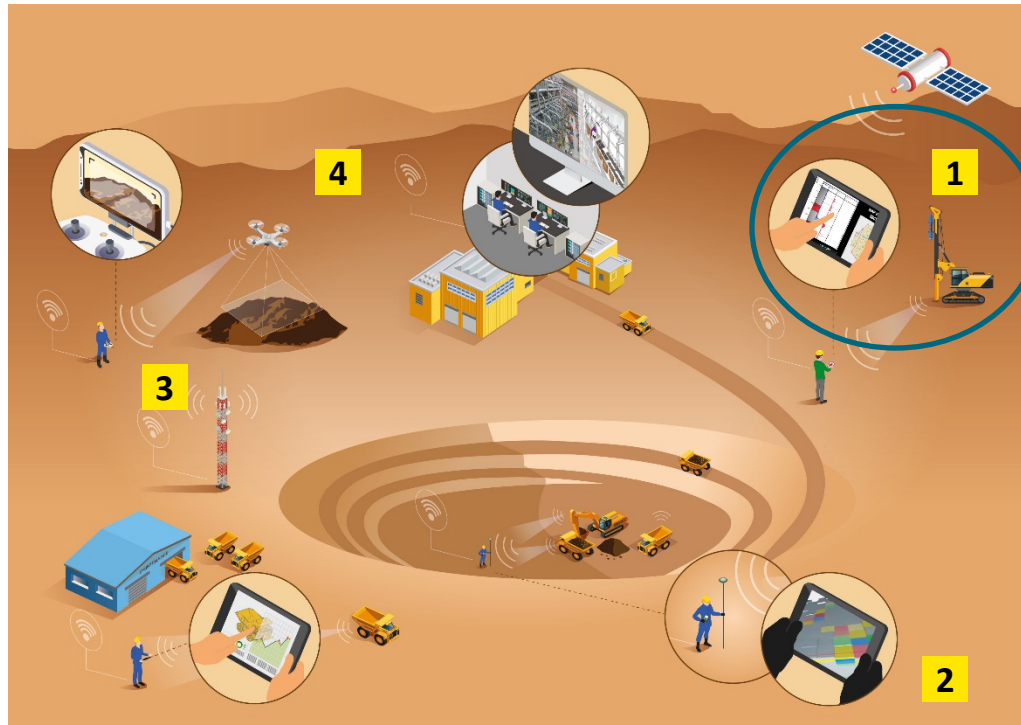
- General presentation
- R&D Overview
- Digital challenges

## 2. Needs in nuclear measurement in U mine

- Global overview along the mining process
- Examples : In diagraphy, mining extraction, process control

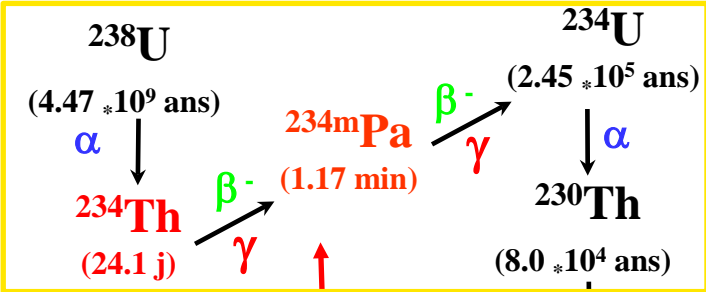
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# Nuclear measurements innovation along the mining process



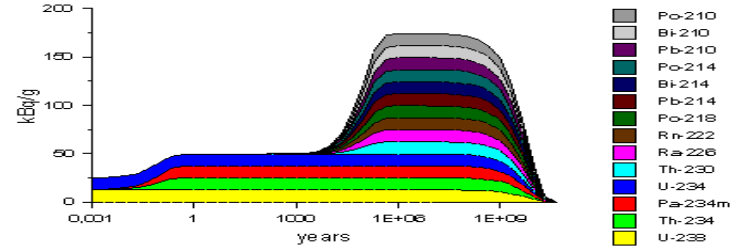
- 1** New gamma spectrometry LaBr probe
  - Measure in situ U and U/Ra ratio
  - decrease uncertainty of geological model
- 2** Accurate decisions in the field about mining selectivity by improved measurements and augmented operator
- 3** Geolocalize trucks in real-time, optimize haulage and accurate measurement to replace a portal monitor with a measurement on conveyor belt
- 4** React more effectively to modifications of ore entrance variation in order to optimize processes via use of online Xray elemental characterization system

# $^{238}\text{U}$ Uranium progenies



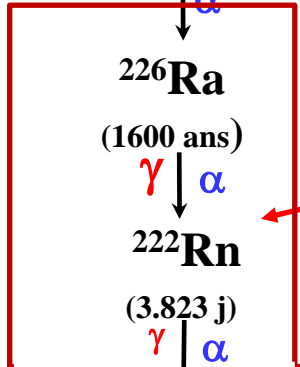
U

Natural Uranium Activity  
(stacked diagram)



