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Nature Conservation, Land Use Planning and Exploitation of Ornamental Stones - The Case Study of Cabeça Veada (Portugal)

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Abstract. *Cabeça Veada* is the name of a relatively small exploitation cluster for ornamental limestones occupying an area of 98 ha in the Portuguese Natural Park of Serra de Aire e Candeeiros, which is also a Natura 2000 Network protected area. Supported by comprehensive geological, mining and environmental studies, a specific methodology was developed in order to address the compatibility between the long term sustainability of this industry with the preservation of existing protected natural values. The obtained land use map should allow the *Cabeça Veada* mineral resources to be adequately included in the municipal land use planning process.

Introduction

The way of living of modern societies is (and will be in the future) strongly dependent on the continuous supply of mineral resources [1]–[3] and their long-term availability for exploitation depends, in a first approach, on geological, technical and market conditions [2], [4]–[6]. However, a determinant key for the extractive industry is the need to gain access to land because an unavoidable characteristic of this activity, unlike almost all other industrial activities, is the fact that mineral resources with economic interest only can be extracted where they occur. Hence, accessing land where minerals occur often brings the extractive sector into conflict with other uses of land [7]–[9]. Therefore, the supply of mineral raw materials to society depends also on the constraints imposed by land use planning policies and practices. Nevertheless, despite their importance, they are often overlooked in land use plans, thus limiting their access by the mining industry [10]–[12]. The need to implement European policies that help to solve this problem [13], [14] was the motto for the funding by the European Commission of the recently finished MINATURA2020 project [15] and the ongoing Minland project [16]. Both projects emphasize that mineral deposits should be safeguarded during land use planning processes as a way to grant the access to land by the mining industry. However, the concept of "minerals safeguarding", does not mean their strict protection for being extracted. Rather it means that the land where they occur should not be needlessly occupied by uses that may prevent their extraction, i.e. leading to the loss of the option to extract them – the so called "minerals sterilisation". This concept is very similar to the one already being applied by the UK Government as a guidance on land use planning for minerals (*cf.* [10] and https://www.gov.uk/guidance/minerals#minerals-safeguarding). In addition, Minland project refers that mineral resources safeguarding assumes a fair and equal prior assessment of the possible land

uses [17], because when it comes to public policy, mineral resources must be viewed on equal footing with other natural resources.

Results from the aforementioned projects stress that the main land use conflicts that the mining sector is facing in Europe are those occurring with areas designated for nature conservation (natural and national parks, Natura2000 network) agricultural and forestry areas, and particularly for Nordic countries, socio-cultural areas (reindeer herding areas).

Being the land use planning a tactical tool for reconciling public and private interests with respect to land use, this paper represents a paradigmatic case of reconciling interests regarding the exploitation of mineral resources and nature conservation in a natural park that is part of the Natura2000 network.

The reconciling process was based on holistic approach taking advantage from mining-related experiences and guidance described elsewhere (e.g. [18]–[24]). Multidisciplinary studies were carried out to find the right balance for the efficient management of land occupied by the extractive industry through collaboration between public and private entities, i.e. seeking the compatibility between extractive activity and nature conservation and translating it into an effective integration of mineral resources into the municipal land use planning.

This paper aims to briefly report on the methodological approach applied to the implementation of a land use and environmental planning proposal for the *Cabeça Veada* mining site, which is located in the Natural Park *Serra de Aire and Candeeiros* (NPSAC). Emphasis is given to the geological and environmental assessment studies, as these were considered decisive good practices to the intended objectives.

Setting

The NPSAC is also a designated Site of Community Importance (SCI) of the Natura 2000 Network since 2000 (Ref. PTCON0015). It is located in an uplifted limestone massif of the Lusitanian Basin, Portugal [25] (Figure 1), where several lithostratigraphic sections of Jurassic formations outcrop in extensive areas. The sections of Middle Jurassic age mainly consist of light cream-coloured limestones formed under very specific palaeoenvironmental conditions, leading to their occurrence as massive limestone bodies [26]. These are exploited as 2 m^3 to 6 m^3 blocks for ornamental/high-value applications in about 100 open pits [27].

