Project report 1 (M1-M18)

CHPM2030 Deliverable D8.3

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CHPM2030

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PART B

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1.1 Objectives

General objectives

The strategic objective of CHPM2030 is to develop a novel and potentially disruptive technological solution that can help satisfy the European needs for energy and strategic metals in a single interlinked process. In the CHPM technology vision, the metal-bearing geological formation will be manipulated in a way that the co-production of energy and metals will be possible, and may be optimised according to the market demands at any given moment in the future.

Specific objectives

Below the specific objectives are listed. Being in an early stage of the project implementation, these objectives are not fulfilled yet but several activities contributed to their realisation.

Objective 1: Deliver proof of concept for the technological and economic feasibility of mobilisation of metals from ultra-deep mineral deposits using a combination of geo-engineering techniques to enhance the interconnected fracture systems within the orebody

The objective will be completed in a later stage of the project. Until now, *Tasks 1.1*, *1.3* and *2.1* provided background for it. Understanding the internal qualities of orebodies is essential for the formulation of the CHPM concept. The mineralogy, the geochemistry, the geometry, the extent, the structure and the textural characteristics of the ore bodies are influenced by the host rocks, the magmatic/hydrothermal processes and the fluid-rock interaction. These processes define the metal content and the possible ways of metal mobilisation.

Within Task 1.1, the geological processes were identified which lead to the enrichment of metals and formation of ore deposits. Special focus was put on those deposits which can be found in the depth required for the geothermal energy production and from which metals can be mobilised in hot aqueous solution. The geometry and structure of the deposit types were also described. A review on the European metallogenic provinces with a short assessment on the EGS potential of each metallogenic province was also made in order to identify the potential areas of future CHPM plants.

Related to Task 1.3, laboratory investigations on ore samples were carried out. The samples represented different types of ore deposits. The mineralogy, the geochemistry and the structural features of the samples were analysed by different laboratory techniques. The results were assessed in a relevancy to the CHPM technology and will be used during the completion of WP5 in the assessment of the technological and economic feasibility.

Task 2.1 is still going on. It involves a combination of laboratory experiments and predictive computer modelling for the simulations for integrated reservoir management. A task-specific, high-pressure and high-temperature reactor has been designed and built to carry out flow-through measurements and to determine soluble mineral content.

Results are laid down in the following deliverables:

- D1.1: EGS-relevant review of metallogenesis (M6),
- D1.3: EGS-relevant review of orebody structures (M10).

Related to Objective 1, Milestone 1 'Methodology framework for orebody EGS is defined' was also completed in M10.

Feasibility studies will be carried out in WP5. The objective will be completed by the submission of the following deliverables:

- D2.1: Recommendations for Integrated Reservoir Management (M24),
- D5.2: Economic feasibility assessment methodology.

Objective 2: Develop innovative pathways for leaching strategic metals from the geological formation and corresponding electrochemical methods for metal removal and recovery on the surface

This complex objective is supported by *Tasks 2.2, 2.3, 3.1* and *3.2.* All of these tasks are still ongoing. The WP2 tasks aim to prove that metals can be leached from the orebodies in high concentrations over a prolonged period of time and may substantially influence the economics of EGS. The continuous leaching of metals will increase the performance of the system over time in a controlled way and without having to use high-pressure reservoir stimulation, minimizing potential detrimental impacts of both heat and metal extraction. WP3 will prove that the dissolved metal content of geothermal fluids (naturally present or leached within the proposed closed EGS concept) can be removed on surface by electrochemical methods.

In the frame of Task 2.2, approximately 40 low-pressure experiments at 70°C have been carried out to assess a range of different potential leaching fluid compositions. A limited amount of mineralogical work identified the broad types of reactions that had occurred, and this was complimented by analyses of selected fluid samples. The more promising leaching solutions were used in higher temperature experiments. So far, about 15 high-pressure experiments have also been completed. The use of pressure vessels allowed simulation of elevated CO_2 pressures. Preliminary examination appears to reveal initial liberation of metals followed by their re-precipitation.

Task 2.3 involves the selection and screening of carbon nano-materials for metal mobilisation. This has included the modification of selected materials for improved metal sorption selectivity/capacity under different temperature and pressure conditions. Four different carbon materials were characterized and two of the chosen materials were treated with sulphuric acid. The first tests of Zn^{2+} sorption were performed; the effect of pH, amount of adsorbent and concentration of the solution was tested. Modified carbon materials showed better adsorption capacity than unmodified ones.

Task 3.1 aims to recover metals by high-temperature, high-pressure geothermal fluid electrolysis. Since the start of this task in M10, an electrochemical reactor system has been designed and constructed to operate at temperatures up to 250 °C and pressures up to 200 bar, to evaluate kinetics and mechanistic aspects of electrochemical reactions at HTP, which is crucial to evaluating the feasibility of metal recovery.

Related to Task 3.2, experiments on metal recovery take place by electroprecipitation and electrocrystallization. The preparation of the experimental setups was carried out and first tests with 3 relevant model geothermal brine compositions were completed. Analysis of the performance of the gas-diffusion electroprecipitation and electrocrystallization (GDEx) process with respect to different operational parameters was also made as well as the analysis of the products formed through the GDEx process.

Objective 2 will be realised by the submission of the following deliverables:

- D2.2: Report on metal content mobilisation using mild leaching (M24),
- D2.3: Report on metal content mobilisation with nanoparticles (M24),
- D3.1: Report on performance, mass and energy balances and design criteria for high-temperature, high-pressure electrolysis (M32),
- D3.2: Report on performance, mass and energy balances and design criteria for gas-diffusion electroprecipitation and electrocrystallization (M32).

Objective 3: Develop metallic-mineral formation specific solutions for the co-generation of electricity using salt-gradient power reverse electrodialysis

This objective is addressed by *Task 3.3.* The implementation of this task started in M18, hence the fulfilment of the objective is in an initial phase. The preparation of the experimental setup to measure performance of ion exchange membranes with a single pair of membranes was achieved. Experiments initiated with pure NaCl at different concentrations, relevant for geothermal brines.

Milestone 2 'Salinity gradient power generation experiments start' was completed related to Objective 3. The objective will be realised by the submission of the following deliverable:

- D3.2: Report on performance, energy balances and design criteria for salt gradient power reverse electrodialysis (M30)

Objective 4: Develop conceptual designs of a new type of future facility that is designed and operated from the very beginning as a combined heat, power and mineral extraction system

This objective will be realised by the implementation of *Tasks 4.2* which will start in M32.
The objective will be completed by the submission of the following deliverable:

- D4.2: Report on CHPM Process Optimisation (M41).

Objective 5: Develop a new conceptual framework that increases the total number of economically viable geothermal resources in Europe below the depth of 4 km and deeper including high-enthalpy resources

This objective will be achieved by the implementation of *Task 4.1* which will start in M28. However, Task 1.4 already provided initial methodological framework which defines both the overall concept for converting different types of orebodies into an EGS reservoir and the series of experiments and measurements that will need to be conducted in order to validate the concepts to TRL4 in a laboratory environment. Beside the standardisation of the laboratory measurements, the rock properties, the boundary conditions and the measurement techniques for the vertical heat transport modelling were also defined, with the focus on the critical success factors during the establishment of a CHPM facility. Details on the work in Task 1.4 are provided in the following deliverable:

- D 1.4: Conceptual framework for orebody-EGS (M10).

The objective will be achieved by the submission of the following deliverable:

- 4.1: Conceptual Framework for CHPM power plant (M33).

Objective 6: Turn the inherent characteristics of these new resources (extreme content of dissolved metals and often very high temperatures) into an advantage by proposing a new type of geothermal facility

This objective will be addressed by *Task 4.3* which will start in M36. The technical specifications will be finalised and design specifications will be provided.

The objective will be completed by providing the following deliverable:

- D4.3: CHPM schematics and blueprints (M42).

Objective 7: Develop an economic feasibility assessment model to be applied for such new facilities;

This objective will be addressed by *Tasks 5.1, 5.2* and *5.3*. The elaboration of the integrated sustainability assessment framework is started in M18. Baseline economics for energy and mineral raw materials, and decision support for economic feasibility assessment will be provided in the later phase of the implementation of WP5.

Objective 7 will be completed by the submission of the following deliverables:

- D5.1 Integrated sustainability assessment framework (M24),
- D5.2 Economic feasibility assessment methodology (M32),
- D5.3 Self Assessment Tool (M40).

Objective 8: Develop an integrated feasibility assessment framework for evaluating the environmental and socio-economic impacts of the proposed new technology line;

This objective will be achieved by *Task 5.4, 5.5* and *5.6* which will start in M24. However, work in *Task 2.4* also provides input by data collection throughout WP2 for the subsequent assessment of the environmental impacts of the system in WP5. Task 2.4 also defines the parameters that will need to be measured and collected in order to execute WP5. Emerging phenomena that can have relevance from an environmental footprint point of view, or that could affect systems optimisation and performance are also considered. Particular interest is on the fate of leaching fluids, by-products of chemical reactions or level of self-containment. The result of the work in Task 2.4 are laid down in the following deliverable:

- D 2.4 Report on overall systems dynamics (M24).

The achievement of Objective 8 will be performed by the completion of the following deliverables:

- D5.4 Report on policy implications (M42)
- D5.5 Environmental Impact Assessment Framework (M38)
- D5.6 Ethics Assessment Report (M42)

Objective 9: Combine metallogenic models with geothermal datasets to develop a database of suitable areas in selected case-study areas in Europe where such developments could be feasible

This objective will be completed by *Tasks 6.1* and *6.2*, which will start in M24. Task 6.1 will involve a technology visioning process for the further development of the CHPM concepts against the backdrop of different socio-economical-technological scenarios and expected policy developments. Task 6.2 aims to support the development of technology and economic feasibility plans for pilot implementation of the CHPM plants.

Task1.1 and *1.2* also support the achievement of Objective 9. Four potential case-study areas had already been selected in the preparation phase of the proposal. The implication of these test areas in the metallogenic belts of Europe was examined in Task 1.1. Within Task 1.2, an overview of the four test sites (four major ore districts in Europe, namely in SW England, southern Portugal, NW Romania and central and northern Sweden) was made. It was completed with a survey of existing boreholes in the European countries, where temperatures at depth in access of 100°C are observed. The geological settings were described, attempts were made to estimate their geothermal potential.

Results of this work are described in the following deliverables:

- D 1.1 EGS-relevant review of metallogenesis (M6)

– D 1.2 Report on data availability – compiled from 5 reports (M10)

The objective will be achieved by the submission of the following deliverables:
– D6.1 Report on Emerging and Converging Technologies (M42)
– D6.2 Report on Pilots – compiled from 5 reports (M40)

Objective 10: Develop a roadmap in support of the pilot implementation of such system before 2025, and the full-scale commercial implementation before 2030

This objective will be achieved by *Task 6.3*, which will start in M33. Two roadmaps will be created, a practical and goal-oriented one, and a technology vision oriented one. The objective will be achieved by the submission of the following deliverable:
– D6.3 Roadmap for 2030 and 2050 (M42)

1.2 Explanation of the work carried out per WP

1.2.1 Work Package 1

WP title:	**Methodology framework definition**		
Lead beneficiary:	UNIM	Participants:	USZ, EFG (with LTPs), ISOR, NERC-BGS, LNEG, IGR, SGU
Start date:	01.01.2016	End date:	31.10.2016

Objectives of the WP

Within WP1, the conceptual framework is created for a novel EGS for the production of energy and the extraction of metals from ore deposits located at ultra-depths (below 4 km). The objective is to synthesise our knowledge of ultra-deep metallic mineralisations that could be converted into an "orebody EGS", and to investigate the characteristics of these bodies and their implications for EGS. Working on the boundaries of geophysics, geochemistry, hydrogeology and geoenergetics the aim is to discover and examine the geological, tectonic, geochemical, and petrologic factors that define the boundary conditions of such novel EGS both in terms of energy and potential for metal recovery.

Synthesis of work done and results achieved

Work in WP1 is organised into four tasks. Task1.1 lasted for 6 months while Tasks 1.2, 1.3 and 1.4 lasted for 10 months.

Task 1.1 *EGS-relevant review of metallogenesis and ore deposit formation* was carried out by UNIM. Within this task a study was prepared based on literature research. The aim was to investigate Europe's mineral potential in depth and temperature zones that are currently the target of EGS technology (Figure 1). This is usually 4 km or more, but in favourable geothermal conditions it can be a shallower depth. The processes of ore formation and the metallogenic provinces of Europe were reviewed, keeping an eye on the relevancy with the EGS application, in order to identify the possible zones where the CHPM technology can be applied. Special focus was given to the composition, geometry, extent, structure and textural characteristics of ore bodies, as well as the scale, pattern, and formation of the fracture systems. Attempts were also made to draw conclusions on how the available information may be used to predict geological and physical conditions relevant to the present task at greater crustal depths.

Task 1.2 *Knowledge gaps, updating information* was led by SGU, and NERC-BGS, LNEG, IGR and EFG with 17 LTPs also contributed. Within this WP, a comprehensive study was made by the condensed compilation and evaluation of five reports on the availability of data of some of the European ore districts for the development of enhanced geothermal systems (Figure 1). These reports were written by individual working groups from the UK, Portugal, Romania, Sweden and the European Federation of Geologists (EFG), and focused on the potential pilot sites of the CHPM technology. The reports comprise geological data and descriptions of mineralised areas in these countries. NERC-BGS provided a report on data availability in SW England. LNEG reviewed the Iberian Pyrite Belt in Portugal. In Romania, IGR assessed the Banatitic Magmatic and Metallogenetic Belt. SGU assessed the available data on three major ore districts in Sweden. The EFG presented a European inventory of drill holes with temperatures in excess of 100°C, availability of data for these holes, and whether any metal enrichment have been encountered at depth. Data collection by the EFG LTPs covered 24 European countries.

Figure 1: Cover of D1.1 (left) and D1.2 (right) deliverables.

Task 1.3 *Understanding the rock-mechanical and geo-chemical properties of orebodies from an EGS perspective* was led by UNIM, and USZ also participated in the implementation. In this task, the mineralogical, petrographic and geochemical features of rock and ore samples were investigated that represent different mineralisation types. 26 samples were examined which were collected mostly from the four study sites. The samples were analysed at UNIM by X-ray diffraction, X-ray fluorescence spectrometry, optical microscopy and electron microprobe and EDX measurements. The mineralogical analysis was qualitative as the samples do not represent the ore grade of the deposits. Beside the identification of the mineralogical and geochemical components, the textural parameters were also examined. The results were evaluated in terms of their relevance to the application of the CHPM technology. A methodology for the rock mechanical measurements carried out in Task 2.1, in order to clarify the rock stresses and their impact on fracture formation, was also provided. USZ contributed to this latter phase of the work (Figure 2).

