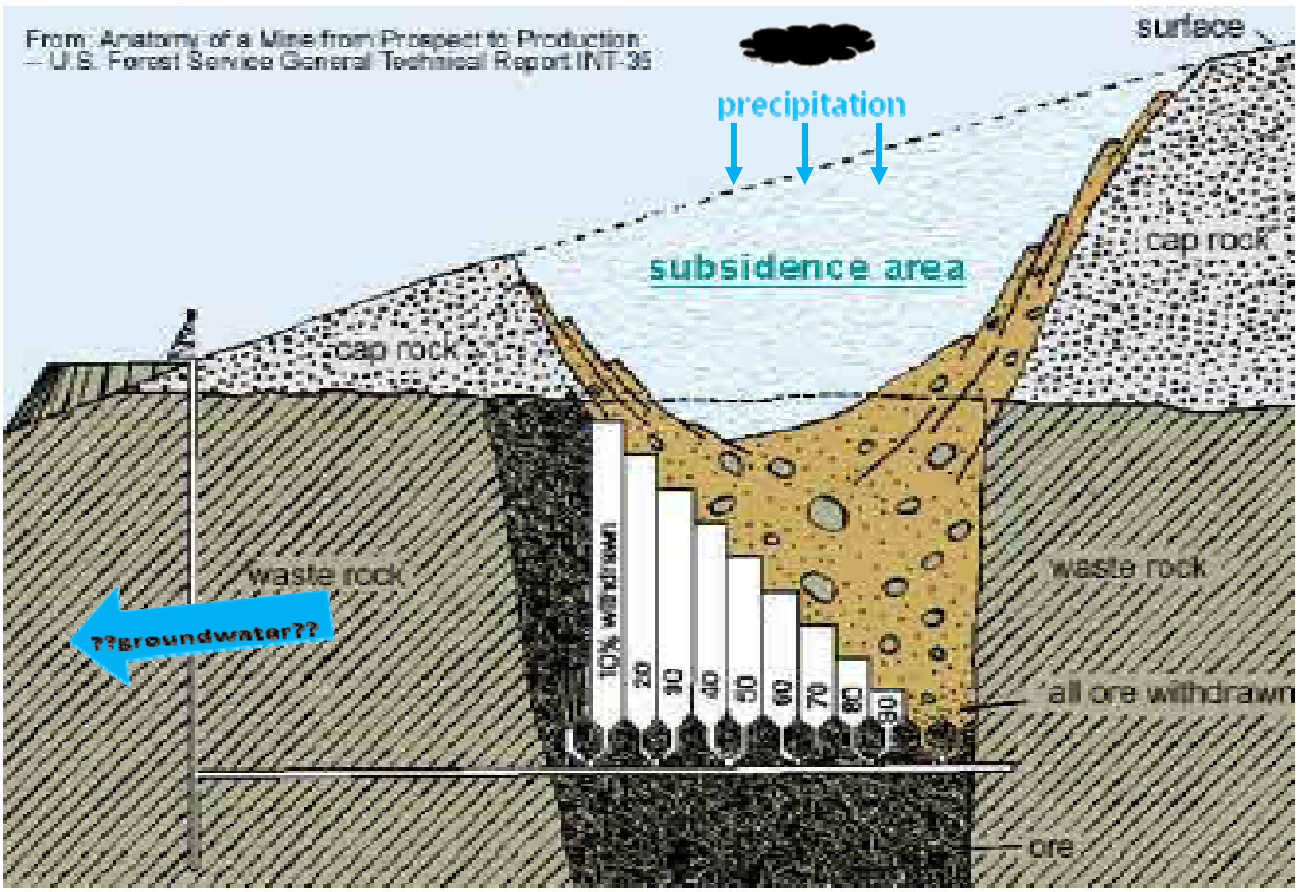
BLOCK CAVING[1]

This is a short summary of the block caving mining method employed to extract large volumes of ore from an underground mine.

Underground mining is more expensive than open pit mining because access to the ore body is gained by drilling a series of shafts and tunnels through non-ore rock. Underground mining is much more labor intensive than open pit mining, requires more safety and support equipment, and is much less productive in terms of ore production per man-hour than open pit mining. Ore for an underground mine must be of comparatively higher grade to justify the increased costs of this type of ore extraction.

