The Extractive Industries and Society 27 (2026) 101930

Contents lists available at ScienceDirect

The Extractive Industries and Society

journal homepage: www.elsevier.com/locate/exis

Original article

From extraction to engagement: Post-mining transition and science communication in Lousal, Portugal

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ARTICLE INFO

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Keywords:
Mining
Heritage
Museum
Communication
Culture
Climate
Transition

ABSTRACT

Former mining sites are increasingly tasked with mediating extractive pasts while engaging publics with contemporary sustainability challenges. Examining the case of the Lousal Cultural Complex – in Portugal's Alentejo, 140 km south of Lisbon – this paper highlights tensions in heritage interpretation, science communication, social engagement, and environmental responsibility. Drawing on documentary analysis, site visit, exhibition analysis, and interviews with institutional actors, the study assesses how mining history, environmental impacts and rehabilitation, and energy transition are communicated within the complex, across its permanent exhibitions and mediated activities.

The Lousal Cultural Complex is a case that exemplifies both the possibilities of the integration of heritage reuse and science communication, and the curatorial challenges of balancing immersive and memorable engagement with the communication of just and transformative energy transitions. While the complex demonstrates substantial technical, cultural, scientific, and educational achievements, the findings reveal a marked narrative asymmetry: Narratives of extractive dependency and technological progress are embedded in permanent and interactive exhibitions, while social histories, environmental degradation, remediation limits, and post-extractive futures are communicated through incidental verbal interpretation, temporary exhibitions, or event-based programming. As a result, the potential to foster environmental citizenship is constrained, although possible to overcome by curatorial changes that engage publics with social histories and equip them with critical perspectives on consumption, circular economy, and mineral futures to promote just and green transitions.

1. Introduction: mining heritage, science communication, and environmental transitions

Mining heritage encompasses both the physical remains of extraction – such as infrastructure, machinery, and landscapes – and the social practices, knowledge systems, and ways of life historically shaped by mining activity (Jelen, 2022). The process of heritagisation involves a range of interventions, including preservation, restoration, rehabilitation, and adaptive reuse, often accompanied by the documentation of intangible dimensions through oral histories and testimonies. These processes are frequently extended through musealisation and tourist-oriented development, whereby sites are reinterpreted, exhibited, and integrated into broader economic strategies, often framed as pathways towards economic renewal through a shift from extractive production to heritage-based economies (Dias Sardinha et al., 2013; Edwards and Llurdés, 1996; Ghosh and Sanyal, 2022; Jones and Munday, 2001; Kirshenblatt-Gimblett, 1998; Krassakis et al., 2024; Oakley, 2018; Smith, 2006). As Kirshenblatt-Gimblett (1998) argues, such sites acquire a 'second life as heritage,' becoming 'destination museums' distinguished by altered landscapes, industrial ruins, and accessible mine sections that offer 'different' experiences into past lifestyles. In this sense, heritage is not simply preserved but actively produced through the 'agency of display,' which shapes narratives, frames meaning, and influences public understanding.

Heritage interpretation in these contexts often privileges celebratory and depoliticised accounts (Oakley, 2018), reproducing what Smith

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https://doi.org/10.1016/j.exis.2026.101930
Received 10 February 2026; Received in revised form 6 April 2026; Accepted 6 April 2026
Available online 13 April 2026

(2006) conceptualises as an Authorised Heritage Discourse, grounded in institutional expertise and narrative authority. Mining museums frequently advance progress-oriented narratives that frame the extraction of national resources as a driver of modernity, technological advancement, and development (Bridge, 2008; Glaser, 2023; Jørgensen and Thorade, 2026; Koch and Perreault, 2018; Macdonald, 1998; Oakley, 2018). These narratives are often accompanied by what Macdonald (2013) terms a 'naïve' nostalgia, through which the mining past is selectively romanticised (Oakley, 2018). Such framings tend to normalise extraction as inevitable or necessary, while environmental damage is framed as the 'price to pay' for modern and comfortable lifestyles, producing 'sacrifice zones' (Storm, 2014), that are claimed to be manageable through environmental rehabilitation – particularly where corporate influence persists (Kirsch, 2014).

At the same time, mining sites are framed as 'hard places' (Francaviglia, 1991), and 'scars' (Storm, 2014), which heritage is emotionally charged, difficult, dissonant, and contested, entangled with histories of labour exploitation, social inequality, and environmental harm (Smith, 2020; Varriale et al., 2023). Yet, despite this recognition, social and environmental dimensions often marginal in their interpretation. This imbalance is reflected in what Frost (2011) terms 'incidental interpretation,' where such issues are addressed reactively rather than systematically. It is further reinforced by exhibition strategies that prioritise affective engagement, immersive experiences, and edutainment (Illsley et al., 2025; Macdonald, 2022), which, if insufficiently contextualised, may limit critical reflection (Kidd, 2018; Løvlie et al., 2021). Nevertheless, heritage institutions, including former mining sites, are increasingly becoming critical venues for negotiating the intertwined legacies of extraction and communicating their social and environmental costs. At the same time, their capacity to foster environmental citizenship is being re-evaluated, with growing expectations that they address climate change, circular economies, and mineral futures in support of green transitions (Cameron, 2011; Harrison, 2026; Harrison and Sterling, 2021; ICOMOS, 2019; McGhie, 2021).

This paper examines the case of the Lousal Cultural Complex, where a mining museum and a science centre coexist within a rehabilitated industrial landscape. It contributes to international debates on the heritagisation and musealisation of mining sites, focusing on narrative construction, modes of engagement, and touching on visitor perceptions. The study is informed by a site visit conducted between 21 and 24 October 2025, accompanied by Margarida Oliveira, Science Communicator at ACCVL *(Associação Centro de Ciência Viva do Lousal)* since 2010, specialising in geology and museology. Post-visit interviews were conducted with both Oliveira and Álvaro Pinto, Executive Director of ACCVL and Professor of Geology at the Faculty of Sciences of the University of Lisbon. These interviews provided professional insights into visitor profiles and perceptions, as well as institutional perspectives on remediation narratives, science communication strategies, community engagement, operational challenges, and future directions at the complex.

2. Lousal's cultural complex: from post-mining rehabilitation to heritage interpretation

Lousal is a former pyrite mine located in the municipality of Grândola (Setúbal district), approximately 140 km south of Lisbon. It lies within the Iberian Pyrite Belt, one of the world's most significant massive sulphide provinces (Tinoco et al., 2002), with mining activity dating back to the Bronze Age (c. 3300 BCE). Modern extraction took place between 1900 and 1988 for the production sulphuric acid used in fertilisers (Matos et al., 2008; Oliveira, 2022; Relvas et al., 2014), positioning the mine's owner SAPEC (*Sociedade Agro-Pecuária e Comercial*) as one of Portugal's main fertiliser producers. Mining activity intensified during the mid-twentieth century, paired with major technical and organisational reforms under the management of Frédéric Velge (Belgian Forestry Engineer, assumed management in 1958). These reforms included mechanisation, improved safety, and expanded social infrastructure for workers and their families (Rodrigues, 2013). During its peak, the mine provided employment for 1100 workers in a population that neared 2500 (Rodrigues, 2005). However, economic shifts in the late 1970s rendered pyrite extraction economically unviable, leading to the mine's closure on 31 May 1988. Following deactivation, Lousal experienced severe socio-economic decline, marked by unemployment, out-migration, and population ageing, alongside the deterioration of housing and infrastructure (Rodrigues, 2005). The population now counts for a couple hundreds, and the landscape is heavily degraded, characterised by waste heaps and polluted lagoons, with acid mine drainage that had previously caused soil acidification and metal contamination, affecting local aquifers, including the Corona stream, a tributary of the Sado River (Luís et al., 2011).

