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Conservation and promotion of the Coal Mining Heritage as Europe's cultural legacy

Deliverable 4.2

Visual Map Journal based on geospatial data and attribute data

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Table of Contents

Table of Figures

List of tables

EXECUTIVE SUMMARY

Deliverable D4.2 presents the development and implementation of the European Visual Map Journal (EVMJ), an interactive digital storytelling platform designed to showcase Europe's coal mining heritage. Built upon the harmonised geospatial and multimedia datasets compiled in D4.1, the EVMJ integrates maps, photographs, videos, narratives, and 3D models into an immersive user experience accessible through ArcGIS Online.

The methodology adopted includes a comprehensive data harmonisation and validation process, the design of national feature datasets, and the technical transformation of 2D and 3D data into web-compatible formats. Each participating country—France, Germany, Greece, Poland, and Slovenia—contributed thematically curated content highlighting key coal heritage sites, integrated into a structured digital itinerary.

Special emphasis is placed on public engagement through the concept of microadventures, encouraging users to explore heritage landscapes both virtually and in-person. The publication of 3D models and spatial data also enables use in educational and interpretive contexts, supporting the project's goals of awareness and sustainable cultural tourism.

Furthermore, a harmonised dataset of 99 heritage sites has been integrated into the European Geological Data Infrastructure (EGDI), ensuring broader access, interoperability, and long-term preservation. The EVMJ stands as a replicable model for digital heritage communication and an effective tool for promoting the legacy of coal mining regions in transition.

1. INTRODUCTION

This report presents Deliverable 4.2 "Visual Map Journal based on geospatial data and attribute data". This tool aims to preserve, promote, and communicate the industrial and cultural legacy of coal mining in Europe through an interactive, web-based storytelling platform. The European Visual Map Journal (EVMJ) is built upon the geospatial and multimedia data compiled and harmonised in Deliverable 4.1, serving as a narrative medium to support the just transition of coal-dependent regions. The map journal combines spatial data, attribute tables, 3D models, photographs, videos, and textual descriptions into an accessible visual interface. It is designed to present significant sites and artefacts of coal mining heritage across five participating countries: France, Germany, Greece, Poland, and Slovenia. The interactive maps allow users to explore historical mining sites, technical infrastructures, machinery, and cultural landmarks, while the narrative elements provide historical and social context.

This deliverable provides a comprehensive overview of:

- The methodological framework used to design and implement the EVMJ;
- The technical infrastructure and tools employed;
- The structure and content of the journal itself;

Ultimately, the EVMJ contributes to the broader objectives of the CoalHeritage project by enhancing public awareness, supporting education and tourism, and promoting sustainable heritage management through modern geospatial technologies

2. METHODOLOGY

The methodology for the development of the European Visual Map Journal (EVMJ) was structured around transforming the harmonised geospatial database created in Deliverable D4.1 into an interactive and narrative-driven platform. The core approach combined cartographic visualization, data storytelling, and user experience (UX) principles, supported by modern WebGIS technologies.

- Conceptual design and storyboarding, defining the structure, logic, and thematic flow of the journal
- Data preparation and integration, based on harmonised geospatial and attribute data from five partner countries
- Platform selection and tool deployment, relying on the ESRI ecosystem and photogrammetry workflows
- Development and validation of interactive features, including the integration of 2D layers, 3D models, multimedia elements, and expert feedback.

2.1. Conceptual Design of the Visual Map Journal

The conceptual design of the EVMJ was guided by the need to balance technical accuracy with public engagement. The journal was envisioned as a narrative structure comprising geographic stories that guide the user through the industrial past and cultural significance of coal-related sites across Europe. Key design principles included:

- Thematic segmentation by country and topic. The EVMJ is organised into chapters or sections, each focusing on a specific country (France, Germany, Greece, Poland, Slovenia) and subtopics such as infrastructure, machinery, mining zones, or cultural events.
- User-centred navigation and intuitive flow. The design prioritised ease of navigation, ensuring that users can move smoothly between maps, media, and texts without technical barriers. A consistent layout, clickable elements, and embedded side panels were used.

- Integration of multimedia storytelling. The narrative is enriched with photos, videos, archival documents, and 3D reconstructions, presenting each site not only as a coordinate on a map but as a story with visual and historical context.
- Interactive spatial experience. Each site or feature includes pop-ups, detailed metadata, links to external resources (e.g., EGDI), and in some cases immersive 3D visualizations that allow for object rotation, zoom, and inspection.
- Didactic and heritage-oriented tone. Beyond technical data, the journal was designed to promote learning and heritage appreciation. It incorporates mining traditions (e.g., Saint Barbara's Day), testimonies, and heritage values, aligned with the objectives of cultural conservation and just transition.

This conceptual framework ensured that the EVMJ serves as both a scientific inventory tool and a public-facing digital exhibition.

2.2. Data Sources and Preparation

The foundation of the European Visual Map Journal (EVMJ) is the harmonised geodatabase developed in Deliverable 4.1, which contains both spatial and non-spatial data from five countries: France, Germany, Greece, Poland, and Slovenia. The datasets were collected under Tasks 2.1 and 3.3 and systematically structured by CERTH and project partners using ESRI standards.
The data used in the European Visual Map Journal (EVMJ) can be classified into several categories, beginning with spatial data in vector formats. These include point features representing heritage sites, mining infrastructure, and significant areas of interest, typically stored as shapefiles. Polygon features are used to define regional and coalfield boundaries, such as those found in France and Greece, offering broader geographical context. Additionally, polyline features capture linear elements such as underground mining networks, with a notable example being the multi-temporal infrastructure data from Slovenia (PV_mine_map_2015–2024). Table 2.1-Table 2.5 illustrate the feature datasets that were created for each case.

Table 2.1: Descriptive table of shapefiles from the **France** feature dataset

Feature	Description
FR_boundaries	Regional and department boundaries of Frances that were utilized for illustration purposes.
FR_Coalfields	Coalfield areas boundaries that were digitized from maps to visualize a historic archive of coal mine activity in France.
FR_sites	Points of interest that were collected as CoalHeritage sites representing the Coal mine heritage of each country.

Table 2.2: Descriptive table of shapefiles from the **German** feature dataset

Feature	Description
GER_sites	Points of interest that were collected as CoalHeritage sites representing the Coal mine heritage of each country.

Table 2.3: Descriptive table of shapefiles from the Greece feature dataset.

Feature	Description
GR_mines_CLC2018	Boundaries of areas that are related with coal mine activity (Operating or Preserved) in Greece according to the Corine Land Cover 2018.
GR_Sites	Points of interest that were collected as CoalHeritage sites representing the Coal mine heritage of each country.

Table 2.4: Descriptive table of shapefiles from the Poland feature dataset.

Feature	Description
PL_sites	Points of interest that were collected as CoalHeritage sites representing the Coal mine heritage of each country.

Table 2.5: Descriptive table of shapefiles from the Slovenia feature dataset

Feature	Description
PV_mine_map_2015	Spatiotemporal drawings of Šalek Valley pit-mine network above and underground the surface.
PV_mine_map_2016	
PV_mine_map_2017	
PV_mine_map_2018	
PV_mine_map_2019	
PV_mine_map_2020	
PV_mine_map_2021	
PV_mine_map_2022	
PV_mine_map_2023	
PV_mine_map_2024	
SL_sites	Points of interest that were collected as CoalHeritage sites representing the Coal mine heritage of each country.

Attribute data used in the EVMJ were prepared in Excel format and structured according to a harmonised schema applied across all point datasets. Each record includes key descriptive fields such as the name of the site, its latitude and longitude coordinates, the period during which it was active, its current mining status, and the type of mining activity conducted. Additional fields specify the available facilities at each location, the classification or type of the site, and the country in which it is situated. This standardised structure ensures consistency and comparability across the five participating countries.

The geospatial data compiled for the European Visual Map Journal include multiple feature datasets provided by each participating country. These datasets are tailored to reflect the specific characteristics and documentation standards of each national context. Alongside these, each country has produced a harmonised shapefile structured with a common set of attributes, including fields such as name, coordinates, mining activity, operational status, available facilities, site type, and country. This consistent schema ensures comparability and integration across the full geodatabase.

- **OBJECTIVEID (ID):** A unique identifier for each record in the dataset.
- **Shape (Geometry):** The shape of the spatial entities which are Points.
- **ID (Long):** A unique identifier for the whole dataset.
- **Name (Text):** The name of the mining site or park.
- **Latitude (DD) (Double):** The latitude coordinates of the site in decimal degrees.
- **Longitude (DD) (Double):** The longitude coordinates of the site in decimal degrees.
- **Active Period (Text):** The period during which the site was active for mining or other activities.

- **Mine Status (Text):** Indicates whether the site is preserved, abandoned, operating, or has no data available.
- **Mining activity (Text):** Describes the type of mining activity which can be Underground, Surface Mining, Underground and Surface Mining, or none of the above (None).
- **Available Facilities (Text):** Lists the facilities and amenities available at the site for visitors or activities.
- **Type (Text):** Specifies the type of site, such as infrastructure, mining area, or machine.
- **Country (Text):** Indicates the country where the site is located.

The harmonised shapefiles consistently represent sites associated with coal mining heritage across all participating countries. In parallel, each country has contributed additional geospatial datasets that reflect specific aspects of its national context, such as administrative boundaries, coalfield extents, or underground infrastructure. Together, these datasets provide a comprehensive spatial representation of coal-related heritage, tailored to the unique characteristics of each region. A description of the national datasets is provided below.

2.2.1. France

The feature dataset titled “France” includes three geospatial layers related to mining areas and regional boundaries within the scope of the CoalHeritage project. The shapefile FR_Coalfields (Polygon) (Figure 2.1, Table 2.6) contains 135 polygon features representing the boundaries of historical coalfields across France. As this layer was developed primarily for the purpose of visualising the general distribution of coal sites, its attribute table includes only the default spatial fields generated during processing—such as a unique identifier (ID), geometry type (Shape), perimeter (Shape_Length), and area (Shape_Area). At a later stage of the project, additional attributes such as site names may be incorporated where such information becomes available. It should be noted that the number of features, as well as the recorded lengths and areas, do not necessarily reflect the current status or active extent of coal mining areas in France.

Table 2.6: Descriptive table of shapefiles from the “France” feature dataset & shapefiles’ visualization from the feature dataset.

	Feature	Geometry Type	Number of Entities	Fields (type)
	FR_Coalfields	Polygon	135	OBJECTID (Object ID), Shape (Geometry), Shape_Length (Double), Shape_Area (Double)
	FR_boundaries	Polygon	96	OBJECTID (Object ID), FID (Object ID), Shape (Geometry), NAME_1 (Text), NAME_2 (Text), Class (Text), Shape_Length (Double), Shape_Area (Double)
	FR_sites	Point	12	Active_period (Text), Mine_Status (Text), Mining_activity (Text), Available_Facilities (Text), Type (Text), Country (Text)

	OBJECTID *	Shape *	Shape_Length	Shape_Area
1	1	Polygon	25205,990078	45144036,866887
2	2	Polygon	8369,997451	3068712,263498
3	3	Polygon	1492,558688	58126,233096
4	4	Polygon	22509,07289	34842705,749285
5	5	Polygon	33015,821827	80502974,906437
6	6	Polygon	9462,269111	5263574,332001
7	7	Polygon	11613,514328	7437294,405053
8	8	Polygon	9439,146574	5547018,398099
9	9	Polygon	8190,702835	3928332,431377
10	10	Polygon	10885,510146	6863784,239462
11	11	Polygon	10424,360449	6601867,103297
12	12	Polygon	10574,411104	6544425,035887
13	13	Polygon	10540,741115	6406017,789066

0 of 135 selected

Figure 2.1: Visualization of the vector layer FR_Coalfields within the ArcGIS environment, from the feature dataset "France".

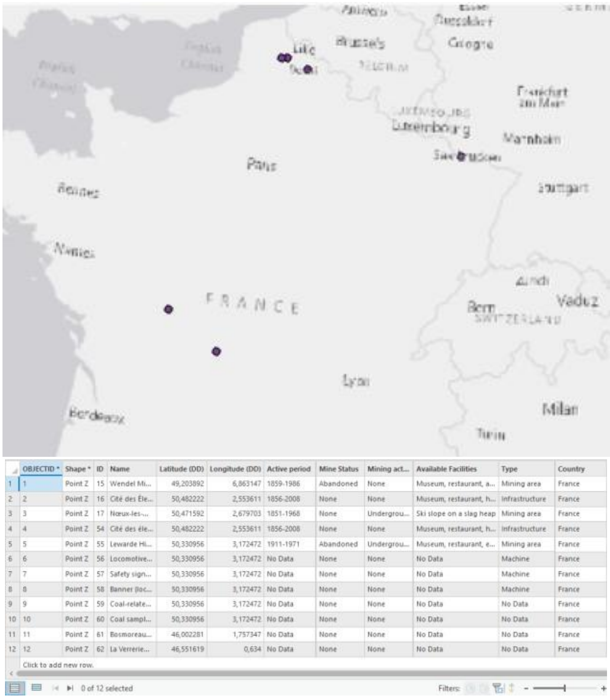
The second shapefile, titled FR_boundaries (Polygon), represents the administrative department boundaries of France (Table 2.6, Figure 2.2). The attribute table includes information such as the name of the broader administrative region to which each department belongs (NAMES_1), the name of each individual department (NAMES_2), a classification field (Class), and the default spatial attributes Shape_Length and Shape_Area. The Class attribute, similar to the one used in the FR_Coalfields layer (Figure 2.1), was created specifically for visualisation purposes within the EVMJ platform. It is used to differentiate selected areas by assigning specific colours (e.g., Blue, Grey, Yellow). In cases where no classification was applied, the field is marked as "None".

	FID *	Shape *	NAME_1	NAME_2	Class	Shape_Length	Shape_Area
1	1	Polygon	Auvergne-Rhône-Alpes	Ain	None	478577,289845	5785414300,734514
2	2	Polygon	Auvergne-Rhône-Alpes	Allier	Orange	538995,912765	7380088567,446363
3	3	Polygon	Auvergne-Rhône-Alpes	Ardèche	None	432305,424843	5564737559,644226
4	4	Polygon	Auvergne-Rhône-Alpes	Cantal	Orange	514524,224143	5776218021,411407
5	5	Polygon	Auvergne-Rhône-Alpes	Drôme	None	641322,105546	6559408994,52821
6	6	Polygon	Auvergne-Rhône-Alpes	Haute-Loire	Orange	458399,792616	5004660685,806647
7	7	Polygon	Auvergne-Rhône-Alpes	Haute-Savoie	None	411826,197468	4881364328,148808
8	8	Polygon	Auvergne-Rhône-Alpes	Isère	Grey	610521,375747	7875548529,912965
9	9	Polygon	Auvergne-Rhône-Alpes	Loire	Yellow	513431,31131	4806385212,95062

0 of 96 selected

Figure 2.2: Visualization of the vector layer FR_boundaries within the ArcGIS environment, from the feature dataset

The third shapefile, FR_sites (Points), represents the geographic locations of sites associated with the coal mining heritage of France. This vector layer contains 12 point features (Figure 2.3, Table 2.6), each corresponding to a documented site. The attribute table includes detailed information such as a unique identifier (ID), the name of each site (Name), geographic coordinates in decimal degrees (Latitude (DD) and Longitude (DD)), the period during which the site was active (Active Period), its current status (Mine Status), the type of mining activity conducted (Mining Activity), available on-site facilities (Available Facilities), the general classification of the site (Type), and the country of location (Country). In addition to these descriptive fields, the table also contains system-generated attributes such as OBJECTID and Shape.