Quarrying in NPSAC is one of the fundamental economic activities with local and regional impact, supporting one thousand direct jobs and generating wealth of over €100 million. Ornamental limestones exploited and transformed here are exported all over the world. The quarries are not dispersed; instead, they are clustered in five main exploitation areas of suitable stone quality. These integrate the general land use plan of NPSAC as Areas for Specific Intervention (ASI). One of them corresponds to the relatively small *Cabeça Veada* mining site, with an area of 0.29 km^2 (Figure 2).

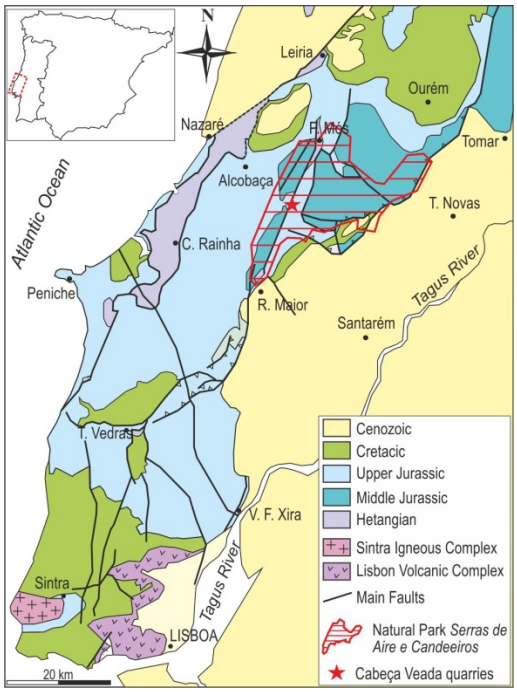

Figure 1 - Geological setting of the *Cabeça Veada* quarrying site and NPSAC in the Lusitanian Basin (adapted from the Portuguese Geological Map, 1:1.000.000, edited by LNEG-LGM).

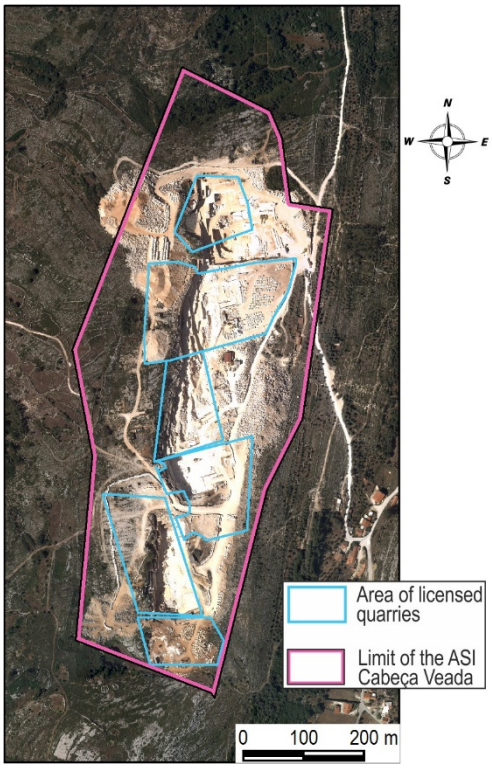

Figure 2 - The *Cabeça Veada* mining site and operating licensed quarries.

Methodology

According to the regulatory framework of the NPSAC, the *Cabeça Veada* site should be subjected to detailed land use planning at the municipal level aimed at the establishment of compatibility measures between rational mining activity, the environmental restoration of degraded areas and the conservation of existing natural values. Because the *Cabeça Veada* mining site includes six neighbouring pits (Figure 2) each one with its own mining plan and restoration solution, the regulatory framework points to the need of a single mining plan design. Taking into account these

objectives, the adopted methodology was based on comprehensive geological, mining and environmental studies.