2.1. The RELOUSAL project

Along with the Municipality of Grândola, SAPEC launched the RELOUSAL rehabilitation project in 1991, aiming to address social, economic, environmental, and cultural challenges (Relvas et al., 2014). Pinto reveals that the project was initially conceived to erase visible mining traces. However, following discussions with the entity responsible for environmental recovery EDM (*Empresa de Desenvolvimento Mineiro*) and plans to establish a science centre, the project adjusted its aims to preserving mining memory and reframing the site as a centre for culture, science communication, and learning. Under this strategy, the Frédéric Velge Foundation was created in 1994 to coordinate the rehabilitation project. In 1996, the Foundation resorted to the Portuguese Association of Industrial Archaeology (APAI) to develop a musealisation programme (APAI, 1998). Both rehabilitation and musealisation were carried out by local contractors and residents, with former miners and their families involved in staffing and tour guiding (Tinoco et al., 2002).

2.2. Environmental remediation

In parallel, environmental remediation has been led by EDM[1] and complemented by research and innovation projects. The first two phases (2010–2015)[2] addressed acid drainage containment through the construction of impermeable walls, phytoremediation pools, and zero-discharge dams. A third phase is scheduled for 2026 to address residual contamination by removing pyrite-rich waste heaps generating acidic runoff.[3] Beside EDM's interventions, the EU-funded LIFE RIBERMINE project (2019–2024)[4] applied geomorphological, geochemical, and ecological restoration techniques, contributing to improved water quality, reduced metal concentrations, and increased biodiversity (LIFE RIBERMINE, 2022). Long-term monitoring systems were subsequently installed to track environmental recovery.[5] Recently, developed within the REPAIR project (Research in Environmental Pollution, Advanced Industrial Remediation), a pilot installation is scheduled for 2026 to test a macroalgae-based technique for extracting rare earth elements, cobalt, and nickel from acidic mine waters (Viana et al., 2024). Pinto notes that this approach is beneficial both to recover critical elements and to improve water quality.

[1] EDM developed rehabilitation plans for contaminated mining areas across the country as documented in its report *The Legacy of Abandoned Mines* (EDM and DGEG, 2011).

[2] https://edm.pt/en/projetos/environmental-remediation-of-the-lousal-mining-area/ [Accessed on 3 March 2026]

[3] https://edm.pt/projetos/recuperacao-ambiental-de-aljustrel-e-lousal-fase-complementar/ [Accessed on 3 March 2026]

[4] https://liferibermine.com/en/homepage_en/ [Accessed on 3 March 2026]

[5] Findings are made publicly available through LIFE RIBERMINE publications: https://liferibermine.com/en/publications/ [Accessed on 3 March 2026]

2.3. Lousal's Cultural Complex

Lousal's Cultural Complex currently consists of three components: the Mining Museum (2001), the Science Centre (2010), and the Mine Gallery (2015). Since 2011, it has been managed by ACCVL *(Associação Centro de Ciência Viva do Lousal)*, a non-profit private entity with a multidisciplinary team, spanning geology, museology, sociology, science communication, chemical engineering, mathematics, biology, and environmental education. ACCVL has five partners: the National Ciência Viva Agency, the Municipality of Grândola, the Faculty of Sciences of the University of Lisbon, and two private companies, SAPEC Parques Industriais and Costa Terra. ACCVL is funded primarily by its institutional members, with the faculty contributing mainly through personnel, complemented by ticket sales, merchandising, and participation in national and international funding programmes and research projects. Following are descriptions of the complex's exhibition spaces and available experiences.

2.3.1. Mining Museum

Housed at the former power station, the museum was first inaugurated in 2001 following APAI's musealisation proposal (APAI, 1998). After ACCVL assumed management, the museum underwent successive remodellings and addition of bilingual panels and interactive screens, in Portuguese and English, and a Robo Guide named FeS_2 (the chemical formula of pyrite).

As illustrated in Fig. 1, the visit opens in the Compressed Air Production Hall (1), where original machines are interpreted through detailed technical and historical descriptions. The mine's technical and operational characteristics are introduced in Bottom of the Mine (2), along with displays of archival materials, a collection illustrating the evolution of gasometers, and a virtual-reality simulation of pneumatic drilling providing an immersive experience to visitors (Fig. 2). Historical mining techniques are presented in 19th Century Mine Models (3) through 16 wooden models.

