EDUCATION RELATED TO MINERAL RAW MATERIALS IN THE EUROPEAN UNION

PRELIMINARY REPORT ON AVAILABLE STUDY PROGRAMMES AND EXISTING SKILL SHORTAGES

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AUTHORS

Anders Sand, Jan Rosenkranz

Luleå University of Technology

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CONTENTS

1 INTRODUCTION

1.1 Background of work

Skills and knowledge issues have been recognised both on the European and on national levels of many EU Member States as one of the key challenges for the successful implementation of national and EU-level raw material strategies. In the Strategic Implementation Plan for the European Innovation Partnership on Raw Materials, Part I (2013), knowledge and skills are listed as one of the priority areas. The specific aims listed in the report includes the building of an innovative knowledge base for EU resources, improving the quantity and quality of higher education addressing the entire raw materials value chain, as well as improving the cooperation between actors across the value chain.

The same issues are also addressed in the ERA-MIN research agenda and roadmap for research activities (Vidal et al. 2013). For instance, it is stated that there is a need to promote education and training in all parts of the mineral raw material life cycle, and especially in teaching and training in the latest clean technologies. Recommended measures to be taken include the revision of university curricula, promotion of short courses both directed towards specialists and for a broader public. Furthermore, cooperation between the public and private sector needs to be intensified. Also several independent expert groups, e.g. the Materials Science and Engineering Expert Committee (Jarvis et al. 2012), have called for increased and coordinated efforts across the entire materials value chain, from material discovery, alloy design to processing etc. in order for European companies to accelerate innovation and maintain competitiveness, for instance for the development of emerging fields like green technology.

On national level, especially in countries active within extractive industries and which have developed their own national raw materials strategies, the issue of skill shortages has also been specifically addressed. For instance in Finland's Mineral Strategy (2010), it is stated that "The Finnish minerals sector is facing a shortage of experts". This is reported to be caused by increased investments and an overall expansion of the mining sector at the same time as training programmes within the sector have suffered from downscaling and poor coordination. In Sweden's mineral strategy (Ministry of Enterprise, Energy and Communications, 2013), access to a skilled workforce is recognised as one of the prerequisites for enabling the foreseen expansion of the mining and mineral industry. Furthermore, the Swedish report stresses that the attractiveness of the industry should be improved in order to increase the interest in and the intake of students to related educational programmes.

Other European Member States which have developed national mineral strategies include Germany (Federal Ministry of Economics and Technology: The German Government's Raw Materials Strategy, 2010), France (European Environment Agency: Resource Efficiency in

Europe, 2011), The Netherlands (A Review of National Resource Strategies and Research, 2012) and Austria (Weber, 2012). Due to the small mining sectors in these countries, focus has been put more towards securing the supply of mineral resources, recycling and substitution, and in some cases increased exploration and land use issues rather than on competence building and the development of the education and training sector.

The indications above paint a clear picture that there is a need for a systematic survey of educational offer versus educational demands along the raw materials value chain, within the various regions of Europe and across different stakeholder groups. This report attempts to fulfil the need for addressing the issues of skill shortage along this value chain, including primary raw material exploration, extraction and processing as well as processes related to the beneficiation of secondary raw materials and recycling. The report is mainly focused towards the mapping and identification of current educational offer within the EU. Further work within the project will include the mitigation of identified skill shortages amongst the various stakeholder groups.

1.2 Raw materials industry within the European Union

1.2.1 Introduction

Before addressing educational offer and demand related to the raw materials value chain, a general overview of the state of the mineral raw material industry in Europe is needed. In this section a brief summary and some key insights are given related to the status of the industry in Europe.

The level of self-sufficiency on raw materials within EU is very low for many minerals and metals, for instance 0% for platinum group and rare earth ores, 14% for nickel, 17% for iron, 20% for zinc and 26% for copper. Related to construction material (e.g. aggregates) as well as some industrial minerals, the EU is self-sufficient (EIP-SIP 2013). Some of the major reasons are the low product value, general abundance and ease of access in most countries, which make imports and long distance shipment uneconomic.

1.2.2 Mineral exploration

In the ERA-MIN roadmap (Vidal et al. 2013), the need for rapid increase in exploration investments is acknowledged. This is driven by the challenge of securing an increased raw material supply from European sources. Currently, the exploration for new deposits is dominated by Finland, Sweden and Poland, reaching about 300 M$ in investments in 2012 (Ericsson, 2012). To a lesser extent, exploration is also taking place in Ireland, Portugal and Eastern Europe (150 M$ combined), while being virtually non-existent within most of Central Europe. The investment costs in exploration are illustrated in Figure 1. The level of exploration activities corresponds well with overall mining activity in the various regions as well as the expansion of existing and development of new projects.

Exploration in Greenland is reported to currently being at roughly the same levels as in Finland and Sweden, 100 M$. Greenlandic exploration has been strongly focused on rare earth minerals (IntierraRMG report 2013).

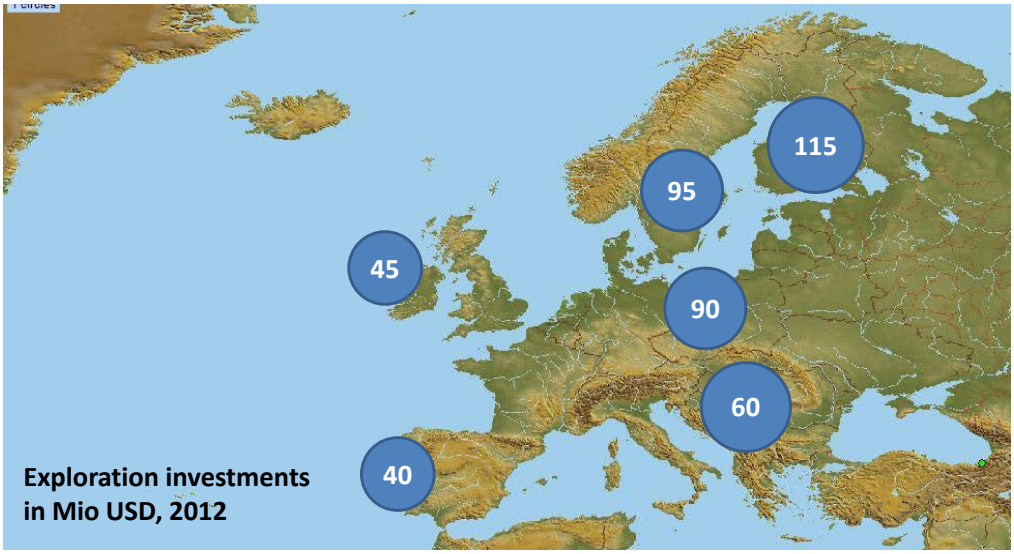

Figure 1: Investments in exploration within the EU (M. Ericsson, Raw Materials Group, 2012)

In other European regions, e.g. in Germany, the exploration of historically known deposits including also closed mine sites has been initiated in order to re-evaluate their economic value. This is due to the fact that prices for minerals and metals have changed and technology has improved, or in order to identify deposits with minerals that have become relevant only recently, for example those listed as critical by the European Commission.

1.2.3 Mineral extraction and processing

With regard to metallic ores and other high-value mineral products, mining and mineral processing activities within the EU are mostly taking place in the Nordic countries (Finland and Sweden), to some extent on the British Isles, on the Iberian Peninsula and in Eastern Europe, primarily represented by Poland, Bulgaria, Romania and Hungary. Greenland has a high natural resource potential and is expected to rise as an important mining region in Europe, but as yet only has a few operational mines. On the contrary several of the countries in Central Europe belong to the largest consumers of mineral raw materials for industrial production (Roto, 2009).

During the latest years, the development of new projects has mainly taken place in Sweden and Finland (Figure 2). The Nordic countries currently represent 90% of the iron ore, 80% of gold, and 40% of lead production within the European Union. Poland is strong particularly in copper (60%) and silver (73%), while Ireland is the dominating zinc producer (50%) (Ericsson, 2012). The ore production in the Nordic countries is expected to nearly double during the coming 10 years (Figure 3). On a global level, however, Europe is a minor player in the

production of primary raw materials. It is estimated that Europe stands for 3% of the world's metal production, while consuming roughly 20% (Raw Materials Group 2012).

