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Introduction and general characteristics of the underground mining sector

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Introduction and general characteristics of the underground mining sector

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Foto de portada: Deep Underground Mining
(<https://new.abb.com/mining/future-of-mining/>)

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This document has been formatted for viewing and use on electronic devices and to save on paper and toner consumption. Before printing it, think about whether it is necessary to do it.

- Each deposit requires **a specific model of excavations** for its mining extraction.
- The mining method is the **architecture** that allows the extraction of mineral reserves in a technologically efficient and economically viable way.
- The design of an underground mine is the mining engineering process that defines such architecture with the support of the calculation of the following aspects, all of them associated with a given architecture:
 - Mining recovery
 - Dilution
 - Health and Safety
 - Costs
 - Profitability and economic benefit
 - Reliability of production estimates
 - **Sustainability and social and environmental impact**

- The **production schedule** refers to how the design is deployed and developed over time and how the production goals are achieved with the design tool, management, etc.

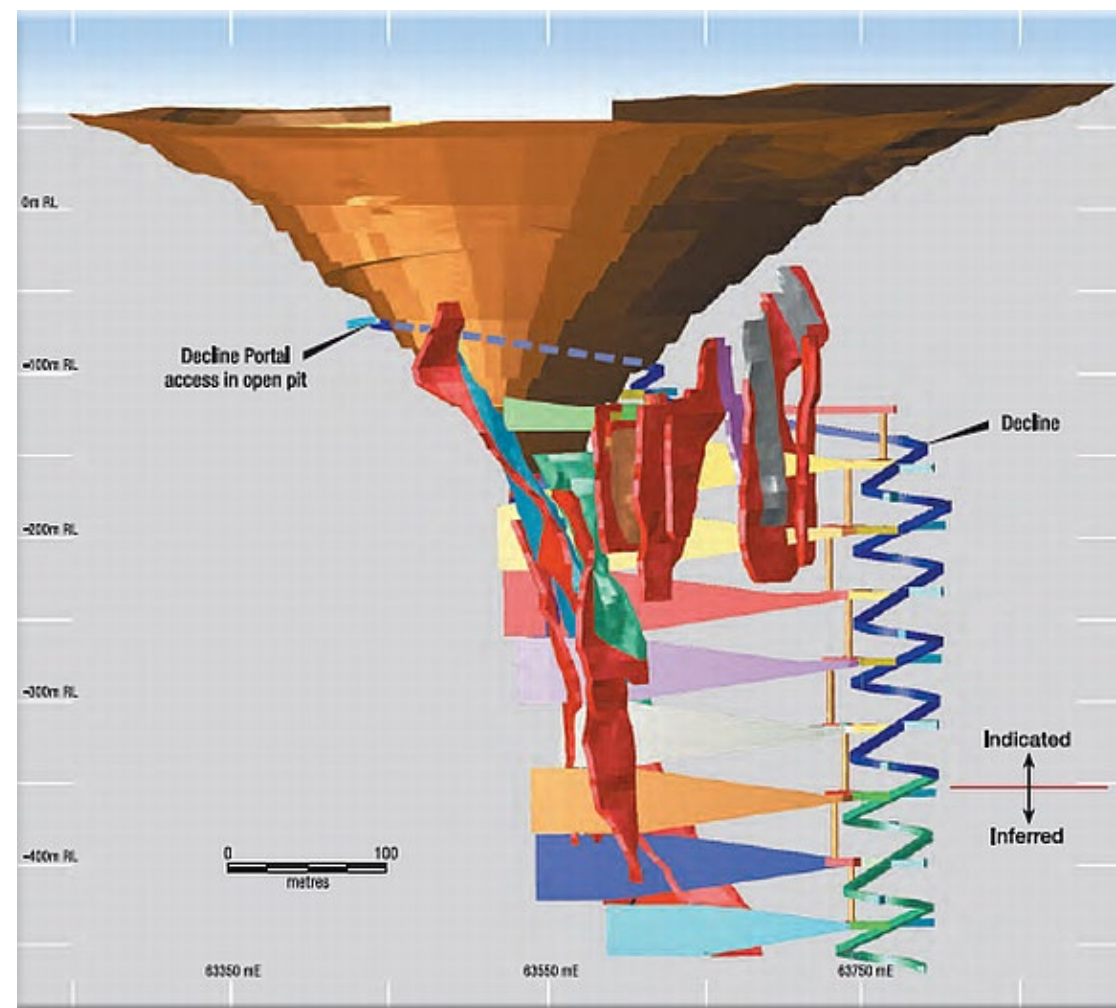
- The mining methods applicable to the exploitation of a deposit depend, among other factors, on:
 - The nature of the ore deposit.
 - Reservoir thickness.
 - Body shape and extension.
 - Distribution of mineralization.
 - Geomechanical properties.

 - Technological advance and new technologies integrated in the project.
 - Technical & economical considerations surrounding the project.
 - Provisions, rules and regulations.

