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# Exploitation strategic plan and business model - final

Deliverable 8.4




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## ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| BGS | British Geological Survey |
| CLC | Cobre Las Cruces |
| CRM | Critical Raw Materials |
| EIP | European Innovation Partnership on Raw Materials |
| ETP SMR | European Technology Platform on Sustainable Mineral Resources |
| Euromines | European Association of Mining Industries, Metal Ores & Industrial Minerals |
| IPR | Intellectual Property Rights |
| M2M | Mine to Metal |
| NGO | Non-Governmental Organisation |
| RMSG | Raw Materials Supply Group |
| RSS | Rich Site Summary (summary of website content) |
| SIP | Strategic Implementation Plan (of the EIP) |
| UNEP | United Nations Environment Programme |
| USGS | United States Geological Survey |

# 1. PURPOSE

The purpose of this report is to provide the final version of the exploitation strategic plan of INTMET basing on the initial version (D8.2). It includes Task 8.3 (business model), Task 8.4 (innovation management/plan) and refers to Task 8.5 (exploitation, application strategy) and also contributes to Tasks 8.2 and 8.1.

D8.4 starts with the description of the business model (chapter 2). Chapter 2 is the basis for discussion of the innovation management/plan (chapter 3) and preliminary discussion of the exploitation/application strategy of INTMET (chapter 4). In chapter 5, conclusions are presented.

# 2. BUSINESS MODEL

The business model is based on the following sections (i.e. general features of any business model/plan): basic idea, product and services, marketing, cooperation and financing.

## 2.1 BASIC IDEA

The INTMET approach represents a unique technological breakthrough to overcome the limitations related to difficult low grade and complex polymetallic ores to achieve highly efficient recovery of valuable metals (Cu, Zn, Pb, Ag) and CRM (Co, In, Sb). The main objective of INTMET is applying on-site mine-to-metal hydro and bio-hydro processing of the produced concentrates enhancing substantially raw materials efficiency thanks to an increased Cu+Zn+Pb recovery over 60% vs. the existing selective flotation method (considered difficult and inefficient) to produce saleable concentrates of each metal. Moreover, the INTMET process will add secondary materials like mine tailings and metallurgical wastes to the process for valorisation and metal recovery.

The innovative approach of INTMET spreads the principle Mine to Metal. The Mine to Metal (M2M) principle is a modern way to treat mineral resources. Minerals are being processed on site without the need to transport large amounts of concentrates to other plants.

INTMET products will bring innovative technologies for members of the consortium and also high quality products for customers in the industrial sector. Products are intended to be used for the highly developed metallurgical industry in the European Union. The new flotation concepts have a huge potential for application when combined with appropriated hydro and/or bio-hydro metallurgical processes developed within the INTMET project. This will be addressed in a market analysis (see chapter 2.3)

## 2.2 PRODUCTS AND SERVICES

The innovation potential and added value of INTMET product(s) needed to be demonstrated. In a nutshell, this is an “INTEGRATED INNOVATIVE METALLURGICAL SYSTEM TO BENEFIT EFFICIENTLY POLYMETALLIC, COMPLEX AND LOW GRADE ORES AND CONCENTRATES”.

The following paragraph give a basic description of the man results of the INTMET project. More details of these products are available from the INTMET deliverable D7.5 on ‘Technology and Life Cycle Assessment’ and from the related project partners. The added value of the products is important for the (business) application of them. We described the added value i.e. innovative potential compared to the conventional concepts to approach “INTMET customers” *during and after* the project. The innovation potential of INTMET was also subject to (permanent) discussion with stakeholders (Task 8.2) and continuous promotion (Task 8.1).

**Main INTMET products**

INTMET Project applies the "Mine-to-Metal" concept to produce in the mine Cu, Zn, Pb, Ag and other refined metals under sustainable conditions, treating polymetallic bulk concentrates through innovative hydrometallurgical solutions based on atmospheric leaching, pressure leaching or bioleaching, jointly with novel more effective metals extraction techniques. Newly developed processes have undergone positive economic and ecological evaluation as well as LCA and Health and Safety assessment. Several potential industrial applications have been identified.

### 2.2.1 RAW MATERIALS SAMPLING AND CHARACTERISATION

Four materials obtained from mineral deposits from CLC, KGHM, BOR and Somincor were sampled and characterised. These included polymetallic ores and concentrates, complex or low-grade copper ores and concentrates and pyrite concentrates. Here the delivery of samples for experimental testing was also coordinated.

Regarding flotation tailings and metallurgical wastes as secondary raw materials, limitations related to polymetallic low-grade and complex ores to achieve high efficiency recovery of valuable metals (Cu, Zn, Pb, Ag) and critical raw materials (Co, In, Sb) have been overcome.

### 2.2.2 ENHANCED PERFORMANCE FLOTATION PROCESS

This activity developed the necessary technology for bulk concentrate production and provides samples for lab-scale and pilot testing. Main areas of activity were comminution and flotation improvements and production of samples from the developed processes.

Newly developed flotation reagents and microwave techniques have been applied. Additionally, pilot plants have been established to confirm results and produce samples for further testing activities. Electrical pulse fragmentation has been tested as a re-concentration technique. The potential energy saving is going to be evaluated.

### 2.2.3 INTEGRATIVE ATMOSPHERIC LEACHING PROCESS

Atmospheric leaching applied on bulk concentrates or middlings is one promising key technology for efficient metals recovery from low-grade, complex and polymetallic ores proposed by INTMET.

Obtained results at lab and pilot scale have shown the high recoveries as expected (e.g. 94% Cu and 95% Zn recovery). It can be stated that a new technological approach has been developed to treat efficiently reserves of polymetallic primary sulphides by means of hydroprocessing.

### 2.2.4 INTEGRATIVE PRESSURE LEACHING PROCESS

High temperature pressure oxidation is a well proven process for Ni, Au and Zn production. A semi-commercial alternative process for Cu is currently under development - pressure oxidation in an autoclave at temperatures

from 135°C to 210°C destroying sulphides rapidly at leach times lower than 60 minutes – releasing base metals into solution for further recovery. INTMET proposes this technology as an efficient way to recover base metals from bulk concentrates and middlings. Lab as well as pilot results obtained showed high Cu and Zn yields (Cu 95%, Zn 99%).

### 2.2.5 INTEGRATIVE BIOLEACHING PROCESS

Bioleaching is a process described as being "the dissolution of metals from their mineral source by certain naturally occurring microorganisms". The bioleaching performance on four polymetallic samples was assessed by means of testing and detailed steady state mass balances. The results indicated maximum extractions achieved of 85% Cu, 75% Zn, 90% Pb, 90% Au and 80% Ag.