Task 1.4 *Development of new concepts for orebody-EGS* was led by USZ, and VITO and UNIM also participated. The goal of this task is to synthesise the outcomes of the previous WP1 tasks. After extended consultations between the three participating partners, standards were set up for the laboratory measurements to define the ore content. The methodology for the clarification of the tectonic setting in order to build 3D models was also defined. The data collection method for creating the vertical heat transport model was described. Existing unconventional reservoir stimulating technologies were studied and the pros and cons were highlighted with particular attention to the CHPM concept. The critical success factors and their effect to the laboratory investigations - and to the whole project - were also defined (Figure 2).

Figure 2: Cover of D1.3 and D1.4 (right) deliverables.

Status of ongoing and finalised deliverables

Deliverable no. and name:	**D1.1 EGS-relevant review of metallogenesis**		
Due date:	30.06.2016	Delivered to the EC on 28.06.2016	Status: approved
Responsible:	UNIM		
Summary:	This deliverable provides a review of metallogenic provinces in Europe. The ore-forming processes, the structure and the metal content of the ore deposits are discussed. Special focus is put on the mineral potential in the depth and temperature zones that are currently the target of EGS. The deliverable was submitted on time. It is also available on the project website. Additionally, it has a DOI number 10.5281/zenodo.580994 and also accessible through the Zenodo open science repository site (https://zenodo.org/).		
Deliverable no. and name:	**D1.2 Report on data availability – compiled from 5 reports**		
Due date:	31.10.2016	Delivered to the EC on 21.11.2016	Status: approved
Responsible:	SGU		

Summary:	This report aims to provide a brief overview of four major ore districts in Europe, namely in SW England, southern Portugal, NW Romania and central and northern Sweden. It is completed with a survey of existing boreholes in the European countries, where temperatures at depth in access of 100 ^{o}C are observed. The report includes descriptions of the geological settings, and on-going efforts in geophysics in seeing deeper and increasing resolution for detecting mineralized zones at depth, as well as attempting to estimate their geothermal potential. The deliverable was submitted with a few weeks delay but without any issues. Beside the Sygma, it is also available on the project website. Additionally, it has a DOI number 10.5281/zenodo.581003 and also accessible through the Zenodo open science repository site (https://zenodo.org/).		
Deliverable no. and name:	**D1.3 EFG-relevant review of orebody structures**		
Due date:	31.10.2016	Delivered to the EC on 14.11.2016	Status: approved
Responsible:	UNIM		
Summary:	This report provides the results of laboratory investigations on ore samples, which represent the study sites of the CHPM2030 project, completed with samples from other ore types. The results are evaluated with a relevancy to the CHPM technology. The methodology for rock stress and strength measurements is also described. These measurements will be carried out in the confines of WP2 and will complete the EGS relevant properties of different ore body types determined in the recent study. The deliverable was submitted with two weeks delay but it did not affect the implementation of the other work phases. Beside the Sygma, it is also available on the project website. Additionally, it has a DOI number 10.5281/zenodo.581018 and also accessible through the Zenodo open science repository site (https://zenodo.org/).		
Deliverable no. and name:	**D1.4 Conceptual framework for orebody-EGS**		
Due date:	31.10.2016	Delivered to the EC on 21.11.2016	Status: approved
Responsible:	USZ		
Summary:	This document provides a summary of outcomes from Task 1.1 – 1.3. A methodological framework is created, which will be used as a guide for the laboratory measurements in WP2. In this report, there is also a framework for data collection for modelling heat transport. A review of currently existing reservoir enhancement technologies is also provided. Collecting, evaluating and defining critical success factors during the establishment of a CHPM facility were in the focus. The deliverable was submitted with few weeks delay but it did not affect the implementation of the other work phases. Beside the Sygma, it is also available on the project website. Additionally, it has a DOI number 10.5281/zenodo.581032 and also accessible through the Zenodo open science repository site (https://zenodo.org/).		

1.2.2 Work Package 2

WP title:	**Laboratory experiments and orebody investigations**		
Lead beneficiary:	NERC-BGS	Participants:	UNIM, USZ, ISOR, VITO
Start date:	01.10.2016	End date:	31.12.2017

Objectives of the WP

Ultra-deep (>4 km deep) orebodies contain networks of naturally-formed, hydraulically-conductive features such as fractures. These can be used within an engineered geothermal system (EGS), to allow flow of fluid from an injection borehole, through the orebody, to a production borehole, and then to the surface for heat/energy recovery/use. Heat will transfer from the rock to the fluid at a rate dependent upon the contact surface area and residence time of the fluid in the rock. In a similar way, metallic minerals lining the flow features within the orebody will dissolve, transferring metals to solution, and then these can be carried to the surface for extraction. In the technology envisioned by CHPM2030, advantage will be taken of these features to facilitate co-production of heat and metals. There are however, several uncertainties/knowledge gaps within this concept, and it is these that this WP2 aims to address through two main objectives:
Objective (1): To develop the tools and methods for orebody EGS reservoir management.
Objective (2): To test and validate the methods using simulations and laboratory experiments reaching and exceeding TRL-4.
In order to meet these objectives, three hypotheses have been proposed, and are tested:

- The composition and structure of orebodies have certain features that could be used to our advantage when developing an EGS.
- Metals can be leached from the orebodies in high concentrations over a prolonged period of time and may substantially influence the economics of EGS.
- The continuous leaching of metals will increase the performance of the system over time in a controlled way and without having to use high-pressure reservoir stimulation, minimizing potential detrimental impacts of both heat and metal extraction.

Synthesis of work done and results achieved

The work in this WP is organised into 4 Tasks, which do not exist in isolation, and there has been active exchange of information between all of them. This includes in-depth discussions at 6-monthly project meetings, and shorter information exchange during the approximately monthly telephone conferences. Other project partners not identified below have also actively contributed comments and information to Tasks within this work package. There was a specific visit by researchers from USZ, (Task 2.1) early in the WP to see a range of laboratory facilities at the BGS. In March 2017 the 3rd consortium meeting in Nottingham, UK, allowed a much broader selection of CHPM2030 researchers to visit these laboratory facilities (especially those linked to Task 2.2). In terms of the four pilot areas, there has also been exchange of rock samples between partners. This allows the same testing equipment to be used on multiple samples, resulting in larger and more comparable datasets, and ultimately higher quality outputs from the project.

Task 2.1 *Concepts and Simulations for Integrated Reservoir Management* is still ongoing. This Task provides an overall conceptual framework for the Work Package, and uses modelling to test the concepts involved. It is led by, and has been largely conducted by USZ. However, there has been notable co-operation with UNIM in terms of exchange of rock samples and data. Progress within this Task appears broadly in-line with that anticipated. Activities so far has included:

- Developing a task-specific, high-pressure and high-temperature reactor designed and built to carry out flow-through measurements and to determine soluble ore-content. This equipment has been commissioned, and initial experiments have been conducted with a relatively simple aqueous fluid, providing information of flow rates and chemical composition (Figure 3). Future experiments will extend the range of fluid types.
- Receiving rock samples for laboratory investigations from UNIM. There has also been input from UNIM on rock strength measurements and data are being analysed.

- Laboratory measurements using high-powered lasers to investigate whether it is possible to enhance beneficial fracture properties are ongoing.
- Ongoing data collection and preparation of a 3D stochastic fracture model, and also a 3D fluid, heat- and mass-transport model (in progress).

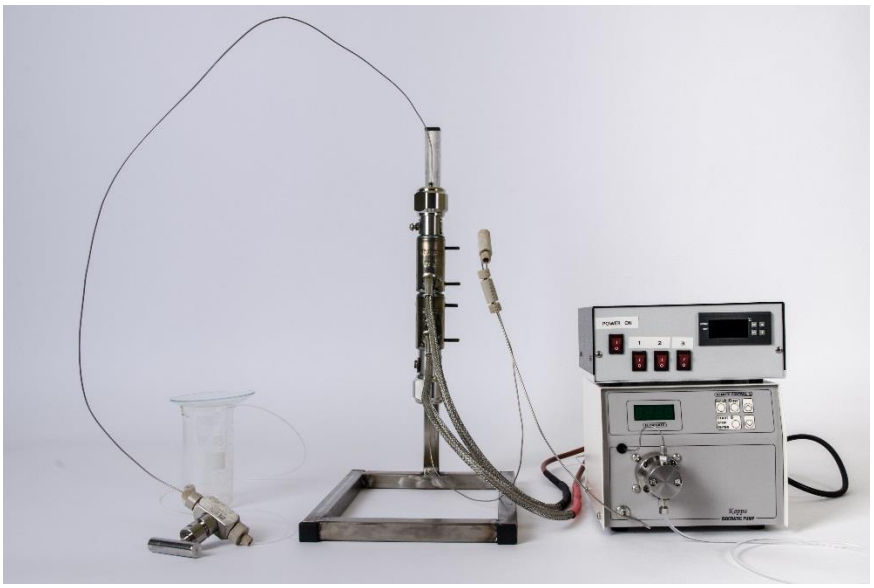

Figure 3: Custom built flow-through leaching device developed by USZ.

Task 2.2 *Metal content mobilisation using mild leaching* is still ongoing. This Task specifically investigates whether relatively 'mild' leaching agents (i.e. those that are relatively environmentally benign, see Task 2.4) are capable of liberating metals into the recirculating fluid within an EGS. If they are capable of doing this, quantifying the rate and magnitude of metal release. Also, to investigate how rock permeability might change during leaching. This Task is led by the NERC-BGS, and many of the experiments are being conducted in the BGS labs. However, there are close linkages with USZ, who are conducting flow experiments in Task 2.1 (these experiments are producing some leaching data, albeit under a different set of pressure/temperature conditions to those at the BGS). Also, there has been a 2-month internship, where a Masters student from UNIM worked in the BGS labs. He helped characterise the experimental starting materials, and helped run the first phase of the laboratory leaching experiments. Progress towards the aims of Task 2.2 has included:

- Sampling of rocks from south-west England to serve as starting materials for many of the laboratory experiments. Plus, project partners providing rock samples from the other three pilot site areas.
- Approximately 40 low-pressure experiments at 70°C to assess a range of different potential leaching fluid compositions (de-ionised water, 0.6M NaCl solution to assess baseline fluid reactivity, but also with additions including: extra oxygen (via hydrogen peroxide), surfactants, organic acid, ammonia). A limited amount of mineralogical work identified the broad types of reactions that had occurred, and this was complimented by analyses of selected fluid samples. The more promising leaching solutions were used in higher temperature experiments (Figure 4).
- Approximately 15 (so far) high-pressure experiments at 100°C and 150°C using samples from all 4 pilot sites, but with a restricted range of fluids. The use of pressure vessels allowed simulation of elevated CO_2 pressures. Reacted samples will be returned to project partners for detailed analysis. The reacted material from SW England is still undergoing analysis at the BGS. However, a preliminary examination appears to reveal initial liberation of metals followed by their re-precipitation.

- Some preliminary mineral solubility calculations (in progress).
- Other modelling is still to begin.

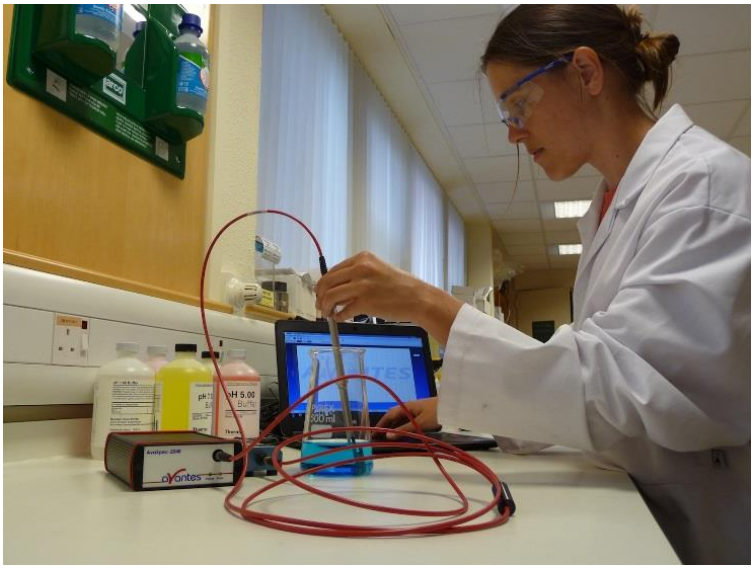

Figure 4: Analysing solutions in the BGS laboratory.

Some issues were identified during the work: equipment corrosion problems at 200°C, followed by experimental failure. This is partly also related to the higher reactivity fluid used. Though these experiments did not involve borehole materials specifically, any useful observations in terms of corrosion will be noted. No 'ideal' experimental flow test sample could be located during our visits in SW England (i.e. containing a mineralised fracture open to fluid flow). Flow experiments may have to be conducted on un-mineralised samples. Though these may not provide much information on metal leaching, they should highlight the potential for permeability changes. A presentation outlining the initial findings of the leaching tests was given at the Santorini geothermal conference. Progress within this Task appears broadly in-line with that anticipated, though experimental problems are hampering some of the higher temperature experiments.

Task 2.3 *Metal content mobilisation with nanoparticles* is still ongoing. This Task involves the selection and screening of carbon nano-materials for metal mobilisation. This has included the modification of selected materials for improved metal sorption selectivity/capacity under different temperature and pressure conditions (i.e. towards targeted recovery of individual metals). It is led by, and has been largely conducted by VITO. However, there has been information exchange with other project partners (e.g. ISOR and the BGS) in terms of likely compositions of major element fluid chemistry, and VITO will support the analysis of metal concentrations in leachates obtained elsewhere within this WP. There is also a close connection of this task to activities within WP3, and exchange of information between these two sets of activities is good. Progress towards the aims of Task 2.3 has included:

- Completion of a literature study about the chemical modification of carbon materials, including assessing their properties versus their ability to sorb different metals.
- Four different carbon materials were characterized (using N2 low temperature adsorption, BET).
- Two of the chosen materials were treated with sulphuric acid.
- Two modified (+original) carbon materials were characterized by ATR, potentiometric titration, TGA and elemental analysis (currently in progress).
- The analyses confirmed the presence of sulfonic and carbonyl/carboxyl surface functional groups.