"Block caving is a mining method in which ore is allowed to collapse due to its own weight in a controlled fashion. Block caving is usually used to mine large orebodies that have consistent, disseminated grade throughout."[2]



[1] This summary was prepared by David Chambers, Ph.D., Center for Science in Public Participation, Bozeman, MT, March 2008

[2] This description of block caving is largely extracted from: www.mininglife.com/Miner/ugmethods/block_caving_description

“Block caving occurs sequentially in segments or blocks in all three directions. A series of haulage tunnels are constructed under the ore to be mined. Along each tunnel in a checkerboard pattern, raises connect the haulage tunnels with another series of crosscuts.[3] In the crosscuts, scrapers or LHD's transport the ore back to the main haulage level. The ore falls down finger raises[4] intersecting the cross drifts[5] below. The ore continues to fall under gravity from the bottom of the block as it is pulled from the raises. No further entry can be made in the finger raises once the block begins to cave in. As broken ore is removed, the capping or non-mineral bearing rock above the ore will gradually descend until broken fragments of it start coming from the draw points, indicating all of the ore has been withdrawn.”[6]

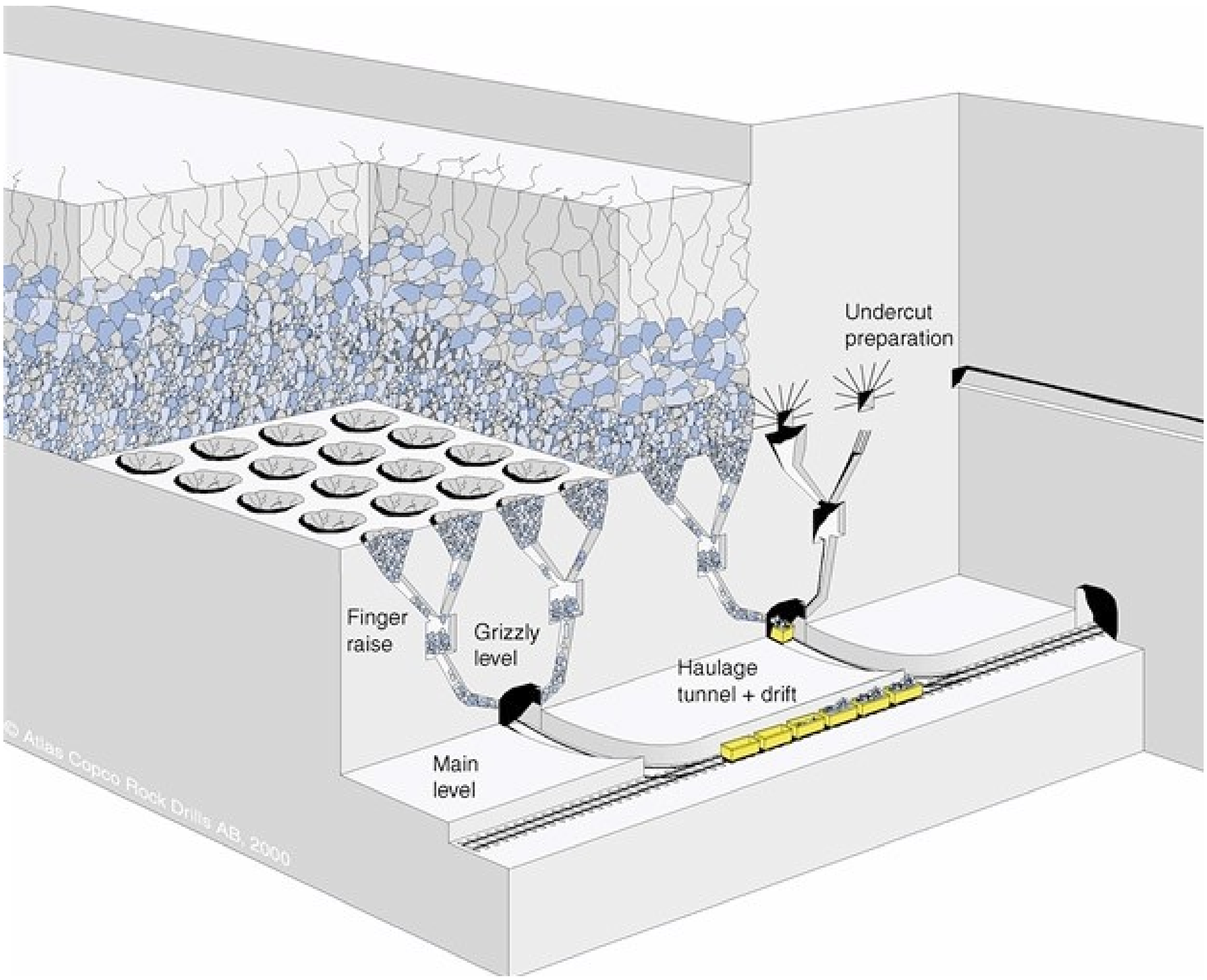


Diagram of block caving – photo from Atlas Copco AB)

[3] **Crosscut –** A tunnel driven from one seam to another through or across the intervening measures; sometimes called "crosscut tunnel", or "breakthrough".
[4] **Raise –** A vertical or inclined underground working that has been excavated upward form a level to connect with the level above.
[5] **Drift –** A horizontal or near horizontal underground opening that follows along the length of a vein or rock formation as opposed to a crosscut which crosses the rock formation.
[6] This description of block caving is largely extracted from: www.mininglife.com/Miner/ugmethods/block_caving_description

“There is typically large scale subsidence[7] on surface as a result of block caving. The area of subsidence is usually greater than the caved block but not as deep since it is usually partly filled with collapsed rock from above the cave block.”[8]

The block caving method of underground mining is employed with massive ore bodies (e.g. porphyry-type ores[9]) that are too far underground to allow the use of open pit mining methods. One of the major economic considerations of open pit mining is the amount of waste material that must be removed relative to the ore. If the ore is too deeply buried, or if there is too much waste commingled with the ore, even low cost mass removal techniques may be uneconomic.

From an environmental standpoint, most underground methods have the advantage of creating less waste rock than open pit mining. The exception to this would be if the deposit is entirely exposed on the surface. In this instance open pit mining might actually be environmentally preferable to block caving because there will be no rubble-rock waste remaining in the mine through which water can move, leaching metals as it percolates downward through the abandoned mine workings.

The primary disadvantage of block caving is that it removes much of the supporting rock from underneath the overburden, which often leads to subsidence of the surface. Once the surface is ruptured, water can percolate down through the rubble-rock material remaining in the mine. If there are contaminants in the rock, either due to the decomposition of sulfide minerals (e.g. heavy metals like copper, zinc, lead, cadmium, or mercury) or from flushing neutral drainage metalloids (e.g. arsenic, selenium, thallium or antimony), these contaminants can flow downgradient to mix with groundwater and/or surface water. With block caving, as with open pit mining, it is very important to understand the hydrology around the minesite. If water is likely to migrate from the minesite through groundwater paths, offsite water contamination is likely to result.

