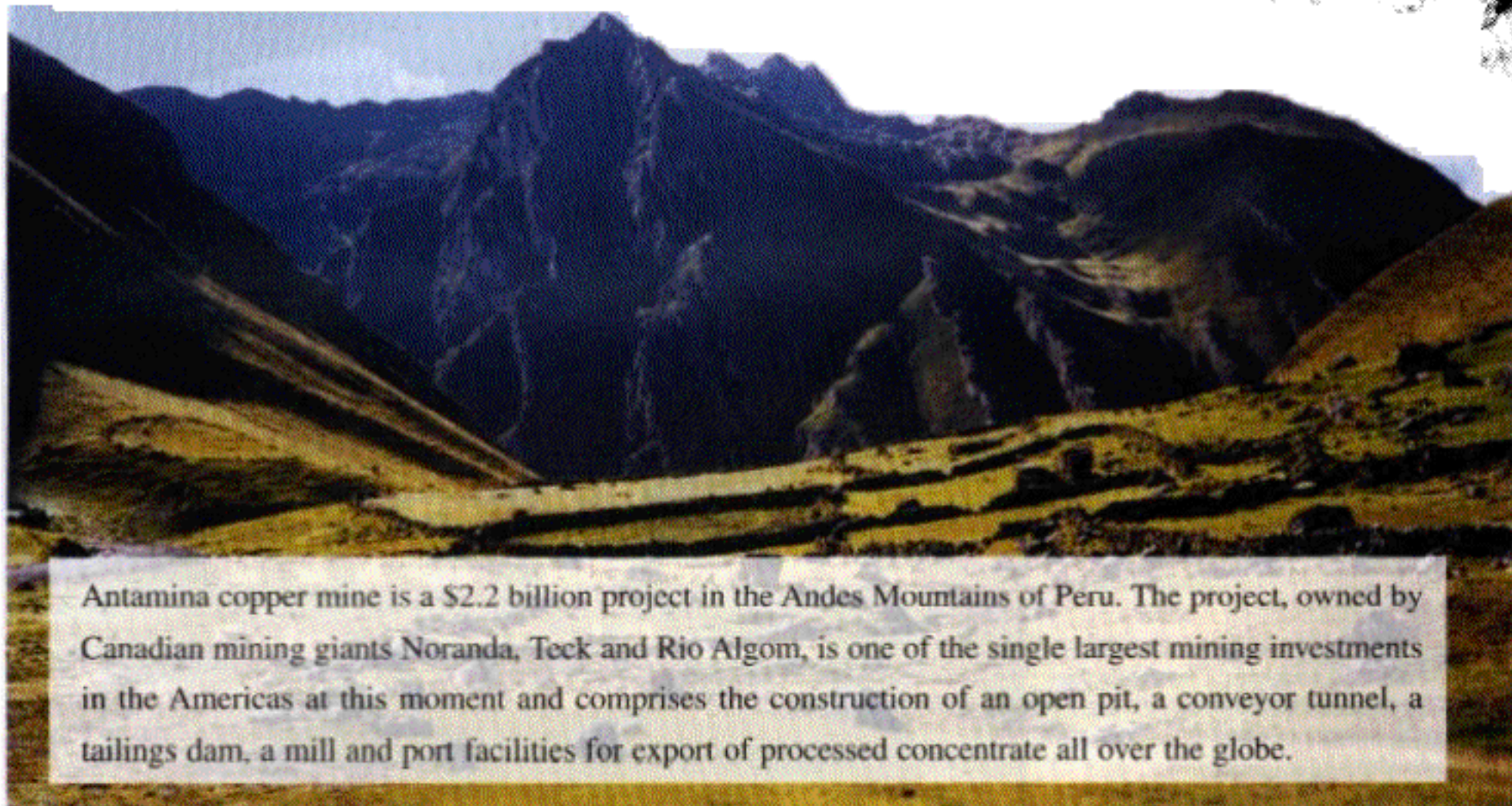


# Shotcrete Red Hot in Peru



Antamina copper mine is a \$2.2 billion project in the Andes Mountains of Peru. The project, owned by Canadian mining giants Noranda, Teck and Rio Algom, is one of the single largest mining investments in the Americas at this moment and comprises the construction of an open pit, a conveyor tunnel, a tailings dam, a mill and port facilities for export of processed concentrate all over the globe.

Figure 1. General landscape at Antamina Mine at 12,600 ft. (3840 m) altitude in Peru.

by Hugo Armelin  
and Denis Blais

The entire project is based on the highest world standards of safety, environmental protection and construction quality, with general construction management being done by Bechtel of the USA in joint venture with Cosapi of Peru.

Amongst the various infrastructure needed is a decant tunnel to take the possible overflow from the

tailings dam to a diversion route. This 1300 m long x 4.0 m high x 4.2 m wide (4293 ft long x 13 ft high x 13 ft 9 in. wide) section tunnel happened to be in the critical path of the entire project and therefore required strict tolerances for time of completion.

