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Workshop on
"Opportunities and Challenges for the Classification & Reporting of Anthropogenic Resources"

6/7 October 2016
Geological and Geophysical Institute of Hungary (MFGI)
Hungary, Budapest

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Opportunities and Challenges for the Classification & Reporting of Anthropogenic Resources.

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Geological and Geophysical Institute of Hungary (MFGI)
14 Stefania út
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Hungary

Workshop Programme Committee

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1.0	2016/09/13	First release for review	U. Kral, M. Simoni
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3.0	2016/11/15	Final version	U. Kral, M. Simoni

Content

Workshop Outline

The 1st workshop of the COST Action MINEA "Mining the European Anthroposphere" Working Group 4 (WG4) on "Classification of anthropogenic resources" will investigate whether and how existing classification systems for primary resources can be adapted - or complemented - to accommodate anthropogenic resources.

During the first part of the workshop an overview over existing resource classification systems and codes will be compiled, in order to identify shortcomings and challenges concerning the expansion to/integration of secondary resources. The evaluation of the CRIRSCO code family provides an introduction to the most commonly used reporting codes and standards for primary resource classification for minerals. The UNFC-2009 Framework illustrates on-going bridging activities between different reporting codes. UNFC (United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources) uses a three-dimensional system to classify projects based on criteria which are attributed along three axes: Economic and commercial viability, field project status and feasibility, and geological knowledge.

The second part of the workshop will identify the key criteria commonly used for the classification of primary resources, based on the requirements of government and industry. Geodata standards and models are equally important and serve as a basis for the development of a common ontology for primary and anthropogenic resources; practical aspects of resource data storage, information exchange and web service developments are closely linked to this.
The third part will focus on secondary resources, and will include an introduction to current waste codes as well as the conflicts of having both valuable and harmful substances in waste. In addition, material flow analysis and technological developments are a matter of discussion for assessing the availability and recoverability of secondary mineral resources in general. Examples for the recovery of resources from the Anthroposphere give an insight into some of the key challenges.

All presentations serve as basis for discussions with the goal how we can develop a common understanding, nomenclature and methodology for mapping different anthropogenic resources.

Workshop Programme

6. October 2016

N°	Time	Duration	Topic	Facilitator / Presenter	Abstract on page
	08:15	30'	Working Group Meeting	S. Heuss	
	09:45	15'	Official registration and welcome coffee	MFGI	
1	**Resource classification systems and codes (plenary session, starting point)**				
	10:00	15'	Welcome and introduction of the speakers	G. Turczi S. Heuss	
	10:15	45'	Classification according to UNFC	S. Heiberg	17
	11:00	60'	Plenary discussion: Bridging between the reporting codes and the classification framework	S. Heuss-Aßbichler	-
	12:00	*60*'	***Lunch***		
2	**Classification of primary resources**				
	13:00	15'	Geological Survey perspective and requirements: results of the EGS Survey	Z. Horváth	17
	13:15	7'	Harmonization of primary resources - example of the Hungarian mineral resource inventory *FOCUS: government reporting*	K. Sari	19
	13:22	7'	Government Mineral Inventories and Reporting: The Geological Survey Perspective. *FOCUS: government reporting*	M. Simoni	20
	13:30	30'	Procedures to Report Mineral Resources and Reserves to Support Mining Investment *FOCUS: industry reporting*	M. Howson	21
	14:00	30'	CGI - geostandards - EarthResourceML and GeoSciML with related vocabularies. *FOCUS: data storage, exchange and services*	J. Vuollo	22
	14:30	30'	Plenary discussion: Lessons learnt from the reporting of primary resources.	S. Heuss-Aßbichler	-
	15:00	***15'***	***Coffee break***		
	Analysis of secondary resources				
3	15:15	30'	A paradigmatic case of proper sequential utilization of primary and secondary resources by a mineral-based industry.	R. García-Tenorio	23
	15:45	15'	End-of-waste in the United Kingdom	J. Stegemann	24
	16:00	15'	Closed Mining Waste Facilities in the service of the Potential Assessment of Secondary Mineral Raw Materials in Hungary	C. Vígh	25
	16:15	30'	System of Environmental-Economic Accounting (SEEA): methodology, application, implications and case studies	J. Hilton	26
	16:45	***15'***	***Snack & Juice***		
4	17:00	30'	Systems analysis of the anthropogenic metabolism as a first step to integrate primary and secondary resource classification	D. B. Müller	27
	17:30	30'	Summary discussion: Key challenges of a reporting system for secondary resources.	S. Heuss-Aßbichler	-
	18:00		**End**		