	OBJECTID *	Shape *	ID	Name	Latitude (DD)	Longitude (DD)	Active period	Mine Status	Mining act...	Available Facilities	Type	Country
1	1	Point Z	15	Wendel Mi...	49,203892	6,863147	1859-1986	Abandoned	None	Museum, restaurant, a...	Mining area	France
2	2	Point Z	16	Cité des Éle...	50,482222	2,553611	1856-2008	None	None	Museum, restaurant, h...	Infrastructure	France
3	3	Point Z	17	Nœux-les-...	50,471592	2,679703	1851-1968	None	Undergrou...	Ski slope on a slag heap	Mining area	France
4	4	Point Z	54	Cité des éle...	50,482222	2,553611	1856-2008	None	None	Museum, restaurant, h...	Infrastructure	France
5	5	Point Z	55	Lewarde Hi...	50,330956	3,172472	1911-1971	Abandoned	Undergrou...	Museum, restaurant, e...	Mining area	France
6	6	Point Z	56	Locomotive...	50,330956	3,172472	No Data	None	None	No Data	Machine	France
7	7	Point Z	57	Safety sign...	50,330956	3,172472	No Data	None	None	No Data	Machine	France
8	8	Point Z	58	Banner (loc...	50,330956	3,172472	No Data	None	None	No Data	Machine	France
9	9	Point Z	59	Coal-relate...	50,330956	3,172472	No Data	None	None	No Data	No Data	France
10	10	Point Z	60	Coal sampl...	50,330956	3,172472	No Data	None	None	No Data	No Data	France
11	11	Point Z	61	Bosmoreau...	46,002281	1,757347	No Data	None	None	No Data	No Data	France
12	12	Point Z	62	La Verrerie...	46,551619	0,634	No Data	None	None	No Data	No Data	France

Click to add new row.

0 of 12 selected

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Figure 2.3: Visualization of the vector layer FR_sites within the ArcGIS environment, from the feature dataset "France".

2.2.2 Germany

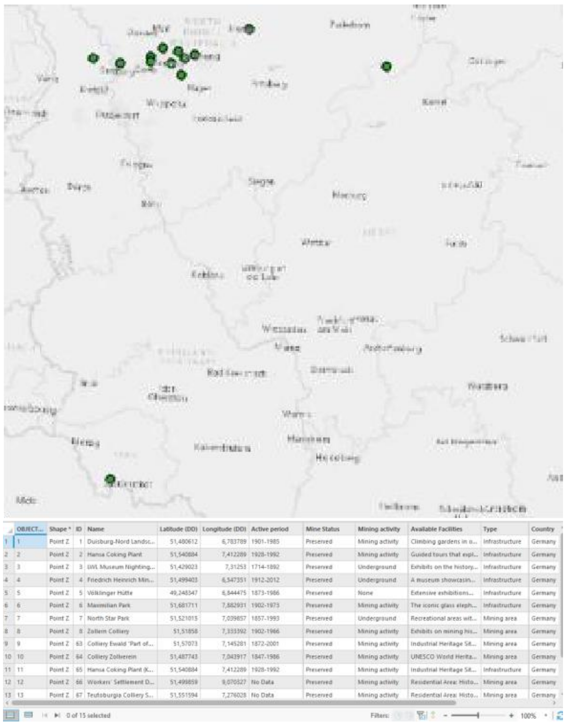
The feature dataset for Germany includes a single shapefile, titled GER_sites (Points), which documents coal mining heritage sites. This vector layer contains 15 point features (Table 2.7, Figure 2.4), each representing a significant heritage location related to coal mining history.

The attribute table follows the harmonised structure used across all partner countries and includes fields such as ID, Name, Latitude (DD), Longitude (DD), Active Period, Mine Status, Mining Activity, Available Facilities, Type, and Country. Additionally, default fields like OBJECTID and Shape are included as system-generated attributes.

This dataset offers an overview of key preserved or historically significant sites in Germany, which are also presented within the EVMJ platform with associated narratives and multimedia elements.

Table 2.7: Descriptive table of shapefiles from the "Germany" feature dataset & shapefiles' visualization from the feature dataset.

	Feature	Geometry Type	Number of Entities	Fields (type)
	GER_sites	Point	15	Active_period (Text), Mine_Status (Text), Mining_activity (Text), Available_Facilities (Text), Type (Text), Country (Text)



OBJECT...	Shape *	ID	Name	Latitude (DD)	Longitude (DD)	Active period	Mine Status	Mining activity	Available Facilities	Type	Country
1	Point Z	1	Duisburg-Nord Landsc...	51,480612	6,783789	1901-1985	Preserved	Mining activity	Climbing gardens in o...	Infrastructure	Germany
2	Point Z	2	Hansa Coking Plant	51,540884	7,412289	1928-1992	Preserved	Mining activity	Guided tours that expl...	Infrastructure	Germany
3	Point Z	3	LWL Museum Nighting...	51,429023	7,31253	1714-1892	Preserved	Underground	Exhibits on the history...	Infrastructure	Germany
4	Point Z	4	Friedrich Heinrich Min...	51,499403	6,547351	1912-2012	Preserved	Underground	A museum showcasin...	Infrastructure	Germany
5	Point Z	5	Völklinger Hütte	49,248347	6,844475	1873-1986	Preserved	None	Extensive exhibitions...	Infrastructure	Germany
6	Point Z	6	Maximilian Park	51,681711	7,882931	1902-1973	Preserved	Mining activity	The iconic glass eleph...	Infrastructure	Germany
7	Point Z	7	North Star Park	51,521015	7,039857	1857-1993	Preserved	Underground	Recreational areas wit...	Mining area	Germany
8	Point Z	8	Zollern Colliery	51,51858	7,333392	1902-1966	Preserved	Mining activity	Exhibits on mining his...	Mining area	Germany
9	Point Z	63	Colliery Ewald 'Part of...	51,57073	7,145281	1872-2001	Preserved	Mining activity	Industrial Heritage Sit...	Mining area	Germany
10	Point Z	64	Colliery Zollverein	51,487743	7,043917	1847-1986	Preserved	Mining activity	UNESCO World Herita...	Mining area	Germany
11	Point Z	65	Hansa Coking Plant (K...	51,540884	7,412289	1928-1992	Preserved	Mining activity	Industrial Heritage Sit...	Infrastructure	Germany
12	Point Z	66	Workers' Settlement D...	51,499859	9,070327	No Data	Preserved	Mining activity	Residential Area: Histo...	Mining area	Germany
13	Point Z	67	Teutoburgia Colliery S...	51,551594	7,276028	No Data	Preserved	Mining activity	Residential Area: Histo...	Mining area	Germany

Figure 2.4: Visualization of the vector layer GER_sites within the ArcGIS environment, from the feature dataset "Germany".

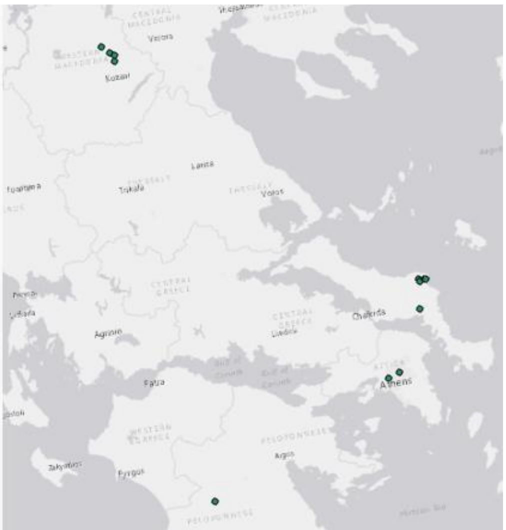
2.2.3 Greece

The Greek dataset comprises two primary shapefiles: GR_sites (Points) and GR_mines_CLC2018 (Polygons). The first, GR_sites, contains 24 point features that represent coal mining heritage sites across Greece (Figure 2.5, Table 2.5).

Its attribute table follows the harmonised schema and includes values for ID, Name, Latitude (DD), Longitude (DD), Active Period, Mine Status, Mining Activity, Available Facilities, Type, and Country, along with default fields such as OBJECTID and Shape.

Table 2.8: Descriptive table of shapefiles from the "Greece" feature dataset & shapefiles' visualization from the feature dataset.

	Feature	Geometry Type	Number of Entities	Fields (type)
	GR_sites	Point	24	Active_period (Text), Mine_Status (Text), Mining_activity (Text), Available_Facilities (Text), Type (Text), Country (Text)
	GR_mine_CLC20218	Polygon	4	OBJECTID (Object ID), Shape (Geometry), Shape_Length (Double), Shape_Area (Double), Mine (Text)

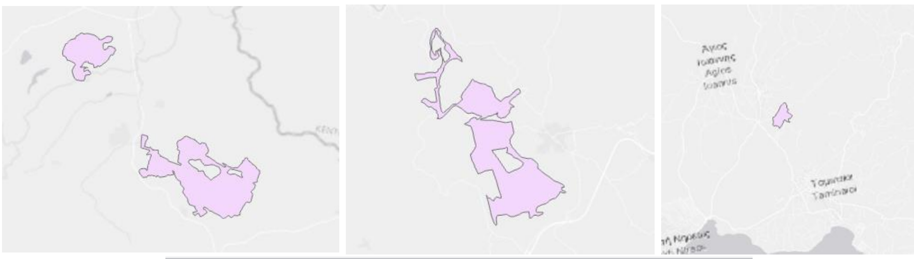


	OBJ...	Shape *	ID	Name	Latitude (...	Longitud...	Active period	Mine Status	Mining activity	Available Facilities	Type	Country
1	1	Point Z	30	School o...	40,413005	21,782004	No Data	No Data	No Data	No Data	No Data	Greece
2	2	Point Z	31	West Ma...	40,473125	21,74883	No Data	No Data	No Data	No Data	No Data	Greece
3	3	Point Z	32	Memorial...	40,523391	21,682978	No Data	No Data	No Data	No Data	No Data	Greece
4	4	Point Z	79	Prinias fa...	38,433917	24,033417	No Data	No Data	No Data	No Data	Infrastructure	Greece
5	5	Point Z	80	Kazarma...	38,631056	24,068111	No Data	No Data	No Data	No Data	Infrastructure	Greece
6	6	Point Z	81	LIPTOL li...	40,457778	21,785389	No Data	No Data	No Data	No Data	Infrastructure	Greece
7	7	Point Z	82	Air separ...	38,433917	24,033417	No Data	No Data	No Data	No Data	Infrastructure	Greece
8	8	Point Z	83	Wagon li...	38,433917	24,033417	No Data	No Data	No Data	No Data	No Data	Greece
9	9	Point Z	84	Vibrating...	38,433917	24,033417	No Data	No Data	No Data	No Data	Infrastructure	Greece
10	10	Point Z	85	Mine hoi...	38,433917	24,033417	No Data	No Data	No Data	No Data	Infrastructure	Greece
11	11	Point Z	86	Air ham...	38,433917	24,033417	No Data	No Data	No Data	No Data	Infrastructure	Greece
12	12	Point Z	87	Machine...	38,433917	24,033417	No Data	No Data	No Data	No Data	Infrastructure	Greece
13	13	Point Z	88	Hydraulic...	38,433917	24,033417	No Data	No Data	No Data	No Data	Infrastructure	Greece

0 of 24 selected   Filters: 100%

Figure 2.5: Visualization of the vector layer GR_sites within the ArcGIS environment, from the feature dataset "Greece".

The second layer, GR_mines_CLC2018, consists of 4 polygon features representing mine boundaries, derived from the Corine Land Cover (CLC) 2018 dataset (Figure 2.6). This supplementary layer provides broader contextual information on the spatial extent of mining activities in Greece, complementing the point-based documentation of heritage sites.



	FID *	Shape *	Shape_Length	Shape_Area	Mine
1	1	Polygon	2880,601059	313904,63535	Aliveri
2	2	Polygon	64000,502572	19319934,749449	Megalopoli
3	3	Polygon	88947,488707	81566438,649601	Ptolemaida
4	6	Polygon	32453,726571	25442827,996849	Amyntaio

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0 of 4 selected

Figure 2.6: Visualization of the vector layer GR_mine_CLC20218 within the ArcGIS environment, from the feature dataset "Greece".

2.2.4 Poland

The Polish contribution to the geodatabase is one of the most extensive and includes a shapefile named PL_sites (Points). This vector dataset contains 27 point features that represent a wide range of coal-related heritage sites throughout Poland (Figure 2.7, Table 2.9).

Table 2.9: Descriptive table of shapefiles from the “Poland” feature dataset & shapefiles’ visualization from the feature dataset.

	Feature	Geometry Type	Number of Entities	Fields (type)
Poland PL_sites	PL_sites	Points	27	Active_period (Text), Mine_Status (Text), Mining_activity (Text), Available_Facilities (Text), Type (Text), Country (Text)

Each feature is described using the standardised attribute structure: ID, Name, Latitude (DD), Longitude (DD), Active Period, Mine Status, Mining Activity, Available Facilities, Type, and Country, in addition to system-generated fields such as OBJECTID and Shape.

Poland’s dataset is notable for its integration with 3D models—several of the sites represented in the shapefile have corresponding digital reconstructions created through photogrammetry, which are embedded in the Visual Map Journal. These models significantly enhance user engagement and provide a visually rich exploration of Polish mining heritage.

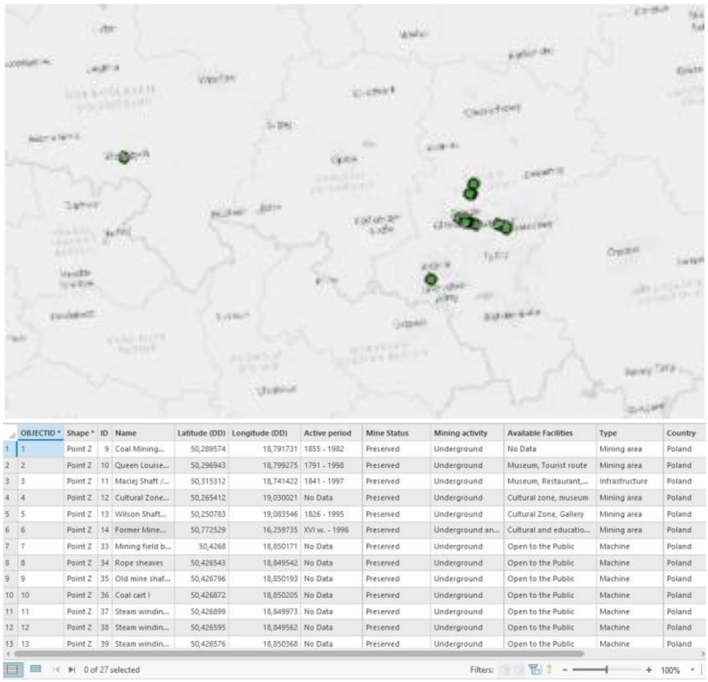


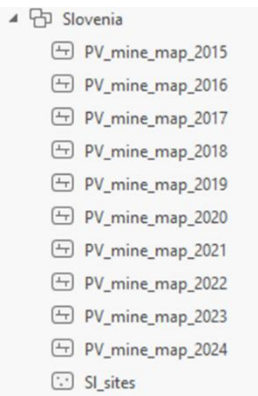
Figure 2.7: Descriptive table of shapefiles from the “Poland” feature dataset

2.2.5 Slovenia

The Slovenian dataset includes both point and polyline shapefiles, reflecting the country’s detailed documentation of underground mining infrastructure over time. The point layer, titled SL_sites (Points), consists of 21 entities representing heritage-related sites (Table 2.10). Its attribute table is aligned with the harmonised schema used across all partners.