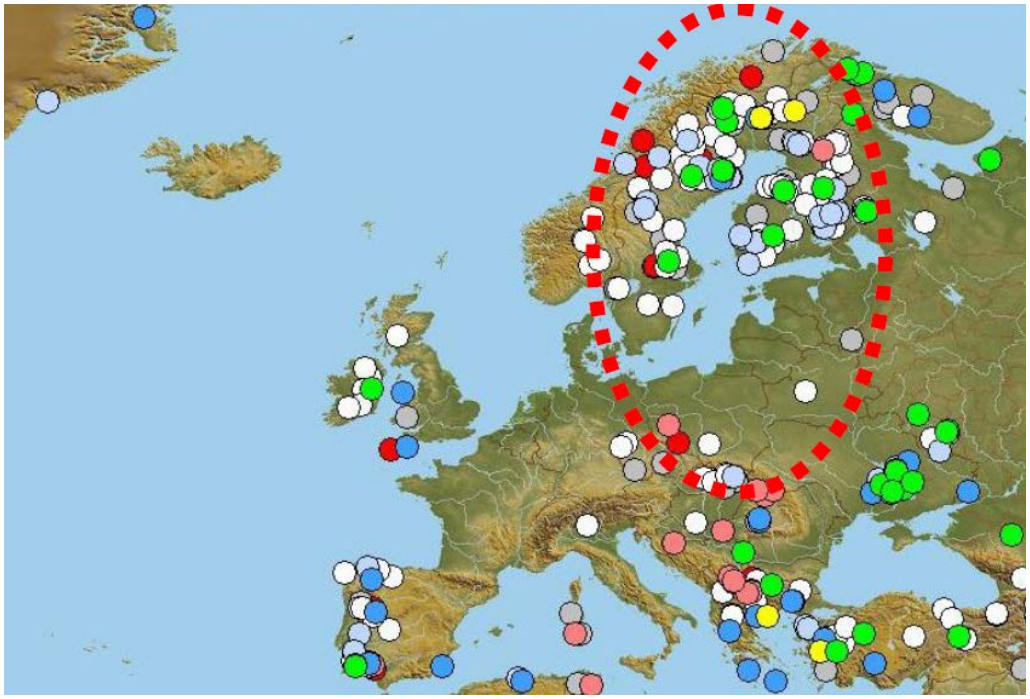

Figure 2: Existing and planned mining projects in Europe (M. Ericsson, Raw Materials Group, 2012).

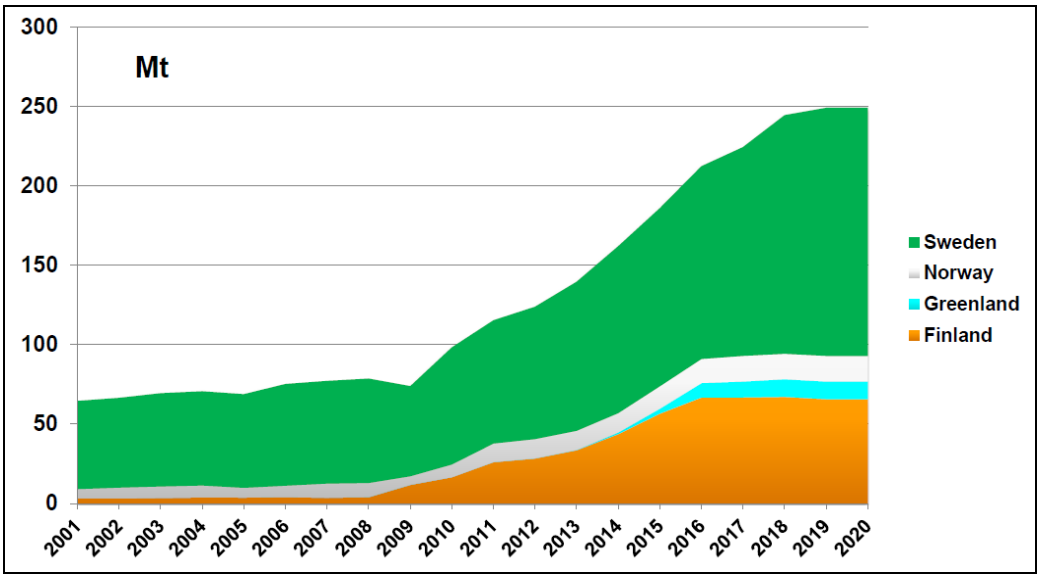

Figure 3: Nordic ore production estimates 2010-2020 (M. Ericsson, Raw Materials Group, 2012).

1.2.4 Metal production and recycling of metals

The European Union (EU-27) currently produces 170 Mio tonnes of crude steel annually, which represents 11% of the world's production. The EU-27 ratio of world production has declined by 35% since only five years ago, mainly due to strong production increases in Asia

and due to the economic crisis in Europe. European steel production has however also decreased in real numbers, about 20% over the same time period. The largest European producers are Germany (25%), Italy (16%) and France (9%) followed by Spain (8%) (World Steel Association Statistics, 2012). In copper production Aurubis (Germany) and KGHM (Poland) belong to the 10 largest copper refining companies. Germany is also ranked on the 6th place worldwide when it comes to copper refining (BGR, 2012).

Due to the high consumption of metal containing products, Europe could be considered having a large potential in the beneficiation and recycling of secondary raw materials. In fact European companies like Boliden (Sweden), Umicore (Belgium) and Aurubis (Germany) are belonging to the world leading recycling companies when it comes to non-ferrous metals (Sundqvist, 2012). Therefore, at least part of EU's need for raw materials can be covered by these types of sources. Many EU policies addressing this issue, put a high emphasis on recycling and substitution (Strategic Implementation Plan, Part I (2013)).

A recent trend, however, is that the EU is exporting an increasing amount of waste materials to other countries, mainly in Asia. Especially for valuable metals but also for plastics, this increase is significant. From 1999 to 2011 the export of iron and steel waste has increased by 160%, of copper, aluminium and nickel by 210% and of precious metals by 140%. For plastics the increase is as high as 600%. See Figure 4.

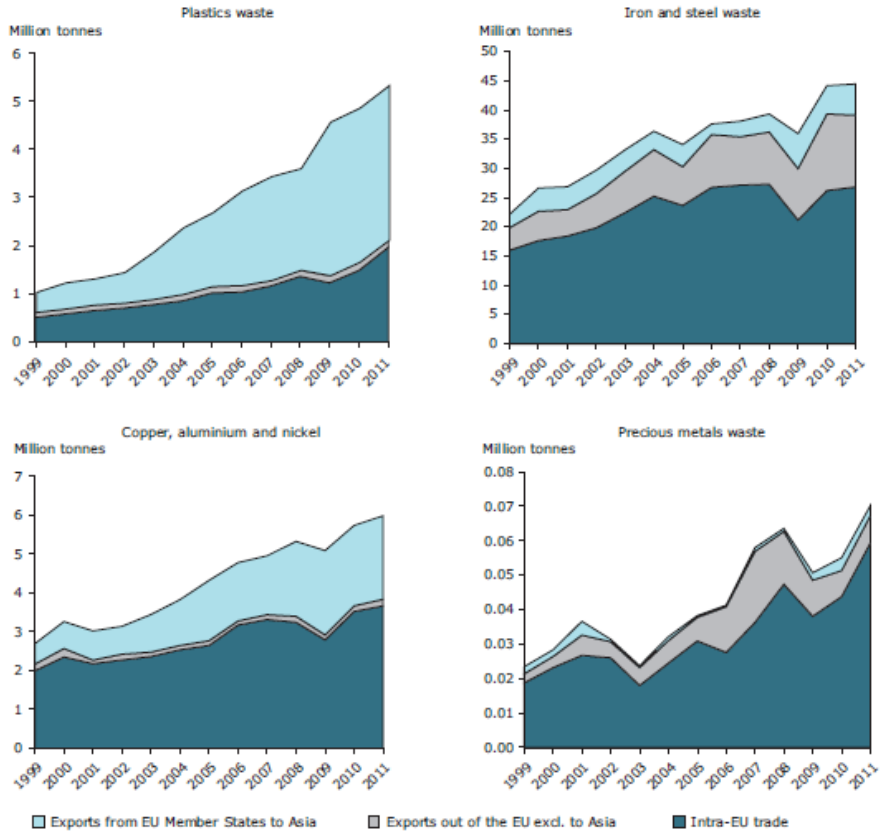

Figure 4: Exports of waste plastics and selected metals within and from the EU, 1999-2011 (European Environment Agency Report 2012, based on Eurostat statistics)

