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ORIGINAL ARTICLE

Unveiling the Legacy of the Nineteenth Century Riotinto Mining Railway: From Historic Heritage to Thriving Tourist Attraction

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Abstract
The Riotinto mining railway is a remarkable construction. Stretching an impressive 348 km it was built between 1873 and 1875 to transport minerals from Riotinto's mining operations to the international port of Huelva. At its height in the 1950's, this monumental railway network had a fleet of 162 locomotives (mostly steam but also diesel and electric) and around 3,300 freight cars and carriages. Towards the end of the 1960's the line began to fall into disuse, and it was closed entirely in 1984. Since the establishment of the Rio Tinto Foundation in 1987, dedicated efforts have been made to preserve this invaluable railway heritage and today, the fruits of their labor can be enjoyed at the Riotinto Mining Park where tourists can ride a fully restored 22 km section of this historic rail network. The park is highly successful and has recovered strongly after the COVID-19 pandemic attracting a record 96,935 visitors in 2022. The majority of the park's tourists are from Spain but also a significant number are international (principally from Germany) highlighting the global importance of this site and the railway as a sustainable heritage tourism destination. Taking the restoration of the Riotinto mining railway as a case study, we aim to demonstrate the transformative power of the preservation and restoration of industrial heritage.

Keywords Railway · Heritage · Restoration · Tourist · Mining park

Introduction

The harnessing of steam power marked a significant technological leap forward and its advent brought about a wave of innovations in transportation and industry (Kerker 1961). A key development was the piston engine which transformed the reciprocating motion of a piston, into a rotary motion using an ingeniously simple connecting rod.

A pioneer in the development of steam power in Spain was the Navarre born Jerónimo de Ayanz y Beaumont (1553–1613). Something of a polymath, his business interests involved the oversight of more than five hundred active mines in Spain, however he had most success as an engineer and inventor. Documents in the Simancas Archive show that in 1587 alone, the king (Philip II) granted Ayanz y Beaumont 48 "privileges of invention" or patents (García Tapias 2018). Spurred by his interest in mining, Ayanz y Beaumont's most notable invention is a rudimentary steam engine for pumping water out of mines; the patent for this device was registered in 1606 (García Tapias 2018) preceding James Watt's engine by more than 150 years this places Ayanz y Beaumont among the most significant, if neglected, figures in the history of steam-engine technology. To put this in context, the earliest steam engines are usually dated to around1690, and it was not until 1769 that James Watt designed and patented what might be termed the modern steam engine Watt's first patent included numerous improvements to Newcomen's machine (Greener 2018), such as the steam jacket, oil lubrication and cylinder insulation, to maintain the high temperatures necessary for maximum efficiency and these innovations secured Watt's place in history and solidified the enduring societal impact of steam power (Wisniak 2018).

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James Watt thus laid the foundations for the application of steam to locomotion; as early as 1784, he published a memoir describing an engine he had invented to move vehicles along roads. However, there were many other advances in this technology performed by other inventors and researchers. For instance, in 1782, the American Oliver Ewans invented a high-pressure machine in which steam worked at a pressure of 3 to 4 atmospheres and was immediately released into the system (Atack 1981). In 1814, George Stephenson (Duffy 1981), who has been called the "father of locomotives", presented Lord Rawensworth, the owner of the Killingworth Colliery, where he worked as a boatswain, with a plan for a six-wheel locomotive, which was immediately built after having worked as a simple miner.

In Spain, the introduction of railways, or "iron roads" as they were initially referred to, was significantly delayed, lagging behind other nations by a quarter of a century. The emergence of mining railways coincided with a tumultuous political landscape marred by bloody civil wars, a scarcity of financial resources, and a lack of interest from private investors, leading to the neglect of the country's vast mining wealth (Martí-Romero et al. 2021). However, the Spanish government's facilitation of foreign investment swiftly triggered a massive influx of European capital (Monge-Ganuzas 2023). In the case of Huelva, the exploitation of its pyrite reserves was spearheaded principally by British investors, with French and Belgian investors following from a distance (Avery 1974). The pressing need to transport the extracted ore to the seaports gave rise to a network of narrow-gauge railway lines, financed by foreign investors and, initially, laid exclusively to provide mining operations with these vital transport links (Dávila et al. 2018).

The influx of foreign capital to Huelva's mines began in 1727, when Wolters restarted operations at the Riotinto mines. From the 1850's however, these same investors turned their attention to the southwestern region of the Iberian Peninsula, specifically the Iberian Pyrite Belt. The prosperity achieved by these pioneering ventures inspired numerous companies to establish a presence in these regions. Spain's belated industrial development prompted foreign enterprises to seek fresh sources of raw materials, effectively giving rise to what some authors (Fourneau 1983) aptly describe as the semi-colonization of the province of Huelva. However, the advancement of mining on an industrial scale necessitated modern techniques, including the implementation of an efficient transport system aligned with this vision. This entailed establishing an extensive network of railway lines to facilitate the transportation of such valuable commodities to the port.

In recent years, restored mining and railway heritage has proved its potential as a draw for tourists (Oktay Vehbi et al. 2022). Furthermore, mining activity and the transportation of minerals has left a legacy of soil pollution (Gallego and Fernández-Caliani 2023), thus, the transformation of disused mining railways into tourist attractions is key to the regeneration of ex-industrial sites, particularly in terms of environmental remediation.

This research has two main objectives: on the one hand, recovering the historical background of the Rio Tinto mining railway, its history and mining legacy. On the other hand, describing how this can be rehabilitated into a tourist attraction, being important as an example of restoration of these railways to give them a second life.

Research Methods

This research is presented in three methodically distinct sections. The first provides a comprehensive overview of the Riotinto Mining Railway's role in the provincial landscape, tracing its historical development and eventual abandonment. The second section focuses on the process of transforming the railway into a vibrant tourist destination, with particular attention to the restoration of railway carriages and infrastructure, and the preservation of industrial heritage structures, including the stations and whistle-stops along the tourist train route. Key historical data for this section were obtained primarily from the Rafael Benjumea Historical Mining Archive.[1] The second section also incorporates insights from relevant literature concerning Huelva's railway history (Romero 2007; Delgado 2006, 2007, 2009) and is enriched by personal narratives from residents, whose accounts were corroborated with existing records.

