

Underground Limestone Mining

Trading Costs For Profit

Limestone is in such great demand, both as high quality roadstone and as the raw material for cement manufacture, that its mining is frequently carried out underground. Proximity to the market, or availability of a suitable mineral deposit, may be the driver, but economic extraction is the deciding factor. In essence, the underground limestone mines are trading off the savings in surface transportation costs by being closer to the point of use, against the marginal difference in production costs between surface and underground working. Where these are approximately in balance, an underground mine can be profitable. Hence, the major characteristic of a successful underground limestone mining operation is its efficiency, and the single greatest factor affecting this is the cost of drilling and blasting. Atlas Copco drillrigs are bringing down this cost by a combination of drilling speed and accuracy with low maintenance and longevity. Matching the drillrig to the job ensures that, whatever the mining situation, economic long-term production can be achieved, sometimes with the whole operation dependent upon a single machine. The following case studies from three very different locations serve to underline this point.

Auersmacher, Germany

Since 1936, almost 20 million t of limestone have been produced at Auersmacher, a border town in Saarland, Germany. Mining activity has left a cavity of nearly 7.8 million cubic metres in the form of 225 km of underground roadways. The mining area covers almost 4 sq km, with overburden of approximately 50 m in



Atlas Copco Rocket Boomer L1C-DH drilling the face at Auersmacher limestone mine.

thickness, and an average mining height of some 6 m. The Triassic strata comprises a shelly limestone, which is excellently suited as an aggregate for the local steel industry.

The mine is working a room and pillar system of extraction in the horizontal deposit, and the normal face is 5 m high and 6.5 m wide. The length of a room plus pillar is about 100 m, and some limestone is left to form the roof.

The mine uses a diesel-powered Atlas Copco Rocket Boomer L1C-DH hydraulic drillrig, because there is no electricity supply installed to the faces. It is equipped with the CAN-bus system, and a COP 1838HF rock drill with 22 kW output. As a result, blast holes of 51 mm diameter can now be drilled to depths of 3.4 m at a rate of 6-8 m/min. Each V-cut round of 35 holes produces up to 340 t, and takes only an hour to drill.

Since the Rocket Boomer rig started operations, it has drilled the entire daily production output in a one-shift operation, returning very favourable

operating and wear costs. Mine output is now 350,000 t/year, and the rig is drilling six rounds/day, working dayshift only. The rest of the mine works two 8 h shifts/day, 5 days/week, with a Saturday morning shift for non-production work if required.

Experience with the diesel hydraulic unit has shown it to be economic on fuel, and to exhibit low exhaust gas emissions.

The Boomer L1C-DH features a Deutz BF6M 1013 CP engine, with EMR and catalyzer, which consumes only about 19 litres of diesel for each percussion drilling hour, and can complete two shifts on a single tank of fuel. The excellent exhaust emission values are very important in underground mining, where ventilation can be costly.

Due to the very good drilling and flushing characteristics using water mist, drill rod losses are negligible. Water consumption varies from 2-5 lit/min depending upon rock conditions, and a full tank contains 840 litres. The water mist mix is adjusted by the operator to achieve the



View from the driver's seat of the Rocket Boomer L1C-DH.

desired effect. With too little water, it is impossible to drill, and with too much, the cuttings become slurried.

The rotation speed has a profound effect on penetration rate. In the limestone rock at Auersmacher, the optimum speed is 400 rev/min. Dropping it to 300 rev/min reduces the penetration rate by 2 m/min.

Drilling is carried out exclusively with Atlas Copco shank adapters and drill rods, and the very good dampening and anti-wear properties of the equipment has resulted in enormously long service lives, despite the high work capacity. For example, the

approximate service life of drill bits is 3,200 drillmetres, rods 10,000 drillmetres, and shank adapters, 18,500 drillmetres.

Secoroc shank adapters and steels are used with a 51 mm ballistic bit. The mine switched from 42 mm bits for a 2 m/min improvement in penetration rate, with accompanying gains in ANFO blast yield.

At the start of each drilling shift, the operator takes around 15 minutes to check the engine oil, feed hoses and grease points. His training as a mechanic helps him to get the best out of the sophisticated engine. The

servicing requirements have no negative impact on mine production.

High temperature greasing of the rock drill gearbox is carried out every 40 hours, or once a week.

The close support of the Atlas Copco team has resulted in a collaborative relationship that gets the best out of the equipment.

Linwood, USA

Another Rocket Boomer L1C-DH was delivered to the Linwood Stone mine in Iowa, USA for use in limestone with an average compressive strength of 165 Mpa. This rig is equipped with RCS, using ABC Basic software for assisted boom positioning, collaring point, hole direction, hole depth control, and statistics. A Diarot study was conducted on this rig, in order to calculate the correct settings for the rock drill, without using trial and error.

Increased performance was obtained by adjusting the rotation speed to 400+ rpm, and using a newly developed button bit from Secoroc, which features increased button protrusion, and more and bigger flushing holes.