In addition to the point data, Slovenia has contributed a unique temporal dataset titled PV_mine_map_2015–2024 (Polylines). This collection includes eleven polyline layers, each corresponding to a specific year between 2015 and 2024. These layers were derived from annual AutoCAD-based mapping of the underground mining galleries in the Šalek Valley region. While the polyline layers contain only default system attributes such as OBJECTID and Shape, they provide a valuable visualisation of the temporal development of mining infrastructure and are included in the EVMJ as time-referenced visual content.

Table 2.10: Descriptive table of shapefiles from the “Slovenia” feature dataset & shapefiles’ visualization from the feature dataset.



Feature	Geometry Type	Number of Entities	Year	Fields (type)
PV_mine_map_2015	Polyline Z	13.132	2015	OBJECTID (Object ID), Shape (Geometry), Layer (Text), Elevation (Double), Year (Text), Shape_lenght (Double)
PV_mine_map_2016	Polyline Z	12.197	2016	
PV_mine_map_2017	Polyline Z	12.289	2017	
PV_mine_map_2018	Polyline Z	12.814	2018	
PV_mine_map_2019	Polyline Z	13.051	2019	
PV_mine_map_2020	Polyline Z	13.461	2020	
PV_mine_map_2021	Polyline Z	13.424	2021	
PV_mine_map_2022	Polyline Z	13.515	2022	
PV_mine_map_2023	Polyline Z	12.924	2023	
PV_mine_map_2024	Polyline Z	12.129	2024	
PL_sites	Point	21	-	Active_period (Text), Mine_Status (Text), Mining_activity (Text), Available_Facilities (Text), Type (Text), Country (Text)

The image below (Figure 2.8) illustrates the visualisation of the PV_mine_map vector layers, representing underground mining infrastructure in Slovenia from the years 2015 to 2024, within the ArcGIS environment. These layers are part of the “Slovenia” feature dataset and are displayed as a temporal sequence. Each annual layer is numbered from 1 to 10, corresponding to its respective year.

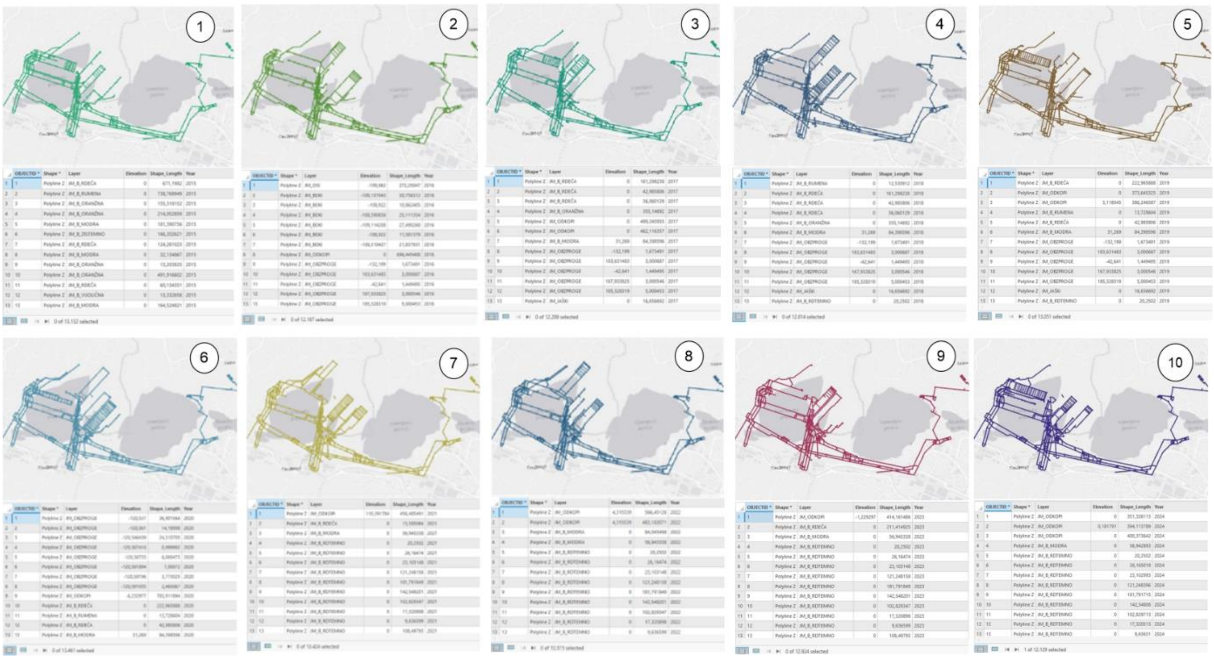


Figure 2.8: Visualisation of the PV_mine_map vector layers (2015–2024) from the Slovenia feature dataset in the ArcGIS environment

The second feature layer of Slovenia feature dataset, is title as SL_sites (Points) and contains all the recorded sites that are related to coal mine heritage in wider area of Slovenia (Figure 2.9). In particular, the most of the presented sites in this layer are consecrated in Šalek Valley and are highlighting the location of infrastructures, machines and landmarks that are connected with the mining activity. Specifically, this layer has 21 spatial entities and follows the same structure as the aforementioned layers in the other feature datasets (e.g., FR_sites, GER_sites, e.t.c). In particular, the attributes of SL_sites are: OBJECTIVEID, Shape, ID, Name, Latitude (DD), Longitude (DD), Active period, Mine Status, Mining Activity, Available Facilities, Type, and the Country.

Figure 2.9: Visualization of the vector layer SL_sites within the ArcGIS environment, from the feature dataset "Slovenia".

In addition to geospatial layers, the European Visual Map Journal incorporates non-spatial data in the form of multimedia elements. These include photographs, videos, historical descriptions, and textual narratives, which were collected primarily through activities conducted in Work Packages 2 and 3. The multimedia content was archived as PDF documents and media files and later integrated into the storytelling components of the platform to enrich the user experience.

All geospatial datasets used in the EVMJ were standardised to ensure consistency across countries and data types. The coordinate reference system adopted was the European Terrestrial Reference System 1989 (ETRS89), in accordance with guidelines established by the INSPIRE Directive and the Water Framework Directive (WFD) GIS Working Group. Data formats were selected for compatibility with ESRI software, and included shapefiles, feature classes, and Excel tables.

To organise the data efficiently, two structured geodatabases were developed. The first, titled CoalHeritage.gdb, contains 2D feature classes (Figure 2.10) comprising point, line, and polygon datasets representing spatial elements such as sites, boundaries, and underground networks.

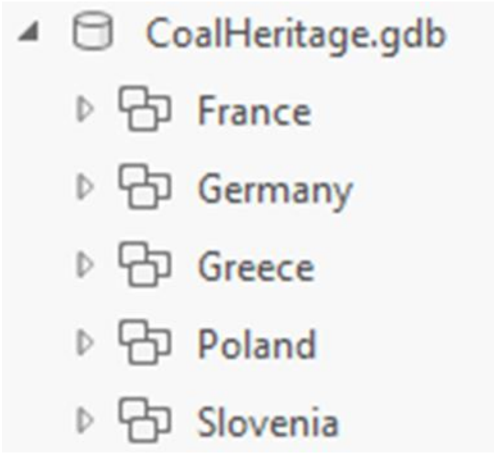


Figure 2.10: Schema of the geodatabase structure (CoalHeritage.gdb) that was developed during the project.

The FINAL_3D_MODELS_SCALED.gdb geodatabase (Figure 2.11) contains the processed and georeferenced 3D model scene layers used in the European Visual Map Journal (EVMJ). These layers represent detailed reconstructions of coal mining heritage artefacts and infrastructure, developed using photogrammetry techniques. The 3D models were originally created in GLB format and subsequently converted to Scene Layer Package (SLPK) format to ensure compatibility with ArcGIS Pro and ArcGIS Online. Each model has been appropriately scaled and positioned, enabling seamless integration within 3D scenes and interactive visualisations throughout the EVMJ platform

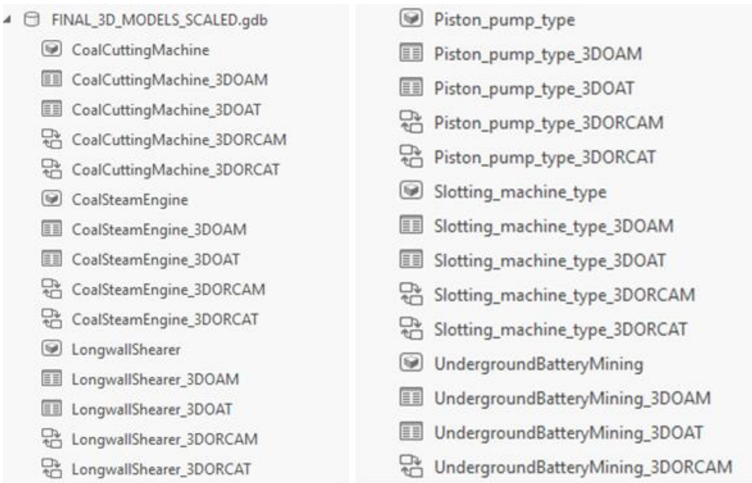


Figure 2.11: Schema of the 3D geodatabase structure (FINAL_3D_MODELS_SCALED.gdb) that was developed during the project

The methodology for converting GLB (GL Transmission Format) files to be used in ArcGIS Pro and ArcGIS Online is described below. It also provides a detailed description and specifications of the 3D items involved. This process enables the integration of 3D models into geographic information systems (GIS) for advanced spatial analysis and visualization.

2.2.6. Step 1: Preparing the GLB File

The initial step in integrating 3D models into the Visual Map Journal involves the preparation and validation of GLB files to ensure their compatibility and performance. This begins with verifying the integrity of each GLB file to confirm it is complete and free of errors. Tools such as the GLTF Validator can be used for this purpose. Once validated, the files are optimised using utilities like gltf-pipeline, which help reduce file size and enhance loading efficiency during web deployment. For more advanced adjustments or refinements, software such as Blender may be employed to edit or enhance the models as needed.

The 3D models were developed using photogrammetry, a method that reconstructs photorealistic digital models from photographs of real objects. This technique ensures high visual fidelity and allows the resulting models to be used not only for presentation in the Visual Map Journal but also as educational resources in modern teaching environments, including multimedia presentations and Extended Reality (XR) applications. All GLB-format models were produced by the project partner KOMAG, and selected examples of these 3D reconstructions are presented in the following image (Figure 2.12).

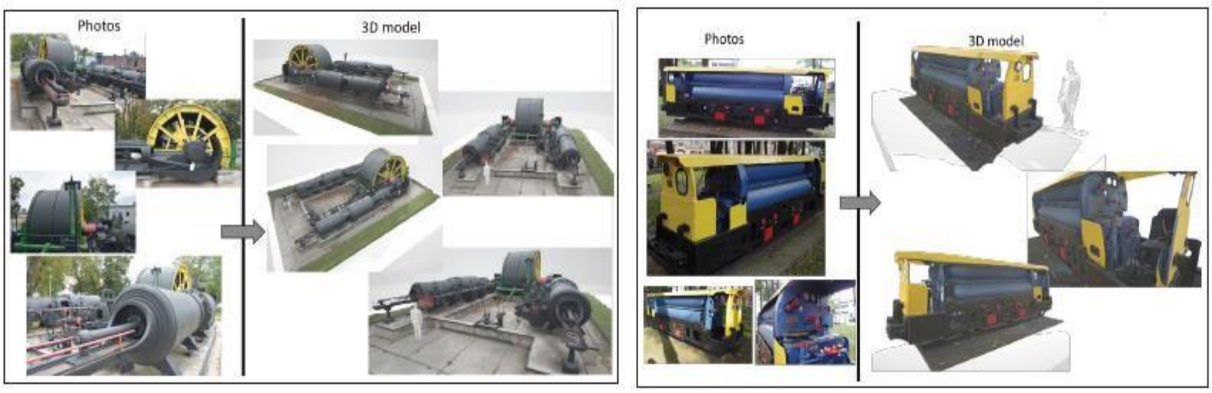


Figure 2.12: A locomotive and a steam hoisting machine photos and 3D models

2.2.7 Step 2: Converting GLB to a Supported Format

ArcGIS Pro and ArcGIS Online support various 3D data formats, including I3S, 3D Object Scene Layers, and Scene Layer Packages (SLPK). For optimal integration into the Visual Map Journal, the recommended workflow involves converting GLB files into the Scene Layer Package (SLPK) format. This conversion can be carried out directly within ArcGIS Pro using its built-in geoprocessing tools.

To begin the process, launch ArcGIS Pro and access the Geoprocessing pane. From there, select the tool "Create 3D Object Scene Layer Package", input the desired GLB file, and define the output location along with any relevant parameters. This method ensures compatibility with both ArcGIS Pro and ArcGIS Online, allowing for seamless publication and web-based visualisation of 3D content. In cases where ArcGIS Pro is not available, alternative third-party tools or conversion scripts may be used, provided they generate output compliant with ESRI's 3D publishing standards.

2.2.8 Step 3: Importing into ArcGIS Pro

After converting the GLB file to the Scene Layer Package (SLPK) format, the model can be imported into ArcGIS Pro for further visualisation and analysis. Begin by opening ArcGIS Pro and either creating a new project or working within an existing one. To display the 3D content, navigate to the 'Insert' tab and select 'New Scene' to add a 3D scene to the project. Then, use the 'Add Data' function to load the SLPK file into the scene. Once added, the 3D model becomes fully interactive within the GIS environment, allowing users to manipulate, rotate, and analyse it in spatial context (Figure 2.13).