**Plan to mine and
mine as planned**

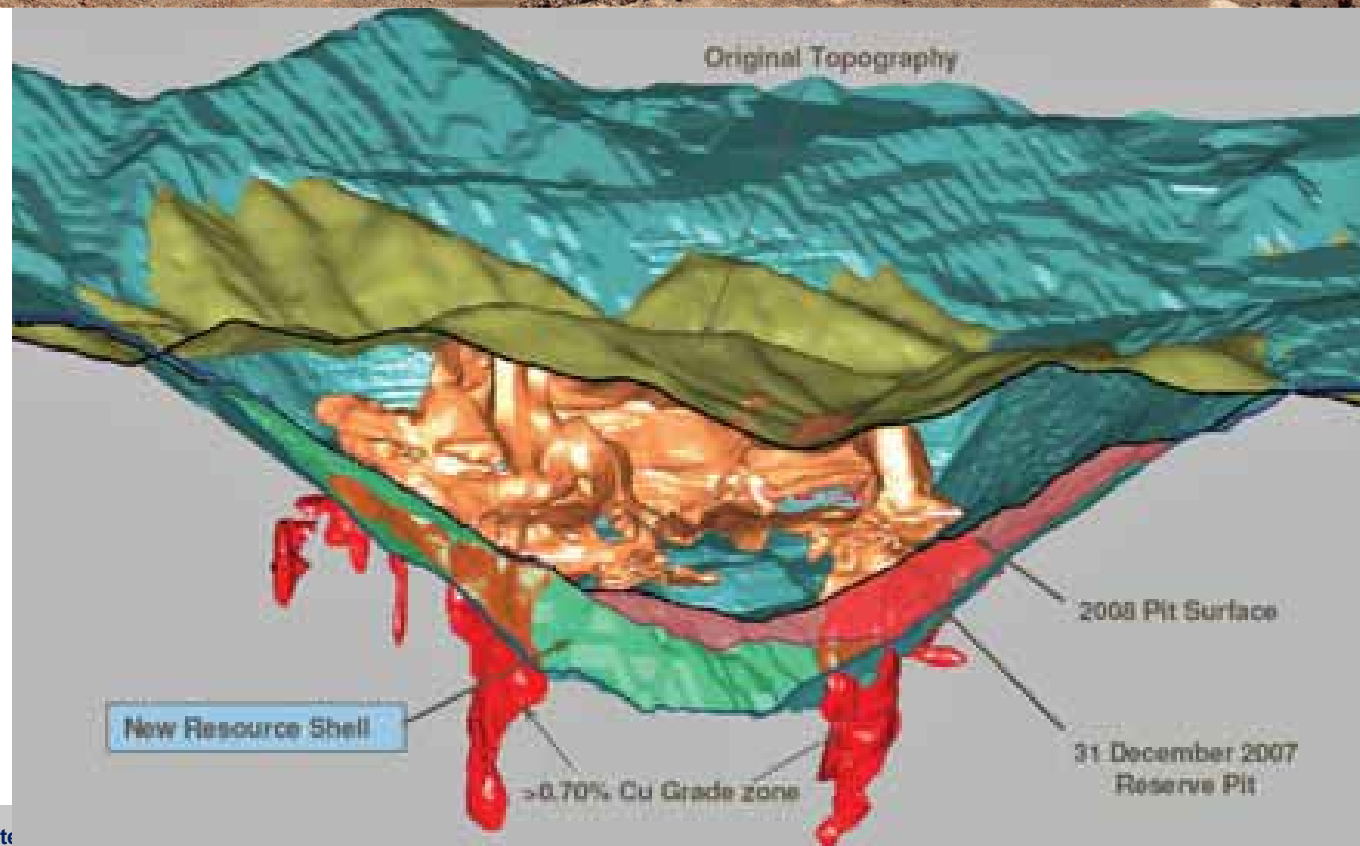
Conception of an underground mine

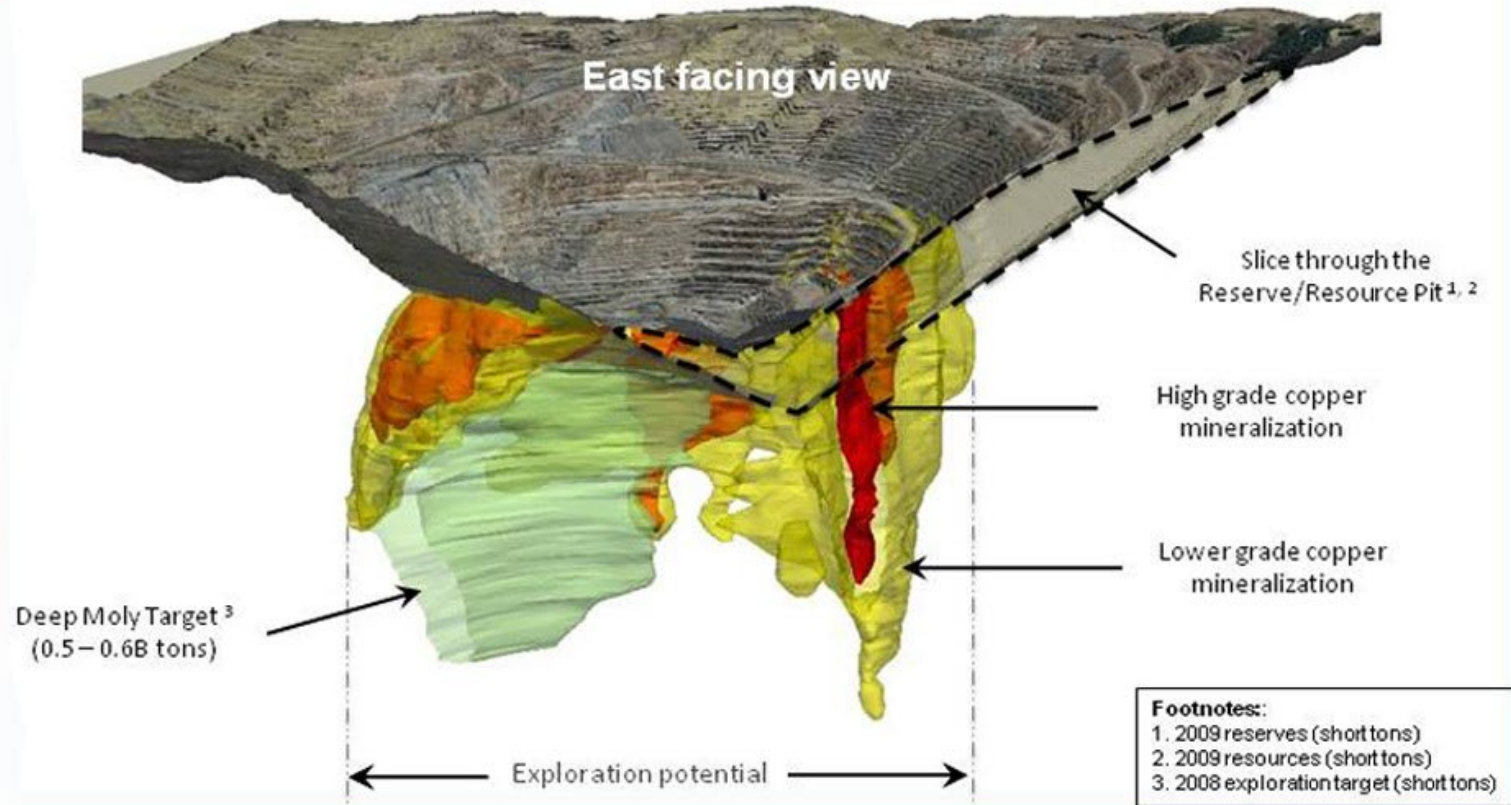
An underground mine is a **set of shafts, drifts, ramps and chimneys or vertical passes, as well as mining works,** intended to allow the **efficient exploitation** of an ore (one mineral or a group of minerals) from an ore deposit located at a certain depth and that is not accessible by open pit mining methods, **either for technical, economic, environmental or social reasons.**





Bingham Canyon (USA)





Conception of an underground mine

- The design, construction, operation and closure of an underground mine involves a wide range of excavation and construction activities..
- These activities vary from project to project and depend on:
 - Site conditions.
 - The geological and geomechanical conditions of the deposit.
 - Closure conditions.
- If the deposit is sufficiently close to the surface, it is likely that its exploitation will begin with an open-pit mining, and that this will later become underground.
- The excavation and extraction of the ore constitutes only a part of the mining process, which also includes the geological investigation, the mineralogical process, the management of mining waste, the environmental and safety protection, etc.

Open pit mining

■ Advantage:

- High productivity and low cost.
- Earlier start of production.
- Flexibility.
- Larger machinery.
- Low cost of fragmentation.
- Good recovery.
- Good working conditions.

■ Disadvantage:

- Depth limitations (waste/ore ratio).
- High investment.
- Restoration cost.
- Impact of the weather on the operation.
- Greater extraction of waste (dumps).
- Slope stability.



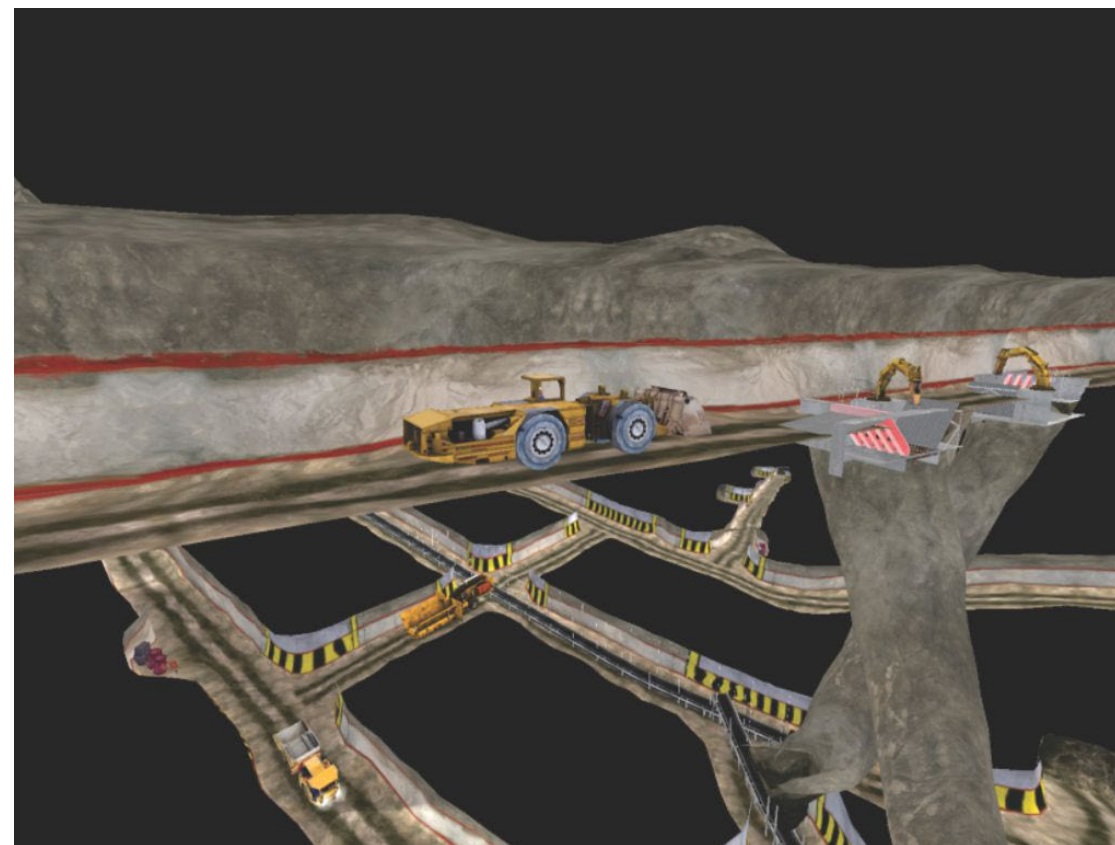
Underground mining

■ Advantages:

- Lower mine waste production
- Less environmental impact
- Lower restoration cost
- Greater precision in extraction.