7. October 2016

N°	Time	Duration	Topic	Facilitator / Presenter	Abstract on page
1	08:30	15’	Summary of the first workshop day, designation and goals of the first Workshop of WG 4	S. Heuss-Aßbichler	
2	08:45	30’	Keynote: The EU raw materials policy perspective	D. Wittmer	
3	09:15	30’	Plenary discussion: meeting the EU expectations	M. Simoni	
4	09:45	60’	Round table discussion part 1: What are the key requirements, definitions, and system boundaries for secondary resource classification?	U. Kral S. Heuss-Aßbichler J. Hilton M. Simoni	
	10:45	***15’***	***Coffee break***		
5	11:00	60’	Round table discussion part 2: How to develop secondary resource classification to meet the key challenges (what is missing, methods, model systems, visions - results to be reported)?	U. Kral S. Heuss-Aßbichler J. Hilton M. Simoni	
6	12:00	30’	Summary of the discussions - result presentations and draft recommendations for the development of a classification of anthropogenic resources	U. Kral S. Heuss-Aßbichler J. Hilton M. Simoni	
7	12:30	30’	Next steps and outreach activities	U. Kral	
	13:00		***End of official meeting***		
	13:00	90’	Voluntary collective lunch and/or visit of the palace of geology		

Biographies

(in alphabetical order without titles)

García-Tenorio, Rafael [University of Seville, Spain]

Rafael García-Tenorio is Professor in Applied Physics and Head of the Research group "Applied Nuclear Physics" at the University of Seville.
He is author and co-author of more than 150 papers in peer-reviewed journals, supervisor of a dozen of PhD thesis, and project leader in national and European projects since the 5th Framework Programme.
During the last years he has specialized in studies and research related with NORM (Naturally OCCURRING RADOACTIVE MATERIAL) in mining and industrial processes, with special efforts in the valorization of mineral residues and by-products. Rafael has been acting as an IAEA consultant in the preparation of several Safety guides related with NORM activities.

Hallberg, Anders [Geological Survey of Sweden, Sweden]

Anders Hallberg is a senior economic geologist at the Geological Survey of Sweden (SGU). He graduated from Stockholm University and holds a PhD in economic geology from Uppsala University.
His career started with working ten years for SGU's Mineral Resources Information Office in Malå, Northern Sweden, where the rapidly growing exploration industry had an enormous need for new geological information. The work involved extensive data collection and compilation, which contributed to building the first national Swedish mineral resources database, as well as the development of the international Fennoscandian Ore Deposit Database.
After ten years in the North Anders now lives with his family in a small historic mining village north of SGU's head office in Uppsala. Here, he continues his work with mineral information, mining statistics, and publishing in Economic Geology, while intermittently working as a consultant for the mining and exploration industry. Recently his focus has expanded into information management and statistics on mining waste, both in national and international projects.

Heiberg, Sigurd [Petronavit a.s, Norway]

Sigurd Heiberg is the chairperson of Petronavit a.s, focusing on geological resources, including energy resources.
Sigurd has spent most of his working life in Government and industry working on petroleum resources management and strategy.
He chaired the Oil and gas reserves committee of the Society of Petroleum Engineers (2000-2001), the UNECE Expert Group on Resource Classification (2002-2009) and the Bureau of the UNECE Intergovernmental Committee on Sustainable Energy (2010-2012). He is a member of the Steering Committee of the EU project on Statistical Information on EU Raw Materials Deposits.
Sigurd has engaged in education by helping the NPD build PETRAD. He has been a lecturer at the MIT Sloan Executive Education and at the University of Stavanger. He was a guest editor with MIT Professor Donald Roy Lessard of "Innovation in oil and gas through partnering", a special volume of Energy Strategy Reviews.
Sigurd holds a BSc (Magna cum laude) degree from the University of California, Los Angeles '67, and a SM degree from the Massachusetts Institute of Technology '69. He has received formal management training at IMD (International Management in 1981 and High Performance Boards in 2011).