2 OBJECTIVES OF SURVEY

Being part of Work package 3 (Tackling skill shortages) of the COBALT project (http://www.cobalt-fp7.eu/), this work aims at supporting universities, industry and public agencies in tackling skill shortages. Due to the increasing importance of eco-efficiency and sustainability issues within primary raw materials extraction and processing, but also with respect to the recycling of secondary raw materials, the required competences have changed. This survey comprises the identification of available tutoring offers and existing skill shortages, and based on that define the skills needed and develop suitable syllabi and courses that address the specific prerequisites and needs of the various stakeholders.

In the first part the work package, and within the scope of this project deliverable, a mapping is conducted across the value chain for raw material related educational offers within the European Union. The various steps considered within the value chain include

- Exploration
- Extraction (mining)
- Mineral processing
- Metallurgical processing and
- Processing of secondary raw materials.

Environmental technology is also considered when linked to any of the value chain constituents listed above. The stakeholder groups taken into account include institutions for polytechnic and higher education, industry (SMEs, consultancies and training providers), geological surveys and other public agencies. However, since only universities can provide the full value-chain focus, the preliminary mapping will at first consider higher education level institutions. Thus, vocational programmes or single short-course training offers are not considered in this survey.

3 APPROACH AND DEFINITIONS

3.1 Classification of skill shortages

3.1.1 Lack of work force

In order to mitigate skill shortages one first needs to categorize the different areas and levels where skills may be lacking. An obvious skill shortage could simply imply a quantitative lack of skilled professionals within a certain region and within a specific section of the value chain as compared to the demand or projected demand of such workforce. This is for instance mentioned as a key obstacle to the expansion of the raw materials sector within Finland's

Mineral Strategy (2010). On a global level, surveys have been carried out, where the output of workforce within the minerals industry is put in relation to the scale of raw material production. Such an investigation is summarised by Cilliers et al (2013).

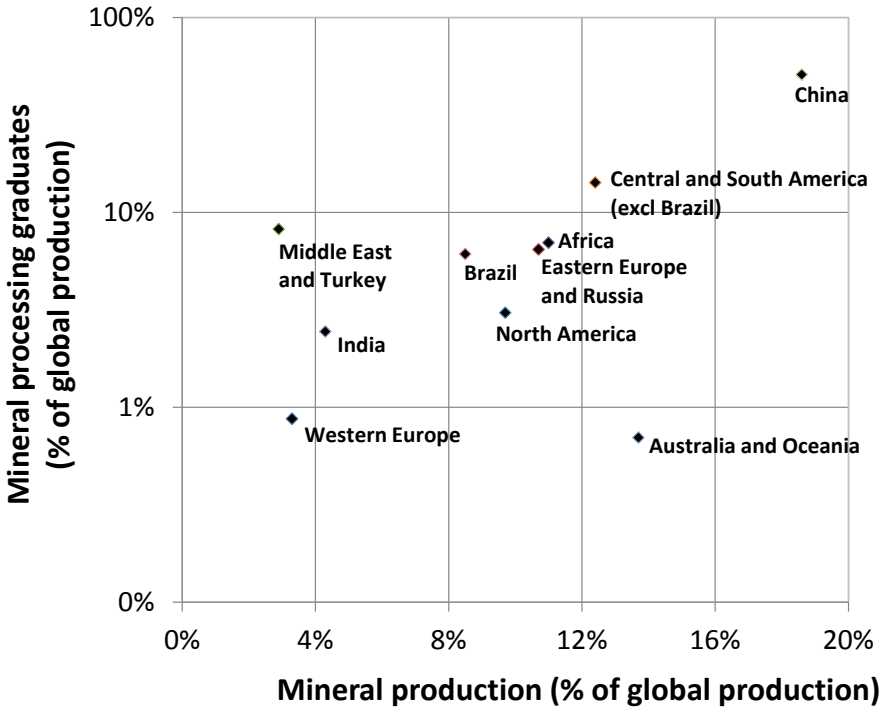

Figure 5: Fraction of global mineral production versus percentage of mineral engineers educated (based on Cilliers et al, 2013).

In Figure 5, regions to the bottom right of the chart indicate low education output relative to high mineral production while regions to the top left indicate high educational volume relative to lower mineral production. Although this figure gives some indications, it does not account for lower labour demand due to high level of automation or labour market adjustment for decreasing or increasing production, production site maturity and establishment of new greenfield projects.

In studies comparing number of job vacancies in applied geology positions compared to the number of graduates in Europe, strong regional imbalances can be observed (Trimboli, 2009). While there is a nearly 1:1 parity between new vacancies and graduates overall in the EU-15 region, the domestic graduate output in several of the dominating ore producing countries is much lower than the demand for the corresponding workforce. In Finland in 2007 there were more than 8 job openings per geology graduate, in Ireland and Sweden close to 2 new positions per graduate every year. On the Iberian Peninsula and in Eastern Europe, however, the educational system was largely able to satisfy the demand. In several southern European countries there is a significant overproduction of geology graduates. For

instance in Portugal and Greece reported 3.3 and 2.5 new graduates for each new job opening, respectively.

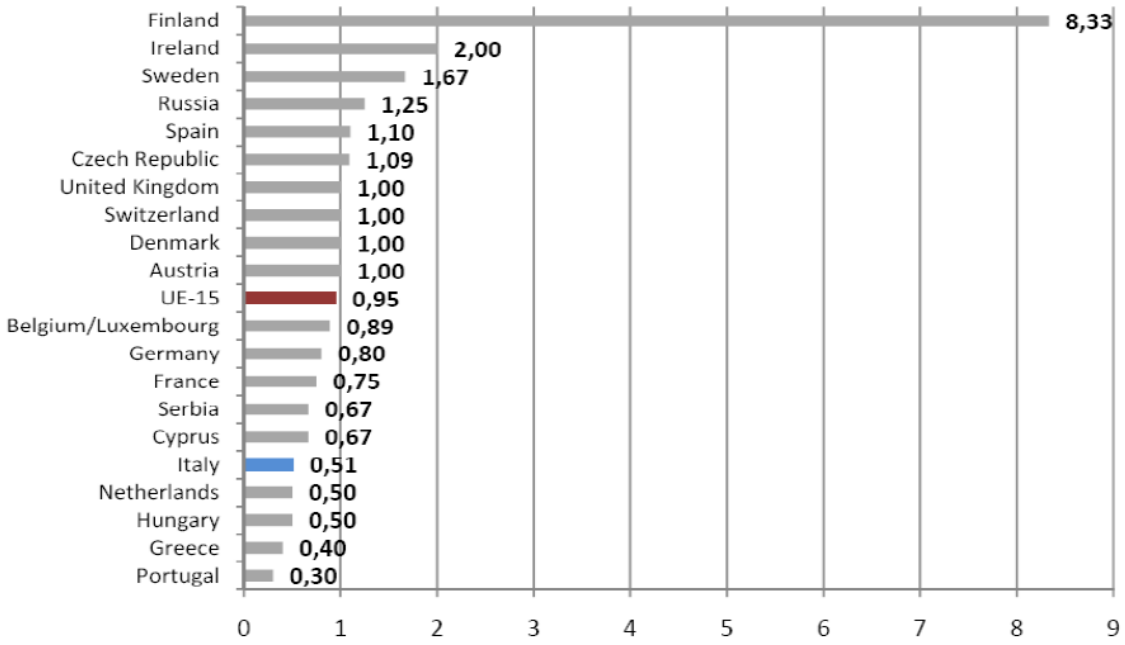

Figure 6: Number of job vacancies for geologists p.a. versus number of graduates p.a. in Europe. Source: Federazione Europea dei Geologi, MIUR, Almalaurea (2007).