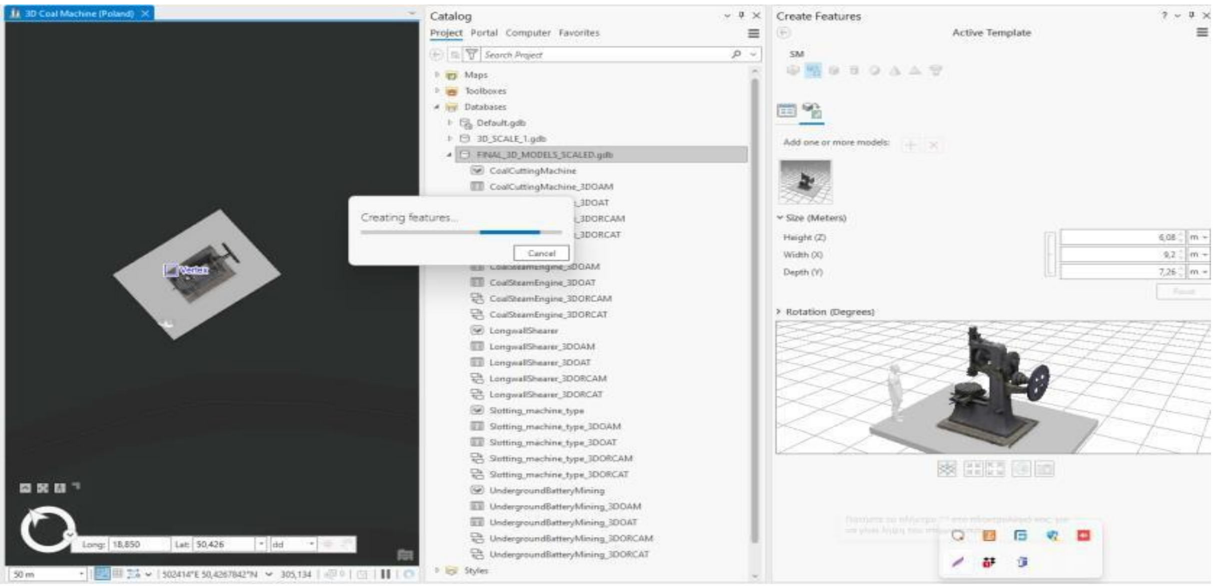


Figure 2.13: Publishing to ArcGIS Online.

To make the 3D model accessible via the web, it must be published to ArcGIS Online. Begin by ensuring that the SLPK file is correctly added to a scene or map within ArcGIS Pro. After signing in to your ArcGIS Online account, navigate to the 'Share' tab and select the 'Share As Web Layer' tool. From there, choose the appropriate layer type—typically Scene Layer—and complete the required metadata fields, such as title, summary, and tags. Configure the sharing permissions according to your intended audience (e.g., public or organisation-only access). Once the publication process is complete, the 3D model will be available on ArcGIS Online for interactive visualisation and further analysis.

2.2.9 Description and Specifications of 3D Items

The 3D items used in ArcGIS Pro and ArcGIS Online typically include various types of geographic features and models. These items can range from simple buildings and structures to complex urban landscapes and natural environments. Each 3D item is characterized by several specifications:

- **Geometry:** Defines the shape and structure of the 3D model. It includes vertices, edges, and faces that form the model's mesh.
- **Textures:** Provide surface details and color to the 3D model. Textures are often mapped onto the geometry to enhance realism.
- **Materials:** Define the appearance of the 3D model's surface, including properties such as color, reflectivity, and transparency.
- **Level of Detail (LOD):** Indicates the complexity of the 3D model at different scales. Higher LODs provide more detail but require more computational resources.
- **Metadata:** Includes information about the 3D model, such as its source, creator, date of creation, and any associated attributes or data.

By following this methodology, GLB files can be effectively converted and integrated into ArcGIS Pro and ArcGIS Online, enabling robust 3D spatial analysis and visualization within a GIS framework. This process ensures that 3D models are accurately represented and optimized for performance in both desktop and online environments.

Until now, four 3D models have been uploaded in EVMJ platform within the boundaries of Poland, where user can explore their dimensions in the real word. For instance, the 3D model of Frederick Hurda's first chain coal cutting machine (Figure xx) located in Poland, which was used widely in English and German mines in the 19th century is depicted at a real scale providing a realistic sense of size and space (Figure 2.14). This scale helps in understanding the physical dimensions of the machine relative to the surrounding area, such as adjacent buildings or infrastructure.

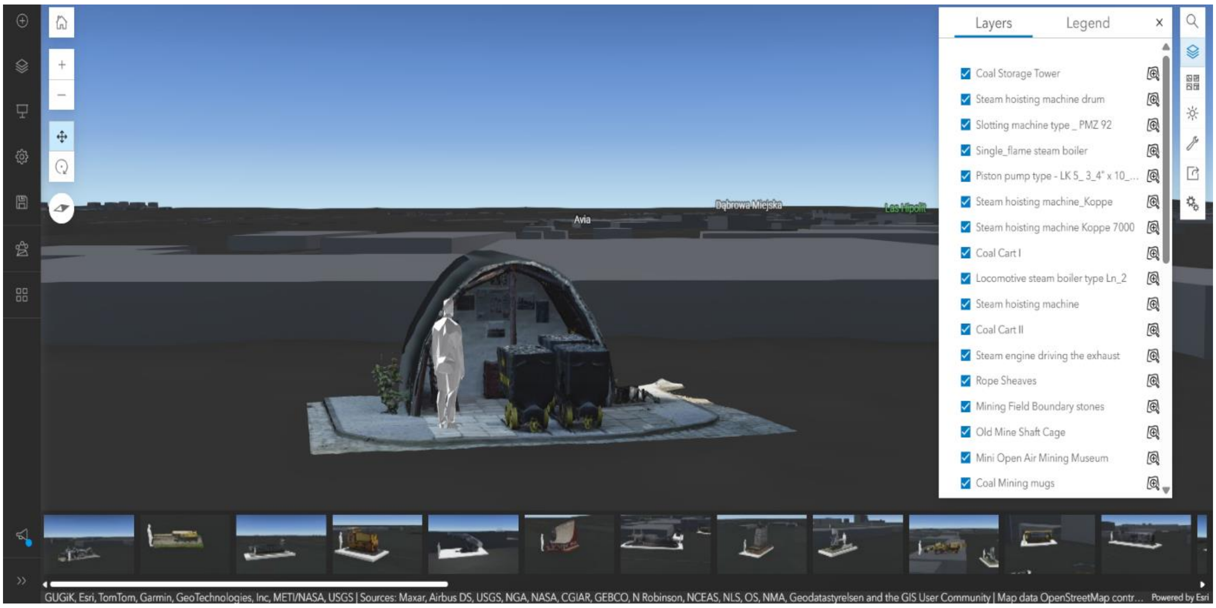


Figure 2.14: Screenshot from the 3D model of The Mini Mining Open-Air Museum in Radzionków is an exhibition commemorating the many years of operation of the local hard coal mine, named "Radzionkau Grube", "Radzionków" and "Powstańców Śląskich".

A curated set of 99 spatial entities has been made publicly accessible and integrated into the European Geological Data Infrastructure (EGDI) platform. These data have been harmonised using the EPSG:4326 (WGS 84) coordinate reference system to ensure compliance with EGDI standards. The dataset includes downloadable content and associated metadata, enabling direct linkage with the European Visual Map Journal (EVMJ) and supporting broader dissemination and interoperability across platforms.

As part of the CoalHeritage project, the geospatial data derived from the national feature datasets—previously described for France, Germany, Greece, Poland, and Slovenia—have been successfully integrated into the European Geological Data Infrastructure (EGDI) (Figure 2.15). This integration involved merging all point-based datasets from the participating countries into a single shapefile, structured in accordance with EGDI's standardised data model.

The incorporation of these datasets into EGDI offers several significant advantages. First, it enhances accessibility, making coal mining heritage data readily available to a broader audience, including researchers, policymakers, educators, and the general public. Second, adherence to EGDI standards ensures full interoperability with other geological datasets across Europe, thereby facilitating cross-border and interdisciplinary research. Third, the harmonisation process enables direct comparison and joint analysis of heritage data from different countries within a unified spatial framework. Finally, this integration contributes to the long-term preservation and open accessibility of Europe's coal mining heritage, reinforcing its value within the broader European geological knowledge base.

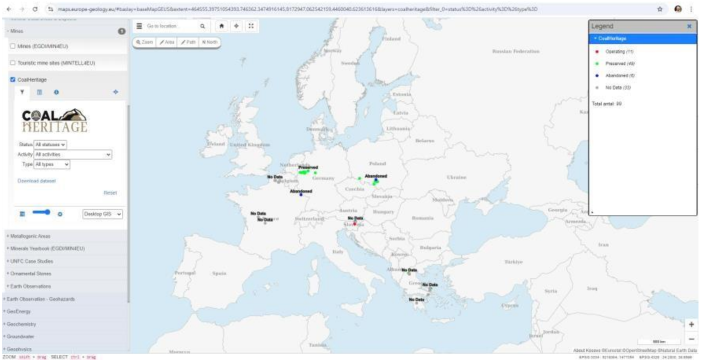


Figure 2.15: Screenshot of the integrated geodatabase into the EGDI platform

The European Geological Data Infrastructure (EGDI) serves as a pan-European platform for geological information, promoting consistency and interoperability among national datasets. To align with these standards, the integration of CoalHeritage data into EGDI required a systematic harmonisation of attributes across the different country-specific point datasets.
Each national dataset—initially structured with fields such as Name, Latitude, Longitude, Period, Status, Activity, Facilities, Type, and Country—was carefully reviewed and, where necessary, adjusted to conform with EGDI's attribute schema (Figure 2.16). This process involved standardising attribute names, unifying data formats, and ensuring consistency in the way information was represented across all records. Additionally, an extra column was added to include a direct hyperlink, allowing users to access the CoalHeritage website for further information and extended content related to each site.

CoalHeritage

Go to	Name	Latitude	Longitude	Period	Status	Activity
	LWL Museum Nightingale Colliery	51.429023	7.31253	1714-1892	Preserved	Underground
	Friedrich Heinrich Mine Park	51.499403	6.547351	1912-2012	Preserved	Underground
	North Star Park	51.521015	7.039857	1857-1993	Preserved	Underground
	Coal Mining Museum in Zabrze	50.289574	18.791731	1855 - 1982	Preserved	Underground
	Queen Louise Adit	50.296943	18.799275	1791 - 1998	Preserved	Underground
	Maciej Shaft /Zabrze	50.315312	18.741422	1841 - 1997	Preserved	Underground
	Cultural Zone in Katowice	50.265412	19.030021	No Data	Preserved	Underground
	Wilson Shaft Gallery	50.250783	19.083546	1826 - 1995	Preserved	Underground

Facilities	Type	Country	
Exhibits on the history of coal mining and the industrial revolution. Guided tours of the mine and its equipment. Demonstrations of mining techniques. Educational programs and workshops. Event spaces for cultural activities.	Infrastructure	Germany	Link...
A museum showcasing mining history and equipment. Recreational areas with walking and biking trails. Event spaces for cultural and community events. Art installations and sculptures. Information centers and guided tours.	Infrastructure	Germany	Link...
Recreational areas with playgrounds, walking, and cycling paths. The landmark Nordstern Tower, which offers panoramic views and hosts exhibitions. Amphitheater for concerts and performances. Sculptures and art installations. Event spaces for community ev	Mining area	Germany	Link...
No Data	Mining area	Poland	Link...
Museum, Tourist route	Mining area	Poland	Link...
Museum, Restaurant, cultural Zone	Infrastructure	Poland	Link...
Cultural zone, museum	Mining area	Poland	Link...
Cultural Zone, Gallery	Mining area	Poland	Link...

Figure 2.16: Screenshot of the integrated geodatabase into the EGDI platform.

Following the harmonisation process, the national datasets were consolidated into a single, unified shapefile. This merged dataset integrates spatial entities from all five participating countries, offering a comprehensive overview of coal mining heritage sites across the CoalHeritage project area. To ensure compatibility with the European Geological Data Infrastructure (EGDI), the unified shapefile underwent a thorough validation process. This included checks for data format compliance—specifically conversion to GeoPackage—as well as verification of attribute completeness and alignment with the required spatial reference system (WGS 1984, EPSG:4326). This validation was essential to ensure seamless integration into the EGDI platform, thereby supporting wider access, interoperability, and long-term usability of the dataset.

2.3. Tools and Platform Architecture

The implementation of the European Visual Map Journal (EVMJ) was based on an integrated technological framework that combined desktop GIS software, web-based mapping platforms, and photogrammetry tools for the creation and deployment of both 2D and 3D spatial content. The selected infrastructure ensured interoperability, accessibility, and the ability to deliver engaging, high-quality visual narratives for a wide audience.

The primary software environment used for data preparation and management was ArcGIS Pro 3.3, developed by ESRI. This desktop application enabled the structuring of the geodatabase, the definition of layer symbology, the preparation of metadata, and the validation of both spatial and non-spatial content. It also provided the tools required for converting 3D models into formats compatible with web-based publication, particularly the Scene Layer Package (SLPK) format.

The cloud-based deployment of the EVMJ was achieved through ArcGIS Online, which hosts the journal and supports the publication of web maps, 3D scenes, and multimedia narratives via the ArcGIS StoryMaps platform. This environment allows for dynamic user interaction through features such as clickable elements, embedded videos, 3D rotation, and pop-up attribute tables. The link to the public platform is provided in the Introduction of Deliverable 4.1 and can be accessed via: https://storymaps.arcgis.com/collections/987904b97d664cedb2ea4c161fb0f31e.

The Visual Map Journal is supported by two core geodatabases. The first, titled CoalHeritage.gdb, contains all 2D spatial data—points, polygons, and polylines—structured by country and harmonised according to ESRI standards. This structure is presented in Figure 2.1 of Deliverable 4.1. The second geodatabase, FINAL_3D_MODELS_SCALED.gdb, stores the 3D digital assets, which were processed and optimised for visualisation in the map journal. The schema of this 3D geodatabase is depicted in Figure 2.2 of the same deliverable.

Photogrammetric modelling was carried out by project partner KOMAG, which provided 35 high-resolution 3D models derived from real coal mining heritage assets. These models were initially developed in GLB format using photo-based reconstruction methods and were further refined using Blender and gltf-pipeline tools to optimise file size and rendering performance. The models were then converted to SLPK format using ArcGIS Pro tools and integrated into the EVMJ. Details on this process, along with example visuals, can be found in Section 4 of Deliverable 4.1 (Figures 4.1 to 4.4).

Upon completion of the data processing and formatting stages, the content was published to ArcGIS Online. Hosted feature layers and scene layers were created and linked to the narrative elements of the StoryMap. The web platform was configured for open public access, ensuring full visibility of the project outputs. Links to the published maps were embedded in both the EVMJ platform and the European Geological Data Infrastructure (EGDI) for broader dissemination.

2.4. Integration of 2D and 3D Content

A central aspect of the European Visual Map Journal (EVMJ) is its ability to merge traditional 2D geospatial data with interactive 3D models, creating an enriched spatial storytelling environment that bridges historical interpretation with technological innovation. This integration required careful planning in terms of data architecture, platform compatibility, and user interface design.

The 2D content forms the structural backbone of the journal. It includes spatial entities such as coalfield boundaries, mine sites, infrastructure locations, and underground network layouts. These features were derived from the harmonised geodatabase developed in Deliverable 4.1 (CoalHeritage.gdb) and were published as feature layers in ArcGIS Online. Each national dataset was formatted to a common attribute schema, which allowed for consistent visualisation across the map journal. Users can explore these layers via interactive maps embedded within the journal, which offer pop-up windows displaying site-specific data, operational history, mining status, and other relevant attributes.