Heuss-Aßbichler, Soraya [Ludwig-Maximilian Universität München, Germany]

Dr. Soraya Heuss-Aßbichler is professor for mineralogy at the Department for Earth and Environmental Sciences of Ludwig-Maximilians Universität in Munich, Germany. Since 1999, her research is focused on Environmental Mineralogy. She has various EU and national research projects in collaboration with industrial partners and research centers in the field of waste-to-energy (WTE) plants, with a special focus on understanding physical, chemical and mineralogical processes in municipal solid waste incineration (MSWI) residues, including their environmental risks and potentials as secondary resource. She is also head of a research group with the research aim to develop a comprehensive technology to recover heavy metals from wastewater and so to avoid the dissipation of valuable elements. Focal point is to produce industrially interesting products. These studies enclose requirements for material flow and stock analysis of the secondary resources. The projects are performed in close collaboration with industry partners and Environmental Authorities. She was from 2003 – 2011 visiting professor for environmental mineralogy at University Salzburg, Austria. Since 2001 is she member of the working group PHOENIX, a task group of IWWG.
Soraya is leader of the Working Group 4 "Resource Classification" within the scope of the COST action MINEA.

Hilton, Julian [Aleff Group, United Kingdom]

Dr. Julian Hilton is Chairman of the Aleff Group, leading its section for NORM industry projects. His particular interest is the transformation of secondary resources such as tailings and residues (e.g., red mud and phosphogypsum) into commercially viable products as part of a wider "zero waste" sustainable development strategy.
He is currently project lead on a major phosphate mine tailings remediation project in Jordan and on a project for residue management and use in a major industrial city in Saudi Arabia, concerning aluminium, copper, iron/steel, phosphate and zinc residues. He led the consulting team that developed the IAEA Safety Report on the Phosphate Industry (2013). Since 2009 he has participated in numerous IAEA Expert Missions on uranium, phosphates and rare earths and leads a related IAEA Expert Working Group.
Julian is a member of the Technical Committee of the International Fertilizer Industry Association (IFA) and co-Convenor of its NORM & Phosphogypsum Working Group, recently responsible for the IFA Report on the Sustainable Management and Use of Phosphogypsum (2016). He is a member of the UNECE Expert Group on Resource Classification (EGRC), and serves on the EGRC Sustainability Working Group.

Horváth, Zoltán [Geological and Geophysical Institute of Hungary, Hungary]

Dr. Zoltán Horváth is a geologist and soil-engineer, expert on general geology, mineral resources management and non-metallic solid mineral raw materials. He is the head of the Department of Earth Resources in the Geological and Geophysical Institute of Hungary (MFGI).
He worked on the startup of the environmental impact assessments related to domestic hydrocarbon concessions. In the last five years the main work profile is the assessment of the potential of non-metallic solid minerals including the development of methodology to analyse the access to minerals, as well as the mapping and harmonization between national mineral resources inventories and the international mineral resource classification (UNFC-2009) and reporting systems (CRIRSCO, JORC, PERC).
As a work package leader he was involved in the SNAP SEE project that dealt with sustainable aggregates planning in South East Europe (regulatory framework, multi-sectoral analysis, guidance, joint vision, stakeholder consultations). He is involved as a work package leader in the MINATURA 2020 project aiming at the development of the concept of Mineral Deposits of Public Importance.
Zoltán is an active member of the Mineral Resources Expert Group of the EuroGeoSurveys, the international project of the UNECE Expert Group of Resource Classification, and the Hungarian Geological Society.

Howson, Mark [Pan-European Reserves and Resources Reporting Committee, UK]

Mark Howson is a Mining Geologist specializing in the development, estimation, classification and extraction of mineral resources. He is secretary of the Pan-European Reserves and Resources Reporting Committee (PERC), a member of CRIRSCO, the Committee for Mineral Reserves International Reporting Standards.

Since graduating in Mining Geology at Imperial College of Science and Technology, London in 1977, Mark started his career at Nchanga copper mines in Zambia and was employed by Rio Tinto for 31 years. Now, with his consultancy company Mineral Resources Professional Limited, he assists mining companies to introduce and apply new best-practice procedures and technologies, and in due diligence for acquisitions and divestments.

