MINING AND ENVIRONMENTAL PLANNING OF AGGREGATE EXPLOITATION IN ALHAURÍN DE LA TORRE (MÁLAGA, SPAIN)

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ABSTRACT

A large part of the production of aggregates in the province of Málaga is focused on a small area to the east of the Sierra de Mijas mountains, with an increase in demand being expected for the coming years due to the construction work under way at Málaga port and the building of a new motorway. At the area of maximum exploitation, the deposit has been broached from various quarries, mostly corresponding to mining rights over limited surface areas which are concentrated to a large extent on a specific zone. This has created severe problems not only from the technical point of view but also from an environmental standpoint.

With a view to regulating exploitation, the Andalusian Regional Government's Department of Employment and Industry and the Spanish Geological and Mining Technology Institute have signed a joint action agreement to carry out a mining and environmental planning project for the exploitation of the aggregates in Alhaurín de la Torre. This project is currently under way and is structured in four blocks, each with the following objectives:

- *Division of the mining-resource territory into areas depending on the suitability for exploitation purposes, both from a mining standpoint and also from the point of view of the environment. Creation of a Mining and Environmental Planning Map synthesizing a collection of thematic maps on mining and environmental questions used as the basis for the integration of mining activity into the Land Use Planning.*
- *Establishment of exploitation models which combine maximum productivity and minimum impact criteria.*
- *Determination of criteria and restoration models for the terrains affected by the exploitation of aggregates.*
- *Drafting of a Mining and Environment Master Plan for the area currently presenting the maximum concentration of quarries, so that the technical and environmental problems can be corrected and minimized.*

INTRODUCTION

A large part of the production of aggregates in the province of Málaga is focused on a small area to the east of the Sierra de Mijas mountains within the municipality of Alhaurín de la Torre (Figure 1), with an increase in demand being expected for the coming years due to the construction and infrastructure work in the outskirts of Málaga.

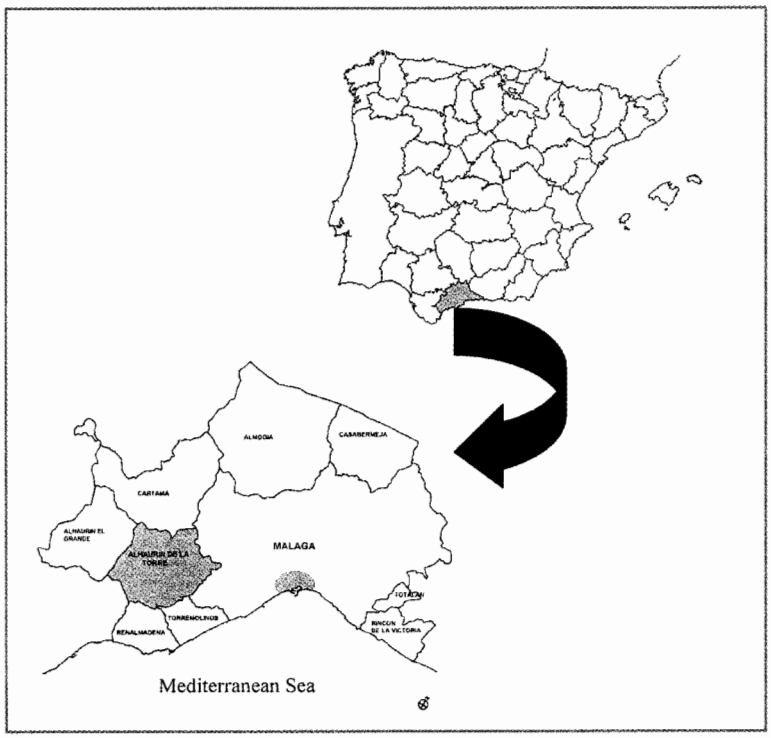

Figure 1. Location map.

The geotechnical characteristics of the carbonate rocky massif make the extraction of this material relatively easy, although the exploitation has, nonetheless, been carried out in a generally disorganized way and without the total application of the criteria and specifications included in the legislation and regulations currently in force for mining and environmental questions.

There are seven quarries concentrated in this area each with small surface areas, leading to severe problems for their enlargement. The result in general is that, from the mining standpoint, the problems can be summed up as follows:

- Low economic performance of the exploitations basically due to the small size of the mining rights.
- Safety risks due to the lack of geotechnical surveys.