The third and final section presents an evaluation of the Riotinto mining railway's appeal and impact as a tourist attraction. In this analysis various dimensions are considered, such as how the number of visitors has grown since the mining park's inauguration in 1994 until 2022; the demographic profile of visitors including their nationalities and, in the case of Spanish tourists, which regions and autonomous communities they come from. The dataset for this analysis was generously provided by the Riotinto Mining Park Museum.

Heritage of the Rio Tinto Mining Railway

The creation of the Río Tinto Company Limited signaled the arrival of a railway that was both a profitable and efficient link between the mining area and the Huelva port, from which the minerals departed towards international markets

[1] This organization is recognized by the Spanish government and was formerly known as the Historical Mining Archive of the Rio Tinto Foundation.

(Pinedo-Vara 1963). This method of transportation symbolized the arrival of the Industrial Revolution, contributing to improved economy and social conditions for the inhabitants of the mining district.

Construction on the railway network began on June 11, 1873, just six weeks after Río Tinto Company Limited was incorporated. As it was expedient to finish as soon as possible, work started in five different sections. It finalized on July 28, 1875, when the first train left Huelva for Riotinto, three months ahead of schedule, with a reduced cost of 767,190 £ (García-Mateo 2000).

The trajectory was planned and supervised by arguably the nineteenth century's finest engineer. Sir George Barclay Bruce designed an 83,524 km. narrow-gauge railway, also known as the "main line," linking Riotinto with the Huelva port, as well as 264 km of branch lines joining the workshops, storage tanks, gorges, and mining villages, which were part of the most singular narrow-gauge railway line worldwide between the end of the nineteenth century and the beginning of 20th. The railway was built by Clark & Punchard (Allen and Wheeler 1987).

Its platform rises from the banks of the Tinto River at sea level in Huelva, reaching the Rio Tinto Station at 320 m, with an average inclination of 1.176% and a maximum of 2% (Sewell 1991). It follows the river along its right side in a circuitous route through trenches bordering the jagged, high mountains of Eastern Andévalo, while other segments cross the river. On occasions, it goes through tunnels built to reach other sections. In total, eight bridges and five tunnels were built. Twelve stations were erected along the railway to regulate the traffic of merchandise. The main line ended at Huelva; a platform was built to allow the trains to load and unload their merchandise directly onto the moored boats (Delgado et al. 2007a).

The railway was not only used for transporting minerals from Riotinto to Huelva but was also fundamental in the direct mining of various veins and pits. Two were built: No. 11, a steam locomotive, and No. 16, using electrical power; the locomotives pulled 10 ten-ton cars from the grinding to the concentration plant, where the pulverized, powdered mineral was sent directly to Huelva (Perejil-Delay 1998). This was then taken to the Tinto platform, where it was exported to points around the globe. All the abovementioned processes were carried out using the railway.

The Río Tinto Railway's branch lines connected the different villages comprising the Riotinto Mining basin, as well as transporting passengers and workers to the capital of the province. The railway was used to move workers and passengers until 1968, when a bus service began (Delgado et al. 2007b).

The trains also moved perishable goods throughout the mining area, such as vegetables and fish, which until then could only be consumed in dried or salted forms. The company built Talleres Huelva wagons for this task, and some cars included refrigerators, which lowered the price of these products and improved the quality of life of the area's inhabitants.

Thanks to the busy traffic of the Rio Tinto Railway, a great number of cars were acquired, making the collection Spain's second most important. At its peak, there were 147 steam engines, nine hydraulic diesel and twenty-one electric locomotives, and one running on compressed air. A total of 1,300 different types of train cars and 2,000 mining cars were utilized to transport the materials. Thirty-six cars were used for transporting passengers and were divided into two classes: First Class, for management, and Third Class, to be used by workers and other travelers (Pérez-López 2000).

The railway functioned throughout the time that the mines were under the ownership of the Riotinto Company Limited, and it continued to run even after 1954, when Spanish proprietors took over (García-Gómez and Pérez-Cebada 2020). Its decline began after 1964, when a new industrial area, the Polo Químico, was built in Huelva and the export of minerals to Britain ceased. These two factors made road transport a far more cost-effective solution (Muller 2020).

In 1975, the Rio Tinto dock ceased its operations; the railway began transporting the minerals from the mining area to the las Mallas station (Niebla). Its final journey took place on February 8, 1984: a BoBo 911 locomotive travelled from Las Mallas (Niebla) to Riotinto. This signaled the end of the 109 years of the Riotinto Mining Railway, during which time it is estimated that 130 million metric tons of minerals were transported (Romero 2007).

Tourist Mining Railway: The Renaissance of the Rio Tinto Railway

After it was shut down, both the railways and the train cars were vandalized. Many track sections were dismantled and found to be used as construction beams. The cross members are often employed in enclosures and gates, while parts of the bridges' metallic elements have been removed to be used as scrap. The cars were also ravaged. Therefore, perhaps those who benefitted the most from the old railway were the area's junkmen (Fig. 1, Rowcroft 1935).

Despite being abandoned for many years, in 1973, the Explosivos Río Tinto S.A. Company created a Railway Museum in one of the Locomotive Deposit rooms to commemorate its 100th anniversary. Several elements from the car deposit as well as auxiliary railway elements are kept there. Despite this first conservation attempt, the railway items suffered the deterioration of time and the effects of the looters until 1987, when Río Tinto Minera S.A. created the Río Tinto Foundation for the Study of Mining and Metallurgy, which was the starting point for recuperating,

Fig. 1 A Garrat Locomotive (No. 145). These engines were used to pull type M trains during the mid-twentieth century (Rowcroft 1935)

conserving, and getting publicity for the Mining Railway. In keeping with this goal, the Rio Tinto Foundation has devoted itself to recuperating railway elements and portions of the track. Thanks to these efforts, on November 4, 1994, the tourist mining railway commenced operations: first with diesel traction, and three years later, steam power reached the Frailes station on February 13, 1997. The Riotinto Mining Park has two of the oldest functioning steam engines in Spain: locomotive No.14, type C dating back to 1875 (Fig. 2), and No.51, type I, dated 1883 (Delgado 2006).