■ Disadvantages:

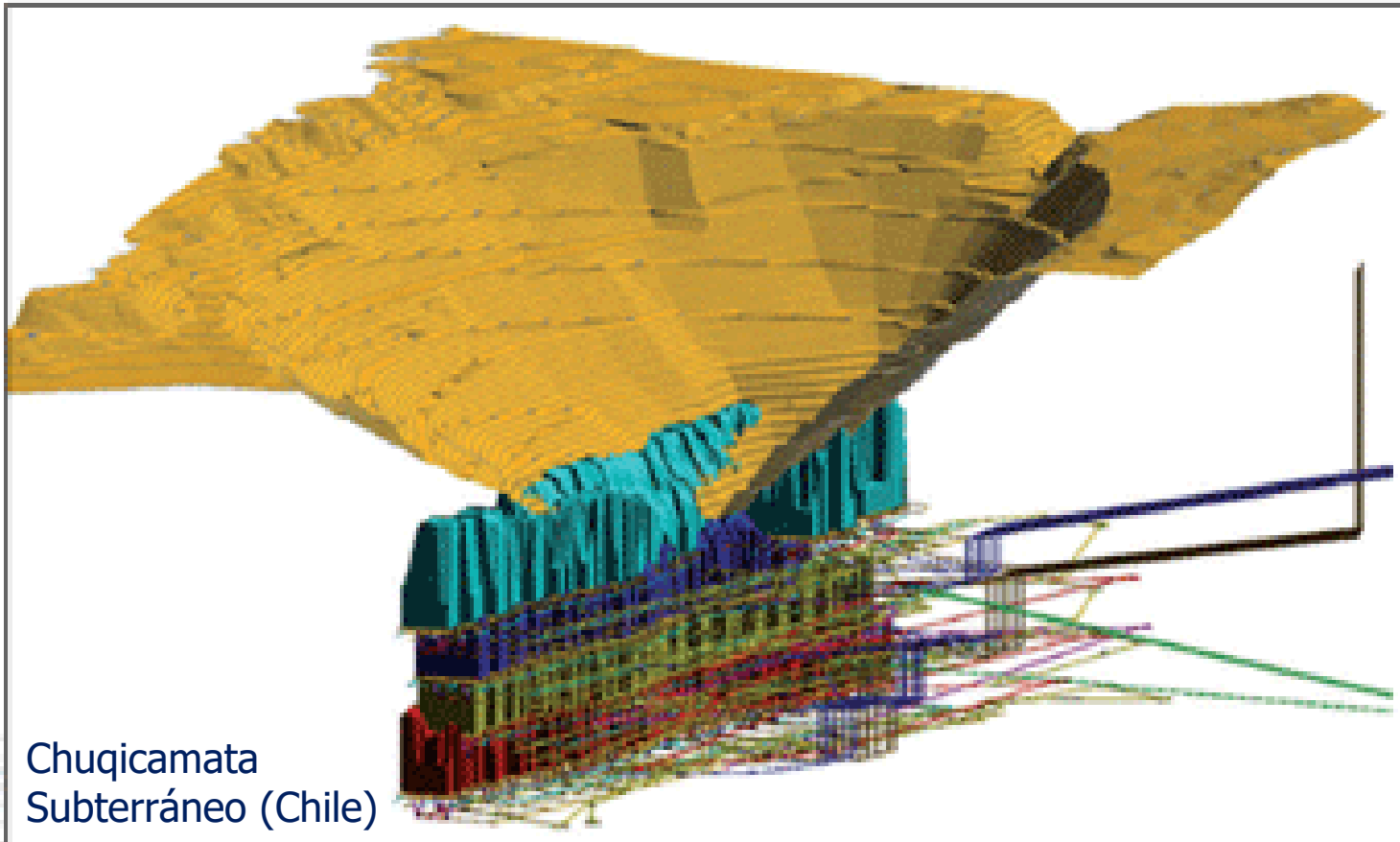
- Longer production run.
- Need for ventilation and roof stability control.
- Work in confined spaces.
- Greater considerations concerning security, which today does not mean less security in operations.
- Higher energy consumption per ton produced.
- Difficult control of grades and dilution.
- Lower production rates.