This tunnel, designed by Golder Associates' Vancouver office in association with Ingetec of Co-

lombia, was awarded to **Redpath Mas Errazuriz Peru (RME Peru)**, a tunnel contracting joint venture of **Redpath** of Canada and Mas Errazuriz of Chile. It was designed to be shotcreted during excavation with different shotcrete thicknesses according to ground conditions (see Table 1). The design shotcrete strength was 28 MPa (4000 psi).

The options to the contractor were to either produce its own shotcrete on site or to contract the work out to a specialized shotcrete supplier. Given other contractors' difficulty in attaining specified strength plus the difficult working conditions that Antamina poses—site altitude of 4200 m (13,800 ft.), 20 hour trucking distance from Peru capital Lima, high con-

Table 1: Ground Support

Ground	Support	Ground description
Type I	Unsupported, only occasional shotcrete or bolts	Good quality competent ground, typically limestone
Type II	50 mm (2 in.) thickness shotcrete w/ 4 + 3 bolts at 2 m (6 ft) length	Somewhat fractured ground, mixed limestone and claystone
Type III	100 mm (4 in.) thickness shotcrete w/ 7 + 6 bolts at 2 m (6 ft) length	Moderately fractured ground, mixed limestone and claystone
Type IV	Same as III plus steel ribs	Poor quality highly fractured ground, typically claystone near faults



Figure 2. Shotcreted outlet portal, Antamina Decant tunnel in Peru.

struction standards and contractual delay penalties—it was **RME Peru's** decision to contract out the shotcrete supply to Target Products of Canada. The main factors for this decision were:

- High shotcrete quality standards imposed by the client
- Shotcrete supplier's guaranteed shotcrete delivery
- Ability to deal with a single supplier for all shotcrete related matters rather than several suppliers (cement, aggregates, admixtures, fibers, mixing equipment, etc.)
- Less supply items to manage on site (stock only shotcrete rather than cement, admixtures, etc.)
- Less equipment on site, where problems are difficult and costly to solve
- Less manpower on site, lower boarding and transportation costs
- Gain in construction speed by having shotcrete always available on site
- Access to state-of-the-art personnel and expertise from supplier's staff

The decision to outsource dry-mix shotcrete production to a specialized supplier was also strongly



Figure 3. Worker unloading bulk bags of shotcrete ready to be used at Antamina Mine.

supported by project managers of Bechtel, who had previously worked with this method when successfully speeding up the time schedule on a similar 12 km (7.45 mile) tunnel in the Chilean Andes' Los Pelambres Project (see *ASA Magazine*, V. 1, No. 3, pp. 8-11).

In order to supply the project, Target created an association with La Viga of Peru and met the challenge of initiating supply only one week after signing of the contract with RME Peru.

Given Redpath's, Bechtel's and Target's experience in shotcrete application to other large tunneling projects in remote locations, as well as the



Figure 4. Shotcreted tunnel and inlet face with type III ground to be supported with shotcrete.



Figure 5. Picture of a pre-moisturizer machine used to lower dust emission underground.



Figure 6. Picture of Joe Duro, the shotcrete professor.

## Acknowledgements:

### Owners:

Teck, Noranda and Rio Algom (Canada)

### Construction Management:

George Manson, Bechtel Tunnel Division  
Tom O'Connor, Bechtel Tunnel Division

### Design and Inspection:

Golder and Associates (Canada),  
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### Contractor:

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Operations Manager  
David Hansman, Redpath Mas Errazuriz  
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### Shotcrete:

Hugo Armelin, Target Products Special Projects  
Diego de La Torre, La Viga General Manager

nature of the work required, it was decided by all parties that dry shotcrete be used in 1200 kg (2650 lb) bulk bin bags, thus allowing for shotcrete to be always available at the two tunnel portals and allowing for shotcrete application without delays after blasting and mucking.

This decision proved to be correct and critical, when, with less than 15 m (50 ft) tunnel advance, both working faces hit Type III (unstable) ground, requiring a 100 mm (4 in.) thick shotcrete layer for ground control and up to 27 m<sup>3</sup> (35 yd<sup>3</sup>) of shotcrete consumed per day. Because both working faces did not have to stop to produce shotcrete, RME Peru was able to advance at a peak record speed of 26.7 m (87.6 ft) in a single day, unaffected by difficult ground conditions.

As a result, with 82 days since first blast, RME Peru is showing that the tunnel construction is 16 days ahead of schedule and predicts moving into a final concrete lining operations some 26 days ahead of schedule, thereby demonstrating that for logistically complex projects such as the Antamina tunnel, potential problems should be solved away from the construction site.

**TARGET SHOTCRETE ANTAMINA MINE-PERU**

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