### 2.2.6 VALORISATION OF TAILINGS, WASTES AND EFFLUENTS

The project intended to limit the amount of wastes and effluents by valorising these streams using best tailored technologies. Flotation tailings, wastes materials and effluents are processed to recover iron, non-ferrous metals, CRMs and sulfuric acid. Obtained results showed the high potentiality to integrate the studied technologies improving the economy and the environmental footprint.

### 2.2.7 TECHNOLOGY ASSESSMENT AND PROJECT EVALUATION

INTMET hydrometallurgical technologies are specifically designed to provide a suitable solution to every application. The developed technologies can deal efficiently with feed materials such as bulk concentrates and low-grade concentrates containing low tenor of base metals and precious metals, which cannot be processed in existing refineries. For instance, tested polymetallic concentrates samples from several mines in Europe ranged: 2-5% Cu, 5-15% Zn, 3-10% Pb, 50-500 ppm Ag.

Developed INTMET hydrometallurgical technologies can be an advantageous alternative to conventional processing technologies, allowing:

a) to increase 30-50% overall metals recovery in comparison to actual operations,
b) to process low-grade and complex ores containing impurities such as Hg, Sb, As, etc.
c) to produce in-situ refined metals (commodities),
d) to recover additionally some critical materials (e.g. In, Co, etc.),
e) to rise mineral reserves, reducing the cut-off, in definitive, to achieve a more robust and sustainable mining business.

Final economic and environmental assessment have been performed for several case studies based on mines located in Europe, providing in general rather positive economic results; for example:

Hydrometallurgical plant treating from 0.6 to 1.0 million tpa of bulk concentrate to produce 15-25,000 t/y Cu metal, 40-60,000 t/y Zn metal, 30-80,000 t/y Pb metal and 50-100 t/y Ag.

Internal rate of return, IRR, varies from 14 to 27%, depending on metal production value. Net present value, NPV, ranges $125 to $325 million, depending on specific conditions. Applying sustainable technologies with minimum footprint because it is not necessary to transport concentrates and not any airborne emission is generated.

### 2.2.8 ENSURING A REAL BUSINESS SOLUTION

The technical, environmental and economic feasibility of the entire approaches have been evaluated to ensure a real business solution of the integrated INTMET process. Innovative hydrometallurgical processes (atmospheric, pressure and bioleaching), and novel more effective metals extraction techniques (e.g. Cu/Zn-SX-EW, chloride media, MSA, etc.) were developed and tested at relevant environments aiming at maximising metal recovery yield and minimising energy consumption and their environmental footprint. Additionally, secondary materials like tailings and metallurgical wastes were tested as well for metals recovery and sulphur valorisation.

INTMET will be economically viable thanks to diversification of products (Cu, Zn, Pb), high-profitable solutions (producing commodities not concentrates), with lower operation and environmental costs (on-site hydro-processing will avoid transport to smelters) and allowing mine-life extension developing a new business-model concept based on high efficient recovery of complex ores that will ensure EU mining industry competitiveness and employment.

Depending on the positive technology assessment as well as other positive results in the context of assessing the INTMET processes, they can be used as a real business solution. INTMET provided information in pilot scale. To obtain a real business case, the technology needs to be applied and tested in real scale.

## 2.3 MARKETING

As mentioned in Section 2.1 above, the current methods of physical concentration are not effective in realising the total contained value of polymetallic ores. For example, it is never possible to obtain complete separation of copper and zinc into separate concentrates, and the extent of separation can only be improved at the cost of greater losses to tailings. The copper content remaining in a zinc concentrate being sold to a zinc smelter would attract a penalty, and the same applies to zinc content in a copper concentrate. Hence ironically valuable metal becomes a liability. The hydrometallurgical processes developed in INTMET have the potential of realising much closer to 100 percent of the full contained metal value than the current methods, even while treating a single bulk concentrate bearing all metals in a single feed stream.

This means that the outputs of the INTMET project are inherently valuable and would be desirable to the mining industry in solving problems that have long been known to exist. The solutions are now ready for implementation in practice. The only task remaining is to tailor the developed solutions to each unique case.

Marketing requires a comprehensive (market) analysis of (as determined in the application) valuable metals (Cu, Zn, Pb, Ag) and CRM (Co, In, Sb) in Europe and beyond.

### 2.3.1 BUSINESS OPPORTUNITIES

In the course of the project, all INTMET partners needed to identify business opportunities and evaluate these in terms of economic conditions and viability.

In order to be able to determine the entire market potential of the INTMET process, we had to identify all potential users of the new developed technology (at global scale). For this, we needed to carry out individual measures, like Internet and literature surveys, a questionnaire survey or market survey on commodity basis.

**Questionnaire**

In order to identify business opportunities or potential applicants for the INTMET technology, we drafted a questionnaire survey (see Annex I). Apart from some general information, we explicitly asked for providing information about currently applied processing and extraction routes, information about the deposit and the commodities relevant to the operation.

We sent this questionnaire out to our stakeholders. We also provided a web-based version accessible via the INTMET website. Unfortunately and despite several activities to promote the questionnaire (via newsletters, through related remarks in conference presentations, even direct contact to several people and finally through the announcement of and registration for the INTMET final clustering conference), we only received 5 (partly) completed responses, whereof only 1 came from a mining operator.

It is clear that this approach was not successful and didn't provide any additional information.

**Assessment of competition and potential customers**

INTMET's results will be used by the heterogeneous INTMET partner consortium in various ways affecting the diverse competitive environments of the partners in different ways. In this sense, a competitor for a metal's producer in INTMET can be a future customer for a technology provider in INTMET. However, a potential commercial launch of the INTMET process will impact on partners' environments. Most of the mining companies nowadays are using a selective flotation process to produce a commercial product (metal concentrate) as a raw material for metal refineries. Consequently, refineries will be affected if new projects using a new flotation concept integrated with the metal production facility are applied. Those companies might be Glencore, Freeport-McMoRan Inc., Norils and other large producers, for which the market for raw material and final products will be affected by new projects using INTMET technology.

Other competitors are companies that would be affected by the improvement of flotation and extraction methods. In principle, the following list applies:

- Engineering companies with expertise in selective flotation and conventional metal refineries.
- Specific Chemicals Producers for Selective Flotation and Refineries.
- Research laboratories specialised in selective flotation and conventional metal refining.
- New projects that are currently in developing stage using selective flotation and conventional metal refining as Red Mountain Project (White Rock Minerals ltd.) in central Alaska, Taylor Deposit (Arizona Mining), Abbeytown Zn, Pb, Ag & Cu Project (Erris Resources, Ireland), Hayes Creek Ag-Au-Zn Project (Australia), Ayawilca Peru (Tinka Resources), etc.

