ROBOMINERS

ROBOMINERS DELIVERABLE D5.3

DATABASE OF EUROPEAN ORE DEPOSITS RELEVANT FOR ROBOMINERS

Summary:

This report presents how public data on mineral deposits which are potential targets of the robotic mining technology, was collected in several European countries, screened and organised in a comprehensive database, to be included in the EU's Raw Materials Knowledge Base.

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EXECUTIVE SUMMARY

The primary role of Task 5.3 is to support the preparation for pilots and higher TRL demonstration of the ROBOMINERS technology (to be made in work package 8), providing tangible information on suitable testing sites.

This report presents how information that has been collected by EFG's linked third parties from publicly available datasets at the national level on mineral deposits (in Task 5.3) was handled and consolidated in a comprehensive database. EFG supervised data collection, gathered and harmonised all data and produced a database that is publicly accessible and integrated into the EU Raw Materials Information System.

In the data collection and treatment processes, particular focus was given to mineral deposits that, due to their characteristics, have not been considered by any other investigations, and their development may only be possible with ROBOMINERS technology. These can be abandoned mines, too small deposits for traditional mining, and/or restricted by access because of, for example, proximity to urban areas or nature conservation areas.

1 INTRODUCTION

The primary role of Task 5.3 is to support the preparation for pilots and higher TRL demonstration of the ROBOMINERS technology (to be made in work package 8), providing tangible information on suitable testing sites. This activity encompassed the collection of publicly available data on mineral deposit types, genesis & occurrences in Europe (with a special focus on deposits and mineral occurrences that were considered uneconomic to exploit), creating a pool of mineral deposits that could become suitable targets for the ROBOMINERS technology.

The collection of information included desk research on past European investigations that created openly accessible geological datasets. Geological reports, publications, and studies have been reviewed by linked third parties of EFG (European Federation of Geologists), that screened and collected publicly available data at a national level.

A particular emphasis was given to mineral deposits/formations that, due to their status, were not considered in previous investigations and whose development may only be possible with ROBOMINERS technology. Examples of such deposits include too small for traditional mining and/or restricted by access deposits beneath urban areas or in nature-protected zones. As this robotic technology can be applied to small-scale mining, we targeted mostly metal-bearing ore deposits. Still, higher value non-metallic commodities, for example graphite, were also considered.

2 METHODOLOGY

The EFG and the University of Miskolc have created a template to be used by EFG's linked third parties to collect the information using similar standards, in order to ensure a good level of homogeneity.
Data collectors were requested to collect data on all known ore deposits in their country, including:

- Operating and abandoned mines or mine-sections with known remaining unfeasible resources;
- Ultra deep (more than 1400m depth) deposits;
- Small deposits considered uneconomic for traditional mining.

The template itself was provided in an excel file containing four tabs, one where the data could be added and the other three with guidelines and background information.

The information collected in the template was organised in the following fields:

- Site name;
- Mine/unexploited resource;
- Country;
- Longitude/Latitude;
- Altitude (MASL);
- Depth of the highest point of the deposit;
- Historic time range;
- Deposit type (drop-down menu);
- Commodity 1 Commodity 2 Commodity 3 Commodity 4 (If applicable);
- Main host rock;
- Geotechnical attributes;
- Magnitude (Small/Medium/Large);
- Technical report available (CRIRSCO compatible;
- Geological Information (Link/DOI, ISBN, ISSN, National archive identifier);
- Geothermal gradient;
- Exploration permission;

- Restrictions;
- Additional notes.

Figures 1 and 2 below illustrate the overall look of the Excel spreadsheet used to collect data.

Data of deposits relevant for the ROBOMINERS technology

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Site name	Mine/unexploited resource	Country	Longitude	Latitude	Altitude (MASL)	Depth of the highest point of the deposit	Historic time range	Deposit type (drop-down)	Commodity 1	Commodity 2	Commodity 3	Commodity 4

Figure 1: Section of the working sheet from the data collection template.

