

SUSTAINABLE DEVELOPMENT OF LOW POPULATION DENSITY REGIONS – ENHANCING SUSTAINABLE TOURISM: THE CASE OF THE PORTUGUESE LITHIUM MINE C-57

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Abstract: The growth in world population and the increasing amounts of energy and raw materials demanded by modern societies are facts of recent decades. Special attention is placed nowadays on the exploitation of lithium an important and scarce geological resource in Europe, which occurs in one of the largest mineralisation zones located in the Iberian Peninsula, namely in the Guarda region. The concerns of societies with sustainability questions are nowadays a priority issue. The H2020 (IC&DT) Project LÍTIO is a joint project between a mining company, three higher schools and the Portuguese professional association of geologists. The priority domain is the valorisation of natural endogenous resources associated with territorial innovation in the mining district of Gonçalo, with the primary areas of this project being the preservation and sustainability of lithium through the development of products, processes, and services, as well as the development of innovative proposals for tourism in the region, aiming at the promotion of the mining area.

Keywords: Lithium, Portugal, sustainable geological tourism.

INTRODUCTION

Lithium is the lightest metal on Earth, as well as the least dense solid element. Lithium is a rare metal in the Earth's crust and never occurs freely in nature. Its main sources are the minerals lepidolite, petalite, amblygonite, zinnwaldite and spodumene. Lithium applications are increasingly diverse: it is used in ceramic and glass production, metallurgy of aluminium, manufacture of synthetic rubber and lubricants, in the process of purification of air in confined environments, in batteries as lithium bromide, and as lithium carbonate it is used in the pharmaceutical industry for the treatment of depression. EU's (pre COVID-19) climate-neutrality scenarios

for 2050 estimated demand for several raw materials such lithium, and addresses supply risks at different levels of the supply chains, namely for electric vehicle batteries and energy storage. The EU would need up to 18 times more lithium and 5 times more cobalt in 2030, and almost 60 times more lithium and 15 times more cobalt in 2050, compared to the current supply to the whole EU economy (EU, 2020).

LITHIUM IN PORTUGAL

According to 2022 data from the United States Geological Survey (USGS, 2022), Portugal is the country in the European Union (EU) with more lithium reserves. One of the largest lithium deposits belts in Europe is located on the Iberian Peninsula (*Figure 1*). These deposits are essentially lithiniferous pegmatite bodies that outcrop in metasedimentary rocks and granitoids of Variscan ages, along a zone of NNW-SSE direction in Galicia-Trás-os-Montes Zone (GTMZ) and Central Iberian Zone (CIZ) (Roda-Robles *et al.*, 2018; Farinha Ramos, 2007). The Portuguese National Government, aware of the potential existing in the country, announced the establishment of a working group at the end of 2016 (Declaration No. 15040/2016 of 13 December 2016), with the mission to identify and characterise all of the lithium deposits in Portugal, as well as to evaluate the possibilities of their prospecting and exploitation. This group produced a final report in March 2017 (Report, 2017), which identified nine geological zones with lithiniferous potential in Portugal (*Figure 2*).

THE GONÇALO MINING FIELD

Located in Gonçalo, district of Guarda, mine C-57 is an ore deposit containing rare earth metals that occur in central-eastern Portugal in an area of more than 100 square kilometers between Gouveia, Fornos de

Algodres, Celorico da Beira, Guarda, Belmonte and Sabugal territories, in a granitic bedrock and in some areas, in the shale-greywacke complex. Ore veins are mainly sub-horizontal and usually less than 3,5m thick. The Seixo Amarelo-Gonçalo region (where this mine is located) is in a granitic area (Antão, 2004) (porphyritic Guarda granite mainly composed of biotite), where an aplitic-pegmatitic quartz lepidolite veins with mineralization of rare earth metals such as Lithium, Cesium and Tantalum (LCT) outcrops. Three types of sills can be found in this region (Farinha Ramos, 1998): stanniferous sills, mixed sills and lithium sills. Lithium sills to which the Mine C-57 belongs are rich in lithium and contain strontium (Sr), niobium (Nb) and rubidium (Rb) occupying a higher structural and topographic positions. They have a complex structure with a wide number of minerals such as lepidolite, quartz, potassium feldspar, albite, muscovite, topaz, apatite, cassiterite, and others. This ore deposit veins were deposited in a set of sub-horizontal fissures caused by sub-horizontal tangential stresses responsible for the formation of NNE-SSW shear zones.

