VISUAL IMPACT AND RECLAMATION OF LIMESTONE QUARRIES IN ALGARVE PORTUGAL[1]

T. Panagopoulos[2], R. Matias, and B.R. Ramos

Abstract: Limestone quarries are the most important open cast mining activities in Portugal. Obtaining public acceptance in a rehabilitation project is still considered a challenge. This challenge can be accomplished by reducing the visual adverse impacts and by incorporating aesthetic aspects in quarry rehabilitation projects. With the development of more stringent practice codes and environmentally based guidelines, quarry managers must provide more detailed and comprehensive environmental impact assessment along with their development plans. The visual impact assessment should be made available for public review and demonstrate that the proposed operations will achieve the visual quality objectives. Geographic information systems provide a remarkably efficient means of understanding impacts of quarrying in mountainous areas which is often lost in two-dimensional presentations. To facilitate this understanding, new technologies similar to those found in a flight simulator, were developed to help people visualize change. In this study it will be presented the reclamation project and the visual impact assessment of a group of limestone quarries in the fragmented Mediterranean landscape of Algarve, Portugal. Viewshed analysis of the quarries showed what areas of the disturbed surface can be seen by observers for any visible position and how many observers can see the position. The reclamation method could help governmental officials to take the appropriate decision: accept, reject or suggest aesthetical modifications in any proposed project of the study area.

Additional Key Words: landscape ecology, geographic information system, aesthetic, visual quality, quarry reclamation project.

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[2] Thomas Panagopoulos, Professor of Landscape reclamation, Department of Landscape Architecture, University of Algarve, Faro, Portugal, 8005-139 email: tpanago@ualg.pt . Rita Matias and Bibiana Ramos, Consulting Landscape Architects, VERDESIGN, Lda., 8100 Loulé, Portugal, email: bibianaramos@mail.telepac.pt

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Introduction

Limestone quarries are the most important open cast mining activities in Algarve, changing significantly the Mediterranean landscape. The Algarve represents about 4% of the quarry activity in Portugal, witch corresponds to 5.7 million tons of rock, 81% of that is limestone and 0.16% is material for the production of Portuguese traditional sidewalk blocks. Traditional sidewalk blocks represent a typical element in the Portuguese urban landscape and own a peculiar characteristic in all its process of fabrication, from its extraction, to the manufacture and placement of the sidewalk blocks because it is a handcraft practice. Therefore the limestone quarries for the production of Portuguese sidewalk rock show a quite different organization than the rest of open cast mining activities of the region. Most quarries are small, family managed and without plans for reclamation.

With the development of more stringent practice codes and environmentally based guidelines, quarry managers must provide more detailed and comprehensive environmental impact assessments with their development plans. The visual impact assessment (VIA) should be made available for public review and demonstrate that the proposed operations will achieve the visual quality objectives (Lucas, 1991). Geomorphology, soils, climate, vegetation, land cover and historic and current land uses combine to give a distinctive pattern to the landscape, which is not only scenery but is also emotive and dynamic. Following the appropriate program in all stages of mining, the area can return to the society improved and ready for such uses as agriculture, forestry, recreation, sports, industrial and others.

The geographic information systems (GIS) technology was used by land-use planners to assess the criteria requested to define the suitability of preserved landscapes (Florent and Musy, 2001), to estimate changes of land cover and assess land-use impacts on biodiversity and conservation planning (Miller, 2001), in visual impact assessment (O'Sullivan and Turner, 2001) and in landscape planning and design processes (Kodmany, 2000).

Understanding impacts of quarrying in mountainous areas is often lost in the two-dimensional presentation (Ramos and Panagopoulos, 2006). To facilitate this understanding new technologies, similar to that found in a flight simulator, were developed to help people visualize change (Panagopoulos, 2001). The development of computer tools for creating and representing virtual worlds has dramatically increased our abilities to capture some of the basic elements of the landscape and communicate them to audiences remote from the landscape under study (Orland et al., 2001).

The objective of the present work was to study the visual impact of small limestone quarries in the landscape of Algarve and present the reclamation project of the “Funchais” quarries at “São Bras de Alportel”.