1 % of Gamma

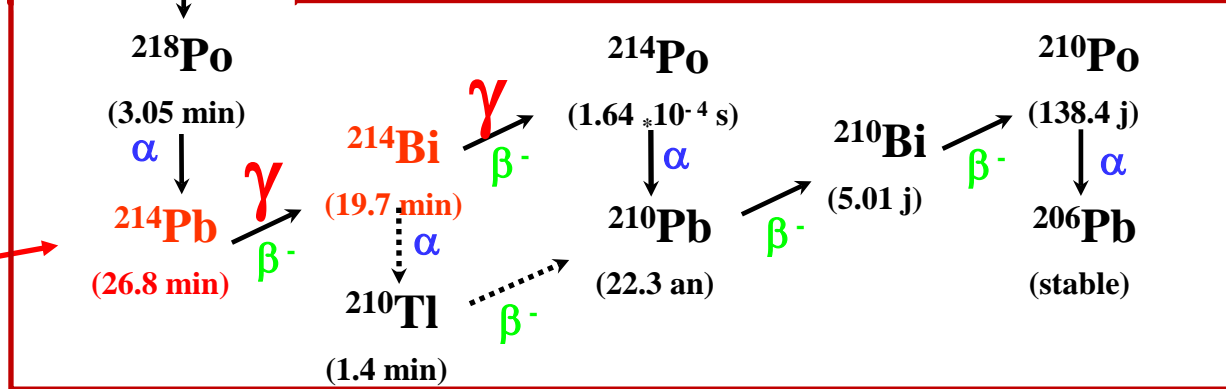
1001keV ray



Ra

2 % of Gamma

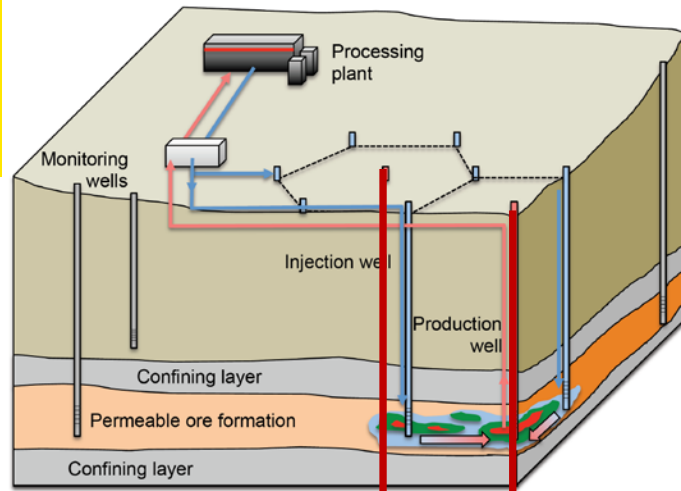
Ra226 186keV ray in interference with U235



97 % of Gamma

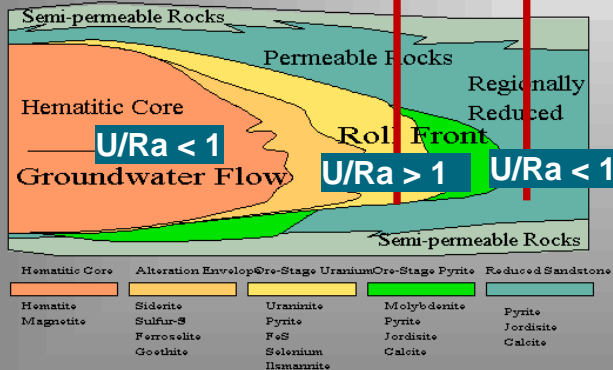


# In Situ Recovery



- Currently during logging, only total gamma counting probes are used.
- The need to optimize production yields makes it necessary to use a spectrometry probe to separate the U from Ra.

CONCEPTUAL MODEL OF URANIUM ROLL FRONT DEPOSIT  
(After Devoto, 1978)



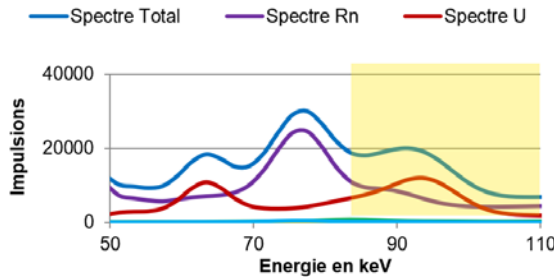
Uranium progresses faster than its progenies, which remain behind the front, except the Ra formed on the front which can then migrate downstream



