Chile stays ahead in the race for scarce minerals with radiation technology

By Jeremy Li

A mining facility in Chile that processes raw copper. Chile is the world's largest producer of coppper.
(Photo: F. Diaz/Trazado Nuclear e Ingenieria Ltda.)

Competition is heating up in the multibillion dollar global race for high-grade minerals and metals as known resources grow scarce and demand increases for their use in all kinds of everyday products, from mobile phones to pots and pans. For countries like Chile, radiation technology is key to keeping a competitive edge.

"Radiation technology offers a hard-to-beat advantage over other techniques," said Francisco J. Diaz Vargas, principal manager of Trazado Nuclear e Ingenieria, a Chilean organization that consults on mineral and metal extraction processes for mining companies. "These tools have become a critical part of how we are growing our most important national industry and keeping our foothold as a global exporter."

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Thanks to its rich mineral reserves, Chile's vibrant mining industry contributes about 9% of the country's gross domestic product (GDP) and represents about half of Chile's total exports. Chile is the world's largest producer of copper, which is exported for use in alloys, buildings and electrical equipment, among other things. Chile's mines are also a major source of molybdenum, a chemical element that plays a critical role in over 80% of nuclear medicine procedures.

To keep their national industry thriving and help meet growing export demands, Chilean mining companies have been working with the IAEA to use radiotracers and nucleonic gauges (see The Science box) to help them streamline their production and mining processes and become more efficient in detecting and measuring mineral and metal concentrations. Compared to traditional techniques, radiation technology does a better job of improving the quality of products, optimizing processes, and saving energy, Diaz Vargas said.

"In many instances, it's simply not practical to use traditional tracer techniques because they involve large equipment that is too bulky to move around and use in the field. Radiotracers are more portable," explained Diaz Vargas. "They are also more accurate and faster than traditional techniques, which means we can save time and money because we have an accurate idea of how much we can expect to extract and process."

Using such innovative techniques is essential to staying ahead in an increasingly competitive global market and ensuring a steady supply of metals and minerals, said Patrick Dominique M. Brisset, an industrial technologist at the IAEA.

More than 2.7 billion metric tonnes of metals and minerals are extracted from natural reserves in the ground and used each year, according to the British Geological Survey's

World Mineral Statistics. These minerals and metals are used in a huge number of products, from machinery to electronics to household goods and automotive parts. In computers alone, more than 60 different kinds of metal are used in making the exterior casing, circuit boards and computer chips.

As the global population grows and the overall standard of living goes up, the demand for products using these materials is rising too. However, the challenge of finding easily-extractable minerals and metals combined with the long mining process — normally 10 to 15 years from discovery of a deposit to the start of extraction — is making it more difficult to accommodate the ever-growing demand.

"The demand is getting more and more difficult to meet because, globally, sources of high-grade metals and minerals are getting exhausted and harder to find, so countries have to find new ways to keep up," Brisset said.

Through IAEA support, specialists from around the world are building knowledge and skills in using nuclear techniques in the mining, metallurgy and mineral processing industries. They are also working closely with experts from countries like Chile that have developed years of expertise through their well-established mining practices and infrastructures.

"The industry is growing fast. If radiation techniques are developed and implemented on a massive scale, we are potentially looking at annual global economic savings of upwards of US $19 billion from the more efficient extraction and production processes and less reliance on human resources," Brisset said.

THE SCIENCE

Radioactive tracers and nucleonic gauges

Radioactive tracers are a family of analytical tools that can provide data to investigate and optimize the various steps involved in the mining and processing of minerals. They are based on radioactive isotopes that are injected into a mixture or fluid that latch onto molecules of a target substance, such as metals and minerals, and move in a similar way to those substances. Special devices, such as scintillators, are then used to detect the radiation being emitted from the tracers. Imaging tools, such as single photon emission computed tomography (SPECT) or positron emission tomography (PET), are also used. These devices produce images that reveal the concentration of mineral and metals — the higher the concentration of a substance in a mixture, the more radiotracers appear in the image. The radiotracer method can also be used to determine the real-time movement of water, oil or pollutants underground and to also map out the flow patterns inside of a system.

Nucleonic measurement and control systems, popularly known as **nucleonic gauges**, use special detection devices and radiation sources to emit gamma radiation or X-rays for measuring and controlling different variables of a product or equipment, such as its thickness, density and composition.

A nucleonic gauge works by passing radiation through a material to reach a special detector device on the other side. The detector picks up on variations in the amount of radiation coming through the material: when material is thinner, has a lower density or a lower concentration level, more radiation passes through it, and vice versa. The variations detected in this way can be used to determine and measure relevant characteristics. In many cases, these gauges can operate without direct contact and can pass through opaque walls or materials. They play a vital role in the production and maintenance of materials and structures without causing them damage or leaving behind any radioactive residue.