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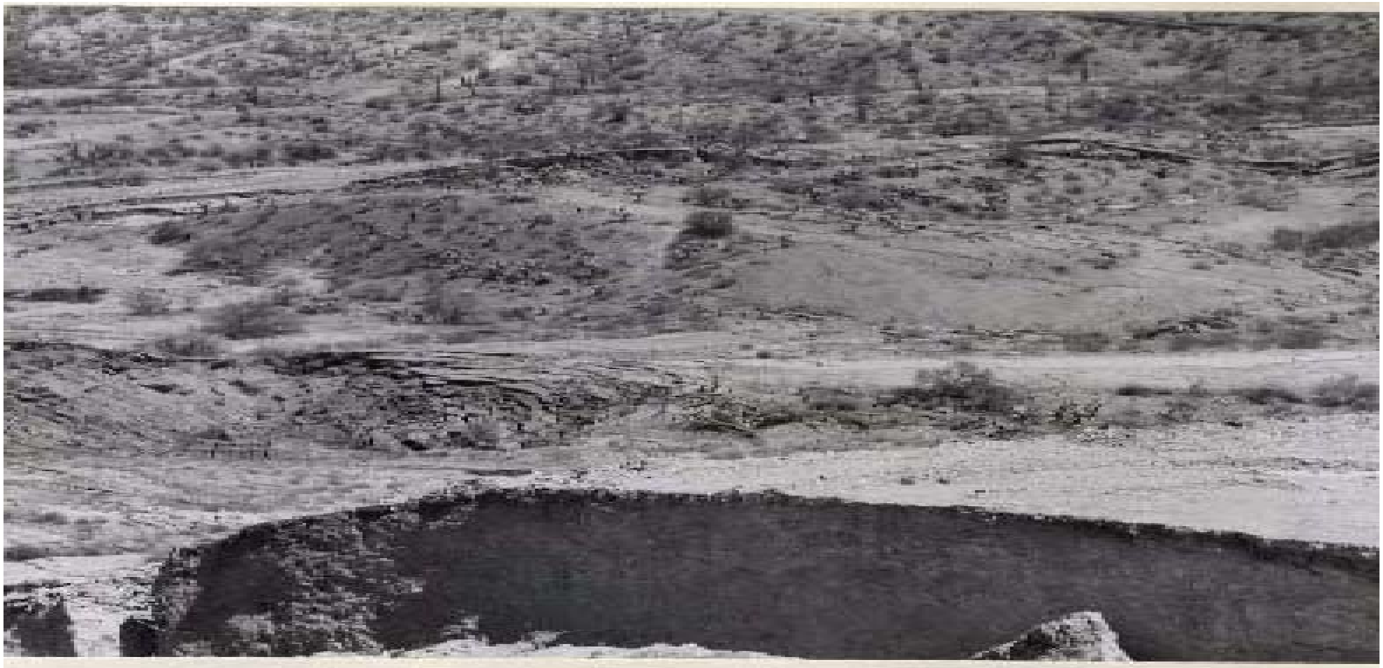
[7] **Subsidence** (in mining**)** – The gradual settling or sinking of the surface due to the removal of ore and waste rock from the mine workings.

[8] This description of block caving is from: www.mininglife.com/Miner/ugmethods/block_caving_description