The Geological Services of the Lousal Mine (4) presents the legacy of

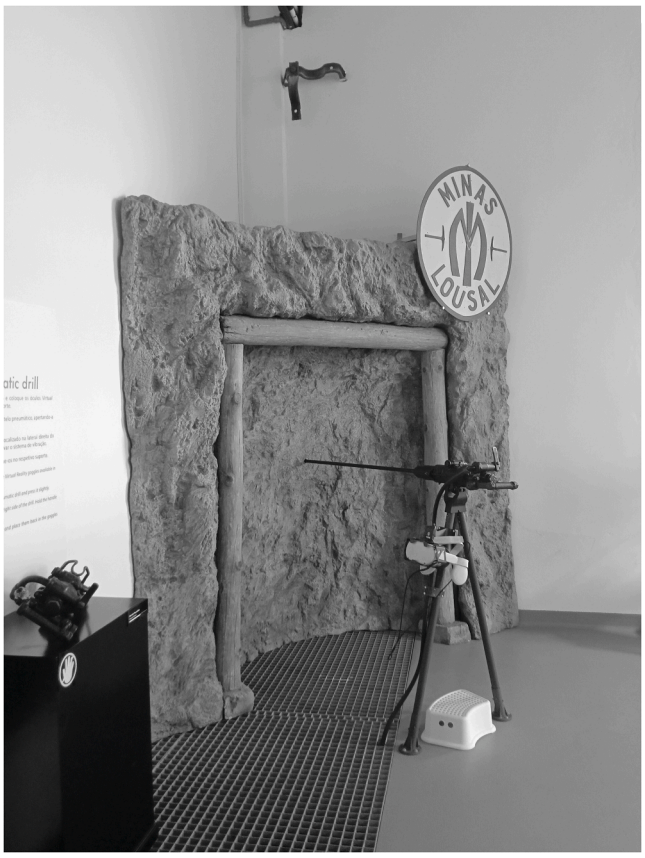
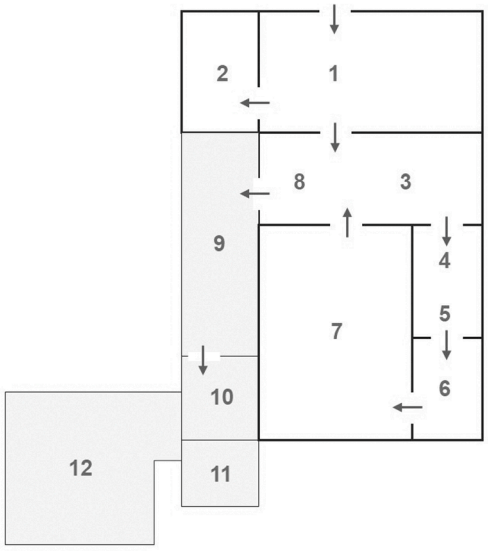
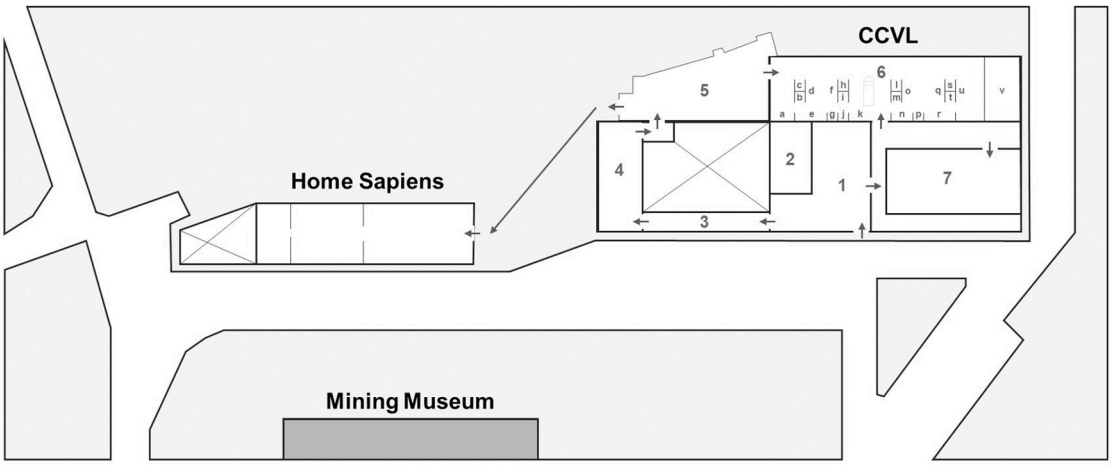


Fig. 2. VR Drilling Simulation at the Bottom of the Mine Exhibition. Author.



1. **Compressed Air Production Hall**
2. **Bottom of the Mine**
3. **19th Century Mine Models**
4. **Geological Services**
5. **The Chemical Laboratory**
6. **The Health House**
7. **Generator Plant**
8. **The Mining Community**
9. Multipurpose (future social history section)
10. Documentation centre
11. Transformer station
12. Offices and annexes

Fig. 1. Exhibition sequencing plan of the Mining Museum. Author.



1. **Atrium**
2. **Reception**
3. **Corridor (Mine gallery simulation)**
4. **No earth, no beetles** (*Sem terra não há carochas*)
5. **Pyrite Patio**

6. **Science Bath**
a. Tesouros Escondidos no nosso Quintal
b. Minérios na Intimidade
c. As pedras e o toque
d. As histórias que os minerais contam
e. Minérios, mistérios e outros assuntos sérios
f. Projeto LIFE RIBERMINE
g. Paisagens minerais
h. Intraterrestres e vida nos extremos
i. Um espetáculo de cortar a respiração
j. A forja de Vulcano
k. Tabela periódica
l. Vida aquática nas trevas
m. Mineiros da natureza
n. Vigilantes da Natureza
o. A natureza também brinca ao "quarto escuro"
p. O mundo de pernas para o ar!
q. Brincar com a luz
r. Detetando minérios ocultos
s. Mangueira de luz
t. Guiar a luz
u. Aqui há bruxas!!
v. Laboratório químico
7. **Auditorium**

Fig. 3. Exhibition sequencing plan of CCVL. Author.

German Geologist Günter Strauss, credited with advancing local geological knowledge and producing important geological maps, as well as video projections of oral testimonies by key local figures from the mine's history, and exhibits of laboratory equipment, archival documents, and ore classifications. The Chemical Laboratory (5) presents equipment used for sulphur levels analysis. The Health House (6) pays tribute to *Casa de Saúde*, where healthcare was provided. It notably references silicosis screening and post- diagnosis measures: *"Workers who showed respiratory insufficiency were then temporarily reassigned to surface jobs subsequently returning to their previous workstations."* The Generator Plant (7) features a restored Carels Ingersoll-Rand 3E three-cylinder diesel engine, installed at the Lousal Mine in 1934 to supply electricity to the entire mining complex, which marked a turning point in the site's technological modernisation and productivity.

The visit concludes with The Mining Community (8), where a short documentary by Mateus Junior (1958) is displayed, illustrating the life at the mine, miners at work, women sorting ore, transportation via the headframe (locally known as '*a malacate*') to the wagons, through the ore route, and to the train station. A replica of the demarcation of the mine in 1883 officially registered by António Manuel is displayed along with a map. Finally, a text describes the closure of the mine, with the final siren blaring on May 31, 1988, at 3:30 PM: *"The last miners of the last shift of the last day of the Lousal mine enter the lift and, for the last time, that immense steel cable is stretched and contorted to settle forever on the reel that now rests inside the winch house. The sense of relief from another day's work was tempered on this day by the bitterness of a cycle coming to an end, leaving Lousal to a new and different reality."*

2.3.2. Centro de Ciência Viva do Lousal (CCVL)

Located opposite the Mining Museum, the centre opened in 2010 following extensive rehabilitation by *Oficina de Arquitectura* (2007–2009). As illustrated in Fig. 3, entrance is through the Atrium (1), where a text on the floor reads *"Exploring science, Extracting Knowledge,"* with a maquette of the town is embedded under glass. A glass wall features an abstract section of the mine, with a pyrite specimen displayed behind it. Introductory panels explain the geological formation of the ore, its composition, the estimated volume of Lousal's deposit, and its exploitation history. Two screens titled 'Faces of Lousal' display archival photographs of residents. Below, demographic data is illustrated, complemented by maps of the mining settlement and texts addressing ore uses, processing methods, work conditions, and the reasons behind mine closure. Additional panels acknowledge the contributions of Frédéric Velge and Günter Strauss. Finally, the RELOUSAL project is introduced as well as the recent LouMu project, of 2022, led by LIP (*Laboratório de Instrumentação e Física Experimental de Partículas*), that applied muon tomography to produce non-invasive three-dimensional images of the mine and surrounding geology.[6]

Adjacent to the atrium is the Auditorium (7), which hosts film screenings, seminars, public talks, and events, and is surrounded by temporary exhibition areas. On the opposite side of the atrium, the visitor route begins at the reception (2) and continues through a corridor (3) that simulates a mine, leading to the exhibition No Earth, No Beetles (4). The exhibition features four Beetle cars mounted on the wall, progressively stripped of non-metallic, petroleum-based, and metallic components until nothing remains. Text panels, a digital screen, and an interactive quiz provide additional information on raw materials and their uses (Fig. 4).

