УНИВЕРЗИТЕТ „ГОЦЕ ДЕЛЧЕВ" – ШТИП
ФАКУЛТЕТ ЗА ПРИРОДНИ И ТЕХНИЧКИ НАУКИ

UDC 622:55:574:658 ISSN 185-6966

Природни ресурси и технологии
Natural resources and technology

ноември 2011
november 2011

ГОДИНА 5 **VOLUME V**
БРОЈ 5 **NO 5**

UNIVERSITY "GOCE DELCEV" – STIP
FACULTY OF NATURAL AND TECHNICAL SCIENCES

ПРИРОДНИ РЕСУРСИ И ТЕХНОЛОГИИ
NATURAL RESOURCES AND TECHNOLOGY

За издавачот:
Проф. д-р Зоран Панов

Печати	**Printing**
„Европа 92“ - Кочани	„Evropa 92“ - Kocani
Редакција и администрација	**Address of the editorial office**
Универзитет „Гоце Делчев” - Штип	Goce Delcev University - Stip
Факултет за природни и технички науки	Faculty of Natural and Technical Sciences
ул. „Гоце Делчев“ 89, Штип	Goce Delcev 89, Stip
Р. Македонија	R. Macedonia

СОДРЖИНА

UDC: 622:574
Стручен труд

RECLAMATION AND ENVIRONMENTAL MANAGEMENT IN DIMENSION STONE MINING

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Abstract

This paper discusses the environmental impacts of dimension stone mining and recommends effective means for dealing with the practical aspects of reclamation and mine closure in dimension stone mining within the context of environmentally responsible business practices.

From the point of view of the environmental impact created, dimension stone mining is a relatively benign industry. There are no emissions besides those of the diesel powered earthmoving equipment utilised in its extraction and a small amount of blasting gases. Contamination of water resources is only likely in the event of petrochemical spillages from storage facilities and equipment, and these can largely be either prevented or cleaned up effectively. The major environmental impacts are of a visual nature, while in sensitive areas, habitat destruction and the destruction of archaeological heritage may become significant impacts.

Key words: *dimension stone mining, reclamation, management.*

ОБРАБОТКА И ЗАШТИТА НА ЖИВОТНАТА СРЕДИНА ПРИ ЕКСПЛОАТАЦИЈА НА АГК

Јонче Димчов[1], Зоран Панов[1]

Апстракт

Во овој труд е разгледано загадувањето на околината при експлоатација на архитектонско-градежен камен (АГК) и се предложени практични решенија за рекултивација и затворање на рудниците на АГК.

Во поглед на загадувањето, експлоатацијата на АГК причинува мала штета по околината. Овде не се среќаваат големи загадувачи на воздухот, освен дизел моторите на работните машини и мала количина на гасови од минирањето. Водата се загадува само во случај на изливање на работни масла и горива во работните простории и тие можат ефективно да се

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избегнат или сопрат. Главно загадување е нарушувањето на релјефот, додека во посебни области нарушувањето на природата или раскопување на археолошки наоѓалишта може да претставува сериозен проблем.

Клучни зборови: *експлоатација на архитектонско-градежен камен, рекултивација, менаџмент.*

Introduction

Dimension stone is a collective term for various natural stones used for structural or decorative purposes in construction and monumental applications. The rapid growth in production and demand has resulted in rapidly increasing environmental impact of the industry, especially in terms of the disposal significant volume of fines generated by dimension stone processing, but also in terms of the increased number of quarries disturbing the natural environment.

The ultimate success in marketing a natural stone as a dimension stone lies firstly in its appearance, and secondly in the possibility of producing rectangular blocks of suitable dimensions (hence the term dimension stone) to allow for successful production of the final product in the required sizes.

A dimension stone block thus has value as a result of its dimensions and appearance, underlain by a set of minimum physical properties (among these are various strength parameters, workability, ability to take a polish, and resistance to physical and chemical weathering).

The physical properties required of a successful dimension stone also have significant environmental implications – due to the requirement for inert materials, which are not affected by weathering, dimension stone residues are typically benign from a pollution point of view. Like natural aggregates, dimension stone is used in its natural state, and does not require concentration and extraction from an ore. It is these latter two processes that result in significant environmental impacts such as acid mines drainage and other toxic effects associated with many of the metal extraction industries.