In parallel, the 3D content provides an immersive dimension to the map journal. It consists of highly detailed digital reconstructions of mining-related artefacts and machinery, developed by the KOMAG partner using photogrammetry techniques. The 3D models were initially processed in GLB format and subsequently optimised using software such as Blender and gltf-pipeline. These assets were then converted to ESRI's Scene Layer Package (SLPK) format to ensure compatibility with ArcGIS Pro and ArcGIS Online. The 3D models were stored within a dedicated geodatabase (FINAL_3D_MODELS_SCALED.gdb) and published as hosted scene layers, enabling full rotation,

zooming, and inspection by users directly within the web platform.
The integration of 2D and 3D components was achieved through the creation of linked content within the ArcGIS StoryMap environment. For example, a 2D map presenting the location of a coal hoisting machine is directly followed by a 3D model of that same object, offering users both spatial context and visual detail. In several instances, site entries include not only geospatial layers but also embedded photographs, video walkthroughs, and historical narratives, allowing for a multilayered exploration of each location.
This dual approach enhances the map journal’s didactic and interpretive potential. The 2D data supports geographic orientation and spatial analysis, while the 3D content engages users visually and emotionally, especially in the case of heritage machinery and infrastructure that are no longer physically accessible. Moreover, the combination of formats supports diverse user needs—from educators and students to planners, researchers, and tourists—aligning with the broader objectives of cultural preservation and public awareness within the CoalHeritage project.
The visual integration of these elements was guided by a consistent cartographic style and user interface logic, ensuring smooth transitions between 2D maps, textual content, and 3D scenes. This cohesive presentation enhances the user experience while demonstrating the value of combining GIS with digital heritage technologies.

2.5 Visualitsation of 2D and 3D spatial content

The 2D spatial elements of the European Visual Map Journal (EVMJ)—including point, line, and polygon features—were visualised through a combination of interactive tools and storytelling techniques offered by the ArcGIS StoryMaps platform. The main objective was to transform traditional geospatial content into an engaging and intuitive experience, accessible to both expert and non-expert audiences. All 2D layers, such as heritage site locations, coalfield boundaries, and underground mining infrastructure, were embedded in dynamic web maps. These maps were displayed on top of 3D basemaps with extruded buildings, offering realistic spatial context and enhancing the sense of place. This approach allowed users to view each heritage site within its actual geographic and built environment (Figure 2.17).

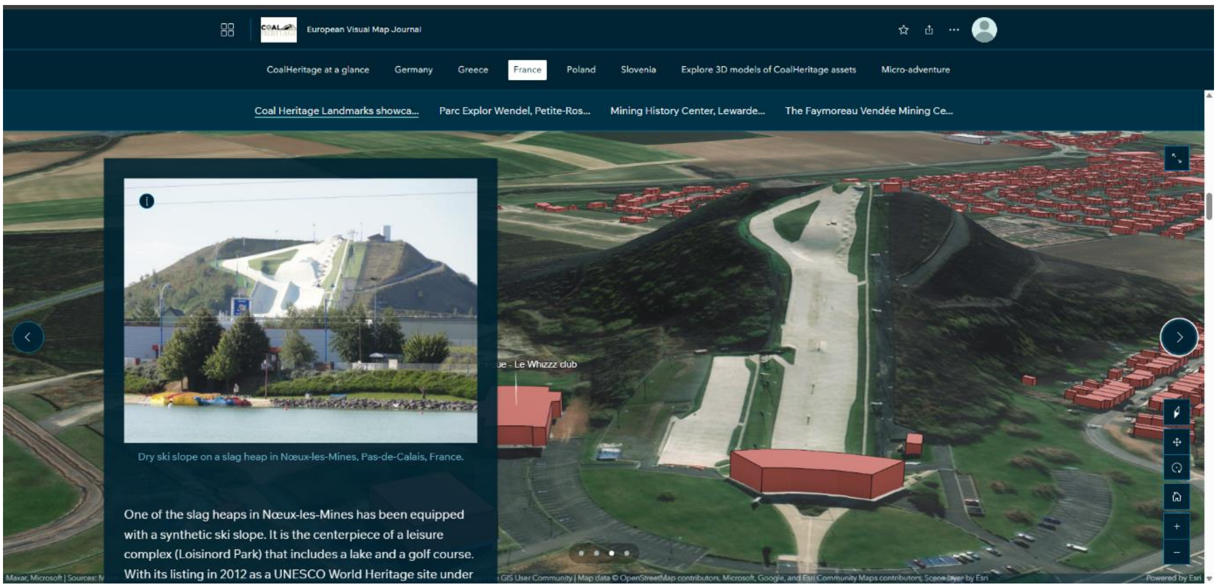


Figure 2.17: Visualisation of 2D spatial data from France overlaid on a 3D basemap, illustrating heritage site locations within their urban and geographic context.

To enrich the spatial data with interpretive content, each thematic section of the story map includes slideshows that combine photographs, historical imagery, and narrative text. These slideshows are linked to specific Points of Interest (POIs), allowing users to engage with the site's story while visually locating it on the map. The multimedia presentation deepens understanding and supports emotional connection with the heritage assets (Figure 2.18).

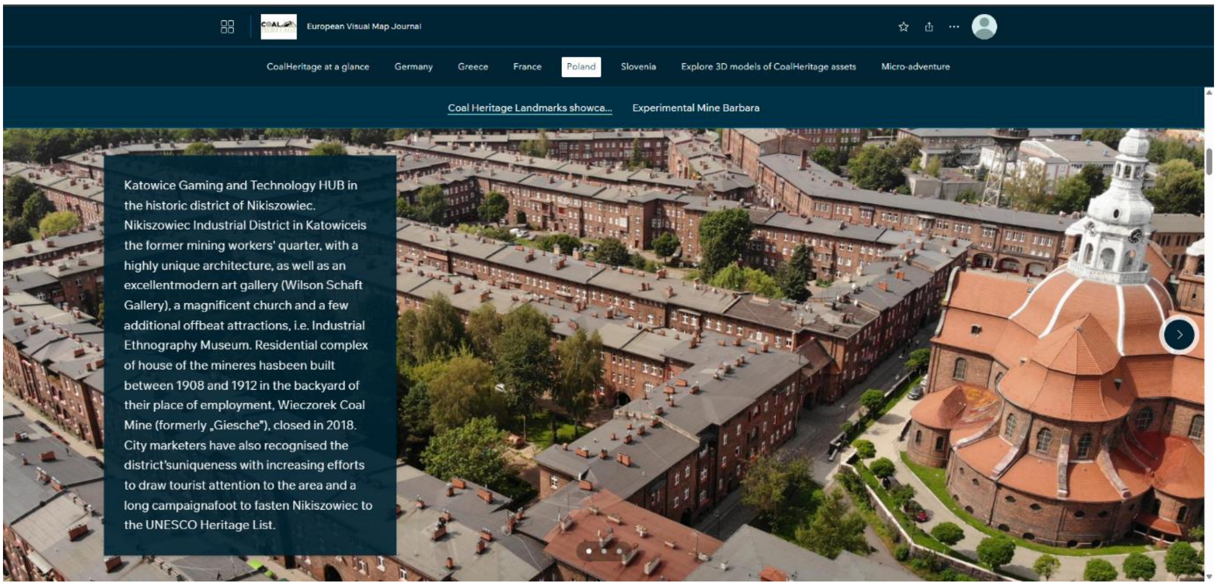
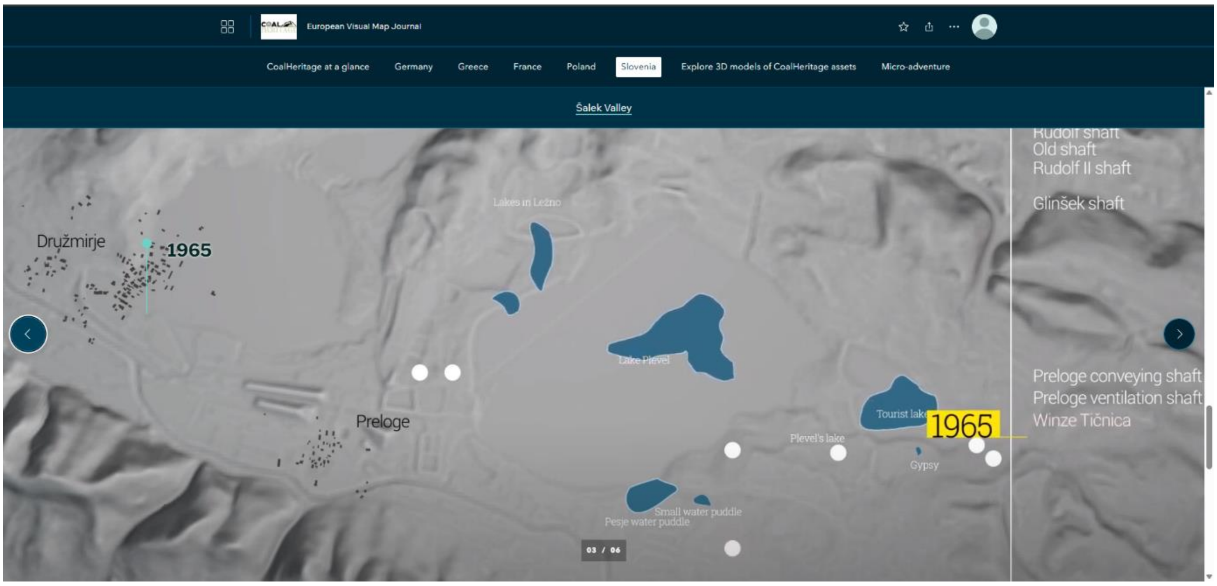


Figure 2.18: Visualisation of Polish 2D spatial data using a slide card interface, combining mapped heritage sites with accompanying photographs and descriptive text to enhance interpretive storytelling.

Moreover, the use of slide cards combined with interactive timelines allows for an effective visual representation of how specific areas have changed over time. By synchronising historical imagery, descriptive narratives, and spatial data, users can observe and understand the temporal evolution of coal mining regions in a clear and engaging manner (Figure 2.19).



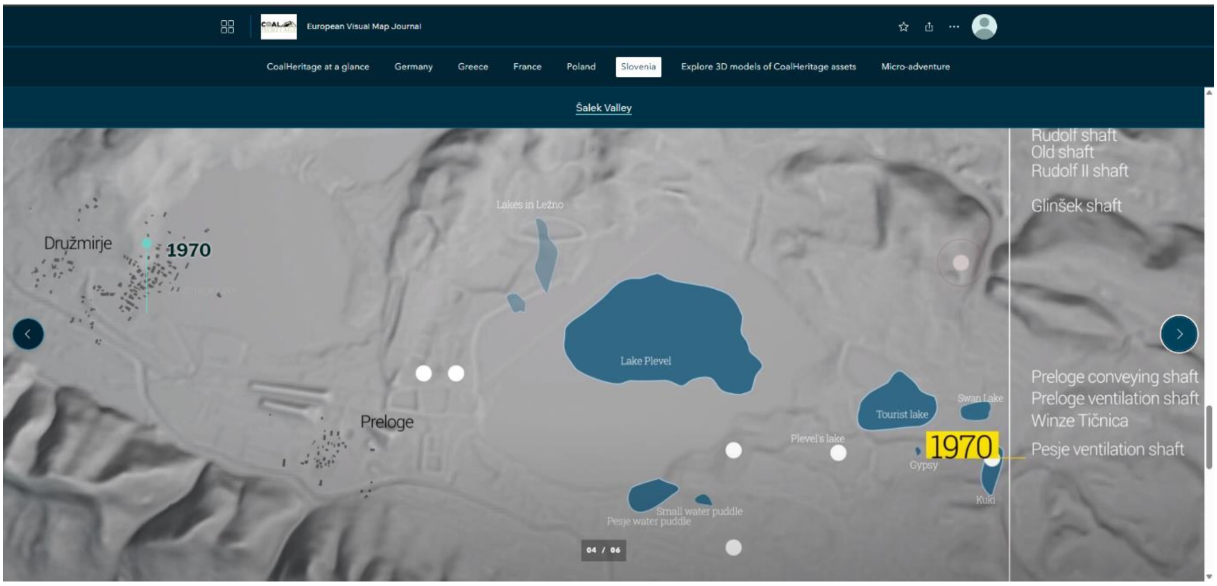


Figure 2.19: Combined use of slide cards and timeline tools to illustrate the spatial and historical evolution of a coal mining area, highlighting changes in landscape and site activity over time for Slovenian case.

Swipe widgets were used to enable comparative visualisation between different data layers—for example, contrasting historical coalfield extents with current land use, or comparing regional boundaries and mining zones. These tools enhance the visualisation of polygon and line features by revealing spatial change and context over time (Figure 2.20).

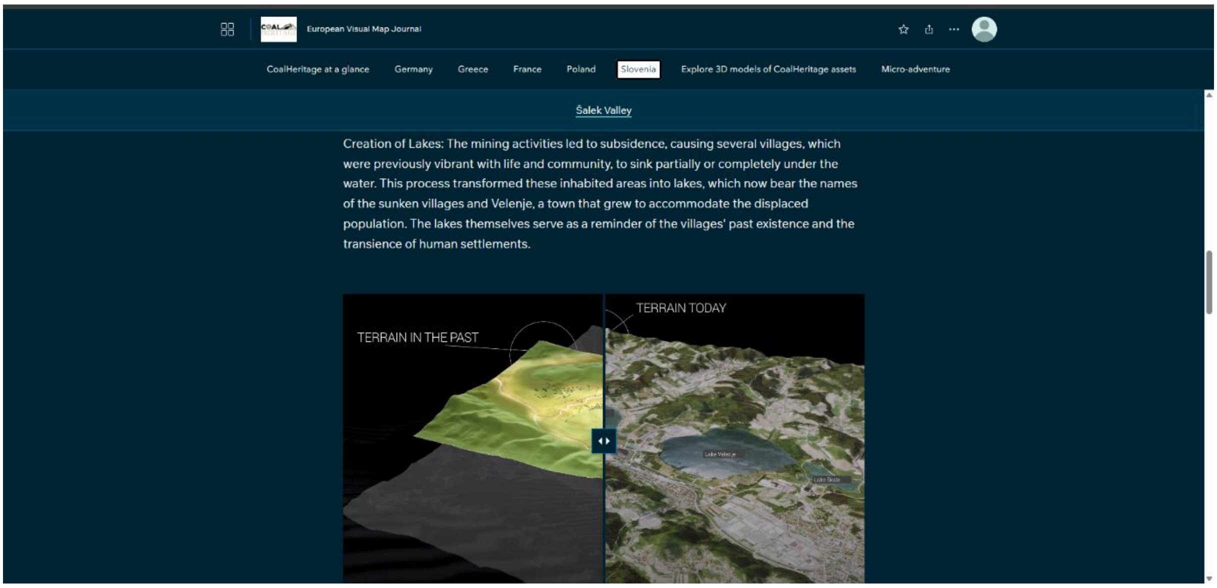


Figure 2.20: Use of the swipe widget to compare different terrain layers, illustrating changes in landscape and mining-related land use over time as part of the terrain evolution visualisation.

In addition, timelines were integrated into the narrative to highlight the most important periods of mining operations and site development (Figure 2.21). This layered visualisation strategy ensures that 2D spatial data is not only informative but also immersive, allowing users to explore Europe's coal heritage through a blend of location, history, and interactive design.