The Study Area

The study area is located in Southeast Portugal in the region of Algarve which is divided into 3 geomorphologic zones: the “Serra” (mountainous area), the “Littoral” and the “Barrocal”. Study area is positioned in the “Barrocal”, where the landscape is mostly defined by Mediterranean mixed farming and in a smaller range by marsh areas and Mediterranean irrigated lands. Most of the soils resulted from the Jurassic and cretaceous compact limestone are thin

classified as red and yellow hard limestone and dolomite Mediterranean soils. Organic matter was lower than 2%.

The climate of the area is continental Mediterranean with very hot, dry summers and mild winters. Algarve is under a strong climatic influence of the Mediterranean, and therefore characterized by a dry season and a very irregular distribution of rainfall during any single year, as well as over a period of years. Average annual precipitation is between 500 and 800mm, depending on altitude. The average monthly temperatures can vary between 10 and 20ºC. Concerning the relative air humidity, the climate of Algarve is general dry, with values between 55% and 75%.

The "Barrocal" natural unit assembles vegetation with a high patrimonial value, pointing out a large number of endemic plants, some of them exclusive from the Algarve. The most characteristic vegetation in the region is *Quercus suber* L., *Quercus ilex* L., *Pinus pinea* L., *Pinus pinaster* Ait., *Ceratonia siliquia* L, *Cistus* spp., *Arbutus unedo*, *Prunus dulcis* Miller, *Ficus carica*. Cereals and fodder plants are the main vegetation species that can be found in the area.

Visual Analysis

A geographic information system (GIS: ArcGIS 8.3, ESRI) was used to understand and manage the natural and visual resources of the study area. At the same time the landscape ecology concepts of edge habitat, patches, fragmentation, corridors, connectivity and mosaics will be incorporated in the quarry management planning in order to help the development of positive design. Numerical values were assigned to factors such as slope, vegetation, observation distance, fragmentation, visual magnitude and human activities in order to analyze, evaluate and characterize the landscape (Canter, 1996; Burley 2001). A numerical rating assigned indicating low (1), moderate (2), high (3), or very high (4) visual sensitivity and quality and as a result, digital maps of the above were elaborated.

Visibility analysis based on viewsheds was used. Key viewpoints were used to identify the location of high visual impact areas. Studied were the viewsheds of primary populations of viewers: viewers from closest households and travelers of the nearby national road (N517). A numerical rating was assigned indicating low, moderate, or high fragility. A landscape with low fragility rating can absorb substantial development without losing its quality. A Digital Terrain Model (DTM) was generated from digitized contour maps (Fig. 1). From the DTM was studied the potential visibility of the area and the viewshed of the quarries. A viewshed is the two-dimensional map of all areas visible from a given point at a given height.

Results and Discussion

With the use of a GPS where located accurately all existing quarries of the study area and then inserted in a GIS. Visibility analysis based on viewsheds is one of the most frequently used tools of geographic information system. It was determined how visible are the quarries. There were two primary populations of viewers: viewers from households and travellers of the closest national road. Viewshed analysis of the quarries showed what areas of the disturbed surface can be seen by observers for any visible position and how many observers can see the position. The result was a grid theme with visibility attributes assigned to every cell. It was produced simulations from every key viewpoint.