[9] **Porphyry –** Any igneous rock in which relatively large, conspicuous crystals (called phenocrysts) are set in a fine-grained groundmass. A porphyry copper deposit is a deposit of disseminated copper minerals in a large body of porphyry.

Subsidence due to block caving at the San Manuel copper mine, Arizona



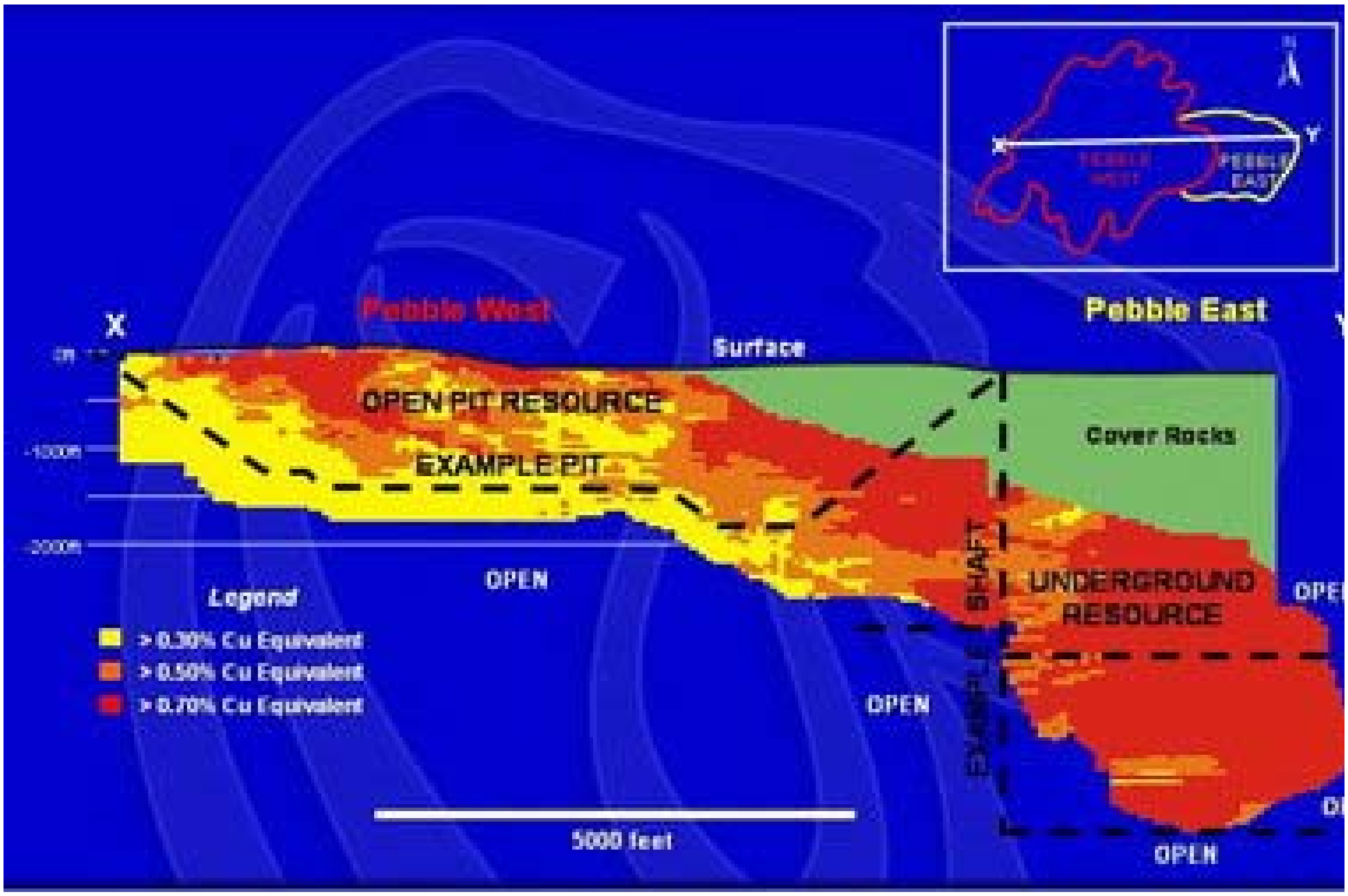
Subsidence due to block caving at the Ridgeway Mine, South Carolina

