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## LKAB develops a new mining method

**When mining depths in underground mines increase, so do the challenges. Therefore, an entirely new method has been developed – raise caving. This is a major groundbreaking step towards a safer, more efficient mine.**

**"Raise caving has been developed for efficient mining at great depth," says Matthias Wimmer, mining engineering manager at LKAB in Kiruna.**

Rock stresses increase as mining moves to ever greater depth. A more complex geometry, in combination with rock-mechanical challenges, places demands on new, sustainable and innovative solutions for the mine of the future. And, underground, safety is paramount.

"Our exploration results are extremely promising and open the way for mining under our current main levels far into the future, beyond 2060. But this also places demands on new technology, on solutions and methods that are adapted for new conditions," says Matthias Wimmer, section manager in the department of mining engineering at LKAB in Kiruna.

The greater mining depth has necessitated the development of the new method, raise caving. Both the method and the machine concept, which is an essential part of the mining method, have been developed by LKAB in close collaboration with Montanuniversität Leoben, in Austria. Large-scale testing will begin next year in the Kiruna mine.

"We still have a huge amount of work ahead of us. Two test areas will be developed: one for the machine concept and one for the mining method. Initially, individual components will be tested step-wise. Thereafter, the complete system will be tested," explains Matthias Wimmer.

### Challenges and possibilities

The method currently applied in LKAB's underground mines, large-scale sublevel caving, has been very successful. This is an effective method that

enables mining of large volumes at a relatively low cost. However, there is some question as to how appropriate this method is for mining at ever greater depth.

"There are some mines with production at extreme depths, down to as much as 4,000 metres. However, mines in which some form of large-scale caving is applied have not yet reached such depths. And there is a lot of uncertainty as to whether they can maintain viable production volumes in the longer term," says Matthias Wimmer.

In other words, the application of caving methods at depth is largely unproven.

Raise caving, as opposed to sublevel caving, is a method that enables mining of the orebody from bottom to top, instead of from top to bottom. In other words, the sequence is reversed, and the technology shift has several advantages, not least in terms of safety.

"Rock stresses can never be eliminated in a mine but, with this method, we are able to determine where seismic events occur, far from the active infrastructure. This means that we allow events, but in specially predetermined places," explains Matthias Wimmer.

In addition, this "upside-down" method, in combination with good draw control, allows good conditions for mining more ore and significantly less waste rock, since dilution is avoided. But raise caving presents even more possibilities.

"Since the infrastructure and drifting, i.e., developing roads in the mine, can be reduced, we have the prerequisites for improving efficiency by as much as 50 percent"

### **New mining layout**

Raises are bored and that is the starting point for mining in slices and caving the ore from the bottom to top. This means that mining starts in the raises and is not done horizontally and conventionally by means of so-called drifts. This implies that no people work directly with drilling and blasting, in a conventional sense, within the raises.

"Concurrently with development of the raise caving method, we have worked with machine development. This is a highly automated machine that can both drill and charge via the raises. We are also developing a module for, among other tasks, rock reinforcement and hydraulic fracturing," says Matthias Wimmer.

Rock stresses are controlled strategically through a system of stress reduction slots. Intermediate pillars will initially withstand high pressure, enabling the development of further slots. Mining can therefore proceed in a stress-reduction zone, thanks to this method.

"The geometry of the pillars changes gradually, which means that they become deformed and the high stresses within the pillars are relieved. This also makes it possible to subsequently mine out the pillars."

### **From idea to production**

Raise caving has evolved within the framework of a larger project entitled *alternative mining methods*, the aim of which is to study several possible mining methods of the future. Raise caving is a versatile method which can also be applied in combination with other mining methods, for example, block caving.

"What started as an idea has developed into something much more, thanks to our many committed and innovative co-workers and colleagues. Together, we have developed raise caving based on existing mining methods, well-established de-stressing principles used in deep mines, and combined the best," says Matthias Wimmer, continuing, "We have several incredibly exciting year of tests and analyses ahead of us. It's a real privilege to work with this team and the journey towards greater depth has just begun."