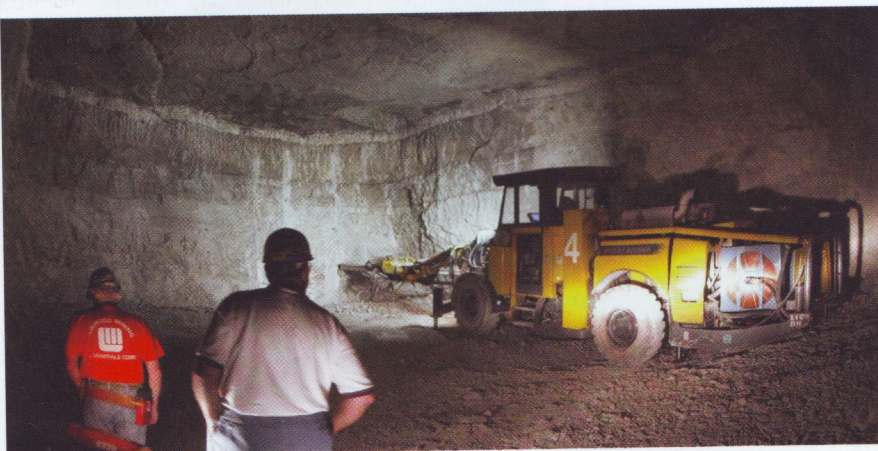
The Rocket Boomer L1C-DH is achieving penetration rates of 3.5 to 4.5 m/min, which is a doubling in output over the previous generation of drillrigs.

Dalen, Norway

A single Atlas Copco Rocket Boomer L2 C with advanced CAN-bus Rig Control System (RCS), and unparalleled reliability, produces an impressive 1 million t/year at Dalen limestone mine, located on the southern coast of Norway. Dalen limestone comprises sediments of Ordovician-Silurian origin, which occur in a regular bed of around 40 m-thickness.

The limestone is located between a footwall of metamorphic rock and a hanging wall of sandstone, and the deposit is dipping 15-20 degrees to the east, below the Eidaneerfjord. The cement plant, and the community of Brevik, sit right on top of the deposit, which comprises the largest underground operating mine in Norway.

Rocket Boomer L1C-DH face drilling at Linwood Stone in Davenport, Iowa.





Norcem Rocket Boomer L2 C drilling a top heading at Dalen mine.

The decision to purchase the Rocket Boomer L2 C rig was helped by Norcem's positive experiences with its previous 23-year old Boomer H 132.

The Rocket Boomer is used both for developing new areas and for production drilling, on two shifts/day, five days/week. Maintenance takes some 3-4 h/week, and rig availability has been close to 100%, with hardly any unplanned stops. The mine gets a lot of work out of the rig, drilling 282,000 m/year.

The Rocket Boomer L2 C rig was specially fitted to Norcem's requirements with COP 1838ME rockdrills, and the RCS and ABC Total automated boom positioning and drilling system. The rig was also equipped with an extra-wide boom console, to increase the width of the coverage area.

Norcem uses the software program Tunnel Manager Lite to design the drilling plans, which are pre-programmed in the office and transferred into the rig's control panel by using a conventional PC card. Drilling logs are also stored on the PC card.

Boom positioning, and drilling of the pre-selected drill plan, can be fully automated, or semi-automated with manual positioning. The cross section of the top headings is 14 m-wide and 8 m-high, and a Vee-cut is used. Here the rounds consist of 105 holes, drilled to depths of 5.4 m at 48 mm-diameter.

For the first crosscut round, where the face is not flat, about 65 holes tend to be drilled in the fully automated mode.

When the top heading drifts are complete, they are followed by horizontal benching, 14 m-wide and 6 m-high, to achieve the full room dimension of 14 m x 14 m. Some 4-5 rounds of 1,500-1,600 t are blasted each day, consuming about 550 kg of explosives/round. Production is switched between working faces in the mine, of which there can be up to 40 at any given time. The 15 km/h tramming speed of the Rocket Boomer L2 C between faces helps its overall high utilization.

Because of the non-abrasive nature of the rock, and the rig's ability

to continuously optimize drilling parameters, shank adapters and drill steel last for up to 8,000 drillmetres, and the 48mm Secoroc drillbits last for around 2,200 drillmetres.

Conventional hydraulic rigs are now expected to last for a million drillmetres/boom, but the combination of self-adjusting rock drills and Norcem's high maintenance standards could well double that figure for their Rocket Boomer L2 C.

Conclusions

At Dalen, a single rig is handling the entire production requirement of 1 million t/y, mainly due to a combination of high performance with high availability. Where there is no suitable electricity supply to the mining areas to power an electro-hydraulic rig, as at Auermacher and Linwood, diesel-hydraulic rigs offer a means of upgrading mining efficiency without excessive capital expenditure. At these mines, drilling rates have doubled with the introduction of the Rocket Boomer L1C-DH, and round depths have increased significantly. These machines, equipped with water tanks and water mist flushing, operate efficiently despite the absence of mains supplies of water and electricity. They are also adaptable, performing on both production and development, and handling rockbolt and ancillary drilling. ■

Section of mining layout at Dalen limestone mine.