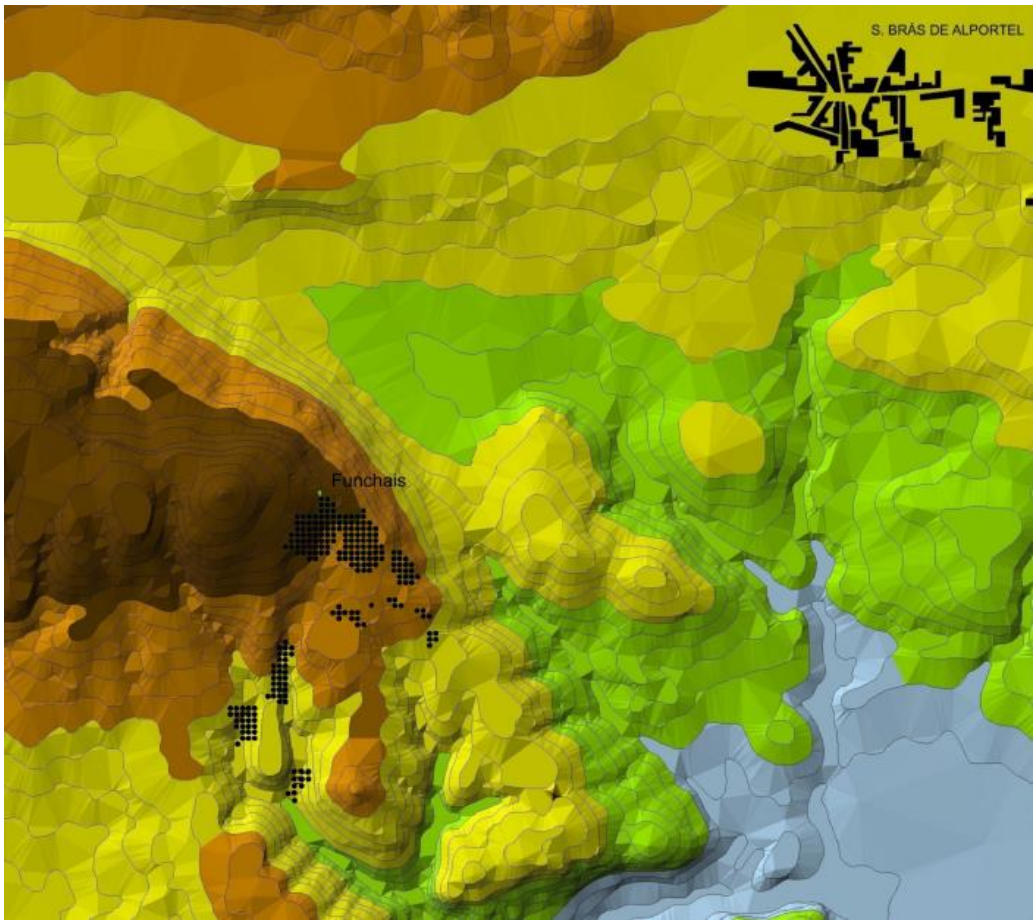

Figure 1: The study area Digital Terrain Model (black spots are the small quarries and at the top-right the nearby city.

Views to the quarries from the households were computed and revealed that the city of "São Bras de Alprortel" will view the greatest number of points on the quarries (Fig. 2). However, only 27% of the quarries area was visible from the city and from a relatively high distance of 2400m approximately.

Travellers from national road N517 will also view the quarries as they drive through the valley. It was recorded that 540m of road are visible from the quarries and with a travelling speed of 60km/h the quarries will be visible for relatively short period of time. Thirty two seconds was the longest viewing time at close range (1000m buffer zone from quarries). To estimate the viewshed of key observation points was used 80^{o} visibility angle and 1000 meters maximum distance that was considered sufficient to not decrease the truthfulness of the results (Panagopoulos and Vargues, 2006). Maximum distance is a very important factor that has to be taken in consideration in a view-shed analysis; because the longer the distance the lower the visual impact that an object can bring to the landscape.

