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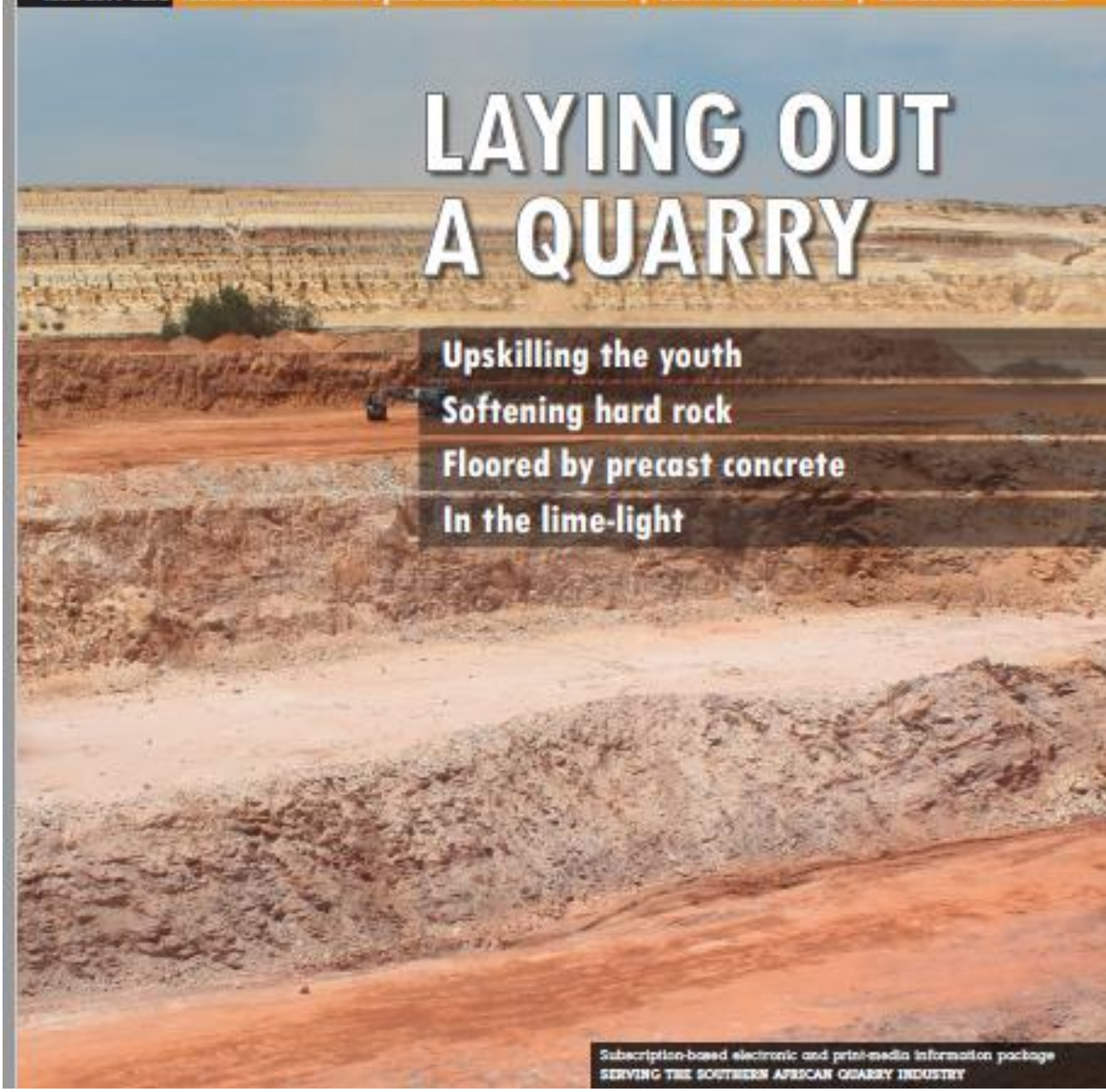