Main host rock	Geotechnical attributes	Magnitude (S/M/L)	Technical report available, Y/N	Geological information				Geothermal gradient	Exploration permission	Restrictions	Additional notes
				Link or DOI	ISBN	ISSN	National archive identifier				

Figure 2: Section of the working sheet from the data collection template. This part is a continuation of Figure 1, located at the right side of it.

The amount of data collected from different countries varies greatly. This can be explained by the size, diverse geological features and mineralogy of each country. But another reason for the disparity of public information available are the differences on public access to geological/mining data in different European countries. Table 1 presents the number of data entries by country, stating these differences.

16 EFG's linked third parties participated in the data collection, covering 17 European countries[1]. However, mineral deposits from Luxembourg are poorly constrained, and no entries for the country were selected for the final database, as they do not meet the final selection criteria.

Table 1: Number of data (entry points) collected by EFG´s linked third parties.

Country	English name of the linked third party	Number of entries
Bel-Lux	Belgo-Luxembourg Union of Geologists	15
Bulgaria	Bulgarian Geological Society	8
Croatia	Croatian Geological Society	126
Czech Rep.	Czech Association of Economic Geologists	18
Estonia	Geological Society of Estonia	6
Germany	Professional Association of German Geoscientists	236
Greece	Association of Greek Geologists	163
Hungary	Hungarian Geological Society	6
Italy	Italian National Council of Geologists	5
Poland	Polish Association of Minerals Asset Valuators	25
Portugal	Portuguese Association of Geologists	407
Serbia	Serbian Geological Society	18
Slovenia	Slovenian Geological Society	141
Spain	Official Spanish Association of Professional Geologists	169
Turkey	Turkish Association of Economic Geologists	14
Romania	National Assoc. of Professionals in Geology and Mining	41
	Total:	**1398**

It is important to remark that the numbers described in the table above are the final ones, obtained after the refinement and the elimination of incomplete/scarce data. Therefore, the original number of data entries provided by the linked third parties was slightly higher.

3 MANAGEMENT OF DATA AND VISUALISATION

3.1 DATA HARMONISATION

Since some of the collected information did not comply with the guidelines provided in the template, and several other entries differed in the format, EFG and the Royal Belgian Institute for Natural Sciences (RBINS) carried out an intense dataset harmonisation effort. Data harmonisation was concentrated on the following entries:

[1] This is due to the fact that one association covers Belgium and Luxembourg.

- **Main host** and **Commodity**

The entries belonging to the *Main host* and the *Commodity* columns were relisted according to the Inspire Codelist (https://inspire.ec.europa.eu/codelist). The use of Inspire Code as a reference document for geological and lithological descriptions aims to facilitate the use of this database by other European projects and the integration with other datasets. All information not compatible with the code list was moved to the *Additional notes* column, to preserve all the original data provided by the linked third parties. Moreover, the *Main host* column has been subdivided into four columns (Main host rock 1; Main host rock 2; Main host rock 3; Main host rock 4) as in the *Commodity*.

- **Coordinates**

It was also necessary to convert coordinates provided in degrees, minutes and seconds for Croatia, Poland, and Romania into decimal degrees.

- **Historic time range**

The number of exploitation years was calculated from the *Historic time range* column, and it is now shown in the corresponding column.

- **Additional notes**

The information regarding publications and articles in the *Additional notes* has been moved to a new column named *Bibliography.*

- **Altitude**

As few countries (Croatia, Germany, Portugal) did not complete all the entries for the altitude value, it was necessary to compute it. To do so, a Python script was created (see Annex 3) in order to extract the altitude value of the given coordinates from the European digital surface model available at EU-DEM — Copernicus Land Monitoring Service.

After those quality checks, the selected entries were ready to be transferred to the database.

3.2 CREATION OF THE DATABASE

The ROBOMINERS database was modelled according to an object-relational model, including information structures in tables and rows. Each row is composed of a unique identifier (primary key) and a collection of attributes organized in columns. The tables are linked via foreign keys allowing referential integrity constraints.