Similarly, mining methods themselves generally have a low impact on the surrounding environment due to the need to carefully extract large blocks or slabs without damage to the stone.

Recent advances in dimension stone mining technology have also had the effect of reducing environmental impacts. Particularly in granites, improvement in diamond wire sawing efficiency has significantly reduced the use of explosives in the extraction of blocks. This has resulted in higher recovery of saleable blocks and therefore less waste to be disposed of, as well as reducing the emissions of blasting gases (SO2 and NOX), noise and ground vibration. Diamond wire sawing has also largely replaced jet flame cutting for loosening benches in hard stone deposits. This has resulted in significant reduction in noise (jet flame cutters operate at over 130dB), as well as reduced energy requirements and thus lowers contribution to greenhouse gases.

In the past, the environmental damage caused by mining was accepted by society because of the economic benefits that derived from mineral extraction.

However, the past few decades have seen a growing awareness among the general public of environmental impacts, and the impacts of mining in particular have come under significant scrutiny. Indeed, "the immediate image of mining is of a dirty, hazardous and environmentally damaging industry". A study in Australia suggested that mining was responsible for 1.1% of presumed extinctions of endangered plant species, compared with 38.2% attributed to grazing and 49.4% to agriculture, we would suggest that public perception sees mining as a far greater threat to biodiversity than agricultural uses of the land.

Environmental impacts of dimension stone mining

Environmental impacts should ideally be identified and mitigated according to the phase in the mining life cycle. This is a more practical way of dealing with environmental impacts since the scale of impact differs according to phase (e.g. impacts made during the exploration phase are much less than those made in the operational phase). In addition, the environmental monitoring and management varies with each phase of the mining life cycle and hence the total project costs. The environmental impacts of dimension stone will therefore be discussed according to phase in the mining life cycle. The life cycle of mining operation goes through the following phases:

- Exploration: Economic deposits are identified and their characteristics are determined to allow recovery.
- Development: Preparations are made for mining.
- Extraction: Valuable material is removed for sale or processing.
- Reclamation: Disturbances caused by any of the preceding activities are corrected or ameliorated.

Environmental Impacts during the Exploration phase

The first stage of management of environmental impacts of quarrying operations comes with the exploration for a new dimension stone deposit. Exploration activity usually impacts the least on the environment in comparison to other phases of mining. However, in the past, prospecting and exploration for dimension stone was the domain of non-professional prospectors, who because of lack of knowledge of the market and industrial requirements of the processing industry, coupled with the absence of professional exploration skills seldom conducted formal investigations or evaluations prior to opening quarries. This has lead to many ugly scars on the landscape, everywhere around the world, as full scale quarrying commenced without any knowledge of the underlying geology, and in these circumstances is often unsuccessful.

The approach to exploration whereby exploration is carried out in phases (these are discussed in more detail in the accompanying paper) - completion of each phase prior to test quarrying does not guarantee a successful quarry, but provides sufficient information to make an informed decision as to whether or not to proceed to the next stage taking the risks of a negative outcome into account. At each step of this sequence, the environmental impacts are taken into account, and the minimum possible footprint is disturbed. From an environmental point of view this phased approach has the benefit that environmental disturbances are minimised considering the possibility of a negative outcome. Thus if an exploration project is abandoned after drilling, the environmental impact is orders of magnitude lower than if the "boots and all" approach had been used.

The phases of exploration are listed below:

- Desktop Study
- Field evaluation
- Detailed mapping
- Geophysical methods
- Drilling
- Bulk Sampling
- Test Quarrying

Environmental Impacts during the Development Phase

Development is the preparation the facilities, equipment, and infrastructure required for extraction of the valuable mineral material, and the phase includes land acquisition, equipment selection and specification, infrastructure and surface facilities design and construction, environmental planning and permitting, and initial mine planning. During this phase of many mining projects, there may also be a need for involuntary relocation of communities located in proximity to the proposed mining area. This can be a fatal flaw of a project and should be facilitated by qualified and experienced consultants. In the case of dimension stone however, given the scale and margins of the average quarry, it is likely that any requirement for significant relocations will render the project unviable. However, given the nature of the mining methods employed (especially if fully no explosive methods are used) it is possible to mine safely much closer to human settlements than with most other surface mines and quarries.