In conclusion, it can be said that rational criteria are missing from the design and planning of the exploitation.

From the environmental standpoint, there are also important problems closely related to this lack of criteria. These environmental problems are due to:

- The small size of most of the mining rights.
- The fact that environmental factors have not been taken into account in the design and planning of the exploitation since the early stages of the project, thus foreseeing the proper restoration of the terrain in question.
- The heavy concentration of exploitations in a very small area, thus accentuating the magnitude of the environmental impact.
- The great pressure for urban development in the area surrounding the exploitations has led to a widespread rejection by residents not only towards the granting of new exploitation permits but also towards the continued presence of the exploitations themselves.

All of this makes it necessary to consider the exploitation in a sensible and responsible way in order to achieve a delicate balance between economic development and the conservation of the environment, achievable through adequate planning and territorial management. In order to carry out this task, it is first necessary:

- To define geographically the mining resources.
- To analyze the current consumption and the future demand.
- To analyze the specific characteristics and technical-economic constraints presented by the mining of the resources.

In order to achieve this planning of the aggregate resources, both from a mining standpoint and from the point of view of environmental protection, an agreement has been signed between the Department of Employment and Industry and the ITGE to carry out a Mining and Environmental Planning Project combining both aspects with a view to optimizing the exploitation of the mining resources and minimizing the environmental implications. This project is currently in the process of being carried out.

To make the exploitation of the resources compatible with the protection and conservation of the environment, the following objectives are proposed:

- To divide the mining-resource territory into areas depending on the suitability for exploitation purposes, both from a mining standpoint and also from the point of view of the environment. This will be achieved through the creation of a Mining and Environmental Planning Map synthesizing a collection of thematic maps on mining and geological as well as environmental questions. This map can be used as the basis for the integration of mining activity into the Land-Use Planning.
- Establishment of exploitation models which combine the criteria of maximum productivity and minimum environmental impact.
- Determination of criteria and restoration models for the terrains affected by the exploitation of aggregates.
- Drafting of a Mining and Environment Master Plan so that the technical and environmental problems can be corrected and minimized and a greater rationalization and planning of the exploitations achieved.

THE SOCIO-ECONOMIC FRAMEWORK OF ALHAURÍN DE LA TORRE

Alhaurín de la Torre forms part of the Metropolitan Area of the city of Málaga and in functional terms is a residential area within the urban space of the metropolitan area.

According to the 1996 municipal census, Alhaurín had a legal population of 16,914 inhabitants. This township underwent considerable growth from the eighties as a result of an intense influx of immigrants (in the period 1981-91, the migration rate was 42.66%) from the city of Málaga.

The supply of quality houses at a more affordable price than in Málaga, its proximity to the city and the tourist resorts along the coast (Torremolinos and Benalmádena), the improvement in communications and its surroundings of considerable environmental quality have all contributed to making Alhaurín a very attractive township for the urban population of Málaga city. If the current trend in demographic growth continues over the coming years, it is estimated that by the year 2001 Alhaurín de la Torre will have a total of 20,818 inhabitants on its census.

As for economic activity, an external economic dependence can be seen. According to the 1991 population census, 50.68% of the active population belonged to the Services Sector depending on the jobs offered in the coastal tourist areas and the city of Málaga itself. A study carried out by the Andalusian Statistical Institute into *"Working mobility in Andalusia. Basic dimensions and territorial organization"* (1996) showed that more than 50% of the active population on the census in Alhaurín were working outside the town, with daily trips to work heading mostly towards Málaga, Torremolinos and Benalmádena.

As for the local economy, the main economic activity is construction and real-estate development. Approximately half of the registered dwellings in Alhaurín de la Torre have been built since 1980, indicating the intensity of the process of urbanization suffered by this township, with the proliferation of numerous developments of individual homes.

Mining, tertiary activities and the goods transport sector are the next sectors in order of importance. The agricultural sector, focused on fruit and vegetable production, especially lemons, is currently in crisis and it is very common for agriculture to be a part-time occupation.

Mining activity in Alhaurín de la Torre shows extreme concentration of aggregate exploitations, with seven active quarries currently in existence.