He has worked at about 50 operations in 25 countries in 6 continents with mineral products including copper, gold, talc, lithium, borates, nickel, PGMs, cobalt, diamonds, trona, vermiculite, ilmenite, uranium, silver, potash, tin, coal, lead and zinc. These include projects and mines ranging from large and profitable to small and marginal, open pit and underground, from exploration to production.

Mark is an Associate of the Royal School of Mines (ARSM), a Member of the Institute of Materials, Minerals and Mining (MIMMM), a Chartered Engineer (CEng) and a Fellow of the Geological Society of London (FGS).

Kral, Ulrich [Technische Universität Wien, Austria]

Educated in Austria (doctoral degree in technical sciences, Vienna University of Technology), Dr. Kral holds a post-doc position at the Institute for Water Quality, Resources and Waste Management at Vienna University of Technology. His research focuses on the life cycle of materials in the anthroposphere, in particular on methodologies to analyse, evaluate and manage material stocks and flows. His PhD thesis focused on an indicator to assess material flows that leave the anthropogenic material cycle into regional sinks. The indicator provides guidance to manage material flows with respect to available sink capacities and allows benchmarks between different regions. Since PhD graduation, his focus is also on the assessment of anthropogenic material stocks in infrastructure assets.

He chairs the COST Action “Mining the European Anthroposphere”.

Müller, Daniel [Norwegian University of Science and Technology, Norway]

Daniel B. Müller is professor in industrial ecology and director of the International MSc Programme in Industrial Ecology at the Norwegian University of Science and Technology (NTNU).
He received a M.Sc. in rural engineering and a Ph.D. in technical sciences from ETH Zurich. Prior to his appointment at NTNU, he was a post-doc at TU Delft and an associate research scientist at Yale University. In 2014, he was a visiting professor at the Chinese Academy of Sciences (CAS). He has served on a variety of committees and institutions, such as the U.S. National Research Council, the Swiss National Research Programme, and The Intergovernmental Panel on Climate Change (IPCC), where he was a lead author of the Fifth Assessment Report, WG III (Mitigation).
Daniel is a council member of the International Society for Industrial Ecology (ISIE), and was the founding chair of ISIE's section "Material Flow Analysis – ConAccount" (today "Socio-Economic Metabolism"). His main research interests evolve around the understanding of the socio-economic metabolism to enable high qualities in built and natural environments.

Müller, Sandra [Swiss Federal Laboratories for Materials Science and Technology, CH]

Sandra Mueller holds an MSc in Environmental Monitoring and Assessment from the University of Southampton, UK. Her Master dissertation was completed in collaboration with the Swiss Federal Laboratories for Materials Science and Technology (EMPA), for which she was developing a geological reconnaissance of End-of-Life (EoL) products as a source for rare earth elements. This reconnaissance involved applying the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC-2009). In particular, she evaluated the geological characteristics of three EoL products in comparison to an operating geological mine.
Currently, she is completing her PhD research, where she is developing an early-stage project evaluation framework for EoL products and the Earth's crust with particular focus on integrating the UNFC-2009 criteria. This research is conducted in collaboration between the University of Southampton and EMPA. Prior to this, she was a research associate at both EMPA and the University of Applied Sciences and Arts of Northwestern Switzerland in the fields of material flow management and cleaner production. There she developed an environmental accounting tool for a evaluating the material and waste costs of a raw material processing enterprise.

Sári, Katalin [Geological and Geophysical Institute of Hungary, Hungary]

Katalin Sári is a Hungarian earth scientist and graduated from the University of Debrecen with a bachelor's degree in 2009 and from the University of Szeged with a master's degree in 2012. She obtained a qualification of English-Hungarian special translator in natural sciences in 2015 at the University of Debrecen.
Since 2012 she works for the Geological and Geophysical Institute of Hungary at the Department of Earth Resources, where she deals mainly with mineral potential and mineral resource classification. She participates in a project aiming to align the Hungarian mineral resource inventory to international mineral resource reporting and classification standards.