THE H2020 IC&DT – LÍLIO PROJECT

Aware of the potential of the region, the Instituto Politécnico da Guarda (IPG), in conjunction with other partners (www.litio.ipg.pt) among which the mining company Pegmatítica-Sociedade Mineira de Pegmatites, Lda., owner of the concession of the C-57 mine, submitted in 2016 an application concerning an IC&DT project titled “*Geology as the basis for quality of life. The sustainability of lithium in the village of Gonçalo Guarda - Portugal*” also known as the Lítio Project (under the umbrella of the Programa Operacional Regional do Centro, Portugal).

The objectives of this project are the

preservation and sustainability of lithium mine zone, as well as the development of innovative proposals for tourism in the region to promote the cultural mining heritage in the Gaia valley where the C-57 mine is located. As this is currently the only region in Portugal with lithium ore extraction/production, the realisation of this project will create in this zone a new set of industrial and commercial activities in the so-called territories of low population density, which will certainly strengthen the zone within the central region of the country. The priority of this project are the preservation and sustainability of this resource (lithium), by the development of product, processes and services, as well as the development of innovative proposals for encouragement of tourism in the region, aimed at the promotion of the mining heritage in the Gaia valley (*figure 3*).

In recent years, tourism is one of the most important sectors of the national and international economy, and the reasons for this success vary. The World Tourism Organisation (UNWTO, 2017) predicts that global revenues from international tourism can achieve the value of 2 billion USD in 2020, which will require an average annual growth of 6 to 7% for the period 1995–2020, much higher than that estimated for the rest of the economy (3.3%), thus providing a prominent place. However, this growth is closely linked to increasing diversification and competition among tourist destinations.

The contribution of tourism to the economic development of countries depends on the quality of the revenue that tourism offers. As tourism is a social and economic phenomenon, characterised by various segments of demand, it can be an element of development of the municipalities and regions that require other sources of revenue or even revitalise the local economy. Thus, we must know how to position tourist destinations,