The selected database engine was PostgreSQL https://www.postgresql.org/ , a free and open-source software developed by a large consortium of contributors. PostgreSQL provides, amongst other things, the data server capacity for web-oriented applications and the information stored in the database can be readily queried thanks to SQL statements, a widely-used language for data and database processing.

The designed structure has a backbone table referred to as the mine table, that hosts many unique data elements for each identified mine. Other linked tables include INSPIRE codelist, for the commodity, the host rock and the countries, and ROBOMINERS codelist, such as the list of the deposit type. A last category of tables includes data that is not necessarily unique for a given mine, like geological information or additional notes.

After the creation of the structure, the data were integrated thanks to an R script that read the data contained in the excel file and automatically direct them to the proper table.

3.3 CREATION OF THE OPEN-ACCESS ONLINE WEB INTERFACE

To browse through the open-access database a map-based interface is being developed by RBINS. This user interface will allow the targeted screening of the database through a OpenStreetMap-based visualization, combined with additional selection criteria. Users will be able to filter the dataset according to specific interests and queries, and to extract relevant information from the online database.

Selection and navigation across mineral deposits may take place through commodity, location (coordinates, region, or country), deposit type, and host rock. When users select a mine/mineral deposit from the map interface a pop-up window will appear with basic information regarding the mine/site name, location, and commodities. Besides, by clicking on the "more" button in the pop-up window, users will be forwarded to another page where all the information concerning the site/mine is listed.

4 CONCLUSIONS

As mentioned in section two, the amount of data collected from different countries varies significantly. This can be explained by the limited availability of open-source records and by each country geological endowment. The scarcity of records in some countries may reflect past policies (e.g. state control over geological information in ex-socialist countries) and the current importance given to the subject by political stakeholders (Italy's five entries and Portugal's 407 entries are most probably explained by this).

Nevertheless, the database includes a considerable amount of data entries, encompassing mineral targets and small/uneconomical deposits that were never collected, screened and organised at the European level. Moreover, the full compatibility with Inspire makes this data relevant for integration with other datasets, hence contributing to enhance and complete the European Union Raw Materials Knowledge Base (EURMKB).

Therefore, the planned hand-over of the ROBOMINERS database described in this document to the Joint Research Centre (the EU institution that manages the EURMKB) will contribute towards enhancing natural resources' management at the European level.

The map-based interface of the database (still being developed) will be accessible in the ROBOMINERS webpage (www.robominers.eu/), and it will also be hand-over to the Joint Research Centre after the completion of the ROBOMINERS project.

5 ANNEXES

5.1 ANNEX 1: DATA COLLECTION TEMPLATE

Table A1: Template distributed to linked third parties for data collection (graphics extracted from Excel spreadsheet, view from left to right hand columns).