### 2.3.2 IDENTIFICATION OF GEOLOGICAL POTENTIAL

In the context of marketing, screening the geological potential in Europe[1], using existing information for example from the Promine project (http://promine.gtk.fi/) as illustrated in Figure 1, is also an important step.

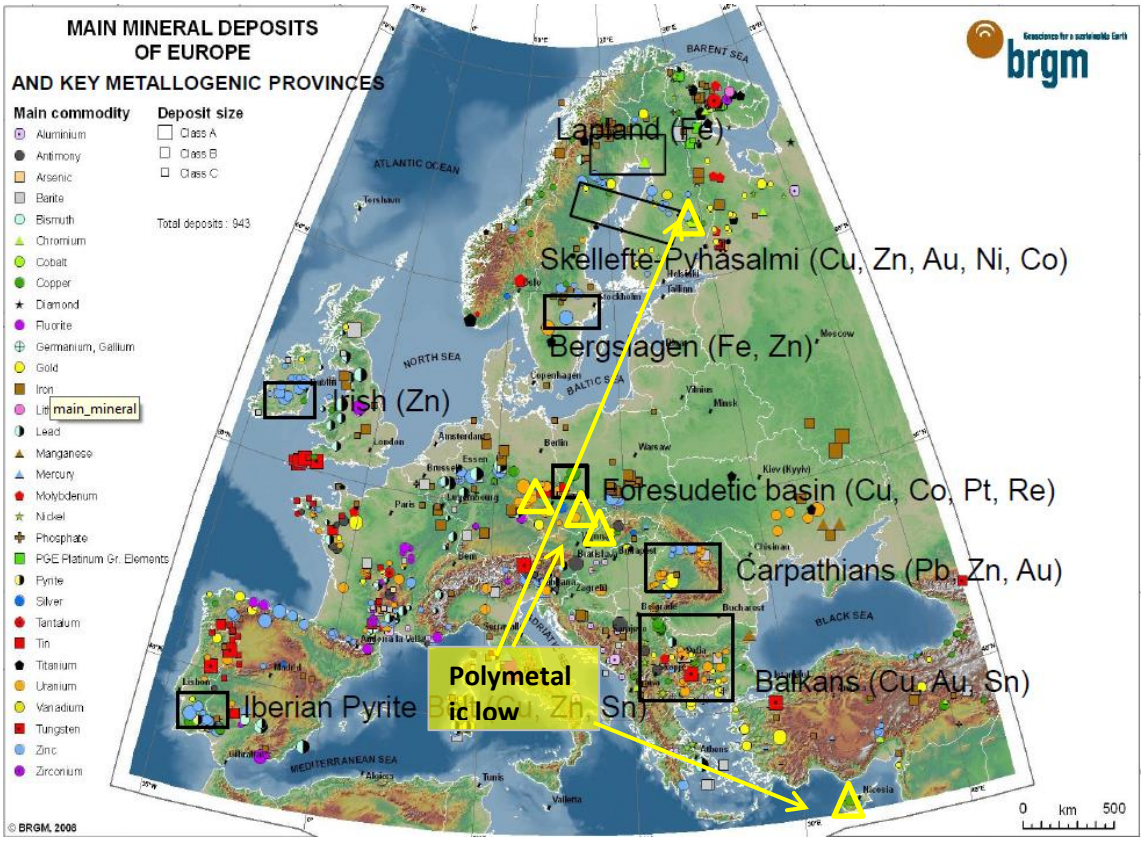



FIGURE 1: MAIN DEPOSITS OF EUROPE (SOURCE: PROMINE; HTTP://PROMINE.GTK.FI/MAIN_MINERAL_DEPOSITS_OF_EUROPA.PDF)

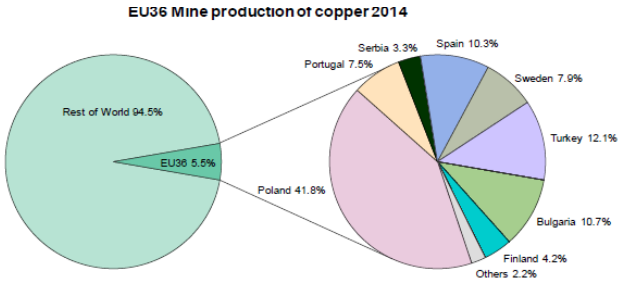
The database provides valuable information about where in Europe polymetallic, low-grade ore can be expected. Those regions are indicated in Figure 1.

[1] The Iberian Pyrite Belt region in the south of Spain and Portugal is as an area rich in volcanogenic massive sulfide deposits which contains polymetallic ores and potential target of INTMET.

### 2.3.3 COMMODITY SURVEY

Market surveys on commodity basis will provide additional information about market size for the INTMET processes. This information provides key figure to decide upon marketing campaigns.

Figure 2 shows the example of the copper case for a market survey on commodity basis and value chain assessment, which is also required (mining, processing, refining). Related information can be collected from sources like BGS, USGS, world mining data[2], etc.