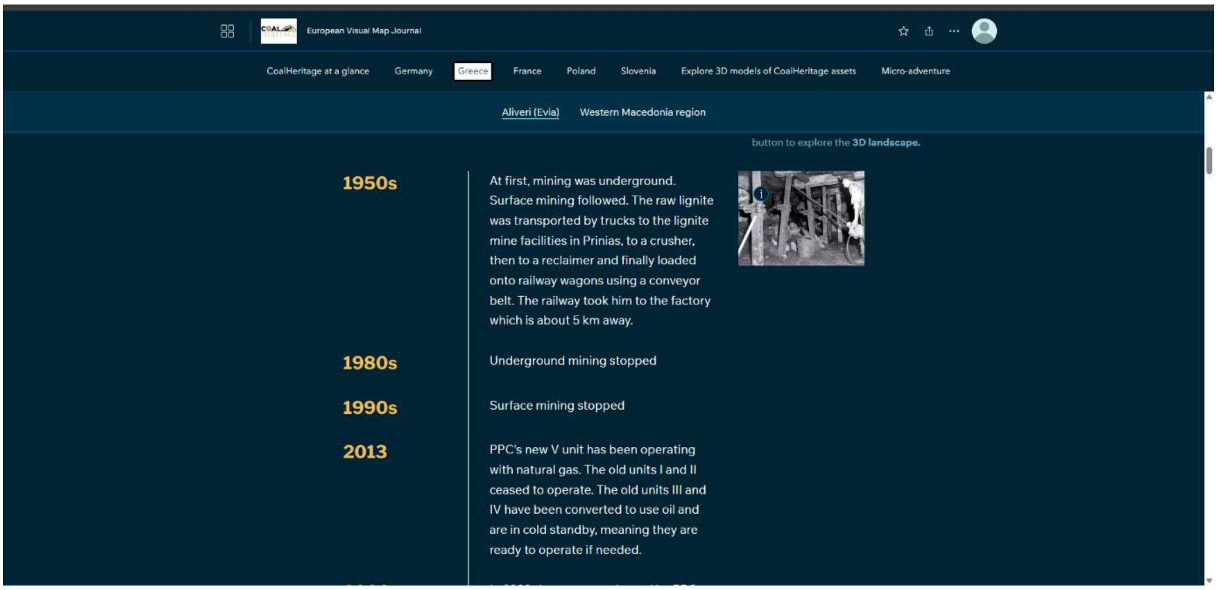


Figure 2.21: Timeline highlighting key historical moments in Greek coal history, specifically related to the mining activities in Aliveri.

In addition to 2D spatial representation, the European Visual Map Journal (EVMJ) incorporates advanced 3D visualisation features to enhance user engagement and provide a more immersive experience of coal mining heritage sites. These 3D elements are based on high-resolution models developed through photogrammetry and are presented within interactive scenes hosted on ArcGIS Online and embedded into the story map platform.

Users are able to navigate these 3D scenes freely, adjusting the view through rotation, zoom, and pan functions to explore the details of mining structures and surrounding environments. Each model is accurately georeferenced and scaled, offering a realistic visual representation of both surface and subsurface heritage elements (Figure 2.22).

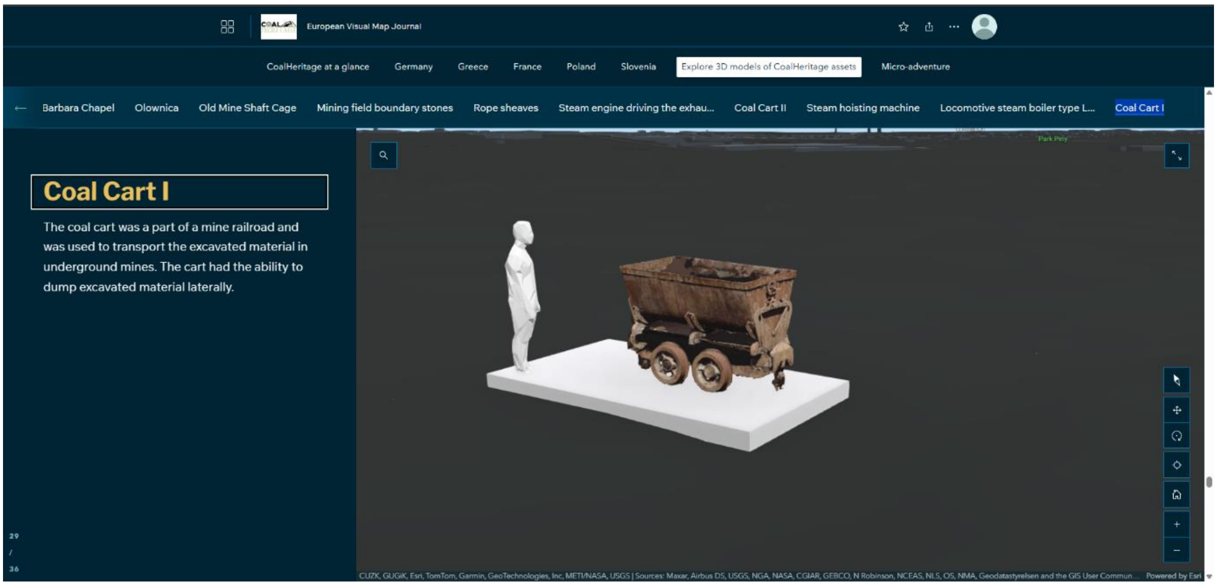


Figure 2.22: 3D item integration into the EVMJ platform accompanied by its relative informative text.

To further enrich the exploration experience, the platform includes interactive tools such as the distance measurement function, which allows users to calculate linear distances between features within the 3D environment (Figure 2.23).

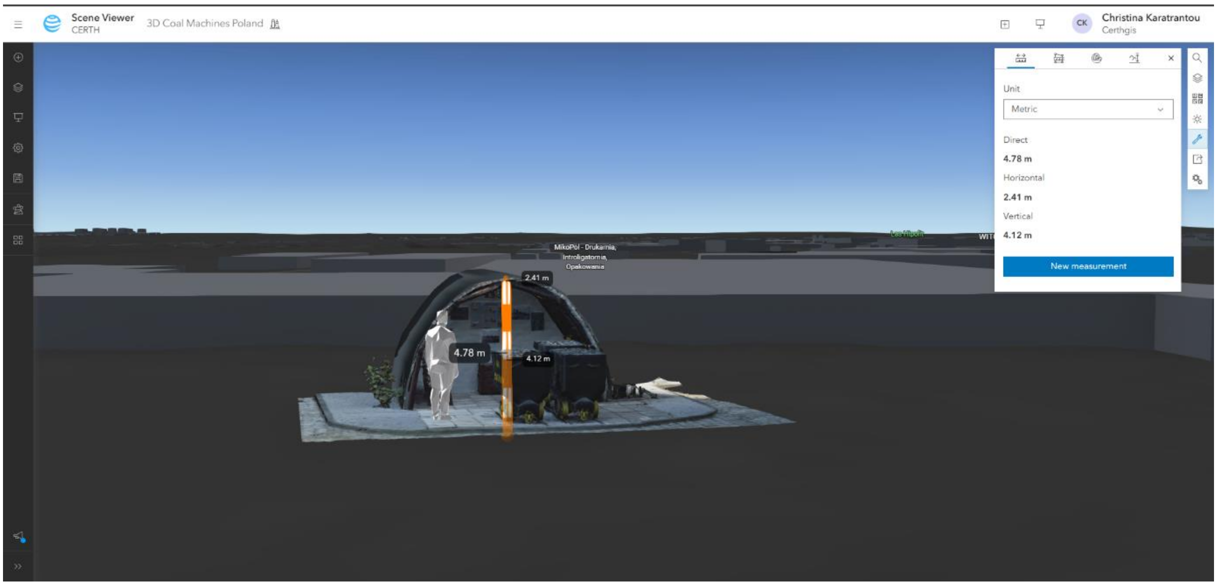


Figure 2.23: Measurement tool used to 3D item

Additionally, a slicing tool is available to virtually cut through models, revealing internal components and structural layouts that are not visible from the exterior. This is particularly useful for examining complex mining machinery or underground galleries (Figure 2.24). Together, these capabilities transform the EVMJ from a simple visual interface into an analytical and educational tool, enabling users not only to view but to interact with and interpret coal heritage data in a spatially rich and engaging way.

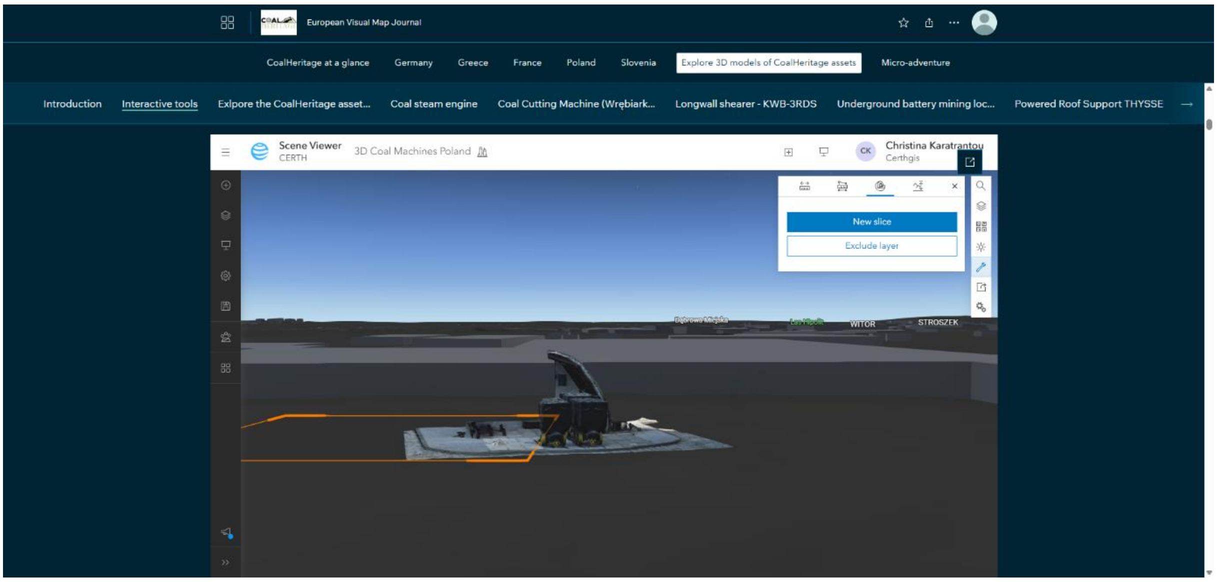


Figure 2.24: Use of slice tool to divide the 3D item.

3 Content of the Visual Map Journal

The European Visual Map Journal (EVMJ) is the digital front-end of the harmonised geodatabase developed under the CoalHeritage project. It translates structured spatial and attribute data into a publicly accessible narrative platform that combines cartographic elements, multimedia content, and 3D visualisations. This section provides an overview of the structure and content of the journal, highlighting how geospatial and descriptive elements are combined to portray coal mining heritage across five European countries.

3.1 Thematic and geographic structure

The EVMJ is organised into five main chapters, each dedicated to one of the participating countries: France, Germany, Greece, Poland, and Slovenia. Within each national chapter, the content is grouped thematically to include sites of industrial infrastructure, machinery, mining areas, and cultural monuments.

Each chapter begins with an interactive map based on vector layers prepared and published via ArcGIS Online. These maps are linked to a standardised attribute table across all countries, allowing users to explore metadata such as the name, location, operational period, mining status, activity type, and facilities available at each site. Accompanying each map is a narrative section that introduces the context and significance of the country's mining heritage, followed by more detailed descriptions of selected locations.

Uniform map design and symbology ensure visual consistency and intuitive navigation across national sections. In many instances, the interactive maps are supplemented with embedded multimedia and 3D content to enhance the user experience and provide a deeper understanding of the sites' historical and cultural importance.

3.2 Multimedia Integration

To complement the geospatial datasets, the EVMJ integrates a variety of multimedia formats that enrich the user experience and convey the cultural value of each site. These include high-resolution photographs, archival documents, and embedded videos describing mining practices, tools, and local traditions. Where possible, media are linked to specific features on the map to contextualise the visuals geographically.

The standout multimedia component is the 3D asset library. Developed through photogrammetry techniques, these models were optimised and hosted as Scene Layer Packages (SLPK) and embedded within ArcGIS StoryMaps. This visual enhancement allows users to interact with tangible heritage elements—such as locomotives, support structures, and mining equipment—as if exploring a virtual exhibition.

The photogrammetric method was particularly effective in preserving detailed surface textures and structural elements, making these assets suitable for educational and museum use beyond the project itself.

3.3 Best Practices and Interpretive Stories

Beyond static documentation, the EVMJ aims to highlight best practices in industrial heritage conservation and storytelling. Selected chapters include interpretive stories that illustrate how coal mining shaped local communities, traditions, and landscapes. For instance, the Polish chapter features a narrative about St. Barbara's Day, a culturally significant event for miners, while the French section presents a regional perspective on adaptive reuse of mining infrastructure.

These interpretive elements demonstrate the broader social and educational value of the map journal. They encourage visitors not only to explore locations but to engage with the human and historical dimensions of coal mining heritage.

4. Technical Implementation

The technical implementation of the European Visual Map Journal (EVMJ) was carried out through a carefully designed workflow that ensured the seamless transformation of harmonised geospatial data into a fully functional, web-based storytelling platform. This section outlines the data architecture, publication process, and deployment features that support the EVMJ's structure and interactivity.

4.1 Data Architecture

The underlying architecture of the EVMJ is built upon two complementary geodatabases developed in ArcGIS Pro and hosted via ArcGIS Online. The first geodatabase, titled CoalHeritage.gdb, contains all two-dimensional (2D) spatial datasets in vector format. These include point features for coal heritage sites, polygon features representing mine boundaries and administrative regions, and polyline features illustrating underground mining infrastructure (particularly in Slovenia). All datasets were standardised according to a common attribute schema described in Deliverable 4.1, ensuring cross-country interoperability.

The second geodatabase, FINAL_3D_MODELS_SCALED.gdb, was designed specifically for storing and managing three-dimensional (3D) assets. These models, initially developed in GLB format using photogrammetry, were processed into Scene Layer Package (SLPK) format to allow for smooth integration into the ArcGIS environment. Each 3D asset was georeferenced and associated with its corresponding site location in the map journal, allowing users to view and interact with the models directly from the web platform.

4.2 Integration with EGDI

In addition to its presence on ArcGIS Online, a harmonised version of the geodatabase was prepared for integration with the European Geological Data Infrastructure (EGDI). This involved converting the national shapefiles into a single, merged dataset with a unified attribute structure and a common spatial reference system (EPSG:4326 – WGS 84). This merged dataset was validated to ensure consistency with EGDI standards, enabling compatibility with other geological datasets and tools used across Europe.

Through its publication on the EGDI platform, the CoalHeritage dataset becomes accessible not only to EVMJ users but also to researchers, policymakers, and institutions interested in European geological and cultural heritage. Direct links to the EGDI-integrated data are also embedded within the EVMJ, enabling users to download or explore additional resources.