PEBBLE PROJECT

The initial discovery at the Pebble site of a low grade copper-gold-molybdenum ore body that outcrops on the surface was made in 1988 by Cominco, Inc.[10] This site is now called Pebble West. Since this orebody outcrops at the surface, and is a disseminated, as opposed to vein-structure type, orebody it would be mined by open pit methods.

The Pebble East deposit was discovered in 2004 by drilling through overburden east of the initial deposit discovery.[11] Pebble East lies under an increasingly thick wedge of unmineralized overburden that is too thick to mine economically by the open pit method.

Pebble Deposit Cross Section



The ore grade at Pebble East is higher than that at Pebble West,[12] but is still relatively low grade in terms of what is usually seen for an underground mining operation. Because the Pebble orebody is low grade,

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[10] http://www.northerndynastyminerals.com/ndm/Pebble.asp, June 12, 2007
[11] http://www.northerndynastyminerals.com/ndm/Pebble.asp, June 12, 2007
[12] http://www.northerndynastyminerals.com/ndm/Pebble.asp, June 12, 2007

the only type that is economically viable for Pebble East is block caving. With underground block caving, no pillars are left to support the mine working during mine operation. In fact, block caving is designed to induce collapse in the ore zones. Block caving is the cheapest way mine underground and, since maintaining production rate is often a problem at underground mines, provides the highest production rate for ore of all the underground mining techniques.

It is highly likely that subsidence will occur as a result of the block caving at Pebble East. Subsidence at the surface will allow water to enter the underground mine from above and come in contact with the broken rock that will remain underground in the mined areas. The rock in the remaining underground workings in the orebody will be mineralized. Unlike the situation prior to mining, where the sulfide orebody was essentially isolated from oxygen, the mined area will have water and oxygen available to it. This could lead to decomposition of the sulfide minerals. If a flow path exists from the mine workings to ground and surface waters down gradient from the mine, migration of contamination off the mine site could be a long term issue.

The information presently available to the public is not sufficient to determine the extent to which this may be problem, but it one of the most important issues in terms of potential long term impact from the mine, and needs to be carefully researched and addressed.

Because block caving will most likely cause surface subsidence, and because the Pebble orebody is a sulfide orebody, the critical determining factor will be the hydrologic regime of the minesite. Predicting and controlling the hydrology will be critical if migration of contamination from the closed mine.

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