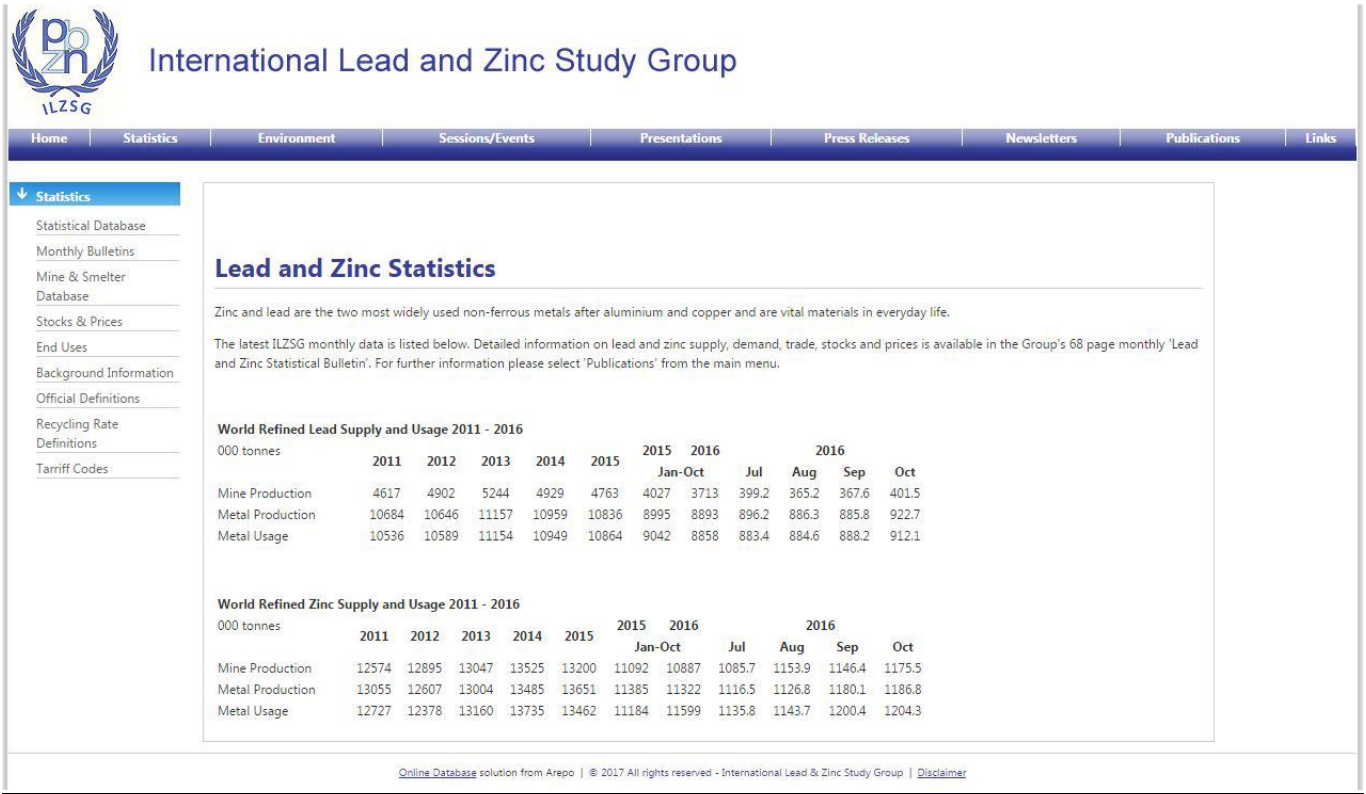

**Mine production of copper** tonnes (metal content)

| Country | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|
| Albania | 2 672 | 4 379 | 5 691 | 5 087 | 3 503 |
| Bulgaria (a) | 112 904 | 114 603 | 118 255 | 115 149 | 108 300 |
| Cyprus | 2 595 | 3 660 | 4 328 | 3 631 | 3 088 |
| Finland | 14 700 | 14 000 | 25 446 | 38 763 | 42 790 |
| Macedonia | 7 912 | 7 555 | 9 506 | 9 802 | 8 187 |
| Poland | 425 725 | 426 665 | 427 064 | 428 879 | 421 700 |
| Portugal | 74 426 | 79 686 | 74 043 | 77 236 | 75 433 |
| Romania | 5 127 | 6 355 | 5 902 | 6 700 | 7 200 |
| Serbia | 22 800 | 26 100 | 32 200 | 36 200 | 33 739 |
| Slovakia | 22 | 28 | 31 | 40 | 46 |
| Spain | 54 335 | 68 511 | 97 452 | 104 600 | 103 900 |
| Sweden | 76 514 | 82 967 | 82 422 | 82 904 | 79 681 |
| Turkey | 79 900 | 92 500 | 104 300 | 120 500 | 122 000 |
| EU36 total | 880 000 | 927 000 | 987 000 | 1 029 000 | 1 010 000 |

**FIGURE 2: COPPER PRODUCTION IN EUROPE (SOURCE: HTTPS://WWW.BGS.AC.UK/MINERALSUK/STATISTICS/EUROPEANSTATISTICS.HTML)**

It is necessary to also look for information about market development, taking into account existing information from metals associations and study organizations. The following Figures 3, 4 and 5 show as an example related information about Zinc. In this example, the Zinc supply may become critical due to recent and expected mine closures, which results in a significant increase of the Zinc price. This situation can be an opportunity for the INTMET processes, to some extent fill the gap between demand and supply by providing Zinc from polymetallic, low-grade ores.

[2] If useful, we may consider also using private sources such as Roskill which produces good marketing reports, e.g. future demand of a metal https://roskill.com/.



International Lead and Zinc Study Group

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## Lead and Zinc Statistics

Zinc and lead are the two most widely used non-ferrous metals after aluminium and copper and are vital materials in everyday life.

The latest ILZSG monthly data is listed below. Detailed information on lead and zinc supply, demand, trade, stocks and prices is available in the Group's 68 page monthly 'Lead and Zinc Statistical Bulletin'. For further information please select 'Publications' from the main menu.

**World Refined Lead Supply and Usage 2011 - 2016**

| 000 tonnes | 2011 | 2012 | 2013 | 2014 | 2015 | 2015 Jan-Oct | 2016 Jan-Oct | 2016 Jul | 2016 Aug | 2016 Sep | 2016 Oct |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mine Production | 4617 | 4902 | 5244 | 4929 | 4763 | 4027 | 3713 | 399.2 | 365.2 | 367.6 | 401.5 |
| Metal Production | 10684 | 10646 | 11157 | 10959 | 10836 | 8995 | 8893 | 896.2 | 886.3 | 885.8 | 922.7 |
| Metal Usage | 10536 | 10589 | 11154 | 10949 | 10864 | 9042 | 8858 | 883.4 | 884.6 | 888.2 | 912.1 |

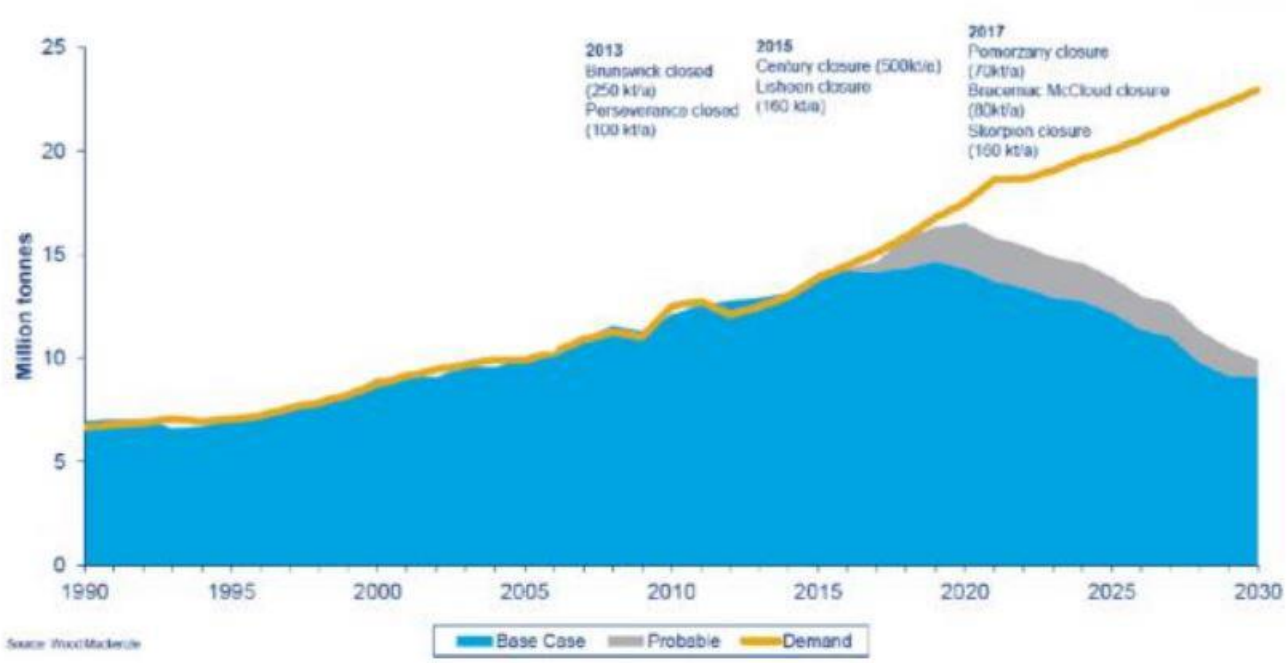
**World Refined Zinc Supply and Usage 2011 - 2016**