Data of deposits relevant for the ROBOMINERS technology

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Mine index	Site name	mine status type / unexploited resources	Country	Longitude	Latitude	Altitude (ASL) (m)	Depth of the highest point of the deposit (m)	Historic time range	Number of exploitation years (known)	Deposit type (drop-down)	Commodity 1	Commodity 2	Commodity 3	Commodity 4
POL0005	Chechlo	Unexploited resources	Poland	18,3999984	50,3999984	174	202	1957-1977	20	MVT	zinc	lead		
POL0006	Zawiercie 3	Unexploited resources	Poland	19,41679	50,48766	133	145	1953-1988, 2011-2018	43	MVT	zinc	lead		
POL0007	Nieoka Grodziecka	Closed mine	Poland	15,71376667	51,22074722	215	45	1940-1989	49	SSC	copper	silver	molybdenum	cobalt
POL0008	Nowy Kosciol	Closed mine	Poland	15,88103333	51,08565833	220	53	1955-1968	13	SSC	copper	silver		
POL0009	Radvanice-Gaworzyce	Unexploited resources	Poland	15,93841111	51,59145833	134	404	2013-Present	8	SSC	copper	silver		
POL0010	Bytom Odrzanski	Unexploited resources	Poland	15,99002222	51,67915278	91	1241	up to 2007		SSC	copper	silver		
POL0011	Glogów	Unexploited resources	Poland	16,11126111	51,64426389	130	1325	up to 2007		SSC	copper	silver		
POL0012	Retków	Unexploited resources	Poland	16,23451111	51,57045833	86	1055	up to 2007		SSC	copper	silver		
POL0013	Wartowice	Unexploited resources	Poland	15,66207222	51,22365556	230	541	up to 2007		SSC	copper	silver		
POL0014	Mozów	Unexploited resources	Poland	15,54007222	52,069475	74	2100	2012-2020		SSC	copper	silver		
POL0015	Sulmierzyce	Unexploited resources	Poland	17,65172778	51,63311111	120	1400	2012-2020		SSC	copper	silver		
POL0016	Nowa Sol	Unexploited resources	Poland	15,88170556	51,89038056	68	1771	2012-2020		SSC	copper	silver		
POL0017	Rudna	Mine	Poland	16,12093889	51,516725	151	844	1970-Present	50	SSC	copper	silver	gold	nickel
POL0018	Sieroszowice	Mine	Poland	16,00863333	51,56933611	140	656	1980-Present	40	SSC	copper	silver	gold	nickel
POL0019	Lubin-Malomice	Mine	Poland	16,20337222	51,424225	150	368	1967-Present	50	SSC	copper	silver	gold	nickel
POL0020	Polkowice	Mine	Poland	16,03505278	51,47870278	148	381	1968-Present	50	SSC	copper	silver	gold	nickel
POL0021	Glogow Gleboki - Przemyslowy	Mine	Poland	16,07269611	51,61713333	120	1164	2005-Present	15	SSC	copper	silver	gold	nickel
POL0022	Zdrada	Unexploited resources	Poland	18,308712	54,726545	45	824	up to 1973		Non-metallic	salt			
POL0023	Chlapowo	Unexploited resources	Poland	18,36958	54,801634	40	752	1964-1980	16	Non-metallic	salt			
POL0024	Mieroszyno	Unexploited resources	Poland	18,313128	54,789816	15	737	1964-1980	16	Non-metallic	salt			