- The first tests of Zn^{2+} sorption were performed; the effect of pH, amount of adsorbent and concentration of the solution was tested. Modified carbon materials showed better adsorption capacity than unmodified ones.

Activities planned for the remainder of the time of this Task include further Zn^{2+} sorption tests (kinetics), sorption tests using a different metal (e.g. $Co^{2+/3+}$), characterization and testing of other carbon materials (e.g. mesoporous carbon), and sorption tests under harsh conditions (e.g. high temperatures and pressures, more representative of those in the deep subsurface). Progress within this Task appears broadly in-line with that anticipated.

Task 2.4 *Overall system dynamics and data for environmental assessment* is still ongoing. This Task integrates the results of activities within WP2, identifying key parameters for the CHPM technology, and feeds them into WP4 (optimisation and performance) and WP5 (environmental impacts). It is led by, and has been largely conducted by UNIM. However, there is input of data from all project partners, though within this WP especially BGS, ISOR, VITO and USZ. Progress towards the aims of Task 2.4 has included:

- Discussions at project meetings in order to capture observations coming out of Tasks 2.1-2.3, plus other parts of the CHPM2030 project.
- Developing a schematic overview of an envisioned CHPM facility, identifying the locations of the critical parameters, drawing up data-capture tables for each critical parameter, and then engaging with other project partners to source missing data.

Progress within this Task appears broadly in-line with that anticipated.

Status of ongoing and finalised deliverables

Deliverable no. and name:	**D2.1 Recommendations for Integrated Reservoir Management**		
Due date:	31.12.2017		
Responsible:	USZ		
Summary:	This deliverable is not yet due. Ongoing experiments and modelling will support this deliverable.		
Deliverable no. and name:	**D2.2 Report on metal content mobilisation using mild leaching**		
Due date:	31.12.2017		
Responsible:	NERC-BGS		
Summary:	This deliverable is not yet due. Ongoing experiments and modelling will support this deliverable.		
Deliverable no. and name:	**D2.3 Report on metal content mobilization with nanoparticles**		
Due date:	31.12.2017		
Responsible:	VITO		
Summary:	This deliverable is not yet due. Ongoing experiments will support this deliverable.		
Deliverable no. and name:	**D2.4 Report on overall system dynamics**		
Due date:	31.12.2017		
Responsible:	UNIM		
Summary:	This deliverable is not yet due. Ongoing concept development, results from experiments and modelling will support this deliverable.		

1.2.3 Work Package 3

WP title	**Metal recovery and electrochemical power generation**		
Lead beneficiary:	VITO	Participants:	KU Leuven
Start date:	01.10.2016	End date:	31.12.2018

Objectives of the WP

Natural networks of hydraulically-conductive metallic mineral veins could readily function as "heat-exchanger surfaces" in a novel type of EGS system designed to tap into both the geothermal and ore potential of these structures at depths of 4 km and more. In the technology envisioned by CHPM2030, large-scale intelligent geoengineering of the geological structure will take place, strictly configured to take advantage of the natural characteristics of the particular metallic deposit. The objective of this WP is to develop the tools and methods for orebody EGS reservoir management and test and validate the methods using simulations and laboratory experiments. There are three hypotheses to be tested in this WP:

- The composition and structure of orebodies have certain advantages that could be used to our advantage when developing an EGS;
- Metals can be leached from the orebodies in high concentrations over a prolonged period of time and may substantially influence the economics of EGS;
- The continuous leaching of metals will increase system's performance over time in a controlled way and without having to use high-pressure reservoir stimulation, minimizing potential detrimental impacts of both heat and metal extraction.

WP3 will implement the methodology framework research programme defined under Task 1.4 that will also provide initial quantitative targets.

Synthesis of work done and results achieved

The work in this WP is organised in 3 tasks. A summary or the work carried out by the beneficiaries involved in each of them, for the reporting period in which the WP has been active (M10-M18), is presented below. Progress within this WP is in-line with that anticipated.

Task 3.1 *Recovery of the metal content by high-temperature, high-pressure geothermal fluid electrolysis* (HTP) is led by KU Leuven. Since Nov 2016, for this task, an electrochemical reactor system has been designed and constructed, to be operated at temperatures up to 250 °C and pressures up to 20 MPa, to evaluate kinetics and mechanistic aspects of electrochemical reactions at HTP, which is crucial to evaluating the feasibility of metal recovery. A literature survey was also conducted and preliminary experiments have been made to evaluate the kinetics of Copper electrolysis at pressures of up to 1 MPa and 150 °C. The results of the work so far are summarized as follows:
Experimental Setup, Design and Construction: Design and construction of high temperature and pressure electrochemical rotating disk electrode (HTPRDE) reactor capable of operating at conditions up to 250 °C and 200 bar (Figure 5A and 5B) is in progress. As a part of the design and construction of the HTPRDE setup, hazardous operability (HAZOP) study and risk analysis was performed on the setup. The pressure rating for the reactor was established by a third-party engineering firm 'TUV Rhineland'. Process flow diagram (Fig. 6) and the operating procedure for the reactor were established. Request for procurement of high pressure gas cylinders, HP gas storage cabinets, and lines for delivering gas was made, which was scheduled and expected to be complete by June 30, 2017.

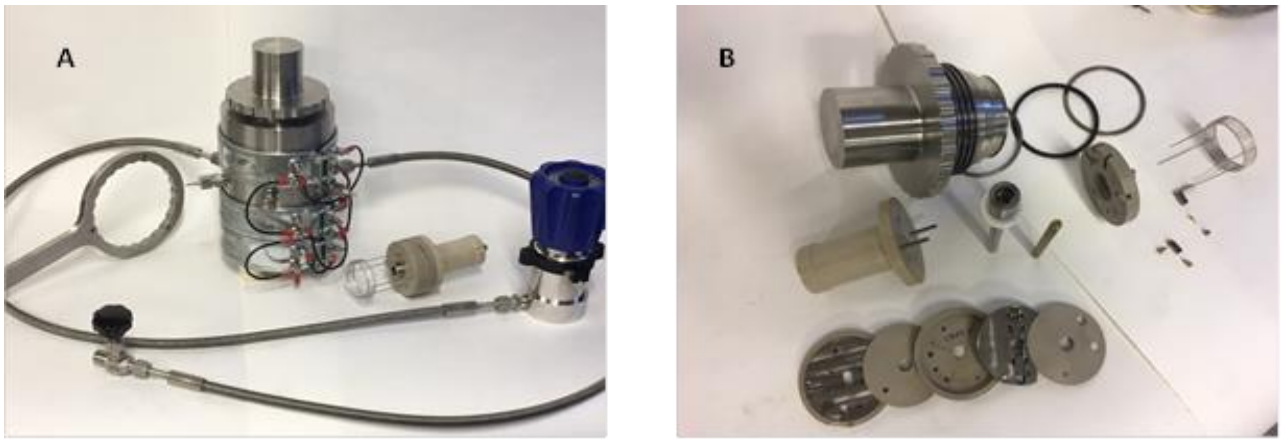

Figure 5: (A) Custom designed HTPRDE electrochemical reactor back pressure regulator, electrode assembly, and key (B) exploded view of electrode assembly in the VITO laboratory

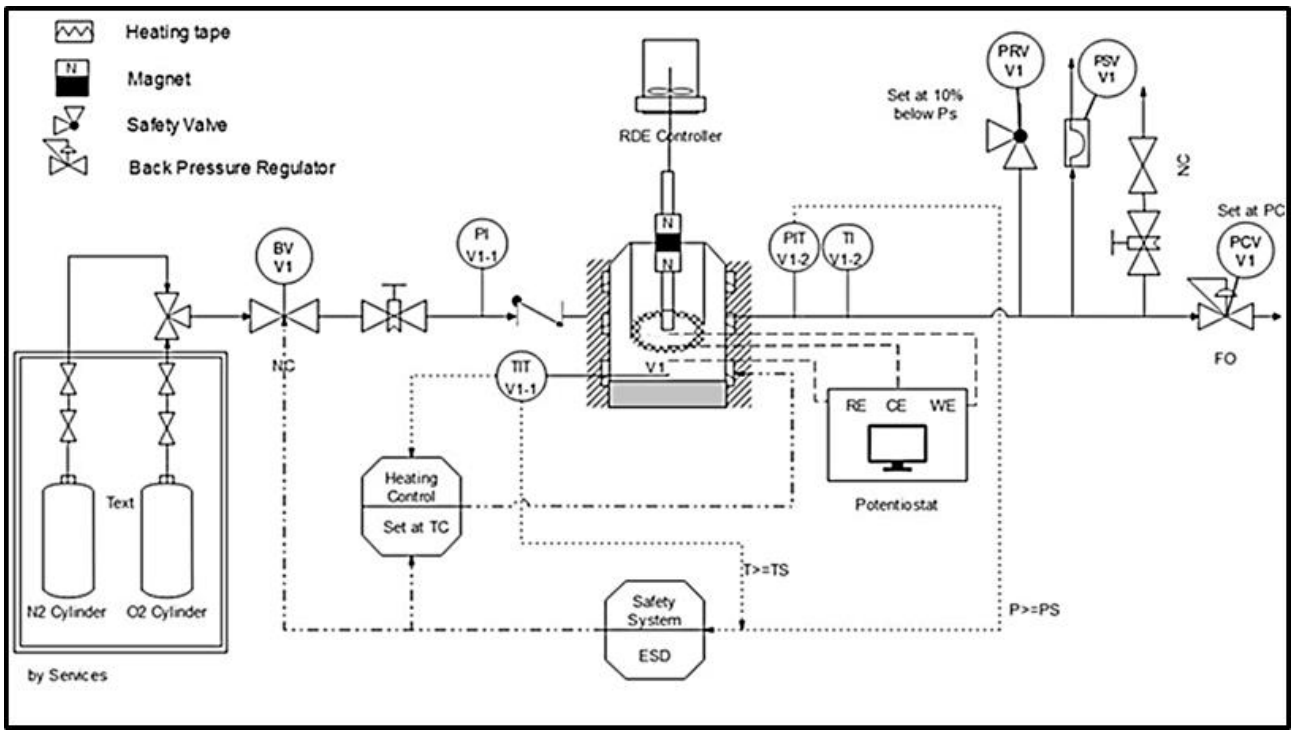

Figure 6: Process flow Diagram for HTPRDE electrochemical reactor system. PCV – Pressure control valve (backpressure regulator), PRV – Pressure relief valve. PSV – Pressure safety valve (burst seal), BV – Manual block valve, PI Pressure indicator, PIT – Pressure indicator transmitter, TI Temperature indicator, and TIT - Temperature indicator transmitter.

Reference Electrode Synthesis and Calibration: Conventional silver-silver chloride reference electrode and Pt pseudo-reference electrodes were synthesized and calibrated for operation at HTP. The stability of the silver-silver chloride reference electrode at HTP was found to be accurate for shorter durations up to a couple of hours. Therefore, Pt wire reference electrode was used synthesized, calibrated, and used for subsequent studies.

Preliminary experiments were conducted to evaluate the kinetics of copper electrodeposition at pressures up to 150 °C and 10 bar. Experiments were conducted on stationary microelectrode. The diffusion of Cu2+ ions, the deposition current, and hence the rate of copper electrodeposition was found to be considerably higher than that at room temperature and pressure. The diffusion coefficient of Cu2+ ions was at 130 C and 5 bar was estimated to be 7.7 x 10-5 cm2 s-1, 530 times higher than that observed at 25 °C and 1 atm.

Task 3.2 *Recovery of the metal content of geothermal fluids by gas-diffusion electroprecipitation and electrocrystallisation (GDEx)* is achieved by VITO. The preparation of the experimental setups to carry out the GDEx process was made. First tests with 3 relevant model geothermal brine compositions were carried out. Analysis of the performance of the GDEx process with respect to different operational parameters was carried out. Analysis of the products formed through the GDEx process was done.

During the work, a set of three relevant geothermal brine compositions was defined for testing metal recovery: (1) a low-silica and low-total-dissolved-solids reservoir in England (tested for Mg and Al recovery), (2) a high-silica and high-total-dissolved-solids reservoir in Iceland (tested for Fe and Cu recovery) and (3) a low-silica and low-total-dissolved-solids reservoir in Belgium (tested for Mg and Fe recovery). Reference measurements were performed in order to assess the performance of the gas-diffusion electrocrystallization process. An analysis of the anions and cations was performed, together with dynamic light scatterins, XRD analysis and the influence of different operational parameters on the recovery process. NaCl, Ca, Mg, Fe, Al and Cu were contained in the simulated geothermal brines. It was found that the metals evaluated precipitate at different pH than calcium and magnesium, under GDEx processing conditions. The full content of Cu, Fe, Al and Cu could be fully removed from the tested streams. No calcium precipitation was found, which is considered to be a positive aspect since calcium hydroxides have low value. Magnesium precipitation took place at higher pH than Fe, Cu, and Al, which makes a pH separation possible. GDEx increase to pH 7.5 is sufficient to remove the total content of Fe, Cu, and Al.

The mean particle size of the precipitates formed through GDEx is >1 µm for the Iceland and England cases, however the case of Belgium produced 90% nanoparticles of about 47 nm (the remaining 10% consisted of large flocks). Polydisperse flocks were formed in all cases. The products formed on the Iceland case were predominantly copper chloride hydroxide and its hydrate; for the England case the predominant product formed by GDEx was aluminium hydroxide, whereas for the Belgium case the predominant products were calcium iron chloride hydroxide hydrate and magnesium hydroxide. More compositions need to be investigated to assess the influence of different metals and their concentrations, and the thermodynamic equilibria of these cases need to be calculated in order to assess the regions of operability of the process. Short term membrane fouling was found for the Iceland case, but a long term investigation is needed. A first evaluation of the basic operational aspects seems promising: there is a good utilization of current for precipitation.

A lower salt concentration resulted in a higher energy use per kilogram of metal removed. The current efficiency decreases with increasing pH at the catholyte. The energy use in the laboratory cell (0.2-2 kWh/m^3 brine) is expected to be sufficiently low for the process to be competitive, e.g. vs energy costs of mining operations (2-12 kWh/ton ore). A set of relevant benchmarking parameters obtained from the GDEx process is presented in Table .