From here, visitors cross the Pyrite Patio (5) to a rehabilitated warehouse hosting the exhibition Home Sapiens – Science at Home, which presents everyday domestic objects from kitchens, living rooms, and bathrooms, explaining materials and technologies through interactive displays and quizzes (Fig. 5).[7] Home Sapiens was funded by the European Union and sponsored by oil company Repsol, which has a display on plastic food containers Tupperware, and Viarco, a Portuguese pencil manufacturer, represented through a section on pencils and graphite.

Returning to the Pyrite Patio (5) and ascending to the first floor, visitors encounter thematic exhibitions in physics and mathematics,

[6] https://pages.lip.pt/loumu/en/lousal-detection-2/ [Accessed on 3 March 2026]

[7] https://luisapacheco.pt/pt-pt/design-de-museus-e-exposicoes/exposicao-home-sapiens-a-ciencia-la-em-casa/ [Accessed on 3 March 2026]

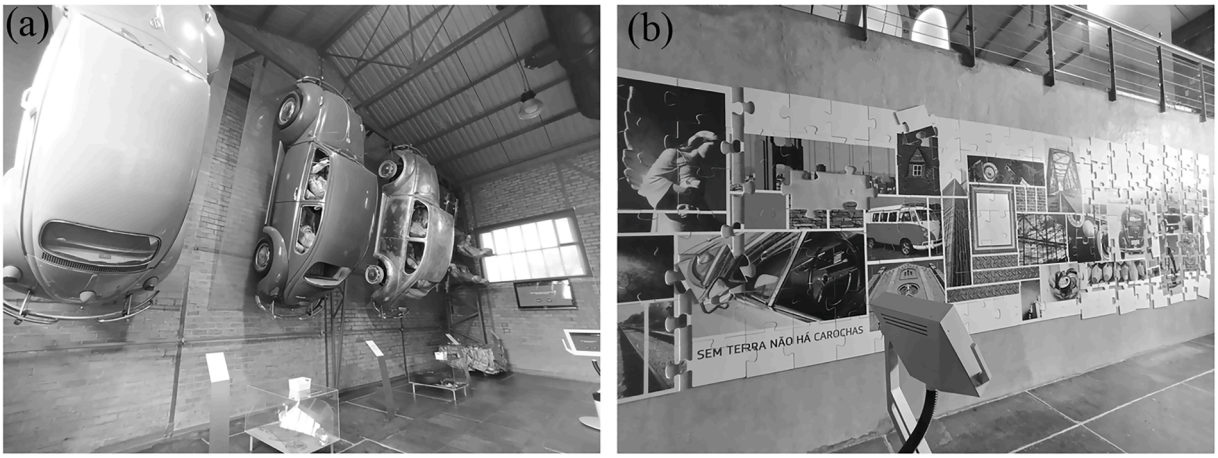


Fig. 4. Exhibition No Earth, No Beetles at CCVL. Author.

Fig. 5. Exhibition Home Sapiens at CCVL. Author.

leading to a children's playground, titled 'Mine for the little people' (Fig. 6). Designed for children up to 12 years old, the playground comprises a sequence of activities in which they wear safety gear, load wagons with foam cubes representing rock and ore, transport them through a headframe, sort materials on conveyor belts, and move ores to the train station.

Accessible from both the Pyrite Patio and the auditorium area, the mine's former shower block was converted into the Shower of Science exhibition (6), featuring interactive modules in geology, volcanism, mineralogy, crystallography, resource mapping, radioactivity, biology, and physics (Mendonça, 2020). The space also includes a Chemistry Laboratory (v) and a presentation on the LIFE RIBERMINE Project (f), featuring an interactive augmented-reality sandbox that simulates the project's geomorphological alteration technology for water runoff management.

2.3.3. *'Lousal Open Air' and the Waldemar Gallery*

The complex offers a requalified outdoor route, titled 'Lousal Open Air,' connecting the site and its mining attractions. Provided signage enables unguided visits along the PR7 GDL pedestrian route promoted by the Municipality of Grândola.[8]

Behind CCVL stands the former crushing warehouse (Fig. 7). It is locally known as '*a Cassagem*' – an adaptation of the French word *concassage*, reflecting the mine's French-speaking management. At this facility, and as illustrated in the Mateus Junior documentary, ore separation was the only task permitted to women as they were prohibited from entering the mine. The building now stands roofless and partially in ruins, with debris scattered across the interior along with artworks by students from the Faculty of Fine Arts of the University of Lisbon, including sculptural and painted representations of mining elements such as helmets, headframes, and infrastructure. On the rear façade, a painting of a female worker with a headframe in the background is placed, in a composition reminiscent of Munch's *The Scream*. Behind this structure is a breathtaking panoramic view overlooking key landscape features of the mining site, including waste heaps, mining pits with exposed rock surfaces revealing different mineral compositions, two acidic lagoons with distinct green and red colours (Fig. 8), and the two headframes connected by the Pyrite Road, which historically linked the mine to the railway platform used for ore transport to Setúbal.

A wooden pedestrian pathway of approximately 2 km connects mining attractions, facilitating access across the site an (Oliveira et al., 2013). Along this route, visitors can explore the Waldemar Gallery, which provides access to approximately 280 m of the original mine. Opened in 2015 and named after Waldemar d'Orey, who registered the mining concession in 1907, the gallery presents outputs from scientific, educational, and heritage initiatives developed by multiple institutions. It features original mining infrastructure, equipment donated by the Velge Foundation, and four rehabilitated explosive storage chambers:

Fig. 6. Mine for the little people playground at CCVL. Author.

[8] https://www.visitgrandola.com/fazer/turismo-de-natureza/percursos-pedestres/poi/pr7-lousal-a-ceu-aberto [Accessed on 3 March 2026]

Fig. 7. Crushing facility and panoramic view of the mining site. Author.

one dedicated to dynamite, one displaying tools and ore samples, one inaccessible chamber currently used for wine ageing, and one housing a muon telescope from the LouMu project, accompanied by explanatory panels. Beyond the gallery, the route continues through mining and remediation areas and concludes at the former railway stop, where a high-pressure steam locomotive is exhibited.

3. Beyond the exhibitions: cultural management and institutional practice

3.1. Societal and local impact

Cultural interventions in former mining towns must engage with local communities and embed themselves within existing social contexts, rather than operating as detached external entities. In the case of Lousal, the relationship between the centre and the local population has gradually improved. The RELOUSAL panel at CCVL refers to initial 'scepticism,' reflecting how residents perceived the centre as an externally driven, tourism-oriented project. According to Pinto, this perception has shifted over time as tangible benefits became evident. The complex now attracts between 15,000 and 17,000 visitors annually, a significant figure relative to Lousal's population of approximately 250–280 inhabitants. This dynamisation has contributed to local economic activity and a degree of demographic revitalisation, with young professionals working at the centre and their families increasing demand for services, schools, and childcare. At the municipal scale, the centre supports year-round inland tourism, complementing seasonal coastal flows. The Lousal complex thus exemplifies Kirshenblatt-Gimblett's (1998) notion of a 'second life as heritage,' where the former mining landscape is reactivated as a destination museum with broad local and regional impacts.