Maintenance workshops should be designed to avoid contamination of soil and water by spilled fuel and lubricants. An important factor at this stage in dimension stone quarries is the choice of location of the waste dumps, and these should be sited in such a way as to minimise the visual impact where possible.

The construction phase is associated with a number of environmental impacts resulting from excessive site clearance, poor waste management, poor site water management and socio-economic impacts. Impacts that may be caused by excessive site clearance during the construction phase, in addition to those mentioned in the exploration phase are excessive dust problems, increased soil erosion and increased noise due to vehicle traffic and the use of explosives. The buffer (mainly vegetation) that limited noise and dust to local communities may also be removed.

Impacts of quarry construction on the social environment have to also be taken into consideration, especially if there is a pre-existing community near the proposed mining project. These impacts include public health risk caused by increased vehicle traffic (dust, hydrocarbon spillage, greenhouse gas emissions) and access to unsecured infrastructure under construction; nuisance factors such as noise, dust and vibration; adverse impact on traditional lifestyle of local communities for example alcohol abuse, prostitution, introduction of a cash economy, in-migration and breakdown of traditional tribal culture.

Environmental Impacts during the Extraction Phase

The major impact of dimension stone mining on the environment is the aesthetic visual impact of quarrying upon the landscape. Any mining activity, which disturbs the surface of the earth, will have a visual impact for its duration, and dimension stone quarries commonly have a high degree of visual impact due to the fact that they are often located in areas of positive relief, and thus visible from large distances and often from many directions. In addition, the geometry of the dimension stone quarry with its regular squared faces stand out within the natural environment, particularly when the faces are created by diamond wire sawing, and thus smooth with much higher reflectivity than the natural surroundings. Visual impact for the duration of mining operations is unavoidable, but is likely to be temporary and restricted to the duration of mining and perhaps some time thereafter, depending on climate and the degree of effort put into reclamation of the quarry and its waste dumps (in Brazil for instance, a dimension stone quarry can hardly be seen after just a few years even without reclamation due to the rapid rate of plant growth and blackening of the fresh rock surface).

Infrastructure found on most small to medium sized dimension stone quarries includes offices, power lines, stockyards, workshops, and dressing yards and waste dumps. Offices usually generate domestic waste, power lines have negligible environmental impacts, stockyards and dressing yards may impact on soil structure in the form of compaction, while the release of granite/stone fines is a significant impact of dress yards, although in most cases they are not harmful.

Management of environmental impacts

During the operational phase of a quarry's life, planning with future closure in mind can lessen the impact on the environmental. It is also good practice to plan mining where possible in such a way as to be able to utilise waste from operational quarries to fill the voids of worked out quarries. By planning properly, many voids from quarries and gravel borrow pits can be filled up during the course of mining at very little extra cost. Comparatively, it would not be economically feasible to fill the worked out voids at the end of the life of the quarry. Similarly, the correct location and construction of waste dumps can significantly assist in lowering the final reclamation cost for the quarry. Waste dumps that are constructed on flat areas should be built up in layers of 6-10 metres in height, with a terrace of at least 6 metres wide between the crest of one layer and the foot of the succeeding layer. In this way, the outside perimeter of a completed layer can be reclaimed concurrently with the dumping of the next layer. Further, if the waste dump is planned in such a way that the final perimeter is constructed first, and then filled back towards the quarry, it is possible to reclaim the outside perimeters at a very early stage, thus reducing the visual impact during the operating phase of the quarry.

Topsoil should be removed in advance of mining and waste dumping and where possible, utilised as soon as possible for reclamation to ensure minimal loss due to erosion and reduced fertility of stockpiled soils as a result of the decrease in nitrogen-fixation organisms and leaching of calcium and potassium from the soils. Where this is not possible, topsoil stockpiles are kept to a height of 2 m in order to limit run-off rate and, in this way, reduce erosion, or where this is not feasible, water control structures are utilised to control run-off and thus minimise erosion of the stockpile. If necessary (this is seldom the case, as it generally contains a fertile seed bank), the stockpile is seeded with seeds of grasses and shrubs to keep organic activity alive, as well as ensure a fertile seed bank in the topsoil when it is finally used.