Table 1 Operational performance parameters of the GDEx process applied to the model geothermal brines tested

	Iceland	England	Belgium	
Treatment rate	230	730	2600	l/(m^2GDE.h)
Electrode surface 100 m^3/h	100	470	760	m^2GDE
Electrode surface/production rate	15	26	12	m^2GDE /(kgmetal.h)

Lab setup energy use (based on I and Ewe vs EC)	0.19	0.96	2.10	kWh/m^3
Lab setup energy use (based on I and Ewe vs EC)	2.9	5.6	3.4	kWh/kg metal rem.
Lab setup current efficiency for metal removal +pH correction	0.97	0.99	0.81	(Eq MeOH + Eq OH-pH)/(e-mol used)

Task 3.3 *Salinity-gradient power from pre-treated geothermal fluids* started in M18 and is carried out by VITO. For the experiments on electrochemical power generation, based on an existing cell for measuring apparent permselectivity of ion exchange membranes, a three-compartment cell was constructed to accommodate two membranes, one anion exchange membrane and one cation exchange membranes. Bulk potential is measured in each of the three compartments. As a starting point, pure NaCl solutions were used for selecting suitable membranes. The highly concentrated brine is circulated in the outer compartments and ions permeate through the respective membrane towards the middle compartment with a low salinity. The potential difference between the three compartments is measured continuously, as is the conductivity. In this way both ion flux and donnan potential can be monitored and a solid prediction of the power output in a full-sized SGP-RE stack can be made. First experiments with pure NaCl at 5M vs 0.1M (achieving milestone M2) showed a power density exceeding 20W/m².

Status of ongoing and finalised deliverables

Deliverable no. and name:	**D3.1 Report on performance, mass and energy balances and design criteria for high- temperature and high-pressure electrolysis**		
Due date:	31.08.2018		
Responsible:	KU Leuven		
Summary:	Experiments ongoing and on time to complete this deliverable (no major deviations anticipated so far).		
Deliverable no. and name:	**D3.2 Report on performance, mass and energy balances and design criteria for gas- diffusion and electroprecipitation and electrocrystalization**		
Due date:	31.08.2018		
Responsible:	VITO		
Summary:	Experiments ongoing and on time to complete this deliverable (no major deviations anticipated so far).		
Deliverable no. and name:	**D3.3 Report on performance, mass and energy balances and design criteria for salt gradient power reverse electrodialysis**		
Due date:	30.06.2018		
Responsible:	VITO		
Summary:	Experiments ongoing and on time to complete this deliverable (no major deviations anticipated so far).		

1.2.4 Work Package 4

WP title	**Systems integration**		
Lead beneficiary:	ISOR	**Participants:**	UNIM, USZ, VITO, KU Leuven
Start date:	01.04.2018	**End date:**	30.06.2019

Objectives of the WP

The aim of WP4 is to integrate downstream and upstream processes into a single system and develop optimisation strategies for energy and metals production. This task will combine the past experience of the consortium members with the design of medium and high-enthalpy geothermal systems and the outcomes of WP2 and WP3 to create a novel technology line that will produce energy and valuable metals in a single, interlinked process. This knowledge will be utilised to adapt contemporary power plant design to the expected temperature and extreme salinity conditions that will occur under the CHPM2030 scheme.

Synthesis of work done and results achieved

The work in this WP involves 3 tasks, none of them have started yet.

Task 4.1 *Conceptual framework(s) for CHPM power plant* will start in M24 but some preliminary activities have already been done. ISOR, as the lead partner, carried out discussions on planning the conceptual framework with LPRC, USZ, MINPOL, VITO and KU Leuven on the personal consortium meetings and also the online meetings.

Task 4.2 *Process optimisation and simulations.* According to the time schedule described in GA Annex I this task will start in M32. However, VITO made literature research as preliminary work to this task.

Task 4.3 *CHPM schematics and blueprints.* According to the time schedule described in GA Annex I this task will start in M36.

Status of ongoing and finalised deliverables

Deliverable no. and name:	**D4.1 Conceptual Framework for CHPM power plant**		
Due date:	30.09.2018		
Responsible:	ISOR		
Summary:	Except some preliminary activities, work on this deliverable hasn't started yet.		
Deliverable no. and name:	**D4.2 Report on CHPM Process optimisation**		
Due date:	31.05.2019		
Responsible:	VITO		
Summary:	According to the time schedule in GA Annex I, work on this deliverable hasn't started yet.		
Deliverable no. and name:	**D4.3 CHPM schematics and blueprints**		
Due date:	30.06.2019		
Responsible:	ISOR		
Summary:	According to the time schedule in GA Annex I, work on this deliverable hasn't started yet.		

1.2.5 Work Package 5

WP title	**Integrated sustainability assessment**		
Lead beneficiary:	USZ	**Participants:**	UNIM, EFG, ISOR, NERC-BGS, LNEG, LPRC, MINPOL, IGR, SGU
Start date:	01.06.2017	**End date:**	30.06.2019

Objectives of the WP

Work package 5 will assess the expected environmental and socio-economical impacts for each component of the proposed CHPM technology followed by an overall systems-level performance assessment. This will include a preliminary LCA and investigations concerning the environmental footprint of the envisioned technology scenarios. Comparison will then be made with existing systems (both for power generation and mineral extraction) to have a good understanding of the relation of CHPM2030 to existing solutions from an environmental and economics performance point of view. Performance indicators will consider the fact that CHPM envisions the integration of two, insofar independent processes for improved economics: the production of energy and the production of metals. Work will focus on the socio-economics, environmental and life-cycle issues, risks, risk ownership and possible risk mitigation, performance and cost targets together with relevant key performance indicators and expected impacts.

Synthesis of work done and results achieved

The work in this WP is organised in 6 tasks. Task 5.1 started in M18, Tasks 5.2, 5.4 and 5.5 will start in M24, Task 5.3 will start in M28, and Task 5.6 will start in M36.

Task 5.1 *Integrated sustainability assessment framework* is in the initial phase of implementation. Work on the integrated sustainability assessment framework started by building a model which is designed to be able to visualize the optimal composition of the produced heat, electricity and metals by the CHPM facility, depending on the world price of each produced metals, the price of the electricity and of the heat. This model would optimally be able to support decision to divert the production of each component if that is not feasible based on the world price. The sustainability of the ore extracting processes and geothermal energy production are crucial part of this task.

Task 5.2 *Baseline economics for energy and mineral raw materials.* Although this WP hasn't started yet, the specifics of co-operation between USZ and MINPOL have been discussed via e-mail exchange, and a personal meeting was also organised in the headquarters of MINPOL, between experts of the two partners. Schedules, responsibilities, deadlines were agreed. The joint work started with the development of a first draft of the contents of D5.2.

Task 5.3 *Decision support for economic feasibility assessment.* As preliminary activities, the content and outline of D5.3 was also discussed on the meeting between USZ and MINPOL. MINPOL made some preparation work in 2016 for Task 5.3 as it is explained in Section 5.2.

Task 5.4 *Social Impact Assessment and policy considerations.* As preliminary activities before the official start of this task, a search for the best practices to study social impact has been started, discussing pros and cons of using a survey to recognise the opinion of the public. If a survey is used, it will have to be representative and not local, to sample opinions from a range as broad as possible.

However, a CHPM facility will always be local, therefore local people need to be polled and informed beforehand, which information may shape their opinion.

Task 5.5 *Environmental Impact Assessment.* The work related to the environmental impact assessment framework was discussed on the second consortium meeting, with the presence of the Advisory Board. During that meeting a few companies and people with possibly relevant experience were contacted for further co-operation and to gain access for the environmental impact assessment of a European EGS project. During this assessment the risk of induced seismicity, environmental pollution, greenhouse gas emission and possible hazards will be taken into consideration with particular attention.

Task 5.6 *Ethics Assessment.* No preliminary activities have been taken yet.

Status of ongoing and finalised deliverables

Deliverable no. and name:	**D5.1 Integrated sustainability assessment framework**		
Due date:	31.12.2017		
Responsible:	USZ		
Summary:	This deliverable is not yet due. Consultations on the content of the deliverable have been made.		
Deliverable no. and name:	**D5.2 Economic feasibility assessment methodology**		
Due date:	31.08.2018		
Responsible:	MINPOL		
Summary:	This deliverable is not yet due. This deliverable is not yet due. Consultations on the approach for the methodology have been made.		
Deliverable no. and name:	**D5.3 Self Assessment Tool**		
Due date:	30.04.2019		
Responsible:	MINPOL		
Summary:	This deliverable is not yet due.		
Deliverable no. and name:	**D5.4 Report on policy implications**		
Due date:	30.06.2019		
Responsible:	MINPOL		
Summary:	This deliverable is not yet due.		
Deliverable no. and name:	**D5.5 Environmental Impact Assessment Framework**		
Due date:	29.02.2019		
Responsible:	USZ		
Summary:	This deliverable is not yet due. Consultations on the environmental parameteres with the Advisory Board have been made.		
Deliverable no. and name:	**D5.6 Ethics Assessment Report**		
Due date:	30.06.2019		
Responsible:	USZ		
Summary:	This deliverable is not yet due.		

1.2.6 Work Package 6

WP title	**Roadmapping and Preparation for Pilots**		
Lead beneficiary:	LPRC	**Participants:**	UNIM, USZ, EFG (with LTPs), ISOR, NERC-BGS, LNEG, VITO, IGR, KU Leuven, SGU
Start date:	01.12.2017	**End date:**	30.06.2019

Objectives of the WP

WP5 will set the ground for subsequent pilot implementation, bearing in mind that CHPM2030 is a low-TRL research project, based on a novel idea that needs further nurturing and support beyond the immediate duration of the project. The other objective of this WP is to map converging technology areas and develop a research roadmap that could help bring forward the realisation of the envisioned CHPM scheme. Given the strong policy push (for both energy and metallic raw materials independence) we expect that if such critical auxiliary research topics can be identified (e.g. novel drilling methods, membrane technology for reverse electrodialysis, etc.) than the industrial-scale deployment of this approach could be brought forward in time.

Synthesis of work done and results achieved

Work of this WP is organised in 3 tasks. Task 6.1 and 6.2 will start in M24, Task 6.3 will start in M33.

Task 6.1 *Horizon Scanning and Visions.* This task has the objectives to start up a technology visioning process against different scenarios, mobilization of expertise from the two research communities, investigate other energy harvesting methods with the goal of defining future industry relevant concepts. Preliminary activities are limited to the discussions on the methodology with the partners on the consortium meetings.

Task 6.2 *Preparation for pilots.* This subtask will support the development of technology and economic feasibility for pilot implementation of such system. Discussion has been made with NERC-BGS, LNEG, IGR and SGU on the CHPM-related features of the potential pilot sites.

Task 6.3 *Roadmapping.* Preliminary activities on this task haven't been carried out yet.

Status of ongoing and finalised deliverables

Deliverable no. and name:	**D6.1 Report on Emerging and Converging Technologies**		
Due date:	30.04.2019		
Responsible:	LPRC		
Summary:	Preparation for this Deliverable will start during the second half of 2017		
Deliverable no. and name:	**D6.2 Reports on Pilots – compiled from 5 reports**		
Due date:	30.04.2019		
Responsible:	LPRC		
Summary:	Preparation for this Deliverable will start during the second half of 2017		

Deliverable no. and name:	D6.3 Roadmap for 2030 and 2050		
Due date:	30.06.2019		
Responsible:	LPRC		
Summary:	Preparation for this Deliverable will start during the beginning of 2018		

1.2.7 Work Package 7

WP title	Dissemination and stakeholder involvement		
Lead beneficiary:	EFG	**Participants:**	UNIM, USZ, ISOR, NERC-BGS, LNEG, VITO, LPRC, MINPOL, IGR, KU Leuven, SGU
Start date:	01.01.2016	**End date:**	30.06.2019

Objectives of the WP

This Work Package seeks dialogue and engagement as well as dissemination of thematic WP outputs towards the stakeholder communities, research organizations, universities, SMEs and large companies, investors, R&D funding organizations, relevant technology platforms, NGOs, professional associations and the general public.

Synthesis of work done and results achieved

Within this Work Package, the work is organised in 3 tasks, which last from the beginning to the end of the project.

Task 7.1 *Dissemination management*. In the first months of the project, a *communication and dissemination plan* has been developed by EFG and presented to the consortium for approval. The communication and dissemination plan defines and prioritises the key objectives of dissemination of CHPM2030 and details the steps to be taken during the project's lifetime in order to achieve maximum impact and reach relevant audiences, combining timing and different media supports with consistent message content, structure and format. It also sets the framework to facilitate communications among the consortium members and between the consortium and stakeholders or the general public.

Task 7.2 *Dissemination support services*. Right at the beginning of the project, EFG prepared a draft of the *project logo* and sent it to partners for approval. Following discussions at the project's kick-off meeting, the logo has been improved and approved by the consortium in March 2016 (Figure 7).

Figure 7: The CHPM2030 logo.

EFG also prepared *project-specific design elements* and *templates* for reports, deliverables, PowerPoint presentations and press releases that create a uniform visual appearance and ensure the

visibility of EU funding. The material has been made available to all partners via the project's Google drive.

The basic *project website* (http://mfk.uni-miskolc.hu/chpm2030) was launched in January 2016, in the month of the project's start. This basic website provided an overview about the project's background and objectives. The final version of the website that was launched in June 2016 includes more detailed information about the project's objectives, approach, dissemination materials and links to the project's different social media channels. All technical reports will be made available through the outreach section of the website (http://www.chpm2030.eu/outreach/). For instance, four deliverables of WP1 were redesigned in a more reader-friendly way and uploaded to the website in January 2017.

The website also includes a news section where the public can find updated information about the project's ongoing activities. The news section has a social media share function that allows to share all news articles on LinkedIn, Twitter and Facebook. EFG updates the website whenever new dissemination materials or news items are available.

At the beginning of the project, EFG set up *social media* accounts for CHPM2030 on LinkedIn, Twitter and Facebook and shares information relevant to the project at least once per week resulting in by now 37 followers on LinkedIn, 98 followers (161 tweets) on Twitter, and 60 likes (74 posts) on Facebook (data as of 7 July 2017).

To help raise awareness to industry stakeholders, both within the partner countries and in other EU countries, the consortium aims at generating at least four *newsletters* during the project's duration. So far, two newsletters have been prepared by EFG (in June 2016 and June 2017) and disseminated to the project's mailing list. The newsletters provided information about the project aims and the current status of work. EFG also disseminated the newsletter via its own communication channels reaching approximately 45,000 geoscientists all over Europe.