The first working phase consisted of the acquisition of geological and environmental data for characterisation and diagnostics. The geological and environmental studies were carried out at a 1:2.000 scale, as legally required for this type of land use planning maps. The geological studies comprised: i) thematic geological mapping oriented to ornamental limestones, ii) fracturing studies, iii) hydrogeological studies, and iv) diamond drilling. The environmental studies consisted of: i) characterisation and mapping of vegetation units, giving particular emphasis to the survey of flora species more relevant for conservation within the NPSAC, ii) identification of fauna species, iii) identification, characterisation and mapping of biotopes and habitats, and iv) identification of geological heritage sites.

A second step consisted on the design of a single mining plan for all the quarries: the Integrated Project for the Exploitation Area. It took place simultaneously with the study of solutions for the rehabilitation of the mining site aiming at obtain a general solution for the best use of the mineral resource in all the six quarries, taking into account the rules of the Natural Park with regard to nature conservation and landscape recovery.

Finally, making use of GIS support, all spatial data was integrated. The main focus was on the compatibility between the extractive industry and the conservation of the existing natural values.

Results

Geology and available resources. Figure 3 depicts the detailed geology of the Cabeça Veada site. Informal names are used when referring to geological units so that the map can be better understood by local mining industry technicians. Nevertheless, a chronostratigraphic correspondence of detail is established, which in the present map is abbreviated in order to synthesize the information.

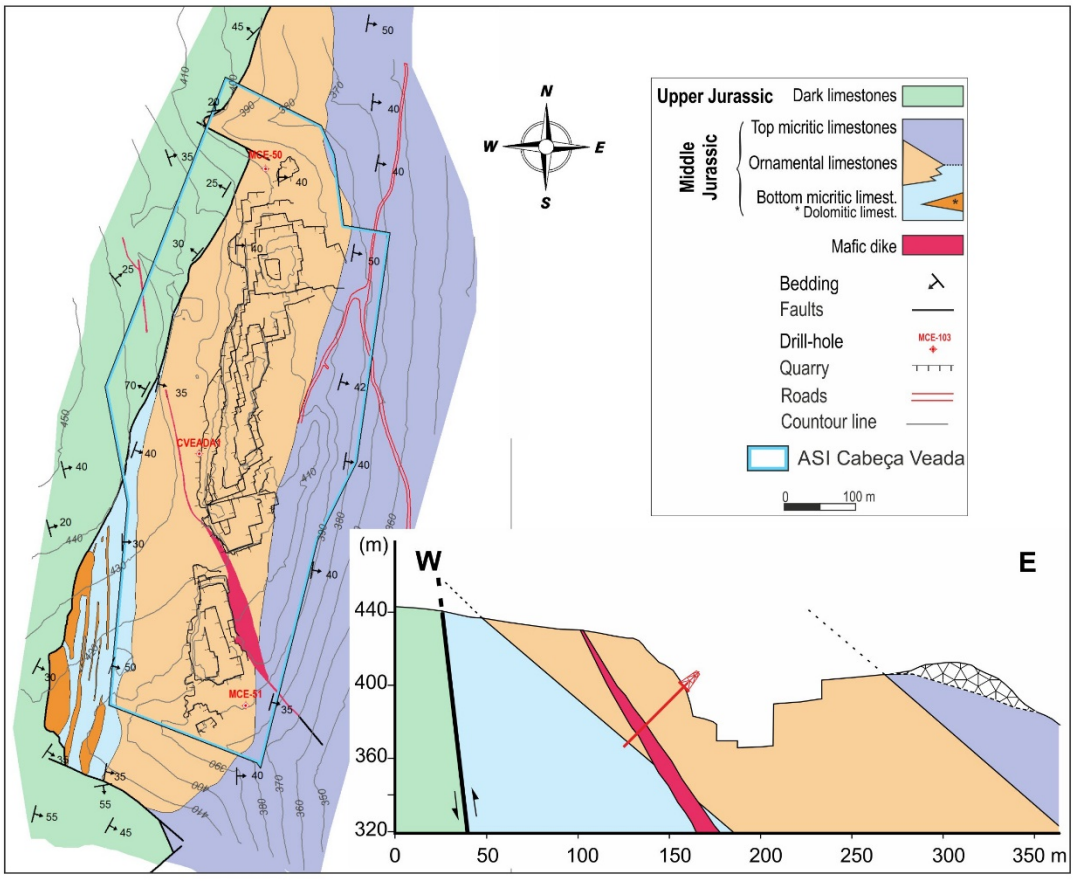

Figure 3- Geology of the *Cabeça Veada* mining site [28].