Any contaminated soil is bio-remedied using proprietary products kept on all sites for the purpose. The process involves loosening the contaminated soil to allow for oxygen penetration (the soil is usually transported to a specific impervious site for treatment to avoid compaction during the process), and adding agricultural fertiliser and the proprietary products containing appropriate microbes to break down the hydrocarbons. The soil is kept damp and is turned periodically over a period of several weeks as the microbes break down the hydrocarbons.

Technically, oils, grease and hydraulic fluid spills must be cleaned up by removing all contaminated soil and disposing such soil in a waste disposal receptacle or at a licensed facility.

Regarding the transport, all gravel roads in quarry areas have a speed limit of 60km/h for light vehicles and 30km/h for heavy vehicles in order to minimise the amount of dust generated by vehicles. During the operational phase of a quarry, attention is also given to removing trees and shrubs where possible, and replanting these either in a nursery, in areas where reclamation is in progress or outside the mining area, thus lessening the impact on floral biodiversity.

Reclamation of dimension stone quarries

The term rehabilitation has traditionally been used for the range of activities relating to the remediation of environmental damage to the surface of a mine after extraction is completed.

The other known term is reclamation, defined as "a response to any disturbances to the earth and its environment caused by mining activity" as it is wider in scope and includes all aspects of management of negative environmental impacts caused by mining.

As dimension stone mining is a clean operation, the main aims of reclamation are as follows:

- Ensure that worked-out areas are safe for future uses,
- Minimise visual impact of disturbed areas,
- Re-vegetate worked-out areas with suitable plant species,
- Achieve long-term stabilisation of all worked out areas to minimise ongoing erosion and
- Monitor and manage reclaimed areas until the vegetation is self-sustaining.

Landscaping

While many historical voids are filled during the course of mining as discussed above, there are several old quarries which have become perennial water holes, and ecosystems have established themselves around these holes as discussed below. Filling all of these would be environmentally detrimental, but they do pose a risk to human and animal life in terms of their steep sides, and if left as is pose a long-term safety risk for the mine owner. The solution being applied to these is to landscape the approaches to these water holes where possible in order to provide for safe access for humans and animals, and to pack waste blocks along high walls which cannot be so landscaped in order to prevent inadvertent access.

Another important part of final landscaping work is the construction of berm walls to control rainwater runoff and prevent erosion of the topsoil. It is important to note that the limited topsoil used on the sides of waste dumps is initially subject to some erosion due to the steepness of the natural angle of repose (37°).

Re-vegetation

Re-vegetation is the most effective and economic method of stabilising the soil against erosion assists in re-establishing biodiversity in the reclaimed area and helps ameliorate visual impacts.

Topsoil reclaimed in advance of waste dumping has high seed content, particularly of grasses, and where possible is used directly from stripping for reclamation. In this way, rapid re-vegetation is obtained at minimal cost. In some areas where topsoil is in short supply, it is necessary to mix topsoil with norite gravel in order to obtain the coverage required. In these cases the mixture is fertilised with cattle and goat manure purchased from local communities, or else fertiliser in the form of limestone ammonium nitrate is added.

A mixture of waste rock and soil (the waste rock helps provide stability to the soil and allow steeper slopes, which in turn allow for a thicker deposit within the available space) is placed against the foot of the high wall (which itself may be rock shaded) and seeded with grasses, shrubs and small trees. The bench surfaces are covered with soil, and it is attempted to slope this away from the high wall crest to prevent erosion. In many cases, waste blocks are packed along the high wall crest to form a permanent safety barrier, and these in combination with manually packed stone berms these may also assist in preventing erosion of the soil.

Conclusion

While the environmental impacts of mining are often largely exaggerated in the eyes of the public, it cannot be escaped that mining has an appalling public image. While the industry can take some of the blame for this given a historical track record of contempt or ignorance of its impacts, much of this has to do with the fact that the impacts of mining are often far more visible than those of other industries. In fact, it is ironic that the visual impacts which inflame public opinion against mining are often the least significant impacts of metalliferous and coal mining operations – the potential for severe pollution from these operations is far more significant than their visual impacts or local destruction of ecosystems by extensive surface mining.

Dimension stone mining, by the very nature of the requirements for the final product is a clean industry from a polluting point of view. However, the visual impacts are often significant, given that many deposits are situated in hills or mountains.

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