The Rio Tinto Foundation has carried out work in three areas: rail cars, railway infrastructure, and auxiliary railway elements.

Rail Cars

When the Río Tinto Foundation was formed in 1987 by Río Tinto Minera S.A., it included the items that had been in the Railway Museum created in 1973. This was made up of seventeen locomotives, of which nine were steam, six were diesel, and two were electric. A fleet of over a hundred units was moved, including passenger cars, vans, steam-powered cranes, animal-drawn cranes, and other types (Delgado 2007). All the abovementioned items had to be cleaned, refurbished, and moved to the site. This activity has been an ongoing project of the institution since the end of the 1980's, with two goals: exhibition and receiving orders to run.

Fleet on Display

The museum has two rooms dedicated to the mining railway, rooms 12 and 14, housing a range of locomotives and carriages including the Maharaja's carriage, the most luxurious narrow-gauge passenger rail carriage in the world. Other items in the collection are locomotive No.106, a No. locomotive No.150 (see Fig. 3), and a P-type electric locomotive (See Fig. 3).

Fleet Preparation

To open the tourist railway line, a fleet of rolling-stock was selected and restored. Work began in 1980 and restoration efforts were concentrated on diesel locomotives No. 931 and No. 932 (see Fig. 4), as these engines were in the best condition. These engines were the first to being operating when the Mining Tourist Railway was inaugurated at the end of 1994.

Restoration work continued and early in 1997, steam locomotive No. 51, originally built in 1883, was ready for service shortly followed (in 2002) by locomotive No. 14, built in 1875. These locomotives are recognized as the oldest working steam engines in Spain.

Many historic locomotives remain to be rehabilitated and the restoration project is ongoing. Currently, work is focused on a Billard No. 941, a Garrat No. 146, and a Class 200 No. 204 (Delgado 2006). This long-term commitment to restoring and maintaining these locomotives not only concerns the preservation of an essential aspect of Spain's industrial

Fig. 2 A type C steam locomotive (No. 14), built in 1875, about to depart the Mining Railway Museum. It is the oldest functioning example of its type in Spain

Fig. 3 Left, Locomotive No. 150, on display in room No. 14 of the Riotinto Mining Museum. Right: P-type electric locomotive displayed in room No. 12 of the Riotinto Mining Museum

Fig. 4 Diesel locomotive No. 932, restored to full operation and stationed in the depot

Fig. 5 The Maharaja's carriage: the first passenger carriage on the mining railway (room No. 14, Riotinto Mining Museum)

heritage but also to the future survival of the railway as an educational and tourist resource.

Towed Fleet: Passenger Classes

The nineteenth century society was clearly remarked by social classes. When we speak about late 19th and early twentieth century social classes and means of transport, an illustrious example to imagine is the unfortunate RMS Titanic transatlantic. Indeed, it belonged to a similar time as the Rio Tinto mining and operated under British culture. The Rio Tinto Foundation has only three passenger cars: one first-class (Fig. 5) and two third-class forty-one models (Fig. 6). These cars were not in a very good state of conservation because the transit of passengers ceased in 1968, when most of these trains were scrapped. Transporting travelers was one of the secondary uses of the Rio Tinto Mining Railway. When the consortium, which was largely British, bought the mines, the Spanish government included a clause making it obligatory for the company to transport travelers on a certain number of trains. This was initially not regulated, leading to protests until September 1895, when transporting people became authorized.

This train had two main trajectories for transporting people. One of these connected the Riotinto Mining basin with Huelva, while the other was a service transporting workers from villages and mining towns to their places of work and back again. Two lines were built: the first line joined Zalamea la Real to the Río Tinto Station. The second linked Nerva with the village of Rio Tinto. In 1908, company management reclassified the existing passenger trains to third- and first-class cars; the second-class car was upgraded to first class. As highways improved during the thirties, fewer passengers took the trains. The number of passenger trains continued to decline until 1968, when, due to their lack of profitability they were replaced by a bus service.

In 1987, the three remaining passenger cars became part of the Rio Tinto Foundation. The Maharaja's carriage built by the Birmingham Railway Carriage & Wagon Co. in 1892, is considered to be the most luxurious narrow-gauge car in the world. In 1991, it was moved to the Riotinto Mining

Fig. 6 Left, construction of a covered car on an F1-type platform. Right, moving an electric locomotive into the museum

Museum, where it was restored, and it is currently on display in room No. 14.

To start up the Tourist Mining Railway, it was important to have a train capable of transporting passengers. Thus, the auxiliary "F" type car was set up in order, with fifty seats, as well as the third-class, 64-seat J3-type passenger train, built in 1914 by Construcciones Metálicas Beasaín. Apart from the F1 platforms, two cars were built based on the original J3 diagrams: one covered and one open-air car, both with sixty-four seats, bringing the current maximum capacity for the Mining Tourism Railway to 242. Using the F1 platform, in 2000 and 2008, two auxiliary cars were built, with characteristics similar to open J3.

Railway Infrastructure

Since the Rio Tinto Foundation was created in 1987, plans were made to restore the Mining Museum to comply with the entity's basic goals. Therefore, apart from restoring the train cars, work began on recuperating the railway infrastructure necessary for them to run. The first project started the mining railway for tourism in 1990, but due to the initial cost and the fact that it needed altering the original path, a second project was designed in 1993, which was instrumental in the establishment of the tourist mining railway (Delgado 2009). There were four parts to the plan for reestablishing the railway: Phase 1) Mine workshops – Zarandas (5 km). Phase 2) Zarandas – Los Frailes (10 km). Phase 3) Los Frailes – El Manzano (7 km). Phase 4) El Manzano – Manantiales (17 km). Phases I and II are now finished in 2023, while Phase III should be underway shortly. The current full that is constructed (Phases 1 and Phases 2) is shown in Fig. 7.