Palabora UG

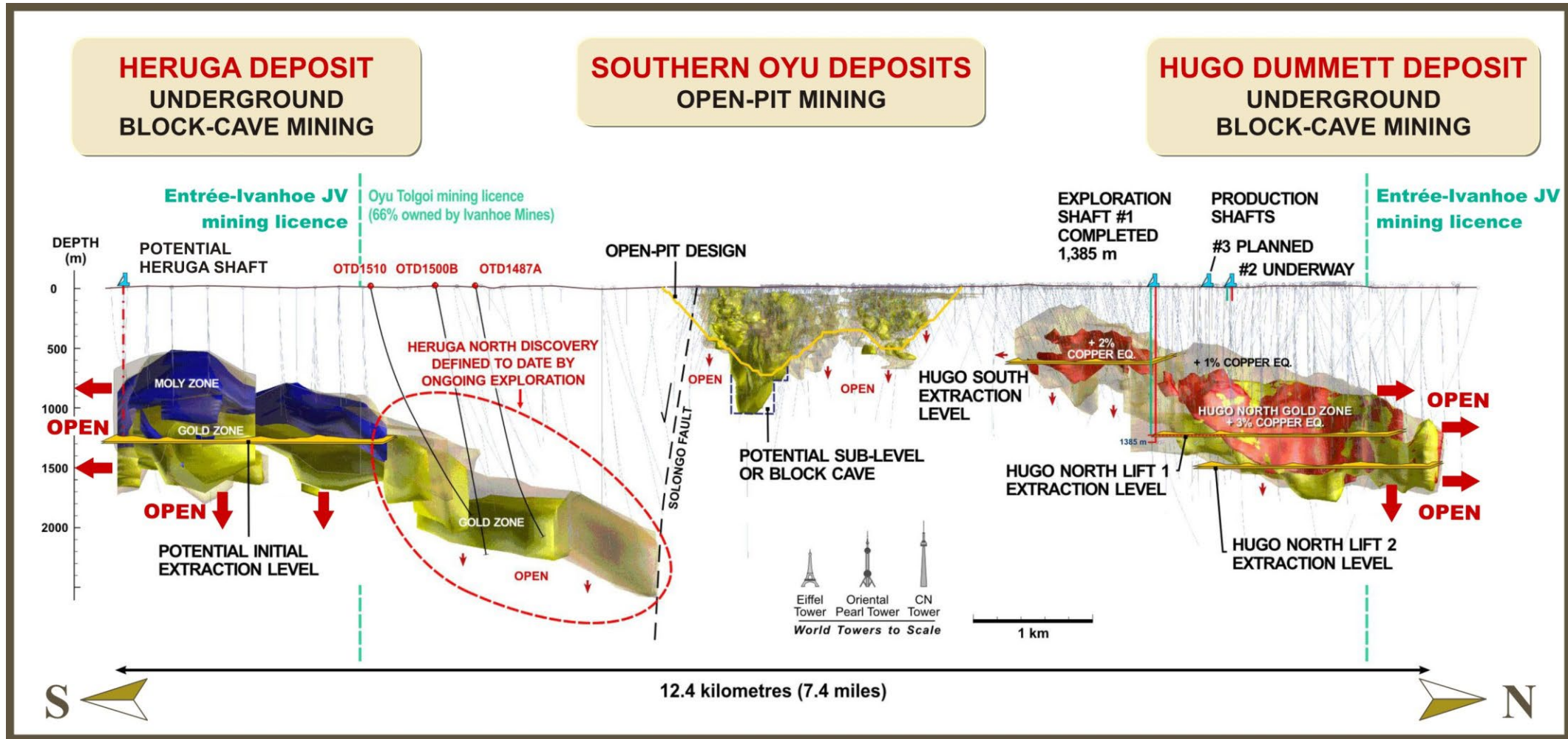




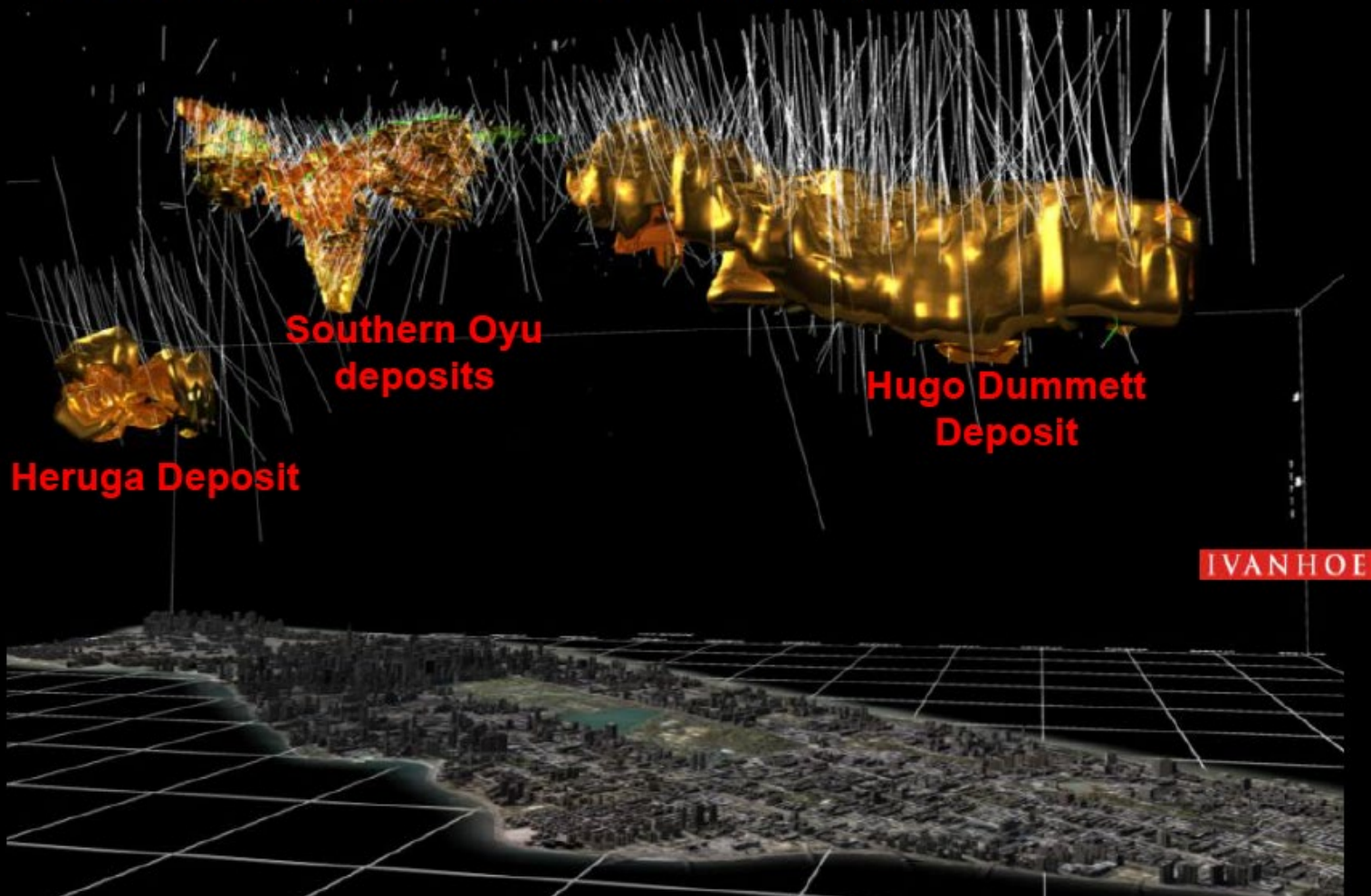
HERUGA DEPOSIT UNDERGROUND BLOCK-CAVE MINING

SOUTHERN OYU DEPOSITS OPEN-PIT MINING

HUGO DUMMETT DEPOSIT UNDERGROUND BLOCK-CAVE MINING



Deposits at Oyu Tolgoi after 10 years of drilling shown to scale over Manhattan, NY



Underground methods

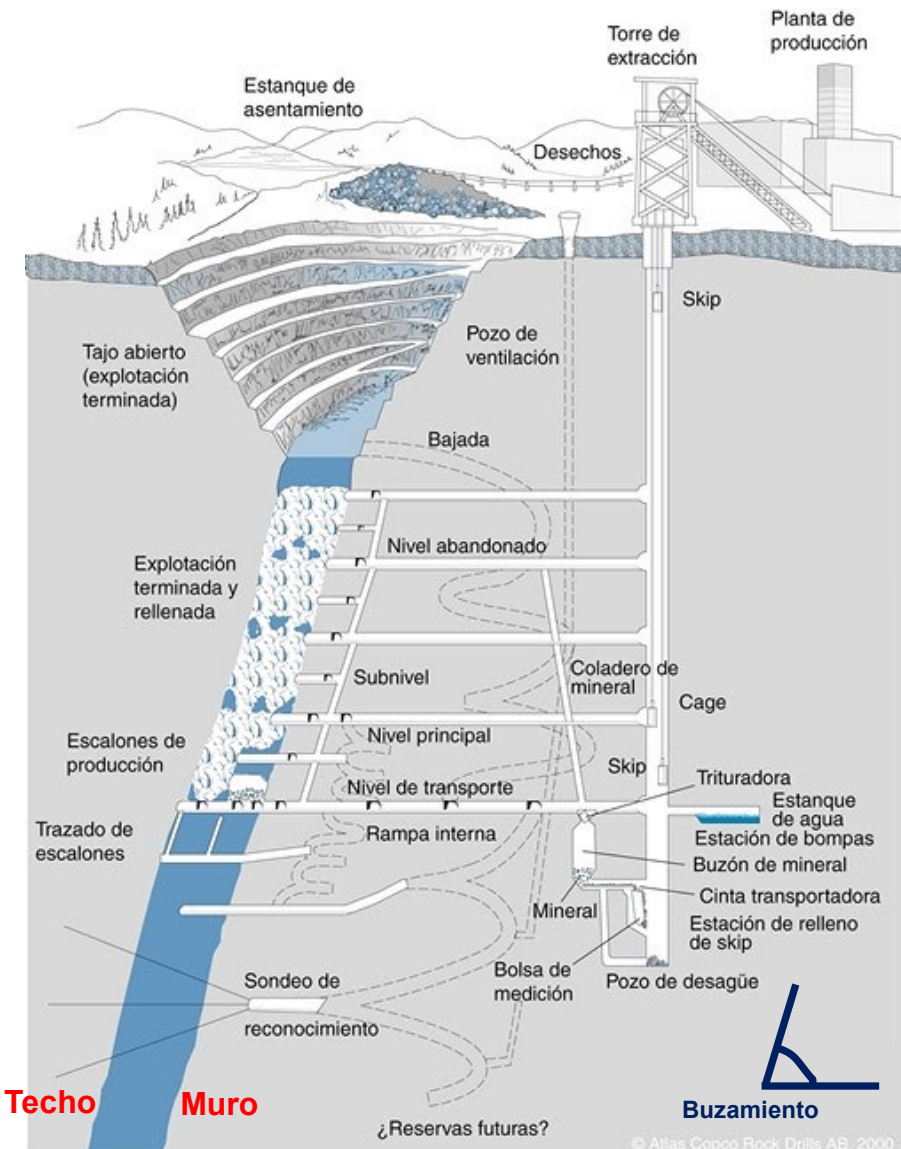
- These are methods used for medium to high ore grades.
- Production rates generally between 500-50,000 t/day approximately.
- They have a more selective character than the open pit method (with the exception of sinking methods).
- Design issues:
 - Underground mine geometry
 - Stability and sustain
 - Access location
 - Logistics for the transport and movement of ore
 - Mine ventilation and drainage
 - Infrastructure and operation
 - Machinery

Preparation and mine development

To achieve the efficient extraction of mineral reserves in conditions of sufficient profitability, safety and environmental protection, every deposit requires the construction of a specific project.

- Este proyecto This specific project,
 - It is created and developed in a phase prior to the production of the ore,
 - It is **closely dependent on the** selected **mining method** and,
 - Its purpose is the creation of the **basic components of the entire mine** and necessary to **ensure efficient and sustainable production**.

- This project is necessarily articulated around:
 - The entrances
 - The preparation (construction) of the mine: mine development, roof support, ventilation, lighting, services, etc.
 - The selection of the mining methods

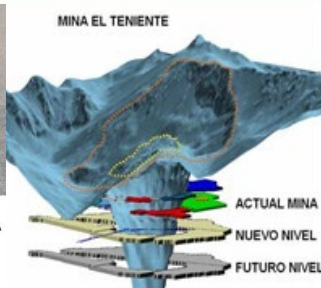
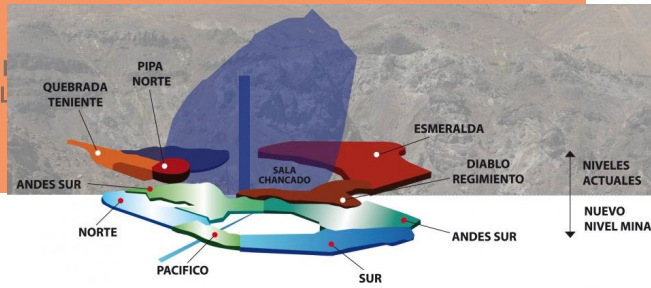


- The accesses are the mining works that open the way from the surface to the mineralized body for its exploitation..
- The preparation and development includes all the excavations and constructions that precede the mining extraction of the ore, while preparing the deposit for the starting of the mining production.
- It therefore includes the configuration of a carefully planned network of mine developments that integrates:
 - Access, production and/or ventilation shafts (if applicable, ramps or sinkhole as appropriate).
 - Inside and secondary ramps
 - Tunnels and exploration shafts
 - Drifts (main and secondary)
 - Configuration and preparation of chambers and pits
 - Auxiliary shafts, tapholes, chimneys, ramps, etc.
 - Infrastructure for staff and workforce
 - Infrastructure of auxiliary services: ventilation, drainage, security, etc.
 - Crushing infrastructure
 - Loading stations
 - Infrastructure for maintenance and service stations
- The preparation is intimately connected with the mining method and defines the infrastructure of the mine.