Middle Jurassic (Bathonian) consists of cream coloured micritic limestones in which a lenticular unit of light cream sparitic calcarenites and calcirudites occurs – the ornamental limestones. This

lenticular unit has a maximum thickness of 130 m in the ASI *Cabeça Veada*. Dark coloured micritic and argillaceous limestones of Upper Jurassic age overlie the Middle Jurassic limestones. A NNE-SSW reverse reactivated normal fault establishes the contact between Middle and Upper Jurassic rocks, which dip to the east.

Fracturing is represented by an orthogonal system of joints oriented according WSW-ENE and NNW-SSE.

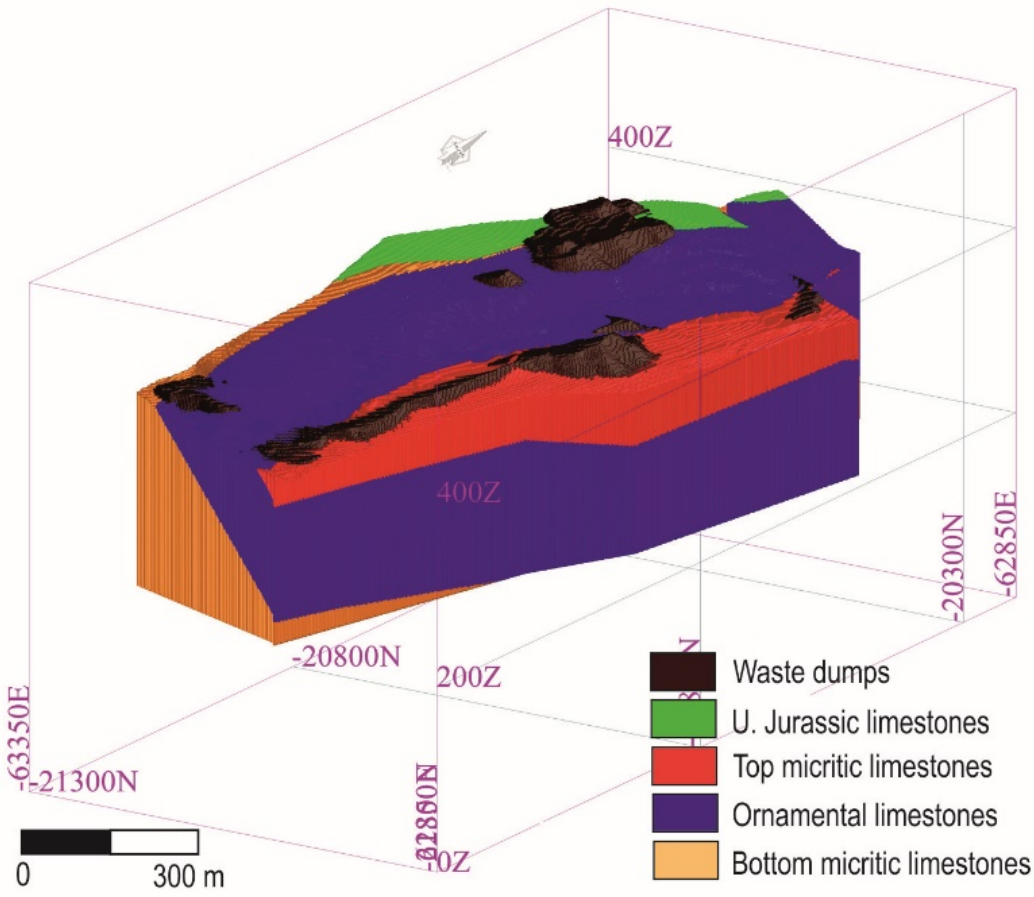

Figure 4- Block-diagram of the *Cabeça Veada* mining site.