| 000 tonnes | 2011 | 2012 | 2013 | 2014 | 2015 | 2015 Jan-Oct | 2016 Jan-Oct | 2016 Jul | 2016 Aug | 2016 Sep | 2016 Oct |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mine Production | 12574 | 12895 | 13047 | 13525 | 13200 | 11092 | 10887 | 1085.7 | 1153.9 | 1146.4 | 1175.5 |
| Metal Production | 13055 | 12607 | 13004 | 13485 | 13651 | 11385 | 11322 | 1116.5 | 1126.8 | 1180.1 | 1186.8 |
| Metal Usage | 12727 | 12378 | 13160 | 13735 | 13462 | 11184 | 11599 | 1135.8 | 1143.7 | 1200.4 | 1204.3 |

Online Database solution from Arepo | © 2017 All rights reserved - International Lead & Zinc Study Group | Disclaimer

**FIGURE 3: LEAD & ZINC STATISTICS**

## Zinc Supply / Demand Outlook




## Mine Closures and Production Losses

| Mine | Year of Closure | Production Removed (kt/a) |
|---|---|---|
| Brunswick | 2013 | 250 |
| Perseverance | 2013 | 100 |
| Century | 2015 | 500 |
| Lisheen | 2015 | 160 |
| Pormorzany | 2017 | 70 |
| Bracemac McCloud | 2017 | 80 |
| Skorpion | 2017 | 160 |
| Total | | 1,320 |

**FIGURE 4: ZINC OUTLOOK**


FIGURE 5: ZINC PRICE STATISTICS

## 2.4 COOPERATION

### 2.4.1 COOPERATION WITH OTHER PROJECTS

Cooperation with other running H2020-projects and already finalised related FP7-projects as well as the further use of technology in future projects is important. This cooperation was necessary in order to retrieve information and technology needed for the further course of INTMET. It generated a kind of cross-fertilisation.

Examples of project are:
Minerals4EU (http://minerals4eu.brgm-rec.fr/minerals4EU), I²Mine (http://www.i2mine.eu), MINATURA, BIOMORE or FAME.

### 2.4.2 MAPPING OF POTENTIAL OF INTMET PARTNERS

Europe still has active mines and several facilities, which are processing ores and reprocessing secondary material[3]. INTMET results will have positive effects on ability to process low-grade ores and/or with imported concentrates[4].

#### 2.4.2.1 SPAIN

**COBRE LAS CRUCES (CLC)**

The new facility for processing low-grade and complex ores will extend the life of CLC mine. CLC is an important employer in the region and thanks to INTMET cooperation it will be possible to hire graduates and train experts in mineral extraction. First Quantum Minerals Ltd. (the owner of CLC) has announced that the life of the Las Cruces mine will extend until the year 2022. With a new extraction facility for low-grade ores the mine life will even extend until 2040 (though this will depend on demand). The Las Cruces mine site lies in the Sevilla province in the South of

[3] http://copperalliance.eu/industry/structure/copper-exploration-production-and-fabrication-map-in-europe
[4] http://www.euromines.org/mining-europe/production-mineral#Copper

Spain. According to the European Job Mobility portal, the unemployment rate in the Sevilla province reached 31,3% in 2015. This only underlines the importance of the mining industry in the region as a local job creator of an industry that can grow on domestic mineral supplies.

**AGQ MINING & BIOENERGY**

AGQ Mining & Bioenergy consists in technological centres which provide research, service and support to the global process of the benefit of minerals: mining exploration, hydrometallurgy and mineral processing, quality metal products and mining environmental impacts. The company has broad experience in developing mining effluents treatments in mining field and innovative approaches in metal valorisation, and innovative approaches in ecology. Currently, AGQ is involved in several, national and international, R&D projects regarding to the implementation of new technologies in different mining processes. Also, the presence of AGQ in other countries (most of them located in South-America) is a potential key aspect to be considered, and the INTMET project can became an important impact for the AGQ business activity.

**TECNICAS REUNIDAS (TR)**

TR is a general contractor and technology provider with a global workforce of more than 9.000 employees engaged in design and construction of industrial plants as well as in process development. Focusing on the NFM sector and hydrometallurgy technologies, since 1971 TR has maintained a leadership position in engineering and R&D projects in hydrometallurgy with early contacts in the Spanish Pyrite Belt. Its extensive knowledge of the ores, mines, processes, companies and people has provided value to companies and projects such as Rio Tinto, Xtrata, Glencore, Horsehead, Nyrstar, among many others. INTMET results will be used for improving TR's technology portfolio constructions. This constructions knowledge will create export potential for innovative technologies in mining and smelting industry, which is a goal of the European Union.

#### 2.4.2.2 FINLAND

**OUTOTEC OY**

The Finnish partner Outotec is a company providing technologies and services for the metal and mineral processing industries. It is specialized in developing solutions of copper, zinc, lead, gold, silver and platinum group metal refining at all stages in the value chain from ore to metal. The company has a leading position in the market and on the technology ground of mineral processing all around the world. Outotec's technologies can help reduce the environmental impact of a large number of operations in the metallic-mineral industry. INTMET will bring new elements into Outotec's portfolio and improve the effectiveness of polymetallic ore-product process and sustainability in the supply of metallic materials in the European market.

#### 2.4.2.4 PORTUGAL

**SOMINCOR**

SOMINCOR is a Portugal based mining company operating the Neves Corvo underground mine. SOMINCOR is important regional employer with nearly 2200 employees. It has built a wide spread network of roads and railways, which brings prosperity and employment to associated sectors. INTMET technologies have a potential to boost up company and region because so far the company is only producing concentrates[5]. INTMET technology will enable it to produce cathodes with high added value.