Main host rock 1	Main host rock 2	Main host rock 3	Main host rock 4	Geotechnical attributes	Magnitude (S/M/L)	Technical report available, Y/N	Geological information			
							Link or DOI	ISBN	ISSN	National archive identifier
Dolomite				20-70 Mpa	S	N	N/A	N/A	N/A	CDBG 947475
Dolomite				20-70 Mpa	M	Y	N/A	N/A	N/A	CDBG 1243245
carbonateSedimentaryRock	sandstone	shale		10-40 Mpa	M	N	https://doi.org/10.1515/gospo-2016-0019	ISBN 83-86286-83-0	N/A	NAG 6260 CUG, NAG 8933 CUG, NAG 9008 CUG, NAG 24/92, NAG 118/96, NAG 4518/2009
mudstone	limestone			10-40 Mpa	M	N	N/A	ISBN 83-86286-83-0	N/A	NAG 1798/96
sandstone	dolomite	shale		15-144 MPa	L	N	https://doi.org/10.1515/gospo-2016-0019	ISBN 978-83-922065-7-6	N/A	NAG 2800/2015
sandstone	dolomite	shale		15-144 MPa	L	N	https://doi.org/10.1515/gospo-2016-0019	ISBN 978-83-922065-7-6	N/A	NAG 17185 CUG, NAG 2596/96, NAG 246/99, NAG 1058/2004, NAG 4513/2009
sandstone	dolomite	shale		15-144 MPa	L	N	https://doi.org/10.1515/gospo-2016-0019	ISBN 978-83-922065-7-6	N/A	NAG 1075/94, NAG 2539/96, NAG 244/99, NAG 1057/2004, NAG 4514/2009
sandstone	dolomite	shale		15-144 MPa	L	N	https://doi.org/10.1515/gospo-2016-0019	ISBN 978-83-922065-7-6	N/A	NAG 2600/96, NAG 245/99, NAG 1056/2004, NAG 4515/2009
mudstone	limestone			10-40 Mpa	M	N	https://doi.org/10.1515/gospo-2016-0019	ISBN 978-83-7538-695-0	N/A	NAG 12951 CUG, NAG 119/96, NAG 4517/2009
sandstone	dolomite	shale		15-144 MPa	M	Y	https://doi.org/10.3390/min9100592	N/A	N/A	N/A
sandstone	dolomite	shale		15-144 MPa	M	Y	https://doi.org/10.3390/min9100592	N/A	N/A	N/A
sandstone	dolomite	shale		15-144 MPa	L	Y	https://doi.org/10.3390/min9100592	N/A	N/A	NAG 1280/2020
sandstone	dolomite	shale		15-144 MPa	L	N	N/A	ISBN 978-83-922065-7-6	ISSN 1938-4548	NAG 14367 CUG, NAG 708/92, NAG 640/94, NAG 812/2012
sandstone	dolomite	shale		15-144 MPa	L	N	N/A	ISBN 978-83-922065-7-6	ISSN 1938-4548	NAG 13936 CUG, NAG 1072/92, NAG 636/94, NAG 811/2012
sandstone	dolomite	shale		15-144 MPa	L	N	N/A	ISBN 978-83-922065-7-6	ISSN 1938-4548	NAG 15118 CUG, NAG 15797 CUG, nr NAG 728/93, NAG 637/94, NAG 810/2012
sandstone	dolomite	shale		15-144 MPa	M	N	N/A	ISBN 978-83-922065-7-6	ISSN 1938-4548	NAG 14292 CUG, NAG 676/95, NAG 638/94, NAG 813/2012
sandstone	dolomite	shale		15-144 MPa	L	N	N/A	ISBN 978-83-922065-7-6	ISSN 1938-4548	NAG 1059/2004
evaporite				N/A	M	N	http://igs.pgi.gov.pl/zloze.asp?ID=247&mode=dokumenty,BSL7-0028-0006	N/A	0043-2075	NAG 3026/113, 3026/113/36, 10441 CUG
evaporite				N/A	M	N	http://igs.pgi.gov.pl/zloze.asp?ID=250&mode=dokumenty,BSL7-0028-0006	N/A	0043-2075	NAG 7790
evaporite				N/A	L	N	http://igs.pgi.gov.pl/zloze.asp?ID=249&mode=dokumenty,BSL7-0028-0006	N/A	0043-2075	NAG 7790

	AA	AB	AC	AD	AE
1					
2					
3					
4	**Geothermal gradient**	**Exploration permission**	**Restrictions**	Bibliography	Additional notes
5					
593	2,2	N/A	Protected areas: Nature 2000, Landscape Park		Small amount of resources in relation to the depth of deposit Favorable form of the deposit. Dolomite
594	2,2	Concession to 2030	Water hazard, Zawiercie City buildings		The richest part of the deposit located directly under the Zawiercie city infrastructure. Dolomite
595	3,0	N/A	N/A		The mine has been flooded Part of resorces remains unexploited Carbonates, Shales, sandstone
596	3,0	N/A	N/A		The mine was closed due to small amount of resources. Marls, limestone
597	3,0	Concession to 23.02.2065	N/A		Depth of the deposit occurence has impact on economic profibility. Sandstone, dolostone, shale
598	2,7	N/A	N/A		Depth of the deposit occurence has impact on economic profibility. Sandstone, dolostone, shale
599	2,7	N/A	N/A		Depth of the deposit occurence has impact on economic profibility. Sandstone, dolostone, shale
600	2,7	N/A	N/A		Depth of the deposit occurence has impact on economic profibility. Sandstone, dolostone, shale
601	3,0	N/A	N/A		Depth of the deposit occurence has impact on economic profibility. Marls, limestone
602	2,7	N/A	N/A		Depth of the deposit occurence has impact on economic profibility. Sandstone, dolostone, shale
603	2,7	N/A	N/A		Depth of the deposit occurence has impact on economic profibility. Sandstone, dolostone, shale
604	2,7	N/A	N/A		Depth of the deposit occurence has impact on economic profibility. Sandstone, dolostone, shale
605	3,0	Concession to 31.12.2063	N/A		In operation. lead, Se, Re. Sandston, dolostone, shale
606	3,0	Concession to31.12.2063	N/A		In operation lead, Se, Re, rock salt. Sandstone, dolostone, shale
607	2,7	Concession to 31.12.2063	N/A		In operation lead, Se, Re. Sandstone, dolostone, shale
608	2,7	Concession to31.12.2063	N/A		In operation lead, Se, Re. Sandstone, dolostone, shale
609	3,0	Concession to 25.11.2054	N/A		Depth of the deposit occurence has impact on economic profibility lead, Se, Re. Sandstone, dolostone, shale
610	2,2	Concession to 31.01.2025	N/A		Significant depth of the deposit occurence Deposit located in the coastal turist areas. Polyhalite Evaporites
611	2,2	Concession to 31.01.2025	Protected areas: Landscape Park		Significant depth of the deposit occurence Deposit located in the coastal turist areas. Polyhalite and halite Evaporites
612	2,2	Concession to 31.01.2025	Protected areas: Landscape Park		Significant depth of the deposit occurence Deposit located in the coastal turist areas. Polyhalite and halite Evaporites

