

# The Living Mine

In their third article for *MM*, George Hemingway and Jeff Loehr explore how advanced technologies could converge to create an entirely new way of mining

*A swarm of micro-bots working as a group to mine underground*

**“The Living Mine enables the mining of orebodies that were previously ‘un-mineable’, either because of location or geology”**



George Hemingway and Jeff Loehr

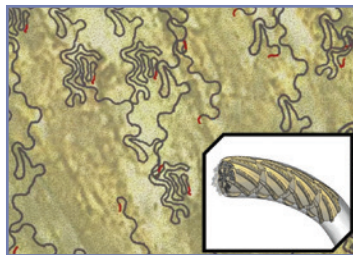
Strategic Futurecasting allows companies to explore possible futures based on observable trends today, and to use these scenarios to guide their strategy and investments. In our first two articles we introduced the concept of Futurecasting and our first operating scenario of the future; The Rock Factory.

The Rock Factory, a big-data enabled vision of equipment working as a system to create a factory-like continuous operation is a recognisable, although technologically advanced, type of large-scale mine. It met a lot of the original criteria we laid out for future mining operations of being scalable, reduced, adaptable, consistent, safe and more sustainable than mining today. But it is still a mine. This prompted new questions. What might a mine look like if we reduced the footprint even further? How might we mine a very complex, very low-grade orebody efficiently and with little human involvement?

## THE LIVING MINE

Our second scenario, The Living Mine, is one answer to those questions. This mine operates in such an organic way that it resembles a living organism. The Living Mine is ‘alive’ in that it is:

- **Intelligent and organised:** Within the mine, microscopic machines operate together with ‘swarm logic’ enabled by artificial intelligence. Just like insects working together to attack larger prey, these tiny machines organise to attack a complex orebody and reach minerals, no matter how small.
- **Adaptable and responsive:** With little transparency into the mine from the surface, machines must adjust themselves in real-time to ground conditions and find minerals. Mine design here is more about creating a responsive technological system than designing a definitive mine plan.
- **Organic and reproducing:** Much of the mine is actually alive, relying on biologic mining technologies such as modified bacteria that can digest, leach or convert minerals or modify host conditions to free them up.
- **A self-regulating ecosystem:** The mine works as an interconnected



technological ecosystem with sustainable closed-loop systems for energy and water, underground processing and the reuse of materials.

## BETTER MINING ANYWHERE

The Living Mine can exist almost anywhere. There are no large trucks moving earth, and no need for large-scale surface operations, or even to fully visualise the orebody or internal mine workings. The Living Mine enables the mining of orebodies that were previously ‘un-mineable’, either because of location or geology.

Mine operators cannot actually see what is going on underground or in the mine. Instead, sensor-enabled nano-robots and bacteria miners start with an estimate of where there may be target minerals and work on a probabilistic basis. Swarming under the surface, they seek out valuable ores and congregate when they discover it, no matter how minute the mineralisation.

Unlike The Rock Factory mine, which seeks to eliminate variability with precise information, The Living Mine adapts to unexpected variations and re-aligns itself to underground realities. Big data still matters here, but much of the operational analytics are done in real-time within the mine itself.

There is also an efficiency benefit to The Living Mine, as much of the mineral processing takes place in-situ, reducing surface processing plants and the alignment of large machines. The technological ecosystem’s closed energy, materials and water loop also makes for a less costly and more sustainable footprint.

## GLIMMERS OF POSSIBILITY

As with the Rock Factory, much of this technology is being developed and

applied, in one form or another, today. Unlike our previous scenario, however, more work needs to be done to create the technological ecosystem for The Living Mine.

In addition to the higher-order technologies mentioned in the Rock Factory, concepts that enable The Living Mine include:

- **Nano-robotics:** Technology under development includes nano- and, in some cases, atomic-scale machines and structures that can manipulate other molecules in specific ways. Today, these nano-robots can travel the bloodstream to deliver medicines; tomorrow this same thinking will lead to microscopic robots tunnelling for ore.
- **Artificial intelligence and learning:** Several steps beyond simply solving complex problems, robots are now able to work in groups, learning from and adapting to their environment. In the future, this intelligence will allow the robots to explore, adapt and mine all at the same time.
- **Advanced materials:** Advancements in this area include construction materials that can make equipment lighter and stronger, self-powered and contained sensors, and lubricants and coatings that can dramatically reduce friction and maintenance needs, even at microscopic levels.
- **Bio-mining and genomics:** Beyond bioleaching, which could itself change mining, new types of organism have been developed that can process and concentrate materials or interact with their environment to precondition rock. This represents a potential disruption to traditional mining as it could replace the need to mine through biologically engineered solutions.

## CAVEAT MINER

Both scenarios are different views on how technologies today may evolve and combine to change the operations of the future. They provide a starting point for thinking. Rather than seeking out which future is ‘right’, mining companies should explore what can be learned from these concepts and how they can use these technologies today and in the near future.

Operations, however, are just one aspect of mining. Future technologies are enabling entirely new ways of working. Next month, we will explore our vision for the future of work and the mining organisation; The Symbiotic Structure.▼

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