# Method for U extraction

Low Energy counting :  $C_{LE}$

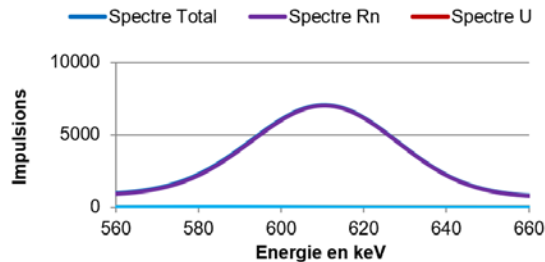
U+Ra area : 88-110 keV



$$C_{LE} = a.U + b.Ra$$

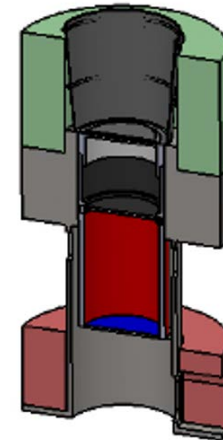
High Energy counting :  $C_{HE}$

Ra area : 560-660 keV



$$C_{HE} = c.Ra$$

On Sample:  $a / b \sim 0,5$



Need for an LaBr scintillator for its sensitivity and resolution

# 2 Orano LaBr products

Sample characterisation

Logging probe

R&D partner



Patented

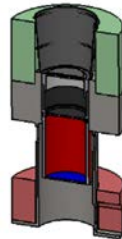
Detector



Electronics



Mecanics



Software

Logging



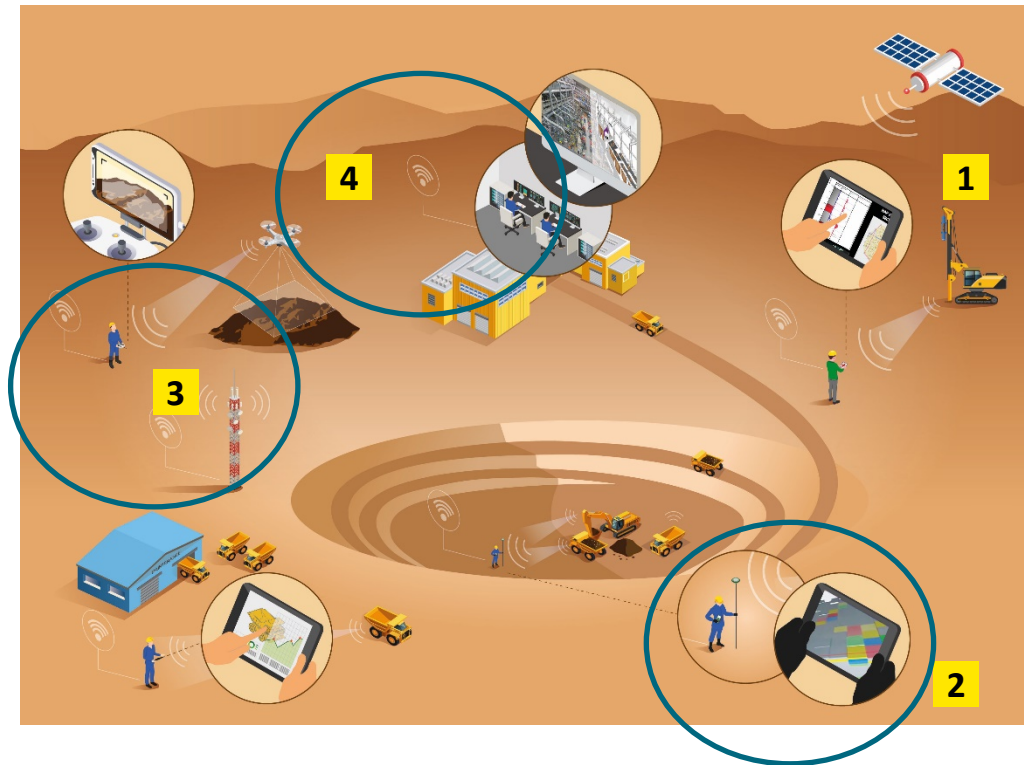
N/A

GeoVista



to be tested in 2022  
in Kazakhstan at  
Orano KATCO Mine

# Nuclear measurements innovation along the mining process



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# Geological control at SOMAIR open pit mine

Optimisation of the mining process by replacement of old measurements by robust ore grade measurement