3.1.2 Lack of competence

Another viewpoint of skill shortage confers to lack of competence of active professionals within their own field of work. This in turn can be caused by the workforce having an educational background from rather unrelated fields, or low quality of education within the field (e.g. programmes lacking appropriate accreditation). Furthermore, a cross value chain approach can be taken: Skill shortages can also be identified as the lack of understanding of the activities and needs of preceding or subsequent supply chain activities by one group within a specific supply chain position or as a lack of collaboration across the value chain.

In practice, a lack of knowledge and understanding can exist to some extent, but the main cause for underdeveloped coordination between the different players along the value chain is likely to be related to conflicting needs and objectives. For instance, the manufacturing industry is likely to seek the cheapest materials possible and prioritise consumer aspects for any given product. The recycling industry, on the other hand, would prefer products which are constructed to be simple to disassemble and recycle, and containing expensive materials that are profitable to extract. This lack of coordination across the value chain will act as an obstacle to the development of best practices and overall life cycle efficiency, both in terms of productivity and financial benefit as well as improved eco-efficiency and minimisation of environmental impact.

Finally, from the societal viewpoint, public opinions based on erroneous perceptions of extraction, processing and use of raw materials may prove detrimental to social acceptance. This may lead to policymakers' inadequate attention to security of supply issues, access to education, and consequently negatively affecting European competitiveness in the sector. To respond to lack of know-how mining and processing technology as well as technical relations of the entire value chain special study offers are needed.

3.2 Method

The tools to be used within the work package include literature reviews, internet surveys and interviews with various stakeholder groups. This report will mainly focus on the supply side of raw material-related education, and is thus mainly conducted through literature reviews.

An investigation related to the demand for skills, both quantitative needs for a skilled workforce as well as need for specific skills, has been recognised as difficult by previous studies (e.g. Cilliers 2013). This is due to company secrecy and a lack of statistics specific to the non-energy raw materials sector. Further insecurity in this type of mapping is induced by the market cycles, which in particular extractives and metallurgical industries are sensitive to. It is therefore extremely difficult to make long term estimates on labour and skill demand within these sectors. However, the demand of certain skills can be discussed in a qualitative way, based on the availability of educational programmes in different European Member States as well as the assessment of the needs of the different stakeholder groups, i.e. local industry, governmental organisations etc.

For the survey a questionnaire has been developed that lists the essential information for each educational programme in tabular form (see 8.1. Annex for the questionnaire template). During the further procedure this format is intended to serve as the blue print for a database on the educational offer related to the field of mineral raw materials.

3.3 General definitions and prerequisites

Due to variations in terminology within Europe, a number of expressions need to be defined and clarified. A list of definitions used in this report and in the survey of educational offers in section 5, is given below:

- "Raw material" is in this report defined as non-energy mineral raw materials or their corresponding secondary raw materials. Agricultural products or other products of organic origin, in particular fossil and non-fossil fuels, are not considered.
- "Course" shall in this report refer to a component of an educational programme, where students upon completion are granted credits as part of their pursuits for an academic degree.

- "Programme" refers to the collective set of courses and other requirements for students (e.g. practice) in order to pursue a specific academic degree.
- The definition of "Polytechnics" education is a bit troublesome since in some countries (e.g. Poland and France) it refers to Universities of Technology, while in most countries identified as the level below University, often referred to as University of Applied Sciences.
- "Undergraduate" refers to a student pursuing a degree on Bachelors level or below.
- "Graduate" refers to a student pursuing a Masters or Doctors degree.
- "Postgraduate" refers to a person that has a Doctorate.

4 EDUCATIONAL OFFER

4.1 General trends

As already observed by McDivitt (2002), the number of educational programmes dedicated to the raw materials sector, especially in the developed countries, is in a state of decline. Most of these programmes have been either cancelled or merged with more generalist material science, civil engineering, chemical engineering or environmental technology programmes. McDivitt argues that this development is a result of mineral development becoming more complex and technical – requiring a more diverse skill set than was previously the case. He states that the changing pattern of mineral industry education has simply been a useful and well needed adaption to new demands. This is certainly true to some extent, considering the need for skilled professionals for instance in process automation, IT, and environmental technology that has emerged within the extractive and metallurgical industries during the past decades. On the other hand, an overall trend during the same time has been that an ever greater part of raw materials extraction and processing has moved to newly industrialised countries and emerging economies. Both exploration and the development of new projects within most developed countries, has declined drastically. Europe has been leading the decline. Today this can be noted as high import levels for primary raw materials, low degree of self-sufficiency, concerns about security of supply and European mining companies having problems in finding domestic workforce with the appropriate skill set. For instance, more than 90% of mineral processing graduates are now reported to be educated in Asia, Africa, South and Central America, while the figure for Western Europe is less than 1% (Cilliers, 2013). Furthermore, the number of graduates within Asia, Africa, South and Central America is expected to rise by 15-20% over the coming years, while the levels are projected to remain stagnant in Europe (Cilliers 2013).

4.2 Survey of educational offers within the EU

4.2.1 Scope of the survey

The mapping below constitutes a summary of university-level educational programmes related to exploration, extraction and processing of mineral raw materials within the European Union. Furthermore, educational programmes and courses linked to processing of secondary raw materials (recycling) and environmental engineering are considered. A database containing detailed information on educational offers is being built up at Luleå University of Technology as part of the activities within WP3 of the COBALT project. This report summarises some of the data and findings.

It should be noted that the survey below is currently based on literature and internet surveys. Due to varying level of detail at university home pages, the information is in some cases based on interpretations which may not always be fully accurate. Variations in terminology, level of detail in various languages, lack of description of specific course contents all contribute to a certain level of uncertainty.

Especially in the case of geosciences, it has proven difficult to determine the applicability of educational offers to applied geology professions that can be found in industry. In this study, institutions with activities in geosciences are typically listed only if strongly linked to non-energy extractive industries. Environmental engineering is typically listed only if there is a clear link to the raw materials sector, e.g. dealing with analysis or mitigation of industrial emissions, industrial wastes, etc. Recycling is listed if activities related to the collection and processing of secondary mineral-based raw materials, including recovery of metals or minerals, exist at the investigated institution. Finally, the evaluation of civil engineering in earth or rock construction in relation to mining engineering is not always straight-forward.

The survey focusses on EU Member States within three regions as defined by COBALT; A North Sea region, the Iberian Peninsula and Eastern Europe (please see the respective table in the annex).

Vocational schools including Institutes of Technology or vocational universities are typically not considered in this report. An exception of this rule has been made with respect to so-called Universities of Applied Sciences, a concept that exists in Germany, Finland, Austria and the Netherlands. The term used on the British Islands, University College, is sometimes defined as a vocational university and sometimes as a subdivision of a university. A further complication is that some formerly vocational level institutions which have obtained full university status are still using their old name, as for instance the Royal Institute of Technology in Sweden.