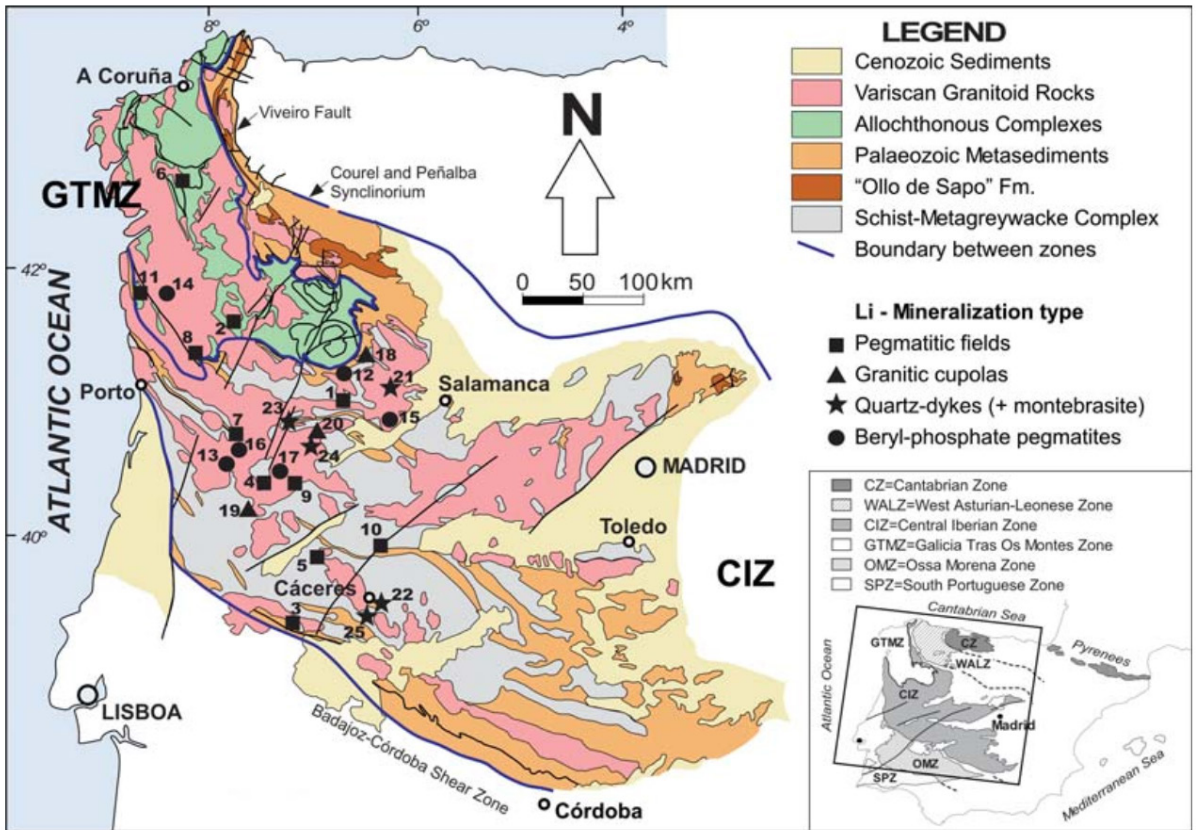


Figure 1. Schematic geological map of the Central Iberian Zone (CIZ) and the Galicia-Trás-os-Montes Zone (GTMZ), with the location of the different Li mineralisation areas of Iberia (4 - C57 Mine Concession). (From Roda-Robles et al. 2016, p. 105).

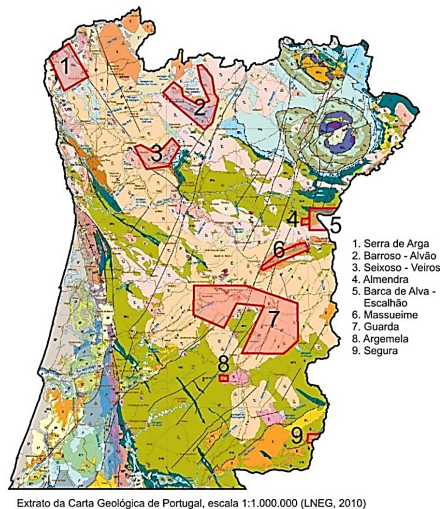


Figure 2. Formations with lithiniferous potential in Portugal (Report of lithium working group, available online at <http://www.lneg.pt/divulgacao/noticias-institucionais/535>)



Figure 3. The Gaia valley and the C-57 mine outcrops



Figure 4 – Proposed Mine Tour (<http://litio.ipg.pt/webmap/kml/#9/40.6938/-7.2235>)



Figure 5 – Proposed Thermal Spa Tour of extinct spa (Águas Radio) and active ones (Termas de Cró) (<http://litio.ipg.pt/webmap/kml/#9/40.6938/-7.2235>)

in a sustainable way, in the national and international markets, which are increasingly demanding and complex. It is common to say that the development of tourism must be based on sustainable tourism practices that act by themselves. Since tourism is a social and economic phenomenon, characterized by several segments of demand, it can be an element of development of regions that need other sources of income or even revitalize the local economy. Existing in the region of Guarda (Portugal), a lithium mine, which provides an important source of income for the region, can at the same time become a “sanctuary” for those in love with the study of the lithium phenomenon in the world. The privileged location of the Guarda area, will potentiate the development of thematic routes, which we will call the Route of Lithium Geological Knowledge. With the development of this route, a differentiating tourism product is sought. Visiting the mining heritage, abandoned or in exploitation, associating all the potential of oral and collective memory of Men, allow at the same time a register of traditions and culture, but also knowledge and development of these depressed regions.

As a former mining area with visible deep scars on the territory and in the local community, the involvement of the population through knowledge of the advantages of their natural heritage of geological origin is very important. The elaboration of thematic tours relating to mining heritages, delimitation of an “open-air museum”, as well as the implementation of visits of schools on all education levels (Moreira *et al.*, 2014) and other institutions, aims at the promotion of this resource in the structuring of differentiated tourism products, such as geotourism and the tourism of experiences. Therefore, the aim is to disclose their own territory to the local community, maximising it as a specific product in the region, which has so far been

somewhat ignored on a national scale and in the tourist industry.

POTENTIAL OF THE REGION FOR TOURISM

Nature-based tourism is in many countries a key component of the tourist industry. The offer available for tourism based on nature includes ecotourism, geotourism, adventure tourism, wine tourism, wildlife, camping, among others. Much has been written about ecotourism but there is no consensus about its meaning. In 2015, the International Ecotourism Society (TIES) provides an updated definition of ecotourism that includes the responsible visit to natural areas that promotes environmental conservation, the well-being of local inhabitants as well as interpretation and education. And specifies that education is intended both for the staff and the visitors. A tourist product should be treated as any product that is placed on the market. When dealing with the creation, development, and management of routes, Figueira (2013) notes that “the creation of tourist routes must follow a management model that strengthens the tourism system to which it belongs”.

The three tours here offered, share the passage through the C-57 Mine in Gonçalo. This mine offers the opportunity to see local geology and geological phenomena, examine million-year-old rocks, identify constituent minerals, and even collect samples. Enjoy the landscape in all its manifestations and the typical geomorphology of the region with its hilltops and green valleys. This is the commitment to a project that intends to inform and educate about the history of mining in the region, to enable the contact with the region’s earth sciences, especially geology and lithium minerals, and raise awareness to issues related with mining and the sustainability of the region.