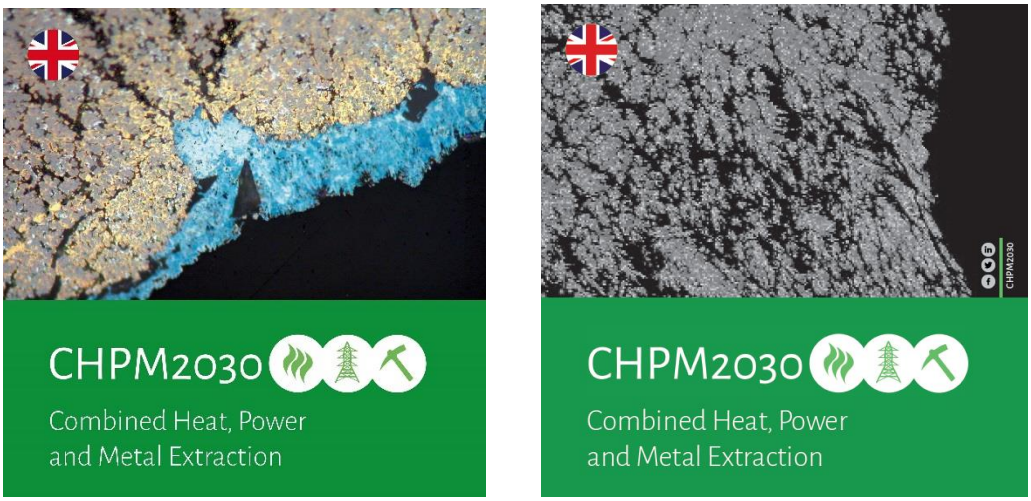

Figure 8: Cover of the first (left) and the second (right) project brochures.

With the help of UNIM who prepared the texts, two project *brochures* have been designed by EFG and were printed in month 6 and month 18 (Figure 8). The first version of the brochure was designed to provide a general overview of the project objectives; the second version introduced interim project results and provided an overview of the current status of work. The first version of the brochure has been translated by the EFG Linked Third Parties into 14 European languages (Czech, Dutch, Finish, French, German, Greek, Hungarian, Italian, Polish, Portuguese, Romanian, Serbian, Slovenian,

Spanish) and made available on the project website. The translated versions of the second brochure are currently under preparation. Another update of the brochure is planned for month 32.

All promotional materials are available to partners via the project's Google drive.

In summer 2017, a *YouTube Channel* will be set up for CHPM2030. In collaboration with LPRC, a project *video* is currently under preparation and will be uploaded to the YouTube Channel and broadly disseminated through the social media.

EFG also designed a *poster* providing general information about the project that partners may use to promote CHPM2030 at conferences or exhibitions (Figure 9).

Figure 9: CHPM2030 poster for promotion.

As part of WP7, the EFG office also disseminated project news using the weekly EFGeoWeek newsletter, the monthly GeoNews and the trimestrial EFG Project newsletter. Several articles were published on the EFG website and in the bi-annual European Geologists Journal. The approximated audience size of these online and print publications is ~50,000 covering mainly geoscience professionals, scientists and policy makers through the national member associations.

EFG's efforts in disseminating the project towards the European geoscientists' community are supported by the LTPs, national member associations of EFG. They disseminate the results of the

CHPM2030 project at national level in web portals, newsletters, magazines, articles, conferences, workshops, educational activities, exhibitions or any other relevant means. They will also translate the three project brochures into the national languages (the first brochure has already been translated in 2016). 7 EFG member associations do not take part in the project but they also disseminate the project results at a basic level in their own countries (newsletter, website) as a part of the usual communication channel between EFG and the national professionals. One of the LTPs, RBINS doesn't take part in the dissemination. Dissemination materials have been provided to the LTPs in English by EFG.

Contribution to the Task 7.2 by the other partners are as follows:

UNIM actively participates in the dissemination. Consultations with EFG were carried out on the deliverables D7.1, D7.2, D7.3, D7.4, D7.5, D7.6, D7.8, D7.9 and D7.12. Tamás Madarász was the reviewer of D7.12. Éva Hartai provided texts for the website and for the brochures. For sharing documents and files, the CHPM2030 project established a Google Drive repository. UNIM manages the dissemination table on the Drive. In this table, all project related dissemination actions are listed.

ISOR: Participation in the CHPM2030 video and contribution of photos to support the project's promotion.

LNEG: Publication of the CHPM2030 newsletter on the LNEG's webpage.

LPRC actively participates in the dissemination:

- CHPM2030 news items and project description on the LPRC website:
  http://www.lapalmacentre.eu/portfolio-item/chpm2030/
  http://www.lapalmacentre.eu/tag/chpm2030/
- Twitter posts and retweets on CHPM2030:
  https://twitter.com/lapalmaresearch
- LPRC is preparing a short introduction video of the project by interviewing the WP leaders. The interviews have been recorded already, the editing work will be during summer (2018).

IGR reviewed D7.8 and translated the text of D7.5 1st Brochure into Romanian.

Task 7.3 *Leveraging dissemination and dialogue*. The consortium has been participating actively in several workshops and events organised by the EC and/or other projects and institutions addressing energy efficiency and/or mining. Project partners are also participating at various working groups, panels and EU initiatives. These interaction possibilities provide an important opportunity to improve the outcomes of each work package, and supply opportunities for dialogue and engagement with other EU networks (such as ERA-MIN, the EIP on Raw Materials or the ETP-SMR) and external stakeholders (such as the IUGS, UNEP, the Committee for Mineral Reserves International Reporting Standards (CRIRSCO), EuroGeoSurveys and the International Council on Mining and Metals (ICMM)).

Details about the activities carried out by each partner within task 7.3 are listed below:

EFG presented the project and disseminated promotional material on international conferences in Offenburg (GeoTHERM 2016), Moscow (Russian State Commission of Mineral Reserves, 90th anniversary international conference) and Paris (EAGE Conference & Exhibition 2017). The main audience was the geothermal and mining communities (Offenburg, Moscow) and geotechnical community (Paris). EFG is supporting the organisation of the "Geochemistry of geothermal fluids" workshop to be held in Miskolc, Hungary, in October 2017 by setting up a dedicated page on the

CHPM website (http://www.chpm2030.eu/workshop-geochemistry-of-geothermal-fluids/) and promoting the workshop through its communication tools.

UNIM, in the representation of the CHPM Consortium, joined the alliance of the running H2020 geothermal projects. The alliance was initiated by GFZ Potsdam (DESTRESS project). Related to this, Tamás Madarász participated in the *Joint Geothermal Projects* Meeting on 8-9 Marc 2016, in the TNO headquarters in Utrecht, providing a presentation. He also attended the Geothermal Research and Innovation Projects Meeting on 9 September 2016, organised by INEA in Brussels, and provided a presentation. He participated in the teleconference on the H2020 geothermal projects on 29 November, organised by INEA. For the request by INEA, UNIM collected and provided dissemination materials to INEA. Aranka Földessy attended the EuroGeoSurveys Raw Materials Week Workshop on 30 November in Brussels, and disseminated promotion materials. Beside the above-mentioned actions, UNIM participated in several international and national conferences and workshops and presented the project results:

- EuroWorkshop 'Geothermal - The Energy of the Future'. Santorini, Greece (2 presentations)
- National Groundwater Foundation Annual Event, Siófok, Hungary
- Mineral Resources of Hungary, Miskolc, Hungary
- Budapest Water Summit, Budapest, Hungary
- New results in earth-science related research. Hungarian Academy of Sciences, Budapest, Hungary

Éva Hartai was interviewed by a Hungarian public online magazine on the CHPM2030 project.
Éva Hartai with co-authors (Balázs Bodó and the CHPM2030 Team) published an article in the 43rd issue of the European Geologist journal.

USZ participated in several international and national conferences and workshops and presented the project results:

- Well Stimulation – Hydraulic Fracturing in Focus Conference, Herceghalom, Hungary
- European Geothermal PhD Day, Bochum, Germany
- Triennial General Assembly of Hungarian Geological Society, Sárospatak, Hungary

BGS actively participates in the dissemination work package, both within-project (e.g. via the Google Drive) or externally to interested parties.
In terms of dissemination outside of the CHPM2030 project team, BGS has been involved in:

- Attending the First EERA symposium in Birmingham, UK, and presenting a general poster on the CHPM2030 concept,
- Attending the Santorini geothermal workshop, and giving a talk on progress of the WP2 leaching experiments,
- Distribution of the CHPM2030 brochure including the Spanish-language version in Mexico.

BGS provided helpful comments on written outputs, including the article in the 43rd issue of the European Geological journal.

LNEG participated in the Green Business Week and presented the CHPM project in Lisbon-Portugal, 15-17th March, 2017

VITO has been involved in:

- Attending the Santorini geothermal workshop, and giving a talk on progress of the WP3 electrochemical experiments.
- Distribution of the CHPM2030 brochure wherever possible.

- VERAM project workshop for the roadmap of critical raw materials up to 2030 & 2050, where the relevance of geothermal projects on the recovery of critical metals was highlighted and brought as a topic on the research agenda.
- Geothermal workshop Santorini: presentation on metal recovery and electrochemical power generation

Comments on text of CHPM2030 written outputs, including an article in the 43rd issue of the European Geological journal.

LPRC has been involved in the following activities:

- Preparation of a short introduction video of the project by interviewing the WP leaders. The interviews have already been recorded, the editing work will be during the summer of 2017.
- European Geosciences Union General Assembly 2017 - participation with a poster presenting CHPM2030 (Figure 10).
- 20th Congress of Hungarian Geomathematicians and 9th Congress of Croatian & Hungarian Geomathematicians conference participation and introducing CHPM project, brochure distribution.

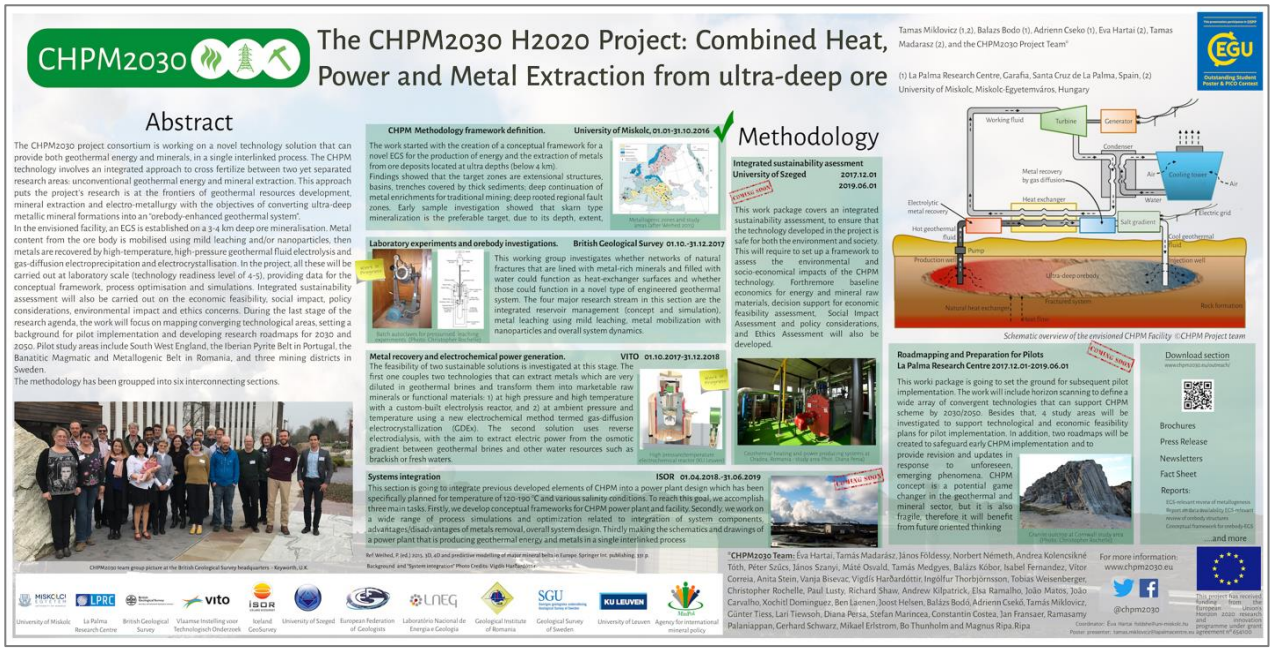

Figure 10: The CHPM2030 poster presented at the European Geosciences Union 2017 congress.

MINPOL has inked its website to the website of CHPM project. Maria Kehrer and Blazena Hamadová disseminated the CHPM leaflet at the first consortium meeting of the MINFUTURE project at TU Wien, 7-9 th June 2017. Angelika Brechelmacher displayed the CHPM leaflet at the AIMS Mining in Europe, Aachen, Germany, 7-8 th June 2017.

IGR: Three representatives of IGR participated in EuroWorkshop Geothermal - The Energy of the Future, in Santorini, Greece, where a poster was displayed which was also made available on researchgate.net. There was an oral presentation by Diana Persa on the project on the 110th anniversary of IGR, 12th June 2016, during a scientific session. The event was hosted by the National Geological Museum of Romania. Diana Persa also gave an interview to a Romanian national radio channel (Radio Romania Cultural).

KU Leuven is committed to active dissemination of results as they are obtained. For this reporting period, WP3 results were presented by Joost Helsen at the EuroWorkshop Geothermal - The Energy of the Future. Santorini, Greece. KU Leuven plans to publish their findings in peer-reviewed journals and present the results at the upcoming Electrochemical Society international conferences.

SGU has been providing and revising material for dissemination and assembling relevant literature.

In summary, the results achieved in WP7 can be resumed as follows:
The consortium has produced various electronic and printed deliverables that support the efforts made by all partners to promote the project:

- Website
- Powerpoint templates
- Press-release templates
- Two brochures
- Two newsletters
- Two posters
- Social media

On the other hand, an extensive list of dissemination activities has already been achieved, including:

- Presentations (oral and posters) at various conferences and workshops both at national and international level;
- Articles submitted to peer reviewed journals;
- Publication of news articles on websites and newsletters.

The full list of dissemination activities, continuously updated, may be consulted in the 'Dissemination Table' on the project's Google drive at
https://docs.google.com/document/d/1RWPSYMdrFvYQkXrF_ccmPK31PvMdOVOJi7uA5MfIfQc/edit?usp=sharing

The table includes the dissemination actions at international conferences and EU-level workshops; presentations at national conferences and workshops; publications in journals or on internet, and actions on other types of promotion (leaflets, interviews, etc.). Supporting documents for each action are also uploaded to the drive. The full list of the dissemination activities by the project partners and the EFG Linked Third Parties is available in Annex1 of this report.