According to the figures from ANEFA (National Association of Aggregate Manufacturers) and the Málaga Association of Mining Companies, the exploitations in Alhaurín de la Torre supply 80% of total aggregate production of the province. The estimates of these associations show that the production of this sector in the town is approximately twelve million tonnes per annum with a estimated price per tonne of around 500 pesetas at the quarry. This represents minimum sales of around six thousand million pesetas annually. These estimates highlight the economic importance of this sector.

Production is focused mainly on construction and public works, with the re-channelling of the Guadalhorce river, the eastern pier at the port of Málaga and the Western Costa del Sol motorway currently the projects with the greatest demand for aggregates.

The employment generated by this sector is approximately 300 direct jobs, while indirect employment corresponds mainly to the transport sector.

This sector currently has to face severe problems. According to the data obtained from the exploitation activity plans, the total reserves of aggregates in 1998 were 50.435.223 tonnes. Except for one of the existing mines which represents almost 60% of the total reserves with 30 million tonnes, the others are on the verge of exhausting their resources. These companies, therefore, give the maximum priority to obtaining further permits to continue exploiting the mining resources. In this sense, mining interests clash head-on with the opposition of the town council and the residents of Alhaurín de la Torre to the opening of new quarries.

There is an active citizens' group working against mining and this sees the exploitation of aggregates as a threat to health and the environment. The figures on dust emissions in quarries supplied by the Andalusian Regional Government's Department of the Environment show that the housing developments closest to the exploitations and the town centre have given results below the threshold level considered harmful for health under current legislation. It is clear that the population is directly affected by the constant coming and going of lorries through the town. This traffic generates problems on the road bearing the brunt of the heavy traffic. Nonetheless, the imminent construction of the bypass at Alhaurín de la Torre and the adequate preparation of a mountain road to provide a new exit to the N-340 will considerably reduce this effect on the social environment.

The importance of mining as an activity must be analyzed from the local and regional scale as it has encouraged the development of the building sector in Alhaurín and all the metropolitan area and thus also residential tourism, the main economic activity of Málaga and the tourist resorts along the coast.

DESCRIPTION AND METHODOLOGY OF THE PROJECT

In order to cover the objectives indicated, the work to be carried out comprises four stages:

Mining and Environmental Planning Map

The purpose of producing a Mining and Environmental Planning Map is to allocate territorial categories to the areas with potential for resource exploitation, depending on the feasibility of setting up mining activity there. This feasibility is going to depend on technical and economic factors as well as envi-

ronmental criteria and the harmonization with the other current or potential land uses present in the area.

The key points for drawing up this map are as follows:

- **Analysis of the environment**

  This analysis is aimed at understanding the territorial model, comprising the natural features, the economic, social, cultural and environmental processes and their territorial repercussions. Through this analysis, a series of thematic maps will be drawn up and handled through a Geographic Information System.

  The 1:10.000 thematic maps to be drawn up and digitized of the 3.200 hectare area are:

  * Geological map
  * Geomorphological map
  * Soil map
  * Vegetation map
  * Water map
  * Land use map

  With regard to the geological cartography, this will cover the areas in which there are potentially exploitable resources and the geomechanical data for the rocky massif with a view to establishing the geological and geotechnical cartography for the area under study.

  The results of this part of the project will be a collection of thematic maps at 1:10.000 scale in digital format and handled by a G.I.S. together with explanatory reports on the current physical and socio-economic situation of the environment in the area under study.

  In order to complete this analysis, a technical and environmental characterization of the mining exploitations will be carried out to identify and detect the features and problems these have with regard to the Master Plan.

- **Territorial diagnosis. Mining and Environmental Planning Map**

  The final objective of this stage of the Project is to draw up a map of the mining and environmental planning of the resources with potential for exploitation in the area under study, with indication of the areas where exploitation is not recommended and those other exploitable areas with different degrees of priority depending on the results of the analysis of the capability/vulnerability balance and criteria for the protection of inhabited areas, infrastructures and those elements of the surroundings with the greatest significance.

