Vale Base Metals Copper Cliff Mine Blasting Fact Sheet

What is Blasting?

Blasting is the third step of the mining process that follows drilling and charging and precedes mucking, surveying, and ground support as seen in Figure 1. It is an essential part of the mining process incorporating explosives to create excavations and recover valuable ore. There are two types of blasting in a hard rock mine:

1. ***Development blasting*** – the excavation of horizontal or vertical tunnels in the mine to build critical infrastructure or to directly access ore deposits. These blasts are relatively small and consist of multiple small diameter (>2.5-inch diameter, 16-foot long) drillholes. From the surface, these blasts create very faint sounds which resemble the popping of popcorn.

2. ***Production blasting*** – the excavation of larger "blocks" of ground or "ore" in production areas, also known as stopes. Each stope is extracted through a series of 4-7 blasts and consist of drillholes ranging from 4.5 to 6 inches wide. These drillholes can be up to 230 feet deep and are loaded with explosives (up to 20 feet) for any given blast. From surface, these blasts can often be compared to the sound of thunder and can create minor shaking of the ground.

Figure 1: Mining Development Cycle
*Similar to production blasting except bolting activity is replaced with filling

What is Mining Induced Seismicity?

It is not uncommon in deep hard rock mining for seismicity to occur, induced by the mining (excavating) of the ground. Mining induced seismicity is very much like natural seismicity in that it is the result of the redistribution (movement) of stresses within the rock. In the case of naturally occurring seismicity this is often the result of the build-up of tectonic pressures. Seismicity related to mining activity is more likely a result of excavating the rock (the stress in the rock that has been removed now needs to redistribute itself to the surrounding rock). This can be influenced by several factors, some of which are naturally occurring (rock types, properties or geological structures) or pertaining to mining (mining geometries and extraction ratios). Mining induced seismicity is most likely to occur during or just after blast times (the stress distribution is often triggered by the blast). Less frequently, these events do occur outside of the set blasting times seen below under "*Firing Times*", otherwise known as the blasting window.

Mining/Blasting Methods

Copper Cliff Mine Complex (CCM) uses one main type of production mining method known as Slot-Slash Open Stoping.

Slot-Slash Open Stoping is a bulk mining method that entails blasting vertical slices of ore to a free face, which initially will be blasted using an inverse raise, or bore raise. The amount of ore that can be blasted is entirely dependent on the void created from previous blasts. In the process of production stope drilling and blasting, blastholes are drilled using an in-the-hole (ITH) drill and are loaded with explosives by staggered decks to break anywhere from 10 feet to 40 feet. Prior to blasting, long blastholes are surveyed to determine their location and all holes are probed with a conductivity probe to confirm ore grade and limits. The blocks are incrementally slashed out in four to seven separate blasts up to the stope boundaries with a final blast which is called the crown. Stopes of 25,000 to 60,000 tons of ore can be completely mined out with a minimal number of blasts, some smaller stopes can be mined out in as little as one blast.

Slot-slash mining maximizes the availability of broken ore and increases the efficiency of stoping without compromising ore grade by diluting with waste rock. During this process, the stope's walls are supported which helps improve stope stability and minimizes issues related to ground control. Ground control, in this context, is the mitigation of risks associated with forms of ground movement within the mine. This method (pictured in Figure 3) can be used in both transverse and longitudinal orientations. Following the blast, removal of blasted ore by LHDs (load haul dump machines) is completed, and the stope is filled with a mixture of consolidated backfill and rock from previous development blasting. Copper Cliff Mine uses tailings from Clarabelle Mill in us backfill which provides a cost-effective source of fill while reducing our overall environmental footprint, reducing the need for tailings ponds.

To learn more about this mining method, click here.