5.2 ANNEX 2: GUIDELINES OF DATA COLLECTION TEMPLATE

Mine index: First letters of the country and a number.
Site/Mine name: Most commonly used name applied to the site.
Mine/unexploited resource: Please indicate if the site is a former/existing mine or an explored but not exploited deposit.
Country: Country in which the site location point is located.
Longitude: Longitude in decimal degrees of site location point (WGS84). NA=not available.
Latitude: Latitude in decimal degrees of site location point (WGS84). NA=not available.
Altitude (MASL): Meters above/below mean sea level regarding the highest known point of the deposit (+ for above sea level, - for below sea level).
Depth of highest point of the deposit: The depth from surface of the highest known point of the deposit in metres.
Historic time range: Time range of exploration and mining activities (if relevant), from year to year.
Number of exploitation years (known): Sum of years indicated in historical periods (Historic time range).
Deposit type: Classification of the deposit type according to Tab. A1.
Commodity: Name of primary commodity or end-product produced at the site listed after the INSPIRE code list.
Main host rock: Type of the dominant host rock according to Tab. A2.
Geotechnical attributes: Geomechanical index of the host rock if known (e.g. RMR, Q-Barton, RQD).
Magnitude: Please take a choice from the three categories of magnitude: S (small, <10Mt), M (medium, 10-100Mt), L (large, >100Mt). Please consider the recently existing (remaining) resources/reserves, not the historical ones. If no data or estimations exist, write in NA (not available).
Technical report available: CRIRSCO-compliant technical report (e.g. PERC, JORC).
Geological information:

- **Link or DOI:** Link to the website or DOI where the most recent comprehensive information about the geology of the deposit is online available.
- **ISBN:** ISBN identifier of publication, if the geological information is available in form of a book or a monograph.
- **ISSN:** ISSN identifier of publication, if the geological information was published in a periodical. In the 'Additional notes' column, please write in the details of the reference (authors, title, journal, volume, page).
- **National archive identifier:** Identifier of reports and documents available in national archives. In the 'Additional notes' column, please write in the details of the report/document (authors, title, date).

Geothermal gradient: Geothermal gradient in the site area.
Exploration permission: Date and duration of exploration and/or mining permission if exists.
Restrictions: Description of any restrictions (e.g. park, geopark, heritage site, etc.).
Bibliography: Any other bibliographical references.
Additional notes: Any other relevant information related to the mine site.

Table A2: Classification of Deposit types of the ROBOMINERS database.