Importantly, ACCVL has engaged in social research, including the collection of oral testimonies from former mine workers. Pinto describes the centre as *"the official custodian of a very large body of documentation produced by the company during its operational phase,"* which has led to the recent creation of a documentation centre (10) within the Mining Museum. Residents are granted free access to the complex and its outdoor areas, which are regularly used for leisure and social gatherings, reinforcing everyday connections to the site. In addition, the centre organises events that engage the local community, some aligned with commemorative occasions such as Heritage Day, Museum Day, and Saint Barbara's Day, the patron saint of miners.

3.2. Enriched and dynamized by art

Pinto describes the presence of art in Lousal as 'unavoidable', emphasising its role in 'creating disruption in the narrative.' Artistic installations intervene in the industrial setting by interrupting linear historical interpretation, prompting reflection, and reframing the visitor experience. The mentioned artwork installations at the former crushing facility exemplify this approach, creating a contrast between the ruins of the building, the historical narratives communicated on site, and the artistic expressions that reinterpret mining heritage.

Artistic initiatives in Lousal stem from a long-standing collaboration, initiated by sculptor Sérgio Vicente, between the Municipality of Grândola and the Faculty of Fine Arts. Notably, *Um Monumento para o Lousal* (2019) was developed through a two-year community-based process, culminating in a monument located in the mining residential quarter. It has a ladder-like metal structure that references the railway infrastructure and access to the underground via ladders, reflecting local identity and mining heritage (Cruzeiro, 2021).[9] Subsequently, the EXTRAI Art and Community in Action Project (2019–2021), also led by Vicente, hosted artistic residencies engaging diverse community groups, including the Cape Verdean community (historically involved in mining), local youth, and women. The project addressed themes such as territorial identity, gender, race, education, and environmental change (Oliveira and Vicente, 2023).

Beyond these initiatives, ACCVL continues to integrate art through a range of cultural programming. This includes musical performances in collaboration with local music schools and *Cante Alentejano* groups (tradition music from the Alentejo inscribed in the UNESCO's list of Intangible Cultural Heritage[10]). ACCVL also holds open-air exhibitions and film screenings either projected at the former crushing facility or organised via mobile setups in partnership with French group *Le plein de Super*.[11] Pinto describes these events as 'fascinating moments', as they activate industrial ruins as dynamic cultural spaces.

Accordingly, art in Lousal operates across multiple registers: it enriches the visitor experience and fosters community participation through co-creation and dialogue. In doing so, it strengthens the relationship between the centre and local society, embedding the complex more firmly within the social and cultural fabric of the town.

3.3. Education and science outreach

Education constitutes one of ACCVL's core pillars, particularly

[9] https://www.facebook.com/watch/?v=999102283611520 [Accessed on 3 March 2026]

[10] https://ich.unesco.org/en/RL/cante-alentejano-polyphonic-singing-from-alentejo-southern-portugal-01007 [Accessed on 3 March 2026]

[11] https://www.maxima.pt/atual/detalhe/vamos-ver-cinema-ao-ar-livre [Accessed on 3 March 2026]

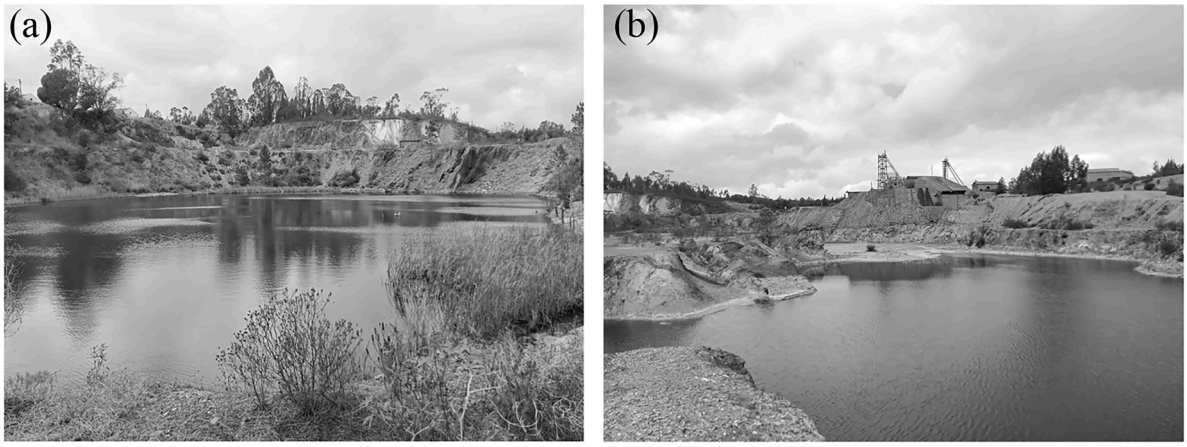


Fig. 8. Polluted lagoons at the mining site. Author.

through its Science School programme (*Escola Ciência Viva*, also known as *A Escola é Uma Mina*). Developed in partnership with the Grândola school cluster and the Municipal Council, the programme ensures that all fourth-year pupils spend a full week in Lousal engaging in hands-on science education. Activities span chemistry, robotics, geology, and biology, and take place across laboratories, museum spaces, the mine, and the surrounding landscape. According to Pinto, beyond its pedagogical value, the programme generates sustained vitality at the site through the regular presence of children, which is positively received by the local community, parents, and pupils alike.

The centre also demonstrates strong engagement with current scientific research and environmental challenges, contributing to knowledge production through collaborations in projects such as LIFE RIBERMINE, LouMu, and REPAIR. Pinto describes this relationship as a 'win–win situation,' enabling the continuous updating and communication of scientific content while supporting research teams in meeting outreach and dissemination requirements. In addition, the centre is part of the national Ciência Viva network, which promotes scientific literacy and public engagement. Through the Ciência Viva Circuits programme,[12] visitors benefit from discounts on accommodation, catering, and transport across the network's 22 science centres, encouraging broader visitation and connectivity between sites.

4. Examining communication and narratives approaches

Since opening, the Lousal complex has received over 195,000 visitors.[13] Visitor profiles are diverse, spanning all age groups and educational levels, from pre-school to university. Visitor patterns have remained consistently bimodal over the past 15 years, with school – particularly at middle and secondary levels – and non-school audiences each accounting for roughly half of total attendance. School visits peak during the academic year, whereas families, tourists, and organised senior groups are more prevalent during the summer months. According to Pinto (2021), >43 % of visitors originate from the Lisbon region, followed by 27 % from the Setúbal region where Lousal is located. International visitors come from 15 to 25 countries annually. Historically, Spanish, German, and Dutch visitors have formed the largest foreign groups. Spanish visitors are prominent due to geographic proximity and coastal tourism flows, German audiences reflect a long-standing interest in industrial heritage, and Dutch visitors are supported by local infrastructure allowing camper-van tourism. More recently, visitors from the United States have grown significantly, becoming the largest international group in 2024, linked to broader tourism dynamics and real-estate developments associated with the centre's partner, Costa Terra.