Rio Tinto Eagle Mine. Vista de infraestructura de superficie

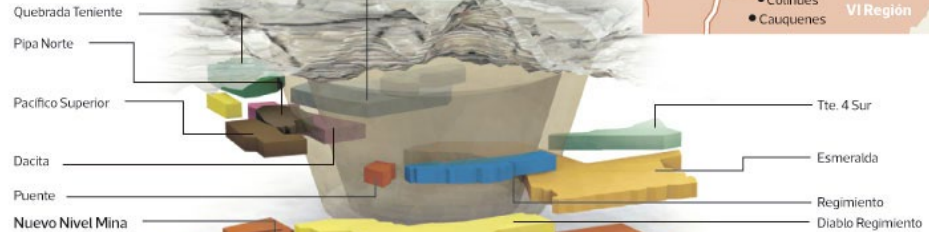




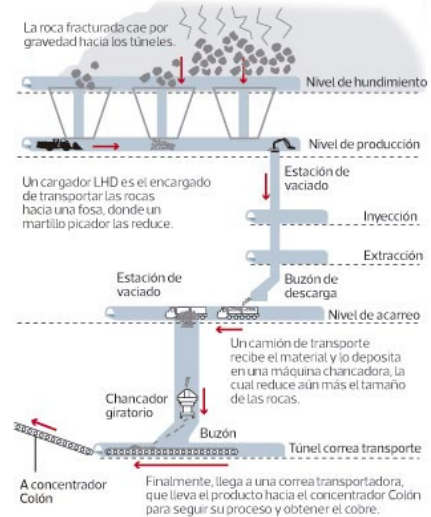
EL INTERIOR DEL YACIMIENTO DE COBRE

Ubicada en el Cerro Negro, en la comuna de Machalí, actualmente cuenta con 11 sectores de explotación, en distintos niveles, que alcanzan los 2.000 metros de altura.

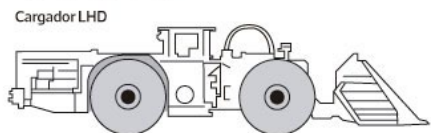
Los niveles



Proceso de extracción del nuevo nivel mina



Algunas maquinarias



Barrio cívico

Ubicados en los túneles, se habilitan con comedores, postas, oficinas, museos, auditorios, baños, para contribuir a la calidad de vida de los trabajadores.

Casino

En el interior hay un casino donde los trabajadores de la mina pueden almorzar y cenar.

Oficinas

Las oficinas de administración y control cuentan con la más alta tecnología.

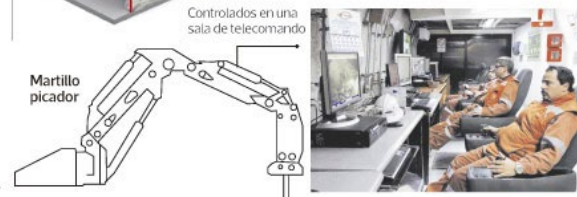
Los túneles

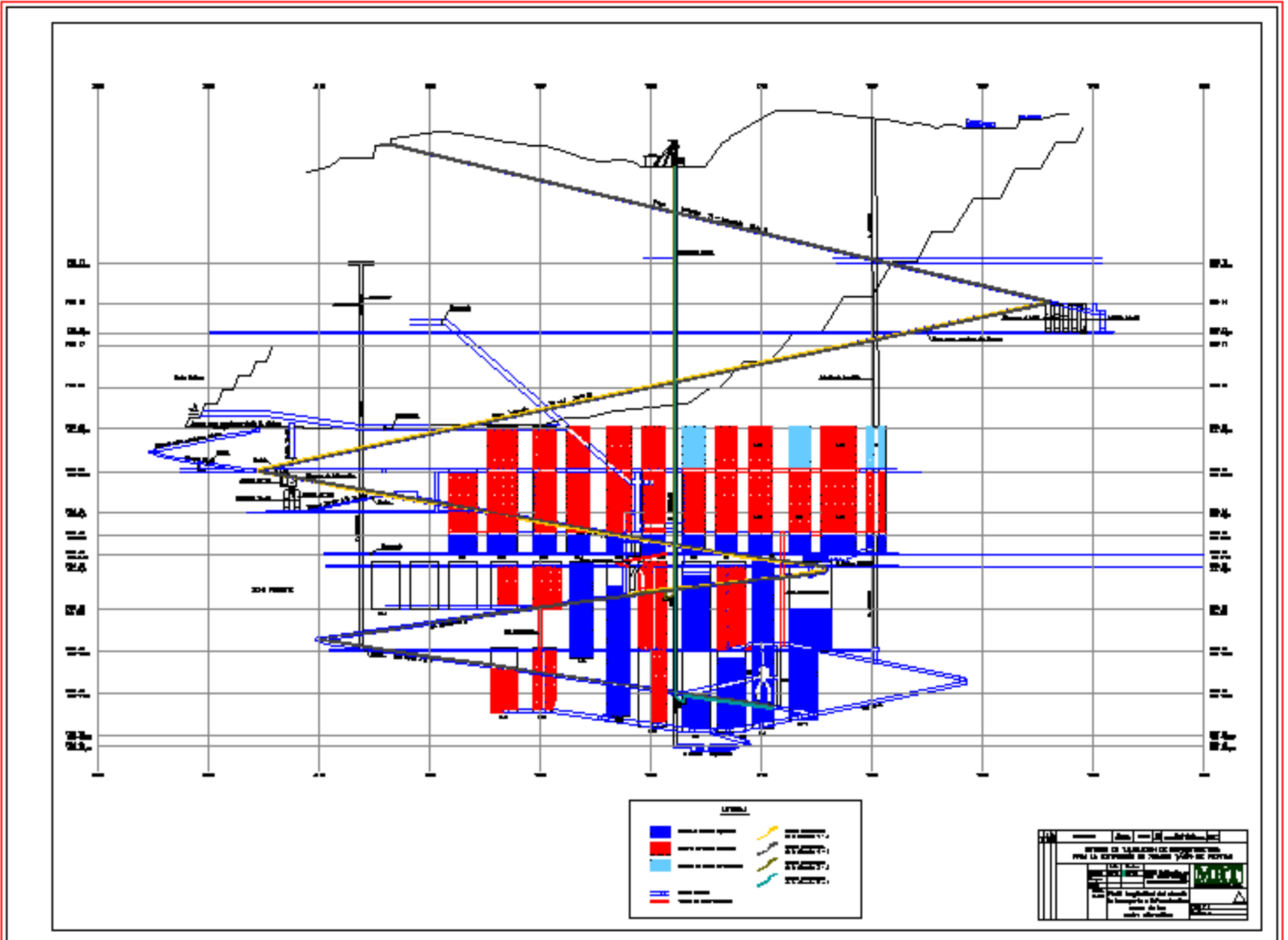


La mina El Teniente posee 3.000 kilómetros de túneles, lo que la convierte en la mina subterránea más grande del mundo.



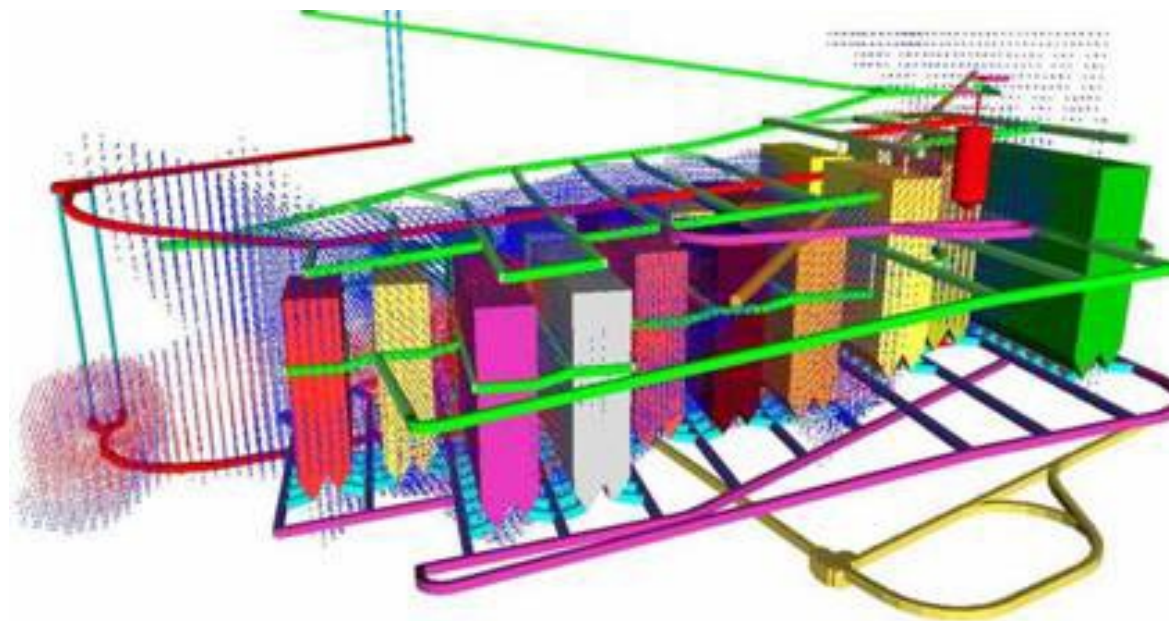
Ropa de seguridad





Current trends

- Increasing development of projects executed by inland mining methods and very presumably, this trend will continue to be predominant in the next 20 years.
- It is expected that 55% of the world's mining production will be underground by the year 2025.
- For the most part, the technological development that currently exists in mining is focused on this type of exploitation.