Status of ongoing and finalised deliverables

Deliverable no. and name:	**D7.1 Basic project website**		
Due date:	01.02.2016	Delivered to the EC on 01.02.2016	Status: approved
Responsible:	EFG		
Summary:	The CHPM2030's basic website (http://mfk.uni-miskolc.hu/chpm2030) was launched in January 2016, in the month of the project's start. The website supported the implementation of the project, providing a project overview, dissemination materials, and links to the project's social media channels.		
Deliverable no. and name:	**D7.2 Final project website**		
Due date:	30.06.2016	Delivered to the EC on 28.06.2016	Status: approved
Contributors:	EFG		

Summary:	The final version of the project website includes more detailed information about the project's objectives, approach, dissemination material and links to the project's social media channels. The website elements evolve with time, to ensure the best possible interaction with users during the project lifetime.		
Deliverable no. and name:	**D7.3 Project image and stylebook**		
Due date:	30.04.2016	Delivered to the EC on 20.04.2016	Status: approved
Responsible:	EFG		
Summary:	The project image and stylebook includes the logo, the project-specific design elements and templates which create a uniform appearance in the project, and is always used for project-related communication by all consortium members.		
Deliverable no. and name:	**D7.4 Communication and Dissemination Plan**		
Due date:	30.06.2016	Delivered to the EC on 28.06.2016	Status: approved
Responsible:	EFG		
Summary:	This document defines and prioritises the key objectives of dissemination of CHPM2030 and details the steps to be taken during the project's lifetime in order to achieve maximum impact and reach relevant audiences. It also sets the framework to facilitate communications among the consortium members and between the consortium and stakeholders or the general public.		
Deliverable no. and name:	**D7.5 Brochure First edition**		
Due date:	30.06.2016	Delivered to the EC on 28.06.2016	Status: approved
Responsible:	EFG		
Summary:	The first version of the project brochure provides basic data about the project, a general overview of the project objectives and expected impacts. It is available not only in English but also in further 14 languages (Czech, Dutch, Finish, French, German, Greek, Hungarian, Italian, Polish, Portuguese, Romanian, Serbian, Slovenian, Spanish).		
Deliverable no. and name:	**D7.6 Brochure Update 1**		
Due date:	30.06.2017	Delivered to the EC on 17.06.2017	Approved
Responsible:	EFG		
Summary:	The second version of the brochure provides updated information on the current status of the project. It will also be translated by EFG's Linked Third Parties to facilitate promotion at national level.		
Deliverable no. and name:	**D7.7 Brochure Update 2**		
Due date:	31.08.2018		
Responsible:	EFG		
Summary:	This deliverable is not yet due.		
Deliverable no. and name:	**D7.8 Newsletter 1**		
Due date:	30.06.2016	Delivered to the EC on 28.06.2016	Status: approved
Responsible:	EFG		
Summary:	Newsletter 1 provides information on the project data, the aims, and the ongoing activity in Work Package 1. It has been disseminated to the project's mailing list and via the EFG communication channels reaching approximately 50,000 geoscientists all over Europe.		

Deliverable no. and name:	**D7.9 Newsletter 2**		
Due date:	30.06.2017	Delivered to the EC on 19.06.2017	Approved
Responsible:	EFG		
Summary:	Newsletter 2 provides information on the current status of the project, focusing on the ongoing activities.		
Deliverable no. and name:	**D7.10 Newsletter 3**		
Due date:	31.08.2018		
Responsible:	EFG		
Summary:	This deliverable is not yet due.		
Deliverable no. and name:	**D7.11 Newsletter 4**		
Due date:	30.06.2019		
Responsible:	EFG		
Summary:	This deliverable is not yet due.		
Deliverable no. and name:	**D7.12 Press-releases and media-kits related to CHPM2030 initiatives and outcomes**		
Due date:	30.06.2016	Delivered to the EC on 28.06.2016	Status: approved
Responsible:	EFG		
Summary:	The first press-release contains the basic information about the project, and details the tasks under preparation.		
Deliverable no. and name:	**D7.13 Fact sheets on the CHPM technology**		
Due date:	31.12.2017		
Responsible:	EFG		
Summary:	This deliverable is not yet due.		
Deliverable no. and name:	**D7.14 International Conference**		
Due date:	31.05.2019		
Responsible:	EFG		
Summary:	This deliverable is not yet due.		

1.2.8 Work Package 8

WP title	**Project management**		
Lead beneficiary:	UNIM	**Participants:**	USZ, EFG, ISOR, NERC-BGS, LNEG, VITO, LPRC, MINPOL, IGR, KU Leuven, SGU
Start date:	01.01.2016	**End date:**	30.06.2019

Objectives of the WP

The objective of WP8 is to ensure a smooth and on-time execution of the project for the entire consortium, based on the description of work and in accordance with the European regulations. Work includes project planning, monitoring of the project progress, maintenance of effective

communication and exchange of relevant information within the Consortium. The Coordination work is shared among the three members of the Coordinating Team.

Synthesis of work done and results achieved

The work of this WP is organised in 6 tasks. Below the activities and the results are listed by tasks.

Task 8.1 *Coordination and supervision of project activities*. University of Miskolc set up its team of project coordination already before the start of the project. The team includes the project coordinator, the project manager and the financial and technical assistant. The project coordination and supervision structure was introduced to and approved by all the partners during the kick off meeting. The structure includes the setting up the Project Steering Committee (WP leaders), the Advisory Board, the Intellectual Property Board and Roadmapping Committee. In order to rationalise the project operational structure, the consortium agreed that the Intellectual Property Board shall be identical with the Steering Committee, and the Roadmapping Committee shall be identical with WP6 researchers/members. Special attention was paid to the setting up of an Advisory Board with highly qualified members representing a broad range of relevent competences. The Advisory Board meets the consortium once per year during the project implementation. The first meeting with the Advisory Board was in October 2016 when the Board started its evaluating and supporting activities. The management has established a fluent communication with the Advisory Board members through e-mails and by sharing documents on the Google drive. Google drive is a very effective tool of the project management. The documents are organised in folders and the continuously updated (Figure 11).

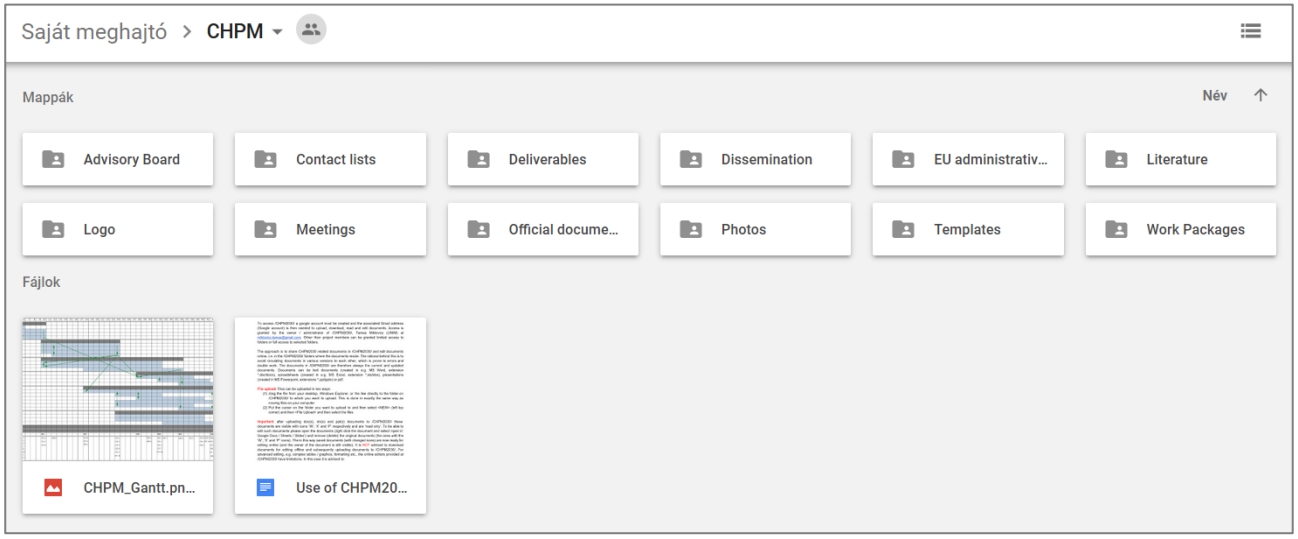

Figure 11: Folders of the CHPM2030 Google drive.

The project activities were arranged into work packages, and responsibilities were undertaken by WP leaders. All major activities of the project are arranged through this structure. The Coordinator continuously monitors activities of WPs through email communication, consortium meetings (twice a year) and monthly online meetings, using the GoToMeeting software. Monthly online meetings started to be held in December 2016. Minutes of the consortium meetings and the online meetings are circulated among the partners and uploaded to the google drive. In the minutes, the due actions, the responsible partners and the deadlines are indicated.

Task 8.2 *Administrative project management.* The project WP structure, deliverables and responsibilities and all unclear issues not fixed during the proposal and negotiation phase were

clarified during the first project consortium (kick off) meeting. The finalised and approved Gantt diagramm serves as the ultimate scenario book of project activities, which has strongly supported a disciplined project implementation (Figure 12).

The project manager has participated in the two Geothermal H2020 project meeting that were hosted by INEA (September 2016, June 2017) and thus the project was integrated into the joint European efforts to ensure the proper realisation of European research goals in the geothermal energy context. Also, the coordinator is continuously keeping close communication with the Project Officer of the project.

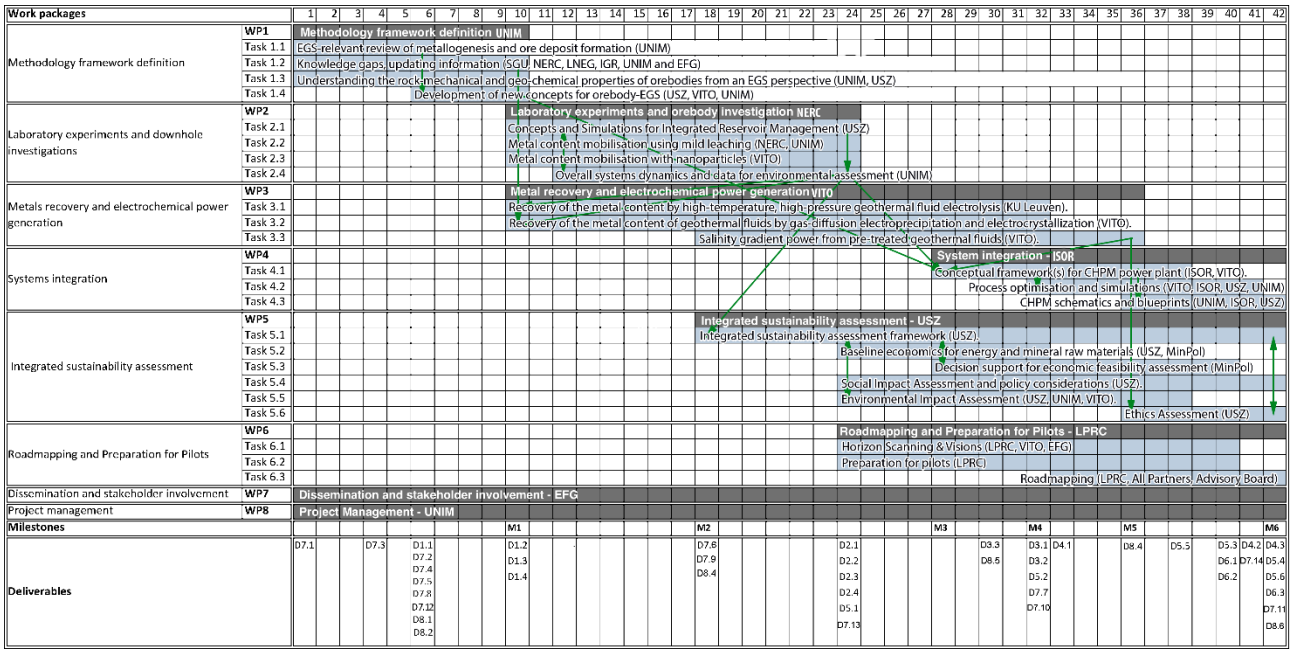

Figure 12: CHPM2030 Gantt diagram indicating the output-input relations between the tasks, the milestones and the deliverables.

The project management has studied in detail all relevant documents legally and financially binding to project implementation (AMGA, Funding Contract, Consortium Agreement, etc.). UNIM as the coordinator highlighted the importance for all partners to carefully study all relevant documents, meanwhile kept them informed in any emerging questions, issues during the first period of project implementation.

All project partners established their own management structures building up their own technical and financial support in their own institutions.

Considerable efforts were put into understanding and complying national and institutional rules with AMGA regulations, especially in the case of Eastern European countries. At some partners, the national regulations and the European concepts were different and difficult to harmonise. In this context, continuous discussion was carried out with the NCP-s of Hungary who have assisted in proper understanding and interpretation of EC's regulations.

Task 8.3 *Administrative project reporting.* The first reporting period of the project covers M1-M18 (January 2016 - June 2017). Under the supervision of the coordinator all partners have started their preparation for the first midterm reporting, including technical and financial reports. Their activities were supported by the internal reporting scheme that was established by the coordinator in M9. All

partners have prepared their internal report which offered a reasonable insight into the partners project specific activities.

Internal deadlines for the first Periodic Report were set during the last consortium meeting (March 2015, Nottingham) and during the subsequent monthly online meetings. All partners are active in preparing and submitting their internal financial and technical report inputs. The coordinator is active in harmonising the partner contents and formulating financial and technical report no later than August 15, 2017.

Task 8.4 *Organisation of project meetings.* A draft schedule of project meetings was agreed by the consortium during the first Kick off Meeting. With some minor modifications, the meetings were organised according to this schedule in compliance with the proposal. All meetings were co-organised by the coordinator and the hosting partner institution. The meeting agenda was prepared/initiated by the coordinator carefully observing contractual obligations and project progress actualities, however logistics, venues, other events were recommended and arranged mainly by the hosting partner. Agenda was circulated among partners about 2 months before the meeting, and all partners (but specially WP leaders) had their active contribution in the content of the working programme of the events.