4.2.2 Grading system

The grading system used below is as follows:

A –Full undergraduate (Bachelor and/or Master level) programme offered with possibility to continue into postgraduate (doctoral level) studies, based on research at the institution

A*- Master level undergraduate programme, based on a general Bachelor programme with the possibility to continue into postgraduate (doctoral level) studies

B – Full BSc and/ or MSc level programme offered, typically linked to research activities or based on competence obtained externally (as for e.g. at Universities of Applied Sciences)

C – Educational offer on single course basis, typically not linked to research activities at the institution

4.2.3 List of institutions (Countries in alphabetical order)

4.2.3.1 AUSTRIA

UNIVERSITY	LOCATION	GEOSCIENCE	MINING TECHNOLOGY	MINERAL PROCESSING	METALLURGY	ENVIRONMENTAL ENGINEERING	RECYCLING	SOURCE(S)
Montanuniversität Leoben	Leoben	A	A	A	A	A	A	www.unileoben.ac.at
Graz University of Technology	Graz	A	-	-	-	-	-	www.tugraz.at
University of Innsbruck	Innsbruck	A	-	-	-	-	-	www.uibk.ac.at

4.2.3.2 BELGIUM

UNIVERSITY	LOCATION	GEOSCIENCE	MINING TECHNOLOGY	MINERAL PROCESSING	METALLURGY	ENVIRONMENTAL ENGINEERING	RECYCLING	SOURCE(S)
University of Mons	Mons	A*	A*	C				portail.umons.a

								c.be
Université de Liège	Liège	A	A*	C				www.ulg.ac.be

4.2.3.3 BULGARIA

UNIVERSITY	LOCATION	GEOSCIENCE	MINING TECHNOLOGY	MINERAL PROCESSING	METALLURGY	ENVIRONMENTAL ENGINEERING	RECYCLING	SOURCE(S)
University of Mining and Geology St. Ivan Rilski	Sofia	A	A	A	-	A	A	www.mgu.bg

4.2.3.4 CROATIA

UNIVERSITY	LOCATION	GEOSCIENCE	MINING TECHNOLOGY	MINERAL PROCESSING	METALLURGY	ENVIRONMENTAL ENGINEERING	RECYCLING	SOURCE(S)
University of Zagreb	Zagreb	A	A			A		www.unizg.hr

4.2.3.5 CZECH REPUBLIC

UNIVERSITY	LOCATION	GEOSCIENCE	MINING TECHNOLOGY	MINERAL PROCESSING	METALLURGY	ENVIRONMENTAL ENGINEERING	RECYCLING	SOURCE(S)
Technical University of Ostrava	Ostrava	A	A	A[1]	-[2]	A	A[1]	http://www.hgf.vsb.cz/en/ (BSc available in Czech and partly in English)

[1)] Offered in combined programme Mineral Raw Material Processing and Recycling.

[2)] Not confirmed as full course lists are not provided online.

4.2.3.6 DENMARK

UNIVERSITY	LOCATION	GEOSCIENCE	MINING TECHNOLOGY	MINERAL PROCESSING	METALLURGY	ENVIRONMENTAL ENGINEERING	RECYCLING	SOURCE(S)
Technical University of Denmark	Lyngby	C	C[1]			A[1]		www.dtu.dk

[1)] Civil engineering programme covers some aspects of infrastructure and logistics related to the mining industry, e.g. construction of dams, industrial plants in cold climate.

4.2.3.7 ESTONIA

UNIVERSITY	LOCATION	GEOSCIENCE	MINING TECHNOLOGY	MINERAL PROCESSING	METALLURGY	ENVIRONMENTAL ENGINEERING	RECYCLING	SOURCE(S)
Tallinn University of Technology	Tallinn	C[1]	C[1]			A[2]		www.ttu.ee

[1)] Detailed course information not available.

[2)] M.Sc (Eng.) programme in Environmental Management and Cleaner Production.

4.2.3.8 FINLAND

UNIVERSITY	LOCATION	GEOSCIENCE	MINING TECHNOLOGY	MINERAL PROCESSING	METALLURGY	ENVIRONMENTAL ENGINEERING	RECYCLING	SOURCE(S)
Aalto University	Espoo	C	A	A	C	A	C	www.aalto.fi
Abo Akademi University	Turku	A	-	-	-	A[2]	-	www.abo.fi
University of Helsinki	Helsinki	A	-	-	-	-	-	www.helsinki.fi/university/
University of Oulu	Oulu	A	C	A	A	A	-	http://www.oulu.fi (some parts available in Finnish only)
University of Turku	Turku	A						www.utu.fi

Kajaani University of Applied Sciences [3]	Kajaani	C	C	C	-	-	-	www.kamk.fi www.kajak.fi
Lappia University of Applied Sciences [3]	Rovaniemi and Kemi	C	C	-	-	C	-	www.lapinamk.fi www.ramk.fi

[1)] Education related to general separation technology, applicable in but not specifically focused towards the raw materials sector.

[2)] Education offered on Master level in Energy and Environmental Engineering.

[3)] Joint programme between Kajaani, Kemi and Rovaniemi

4.2.3.9 FRANCE

UNIVERSITY	LOCATION	GEOSCIENCE	MINING TECHNOLOGY	MINERAL PROCESSING	METALLURGY	ENVIRONMENTAL ENGINEERING	RECYCLING	SOURCE(S)
MINES ParisTech (Paris School of Mines)	Fontainebleau	C[1]	-	-	-	C[1]		www.mines-paristech.eu
École des Mines de Douai	Douai	-	-	B[2]	-	C[2]		www2.mines-douai.fr
École des Mines de Nancy (University of Lorraine)	Nancy	C[6]	A[3]	C[6]		C[4]	A[5]	www.mines-nancy.univ-lorraine.fr

[1)] Education offered on single course basis from Centre de Géosciences, only little information available.

[2)] One Master's programme in "Concrete industry products and processes", single courses offered in environmental engineering.

[3] Specialized Master in Mining and Quarrying – Conversion and sustainable development, economic social and environmental management

[4] Both Geoengineering and Mining and Quarrying programmes offer some courses related to environmental engineering.

[5] Specialized Master in Management, Treatment and Recycling of Waste.

[6] The broad programme Mineral Commodities, Engineering and Risk Management said to include all stages from recognition of mineral deposits to treatment and recycling of tailings, risk management and environmental protection. Detailed course lists and programme contents not available from webpage.

4.2.3.10 GERMANY

UNIVERSITY	LOCATION	GEOSCIENCE	MINING TECHNOLOGY	MINERAL PROCESSING	METALLURGY	ENVIRONMENTAL ENGINEERING	RECYCLING	SOURCE(S)
Technische Universität Berlin	Berlin	A	-	-	-	-	-	www.tu-berlin.de
RWTH Aachen	Aachen	A	A	A	A	-	A	www.rwth-aachen.de
TU BAF Freiberg	Freiberg/S.	A	A	A[1]	A[2]	-	A[2]	www.tu-freiberg.de
Technische Universität Clausthal	Clausthal-Zellerfeld	A	-	-	A[2]	A	A	www.studium.tu-clausthal.de
University of Hannover	Hannover	A	-	-	-	-	-	www.uni-hannover.de
TFH Georg Agricola	Bochum	B	B	C[3]	-	-	-	www.tfh-bochum.de

In the German educational system doctorates are not organized as study programmes at the universities. Universities of Applied Sciences (UAS) today do not have the right to confer doctoral degrees.

[1)] As a specialization within Process Engineering

[2)] As a specialization within Material Sciences

[3)] Focus on cement production

4.2.3.11 GREECE

UNIVERSITY	LOCATION	GEOSCIENCE	MINING TECHNOLOGY	MINERAL PROCESSING	METALLURGY	ENVIRONMENTAL ENGINEERING	RECYCLING	SOURCE(S)
National Technical University of Athens	Athens	A[1]	A[1]	C[1]	A[1]	C[1]	C[1]	http://www.metal.ntua.gr
Technical University of Crete	Chania	A[2]	A[2]	A[2]	-	A[2]	-	http://www.mred.tuc.gr

[1)] School of Mining and Metallurgical Engineering. Very limited information offered on webpage. Distinction between research and education topics not clear. Webpage not updated since 2007.

[2)] School of Mineral Resources Engineering. Not clear if offered as a single combined programme or as several individual study programmes.