TOURIST THEMATIC TOURS

MINE TOUR – 86,8 KM, 1 HOUR 56 MINUTES BY CAR

Aplite-pegmatite veins abound in the Guarda region. This region is known by its intense mining activity often associated with these veins, especially tin (Sn), tungsten (W) and uranium (U) that was mined during the entire 20th century. In the region of Seixo-Amarelo, Vela and Gonçalo, pegmatite rocks are structurally more complex and economically more important for the minerals they contain: cassiterite, columbo-tantalite, lepidolite, beryl, and others. In this tour, the Ribeira de Gaia is also a hotspot because here the Romans have extracted tin from existing alluvia. There have been important mining concessions around Gaia and Maçainhas At Granja Mine, between Maçainhas de Baixo and Vila Soeiro, tungsten has been extracted and in Águas Belas there were some tin and tungsten concessions. In the Guarda region, uranium deposits are ubiquitous and some of them have been exploited for radium (Ra) at Barroca Funda, Cruz da Faia, Forte Velho and Carrascal-Geraldo. South to Alvarrões, between Vela and Gonçalo, lepidolite (lithium ore) can be found (figure 4).

This tour encourages tourists to learn the geology of the region, the history of mining, the uses of ore extracted in the area, the requalified mining sites, and the renovated site of the former Barracão factory, a radium and uranium mining site near Guarda city (figure 4)

THERMAL SPA TOUR - 190 KM, 3 HOURS 27 MINUTES BY CAR

The water's chemical composition is determined by the chemical composition of the geological materials it gets in contact with. Its form of occurrence is also affected by the material, tectonics, structural arrangement and stratigraphy. In a region where thermal

springs abound, the implementation of a thermal spa tour is imperative. This tour (figure 5) aims to disseminate several thermal springs with unique health and well-being properties which are a testimony of the evolution that has occurred in the sector.

The approach to this tour and the tour of the waters begins with the geological, hydrogeological and structural framing to clarify about the origin of the hot springs and the fluvial beaches and to sensitize for its preservation.

WATER TOUR - 77,3 KM, 1 HOUR AND 44 MINUTES BY CAR

In the summer there is a considerable increase in the number of people traveling, especially to the coast and river beaches. This is an opportunity to spread the product that is proposed. We offer a product that joins information/training with leisure. In short sessions we can explain the geomorphology and the aspects related to the origin of fluvial beaches. Pedestrian paths allow the observation of geology, architecture and culture.

Along the proposed routes (figure 6), it is possible to observe the biodiversity and relate it to the geological and geomorphological aspects, culture expressed as legends, beliefs, attitudes and local crafts such as the basketry of Gonçalo, the traditional blankets of Maçainhas, the granite sculptures of Quarta-Feira and the woollen cloth factory of Manteigas. Rural and urban architecture allows to reconstitute the history and identity of local population based on location, the construction materials used, the typology, the dimension and the structures of buildings as well as the accessories used. The tourist also has the possibility to taste the gastronomy of the region.

The target audience includes primarily

young people aged 12 to 24, i.e. students ranging from intermediate school to higher education. These age groups correspond to about 30 percent of leisure and recreation tourism. They may also include other groups of people with an interest in earth sciences and natural resources.

The aim is to offer a person-to-person approach focused on information and interpretation, and not mass tourism. Partnerships are sought with schools of distinct levels of education, with municipalities, with entities that have responsibilities in the fields of exploration and management of mineral resources and companies in the tourism and mining sector.

OPEN-AIR-MUSEUM

An Open-Air Museum was implemented on C-57 mine installations (figure 7), which allow an open window to the knowledge of the origin of the pegmatites on Earth and a historical stone witness and unique assets in the country related to the ancient mining of lithium. The thematic routes should be designed to converge in the museum space, which would be the centre of all activities to be performed. The entire museum and the thematic routes will be a socio-economic added value for the region, acting as a possible structure of innovative tourism products (Hose, 2000). This action in cooperation with the owner of the C-57 mine, aims to contribute to the cultural enrichment and tourism promotion of the locality of Gonçalo and to raise awareness of young students to the natural sciences and to the exploitation of natural resources. These objectives will be maximised by the local population's involvement in the preparation of the activities, through the collection of their experience and diverse materials that reflect the mining activities of the past.