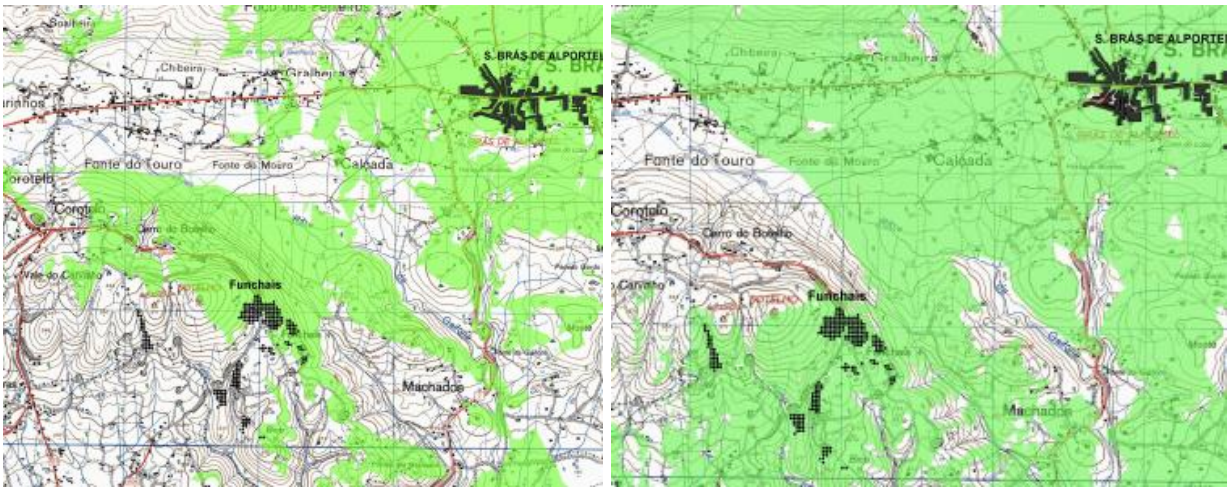

Figure 2. Viewsheds of the city S.Bras Alportel (left) and Funchais quarries (right). The shadowed green surface is showing which will be the areas that observers can see.

One of the purposes of the VIA is to recommend mitigation measures. Various visual mitigation measures were proposed and evaluated, including screening with vegetation, screening with landforms, native shrub and tree planting, adjustment of the location of structures and footprint of the quarries. Finally aerial photographs were superimposed on the terrain to simulate a realistic view of the area. Digital fly-over video was made using ArcScene because high public concern and expectations required public presentation and consultation. Various digital fly-over videos were generated to simulate in a realistic way the appearance of the quarries (Fig. 3). The fly-over video was constructed after a digitalisation of a path in a 2D map display that was then traversed in the 3D scene. However, the 3D extension of Arcview permitted to freely navigate in 3D space and to relate representations in 2D maps with 3D scenes synchronizing user interaction with the database model. Public consultation of proposed quarry reclamation project (Fig. 4) could be facilitated if three-dimensional information of the virtual landscape would be transferred through the Internet (Honjo and Lim, 2001).

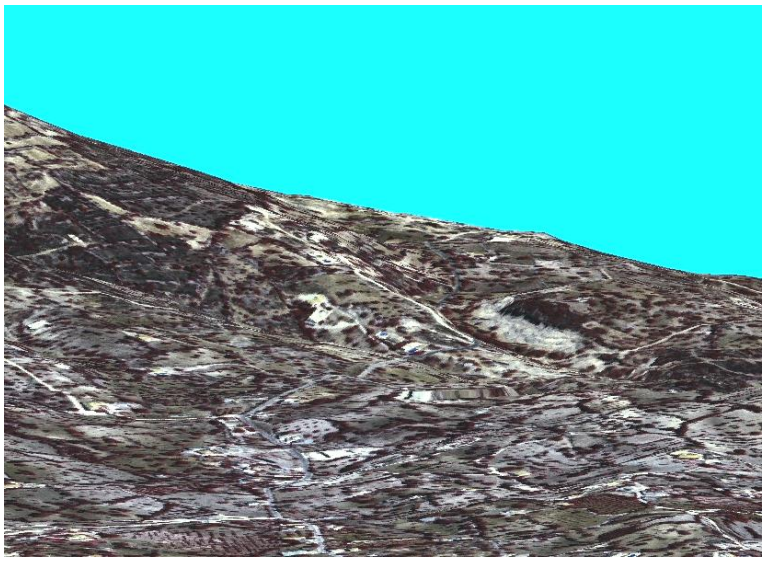

Figure 3. A fly-over scene from the digital video created from a 3D road path in ArcGIS.

Figure 4. Representation of the project concept: reclamation of multiple family managed quarries in a fragmented Mediterranean landscape.

Conclusions

One cause of landscape degradation in Algarve is the inaccuracy of the landscape management plans and unplanned quarry reclamation. Small quarries operate without planning ignoring the reclamation laws. The main environmental impact of those quarries is the visual impact, because most of them are concentrated on hills with a great extension visual basin and inserted in a landscape with high scenery value. Most quarry owners are not able to support the cost of land reclamation. Subsequently governmental entities (Municipalities and Ministry of Environment) should collaborate with quarry owners in the search for socially, economically and environmentally sustainable solutions. The reclamation method of the present study could help governmental officials to take the appropriate decision: accept, reject or suggest aesthetical modifications in any proposed project in the study area. Similar visual landscape management plans could be made for the rest of the territory using the visual impact plan for the area of "Funchais" as a model.

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