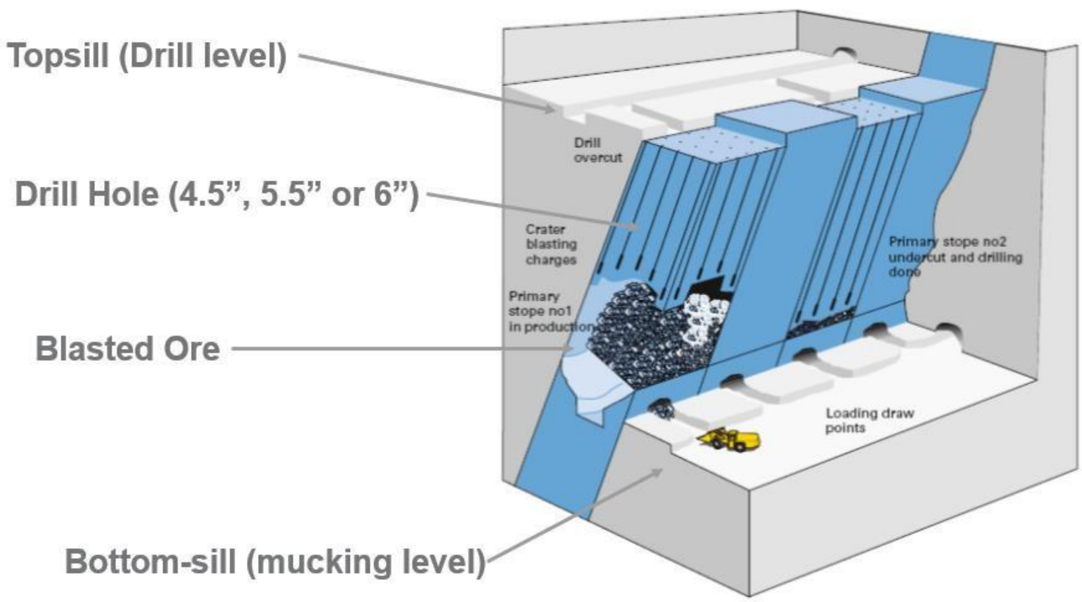

Figure 2: Slot-Slash Open Stoping

Firing Times

Development Blasting

7 days a week

5:30 p.m. to 6:30 p.m. (approximately 5:45 p.m.)

Production Blasting

7 days a week

5:30 p.m. to 6:30 p.m. (approximately 5:45 p.m.)

Monitoring Procedures

There are several monitors in place, both on surface on Vale Base Metals property and in private residences within the community of Copper Cliff, to monitor the vibration from blasts and seismicity induced by mining. There is also a large network of permanent monitors set up underground to monitor and analyze the seismicity at a closer and more precise level. When stopes are blasted and require special monitoring, non-permanent monitors are put in place within close proximity to the blasts to provide a much more accurate reading of the blasting vibrations. Should there be any issues regarding seismicity and blasts, CCM has ground control teams on site to measure vibrations and inspect affected areas thoroughly before allowing underground personnel to return to work.

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What does this mean for The Copper Cliff Community?

Members of the Copper Cliff Community in Greater Sudbury may feel shaking and vibrations from the blasts and seismicity, which can be accompanied by sounds which resemble popping or thunder. The affected locations will vary depending on the location of the blasts underground and the intensity of the effects will vary depending on the depth of the blasts – the further the blasts, the lesser the effects. Distance from the source is by far the highest influence on vibrational response (intensity), however, the amount of explosives initiated at any given instant during a blast (referred to as weight or pounds per delay) is also a very important factor. Other factors include spacing and burden (how much ground we are expecting the explosives to break), the type or size of the blast (production or development), the types of explosives used, the total amount of explosives used, and the structural response of the building from which the vibrations are being realized.

While we recognize that community members may become concerned when they feel the impact of a blast on surface, these are planned events and done so with strict measures on blast design and procedures in place to minimize effects of blasting within the community. If a community member wishes to voice a concern or learn more about blasting as it relates to the Vale Base Metals business, they are encouraged to reach out to our Community Concerns Line 705-222-VALE (8253) which operates 24 hours a day, 7 days a week.