With the support of three-dimensional modelling (Figure 4), 13 million cubic meters of ornamental limestones were estimated as available for exploitation in the ASI *Cabeça Veada*, already taking into account the usual 45% extraction yield for the area.

Environmental evaluation. The environmental evaluation took into account the factors usually considered in Environmental Impact Assessment processes: soils, climate, groundwater resources, hydrology, landscape, air quality, noise, cultural heritage, and socio-economy. However, because the study area is located in a natural park, special attention was given to the characterization of biological factors, in particular flora and vegetation, habitats and fauna. From the ecological correlation between these factors, maps of natural values were produced for the fauna and flora that resulted from valorisation criteria such as the occurrence of species and habitats listed in the birds and habitats directives from the European Commission. The relevance of each natural value was expressed in a range of ecological relevance, from Low to Exceptional, and then combined into a Nature Evaluation Map (Figure 5).

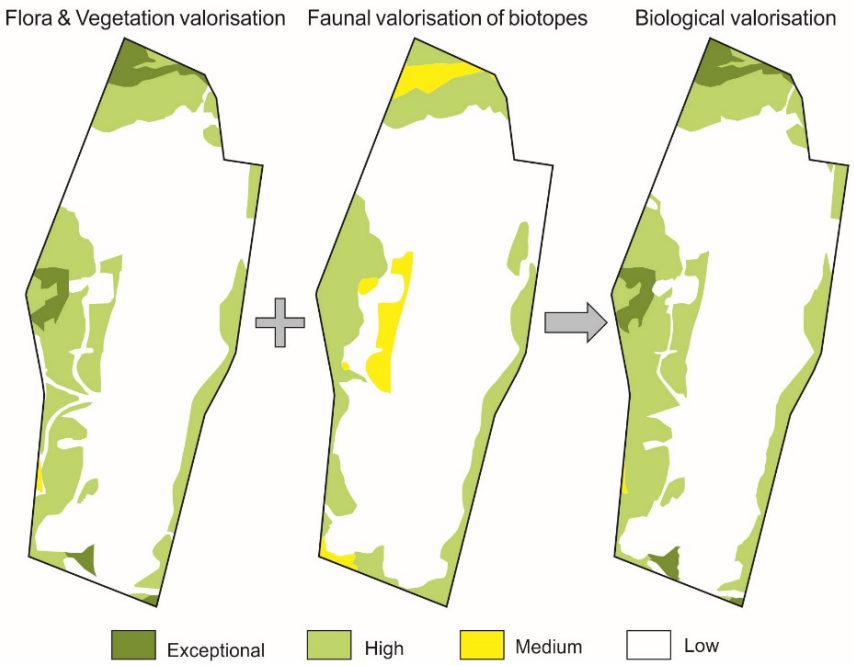

Figure 5 - Ecological relevance of the natural values in the ASI *Cabeça Veada*.

Integrated Exploitation Project and Restoration Plan. The project aimed an integrated approach to the land management of the quarrying area. The main issues considered were i) the rational management of the mineral resource by a single quarrying plan; ii) the revitalization and environmental regularization of the space during and after the exploitation, guaranteeing the preservation of the existing natural values; iii) the minimization of the environmental impacts induced by extractive activity through the adoption of preventive and corrective measures; and iv) the management of the waste.

As a whole, the Ornamental Limestones unit is suitable for the production of blocks, allowing delimiting the extraction area depicted in Figure 6. It shows that the extraction area overlaps the outcrops of the non-suitable Top Micritic Limestones unit, meaning that there will be the need to remove it in order to exploit the suitable ornamental limestones.