Stations and Whistle Stops

After the railway closed, vandalism and looting left most of the stations and other buildings along its route in a state of disrepair. Indeed, the locomotive depot in Zarandas, was one of the few structures that retained its structural integrity.

Thus, recommissioning the railway not only required the restoration of the tracks but also the reconstruction of its stations and whistlestops, one of which is shown in Fig. 8. The line's original starting point, Riotinto station, had been demolished due to ongoing mining activities and as a result, the mine workshop was chosen as the location of the tourist railway's first stop. The new station was designed in an architectural style consistent with the era in which the railway was first built by its British investors, as discussed by Dávila et al. (2018). This approach has ensured that the railway's new structures resonate with the historical aesthetics of the region's industrial heritage.

Once the railway's first new stations had been built, attention was directed towards establishing a further station in Zarandas. This station, shown in Fig. 9, is strategically positioned adjacent to the depot where the renovation of locomotives takes place. As with the other stations on the line, care has been taken to ensure its architectural style is in keeping with the railway's history, in this way, Zarandas station features a fully covered platform typical of the British-designed stations of the Riotinto Mining Railway's heyday.

The tourist railway line terminates at Los Frailes which was also the last station to be refurbished (Fig. 10). Besides the restoration of the building itself, the grounds also received significant attention; the wrought iron fencing was repaired, and a garden laid consistent with the historical period. In addition, the station signage was restored using the same font and color scheme as for all the other stations on the main line. Certain modern upgrades were also implemented: a covered 40-m-long 1.5 m-wide platform was added, and the station's electricity is provided by means of photovoltaic panels. For the comfort of visitors, the station also has a sheltered picnic area.

Signals, Railway Changes, and Auxiliary Railway Infrastructure

Signals are key elements allowing for circulation in safe and normal circumstances. Therefore, from 1879 onwards, these were placed all along the main lines, as well as the

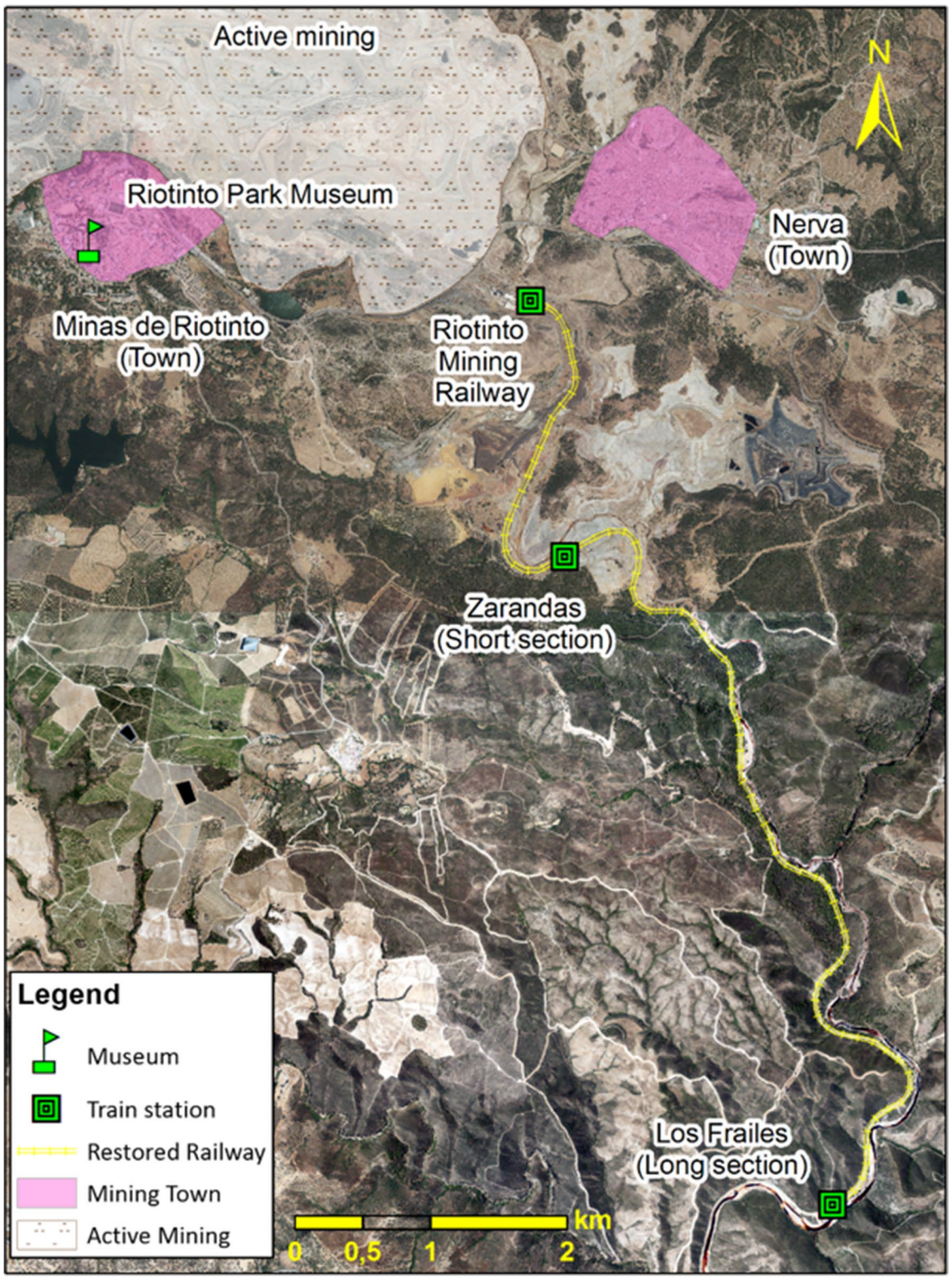

Fig. 7 Map showing the current route of the tourist railway, the location of the stations, the museum, the main town, and current active mining operations

Fig. 8 Mine Workshops Station

Traffic on the railway line was quite heavy, and therefore, at certain junctions, especially the Riotinto beaches, signals were installed (e.g., the Naya signal box, Fig. 11), controlling up to 50 and 60 blocks. Three more signal boxes were located on the restored section of the train line: the North, South, and the Los Frailes signals. When the restoration project began, all these buildings were in a state of near ruin, both structurally and in terms of their signaling mechanisms. On the single-direction general track, a track-blocking system was implemented using "Powles & Moore" devices colloquially known as "cane columns" (several of which are on display at the Riotinto Mining Museum) due to their “pilot cane" blocking mechanism (see Fig. 12).