Schebek, Liselotte [Technische Universität Darmstadt, Germany]

Prof. Dr. rer. nat. Liselotte Schebek is the head of the Chair of Material Flow Management and Resource Economy at the Technische Universität Darmstadt in Germany, and since 2016 of the division Recycling and Reusable Material Cycles of the Fraunhofer Project Group Materials Recycling and Resource Strategies at the location of Alzenau.
Up to 2012 she was the head of the central department of technology-induced material flows at the Karlsruhe Institute of Technology KIT.
Her research interests focus on: closed substance cycles and resource management - including Urban Mining -, energy technologies and systems as well as the material and energetic use of biomass. Employed methods and tools for the system analysis are notably the material flow analysis (MFA), life cycle assessments (LCA), and scenario techniques. The latest research project in the field of Urban Mining investigated the inventories of non-residential buildings, focussing on existing materials in the Rhine-Main area. Furthermore, it analysed the dynamics of the demolition of the existing stock of buildings by combining spatial and building related information that can be used to estimate the flows of secondary resources like metals, concrete, masonry, brick and tiles out of the building stock.

Simoni, Mark [The Geological Survey of Norway, Norway]

Mark Simoni is a researcher in the Georesources Division at the Geological Survey of Norway, NGU. He holds a master's degree in Earth Science from the Swiss Federal Institute of Technology, ETH Zurich.
His field of expertise is mineral resource geology, data harmonization and resource classification with special focus on the mapping, safeguarding and supply of natural construction materials for urban and infrastructure development.
His experience includes working for the Swiss Geotechnical Commission SGTK (the national agency for research on Swiss mineral resources) and the Swiss Geological Survey, swisstopo. He has coordinated research collaboration projects with industry and national and cantonal authorities in Switzerland, both on primary and secondary raw materials. Mark is the Norwegian representative for the Mineral Resources Cluster of the INSPIRE Data Specification Group, and a Norwegian member of the Management Committee of the COST MINEA Action.

Stegemann, Julia [University College London, United Kingdom]

Professor Julia Stegemann is Director of the Centre for Resource Efficiency & the Environment, in Civil, Environmental & Geomatic Engineering at University College London, and also Co-Director of CircEL, a UCL-wide research hub for the circular economy.
Her research is on sustainable technologies, and regulations, policy and other systems, to enable return of wastes to the resource loop, and achievement of "end-of-waste" status.
She studies industrial wastes to understand physical, chemical and biological processes of accumulation and transformation of contaminants, in relation to waste prevention, treatment and utilisation. Much of her work is in collaboration with industry, and includes laboratory characterisation of materials, development of technologies and test methods, preparation of regulatory guidance documents, evaluation of technologies at field scale, and databases and computer modelling.
Julia has a Bachelor's (1984) and a Master's (1992) degree in Chemical Engineering from McMaster University and a PhD from Imperial College London (2001), as well as >30y of research experience gained also at Oxford University, Karlsruhe Institute of Technology, and Environment Canada. She is author of more than 150 publications (WoS H-index = 14), is European Editor of Environmental Engineering Science, and has been on the scientific/organising committee of 14 international conferences.

Vígh, Csaba [Geological and Geophysical Institute of Hungary, Hungary]

Csaba Vígh graduated from the Eötvös Loránd University, Budapest, with Master of Science in Geology in 2011.
His interest in petrology and geochemistry led him to continue his research as PhD student. Since 2015 he has been working at the Geological and Geophysical Institute of Hungary. Currently he is participating in the survey of non-metallic mineral potential of Hungary and the resource potential of mining waste.

Vuollo, Jouni [Geological Survey of Finland, Finland]

Dr. Jouni Vuollo has 20 years of experience in geological data management at Oulu University and the Geological Survey of Finland (GTK). He is currently Head of the Unit for Regional Geology and Interpretation at GTK. Jouni has been involved in the GeoSciML Standards Working Group of the International Union of Geological Sciences (IUGS) Commission for the Management and Application of Geoscience Information (CGI) since 2008, as a GTK delegate. In 2010, he became a member of the Thematic Working Group 'Geology & Mineral Resources' for the development of the European Union's INSPIRE data specifications. Jouni joined the CGI EarthResourceML Working Group in 2010 and has been Chair of the working group since 2012.