#### 2.4.2.5 SWEDEN

Sweden has a highly advanced mining industry with positive approach to new research projects and progressive mineral policy [6].

#### 2.4.2.6 POLAND

Poland is Europe's most important copper producer. Its production is twice as high as that of Bulgaria, Spain and Portugal together.[7] Two consortium members are from Poland.

**The Institute of Non-Ferrous Metals**

The Institute of Non-Ferrous Metals based in Gliwice, Poland, is a leading scientific centre of the Polish non-ferrous industry.

**KGHM POLSKA MIEDZ**

The KGHM Polska Miedz (Polish Copper) company is one of the global leading players in the production of copper and the largest producer of silver in the world (2012). It has several research projects in development. KGHM operates mining sites around the world as well smelting and refinery sites. Products include copper cathodes, raw materials, molybdenum, etc. The INTMET research has a potential to extend mine life and increase benefits for polish economy, employees and new technologies brings new opportunities for local employment market8.

#### 2.4.2.7 SERBIA

**Mining and Metallurgy Institute Bor, MMI Bor, (BOR INST)**

Bor is a town located in eastern Serbia and owns one of the largest copper mines in Europe. MMI Bor is a research institute active in domestic and foreign markets in the field of geology, mining, mineral processing, metallurgy, chemical technologies, chemical control, hydrometallurgy, environmental protection, information technologies, industrial informatics, mechanical engineering, electronics, non-ferrous metals and alloys, energy efficiency, environmental protection, ecology and publishing.

[5] http://somincor.com.pt/en/ms/ms/how-many-are-we-7780-183-castro-verde/ms-90064631-p-4/
[6] http://www.sgu.se/en/mining-inspectorate/mines/mines-in-sweden/
[7] http://www.euromines.org/mining-europe/production-mineral#Copper
[8] http://www.intmet.eu/kghm-polska-miedz-sa-poland/

MMI Bor possesses base data for many non-used primary and secondary mineral deposits in Serbia. These data can be of great interest for possible further mineral explorations, introducing new technologies and new deposits exploration. The Institute publishes two journals, one of international importance, "Mining and Metallurgy Engineering Bor", and one of national importance, "Copper".

#### 2.4.2.8 SOUTH AFRICA

**MINTEK**

Mintek is South Africa's national mineral research organisation and it is one of the world's leading technology organisations specialising in mineral processing, extractive metallurgy and related areas. Working closely with industry and other R&D institutions, Mintek provides service testwork, process development and optimisation, consulting and innovative products to clients worldwide. Founded in 1934, MINTEK has become a leading provider of minerals processing and metallurgical engineering products and services to industries. MINTEK will provide information on local markets and outside market from their experience.

### 2.4.3 IDENTIFICATION OF STRATEGICAL PARTNERS OUTSIDE THE CONSORTIUM

The main purpose of commercialisation of project results is to sell them to the market. Europe still has active mines and several facilities which are processing ores and reprocessing secondary material[9]. Therefore, we need to map these mines and processing facilities outside the INTMET consortium as important targets for marketing activities.

Important targets are the mines located in the Iberian Pyrite Belt in Spain and Portugal. This region provides many potential cases, where the INTMET technology may improve the related economic and also ecological situation.

For example, in Greece we have the Helenic Copper Mine (http://www.hcm.com.cy/site/about-hcm), which appears interesting in the context of INTMET.

Bulgaria is the second largest copper producer in Europe but needs to import considerable amounts of ores and concentrates. New technologies would be highly effective for improving Bulgarian economy. Bulgaria has one of the lowest minimal wage in European union. There for it is essential to install innovative solutions which will stimulate regional economy.

In Serbia, the old copper mines "RTB Bor Group" recently are under reconstruction by the government. In the future strategic partners for privatization will be in demand. Rakita Exploration d.o.o. that purchased the larger share from FreePort McMoRan Inc. is the owner of recently discovered big copper deposits. Furthermore, deposits producing selective Zn and Pb concentrates could be of interest (Rudnik and Trepca at Kosovo and Metohija district). Rich polymetallic ore deposits (Cu,Zn,Pb,Ag,Au), which are not in exploitation due to their complexity, belong to SMEs, such as Bobija AD, Balkan Exploration and Mining, Copper Minerals d.o.o. Coka Marin etc.

[9] http://copperalliance.eu/industry/structure/copper-exploration-production-and-fabrication-map-in-europe

In Romania, VAST Resources Ltd is operating polymetallic mines and are currently considering establishing a new metallurgical complex. INTMET already had contact with Vast, which have to be intensified now.

Outside the EU

Opportunity to share experiences with copper mining will be discussed, e.g. Chile, Canada, Republic of South Africa (RSA: http://www.mintek.co.za/corporate-profile/corporate-information/)

## 2.5 FINANCING

The INTMET deliverable D7.2 provides the results of the "Final technologies assessment and evaluation " of the different INTMET processes. The main conclusion from the technology assessment of the different technologies is that they have been demonstrated as feasible applications to deal with complex, polymetallic and low-grade ores. Feasible projects can be developed with very low metal contents in the bulk concentrate (around 10% Cu+Zn+Pb and 100 ppm Ag).

The economic assessment of the processes also shows good results. The absolute values of the economic figures depend of course on the particular application case. However, it can be expected that the application if the INTMET processes will be economically viable in many cases.

The next step would now be to look for a pilot installation. The intention of the INTMET consortium to do this in the frame of a Horizon 2020 funded Innovation Action unfortunately failed. Therefore, partners will look for other ways to develop pilot plant projects. These projects will be financed in the 'classical' way via private investment, loans and potential subsidies from Regional Development Funds or similar. Related marketing campaigns will be financed from private investment.

# 3. EXPLOITATION STRATEGIC PLAN

## 3.1 INTRODUCTION

The final exploitation plan is a compulsory document for EU funded research projects. It summarises the consortium's strategy and concrete actions to protect, disseminate and exploit the results generated by a project.

## 3.2 RESULTS TO BE DISSEMINATED

Parts of results obtained as outcome of a project may not be suitable for commercial exploitation but may still be valuable as knowledge that can contribute to future scientific developments. In other cases, the results have already been protected and eventually put on the market, but it is still worthwhile to disseminate them to the public to provide an opportunity for future innovation. The exploitation of results also matches the public character of research carried out with the financial support of the European Community. Participants are required to highlight the Community financial contribution to the project in all dissemination activities (as well as in protection activities, such as patent applications).

Nevertheless, the exploitation of results may hamper its protection, its commercial exploitation or even the legitimate interests of some participants. Therefore, it is crucial to always ensure that dissemination activities are carried out with the agreement of all participants and the approval of the Commission, where relevant. Confidential data or key information related to the use of results shall not be disclosed to the public.