The remaining elements used for switching lines were eroded by the passing of time, as well as the looting and vandalism to which they were subjected. Much of the railway’s signaling system was nearly destroyed, as was its auxiliary infrastructure, such as water tanks and coal pits.

Fig. 9 Zarandas Station (present day)

Fig. 10 Los Frailes Station

rest of the railway and provisional sections. Mounted on Stevens & Co posts, signals were normally grouped together, forming porticos. During the mid-sixties, colored light signals were installed, mainly directly on the posts.

Fig. 11 The North (Naya) signal house, completely restored, including its iconic Steven's and Sons-designed lever frame

Fig. 12 Manual switch stand used on the railway

Fig. 13 Workshops turntable before restoration

The work carried out to rehabilitate the railway included replacing all the crossways along the restored section, and in cases where original replacements could not be found, substitutes were made. Of the three block houses, two have been restored: the North and Los Frailes are finished, while the South/Marin house is a project underway.

At the tourist railway's reception center and starting point, an eighteen-meter diameter turntable and 200 m dual-track enables the seamless reversal of locomotives (Fig. 13). A manually operated switch system allows access to the main track. This design mirrors the configuration at the Los Frailes' terminus.

Besides the replacement of trackside signaling, it was also necessary to replace the lamps positioned along the line (Fig. 14-left) for use by train engineers as well as those used to light other areas near the trackside (Fig. 13). Replicas of the electric signal lights in use in the 1960's were also made and are in use in all the stations along the tourist railway line.

Moreover, a metallic structure was built at the Los Frailes Station to be used as a crossing over the tracks to get from the platform to the banks of the Rio Tinto. A sign portico was placed there, reproducing those used by the Rio Tinto Railway. Furthermore, a water deposit was built at the Railway Reception Center for use by the steam locomotives; it is three cubic meters in size, has a spout mounted on a metal platform, with welded laminated edges, and is set into the ground with reinforced concrete plates. The original water deposit was replaced in Zarandas, and the original spout was replaced by a reproduction (Fig. 14-right). Last, another water deposit was built next to the Los Frailes Station using runoff from the El Madroño (Seville) fountain. Finally, a coal bunker was in service at Zarandas for use by the steam trains; a gasoil deposit was also built for the diesel locomotives (Delgado et al. 2010).

Fig. 14 Left) Electric lamp reproductions near Zarandas Station; vertical lights and crossing lights are also evident. Right) Zarandas water pump (reproduction)

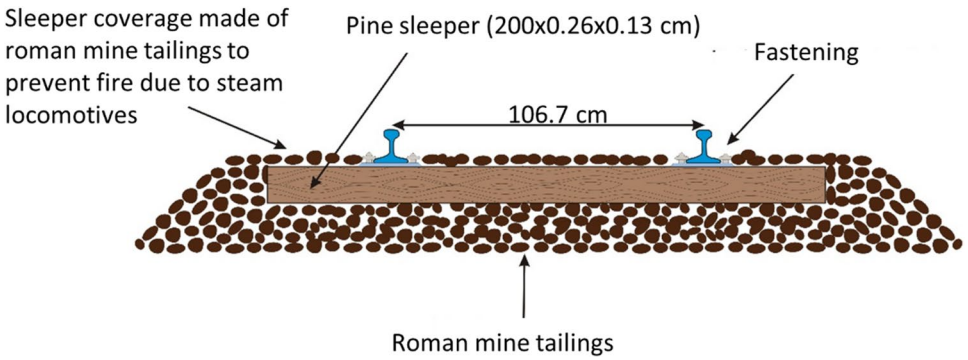

Fig. 15 Sketch showing the section of the railway track. Modified from Delgado 2009

Track

The track had suffered the ravages of time and vandalism after it was closed in 1984; it also fell victim to a lack of maintenance, as it was considered an infrastructure devoted to supply and demand. The rails were extracted and sold for scrap or reused as construction beams. This mainly affected the straight sections of the railway. These splice bars were removed for a variety of uses, although they are widely employed for building fences in small gardens. The tie screws and base plates were sold off as scrap metal.

Thanks to all the work undertaken by the Rio Tinto Foundation starting in 1987, 11 km of railway have been recovered between the Railway Reception Center and the Los Frailes Station. This took place in stages: the first section was between the Railway Reception Center and Zarandas, followed by Zarandas-Jaramar, and finally from Jaramar to Los Frailes.

The section of the track can be seen in Fig. 15. The following is a breakdown of the work that was carried out to get the railway running. First, the tracks were removed down to their cross members to check the state they were in. If they were in good condition, they were put back, and if not, they were then stripped down to the support system and substituted by another creosoted cross member measuring $2 \times 0.25 \times 0.13$ m, since all the repairs and renewal were performed while maintaining the original characteristics. After this step, rails with abnormal bases were substituted to avoid future accidents. Then, new rails were placed (when necessary) on the installed metal tie bars. The rails were placed using tie screws that joined them with screwed-down join bars. The track was braced using screwed metal braces three meters apart. The track was levelled and then covered with ballast with particle size ranging from 300 to 600 nm. Lateral drains were repaired along the platform to avoid flooding.

Auxiliary Elements

When the Río Tinto Foundation was created, all the auxiliary railroad elements from the Río Tinto Mines were included in the assets it took over; most of these belonged to the Railway Museum created by ERT in 1973. These pieces were moved to the Riotinto Mining Museum (Fig. 16), where they were classified, catalogued, and restored when necessary. The institution was the base for this industrial archaeology collection. This is all on display in room No. 11 of the railway department.