DEPOSIT TYPE
○ Bauxite ○ BIF (Banded Iron Formation) ○ Carbonite alkali REE ○ Carlin type ○ Cu-Ni-PGM ○ Epithermal (HS) ○ Epithermal (LS) vein type ○ Greisen ○ Hydrothermal veins ○ IOCG (Iron Oxide Copper Gold ore deposit) ○ Laterite type ○ Layered chromite ○ Magmatic Fe-Ti-V ○ Metamorphic stratabound ○ MVT (Missisipi Valley Type deposit) ○ Non-metallic ○ Oolitic Iron ○ Orogenic gold ○ Pegmatite ○ Placers ○ Podiform chromite ○ Porphyry copper ○ Sandstone hosted uranium ○ SEDEX (Sedimentary Exhalative deposit) ○ Sedimentary black shale ○ Sedimentary manganese ○ Sedimentary phosphate ○ Skarn ○ SSC (Sediment-hosted Stratiform Copper deposit) ○ Stratiform ○ Supergene ○ VMS (Volcanic-associated Massive Sulphide)

Table A3: Classification of the main host rock of the ROBOMINERS database according to the INSPIRE codelist.

MAIN HOST ROCK	
○ amphibolite ○ andesite ○ anorthosite ○ arenit ○ basalt ○ bauxite ○ breccia ○ calcareousCarbonateSedimentaryRock ○ carbonateSedimentaryRock ○ chalk ○ clasticSediment ○ clasticSedimentaryMaterial ○ clasticSedimentaryRock ○ clay ○ claystone ○ conglomerate ○ dacite ○ diorite ○ doleriticRock ○ dolomite ○ evaporite ○ gabbro ○ gneiss ○ granite ○ granitoid ○ granodiorite ○ granulite ○ gravel ○ gypsumOrAnhydrite ○ hornfels ○ igneousMaterial ○ igneousRock ○ kohle ○ latite ○ lignite ○ limestone ○ marble	○ metamorphicRock ○ metasomaticRock ○ micaSchist ○ migmatite ○ monzodiorite ○ monzogranite ○ monzonite ○ mudstone ○ paragneiss ○ pebbleGravelSizeSediment ○ pegmatite ○ peridotite ○ phyllite ○ porphyry ○ pyroclasticRock ○ pyroxenite ○ quartzite ○ rhyolite ○ sandSizeSediment ○ sandstone ○ schist ○ sediment ○ sedimentary ○ sedimentaryMaterial ○ sedimentaryRock ○ serpentinite ○ shale ○ siltstone ○ skarn ○ slate ○ syenite ○ syenogranite ○ trachyte ○ trachyticRock ○ tuffite ○ ultramaficIgneousRock

5.3 ANNEX 3: PYTHON SCRIPT FOR THE ALTITUDE COMPUTATION

```python
#This script is used to extract the value of the elevation from a DEM.tif file.
#In dataframe you need to import the .csv file with the coordinates of the
# point you're interested into.
#Into file you need to import the DEM file you want to use.
#To create the final elevation file (to be post-processed in excel) add the
# last line in the console.

from osgeo import gdal
import pandas as pd

dataframe = pd.read_csv('HR.csv', sep=';')
print(dataframe['Longitude'][0])
dataframe["Elevations"] = ""

# raster dem10m
file = 'DE_HR_WGS84.tif'
layer = gdal.Open(file)
gt =layer.GetGeoTransform()
bands = layer.RasterCount
band=1

def Val_raster(x,y,layer,bands,gt):
    col=[]
    px = int((x - gt[0]) / gt[1])
    py = int((y - gt[3]) / gt[5])
    for j in range(bands):
        band = layer.GetRasterBand(j+1)
        data = band.ReadAsArray(px,py, 1, 1)
        col.append(data[0][0])
    return col

for n in range (0, len(dataframe)):

    x = dataframe['Longitude'][n]
    y = dataframe['Latitude'][n]

    altitude=Val_raster(x,y,layer, band,gt)
    print(altitude)
    dataframe['Elevations'][n] = altitude


print (dataframe)


dataframe.to_csv('HR_alt.csv', index=False)

```