All partners were requested to be represented at all project meetings, which request was met except one case, which was discussed with the partner. When arranging meetings special attention was paid to provide reasonable solutions in terms of logistics and costs. Minutes of the meetings were prepared by the assistance of the coordinator and were distributed for the partners for approval. Attendance list of meetings was signed by all participants and the original documents are filed in the project archive.

List of personal consortium meetings:

- 28-29.01.2016: Kick-off consortium meeting, Miskolc, Hungary
- 11-14.10.2016: 2nd consortium meeting and 1st advisory board meeting, Älvkarleby, Sweden
- 28-29.03.2017: 3rd consortium meeting, Nottingham, UK

Dates of online project meetings in the reporting period:

- 19.12.2016
- 27.01.2017
- 23.02.2017
- 09.05.2017
- 15.06.2017

Other project-related meetings:

- 24.09.2016: INEA H2020 1st coordinators workshop on geothermal energy, Brussels, Belgium
- 17-19.06.2017: ‘Geothermal – the Energy of the Future’ workshop, organised by EFG in Santorini, Greece
- 2017.06.19: INEA H2020 2nd coordinators workshop on geothermal energy, Brussels, Belgium

Foreseen events (under organisation):

- 11-14.09.2017: 4th consortium meeting, project review meeting and 2nd Advisory Board workshop, Brussels, Belgium

- 26-27.10.2017: ‘Geochemistry of Geothermal Fluids’. Workshop with the involvement of running H2020 geothermal projects. Miskolc, Hungary

Task 8.5 *Risk management and conflict resolution.* Risk management and conflict resolution protocols were worked out in details in Deliverable 8.1, that was approved by the consortium. After duly submission the deliverable was approved by the PO. Concerning risk management and conflict resolution the consortium agreed in the following protocol. Risk management in CHPM2030 will follow an approach in three levels:

- Identification of risk,
- Risk assessment,
- Response to issues.

The identification of risks is the duty of each partner within the consortium with their responsibility to inform their WP-leader. The risk identification represents a proactive task for the Coordinator for the entire project and for the WP-leaders within the framework of their WP activities. The assessment and the response is the duty of the Steering Committee (SC). For risks raised by the SC and WP leaders the same process applies. Risk management issues and conflicts were not raised during the reporting period.

Task 8.6 *Technology exploitation, innovation management and IPR.* Due to the rather low TRL level of the project technology exploitation issues were not considered to be relevant by the consortium yet. IPR inputs by partners were documented for further steps of innovation progress in case of successful project implementation.

Status of ongoing and finalised deliverables

Deliverable no. and name:	**D8.1 Risk Management Strategy**		
Due date:	30.06.2016	Delivered to the EC on 28.06.2016	Status: approved
Responsible:	UNIM		
Summary:	This document includes a risk assessment of CHPM2030 and details risk mitigation mechanisms to be embedded in the work implementation. It details the risk initially foreseen and also new risks are described. It also contains control measures for each risk identified, timing for action and corresponding responsible. This strategy will be updated as the project evolves.		
Deliverable no. and name:	**D8.2 Data Management Plan**		
Due date:	30.06.2016	Delivered to the EC on 28.06.2016	Status: approved
Responsible:	UNIM		
Summary:	This deliverable defines the data management policies to be applied by the project partners during the implementation of CHPM2030 project, in accordance with the Guidelines on Data Management in Horizon 2020.		
Deliverable no. and name:	**D8.3 Project report 1**		
Due date:	30.06.2017 (31.08.2017)	Shall be delivered on August 15, 2017	Status: in progress
Responsible:	UNIM and all partners		

Summary:	Progress report 1 shall include the technical and financial report of the whole consortium. The report is according to schedule. At the present status partners are sending their partner contribution, which shall be evaluated, edited and harmonised by the coordinator.		
Deliverable no. and name:	**D8.4 Project report 2**		
Due date:	30.06.2018		
Responsible:	UNIM		
Summary:	This deliverable is not yet due.		
Deliverable no. and name:	**D8.5 Project report 3**		
Due date:	30.06.2019		
Responsible:	UNIM		
Summary:	This deliverable is not yet due.		

1.3 Impact

M1-18 of CHPM2030 project can be considered as an early stage of the project implementation, even though it is a considerable share of the project duration. Due to the nature of the project in terms of its multidisciplinary approach, the broad scope of partners' scientific background required special efforts to familiarize the members of the consortium with all aspects, and the technical elements of the project. Having done that, the main impacts of the project during the first 18 months are as follows:

- Europe's mineralised belts in relevancy with their EGS potential have been screened;
- The data accessibility and the knowledge gaps for these ore formations, including the four potential pilot sites have been identified;
- The EGS relevant geochemical and rock mechanical properties of the ore bodies have been determined;
- The conceptual framework for the orebody-EGS has been developed;
- The partners' knowledge and understanding on the different technological elements have been harmonised;
- A common ground and framework for the planning of the CHPM technology has been established;
- Due to the extensive dissemination activities by the partners and the EFG's linked third parties, the project concepts and the results of the first 18 months have reached about 50 000 scientists and professionals;
- Using the social media accounts on LinkedIn, Twitter and Facebook, project-relevant information has been shared with hundreds of users in the wider public.

2 Update of the plan for exploitation and dissemination of results

The plan for exploitation and dissemination of results as described in the DoA remains effective and doesn't need update. Deliverable 7.4 - Communication and Dissemination Plan, submitted in June 2016, defines and prioritises the key objectives of dissemination and communication and details steps to be taken during the project's lifetime in order to achieve maximum impact and reach relevant audiences. The exploitation and dissemination of results are designed to mobilise the international community, informing them about the project objectives, achievements and results.

3 Update of the data management plan (if applicable)

Not applicable.

4 Follow-up of recommendations and comments from previous review(s) (if applicable)

Not applicable.

5 Deviations from GA Annex 1

No significant deviations from GA Annex 1 occurred.

An amendment request was submitted because of the change of the legal status of one of the partners. The former entity Guenter Tiess, Agency for International Minerals Policy (short name: Minpol) ceased to exist and changed to Minpol GmbH, which took over the complete business of Guenter Tiess.

5.1 Tasks

During the achievement of the tasks, there was a minor delay with the submission of a few deliverables. These delays had no effect on the implementation of the project.

The explanation for the slight delay in the submission of a few deliverables is as follows:

WP1 deliverables:

- D1.2 Report on data availability – compiled from 5 reports, was due on 31.10.2016 and was submitted with three weeks delay, on 21.11.2016.
- D1.3 EFG-relevant review of orebody structures was due on 31.10.2016 and was submitted with two weeks delay, on 14.11.2016.
- D1.4 Conceptual framework for orebody-EGS was due on 31.10.2016 and was submitted with three weeks delay, on 21.11.2016.

The reason for the slight delay of these deliverables was that although the responsible partners started to work on them well in time, the structure and the detailed content had to be discussed and approved by the consortium. This could be carried out on the 2nd consortium meeting in Älvkarleby, which was held on 11-14. October 2016. After that, the responsible partners needed time to finalise the deliverables according to the suggestions made by the consortium and the AB members. The delay was indicated to the Project Officer who accepted the justification and approved the delay.

In May 2017, the Coordinator was informed by the EC that they would start publishing the public project deliverables in CORDIS and the formerly submitted deliverables can be revised before this publication. The Coordinator indicated to the Project Officer that the consortium would like to make some changes to publish these deliverables in a more attractive form. The Project Officer agreed and the deliverables were re-submitted on 9th June 2017. The scientific deliverables of WP1 are also accessible through the project website and the Zenodo open science repository site, and all of them have DOI numbers.

WP7 deliverables:

- D7.1 Basic project website. In the first two months of the project (January-early February), the due date of D7.1 was indicated on Sygma as 1st February 2016. D7.1 was submitted on this date, exactly on time. However, at the end of February, there were some modifications on the Sygma system and a new deadline appeared for this deliverable: 31st January 2016. At the same time, a signal also appeared that 'This deliverable was submitted late', which is actually not the case.
- D7.4 Communication and dissemination plan. The first version of this deliverable was submitted on time, on 28th June 2016 (the deadline was 30 June). One month later, on 28th July 2016 the Project Officer asked for revision. The problem was that that there was a conversion error between the word and the pdf version of the document. The deliverable was amended and re-submitted on 1st August 2016.

WP9 deliverable:

- D9.1 NEC Requirement No. 1. This deliverable was due on 30th April 2016. It was uploaded to Sygma on time but not in a complete form. The Project Officer indicated the problem, then the deliverable was completed and submitted on 9th June 2016.

5.2 Use of resources

Beneficiaries with no financial statement

Guenter Tiess did not declare any costs as after changing the legal status, the complete business was taken over by Minpol GmbH. Costs occurred at Guenter Tiess are reported by Minpol GmbH.

Three EFG Linked Third Parties (IGI, YKL, SGF) also did not provide financial statement. They will declare costs in the next reporting period.

Use of personal costs

The overall allocation of person-months is summarised in Table 2.
Table 2: Planned and used person-months by the project partners.

Partner	WP1		WP2		WP3		WP4		WP5		WP6		WP7		WP8		Total	Total
	planned	used	planned	used	planned	used	planned	used	planned	used	planned	used	planned	used	planned	used	**planned**	**used**
UNIM	25	27,27	15	12,7	0	0	6	0	5	0	6	0	4	1,82	10	5,62	71	47,45
USZ	10	12,76	15	40,2	0	0	2	0	20	0	2	0	1	0	1	0	51	52,96
EFG	4	1,09	0	0	0	0	0	0	2	0	5	0	19	5,52	2	1,21	32	7,82
ISOR	1	0,96	1	0,93	0	0	18	0,21	2	0,64	3	0,01	1	0,08	1	0,65	27	3,48
NERC-BGS	8	7,29	17	10,2	0	0	0	0	1	0	6	0,03	1	0,45	1	0,39	34	18,36
LNEG	8	8,17	0	0	0	0	0	0	1	0,34	6	0	1	0,15	1	0,26	17	8,92
VITO	0	0	10,6	2,23	28,35	5,51	15	3,21	0	0	1	0	1	1,26	1	0	56,95	12,21
LPRC	0	0	0	0	0	0	0	0	6	0	21	0	6	3,56	3	0,8	36	4,36
MinPol	0	0	0	0	0	0	0	0	16	3,9	4	0,25	1	0,32	1	0,15	22	4,62
IGR	9	13,20	0	0	0	0	0	0	1	0	8	0,3	1	1,3	1	0,8	20	15,6
Kleuv	0	0	0	0	32	9,16	11	0	0	0	1	0,01	1	0,14	1	0,33	46	9,64
SGU	8	8,70	0	0	0	0	0	0	1	0	7	0	1	0	1	0	18	8,7
EFG LTPs	13,6	10,86	0	0	0	0	0	0	0	0	13,6	0	4,8	6,92	0		49,78	17,78
	86,6	90,30	58,6	66,3	60,35	14,7	52	3,42	55	4,88	83,6	0,6	42,8	21,5	24	10,2	480,73	211,9

The deviations are justified by partners:

USZ:
The main reason for the excess in man-power allocation is, that a custom-built flow-through reactor was needed to model the conditions prevailing in the target underground reservoirs. Once the reactor was set up, it was agreed that all CHPM samples would be channelled into the laboratory of USZ to ensure comparable results, causing a multiplication in the number of samples investigated and a significant growth in the staff effort dedicated to this activity. Neither setting up the own reactor, nor analysing more samples than originally planned alter the activities described in the DoA. These changes are consistent with the R&D nature of the CHPM project and they contribute to an enhanced understanding of the conditions in the target reservoirs. Despite the unforeseen efforts and time-allocation all activities have been conducted on time, and budget of USZ has neither been exceeded nor does it require modification.

EFG:
EFG spent only 1.08 instead of the anticipated 4 PMs in WP1. This underspending is related to the fact that the generation of national data inventories of drill holes was more complicated than expected for some countries due to data protection reasons and therefore was not possible in the short duration of the work package for all LTPs. Even though the EFG offered considerable support for fulfilling this task, some LTPs were not able to use this which resulted in the underspending of the EFG resources in this WP. However, approximately half of the LTPs generated very extensive inventories highlighting the significance of this task in the context of the CHPM2030 project. In consequence, EFG aims at resuming and intensifying the efforts to generate homogeneous inventories with thorough assessments of the combined heat and metal extraction potential in WP6. Therefore, EFG aims at redistributing the remaining funds from WP1 into WP6.

VITO:
WP4 hasn't started yet but VITO used 3.21 PMs from this WP. This deviation is due to the fact that VITO made preliminary studies related to Task 4.2 – Process optimisation and simulations. The used PMs cover the literature research and also the participation in the consultations with the partners on Task 4.1 – Conceptual framework for CHPM power plant.

In WP7, 1 PM was planned for VITO and it used 1.26 PMs in the reporting period. This is because the VITO Team started to work on a project related article which will be published in a high ranking scientific journal. This research work needed more working hours than originally planned.

MINPOL:
WP5 hasn't started yet but MINPOL used 3.87 PMs for that WP. The reason is that MINPOL had men power available in 2016 and it wanted to avoid bottlenecks later on, since the creation of the planned model is time-consuming and comprehensive. MINPOL is now optimally on schedule, even ahead of time.

IGR:
In WP1, originally 9 PMs were allocated to IGR but it used 13.2 PMs. The reason for this slight deviation is that more geological maps had to be prepared than it was originally expected and a GIS expert had to be involved for this task, which was not planned at the beginning of the project. These maps are important for the future project work, especially in WP6.

In WP7, 1 PM was planned for IGR and it used 1.26 PMs in the reporting period. The reason is that three team members from IGR were interested in the Santorini geothermal workshop. The preparation

for the workshop and the development of a poster, as well as the participation in the workshop needed more time than expected.

5.2.1 Unforeseen subcontracting (if applicable)

Not applicable.

5.2.2 Unforeseen use of in kind contribution from third party against payment or free of charges (if applicable)

Not applicable.