4.2.3.12 HUNGARY

UNIVERSITY	LOCATION	GEOSCIENCE	MINING TECHNOLOGY	MINERAL PROCESSING	METALLURGY	ENVIRONMENTAL ENGINEERING	RECYCLING	SOURCE(S)
University of Miskolc	Miskolc-Egyetemváros	A	A	A	A[1]	A	-	www.uni-miskolc.hu

[1)] Based on a Bachelor in Material Sciences

4.2.3.13 IRELAND

UNIVERSITY	LOCATION	GEOSCIENCE	MINING TECHNOLOGY	MINERAL PROCESSING	METALLURGY	ENVIRONMENTAL ENGINEERING	RECYCLING	SOURCE(S)
University of Limerick	Limerick	C[1]	C[1]	-	-	A[1]	-	www.ul.ie
Trinity College Dublin	Dublin	A	C	-	-	C	-	www.tcd.ie
University College Cork	Cork	A	-	-	-	C	-	www.ucc.ie
University College Dublin	Dublin	A	-	-	-	A	-	www.ucd.ie

[1)] Civil engineering programme contains courses in geology, soil mechanics, geotechnical engineering, EIA, pollution control, etc. Dedicated environmental science programme exists.

4.2.3.14 ITALY

UNIVERSITY	LOCATION	GEOSCIENCE	MINING TECHNOLOGY	MINERAL PROCESSING	METALLURGY	ENVIRONMENTAL ENGINEERING	RECYCLING	SOURCE(S)
University of Cagliari	Cagliari	A	-	-	-	A	-	www.unica.it
University of Trieste	Trieste	A	-	-	-	-	-	www.units.it
University of Bologna	Bologna	A	-	-	-	-	-	www.eng.unibo.it

4.2.3.15 NETHERLANDS

UNIVERSITY	LOCATION	GEOSCIENCE	MINING TECHNOLOGY	MINERAL PROCESSING	METALLURGY	ENVIRONMENTAL ENGINEERING	RECYCLING	SOURCE(S)
Delft University of Technology	Delft	A	A[1]	A[1]	-	A[1]	C	www.tudelft.nl

[1)] As part of an Erasmus Mundus Master Programme

4.2.3.16 POLAND

UNIVERSITY	LOCATION	GEOSCIENCE	MINING TECHNOLOGY	MINERAL PROCESSING	METALLURGY	ENVIRONMENTAL ENGINEERING	RECYCLING	SOURCE(S)
AGH University of Science and Technology[1]	Cracow	A	A, C[2]	A	A	A	-	www.agh.edu.pl (partly in English)
Czestochowa University of Technology	Czestochowa	-	-	-	A[3]	C	-	www.pcz.pl
Lodz University of Technology	Lodz	-	-	-	-	C	-	www.p.lodz.pl
Poznan University of Technology	Poznan	-	-	-	-	-	C	www.put.edu.pl
Silesian University of Technology	Katowice/Gliwice	A	A	A	A	A	-	www.polsl.pl
University of Wroclaw	Wroclaw	A	-	-	-	-	-	www.uni.wroc.pl
Wroclaw University of Technology	Wroclaw	A	A	-	-	A	-	www.dwm.pwr.wroc.pl

[1)] Formerly known as the University of Mining and Metallurgy

[2)] Summer school of Mining engineering within the Framework of the International University of Resources (in English)

[3)] Metallurgy is part of the Faculty of Materials Processing Technology and Applied Physics.

4.2.3.17 PORTUGAL

UNIVERSITY	LOCATION	GEOSCIENCE	MINING TECHNOLOGY	MINERAL PROCESSING	METALLURGY	ENVIRONMENTAL ENGINEERING	RECYCLING	SOURCE(S)
Instituto Superior Tecnico, Lisboa	Lisbon	A	A	C	-	-	-	tecnico.ulisboa.pt
Universidade do Porto	Porto	A	A	-	A[1]	B	C	www.up.pt

[1)] Integrated Master of 5 years

4.2.3.18 ROMANIA

UNIVERSITY	LOCATION	GEOSCIENCE	MINING TECHNOLOGY	MINERAL PROCESSING	METALLURGY	ENVIRONMENTAL ENGINEERING	RECYCLING	SOURCE(S)
Technical University of Petrosani	Petrosani	-	A[1]	C[1]	-	C[1]	-	www.upet.ro/eng
Technical University of Cluj-Napoca	Cluj Napoca			A[2]	A[2]	A[2]		Old.utcluj.ro/English

[1)] Technical University of Petrosani appears very strong in mining technology, and has a few courses that can be considered mineral processing and environmental engineering – but mostly from the mining engineering viewpoint.

[2)] Formerly known as North University Baia Mare. Limited information on webpage makes it difficult to evaluate education, but has programmes in powder metallurgy and advanced materials, engineering and management of advanced material processing, and several programmes related to environmental engineering.

4.2.3.19 SLOVAKIA

UNIVERSITY	LOCATION	GEOSCIENCE	MINING TECHNOLOGY	MINERAL PROCESSING	METALLURGY	ENVIRONMENTAL ENGINEERING	RECYCLING	SOURCE(S)
Technical University of Košice	Košice	A	A	A[1]	A	A	A[2]	www.tuke.sk

[1)] Detailed contents of programmes not available, but MSc level education in "Extraction and Processing of Raw Materials" and "Process Control of Extracting and Processing of Raw Materials"

[2)] BSc programme in "Processing and Recycling of Wastes".

4.2.3.20 SLOVENIA

UNIVERSITY	LOCATION	GEOSCIENCE	MINING TECHNOLOGY	MINERAL PROCESSING	METALLURGY	ENVIRONMENTAL ENGINEERING	RECYCLING	SOURCE(S)
University of Ljubljana	Ljubljana	A[1]	A[1]		A[1]	C[1]		www.uni.lj.si

[1)] Detailed contents of programmes not available.

4.2.3.21 SPAIN

UNIVERSITY	LOCATION	GEOSCIENCE	MINING TECHNOLOGY	MINERAL PROCESSING	METALLURGY	ENVIRONMENTAL ENGINEERING	RECYCLING	SOURCE(S)
Universidad de Oviedo	Oviedo	A	A[1]	C	C	-	-	www.uniovi.es
Universidad Politecnica de Madrid	Madrid	A[2]	A[2]	C	C	A	-	www.upm.es
Universitat Politecnica de Catalunya	Barcelona	A	-	-	-	A*	-	www.upc.edu

[1)] Only BSc

[2)] Master programme not open for new enrolment

4.2.3.22 SWEDEN

UNIVERSITY	LOCATION	GEOSCIENCE	MINING TECHNOLOGY	MINERAL PROCESSING	METALLURGY	ENVIRONMENTAL ENGINEERING	RECYCLING	SOURCE(S)
Chalmers University of Technology	Gothenburg	C[2]	C[2]			A[3]	C	www.chalmers.se
KTH Royal Institute of Technology	Stockholm	C	C		C[4]	C		www.kth.se
Luleå University of Technology	Luleå	A	A[1]	A	A	A	C	http://www.ltu.se

Lund University	Lund	A	-	-	-	A	-	http://www.lu.se
Stockholm University	Stockholm	A				A		www.su.se
University of Gothenburg	Gothenburg	A				A		www.gu.se
Uppsala University	Uppsala	A	-	-	-	A	-	www.uu.se
Bergsskolan[5]	Filipstad	C	A	C	A			www.ltu.se www.bergsskolan.se

[1)] Civil Engineering with specialisation in Mining and Geotechnical Engineering.

[2)] Some courses offered in environmental geology and geotechnical engineering.

[3)] Masters programme in infrastructure and environmental engineering.

[4)] Metallurgy courses offered as part of Engineering Materials Science programme.

[5)] Bergsskolan is part of Luleå University of Technology since 2012.