Visitors can choose between unguided and guided visits, either interacting with a science communicator or using audio guides available at three levels of complexity and in five languages: Portuguese, English, French, Spanish, German, and Portuguese Sign Language. Beyond textual communication, exhibitions feature immersive and interactive elements, including a robot, drilling simulation, touch screens with quizzes and interactive interfaces, and game-based science modules. According to Oliveira, visitors typically conclude their visits with four main takeaways: an understanding of Lousal's history; appreciation of mining heritage and the socio-economic benefits of its valorisation; recognition of the importance of post-mining environmental rehabilitation; and awareness of the need to allocate funding for environmental and heritage initiatives in post-mining contexts, given their transformative and revitalising role in enabling tourism.

Drawing on quantitative data, field observation, discourse analysis, and interviews, the following sections examine how mining heritage, science and technology, and environmental impacts and initiatives are interpreted, structured, and prioritised at the Lousal Cultural Complex. The focus is on communication and narrative approaches, identifying discursive strategies, modes of engagement (including didactic, exploratory, and immersive experiences), tensions, and potential risks.

4.1. Creating unforgettable experiences and confronting difficult histories and realities

In 2019, 36 % of visitors attended the Ciência Viva Centre and 30 % the Waldemar Gallery, while the Mining Museum and outdoor activities each accounted for 17 % of total visits (Pinto, 2021). As these figures predate the Museum's 2024 renovation – which introduced interactive elements such as the Robo Guide and a pneumatic hammer drill simulation – they suggest stronger visitor engagement with the more immersive and interactive components of the complex. According to the interview with Oliveira, visitor interest at the Lousal complex varies significantly according to age, educational background, and motivation. The outdoor mining complex attracts broad interest across all age groups, with particular fascination for the monumental industrial buildings, the malacates, the vividly coloured lagoons, and the Waldemar gallery, described by Oliveira as an iconic feature of Lousal's identity. Younger audiences, particularly children between 3 and 12 years old, display high levels of curiosity and engagement with hands-on and interactive modules. Teenagers tend to disengage more quickly from extended verbal explanations, favouring autonomous exploration and interactive formats such as quizzes and simulations. Adult and senior visitors show interest in both technological and mechanical aspects and in social, medical, geological, and mining histories, especially those with personal or familial connections to mining. The post-mining

[12] https://www.circuitoscienciaviva.pt/ [Accessed on 3 March 2026]
[13] https://lousal.cienciaviva.pt/publicos/ [Accessed on 3 March 2026]

transformation of Lousal frequently elicits surprise and enthusiasm among these groups. University-level visitors, including researchers in geology and environmental engineering, demonstrate more specialised interests, particularly in environmental remediation and technical processes.

Immersive components in museums often highlight the tension between experiential engagement and critical contextualisation (Kidd, 2018; Løvlie et al., 2021), as well as between digital and traditional interpretive modes (Illsley et al., 2025). In Lousal, three examples illustrate this challenge. First, the introductory panel on miners' harsh working conditions in the Bottom of the Mine exhibition (2) is positioned outside the room, while the drill simulation occupies a central space. This spatial prioritisation of simulation over contextual information exemplifies what Kirshenblatt-Gimblett (1998) describes as the 'agency of display,' whereby exhibition design actively structures perception by foregrounding certain narratives while marginalising others. It poses the risk of privileging gamification over historical and social contextualisation. Second, Oliveira notes that the mine gallery simulation (Fig. 3, no 3) was intended as an 'alternative experience' for visitors who choose not to enter the Waldemar Gallery. While this raises questions about the limits of artificial experiences substituting authentic, *in-situ* engagement with mining heritage (Macdonald, 2013; Varriale et al., 2023), it also provides safer and more accessible environments for visitors with mobility constraints or claustrophobia. Third, the playground 'Mine for the Little People' engages children through role-play and interactive prompts, inviting them to *"discover, while laughing, how it is done."* Panels instruct children to put on vests and helmets, stating *"now you are ready to become a miner!"* and include statements such as *"work at the mine cannot stop!"* and *"this ore has to be well mined!."* Such framing risks a simplified and performative understanding of mining labour (Smith, 2006). The use of an authoritative tone that positions children as compliant workers raises questions about how extractivist imaginaries and capitalist-exploitative logics are normalised through play, particularly when role-play implicitly celebrates productivity and uninterrupted extraction. The playground is however complemented by the presence of science communicators, who provide context on harsh working conditions and mining histories, including women's roles in ore sorting. Together, these examples demonstrate the persistent tension between fantasy and reality in mining heritage interpretation (Illsley et al., 2025; Kidd, 2018; Macdonald, 2013), underscoring the broader challenge of balancing immersive, sensory engagement (Jelinčić et al., 2022) with critical reflection and historically grounded narratives (Illsley et al., 2025; Løvlie et al., 2021; Macdonald, 2022; Varriale et al., 2023).

4.2. Appealing to sentiments and social engagement

It is noticeable that textual communication across the complex frequently employs emotive slogans, wordplay, and affective language. We first encounter the slogan *"Exploring Science, Extracting Knowledge"* at CCVL's Atrium, which references geological terminology: 'exploration' evokes early prospecting, and 'extraction' refers to ore removal. The slogan reframes extractive practices in epistemic and positive terms by positioning knowledge itself as a resource to be mined. Also at the Atrium, the RELOUSAL panel is titled *"Building the present by inventing the future."* The slogan again articulates two interlinked processes: 'building' and 'inventing.' The former refers to the material, institutional, and managerial work aimed at rehabilitating the former mining town. The latter can be interpreted as operating at a symbolic and affective level: it frames the future as collectively co-produced and mobilises the local community through shared sentiment, belonging, and optimism. However, the shaping of that future remains largely articulated through institutional actors, with the Science Centre positioned as a central mediator. The accompanying text reinforces this affective framing by invoking collective belonging, stating that the programme involves *"several different actors of the local community,"* and concluding that *"all of us – mine owners, population, sponsors, administrators, technical professionals, and scientists – have become infected by this extraordinary place, where a culturally unique and unusually determined population lives."* A similar affective strategy is evident in the section titled 'Lousal, forever Lousal.' The panel appeals directly to emotion and memory: *"In this place these people have fed dreams and wishes, have loved and saw their children grow; have taken care of their old relatives. Can you still feel their presence?"; "This place has already been a sea and a mine, but also a home and bread for thousands of people. Today, it is future again, it is a land reinvented by the will of many people and sustained by the richest ore: Knowledge."*

This approach aligns with Smith's (2020) understanding of heritage as an emotionally charged practice. While it fosters emotional attachment and a strong sense of place, it risks abstracting social history into a generalised and romanticised narrative, treating memory as what Lambek (2003) describes as a 'romanticized object.' On the other hand, from a participatory heritage perspective, affect and emotion are not inherently problematic. Ross and Saxena's (2019) study on the participatory co-creation of archaeological heritage in Alentejo – culturally relevant given Lousal's regional context – demonstrates how creative interpretation can enhance visitor engagement while recognising affect and emotion as constitutive elements of heritage-making. Equally central to heritage co-production is the visibility of local contributions (Varriale et al., 2023), ranging in Lousal's case from providing oral testimonies to physical and manual labour, including guided tours, presentations, and the reconstruction of museum models by José de Sousa Café, an ex-miner and geological driller (active 1967–1988). At present, however, such contributions remain largely invisible, only communicated through verbal mediation upon inquiry.