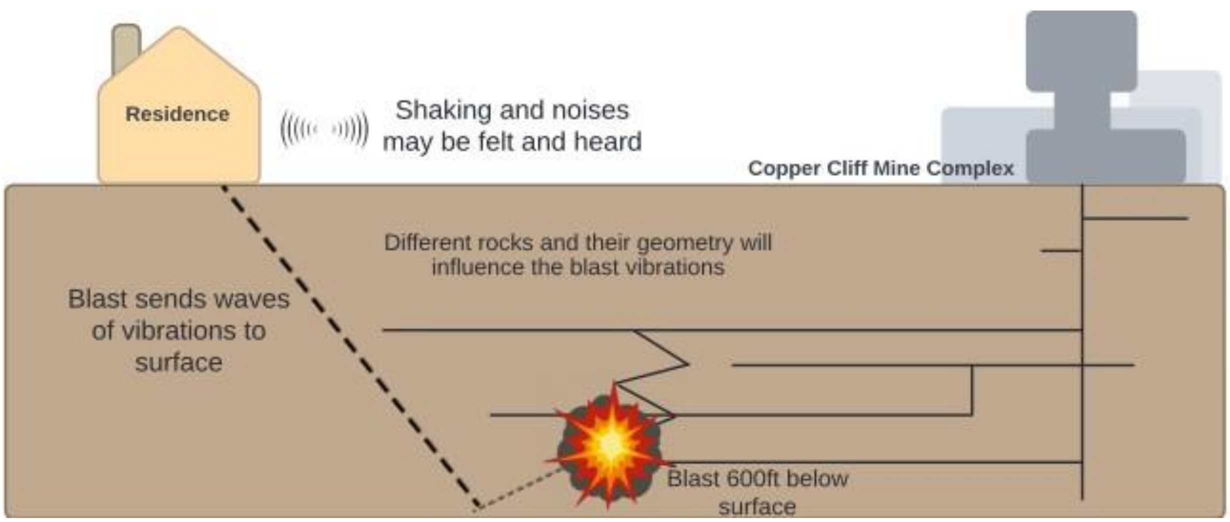

Figure 3: Interaction between blast and community

Underground Blasting: Explosive Limits and Design Considerations

In Slot Slash Open Stoping, 4.5-6 inch diameter blastholes are charged with a combination of ANFO/gel products and/or emulsion while NONEL-type detonators with boosters are used to initiate blasts. In recent years, the use of digital electronic initiation systems (Orica-IKON) has also been used to reduce vibration and minimize wall damage which can cause dilution.

Vale Base Metals has a maximum allowable vibration limit which stands at **12.5mm/sec** (as set out by Ministry of Environment, Conservation and Parks – MECP – Guideline Limits) for neighboring properties. The goal is to keep it as low as reasonably possible and over 95% of production blasts at Copper Cliff Mine are well below **6mm/sec**. There are, however, technical or operational challenges and a very small percentage of our blasts do approach the 12.5mm/sec. Each production area, otherwise known as orebody (O.B.) has limitations on the explosive weight per delay (lbs/delay) based on their proximity to the community and neighboring properties and their geometries in relation to geological influencing structures. Blast holes are designed for optimal spacing and burden (limiting the amount of ground expected to be broken by the explosive) and, when drill hole deviation falls outside of the acceptable limits of good design, redrills are prescribed (drillers are required to redrill the holes with better accuracy).

CCM Blasting Parameters			
Blast Drill Hole Size			
Orebody	Development	Production	
		Uppers	ITH
880 Above 690 Level	2-1/8"	4-1/2"	4-1/2"
880 Below 690 Level	2-1/8"	4-1/2"	6"
865	2-1/8"	4-1/2"	6"
850	2-1/8"	4-1/2"	6"
830	2-1/8"	4-1/2"	6"
810	2-1/8"	4-1/2"	6"

Figure 4: Copper Cliff production maximum blast hole diameters by O.B.

Production Blast Weight per Delay	
Orebody (O.B.)	**Lbs./delay**
880	72-250
100/900	250-450
120	450
810	200-450
865	200
860	350

Figure 5: Limits surrounding the amount of explosives initiated per delay by O.B.