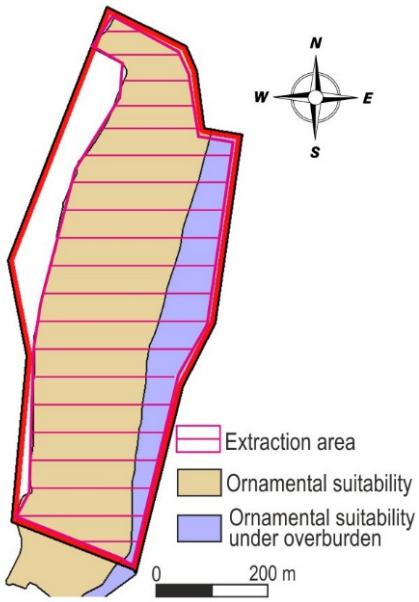

Figure 6 - Definition of the extraction area for the ASI *Cabeça Veada*.

The extraction was design as single open pit with approximately 0.27 km^2 and a depth of 100 m. The excavation was projected with vertical benches with 10 m height and berms approximately 3m large.

It is expected the production of 19 million metric tons of waste. Due to the small size of the ASI *Cabeça Veada* and its integration in a natural park, the project does not foresee any waste dump, except a small amount that will be used for landfill restoration. The main produced waste will be used as by product in other industries, like lime industry in nearby factories and construction aggregates.

The Restoration Plan was designed to minimize environmental impacts, turning the whole area into a natural space in continuity with the surrounding areas by recreating the natural habitats of the natural park. Three different restoration methodologies will be applied.

The first one will leave some final benches without any intervention to simulate the natural scarps and promote conditions for the nesting of birds, properly safeguarded from terrestrial predators (Figure 7-a). The second consists on topographic modelling using waste material to recreate forests, bushes and meadows habitats (Figure 7-b). The third will intercalate meadows with zones with no intervention, in order to simulate the limestone slabs typical of karst zones (Figure 7-c).

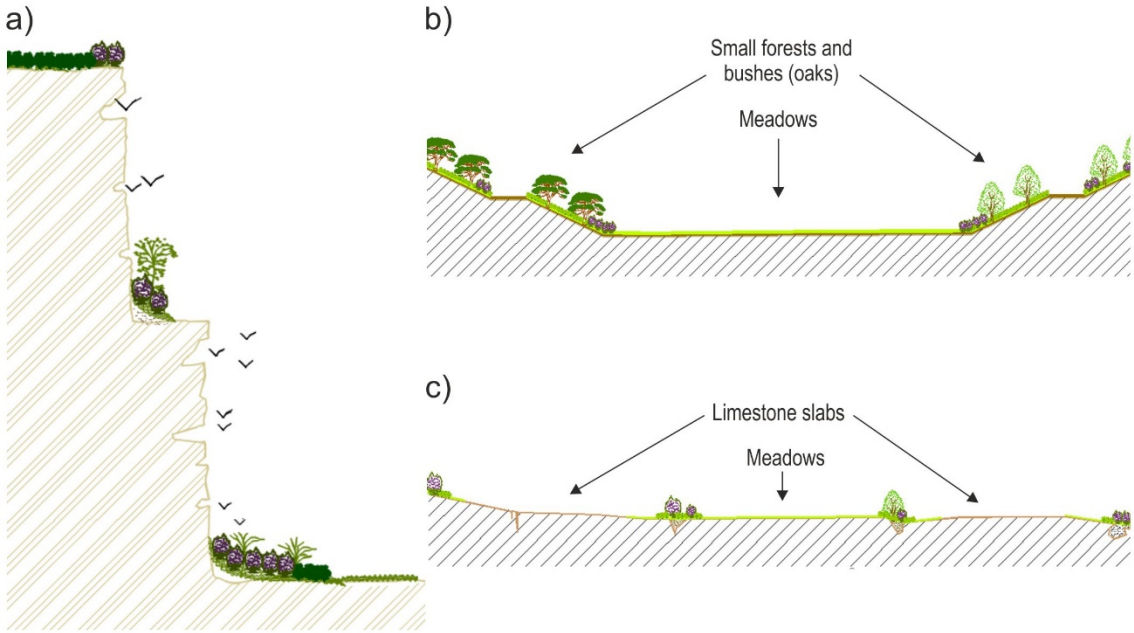

Figure 7 - Restoration methodologies to be applied at the ASI *Cabeça Veada*.