4.3 Web Deployment and Usability

The final platform was deployed via ArcGIS Online using the ArcGIS StoryMaps builder, which offers a modular framework for combining narrative text with spatial data and media content. Each chapter of the journal corresponds to a curated StoryMap section, comprising embedded maps, multimedia panels, and 3D visualisation elements.

To enhance usability, the platform was designed with a uniform interface across all chapters. Interactive features such as pop-up windows, clickable site markers, and side-panel narratives allow users to intuitively explore the content. 3D models are rendered in embedded viewers that support zoom, pan, and rotation, enabling a detailed examination of artefacts from different angles.

Accessibility considerations included the use of responsive layouts for desktop and mobile viewing, the optimisation of image and model file sizes for faster loading, and the application of metadata tags and consistent symbology to improve navigation. Where applicable, content has been made available in multiple languages to increase reach among regional audiences.

The EVMJ is published under open access, with all web maps, scene layers, and story chapters made publicly available.

4.4 Visualisation Workflow and Publishing Procedures

The transformation of geospatial and multimedia content into a functional and publicly accessible platform involved a multi-step visualisation and publishing workflow, primarily carried out within ArcGIS Pro and ArcGIS Online. This workflow ensured that all spatial datasets and 3D elements were prepared, optimised, and published in a way that preserves both data integrity and user experience.
The process began with the creation and styling of web maps in ArcGIS Pro (Figure 4.1).

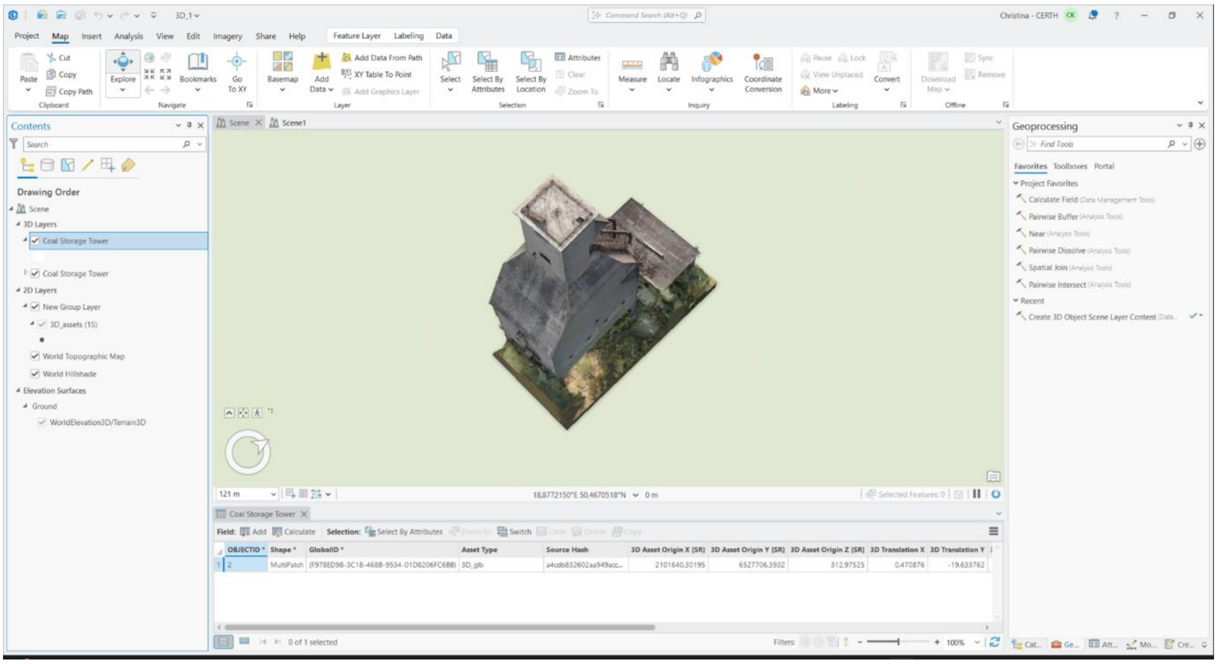


Figure 4.1: 3D item in ArcGIS Pro platform.

Harmonised 2D and 3D datasets were symbolised using attribute-driven rules to ensure consistency across countries. Pop-ups were configured to display key attribute information, and basemaps were selected based on clarity and contextual relevance, with preference given to 3D terrain and urban scenes to enhance realism.
Once the cartographic setup was complete, the content was prepared for publication. The maps were shared as Web Layers through the “Share As Web Layer” tool in ArcGIS Pro. During this step, metadata fields such as title, summary, tags, and usage rights were completed, and sharing permissions were defined based on project requirements. Most layers were published as hosted feature layers or scene layers, enabling full interactivity in ArcGIS Online (Figure 4.2).

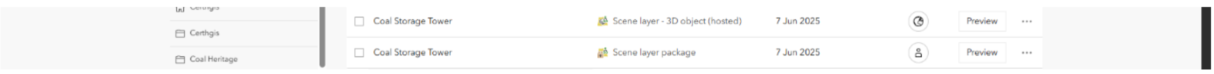


Figure 4.2: Export layers for ArcGIS Pro and Online integration.

3D models, originally created in GLB format, were converted to Scene Layer Packages (SLPK) using ArcGIS Pro’s “Create 3D Object Scene Layer Package” tool. These SLPK files were then uploaded and published as hosted 3D scene layers, integrated into 3D web scenes (Scene Viewer) and embedded in the StoryMaps platform (Figure 4.3).

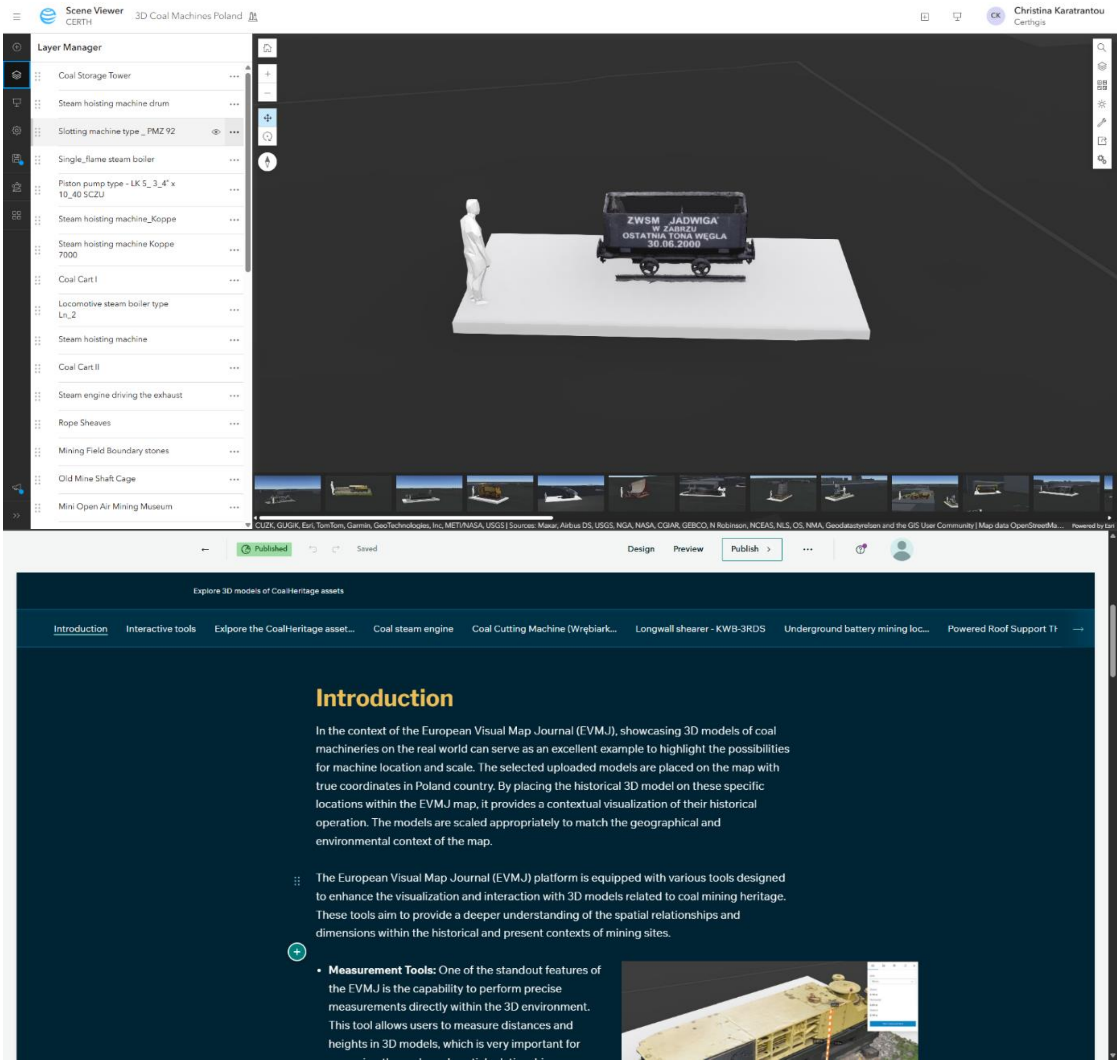


Figure 4.3: Visualisation of geospatial content using the ArcGIS Scene Viewer and StoryMap interfaces, illustrating the integration of 3D models and interactive storytelling elements within the EVMJ platform.

The user interface of each story section was constructed in ArcGIS StoryMaps, using pre-configured web maps, multimedia blocks, timelines, slide carousels, and swipe widgets. These elements were assembled into a cohesive narrative, allowing users to interact with both spatial data and contextual content in an intuitive, scroll-driven environment.
The publishing procedure concluded with the testing of public access, responsiveness across devices, and metadata verification to ensure discoverability. This structured workflow ensured that the European Visual Map Journal would function not only as an informative platform, but as a sustainable and replicable model for digital heritage dissemination.

4.5 User Interface Design and Navigation

The general user interface of the European Visual Map Journal (EVMJ) has been designed to support intuitive navigation across the platform's interactive content. As shown in Figure 4.4, the interface includes dedicated navigation buttons for each participating country, enabling users to directly access the corresponding datasets, thematic stories, and multimedia content. This structure ensures that users can explore the coal mining heritage of each region in a focused and accessible manner

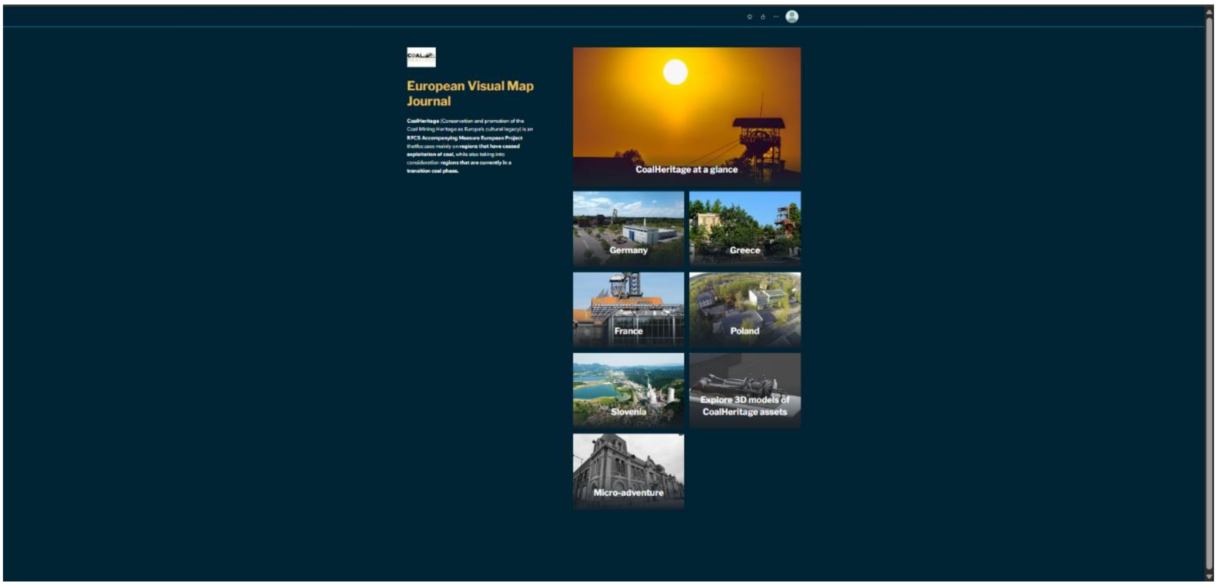


Figure 4.4: Overview of the EVMJ platform's user interface, featuring country-specific navigation buttons that provide direct access to each participant's dataset and thematic content

In addition, Figure 4.5 presents the platform's button bar, which offers quick access to supplementary pages and thematic sections. This navigation element enhances usability by allowing seamless transitions between main story components, such as Micro-adventures, historical overviews, and 3D model scenes. Together, these interface features contribute to a coherent and user-friendly digital experience, supporting both guided exploration and open-ended discover

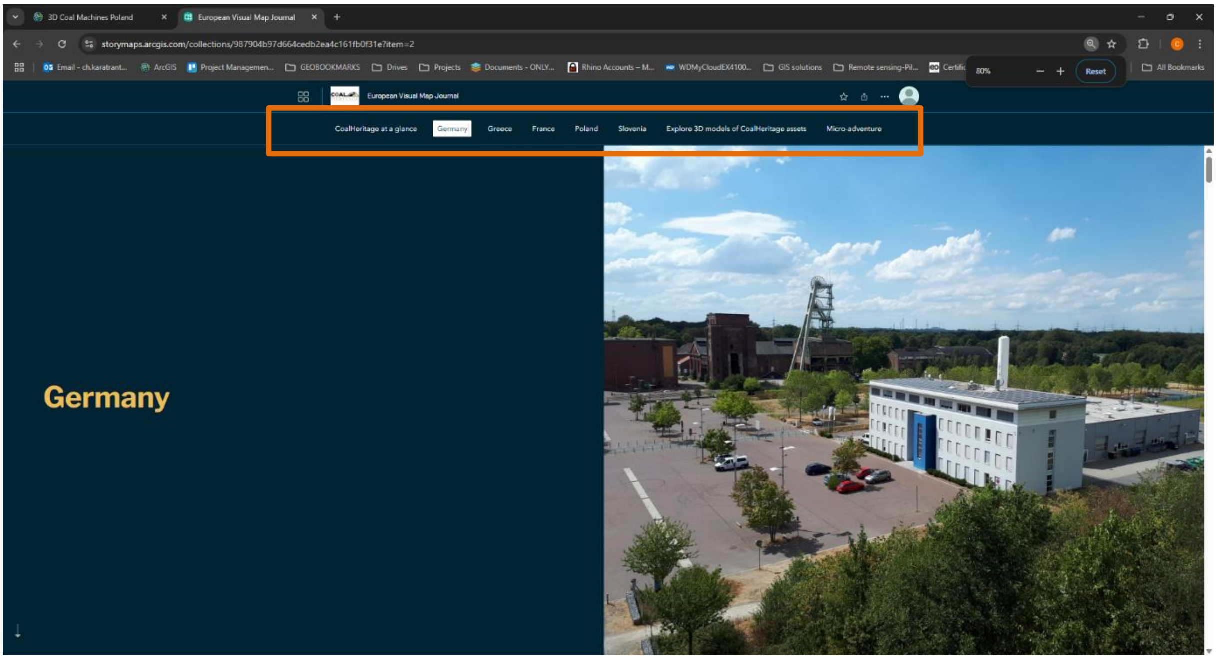


Figure 4.5: Navigation bar displaying shortcut buttons for quick access to additional pages and thematic sections within the EVMJ platform.