The development of the Open-Air Museum

(figure 7), complemented by the proposal for the elaboration of thematic pathways in the network, will reduce problems of seasonality, encourage job creation and promote public awareness for the preservation of the cultural and environmental heritage, bringing in general an undeniable asset and promoting the sustainability of this region. The Open-Air Museum would be located on the former C-57 mine installations, which would allow an open window to the knowledge of the origin of the pegmatites on Earth and a historical stone witness and unique assets in the country related to the ancient mining of lithium. The aim is to offer a person-to-person approach focused on information and interpretation, and not mass tourism. Partnerships are sought with schools of distinct levels of education, with municipalities, with entities that have responsibilities in the fields of exploration and management of mineral resources and companies in the tourism and mining sector.

CONCLUSIONS

Regarding the development and qualification of the tourist offer/players, Turismo Centro de Portugal (TCP, 2018) states the importance of improving the offer and develop the ability to adopt strategies that promote product uniqueness and competition. Accessible tourism is another of the strategic lines to follow. TCP assumes the following priorities in the framework of the Centro 2020 programme:

- Investing on tourist marketing of cultural, historical and heritage resources of the region, in particular those which are classified as World Heritage by UNESCO.
- Investing on tourism promotion, qualification and enhancement of high-value cultural, natural and landscape value, boosting the development of tourism products based on the

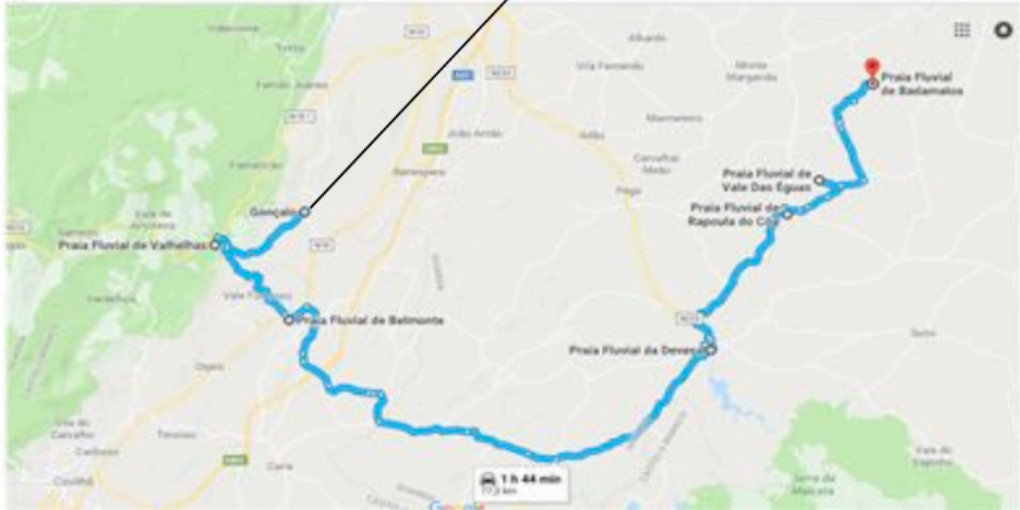


Figure 6 – Proposed Water Tour (<http://litio.ipg.pt/webmap/kml/#9/40.6938/-7.2235>)



Figure 7 - Open-Air Museum poster and activities done

qualification of routes, trails, networks, events or other forms of creating supra-regional synergies.

- Focusing on integrated and effective promotion of the resources, tourism products and services in the region.

The H2020 IC&DT – LÍTIO Project proposal and strategy, is in line with the typology of actions proposed by TCP and the Tourism Strategy 2027 (Turismo de Portugal, 2017), by promoting:

- product sustainability, education, and research.
- social equity and accessible tourism by opening initiatives to the school public.
- training of public entities and operators, when it is available for the formation of specific groups.
- competence of technicians.
- inter-municipalism and networking, resulting from the partnerships proposed.
- the adoption of methods for monitoring and evaluating the impacts of the product.
- continuous improvement

This actions in cooperation with the owner of the C-57 mine, aims to contribute to the cultural enrichment and tourism promotion of the locality of Gonçalo and to raise awareness of young students to the natural sciences and to the exploitation of natural resources. These objectives will be maximised by the local population's involvement in the preparation of the activities, through the collection of their experience and diverse materials that reflect the mining activities of the past.

It is hoped in the future to create a joint venture between mining companies and cultural tourism through the development of thematic routes promoting the beauty

of natural resources, especially those of geological type, which could be attractive not only to the local inhabitants but to a much wider population. The recent approval by the Portuguese government of a National Strategy for Nature Conservation and Biodiversity for 2030 (Resolution of the Council of Ministers No. 55/2018, 7 May 2018) undoubtedly points to the path of conservation of the values of the natural heritage and its geodiversity with the safeguard of the cultural identity.

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