Annex 1: Dissemination activities by the project partners and the EFG LTPs in the period M1-M18

Dissemination by the project partners

International conferences and workshops

	Date	Event details (name & place)	Partner involved	Type of dissemination activity (presentation, poster, exhibition, etc) Name of person involved	Type of audience	Estimated size of audience	Countries addressed
1	25-26.02. 2016	GeoTHERM Conference, Offenburg, Germany	EFG	Keynote speech titled "Why geothermal energy is lagging behind?" *Vítor Correia*	Scientists and professionals from the geothermal sector	200	worldwide
2	8-9.03. 2016	Joint Geothermal Project Meeting Utrecht, The Netherlands	UNIM	Presentation of the CHPM2030 project *Tamás Madarász*	Participants of H2020 geothermal projects	30	EU
3	13.06.2016	Integrated Network for Energy from Salinity Gradient Power (INES) project meeting	VITO	Presentation of the CHPM2030 project *Joost Helsen*	INES project partners		
4	09.09.2016	Workshop of H2020 Geothermal Research and Innovation Projects, Brussels	UNIM	Presentation of the CHPM2030 project *Tamás Madarász*	Participants of H2020 geothermal projects	40	EU
5	09.09.2016	Workshop of H2020 Geothermal Research and Innovation Projects, Brussels	EFG	Presentation of the dissemination actions in CHPM2030 *Isabel Fernandez*	Participants of H2020 geothermal projects	40	EU
6	20-21.09. 2016	Well Stimulation – Hydraulic Fracturing in focus Conference, Herceghalom, Hungary	USZ	Presentation *Máté Osvald*	Professionals from oil and gas industry and academic scientists	150	worldwide
7	24-25.11. 2016	EERA Annual Conference, Birmingham, UK	NERC-BGS	Poster presentation "Combined Heat, Power and Metal extraction from ultra-deep ore bodies." *Chris Rochelle*	Scientists and technologists from a range of energy sectors	150	mainly EU
8	28.02 - 03.03.2017	European Geothermal PhD Day, Bochum, Germany	USZ	Poster and presentation *Máté Osvald*	PhD Students and a few industrial professionals	90	worldwide

9	24-28.04.2017	European Geosciences Union General Assembly 2017	LPRC	Poster presentation *Tamás Miklovicz*	Geoscientists	14 496	worldwide, mainly EU
10	13-15.05.2017	20th Congress of Hungarian Geomathematicians and 9th Congress of Croatian & Hungarian Geomathematicians	LPRC	Oral presentation *Tamás Miklovicz*	Geoscientists	73	Hungary, Croatia
11	18.05.2017	EuroWorkshop Geothermal - The Energy of the Future. Santorini, Greece	UNIM	Oral presentation *Tamás Madarász*	Geoscientists	50	worldwide, mainly EU
12	18.05.2017	EuroWorkshop Geothermal - The Energy of the Future. Santorini, Greece	UNIM	Oral presentation *Éva Hartai*	Geoscientists	50	worldwide, mainly EU
13	18.05.2017	EuroWorkshop Geothermal - The Energy of the Future. Santorini, Greece	NERC-BGS	Oral presentation *Andrew Kilpatrick*	Geoscientists	50	worldwide, mainly EU
14	18.05.2017	EuroWorkshop Geothermal - The Energy of the Future. Santorini, Greece	VITO	Oral presentation *Joost Helsen*	Geoscientists	50	worldwide, mainly EU
15	30-31.05.2017	GKZ (Russian State Commission of Mineral Reserves) 90th anniversary international conference on "The Problems of Expert Evaluation of Mineral Reserves in the Light of Cooperation with International Classifications"	EFG	Dissemination of leaflets *Michael Neumann*	Russian and international mining and petroleum world	500	worldwide, Russia
16	12-15.06.2017	EAGE 79th Conference and exhibition	EFG	Dissemination of leaflets and poster at the EFG booth I*sabel Fernandez, Peter Müller, Lisa Delmoitiez, Anita Stein*	Geoscientists	6500	worldwide
17	19.06.2017	H2020 II Workshop Geothermal H2020 projects	UNIM	Presentation/reporting about the progress and barriers of CHPM2030 *Tamás Madarász*	Geothermal experts of Europe, partners in H2020 projects	50	EU countries

National conferences & workshops

	Date	Event details (name & place)	Partner involved	Type of dissemination activity (presentation, poster, exhibition, etc)	Type of audience	Estimated size of audience	Countries addressed
1	07.04.2016	Water-rock interactions, MSc lecture, Szeged, Hungary	USZ	Presentation of the CHPM2030 project *Máté Osvald*	MSc students	25	Hungary
2	6-7.04.2016.	National Groundwater Foundation Annual event, Siófok, Hungary	UNIM	Presentation of the groundwater related H2020 projects of UNIM *Tamás Madarász*	Industry, authority and academia in groundwater sector	140	Hungary
3	20.04.2016	Mineral Resources of Hungary. Miskolc, Hungary	UNIM	Presentation of the CHPM2030 project *Éva Hartai*	Geoscientists and professionals	50	Hungary
4	24-27.08. 2016	Triennial Outboard Meeting of the Hungarian Geological Society. Sárospatak, Hungary	USZ	Presentation *Máté Osvald*	Geologists, geoscientists	100	Hungary
5	28-30.11. 2016	Budapest Water Summit. Budapest, Hungary	UNIM	Presentation of the CHPM2030 project on poster *Tamás Madarász, Péter Szucs*	wide public	1000	Hungary
6	15.02.2017	New results in earth-science related research. Hungarian Academy of Sciences, Budapest	UNIM	Presentation of the groundwater related H2020 projects of UNIM *Péter Szűcs*	Earth scientists	60	Hungary

Publications in journals or on internet

	Date	Journal/link	Partner involved	Title of publication, author(s)	Type of audience	Size of audience	Countries addressed
1	01.05.2017	European Geologist	EFG	CHPM2030	geoscientists	150 000	worldwide
2	30.12.2016	European Geologist	EFG	CHPM2030	geoscientists	150 000	worldwide
3	29.05.2017	European Geologist	all partners	Mining and energy in an interlinked process – The CHPM2030 project; E. Hartai, B. Bodo, T. Madarász, CHPM2030 Team	geoscientists	150 000	worldwide
4	29.05.2017	European Geologist	EFG	CHPM2030	geoscientists	150 000	worldwide

Other types of promotion

	Date	Means of promotion (event, publication, etc.)	Partner involved	Type of dissemination activity	Type of audience	Size of audience	Countries addressed

				(newsletter, public event, promotional products, etc.)			
1	31.01.2016	GeoNews	EFG	News on CHPM2030 project	geoscientists	50 000	EU
2	24.02.2016	EFG Project News #4	EFG	News on CHPM2030 project	geoscientists	50 000	EU
3	23.05.2016	EFG Project News #5	EFG	News on CHPM2030 project	geoscientists	50 000	EU
4	29.05.2016	24.hu (on-line magazine)	UNIM	Article in an on-line magazine about the CHPM2030 project, report with *Eva Hartai*	wide public in Hungary	500	Hungary
5	28.06.2016	EFG website	EFG	Article about the launch of the CHPM2030 project	geoscientists	1 500	EU
6	30.06.2016	GeoNews	EFG	News on CHPM2030 project	geoscientists	50 000	EU
7	28.10.2016	GeoNews	EFG	Short news on the 2nd consortium meeting in the EFG's monthly newsletter	geo-scientists and -professionals	50 000	EU
8	12.12.2016	Scientific Session organised by IGR in Bucharest at National Geological Museum	IGR	Presentation of CHPM2030 on Powerpoint *Diana Persa*	geo-scientists	30	Romania
9	13.12.2016	EFG Project News #5	EFG	News on CHPM2030 project	geoscientists	50 000	EU
10	13.12.2016	Interview by phone given for Romania Cultural Radio channel	IGR	Presentation of CHPM2030 for the public of this Radio channel *Diana Persa*	wide public in Romania	100 000	Romania
1	17.01.2017	EFGeoWeek #2	EFG	News about project deliverables published by CHPM2030	geoscientists	50 000	EU
12	31.01.2017	EFGeoWeek #4	EFG	CHPM2030 brochure now available in several European languages	geoscientists	50 000	EU
13	03.04.2017	EFGeoWeek #13	EFG	News on the third consortium meeting of the CHPM2030 project	geoscientists	50 000	EU
14	04.04.2017	News on EFG website	EFG	News on the third consortium meeting of the CHPM2030 project	geoscientists	1500	EU
15	28.04.2017	GeoNews April	EFG	EFG projects | CHPM2030 consortium meeting	geoscientists	50 000	EU
16	17.05.2017	EFG Project News #7	EFG	CHPM2030	geoscientists	50 000	EU

Dissemination by the EFG LTPs

Date	Country	LTP	Type of dissemination activity	Venue	Type of audience	Size of audience
07.2016	Czech Republic	CAEG	Translation of the 1st Project Brochure	N.A	Industry and scientific community	500
01.10.2016	Czech Republic	CAEG	Publication	N.A.	Industry and scientific community	500
03.11.2016	Czech Republic	CAEG	Flyers	Brno, Czech. Rep.	Scientific community	50
04.11.2016	Czech Republic	CAEG	Flyers	Ostrava, Czech. Rep.	Scientific community	50
04.11.2016	Czech Republic	CAEG	Flyers	Prague, Czech. Rep.	Scientific community	50
23.11.2016	Czech Republic	CAEG	Flyers	Prague, Czech. Rep.	Scientific community	350
20.12.2016	Czech Republic	CAEG	Web info	N.A.	Industry and scientific community	500
08.2016	Finland	YKI	Translation of the 1st Project Brochure	N.A.	Geo-professionals	500
2016 - 2017	Finland	YKI	Social Media	N.A.	Public	1000
2016 - 2017	Finland	YKI	Periodic information about the project	N.A.	Geo-professionals	500
07-08.2016	Germany	BDG	Translation of the 1st Project Brochure	N.A.	Scientists, professionals	800
2016 - 2017	Germany	BDG	Social Media	N.A.	Wide public	1500
2016 - 2017	Germany	BDG	Periodic information about the project	N.A.	Members of YKI	800
07.08.2016	Greece	AGG	Translation of the 1st Project Brochure	N.A.	Geologists, scientists, students	300
30.03.2016	Greece	AGG	Workshop Presentation	National Research Foundation, Athens	Geologists, scientists, students	200
2016 - 2017	Greece	AGG	Social Media	N.A.	Geologists, scientists, students	1 700
2016 - 2017	Greece	AGG	Periodic information about the project	N.A.	Geologists, scientists, students	1000

01.2017	Greece	AGG	Oral information about the project	Ministry of Environment and Energy	General Directorate of Mineral Raw Materials	10
18-19.05.2017	Greece	AGG	Workshop presentation	Fira, Santorini, Greece	Geologists, scientists, students	70
23.05.2017	Hungary	MFT	Electronic Circular	Budapest, Hungary	Professionals, members of MFT	10000
09.05.2017	Hungary	MFT	Presentation	Budapest, Hungary	Professionals, members of MFT	18
01.05.2017	Hungary	MFT	Printed and electronic newsletter	N.A.	Professionals, members of MFT	1100
01.03.2017	Hungary	MFT	Printed and electronic newsletter	N.A.	Professionals, members of MFT	1100
02.01.2017	Hungary	MFT	Printed and electronic newsletter	N.A.	Professionals, members of MFT	1100
16.12.2016	Hungary	MFT	Electronic Circular	Budapest, Hungary	Professionals, members of MFT	10000
10.2016	Hungary	MFT	Translation of the 1st Project Brochure	N.A.	Public	4000
12-13.09.2016	Hungary	MFT	Interactive Geological Exhibition and Fair	Budapest, Hungary	Public	3000
01.09.2016	Hungary	MFT	Printed and electronic newsletter	N.A.	Professional, members of HGS	1100
25.08.2016	Hungary	MFT	Presentation	Sárospatak, Hungary	Professionals	110
23.05.2016	Hungary	MFT	MFT Board meeting	Miskolc, Hungary	Professionals	8
20.04.2016	Hungary	MFT	Presentation of the CHPM project	Miskolc, Hungary	Professionals	59
07.08.2016	Italy	CNG	Translation of the 1st Project Brochure	N.A.	Professionals	1000
01.01.2017	Italy	CNG	Web	N.A.	Professionals	10000
01.05.2017	Italy	CNG	Web, emails	N.A.	Professionals	20000
14.10.2016	Netherlands	KNGMG	Translation of the 1st Project Brochure	N.A.	Scientific community, industry	300
21.10.2016	Netherlands	KNGMG	KNGMG Newsletter, press release CHPM	N.A.	Scientific community, industry	800
01.10.2016	Netherlands	KNGMG	Project Information on KNGMG website	N.A.	Scientific community, industry	500
17.05.2017	Netherlands	KNGMG	Update of the project on the Annual Meeting of KNGMG	The Hague, Netherlands	Scientific community, industry	35
08.2016	Poland	PAMAV	Translation of the 1st Project Brochure	N.A.	Geoscientists, professionals	300
2016-2017	Poland	PAMAV	Newsletter, press release CHPM	N.A.	Public	300
2016-2018	Poland	PAMAV	Project Information on PAMAV website	N.A.	Public	1000

09.05.2016	Portugal	APG	Dissemination through APG Report	N.A.	Professionals	500
29.06.2016	Portugal	APG	CHPM2030 newsletters dissemination	N.A.	Professionals	5000
30.06.2016	Portugal	APG	CHPM2030 dissemination through APG Website	N.A.	Professionals	237
2016-2017	Portugal	APG	Social Media	N.A.	Professionals	5000
11.10.2016	Portugal	APG	Updating the website link on APG Blog	N.A.	Professionals	7000
31.10.2016	Portugal	APG	CHPM2030 Dissemination through APG News	N.A.	Professionals	5000
15.11.2016	Portugal	APG	Translation of the 1st Project Brochure	N.A.	Professionals	5000
30.06.2017	Portugal	APG	CHPM2030 dissemination through APG website	N.A.	Professionals	5000
08.2016	Serbia	SGD	Translation of the 1st Project Brochure	N.A.	Scientific community, industry	300
2016-2017	Serbia	SGD	Newsletter, press release CHPM	N.A.	Scientific community, industry	300
2016-2017	Serbia	SGD	Project Information on SGD website	N.A.	Scientific community, industry	400
03.10.2016	Slovenia	SGD	Translation of the 1st Project Brochure	Ljubljana	Scientific community	500
31.03.2017	Slovenia	SGD	Abstract in the Proceedings of the 23rd Meeting of SGD	Univ. of Ljubljana	Scientific community	80
31.03.2017	Slovenia	SGD	Poster presentation, 23rd Meeting of SGD	Univ. of Ljubljana	Scientific community	80
2016-2017	Spain	ICOG	Periodic information about the project	N.A	Scientific community, in7dustry	800
07-08.2016	Spain	ICOG	Translation of the 1st Project Brochure	N.A	Scientific community, industry	800
2016-2017	Spain	ICOG	Printed and electronic newsletter	N.A	Scientific community, industry	800