Information about the various dissemination and promotion activities that have been carried out in the frame of INTMET to promote the project, engage with stakeholders and disseminate results can be obtained from the INTMET deliverable D8.5 "Report and results of stakeholder interaction activities – final".

## 3.3 EXPLOITABLE RESULTS

In the initial exploitation plan as outlined in IMTMET deliverable D8.2, participants were instructed about the way to provide their exploitable results and information related to them. The following table summarises the intended exploitation for each identified exploitable result. All information included in the table is status of January 2019.

| TYPE OF EXPLOITABLE RESULTS | Nº | LIST OF EXPLOITABLE RESULTS | PROPERTY OF THE RESULTS | BUSINESS STRATEGY OR EXPLOITATION MODEL FOR THE RESULT | TIMETABLE (COMMERCIAL) USE | TARGET SECTOR, POTENTIAL USERS |
|---|---|---|---|---|---|---|
| **SOFTWARE** | 1 | Communication platform | MINPOL | On-line product with annual subscription. | 2019 onwards | Mining sector, consultancy, government, metal industry, etc |
| | 2 | Web tool for life cycle assessment | Consortium | Payable downloadable catalogue | 2019 onwards | Mining sector, consultancy, etc |
| **TECHNOLOGY** | 3 | Atmospheric leaching Ag catalysed technology | CLC | Process patent and Licensing contracts, replacement of smelters by hydro-metallurgical processing of sulphide concentrates | 2019 onwards | Mines with sulphide deposits and concentration or hydrometallurgical technologies |
| | 4 | Pressure leaching technology | OUTOTEC | Patenting and **cession of patents** | 2019 onwards | High or medium temperature leaching (atmospheric or pressure) current hydrometallurgical industry. This industry currently produces 4000 t of copper global. New mines and modernisation of current exploitation for above 15000 Mt. of reserves in Europe |
| | 5 | Bioleaching technology | MINTEK | Patenting and **Licensing contracts** | 2019 onwards | |
| | 6 | Energy efficient anode | OUTOTEC | Patenting and **cession of patents** | 2019 onwards | |
| | 7 | MSA Technology | CLC | Patenting and **Licensing contracts** | 2019 onwards | |
| | 8 | Chloride media Technology | TR | Patenting and **Licensing contracts** | 2019 onwards | |
| **PILOT / PROTOTYPE** | 9 | Atmospheric leaching Ag catalysed | CLC | Patenting of prototypes and **cession of patents** | 2019 onwards | Once technology is probed and market scaling, demonstration activities previously to commercial. |
| | 10 | Pressure leaching | OUTOTEC | **Patenting** of prototypes | 2019 onwards | |
| | 11 | Bioleaching | MINTEK | **Patenting** of prototypes | 2019 onwards | |
| | 12 | Energy efficient anode | OUTOTEC | Patenting and **cession of patents** | 2019 onwards | |
| | 13 | MSA | CLC | **Patenting** of prototypes | 2019 onwards | |
| | 14 | Chloride media | TR | **Patenting** of prototypes | 2019 onwards | |
| **PROTOCOLL** | 15 | Protocol for industrial application of technologies | CLC, OUTOTEC, MINTEK, TR, MMI Bor (Bor INST) | Patenting and **Licensing contracts New plants** | 2019 onwards | The protocol allows identify market target and define procedure to integration |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 16 | Protocol for industrial application of technologies | CLC, OUTOTEC, MINTEK, TR, MMI Bor (Bor INST) | Process patenting and **Licensing contracts**<br>Technology is compatible with current leaching facilities | 2019 onwards | Allows modernisation of mines to benefit target ores |
| | 17 | Procedure to integrate the different technologies at an industrial Plant | CLC, OUTOTEC, MINTEK, TR, MMI Bor (Bor INST) | **Patents license** and **Licensing contracts** | 2019 onwards | Hydrometallurgical processing plants for mines with target ores |
| | 18 | Safety protocol | CLC, OUTOTEC, MINTEK, TR, MMI Bor (Bor INST) | New methodology in safety assessment. Consultancy and support for executing the protocol For new mines | 2019 onwards | Mine companies and metallurgical industries that implant new facilities |
| **PRODUCT** | 19 | Primary metals (Cu, Zn, Pb) obtained from IMNET solutions | Mines | Implantation of industrial scale process and operation to obtain commodities and value products. In this case, the business strategy continue online with current but extend mine life and add new products. | 2019 onwards | As commodities, directly to market. Cu market consumed 21,019.7 t in 2013 globally |
| | 20 | Additional valuable products (Au, Ag, Sb, Co, In) obtained from recovery process | Mines | | 2019 onwards | Au represent for example a annual market of 25.000 t, Sb, Co, In are consider CRM and Europe is deficitary. |
| | 21 | Valorisation of pyrite<br>Other by products (sulphur, fertilizer salts, construction materials) | Mines | Implantation of industrial scale process and operation to obtain commodities and value products. It's a new market different from metals and will require new commercial networks. | 2019 onwards | Fertilizer producers chemical companies, construction material providers |

| | | | | | | |
|---|---|---|---|---|---|---|
| **SERVICES** | 22 | Valuable productions from tailings and other wastes | Mines | Implantation of industrial scale process and operation to obtain commodities and value products. It's a new market different from metals and will require new commercial networks. | 2019 onwards | Fertilizer producers chemical companies, construction material providers |
| | 23 | Processing of low-grade/low quality commercial concentrates with low value to smelters due to impurities | Mines | New business line to refining and recover metals from commercial concentrates | 2019 onwards | Mines producers of low quality concentrates |
| **KNOWLEDGE** | 24 | Database of various waste streams | Consortium | Demonstration of the way of working with the waste stream, publication of the data. Consultancy to other waste streams. Service, further R&D. | 2019 onwards | Mining companies, metallurgical industry, recycling sector |
| | 25 | Database of different metallic ores | Consortium | Potential technology users identified, **Licensing contracts** | 2019 onwards | Mining companies, metallurgical industry |
| | 26 | Communication platform with the database / awareness related environmental and social initiatives | Consortium | On-line product with annual subscription. | 2019 onwards | Mining sector, consultancy, government, metal industry, etc |
| | 27 | Validation of different technologies in pilot | CLC, OUTOTEC, MINTEK, TR, MMI Bor (Bor INST) | It's a previous phase to implantation of technology and an important commercialisation tool, once developed industrial scaling | 2018 | Publicize of the scientific papers in journals worldwide and scientific papers on the International, regional and local level. |

## 4. CONCLUSIONS

INTMET was a very successful project. It managed to develop integrated alternative (leaching) solutions for the treatment of complex, polymetallic and low-grade ores, which turned out to be technologically feasible and also economically viable. These technologies will have a significant potential to improve metal provision from European sources.