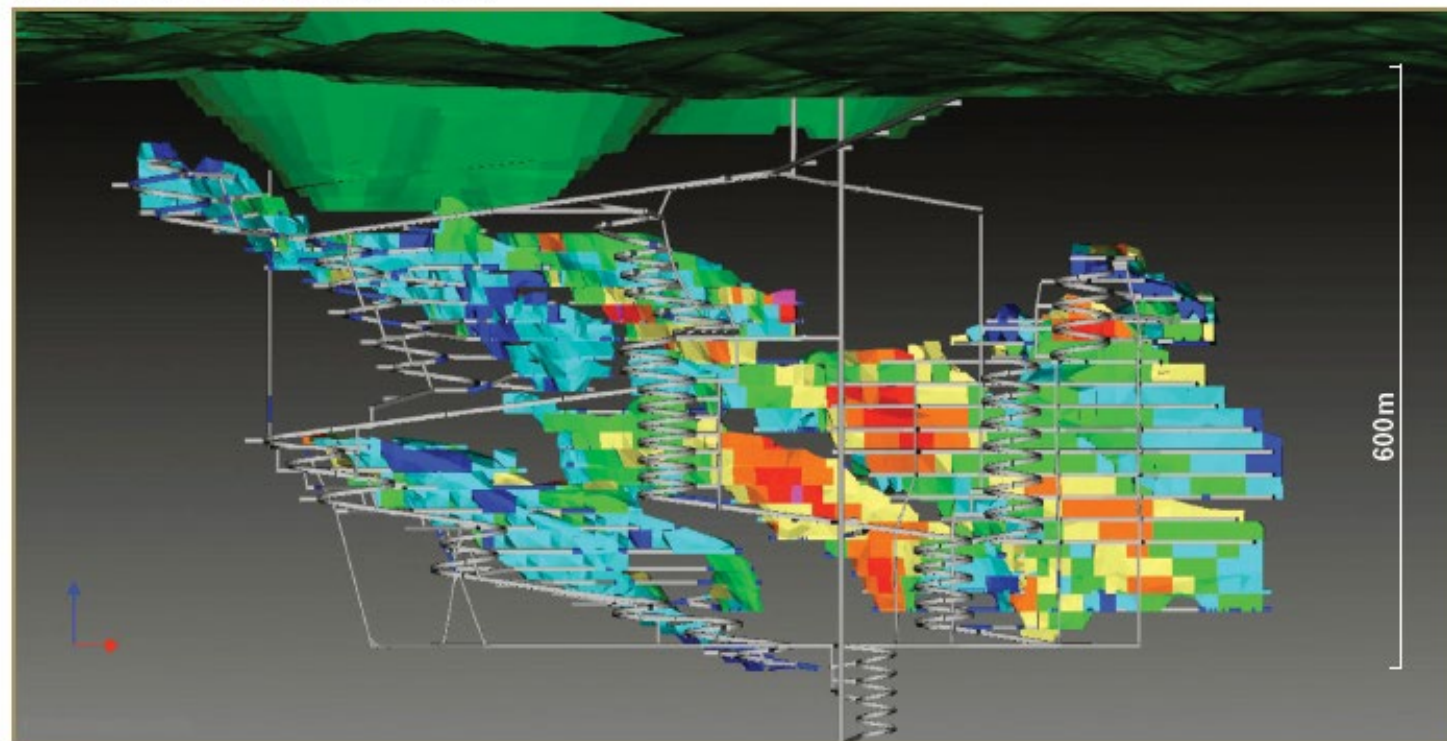


The evolution of the industry towards underground operations is due to several reasons. The following stand out:

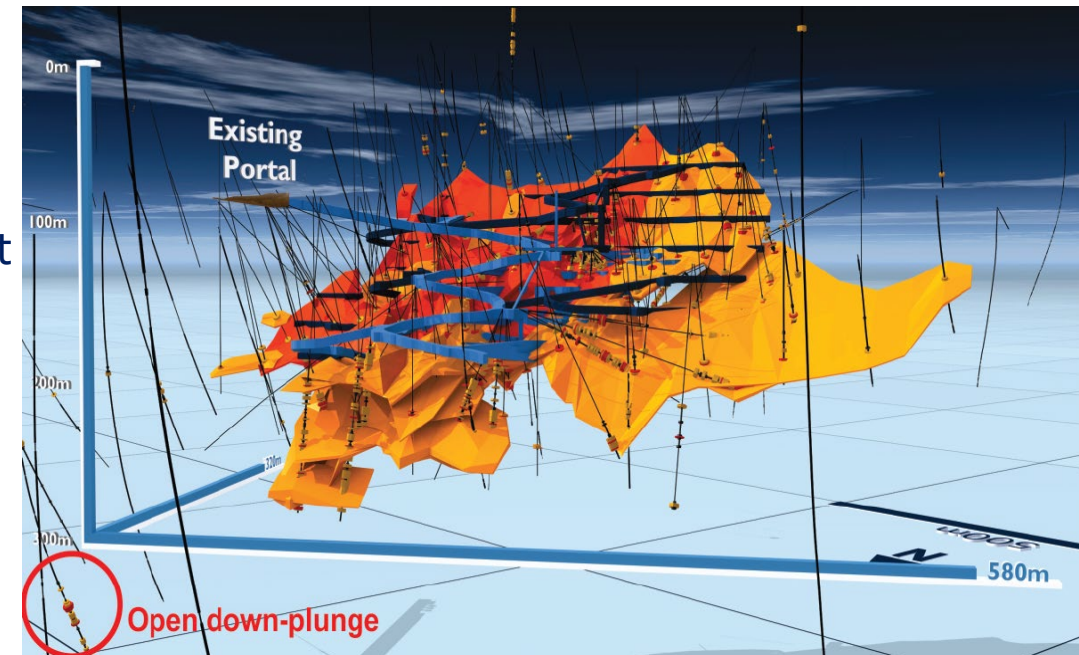
- Many large deposits that have been exploited in the past, which now have better resources at greater depths (Chuquicamata, Bingham Canyon, etc.).
- Development of a large number of newly executed underground projects.
- Modification of operating schemes towards operations with much less environmental impact and less footprint on the territory.
 - Elimination of waste extraction needs, or reduction of it to a minimum.
 - Preservation of the surrounding environmental conditions.
 - Better coexistence with land uses and less impact on communities.
 - Reduction of the environmental impact of operations and better conservation of natural resources.
- **Extracción más eficiente de los yacimientos.**
 - Compared to an open-pit operation, the operating costs of an underground mine are not necessarily higher (in an open-pit mining operation, as its exploitation progresses, it goes deeper and deeper and with it the transportation cost, while also progressively increasing the amount of waste material that must be removed to extract the same amount of ore).
 - Underground mines are safer, less polluting and much cheaper every day compared to how they were a few years ago.

- Much safer materialization of investments.
- Greater use of more advanced technology, so fewer but more specialized workers are needed.
- Safety in operations has been significantly increased, which has substantially reduced accident rates on farms.