4.2.3.23 UNITED KINGDOM

UNIVERSITY	LOCATION	GEOSCIENCE	MINING TECHNOLOGY	MINERAL PROCESSING	METALLURGY	ENVIRONMENTAL ENGINEERING	RECYCLING	SOURCE(S)
Cardiff University	Cardiff	A	-	-	-	-	-	http://www.cardiff.ac.uk/
Imperial College/ Royal School of Mines	London	A	C[3]	C[3]	-[5]	C[4]	-	www3.imperial.ac.uk
University of Edinburgh	Edinburgh	A	-	-	-	A	-	www.ed.ac.uk

University of Exeter / Camborne School of Mines	Penryn	A[1]	A	C[2]	-	A[6]	-	www.exeter.ac.uk
University of Leeds	Leeds	A	C	-	-	A	-	www.leeds.ac.uk
University of Manchester	Manchester	A	-	-	-	A	-	www.manchester.ac.uk
University of Sheffield	Sheffield	-	C[7]	-	A	C[8]	-	www.sheffield.ac.uk

[1)] Camborne School of Mines (University of Exeter) offers 3 geology degree programmes: Bachelor and Master in "Applied Geology", "Engineering Geology and Geotechnics", "Geology".

[2)] Offered e.g. as year 4 courses in the Geology Master's programme.

[3)] Mineral processing and mining engineering offered on a single course basis within the 3 year Bachelor and 4 year Master programme in Geology.

[4)] Offered as part of other programmes such as the Geology and Chemical Engineering programmes.

[5)] Former activities in metallurgy as part of the Royal School of Mines. Has in the present day transformed into standard material science and metals processing.

[6)] MEng programme in Civil and Environmental Engineering, BSc and MSc in Environmental Science.

[7)] Civil engineering programme contains courses in rock mechanics and geo-environmental engineering.

[8)] Some courses available in environmental engineering applicable in mining industry.

5 EDUCATIONAL DEMAND

As has been pointed out in previous reports (Cilliers et al, 2013), the demand side for skilled professionals within the raw material sector is difficult to estimate. This is mainly because relevant statistics is largely missing. To the extent such information exists, e.g. current and future labour needs as estimated by companies, it is typically considered as a trade secret

and kept confidential. Attempts to use various proxies for labour demand have been made, for instance by linking the need for skilled workers to the mineral production quantity or growth by region. While this allows certain regional comparisons to be made, it tells very little about the relationship between supply and demand as well as the potential lack of special skills amongst educated professionals within the sector.

A quantitative estimate of the labour supply-demand relationship as utilised by Cilliers et al (2013) is based on tracking the fraction of undergraduate students within relevant education fields ending up in the raw materials industry. A high fraction would indicate a high demand relative to the supply of students, while a low fraction would indicate that the supply of graduates is higher than the demand. Although this information could serve as a quantitative proxy for skill shortage, any conclusions need to be drawn with care. For instance, students may well end up in high-level jobs relevant to their education; within academia, authorities, NGOs, consultancies or other branches of industry.

One possibility is to assume that the number of study places offered by educational institutions is linked to the demand of such professionals as estimated by the civil society. Thus, considering a ratio of new study applications and the number of study places offered, a lower number of applications would indicate a supply-demand imbalance. This imbalance could be further exacerbated by universities accepting students with a weaker background and, consequently, deteriorating the quality of educational attainment or competence in the field.

Additional factors indicating high demand for skills and competence could include the existence of close and intensive collaboration between industry and academia, heavy sponsoring of research by industry, existence of industry-education collaboration within continuing education (study flexibility). Increased activity on the international level by the institution or study program, e.g. indicated by interuniversity collaborations, availability of courses and study programmes in other than the local languages, joint programmes with other universities, could also be seen as a measure of education quality.

6 CONCLUSIONS

6.1 Evaluation of available study programmes

The conducted survey on existing university study programmes has revealed that the most comprehensive educational institutions can be found in the regions having a strong mining industry and/or a long standing history in mining related education. These institutions not only have established study programmes, but also have the necessary skilled teaching personnel. Furthermore, the close collaboration with the local industry provides the background for research and justifies research funding.

The most relevant players in the North and Baltic Sea region with a broad range of competences are Aalto University (Finland), University of Oulu (Finland), Luleå University of Technology (Sweden) as well as RWTH Aachen and TU BAF Freiberg (Germany). All these institutions are closely linked to industry and take part in international educational programmes. Ireland, which is dominating in e.g. zinc production in Europe, is an exception not having any educational institution strongly focused on mineral raw materials.

In the Eastern Europe region particularly the AGH University of Science and Technology and Silesian University of Technology (Poland), the Technical University of Ostrava (Czech Republic), Technical University of Košice (Slovakia) and University of Miskolc (Hungary) have to be named. In the region comprising the Iberian Peninsula and Mediterranean the University of Porto (Portugal) is having the most complete study offer.

Based on the mapping of educational offers, there appears to be a surplus of geoscience-related educations in Europe. Although some countries suffer from low student intake to these educations in comparison to domestic needs in these academic fields, the supply-demand situation is in balance in Europe as a whole. It also has to be noted that most geoscience educations are not focused towards mineral exploration and extractive industries. Several countries have an overproduction of geologists, while others have severe shortages. As other EU reports have pointed out, lack of workforce mobility is still a problem in the EU (European Commission: Geographical and Labour Market Mobility Report, 2010).

Several Member States appear to be lacking in recycling-related study programmes. This is especially the case in some countries of Eastern Europe, but also in the North Sea and Iberian peninsula/Mediterranean regions. The reasons and consequences of this need to be scrutinised in the further work within the project, to explore the feasibility of constructing study programmes with emphasis topics related to recycling, secondary raw materials or eco-efficient manufacturing.

6.2 Strategies for mitigating skill shortages

The second stage of the COBALT activities on skill shortages will be devoted to constructing syllabi and plan training courses to bridge existing knowledge gaps and skill shortages identified during the mapping phase. The approach is twofold. Partly the outcome of the supply-demand analysis of raw material-related education is utilised in directing efforts towards the most critical shortages. This work is combined with exploring the literature for past experiences of alternative education strategies within the raw materials sector.

The following sections initially summarise and explain suitable strategies that have been identified during the course of the project as well as from findings from the literature survey of alternative educational schemes and their link to the identified skill gaps. Hence, these sections provide recommendations for the construction of training offers within the COBALT framework.

6.2.1 Development of full study course lists and syllabi

In cases where study programmes related to the production of mineral raw materials do not exist at all or have been cut down in the past, the development of new or revised syllabi for entire study programmes can be necessary. Even for regions without own mining industry competences and skills in mineral production will be required in order to implement national mineral strategies for securing the supply in the global context. The programmes should be oriented towards a more holistic approach that, besides teaching pure technical subjects, also considers the economic, social and environmental aspects of the entire value chain. Such up-to-date study programmes that educate tomorrow's mineral resource managers have been launched for example in Japan (Shibayama, 2013). With respect to full study programme development, the outcome of the project work will be limited to the design of draft syllabi, based on the skill issues identified in the various regions and value chain categories.

6.2.2 Development of single training courses

Branch organisations and expert networks such as ERA-MIN (Vidal et al, 2013) have already identified the need for specialist and generalist training courses, which are designed to respond to particular skill shortages of the different stakeholder groups. The development of such specifically tailored courses should consider the following aspects:

- To enhance understanding of technological, economic and environmental issues and their interrelations along the value chain, suitable overview courses for laymen should be provided. These courses should enable the necessary societal dialogues around mineral raw materials. They should for instance target managers within government organisations and public authorities, politicians, and representatives from NGOs.
- For professionals working in industry branches that depend on mineral resource supply and recycling of secondary materials more specialist training courses are needed. This can for example refer to certain minerals or commodities, certain extraction or processing technologies, or to the environmental impact from mining and processing.

The format of this type of courses will rather be short courses which are taught in a compressed schedule, i.e. courses of single or multiple days, or several block modules. Within Nordic countries also internet-based distance learning has proven to be a successful concept.

6.2.3 Development of transformational studies

Transformational studies in this context are defined as the education of a trained person within one discipline, to becoming proficient in another discipline. In raw material-related

education, this could for instance entail training a generalist chemical, civil or mechanical engineer into the specific processes of mining or mineral processing. This could for example be applied for building upon a B.Sc. engineering degree into a specific mining-related M.Sc. degree. It could also include various fast-track or intensive-training schemes aimed at developing supplementary skills identified as needed amongst university graduates or industry professionals, i.e. continuing education type programmes or courses.

