Mine Subsidence

What is mine subsidence?

Subsidence can be caused by natural occurrences or human activities. Anything that creates space underground that can collapse under the weight of structures, rock, water and soil above it can cause subsidence. This includes natural caves or man-made mines and vehicle tunnels.

Mining subsidence is the vertical shifting of the ground, caused by the failure of an underground mine at the mine level. It is caused when the structure of an underground mine can no longer support the rock above it.

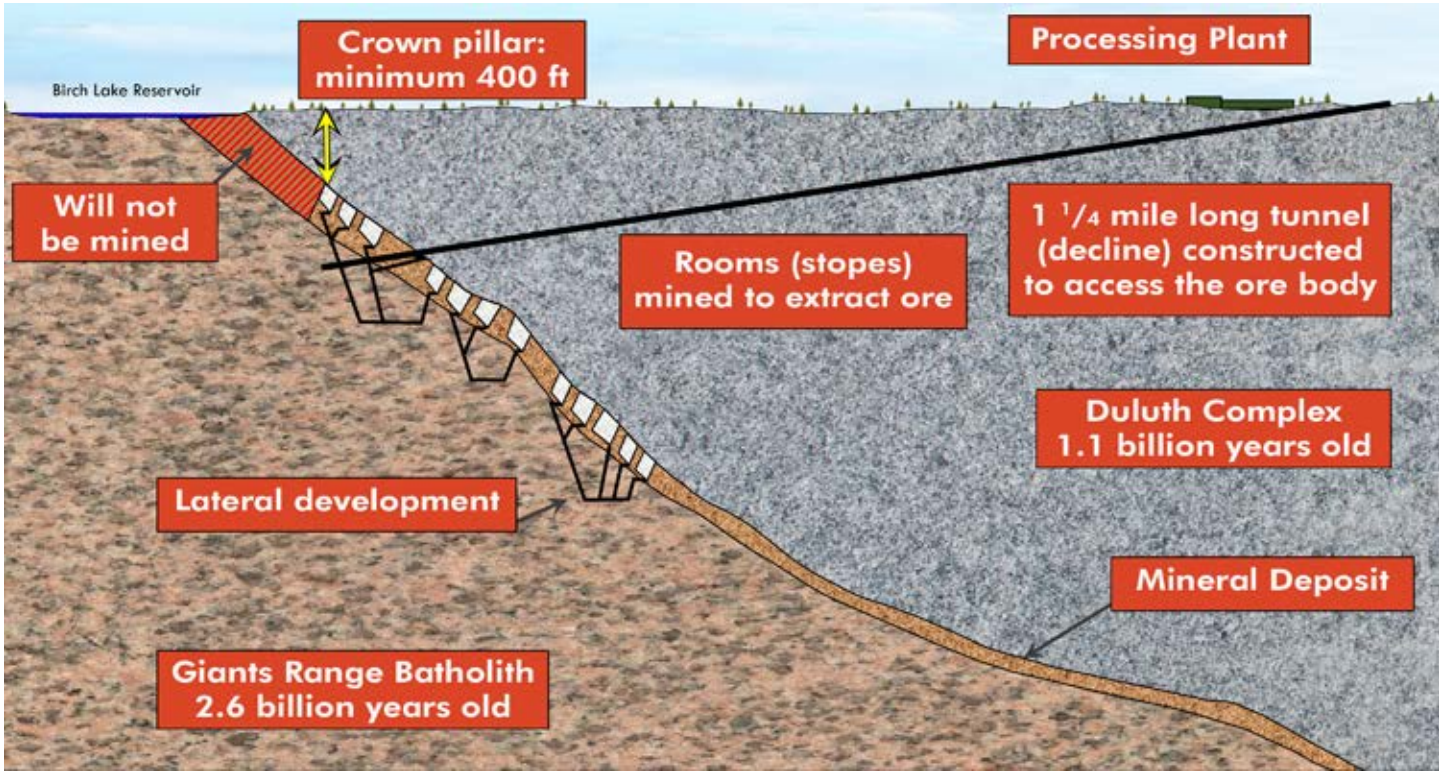
Understanding the surrounding geology and employing proper mine design and operations are critical to mitigating the risk of subsidence both during mining operations and following the closure of a mine.

Preventing the risks of subsidence

The risk of subsidence is different for every underground mine. It can affect small or large areas and can occur long after the closure of a mine. The risk of subsidence can vary from low to substantial depending on the geology of the site and the design of the mine.

The risk of subsidence is calculated by taking into account a number of factors, including:

- The depth of the deposit
- The shape of the mineral deposit to be mined
- The stability of the rock material in the deposit and the crown pillar above
- The mining method used to remove the ore from the deposit
- The method used to provide stability after mining has finished



Twin Metals Minnesota project site

The underground mining method for the Twin Metals Minnesota (TMM) Project is designed to prevent surface subsidence and to avoid impacts to the Birch Lake Reservoir.

The TMM Project deposit is located at least 400 and potentially down to 5000 feet underground with lots of hard strong rock between the surface and the top of the ore deposit.

The crown pillar at the Twin Metals Minnesota Project site would be about 400 feet thick and comprised of stable solid rock between the surface and the uppermost ceiling of the underground mine. About 80% of mining will occur below 1,500 feet and about 40% of mining will occur below 2,700 feet.

The mine would be excavated in sections that would create empty spaces known as stopes. Solid pillars of unmined rock would be left in place for structural support between the stopes and beneath the crown pillar.

In addition to the pillars, up to 50% of the tailings (mined rock processed in the surface mill) would return underground and serve as backfill, mixed with cement, to refill the stopes and further support the excavated mine.

With our understanding of the strength of the rock above the mine, and the method of using pillars, backfill and stope roof support, no measurable subsidence is anticipated at the TMM Project site.

Links to Mine Subsidence Resources:

TMM website
www.twin-metals.com

United States Geological Survey
https://water.usgs.gov/ogw/subsidence.html