KIBALI UNDERGROUND MINE DESIGN

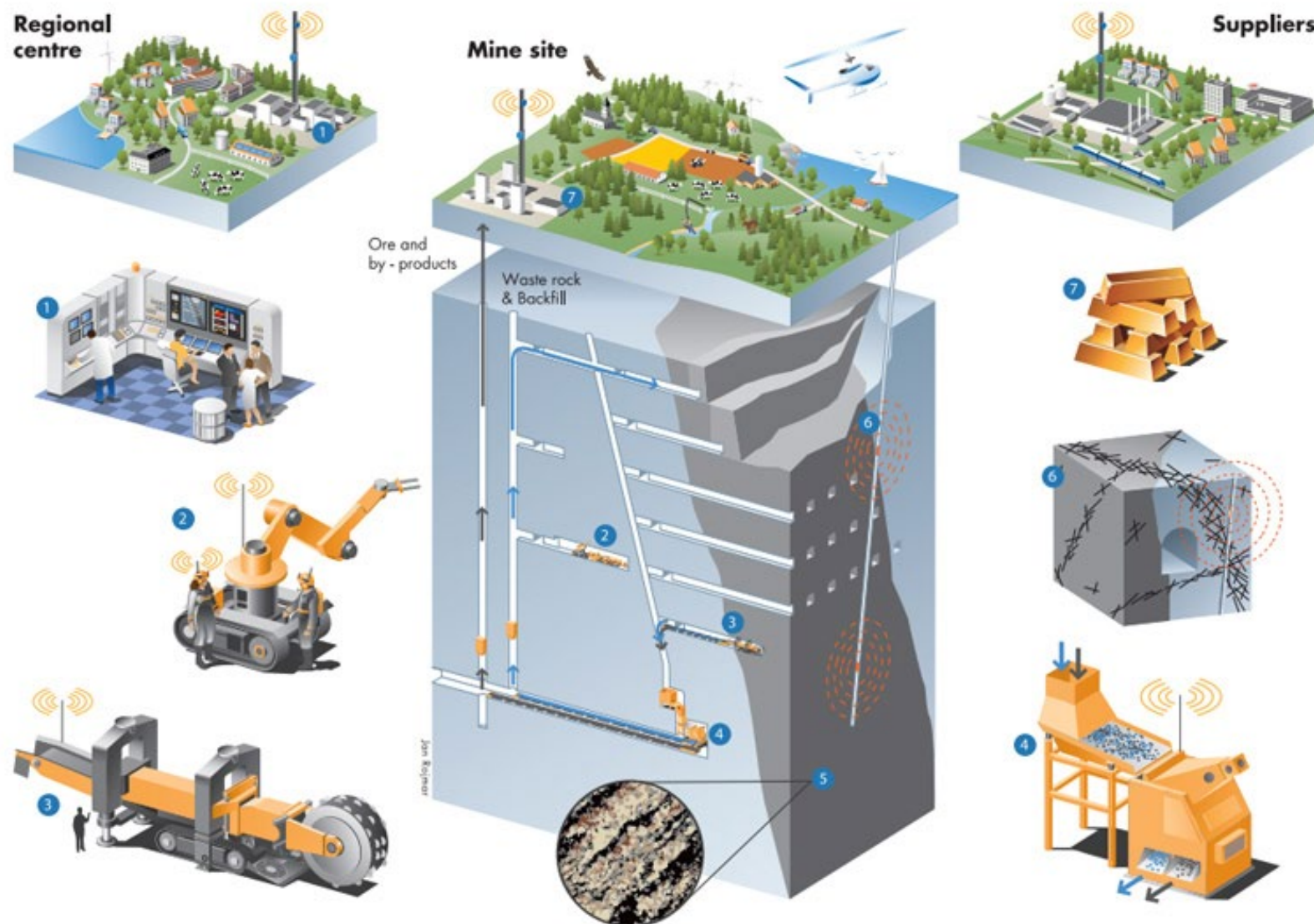


- The future of mining is underground, not only because metals and minerals close to the surface are increasingly rare, but because underground mines have a significantly lower environmental footprint.
- The revolution of underground mining is happening now.
 - High grade ore is becoming increasingly difficult to obtain and production in underground mines is constantly being carried out at deeper levels.
 - This increases the production cost for the companies due to:
 - Industry needs,
 - Higher demand of raw materials
 - Increasing safety
 - Decreasing the environmental footprint
 - Social licence
 - Technology shift to secure the production.
- In this case, rising to the challenge means digging to the depths, and doing it more effectively than ever before in history.



As the operations goes deeper and deeper, it is necessary to develop different strategies and technologies to face the complex and changing conditions of the new mining operations.

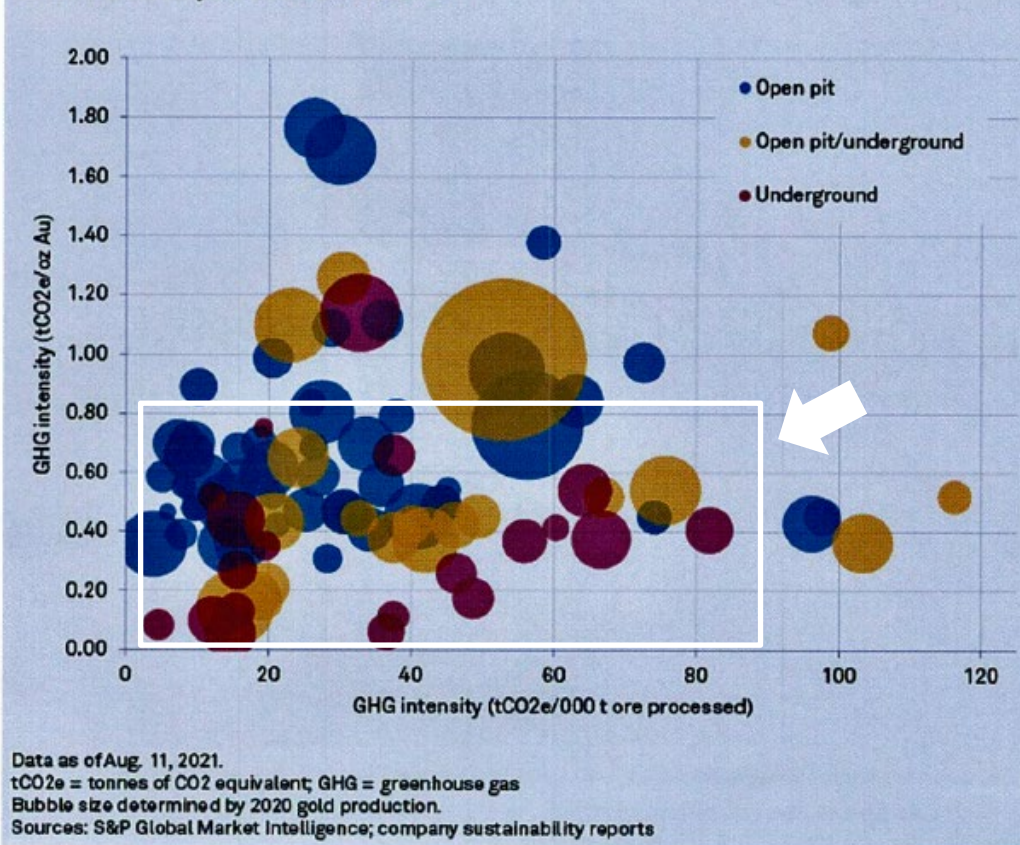
To meet the mining industry's challenges, it is essential to work to create effective solutions that guarantee safe mining operations that are economically, environmentally and socially sustainable. To secure future competitiveness, mines must continue to make the best use of their collective know-how.



MINING VALUE CHAIN



Open pit gold mines higher emitters per ounce produced, lower on per tonne of ore processed in 2020

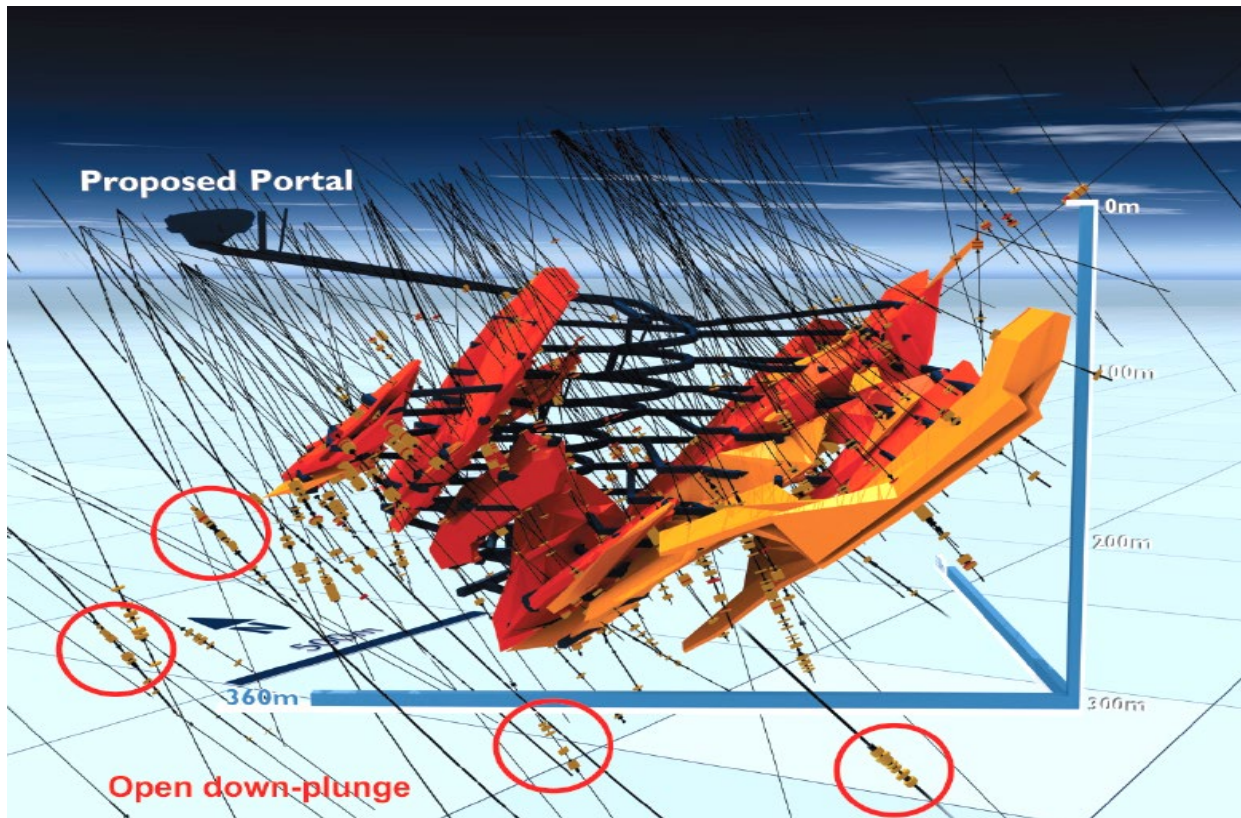


Source: EM&J September 2021

Mines are entering a new era. The environments of a modern miner are being transformed.