In this context, the lack of engagement with social history at the exhibitions becomes more pronounced. It appears only, through photographs in the Atrium, the Mining Community section of the Mining Museum, and selected oral testimonies in the Geological Services exhibition, sites that Oliveira highlights as the most appreciated by the local community. Notably, in its original programme, APAI proposed a dedicated social history section that is yet to be realised (APAI, 1998).[14] However, discussions with Pinto indicate growing institutional awareness of this gap. Planned developments for 2026 include a new exhibition space withing the Mining Museum (9) interpreting the territory from social, geological, and environmental perspectives. Additionally, expansion intentions include the former maternity ward and health centre, which are currently abandoned and deteriorating structures, but hold significant position in local memory as sites of care and birth. Together, these intentions signal recognition of both the absence and the importance of social dimensions in interpreting Lousal's mining heritage.

4.3. Progress and extraction dependency narratives

Progress narratives are common in mining museums with a focus on science and technology, reflecting broader patterns of Authorised Heritage Discourse (Smith, 2006). While foregrounding technological advancement and development, institutional narratives often avoid or limit critical engagement with extractive histories. This approach is evident in the machinery displays at the Mining Museum and in the Home Sapiens exhibition. Moreover, in the Mining Community section, where local development and the provision of services – *"a school, a police station, medical and pharmaceutical services, a market, among others"* – are explicitly attributed to mining economy and 'the exploitation of the mine.' These framings resonate with broader scholarship noting

[14] The section was intended to cover the topics of Workers, Unions, Associations, Struggles and strikes, Housing, Leisure and culture, Diseases, Daily life in the mine, Business Administration (organisation, services, facilities, personnel, offices, other facilities) (APAI, 1998).

increasing acceptance of the socio-economic role of mining industries (Jones and Munday, 2001) and their contribution to local infrastructure and identity (Edwards and Llurdés, 1996). In the Portuguese context, mining towns were often built entirely around extraction sites, functioning as self-sufficient socio-economic systems whose identities extended beyond individual mines to encompass shared regional labour histories (Oliveira, 2015). Particularly in the Alentejo region, this model intersects with a history of economic marginalisation and structural underdevelopment, alongside political struggles and strong labour movements (Guimarães, 2001). While this context supports narratives that frame mining as a foundation of local or regional identity and as the basis of a dignified and prosperous socio-economic past, such representations risk downplaying the social injustices associated with mining in general, including labour exploitation, domestic violence, and entrenched gender inequalities, as well as its environmental impacts. This, in turn, may hinder a more critical and comprehensive understanding of extractive industries.

Discourses of national pride and strategic resources reinforce imaginaries that frame extraction as inevitable and central to development (Bridge, 2008; Glaser, 2023; Koch and Perreault, 2018). In Lousal, the Science Bath features a panel, titled 'Treasures Hidden in our Backyard' (a), that frames mineral resources as national assets. Panasqueira and Neves-Corvo are presented as 'major copper, zinc, tungsten and tin producers in Europe,' while lithium is described as a resource through which Portugal *"may become, in the near future, a major producer on a worldwide basis."* While this narrative contributes to the construction of social imaginaries aligned with national development, technological progress, and global relevance, it omits discussion of the social and environmental costs of mining, as well as the current controversies surrounding lithium extraction in Portugal (Canelas and Carvalho, 2023). These omissions are particularly striking given that extraction-related conflicts extend beyond mining to renewable energy infrastructures (Brás et al., 2024; Campos et al., 2025), where debates on land use, local resistance, and 'green grabbing' have intensified (Canelas and Carvalho, 2023). Notably, in *'Not in anyone's backyard?'*, Delicado et al. (2014) also employ the NIMBY (not in my backyard!) metaphor to describe opposition to windfarms in Portugal. However, according to Oliveira, national visitors often open these discussions during their visits, demonstrating attentiveness to current debates and concern about the need for continued mining, recognising its human and environmental risks without exhibiting sentiments of national pride. Oliveira also observes, however, a general lack of knowledge among visitors regarding geosciences and how mineral resources are embedded in everyday life, to the extent that they are surprised when visiting the Home Sapien and Bettle cars exhibitions.

In No Earth, No Beetles, the introductory panel reads: "We use things, many things, which we call "ours" and take for granted that they exist for our exclusive benefit. The house where you live, the clothes you wear, the road you walk on, the tools you use to work or the computer on which you study, the car standing outside, grandma's medicine, the bedroom window where your dreams get wings." Minerals are described as 'Earth's gifts' and 'georesources,' essential for our daily life, commenting: "what would be left without them?", as demonstrated in the display that strips Beetle cars from their components until nothing remains. As Mendonça (2020) comments, the exhibition could be simply called "without resources there is no development" (p. 43). Pinto confirmed the intention to emphasise "the unavoidable role of the mining sector in society", stating: "It is not possible to maintain our society – even if we were to regress in evolutionary terms – without mining." Similar messages are communicated to children through the Mine for the Little People playground and through gamified modules such as Ore, Mystery and Much More (e) in the Science Bath (6) that use gamification to connect metals to their applications.

Taken together, these narratives illustrate the careful curation of progress and extraction as central to both local identity and national development, yet they reveal significant interpretive asymmetries. While the socio-economic contributions and technological achievements of extractive industries are highly visible, social and environmental costs remain underrepresented. This imbalance highlights the 'agency of display' (Kirshenblatt-Gimblett, 1998) to shape visitors' perceptions selectively, reinforcing assumptions of inevitability and necessity around extraction. Left unchallenged, extractivist framings reinforce lock-in narratives and the perception that continued resource extraction is inevitable, limiting reflection on alternative socio-technical pathways.

4.4. Discussing environmental impacts

The visibly transformed landscape surrounding the complex communicates environmental costs more directly. Panels and science communicators interpret polluted lagoons, remediation areas, and altered terrain. Pinto notes that the LIFE RIBERMINE intervention area demonstrates *"how a mine can return the land it temporarily occupied with minimal ecological, environmental, and geomorphological impact."* While consistent with project objectives, this framing however risks underplaying the severity and persistence of mining-related damage. Remediation is a broad technical term that refers to correcting or rectifying environmental harm and can include different approaches such as restoration, rehabilitation, and replacement. However, full restoration and the complete reversal of pollution and landscape transformation are rarely achievable and highly costly (Favas et al., 2018). Without explicitly acknowledging these limits, visitors could assume environmental harm is manageable – and therefore acceptable.