Before



Gamma logging



Open pit grade control



Portal monitor



Sampling Lab. analysis



Drilling



Blasting



Loading



Rolling



Crushing

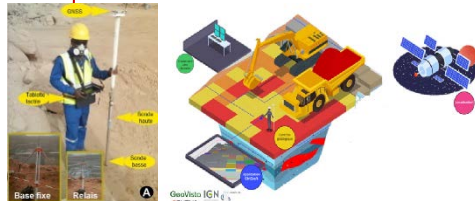


Ore treatment

2021



2



Dec. 2020

3



Jan. 2021

4



2022

# 2 New connected geologists



Old solution



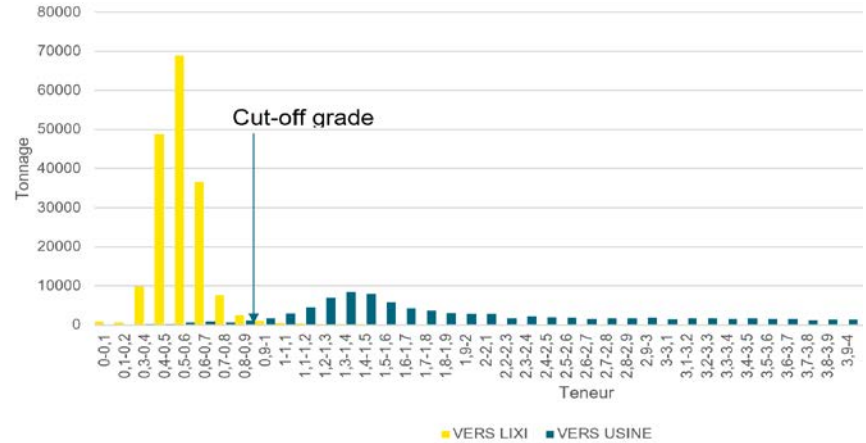
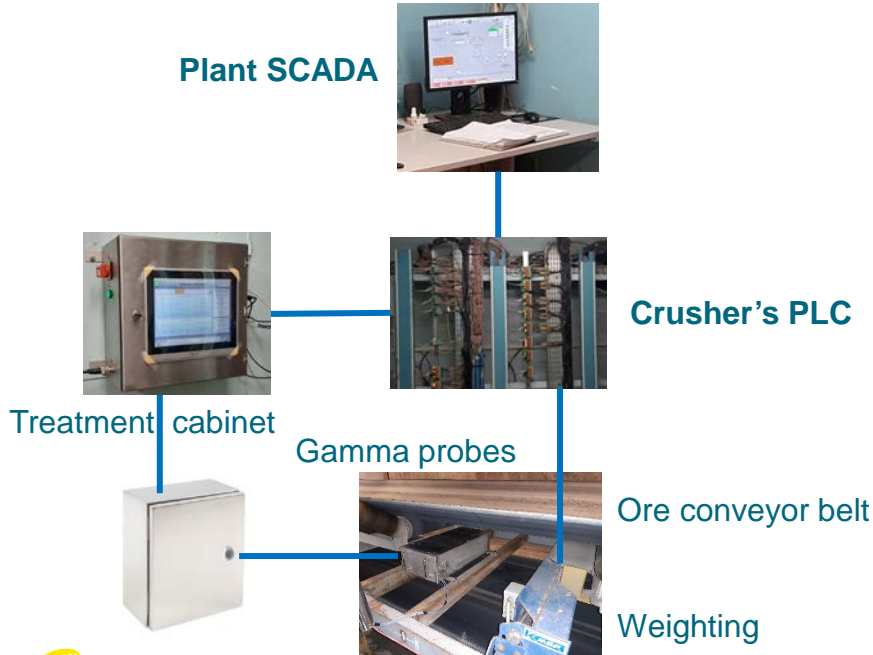
## Patented Solution



# 3 Gamma measurement after crusher

## A sooner and more representative control

- for a better ore grade distribution between heap leaching and plant process



$$T = \frac{M}{k \cdot f_i \cdot P}$$

***M*** : net measurement

***U*** : U mass

***k.f<sub>i</sub>*** : calibration factors

***T*** : U grade

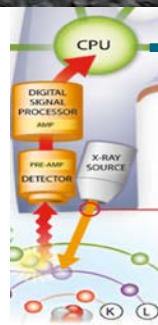
***P*** : production in t/h



# 4 Online X ray fluorescence

to measure at plant front end ore grade and penalizing elements

- Uranium, Ca for Carbonate, and (Al, K, Ti) for clays
- To optimize the addition of reagents and leaching process



Measurement  
treatment  
cabinet

Leaching  
PLC

To define every hour  
quantities of reagents

# Conclusion

**These nuclear measurement realisations are interface with many different departments**

- ✓ **Geological control**
- ✓ **Mine extraction**
- ✓ **Mill production**
- ✓ **Health's physics**
- ✓ **Laboratory analysis**

**All these developments allow Orano mining**

- **to better characterize these ore deposits**
- **with an objective of industrial performance**
- **aimed at a reduction of uncertainties on Uranium grade (locally and temporally) for**
  - ✓ **an improvement of selectivity in mine**
  - ✓ **an increase in leaching yields in plant**





**orano**

Giving nuclear energy its full value