LAYING OUT A QUARRY

Upskilling the youth

Softening hard rock

Floored by precast concrete

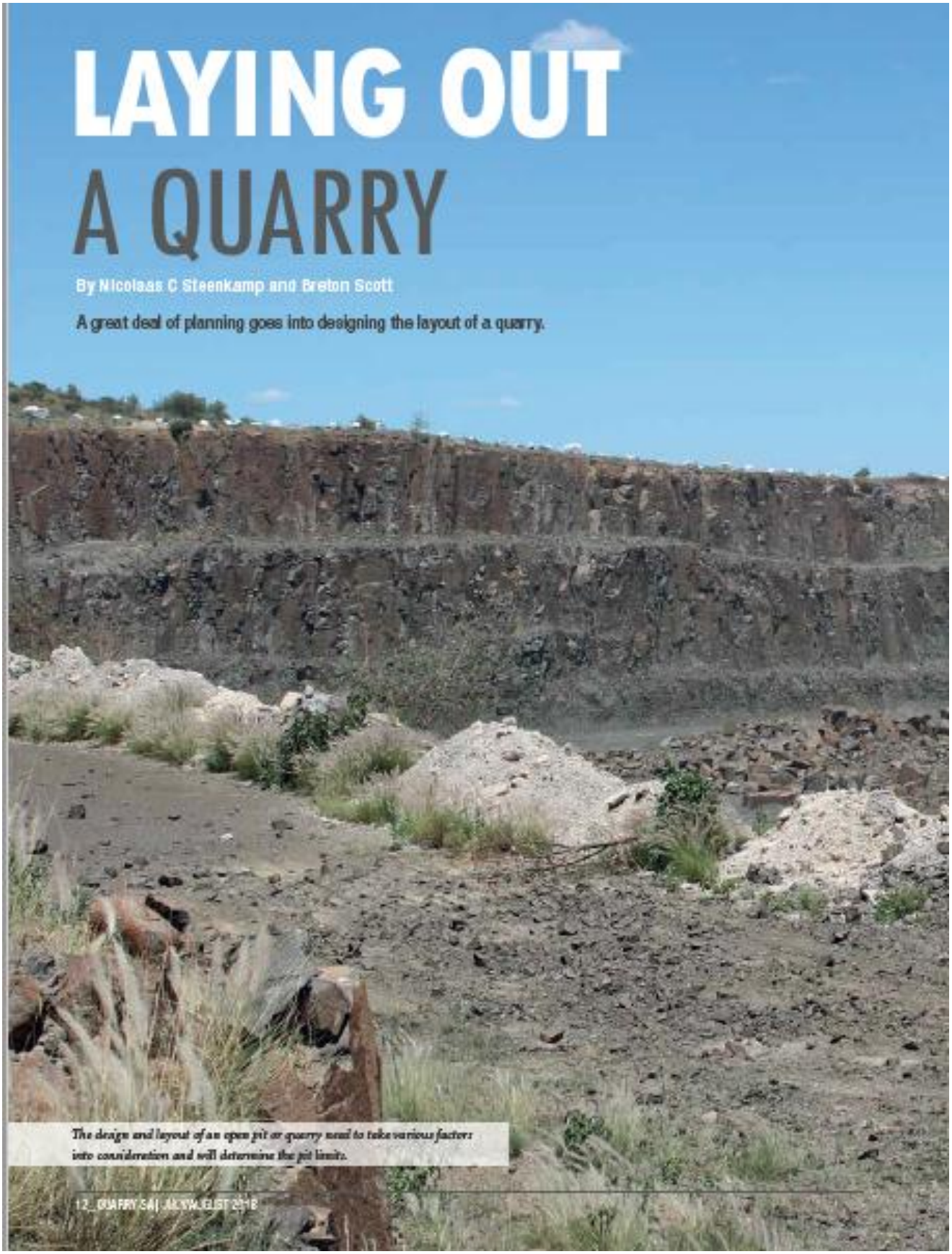
In the lime-light

Subscription-based electronic and print-media information package
SERVING THE SOUTHERN AFRICAN QUARRY INDUSTRY

LAYING OUT A QUARRY

By Nicolaas C Steenkamp and Breton Scott

A great deal of planning goes into designing the layout of a quarry.



The design and layout of an open pit or quarry need to take various factors into consideration and will determine the pit limits.

In planning the layout of an opencast mining operation or a quarry, the main factors that will determine the layout and the potential for profitability are the geological characteristics of the deposit and the economic considerations to first bring the operation into production, including the costs associated with running it.

Geological factors

Opencast and quarry operations target deposits that outcrop on surface or near surface. Opencast mining operations usually target bulk commodities such as iron, manganese, coal, and similar type deposits. The product is sold unprocessed as lumpy ore, or with minor beneficiation, such as washing or pelletising. Quarry operations target industrial materials such as sand, gravel, dimension stone, and related materials that are mostly sold after crushing and screening or sizing. The geological and topographical features determine the extent of mining.

Mining shallow deposits will start off with a desktop study to find suitable deposits or to infer the extent of adjacent mines. This will usually also entail a remote sensing component, such as orthophotos or satellite spectral images. Once the legal requirements such as prospecting and mining right applications, environmental impact assessments, environmental management plans, and public consultation have been completed, sampling of the deposit takes place. Grab samples are collected from the surface, which is used to create geochemical surface maps for opencast mines or material quality domain maps for quarries. This would generally be done in parallel with geophysical studies to delineate the extent of the mineralisation and to detect subsurface structures that are not visible during surface geological mapping.

The next step is to conduct drilling. A combination of core and chip drilling is done to determine the lithology and mineralisation at depth. The surface grab samples and drill core or chip samples are dispatched for assaying to determine the grade. The sample material is also used in metallurgical tests to determine the best recovery methods, which will influence the

Photos by Nicola Thaulsson

Geological characteristics and economic considerations have a considerable influence on the layout of opencast and quarry operations.

design of the plant and the required plant equipment. In the case of quarries, such as dimension stone, the samples will be used to determine the physical appearance and dominant grain orientation, to establish the best extraction layout direction.