The Mining Railway as a Tourist Attraction

Successes and Set-Backs

Figure 17 shows the annual visitor count at the Riotinto tourist mining railway since its inauguration in 1994. While there is an overall upwards trend in visitor numbers over the years, there are also occasional reversals and jumps in this trend reflecting various milestone events in the site's recent history.

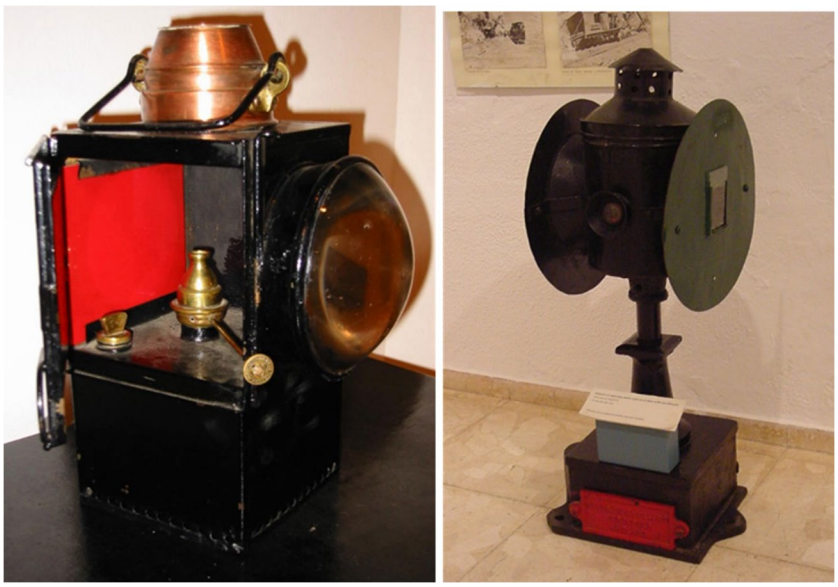

Fig. 16 Auxiliary railway elements. Room No. 11

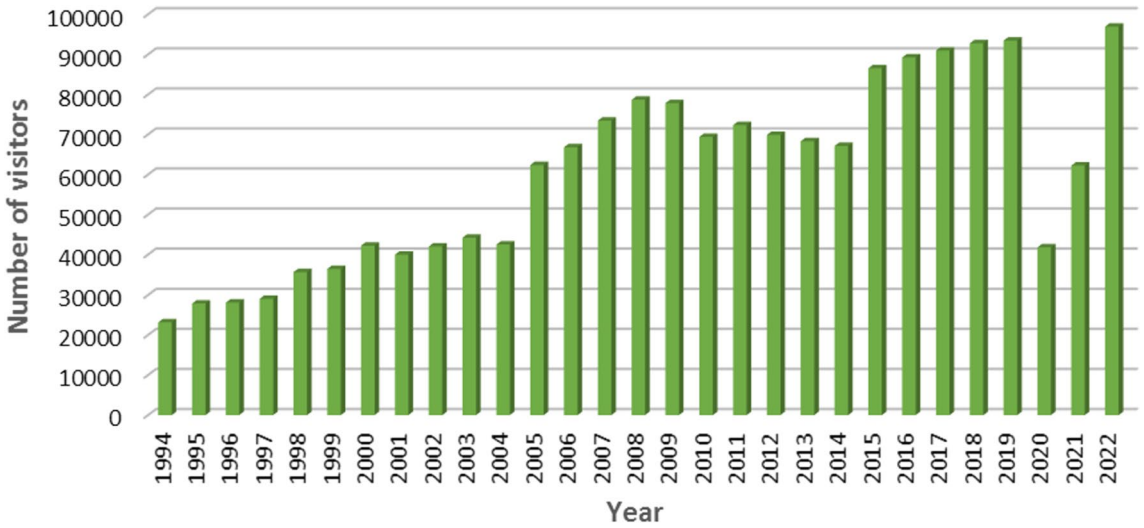

Fig. 17 Annual number of visitors to the tourist mining railway (1994–2022)

Tourist numbers increased steadily during the initial phase (1994–2001) shortly after the mining park was opened reaching a peak of 42,000 visitors; however, following the closure of the mine in 2001, the railway experienced a plateau in tourism, recording an average of approximately 40,000 visitors per year until 2004. In 2005 the Riotinto Mining Basin was declared a Cultural Heritage Site, and this year shows a marked leap in tourist numbers (50%) to approximately 60,000. Numbers reached almost 79,000 by 2008 but after this they begin to decline again until 2014.

In 2014, the Cypriot company Atalaya Mining reopened operations in the Riotinto mining district causing another surge in tourism. Since then, visitor numbers have consistently exceeded 80,000 per year, except in 2020 and 2021, when global travel was curtailed because of the COVID-19 pandemic. Despite this brief dip, a record high of 96,935 visitors was recorded in 2022.

Further evidence of the popularity of the mining railway as a tourist attraction comes from its visitor ratings. The railway's average rating on Google (n.d.) is 4.6 out of 5 stars and on TripAdvisor (n.d.) it is 4.5 out of 5 stars. The trend in visitor numbers and the attraction' star ratings demonstrate the Riotinto mining railway not only has wide appeal but is also a sustainable destination.

Figure 18 provides a breakdown of the site's visitor demographics. It is striking that most visitors to the tourist railway are from Spain (80%) with the overwhelming majority of these (41%) coming from Andalusia, the autonomous