The mine of the future is carbon-dioxide-free, digitalized and autonomous.

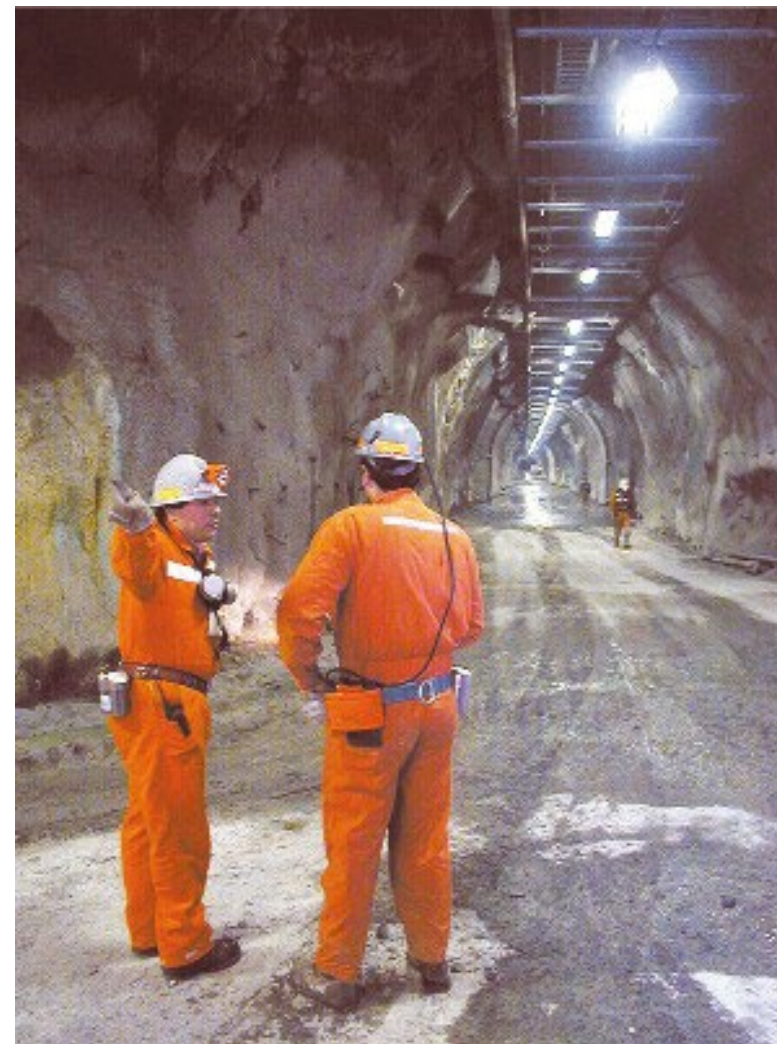
Underground operations can lead the way to a more decarbonized industry with greater emissions reductions



- There are three major trends that are fundamentally transforming the industry into **Climate-Smart Mining**
- Efficient use of electrification and integrated automation are two important parameters to focus on to increase sustainability in the mining industry.
- The innovations required to reach the top are not something that any individual player has the opportunity to develop
 - First, the shift from diesel to **electrification**.
 - Second, there is **digitalization**, which is resulting in increased productivity and more sustainable use of resources while lowering input cost.
 - The third trend is **automation**, which will also increase productivity and change the way we work.
- How things develop in the next 5 -15 years has uncertainties. However, the future is shaped by the innovations and advances of the present.

General scheme of an underground mine

- The aspects that must be analyzed in all underground mining projects include, at least, the following:
 - Accesos:
 - Sinkholes
 - Ramps
 - Pits
 - Inclined pits
 - Machines and/or extraction systems.
 - Development of mine infrastructure. General mine infrastructure plan.
 - Working areas preparation:
 - Drilling
 - Blasting
 - Loading

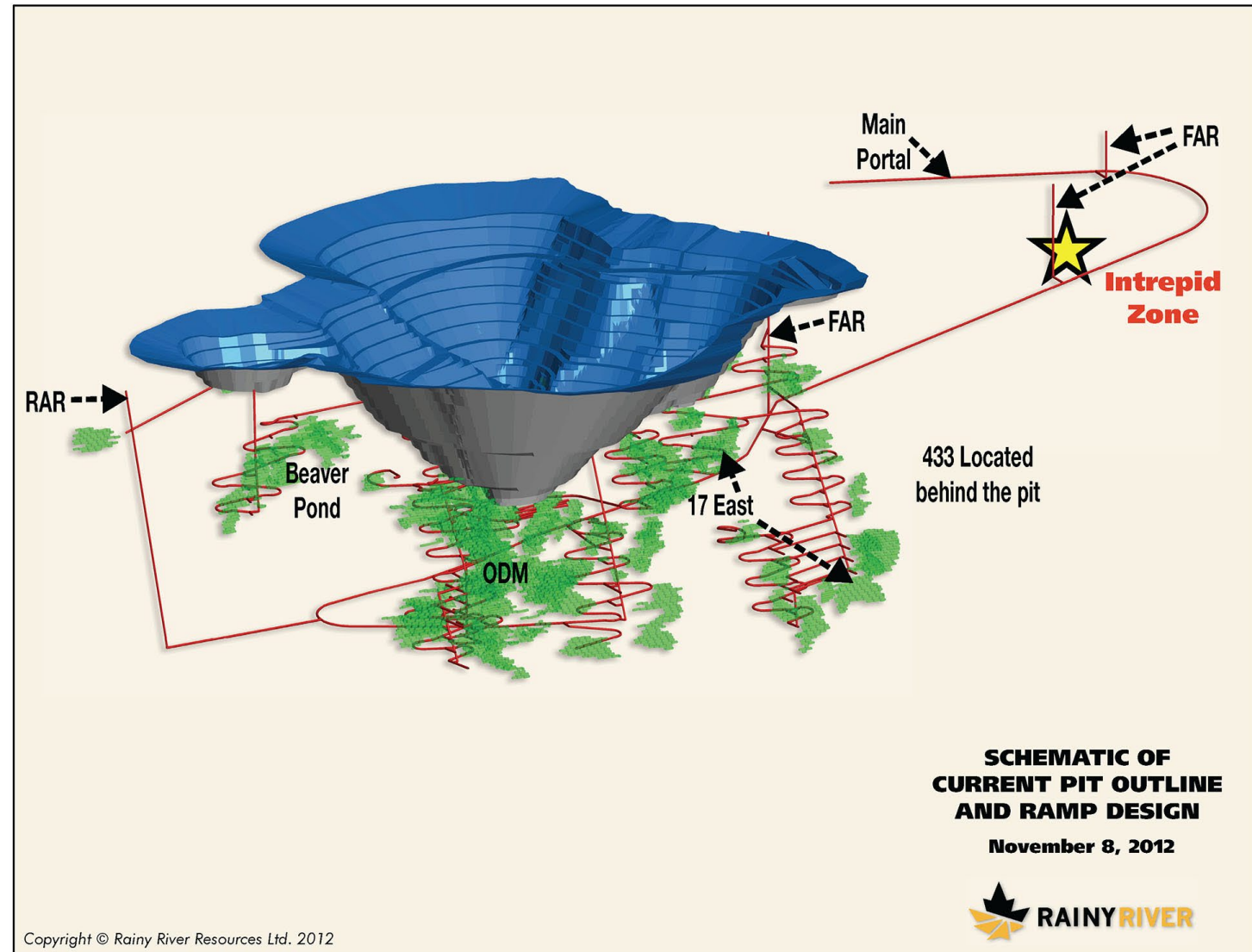


- Roof support
- Transportation of materials and supply
- Transport of ripped materials
- Drainage
- Ventilation
- Illumination
- Emergency and rescue
- Selection of the mining method
 - Productivity
 - Dilution
 - Fleet Determination
 - Cost estimation

- Closure



- The mine of the future will not look like it does today, but that does not mean jobs will disappear. However, the content of the work will look different for employees.
- Through digitalisation and new technology, the work in the mine will become easier, safer and more efficient, all of it with a focus on the people.
- As underground mines get deeper, mining methods must be adapted to mitigate the increased risk of deep tunnels collapsing partially or catastrophically.
- It's about continuing to mine iron ore in an even safer way at greater depths and at the same time continuing to make money.





Dudas y preguntas



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