A structural asymmetry exists: exhibitions emphasise mining dependency through textual panels, simulations, interactivity, and gamification, while environmental narratives rely on oral explanation or specific events. This reflects Frost's (2011) concept of 'incidental interpretation,' where environmental issues are addressed reactively rather than positioned as a central component of communicating mining legacies. This poses a significant risk particularly in the case of unguided visitors, who would encounter predominantly extractivist messaging with limited exposure to environmental consequences or contested dimensions. According to Oliveira, while school audiences are always accompanied by science communicators, non-school audiences – particularly families – largely choose unguided visits and rarely request audio guides. This means that 50 % of visitors navigate the site without guidance, increasing the likelihood of encountering unchallenged extractivist narratives. Pinto recognises this limitation, expressing the need *"to enrich the exhibitions in a self-sustained way* (that operate autonomously without guidance) *around the issue of a paradigm shift: from a linear production chain to a circular economy chain."*

4.5. Communicating green transitions and decarbonisation initiatives

In the No Earth, No Beetles exhibition (Fig. 4), the science communicator points to a wall-mounted puzzle that depicts everyday objects, infrastructure, and monuments – symbolising modern dependence on resources – and comments that some puzzle pieces are deliberately misplaced to signify ongoing adaptation to contemporary challenges, such as the introduction of alternative materials. Nevertheless, based on symbolism and interpretation, this communication approach is subtle and remains marginal to the exhibition's dominant message of resource indispensability. Furthermore, broader discussions on mineral futures, recycling limitations, and alternative pathways are absent, although Home Sapiens has the potential of integrating these themes into its progress narrative, thereby extending it from a historical account to a critical engagement with the present and future.

Decarbonisation is also a concern, in terms of mobility to the site, energy consumption, and communicating the carbon-intensive extraction history of the mining complex. Pinto emphasised ACCVL's involvement in educational and outreach initiatives addressing energy transition and decarbonisation through Science and Technology Week, regional fairs, school programmes, and municipal collaborations such as

the Blue Flag Project,[15] raising awareness of renewable energy, petroleum dependence, and environmental risk.

In terms of mobility, a 2017 survey found that 42.1 % of visitors arrived by private car, 29.4 % by school bus, 18.2 % by tourist coach, 6 % by public bus, and 4.3 % on foot or other modes.[16] Pinto noted that families often combine visits with other activities, reducing carbon impact, while group travel is actively encouraged, particularly evident in school visits and senior group tourism. While 43 % of visitors come from Lisbon (Pinto, 2021), no direct transportation exists. ACCVL has a protocol with CP Railways to make technical stops at Lousal, enabling direct access for organised groups. Otherwise, public transport remains limited. Broader territorial mobility, initiatives include the Iberian Pyrite Belt cycling and walking route, linking regional mining sites and incorporating interpretive sub-routes developed by the centre in collaboration with local partners.

Green transitions are also integrated into the complex itself. Pinto refers to a notable example at the Mining Museum, where solar power installation is planned to restore power production and the former powerplant, yet through renewable energy. A display panel will soon be added to provide visitors with real-time data on consumption, on-site generation, and surplus. Pinto emphasises that this intervention serves both ecological and educational purposes, demonstrating renewable energy technologies and decarbonisation in practice.

5. Conclusion

The Lousal Cultural Complex demonstrates how a former mining site can be reconfigured as a multi-layered post-extractive infrastructure in which heritage preservation, science communication, environmental rehabilitation, and tourism converge within a single institutional framework. The analysis shows that the complex mobilises multiple interpretive modes that appeal differently according to age, educational background, and visitor motivation. However, a clear asymmetry emerges between guided and unguided experiences in terms of exposure to social and environmental dimensions. Guided visits enable science communicators to introduce nuance, provide contextualisation, and address the social and environmental costs of mining more explicitly. Unguided visitors, by contrast, are more likely to encounter the site through its most visible and self-sustained narratives: technological progress, extraction dependency, and heritage valorisation.

Five key tensions emerge that are relevant for both critical reflection and future interventions in post-mining contexts. First, immersive and interactive strategies enhance engagement and make the site memorable and the experience positive, but they can also overshadow the difficult accounts of labour, inequality, and environmental damage. Second, emotive and symbolic language strengthens place attachment and collective identity but risks abstracting social history and romanticising the mining past. Third, narratives of progress, productivity, and national resources remain central to the interpretation of mining heritage, but they risk normalising and promoting extractivist logics at the expense of environmental justice. Fourth, while environmental impacts are materially evident in the landscape, their limited integration into exhibition structures risks perceiving environmental damage as a trade-off, manageable through remediation. Finally, the communication of green transition and decarbonisation is present, but it still occupies a secondary interpretive position relative to narratives of resource indispensability and require additional communicative weight to promote environmental citizenship.

These tensions shape how different audiences encounter the site and influence the takeaways of their visit. More broadly, they highlight the expanding expectations placed on mining heritage sites: to preserve the past, attract visitors, support local economies, communicate science, and engage with contemporary debates on climate change, circularity, and mineral futures. In this sense, Lousal illustrates both the potential and the limitations of repositioning mining heritage sites as platforms for environmental and societal engagement, navigating overlapping and sometimes conflicting narrative registers and modes of mediation. By combining discourse analysis with professional insights on visitor perception, this study contributes to social science debates on post-mining heritagisation by evidencing how visitor interests and curiosities – ranging from interactive exploration and technological processes to social history and environmental concerns – can reinforce, reinterpret, or challenge dominant narratives. These findings highlight the importance of integrating visitor-centred perspectives into curatorial strategies, suggesting that future interventions should not only address representational gaps, but also respond to differentiated audience expectations in order to foster more critical, inclusive, and environmentally informed engagements with extractive pasts and futures.

In addition, the case demonstrates how such sites can generate impacts beyond tourism – through the integration of art, community-based initiatives, educational programmes, and institutional partnerships – thereby fostering local belonging, intergenerational exchange, and regional activation. Moving forward, addressing the identified imbalances will require targeted curatorial shifts, including stronger integration of social history and mining-related injustices, more explicit engagement with environmental impacts and the limits of remediation, and the incorporation of circular economy perspectives and debates on mineral futures. Such developments would strengthen the capacity of the complex to support more critical, inclusive, and environmentally informed understandings of post-extractive transitions.

Funding

This research was conducted at ISCTE-CRIA as part of the EU Horizon Europe program and UK Research & Innovation funded research project ‘Petroculture's Intersection with The Cultural Heritage sector in the context of green transitions (PITCH)’ (project no 101132385).

CRediT authorship contribution statement

Mounir Sabeh Affaki: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The author reports no competing interests.

Acknowledgements

The writing of this article received support from the Centro em Rede de Investigação em Antropologia (CRIA) / IN2PAST (UIDB/04038/2025) and funding by the Horizon Europe project PITCH ‘Petroculture's Intersection with The Cultural Heritage sector in the context of green transitions (PITCH)’ (no, 101132385). The welcoming research environment provided by Associação Centro de Ciência Viva do Lousal (ACCVL) is gratefully acknowledged. The author thanks Executive Director Álvaro Pinto for his availability and openness to critical discussion, as well as Science Communicator Margarida Oliveira for facilitating access to information and sharing practical and historical knowledge and professional insights.

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[15] https://bandeiraazul.abaae.pt/ [Accessed on 3 March 2026]

[16] Campos (2018) collected questionnaires were between March and June 2017 – a year in which the site received 20,302 visitors – based on 385 respondents (227 families, 146 school groups, and 12 international visitors).

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