There is a recently documented attempt to construct fast-track curricula for mixed-background engineering B.Sc. graduates to quickly gain knowledge and experience comparable with that of a M.Sc. within mineral processing, making them capable of working within the mineral processing sector. Ahonen and Heiskanen (2012) reported their experiences of a pilot test of such an approach. In general the experiences were positive with learning goals mostly being fulfilled. However, the high demands on the students to quickly gain knowledge and develop new skills were reported to also cause mental stress and motivational problems, resulting in friction both between students, and between students and teachers. This was despite the high standards of the selection process (possible due to the high number of applicants to the programme relative to the number of places: 12 accepted students of 150 applicants), that allowed the organisers to only select the best and most qualified students. The introduction of the students to the labour market proved very successful with all of them quickly finding relevant positions within mining industry (67%), related engineering companies (25%) and academia (8%).

The type of transformational study programmes described above can prove to be useful in mitigating local or regional skill shortages amongst professionals that want to strengthen their competence for the industry they are working within, or in regions where educational supply cannot keep up with the demands by industry. Especially given the fact that the typical education time of an engineer is in the order of 4-5 years, the educational system within most disciplines is unable to respond sufficiently quickly to labour market changes and increasing or decreasing workforce needs. Short 1-2 year transformational programmes could therefore potentially be a means to fast-track workforce supply to industry or business needs. Problematic issues related to transformational study programme could include the high demands put on students and teachers, the fact that these programme structures go outside most national education funding structures, and that the programmes due to their intensive nature ties up a relatively large amount of teaching resources on a per-student basis. In many regions where companies are able to provide internal workforce training, or where there is an infrastructure with competent training providers offering short specialist training courses, this form of programmes might be redundant. It is the aim of the continued efforts within COBALT to look further in detail at this form of programmes and conclude whether or not there is a need to develop more formalised approaches to this type of education.

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8 APPENDICES

8.1 Template for questionnaire

8.1.1 Part I, Educational programmes

Name of the study program	
Type of study program	• BSc • MSc • Other (technician)
Area of study program	• Applied geology • Mining Engineering • Mineral Processing • Metallurgical Processing • Environmental technology • Other, e.g. Chemical Engineering /Process Engineering /Recycling technology/Material sciences
Name of the institution	TEXT
Type of the institution	• Technical University • University • University of applied Sciences • Other (technical, vocational)
City	TEXT
Country	TEXT
COBALT region	• North sea and Baltic • Iberian peninsula and Med • Eastern Europe
Homepage of program	TEXT
Linked to scientific research	• No own research • Own research • Researcher education (third cycle)

8.1.2 Part II, Programme details

Name of the study program	
Number of students	NUMBER
Number of staff	NUMBER
Contact person	TEXT
Number of places per year	NUMBER
Number of new students in 2012	NUMBER
Number of graduates in 2012	NUMBER
Percentage of female	NUMBER
Single courses/program open to continuing education	• Yes • No
Transformational studies for other disciplines	• Yes • No
Duration (regular study time)	NUMBER
ECTS	NUMBER
Language of the program	• Language of the country • English
Courses in English	• None • Single • Almost all • All
List of relevant courses	TEXT
Erasmus University	• Yes • No
Industrial partners/sponsors	TEXT
Vocational fields addressed	• Industry – Extraction incl exploration • Industry – Processing • Industry – Manufacturing • Science and research • Authorities • Other stakeholders
Comments	TEXT

8.1.3 Focus regions within the EU

North and Baltic sea	Iberian peninsula and Med	Eastern Europe
UK	**Portugal**	**Poland**
Ireland	**Spain**	Czech Rep
France	Italy	**Slovakia**
Belgium	Greece	Austria
Netherlands	Malta	**Hungary**
Germany	Cyprus	**Bulgaria**
Denmark		**Rumania**
Sweden		Slovenia
Finland		Croatia
Estonia		
Latvia		
Lithuania		
Luxembourg		

Bold-marked countries are mentioned in the project DOW.

8.2 Examples of survey questionnaires

8.2.1 B.Sc. in Geology and Mineralogy, Åbo Akademi University

Part I, Educational programmes

Name of the study program	B.Sc. in Geology and Mineralogy
Type of study program	• **BSc** • MSc • Other (technician)
Area of study program	• **Applied geology** • Mining Engineering • Mineral Processing • Metallurgical Processing • Environmental technology • Other, e.g. Chemical Engineering /Process Engineering /Recycling technology/Material sciences
Name of the institution	**Åbo Akademi University**
Type of the institution	• Technical University • **University** • University of applied Sciences • Other (technical, vocational)
City	**Turku**
Country	**Finland**
COBALT region	• **North sea and Baltic** • Iberian peninsula and Med • Eastern Europe
Homepage of program	www.abo.fi/institution/geologi
Linked to scientific research	• No own research • Own research • **Researcher education (third cycle)**

Part II, Institution and programme details

Name of the study program	B.Sc. in Geology and Mineralogy
Number of students (institution)	6000
Number of staff (institution)	1000
Contact person	Peter Österholm
Number of places per year	17
Number of new students in 2012	17
Number of graduates in 2012	3
Percentage of female	49%
Single courses/program open to continuing education	• Yes • No • **Unknown**
Transformational studies for other disciplines	• Yes • **No**
Duration (regular study time)	3 years
ECTS	180 ECTS
Language of the program	• **Language of the country** • English
Courses in English	• None • **Single** • Almost all • All
List of relevant courses	http://web.abo.fi/studiehandbok/natvet/2013-2014/Examensstruktur/Geologi.pdf
Erasmus University	• **Yes** • No
Industrial partners/sponsors	**Unknown**
Vocational fields addressed	• **Industry – Extraction incl exploration** • Industry – Processing • Industry – Manufacturing • **Science and research** • Authorities • Other stakeholders

Comments	New students 2012 has been confirmed, but fraction females, places and graduates have been approximated

8.2.2 M.Sc. in Mineral Processing and Recycling, Technical University of Ostrava

Part I, Educational programmes

Name of the study program	M.Sc. in Mineral Processing and Recycling
Type of study program	• BSc • **MSc** • Other (technician)
Area of study program	• Applied geology • Mining Engineering • **Mineral Processing** • Metallurgical Processing • Environmental technology • **Other**, e.g. Chemical Engineering /Process Engineering /Recycling technology/Material sciences
Name of the institution	**Technical University of Ostrava**
Type of the institution	• **Technical University** • University • University of applied Sciences • Other (technical, vocational)
City	**Ostrava**
Country	**Czech republic**
COBALT region	• North sea and Baltic • Iberian peninsula and Med • **Eastern Europe**
Homepage of program	www.vsb.cz
Linked to scientific research	• No own research • Own research • **Researcher education (third cycle)**

Part II, Institution and programme details

Name of the study program	M.Sc. in Mineral Processing and Recycling
Number of students (institution)	22000
Number of staff (institution)	2900
Contact person	František Tichánek
Number of places per year	Unknown
Number of new students in 2012	Unknown
Number of graduates in 2012	Unknown
Percentage of female	Unknown
Single courses/program open to continuing education	• Yes • No • **Unknown**
Transformational studies for other disciplines	• Yes • **No**
Duration (regular study time)	2 years
ECTS	120 ECTS
Language of the program	• **Language of the country** • English
Courses in English	• None • **Single** • Almost all • All
List of relevant courses	Machinery and equipment in processing plants Non-metallic raw materials treatment (conversion) technology Waste management Rock and soil mechanics Polymer recycling, Recycling of nonmetallics, Coal treatment Technology of Ores Treatment Metallurgy technology fundamentals, Recycling of Metallic and Metalliferrous wastes Wastes deposition and disposal

Erasmus University	• **Yes** • No
Industrial partners/sponsors	**Unknown**
Vocational fields addressed	• Industry – Extraction incl exploration • **Industry – Processing** • Industry – Manufacturing • **Science and research** • Authorities • Other stakeholders
Comments	No published information found on number of students, graduates, etc.