Basing on the INTMET work, a business model was developed and outlined in this document. This model may be refined and adapted depending on the real application case.

The document finally provides the contractually mandatory exploitation plan. It contains a list of exploitable results and information about their exploitation.

# 5. ANNEX I QUESTIONNAIRE FOR IDENTIFYING BUSINESS OPPORTUNITIES

# INTMET Questionnaire

## INTRODUCTION TO INTMET

### The project

INTMET is a European funded project titled. “Integrated innovative metallurgical system to benefit efficiently polymetallic, complex and low-grade ores and concentrates” (http://www.intmet.eu). The INTMET approach represents a unique technological breakthrough to overcome the limitations related to difficult low grade and complex ores to achieve high efficient recovery of valuable metals (Cu, Zn, Pb, Ag) and CRM (Co, In, Sb). Main objective of INTMET is applying on-site mine-to-metal hydroprocessing of the produced concentrates enhancing substantially raw materials efficiency thanks to increase Cu+Zn+Pb recovery over 60% vs. existing selective flotation. Three innovative hydrometallurgical processes (atmospheric, pressure and bioleaching), and novel more effective metals extraction techniques (e.g. Cu/Zn-SX-EW, chloride media, MSA, etc.) will be developed and tested at relevant environment aiming to maximise metal recovery yield and minimising energy consumption and environmental footprint. Additionally, secondary materials like tailings and metallurgical wastes will be tested as well for metals recovery and sulphur valorisation. The technical, environmental and economic feasibility of the entire approaches will be evaluated to ensure a real business solution of the integrated INTMET process.

INTMET will be economically viable thanks to diversification of products (Cu, Zn, Pb), high-profitable solution (producing commodities not concentrates), with lower operation and environmental costs (on-site hydroprocessing will avoid transport to smelters) and allowing mine-life extension developing a new business-model concept based on high efficient recovery of complex ores that will ensure mining industry competitiveness and employment.

### Questionnaire

With the following questionnaire, INTMET would like to invite you to take part in the further course of process development and its commercial application. It is a recommendation of the European Commission that funded research projects should look for commercialisation of their results. Therefore, we are forwarding a couple of questions to obtain an overview of the potential market for our process. The objective of the questionnaire is to collect information as detailed as possible about the processing of low-grade and/or complex ores in order to adapt the parameters of the INTMET process and, subsequently, identify potential application cases for it.

The questions mainly relate to your operational environment and parameters of the input and output of the processes you are using. To identify the individual case in the further assessment process, few questions concerning your organisation are included as well.

We would very much appreciate your contribution to our work. In any case of question, please don’t hesitate to contact us.

We thank you very much in advance for your contribution.

## Part A: General information

*) All items in **bold** should be completed, the others are voluntary.

***) Affiliation/Company:** .....

Name: .....

First Name: .....

Address: .....

Phone: .....

***) Email**[10]: .....

***) Your position in the organisation/company**[11]: .....

***) Type of organisation/company:** private
public

***) Size of organisation (no of staff):**

***) Location of the operation:** .....

***) Year of establishment:** .....

***) Expected life (years from 2016):** .....

***) Date of completing this questionnaire:** .....

[10] To have a contact for further inquiry
[11] Of the person completing this survey

## Part B: Characteristics of the operation

**Mining method:**

Underground
Open cast
Recycling

**Minerals processing:**

***Comminution:***

Crusher
Mill
Other .....

***Sizing:***

Sorting
Cyclone separation (dry)
Hydrocyclone
Screening
Other .....

***Concentration:***

Flotation
Jig concentrators
Panning
Gravity concentration
Magnetic separation
Dry washing
Other .....

**Pyrometallurgy:**

Smelting
Refining
Other .....

**Hydrometallurgy:**

Leaching
Lixiviant
Heap leaching
Dump leaching
Tank leaching
In situ leaching
Other .....
Amalgamation
Solvent extraction

**Electrometallurgy**

Electrowinning
Hall–Héroult process
Castner process
Other .....

**Capacity (kt/a (milled) ore): .....**

**Average composition of processed ore (main components):**

**.....**

**Comments (please specify you interest on a potential use of mine-to-metal (M2M) concept developed within INTMET project):**

**.....**

## Part C: Ore characterisation

**Deposit type:**

Astrobleme-related ores
Carbonatite-alkaline igneous related
Granite related hydrothermal
Hydrothermal epigenetic deposits
Magmatic deposits
Metamorphically reworked deposits
Sedimentary deposits
Sedimentary hydrothermal deposits
Volcanic-related deposits
Other .....

**Ore complexity:**

Complex
Low-grade
Polymetallic
Other .....

**Ore type:**

Acanthite
Barite
Bauxite
Beryl
Bornite
Cassiterite
Chalcocite
Chalcopyrite
Chromite
Cinnabar
Cobaltite
Columbite-Tantalite or Coltan
Dolomite
Galena
Native gold
Hematite
Ilmenite
Magnetite
Malachite
Molybdenite
Pentlandite
Pyrolusite
Scheelite
Sperrylite

Sphalerite
Uraninite (pitchblende)
Wolframite
Other .....

## Part D: Target metal(s), products

| Metal | Concentration/grade in ore/concentrate (%) | Product(s)[12] | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Type[13] | Main product | By-product | Pure metal | Concen-trate | Production rate (kt/a) | Estimated Metal Reserves (Mt) |
| Copper (Cu) | | | | | | | | |
| Gold (Au) | | | | | | | | |
| Iron (Fe) | | | | | | | | |
| Lead (Pb) | | | | | | | | |
| Lithium (Li) | | | | | | | | |
| Molybdeum (Mo) | | | | | | | | |
| Nickel (Ni) | | | | | | | | |
| Niobium (Nb) | | | | | | | | |
| Platinum, Platinum group metals (Pt, PGM) | | | | | | | | |
| Phosphates | | | | | | | | |
| Rare earth elements (REE) | | | | | | | | |

[12] Please indicate and state figures related to the time of completing this questionnaire
[13] E.g. cathode, electrolytic metal, etc.

| Metal | Concentration/grade in ore/concentrate (%) | Product(s)[12] | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Type[13] | Main product | By-product | Pure metal | Concen-trate | Production rate (kt/a) | Estimated Metal Reserves (Mt) |
| Silver (Ag) | | | | | | | | |
| Tantalum (Ta) | | | | | | | | |
| Tin (Sn) | | | | | | | | |
| Titanium (Ti) | | | | | | | | |
| Tungsten (W) | | | | | | | | |
| Uranium (U) | | | | | | | | |
| Vanadium (V) | | | | | | | | |
| Zinc (Zn) | | | | | | | | |
| Zirconium (Zr) | | | | | | | | |
| Other: …… | | | | | | | | |