The geological and assay or quality data are then used to construct a model. In the case of an opencast mining operation, a geological- and block model with the results of the assays is constructed. This will determine the capital footprint and the most suitable area to make the first box cut. It will also give an indication of the amount of material that will have to be removed as part of the overburden or as waste. The block model will give an indication of the tonnages and areal extent of ore reserves.

oxidised and/or fresh ore. Quarries and opencast operations have to consider geological losses, including intrusions such as dolerite dykes or fault zones. The pit shell dimensions are largely influenced by the cut-off grade as it will determine the depth or distance from the plant that material can still be economically mined.

The physical design and layout of the open pit or quarry take the following factors into consideration: stripping ratio, pit slopes, bench heights, road grades, dewatering, and property lines. The stripping ratio refers to the amount of overburden or waste material that needs to be removed before accessing the ore (mineralised material) or the saleable quarry product. Overburden usually refers to the residual or transported soils that cover the outcrop. Most environmental management plans require this top soil not to be mined, but to be stockpiled and used during the mine closure and rehabilitation phase.

The mine layout needs to make provision for areas where waste rock and low-grade stock piles can be built, without influencing mining activities or sterilising mineable ground. The ground control domains determine the angle of the pit slopes and the bench heights to meet the minimum factors of safety. The road grades and width of the permanent ramps, spirals, and loading and tipping points are influenced by the size of the trackless equipment and the effective safe operating slope angle.

The layout of a mine or quarry is also affected by legal and legislative constrains, such as the property limits of the approved mining rights area and servitudes associated with public roads and infrastructure, for example power- or waterlines. The presence of protected flora and historical sites or graves might also influence the layout.

Economic factors

At the end of the day, the aim of all operations is to make a profit. Economic factors will determine the viability of operating a quarry or open pit. The grade of material might be good, but if there is no demand or if the cost of extracting it is too high, it will not be worth developing it.

Evaluating the costs associated with a quarry or opencast mine can be done using techno-financial modelling. The different costs relate to establishing and running of the operation. Capital

The pit shell

The next step would be to determine the pit shell. This could be done by means of various geological or mining software, such as running a Whittle Optimisation of various scenarios, taking the modifying factors into consideration. Such an exercise enables the planners to generate a mine plan and schedule. The schedules usually cover short-term, mid-term, long-term, and life of mine, which can be adjusted according to changing economic or demand conditions.

The design and layout of an open pit or quarry need to take various factors into consideration and will determine the pit limits. The first is the types of ore or material that can be mined in the case of an opencast operation, for example

The equipment will be sized to meet the requirements set out by the mining schedule and the capacity of the plant.

The road grades and width of the permanent ramps, spirals, as well as loading and tipping points, are influenced by the size of the trackless equipment and the effective safe operating slope angle.

expenditures (capex) refer to the cost associated with establishing the mine or quarry. This pertains to the expenses of conducting the front-end studies, such as the appointment of EPCM consultants and contractors to do the various feasibility studies, trade-off studies, and optimisation studies and designs.

Operating costs (opex) are the costs associated with the day-to-day running of the operation. This is the actual nuts and bolts required to run the mine or quarry. It entails everything from the salaries, the fuel, and service of trackless equipment, to the water and electricity of the plant.

Marketing considerations relate to having a market for the product being produced. In the case of an opencast mining operation, it would entail having an offtake agreement in place before the first ton of material is processed. In the case of a quarry, market condition will be driven by construction and associated property development. Dimension stone operations, on the other hand, are at the mercy of the current trends, such as marble versus granite countertops.

The selection of mining equipment is usually done to determine the equipment best suited to the type of material, size of the operation, and on-site processing requirements. The mining equipment selection will include everything from the blasthole drill rigs, excavators, and front-end loaders to haul trucks. The equipment will be sized to meet the requirement set out by the mining schedule and the capacity of the plant. Open pits and quarries use trackless mining, and trade-off studies will usually be done to determine the benefit of using certain brands of heavy vehicles, based on the production specifications. Correct selection of vehicles will also have an impact on the capital layout and operational costs.

The on-site plant set-up will be determined by the level of beneficiation or processing that is required of the product at the mine gate. Quarries may require only basic crushing and screening equipment, whereas opencast operations may require more sophisticated washing plants. The operator has the option of having a fixed capacity plant for the life of mine or flexibility by using a modular plant set-up. As with the trackless equipment, the plant equipment selection is based on the requirements of the operation and optimising it as far as possible.

The rate of production is influenced by commodity or product price and demand. Locating infrastructure in terms of the cost impact it has on the mine is another factor that needs to be kept in mind when doing the plant design and selection. The placement of the entire infrastructure, from the offices, parking bays, and workshops to plant, needs to be optimised. This includes distance from the mining or quarrying operation, without sterilising portions of the deposits, and proximity to the access road(s) for road transport to market delivery or shipping points. ■

ABOUT THE AUTHORS

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Bowline Professional Services provides consultation services during the planning and front-end development of opencast or quarry operations and has a unique service offering called 'Mine in a Box'. This concept fast-tracks (without shortcuts) the design and development processes to bring a small-scale mine into production as early as possible.