Land Use Planning Proposal. For the land use planning proposal, three different possible scenarios were considered. A first scenario only taking into account the geological resource, i.e. a land use plan aimed at maximising the extraction of the ornamental limestones. A second scenario envisaging the exceptional and high biological values supplanting mining interests. Finally, a third scenario considering the compatibility between the extraction of the resource and the biological valorisation, which should be reached with the establishment of environmental compensation measures.

The decision clearly fell in the third option and, for that purpose, a land use planning methodology according to the diagram presented in Figure 8 has been implemented. It is coupled, within the same figure, with the resulting land use planning proposal for the ASI *Cabeça Veada*.

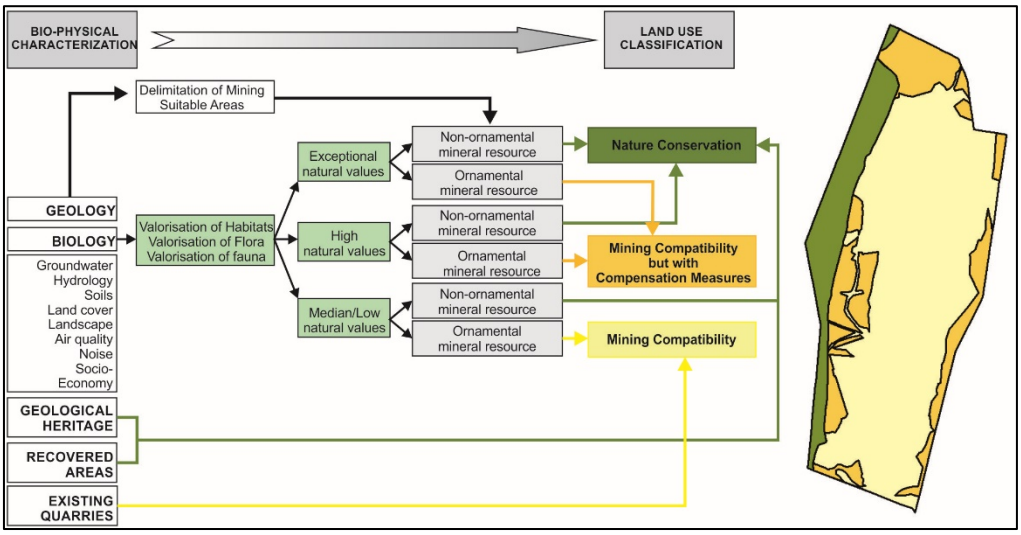

Figure 8 - Land use planning Methodology for the compatibility between quarrying and nature conservation and associated land use planning proposal for the ASI *Cabeça Veada*.

Final Remarks and Conclusions

The land use planning proposal for the *Cabeça Veada* area is just one step of the whole process of including its mineral resources in the formal municipal land use planning. Nevertheless, it is extremely relevant as a scientifically based support for the political decision. It represents also a turning point in the relationship between mining industry stakeholders and environmental protection authorities after more than 20 years of land use conflicts. Working collaboratively, it was possible to accomplish a balance between nature conservation policies and the mining industry.

Furthermore, this work presents good practices that can be applied for similar cases. It demonstrates how crucial geological knowledge is for the suitable practice of land use planning, supporting solutions that prevent the sterilisation of mineral resources. Particularly, when planning for minerals, the geological knowledge should be represented by geological maps at a scale consistent with the required for land use planning maps. In addition, these geological maps are a support for the development of the extraction works. Another good practice to be considered is the biological valorisation process intended to ascertain qualitative orders of magnitude in what respects the conservation needs. Finally, the data crossing methodology that was used for the proposed planning of the mining area, but taking into account the need to preserve relevant natural values.

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