  For the drafting of the mining and environmental planning map, the methodology to be followed is that developed by the ITGE (Barettino et al., 1994; Barettino et al., 1998), comprising the following activities:

  * Definition of Territorial Units
  * Analysis of the capability/vulnerability balance of the aggregate exploitation in each Territorial Unit
  * Zonation of the territory
  * Drafting of the mining and environmental planning map

  The mining and environmental planning map is the starting point for drawing up the Planning Proposal and will be used as the basis for the integration of the mining activity into the Lands Use Plans of the areas with potentially exploitable resources.

Design of exploitation models

The purpose of this second stage is to determine the criteria and standard exploitation models that will allow a rational mining of the aggregate deposits so that the profitability of the mining activity is optimized, the safety considerations in the quarries are improved and the environmental impact is minimized.

A fundamental aspect is the definition of the geometry of the standard quarries so as to ensure the maximum profit from the resources with the minimum environmental effects and guarantee the stability of the operating and closure talus.

The geometry of the standard quarries will be defined on the basis of geotechnical and geomechanical characterization studies. Two boreholes will be made for the purposes of geotechnical tests to obtain the deformation-resistance characteristics of the lithotypes present.

The aspects to be analyzed and, where appropriate, modelled are as follows:

- Geometry of standard quarries
- Exploitation sequences and programming
- Methods and technologies for extraction, loading and transport, with definition of the most suitable equipment
- Design and planning of access and tracks
- Drainage and handling of on-site water
- Location of the crushing and sorting installations and the storage areas
- Internal safety provisions

For the design of standard exploitations, current legislation will be taken into account, particularly the Supplementary Technical Instructions for open-cast exploitations, mine safety, etc.

Restoration criteria

Once the standard exploitations have been defined, an analysis will be made of the potential use of the terrains affected and, depending on these uses, criteria and recommendations will be drawn up together with models for the integral recovery of the terrain affected by mining. These criteria will focus on the following operations:

- Handling and treatment of the top-soil layer.
- Treatment of talus: shaping, stabilization and drainage.
- Improvement of soils.
- Selection of plant species.
- Methods and techniques for the planting of vegetation.
- Calendar and sequence of operations.
- Follow-up and restoration monitoring programme.

Mining and Environment Master Plan

The purpose of this Plan is to achieve greater rationalization and planning of exploitations through technical advice involving the completion of global infrastructure and exploitation projects.

The points to be considered in the Master Plan are as follows:

- Infrastructures shared by various exploitations: access roads, water supply, etc.
- Optimal location of crushing and sorting plants.
- Location of machinery parks
- Location of storage areas.
- Standard exploitation projects. Starting from the results of the second stage of this Project, considering the possible joint exploitation of the adjoining areas between mining rights.
- Standard reclamation projects. Starting from the results of the third stage of this Project and considering the points indicated in the previous paragraph.

As the final product, a procedural manual will be drawn up including the partial regulations.

In order to visualize the conclusions drawn from the Mining and Environment Master Plan, a virtual landscape model will be created to represent the before and after of the works undertaken for the planning, exploitation and restoration of the quarries.

CONCLUSIONS

The aggregate quarries in Alhaurín de la Torre supply 80% of the production of aggregates in the province of Málaga. The strong demand for aggregates comes from the intense activity in the construction sector along the Costa del Sol area and the many large public works projects under way: enlargement of the port at Málaga city, construction of the Western Andalusia Coastal Motorway and the re-channelling of the Guadalhorce river.

The current situation presents economic and mining problems as well as environmental issues, with a strong opposition by the affected population to the opening of new quarries or the enlargement of existing ones.

Nonetheless, it is not easy to find alternative exploitation sites capable of satisfying the current and foreseeable levels of demand within a feasible distance from the building sites, without introducing new environmental and population problems of a similar magnitude or even greater than those existing in Alhaurín de la Torre.

Therefore, the solution to be adopted is the planning of the exploitation at Alhaurín de la Torre based on the following principles:

- Opening of new exploitations in those areas with the least environmental impact and the greatest mining yield, on the basis of the Mining and Environmental Planning Map.
- Exploitation of the aggregate resources using maximum mining yield and minimum environmental impact models.
- Restoration of the affected terrains using models which are technically and scientifically validated.
- Implementation of a Mining and Environmental Master Plan to correct and minimize the current technical and environmental problems, optimizing the profits from the resources by means of a greater rationalization of exploitation, with consideration of the environmental aspects.

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