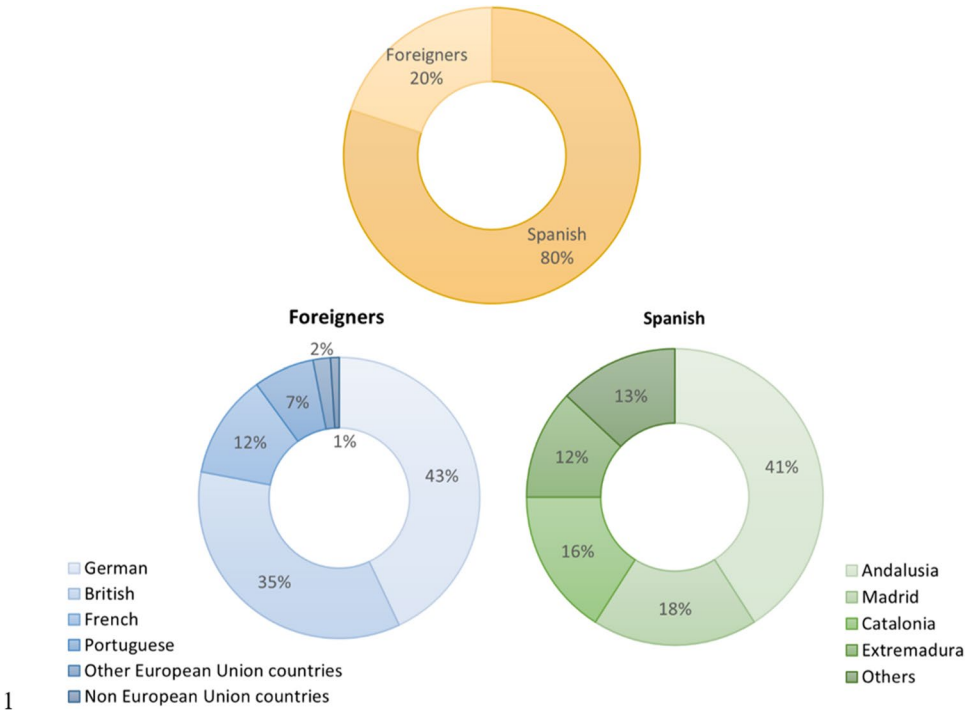

Fig. 18 Origin of visitors of the Riotinto Mining Railway

community in which Huelva is located. Tourists from the Autonomous Community of Madrid (18%) and Catalonia (16%) are also well represented which is not surprising since these regions contain Spain's largest cities. In addition, 13% of visitors come from the neighboring region of Extremadura.

The remaining 20% of the tourist population is international visitors, the majority being Germans (43%), followed by tourists from the UK (35%), France (12%) and Portugal (7%). Only 3% of visitors worldwide come from other countries. These figures suggest that factors such as proximity, population size and economic capacity are important influences on the site's visitor profile: the largest proportions of visitors to the mining railway—both those from Spain and internationally—living closest to the site, being from more populous and/or wealthier regions or countries.

Impressive not only for its 12 km of track and restored rolling stock but for the unique ecosystem in which it is set making it a genuine showcase for landscapes shaped by human activity. However, while the mining railway is a major attraction, it is only one of many on offer at the Riotinto Mining Park. The park's varied and extensive facilities include the largest museum in Spain dedicated to a local history of mining. Furthermore, visitors to the park have the opportunity to explore the mining installations at Peña de Hierro, demonstrating both underground and open-cast mining techniques. In addition, House 21 in the English neighborhood of Bella Vista offers insight into the lifestyle of the British community that managed Riotinto for 80 years. Nevertheless, there is no doubt that the mining railway is the jewel in the crown; in fact, 80% of the mining park's annual visitors rate the railway as their favorite attraction.

The railway runs almost daily, closing only on the 25th of December, the 1st and 6th of January. During peak periods such as the Easter and Christmas holidays, the timetable includes up to five daily departures.

The park has a fleet of five locomotives—three diesel and two steam—and six passenger carriages. On the first Sunday of every month between April and September, the mining railway's oldest locomotives—oldest working locomotives in Spain—take passengers up and down the line providing a unique attraction for railway enthusiasts. In addition, the passenger carriages are also worthy of note. At present there are six carriages on the line the last of which was built in the Riotinto Foundation's workshops from original plans dating back to 1914 and inaugurated at the beginning of 2018. All these features contribute to the railway's ongoing popularity and have helped secure Riotinto Mining Park's place in Spain's industrial and railway history and its pre-eminence as a major heritage tourist site.

Future Prospects of the Riotinto Mining Park

To enhance the tourist experience, the Riotinto Mining Park recently introduced a night tour onto the tourist train timetable. The so-called "Moon Train" (Fig. 19) operates only during the summer on weekends that coincide with the full moon. This strategic scheduling provides travelers with a unique experience: passengers witness the

Fig. 19 The Moon Train

dramatic chromatic shifts across the mining basin as their outward trip is timed for sunset while the return trip is by moonlight. This splendid natural lightshow gives visitors a new perspective on the landscape encouraging return visits to the site.

The round-trip takes approximately 140 min including a short stopover at the Los Frailes terminus. This break in the trip allows visitors the opportunity to walk down to the river, take photographs, and enjoy some refreshments. Additionally, at moonrise, a bar service is provided in the station's picnic area and there is live music.

The Moon Train was launched in July of 2020 and the opportunity to see mining basin's stunning landscape by night has proved extremely popular: all with all over 1,300 passengers bought tickets meaning that services were fully booked. This overwhelming response prompted an expansion of the schedule, and it now runs from June to September.

Conclusion

Thanks to Río Tinto Foundation's work restoring the railway heritage over the past twenty years, 35% of the locomotives were running again, while 17.6% were restored for display. Another 17.6% are currently being restored, with the remaining 29.4% awaiting their turn. Of the passenger fleet, 70% are now in good working order. A total of 11.8% of the track has been restored, making it possible to open the Tourist Mining Train on November 4, 1994. At this early-stage diesel locomotives were used, and the track went from the Mine Workshops to Zarandas; however, less than three years later, in 1997, the track had been restored as far as Los Frailes Station and steam locomotives were running.

The restoration work carried out at the mining park by the Río Tinto Foundation has been recognized in several national and international awards, such as the 1998 Henry Ford and the 2003 Europa Nostra awards and gained the site status as a Cultural Heritage Site in 2005. In this way, the Riotinto Mining Museum and Park, born from the Riotinto Mining Railway, should be considered a significant example of industrial heritage. In 2022, it attracted almost 100,000 visitors, of which 80% were domestic (Spanish) tourists and the feedback from these visitors is overwhelmingly positive both on Google (4.6 out of 5 stars) and TripAdvisor (4.5 out of 5 stars).