5 Framing the EVMJ through Micro-adventures

In addition to its cartographic and educational functions, the European Visual Map Journal incorporates the concept of microadventures—short, accessible, and meaningful excursions that encourage public engagement with coal mining heritage through local exploration. This concept was integrated using the ESRI StoryMaps platform to invite users not only to view heritage sites on a screen, but to experience them firsthand (Figure 5.1).

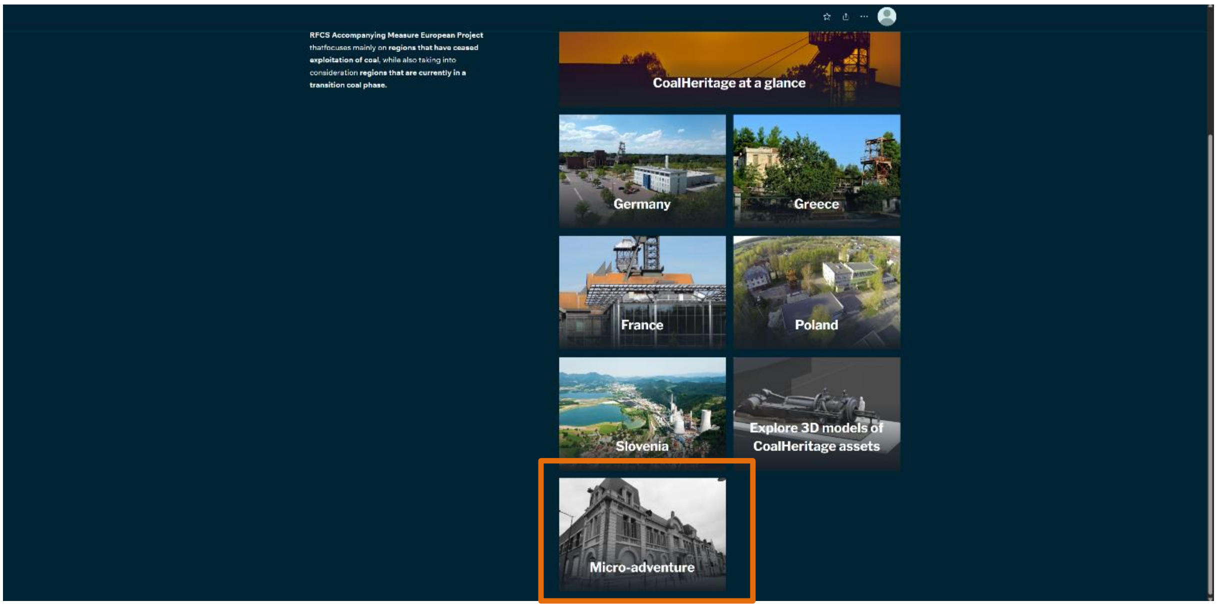


Figure 5.1: The integration of Micro-adventures concept to EVMJ platform

Within the CoalHeritage project, this concept was adapted to heritage and cultural tourism, encouraging visitors, residents, students, and cyclists to explore mining sites, monuments, and landscapes within their own region or during short visits.
Each participating country contributed a thematic itinerary designed to blend interactive maps, narrative descriptions, and multimedia elements, effectively simulating a guided excursion. Recognising that not all heritage sites are physically accessible, and to ensure balanced data representation across partners, it was agreed that each thematic itinerary should include a minimum of ten Points of Interest (POIs). Table 5.1 below presents the microadventure concepts developed by each country, along with corresponding URL links to their published stories.

Table 5.1: List of Micro-adventures concepts developed for each country participant

Country Participant	Micro-adventure concept	Points of Interest
Germany	German Micro-adventure 1 “Through the Heart of Coal Mining: Cycling from Essen to Boshum”	10
	German Micro-adventure 2 “From Industrial landscapes to Green Parks: Cycling from Duisburg to Dortmund”	4
	German Micro-adventure 3 “From Coal Mines to Scenic trails: Exploring Witten, Hattingen, and Hamm”	5
Greece	Discover Evia’s Industrial Heritage “A journey Through Greece’s Coal-Powered Past”	7
	Ptolemaida and the Amyntaio Lignite Plant “A Tour of Greece’s Energy Backbone”	12
France	French Micro-adventure 1 “From West to East: A Journey Through the Nord-Pas de Calais Mining Basin (UNESCO Wolrd Heritage)”	14
	French Micro-adventure 2 “Visiting the Lewarde Mining Historical Center	14
Slovenia	A trip in the footsteps of SHAFTS & DRIFTS	19
Poland	A trip in the footsteps of STEAM ENGINES	5

	A trip in the footsteps of Coal Cutting Machines	3
	A trip in the footsteps of Mining means of transport	6
	A trip in the footsteps of Mining Architecture	9
	A trip in the footsteps of Coal Mine Shafts	7
	A trip in the footsteps of COAL-WASTE DUMPS	4
	A trip in the footsteps of Coal Mining Museums	8
	Mining Settlements	4
	Old industrial quarter in Katowice-Nikiszowiec	13
	Shafts	7

As part of the Micro-adventure concept within the EVMJ platform, the Map Tour tool was utilised to present selected heritage sites in a sequential and visually engaging format. This tool allows users to navigate through a curated itinerary, with each stop featuring a geographic location linked to descriptive text, photographs, and additional context. The example shown in the image demonstrates how the Map Tour enhances user engagement by combining spatial navigation with storytelling, encouraging exploration of coal mining heritage sites as a guided digital excursion. This format supports both virtual visits and the planning of real-world site exploration (Figure 5.2).

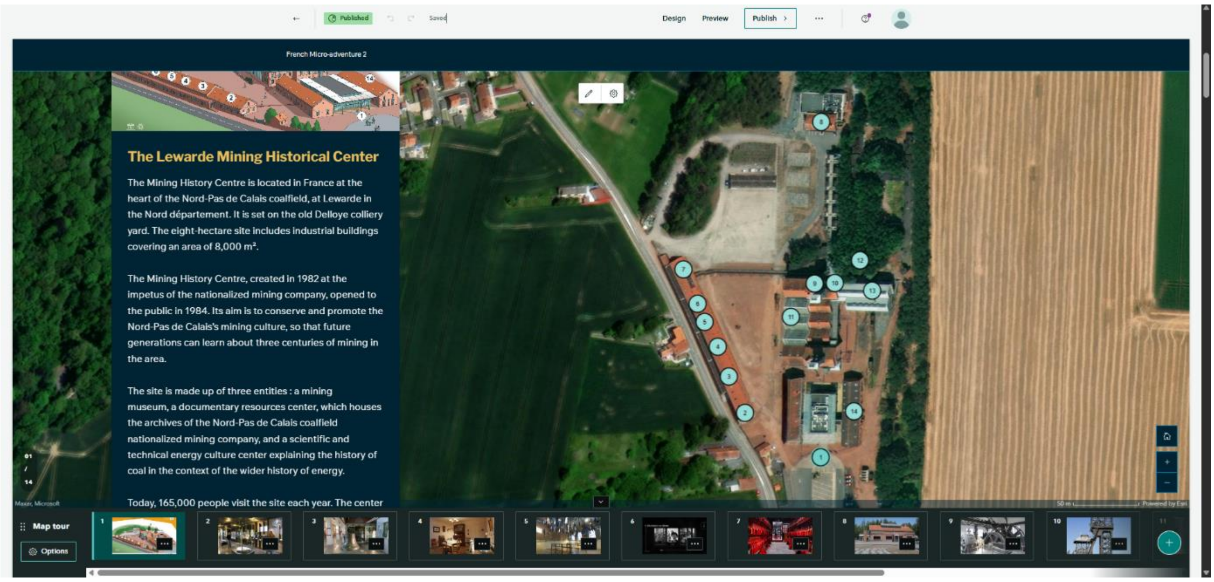


Figure 5.2: Application of the Map Tour tool to present the Micro-adventure concept, guiding users through a sequence of heritage sites with integrated maps, images, and narratives.

Users are introduced to the historical background of each site, followed by suggested routes, nearby landmarks, and stories related to local traditions—such as Saint Barbara's Day in Poland (Figure 5.3) or the evolution of mining communities in Greece and France.

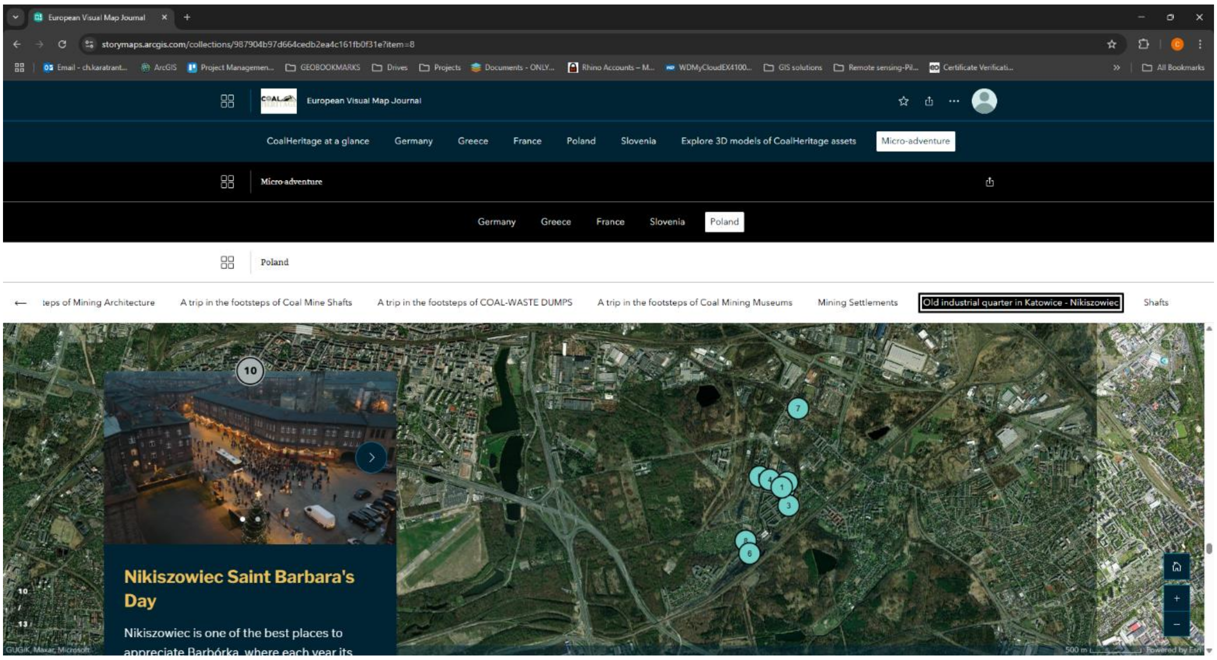


Figure 5.3: Incorporated information for Saint Barbara's Day in Poland

The integration of photographs, videos (Figure 5.4), and 3D models significantly enhances the sense of presence, enabling virtual exploration to serve as a catalyst for encouraging physical site visits.

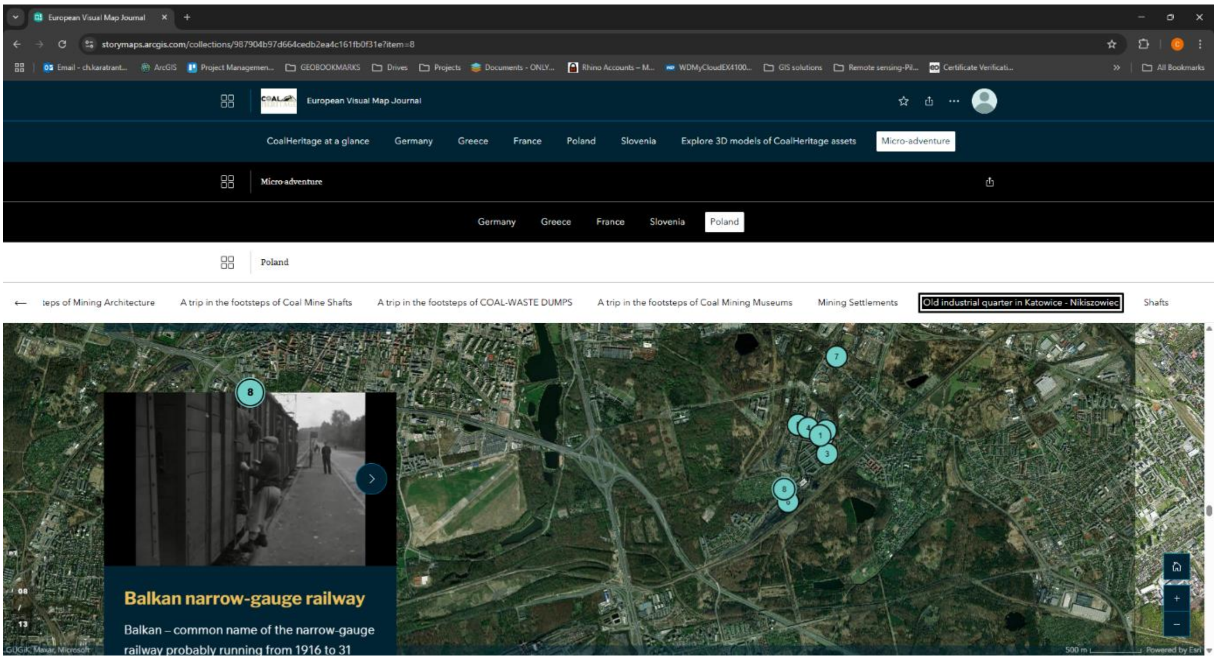


Figure 5.4: Video material related to Balkan narrow-gauge railway

This approach has proven particularly effective in engaging younger audiences and local communities who may not identify with traditional museum-based heritage experiences. By framing coal heritage sites as accessible destinations within reach of a weekend outing, the EVMJ promotes cultural education, regional tourism, and the revalorization of post-industrial landscapes.

Ultimately, the inclusion of Micro-adventure style storytelling serves both practical and strategic goals of the project: it fosters public participation, supports sustainable heritage tourism, and encourages a positive reinterpretation of mining regions in transition.

CONCLUSIONS

The creation of the European Visual Map Journal represents a key achievement of Work Package 4 within the CoalHeritage project. By transforming harmonised geospatial and multimedia datasets into an accessible and engaging storytelling platform, D4.2 delivers a dynamic digital tool that supports heritage visibility, public participation, and educational outreach.

Through the use of modern GIS technologies, 3D modelling, and curated thematic narratives, the EVMJ bridges technical documentation with user-friendly design. It invites both experts and the general public to discover the cultural and historical value of coal mining sites across five European countries. The integration of the harmonised dataset into the EGDI platform further strengthens the legacy and utility of this work, positioning it within a wider European data ecosystem.

In conclusion, the EVMJ demonstrates the potential of spatial storytelling in heritage preservation and awareness. It provides a replicable framework for other post-industrial regions and contributes to the broader objectives of the CoalHeritage project by linking past legacies with future-oriented digital engagement.

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