The Riotinto Mining Park & Tourist Railway is a prominent example of the potential of our industrial past to contribute positively to our cultural present and its restoration could provide a template for other such ex-industrial sites across the world. The careful restoration and contextualization of their historical significance can transform these sites into sustainable tourist attractions providing education and fun in equal measure. In addition, as sustainable attractions they stimulate local economic development, help preserve local identity, and contribute to environmental remediation. These multiple impacts underscore the importance of preserving and repurposing historic infrastructure for contemporary use.

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References

Allen P, Wheeler R (1987) Steam on the Sierra. Aldaba Ediciones

Archivo Histórico Minero Rafael Benjumea [Rafael Benjumea Historical Mining Archive] (2023) Physical location at Minas de Riotinto, Huelva, Spain

Atack J (1981) Oliver Evans. inventive genius of the american industrial revolution. by Eugene S. Ferguson. Greenville, Delaware: Hagley Museum, 1980. pp. 72. $4.95. J. Econ Hist 41:693–693. https://doi.org/10.1017/S0022050700044612

Avery D (1974) Not on Queen Victoria´s Birthday. The Story of the Río Tinto Mine, London

Dávila JM, Melgar SG, Fortes JC, Castilla J, Sarmiento AM (2018) The abandonment of mining facilities in the iberian pyrite belt. constructive analysis of the tharsis line railway stations. Int Multidiscip Sci GeoConference Surv Geol Mining Ecol Manag, SGM 18(54):563–570. https://doi.org/10.5593/sgem2018/5.4/S23.072

Delgado A (2006) Catálogo del Museo Minero de Riotinto. Sevilla. Legal Deposit: SE-4029-06

Delgado A (2009) Ferrocarril Turístico Minero. Huelva. Pasos

Delgado A (2007) El Parque Minero de Riotinto. In Fernández Rubio. R. (Ed.), Activos Ambientales de la Minería Española 117–127. Madrid

Delgado A, Campos A, Fiñana FJ (2007a) Recuperación del Patrimonio Ferroviario llevado a cabo por Fundación Río Tinto, Cuenca Minera de Riotinto (Huelva). De Re Metallica 8 19–28. Madrid

Delgado A, Campos A, Fiñana FJ (2007b) El Ferrocarril Turístico de Río Tinto. Carril n° 65: 3–19. Barcelona

Delgado A, Campos A, Regalado MC, Lorenzo JP (2010) Material diesel del Fc. Turístico Minero de Riotinto. Vía Libre n 538: 69–73. Madrid

Duffy MC (1981) George Stephenson and the introduction of rolled railway rail. J Mech Work Technol 5:309–342. https://doi.org/10.1016/0378-3804(81)90046-2

Fourneau F (1983) La provincia de Huelva y los problemas del desarrollo regional. Diputación provincial. Huelva

Gallego L, Fernández-Caliani JC (2023) Pyrite ore cargo spills as a source of soil pollution and ecological risk along the abandoned railway corridors of the tharsis and Rio Tinto mines (spain). Environ Monit Assess 195:97. https://doi.org/10.1007/s10661-022-10715-3

García Tapia N (2018) Jerónimo de Ayanz y Beaumont: un inventor navarro (1553–1613). Universidad Publica de Navarra

García-Gómez JJ, Pérez-Cebada JD (2020) A socio-environmental history of a copper mining company: Rio-Tinto company limited (1874–1930). Sustainability 12:4521. https://doi.org/10.3390/su12114521

García-Mateo JL (2000) El material Móvil del Ferrocarril de Río Tinto. Consejería de Cultura Junta de Andalucía

Google (n.d.) Parque Minero de Riotinto. Retrieved December 12, 2023, from https://www.google.com/travel/hotels/s/maYrZkjpyAQ6KBQs6

Greener J (2018) The first and third engines. Int J Hist Eng Technol 88:80–111. https://doi.org/10.1080/17581206.2018.152588

Kerker M (1961) Science and the steam engine. Technol Cult 2:381. https://doi.org/10.2307/3100893

Martí-Romero J, San-José A, Martí-Henneberg J (2021) The radiality of the railway network in Spain during its early stages (1830–67): an assessment of its territorial coherence. Soc Sci Hist 45:363–389. https://doi.org/10.1017/ssh.2021.3

Monge-Ganuzas M (2023) Geoconservation in Spain: history, legislation, and future challenges. Geoheritage 15:95. https://doi.org/10.1007/s12371-023-00864-3

Muller S (2020) Autonomous trains in freight transport: should the railway not have the advantage over the trucks? WIT Transactions on the Built Environment 199:3–14. https://doi.org/10.2495/CR200011

Oktay Vehbi B, Mısırlısoy D, Günçe K, Yüceer H (2022) The tourism potential of postmining heritage sites: the Cyprus mining cooperation in Lefka. Cyprus Geoheritage 14:58. https://doi.org/10.1007/s12371-022-00697-6

Perejil-Delay A (1998) Ferrocarriles mineros de la provincia de Huelva. Railway friends association "Cuenca Minera de Riotinto", Huelva, Spain

Pérez-López JM (2000) El Ferrocarril Minero de Río Tinto. In XXXVII Congreso de la federación española de asociaciones de Amigos del ferrocarril (Conference Presentation). Huelva

Pinedo-Vara I (1963) Piritas de Huelva, su historia, su minería y su, aprovechamiento. SUMA, Madrid, Spain

Romero E (2007) Los Ferrocarriles en la provincia de Huelva. Un recorrido por el pasado. Ed. Universidad de Huelva

Rowcroft C (1935) Catálogo del Museo Minero de Riotinto. Huelva, Spain

Sewell A (1991) The Río Tinto Railway. Brighton

Tripadvisor (n.d.) Parque Minero de Riotinto. Retrieved December 12, 2023, from https://www.tripadvisor.es/Attraction_Review-g2393845-d4444237-Reviews-Parque_Minero_RioTinto-Minas_de_Riotinto_Province_of_Huelva_Andalucia.html

Wisniak J (2018) James watt the steam engine. Educ Química 18:323. https://doi.org/10.22201/fq.18708404e.2007.4.65879