Winterstetter, Andrea [Technische Universität Wien, Austria]

Andrea Winterstetter holds a bachelor's degree in "International Business" from the University of Passau (Germany) and a M.Sc. in "Environmental Technology and International Affairs" from TU Wien and the Diplomatic Academy of Vienna (Austria).
In 2016, she completed her Ph.D. thesis on the evaluation and classification of anthropogenic resources within the Christian Doppler Laboratory for "Anthropogenic Resources" at the Institute for Water Quality, Resource and Waste Management at TU Wien, Austria, where she is currently still working as a postdoctorate researcher. She is a founding member of and actively involved with the ISWA Young Professional Group. Her main fields of interests are sustainable resource and waste management strategies in a regional and global context.

Wittmer, Dominic [Joint Research Centre, Italy]

Dominic Wittmer is a Scientific Support Officer at the Sustainable Resources Directorate of DG Joint Research Centre since 2015. He is geologist by training and holds a PhD in environmental engineering (ETH Zurich).

With his PhD thesis, he investigated and characterised the development of anthropogenic copper stocks using a dynamic model. Following, he has worked as consultant in the field of environmental and geological engineering, deconstruction, brownfield sites and waste management, foundation soil analysis and near-surface geothermal energy.

Since 2007, Dominic worked from different perspectives at the science-policy interface, on national and the EU level. He contributed to various national and FP7/Horizon 2020 projects supporting raw material supply, with focus on abiotic resources, their physical accounting and the implied environmental pressures.

His main research fields are sustainable material management, mineral raw material supply, material flow analysis, environmental accounting, and environmental indicators.

Abstracts for oral presentations

(in chronological order)

Classification according to UNFC – Application to anthropogenic resources

Sigurd Heiberg, Petronavit a.s

The United Nations Framework Classification (UNFC) is a management tool to serve policy analyses, Government resources management, industrial business processes and financing. The information carrier is the "Project" and focus is on the products it recovers from the resource base.

Consequently, the classification categories address:

- The economic and social conditions for the projects (E-categories).
- The scientific, technical and project management definition and maturity of the projects (F-Categories).
- The uncertainty in the estimated quantities (G-Categories)

Estimated quantities are of three kinds:

- Quantities to be recovered as sales products addressing the income streams
- Quantities to be recovered but not sold, often addressing household economy and environmental issues
- Quantities remaining in place

The UNFC applies to mineral (including uranium and thorium) and petroleum (oil and gas) resources. The UNECE Expert Group on Resource Classification (EGRC) has prepared applications to injection projects for geological storage, to renewable resources generally and geothermal resources specifically[1].
The UNFC is formally "bridged" to other existing classification systems, notably the CRIRSCO family of classifications for mineral resources, the Petroleum Resources Management System (PRMS) of the Society of Petroleum Engineers (with associated organizations) and the Organisation of Economic Co-operation and Development (OECD) Nuclear Energy Agency (NEA)/International Atomic Energy Agency (IAEA) "Red Book" resource reporting scheme for uranium. The EGRC has prepared bridging documents of the UNFC to the 2013 oil and fuel gas classification of the Russian Federation[1] and to the Chinese classification systems for solid minerals and petroleum.
Most importantly, the UNFC quantities must be coherent with the quantities entering national statistics. It is the basis used in the UN System of Environmental-Economic Accounting 2012 Central Framework[2].

Applying F-categories of the UNFC to anthropogenic resources requires careful consideration of stocks and flows, of dealing with multiple, and alternative products from the same resource base, and of synergies between product/waste streams.
Careful consideration must also be made of the E-axis categories, and of the combination of E- and F-axis categories in defining the efficiency of the industrial ecosystem for using anthropogenic resources.

[1] UNECE Intergovernmental Committee on Sustainable Energy is considering approving these applications at its 25th Session on the 28-30th September 2016.
[2] http://unstats.un.org/unsd/envaccounting/seeaRev/SEEA_CF_Final_en.pdf

Geological Survey perspective and requirements: results of the EGS Survey

Zoltán Horváth, Geological and Geophysical Institute of Hungary (MFGI)
Katalin Sári, Geological and Geophysical Institute of Hungary (MFGI)
Mark Simoni, Geological Survey of Norway (NGU)

The European Geological Surveys Mineral Resources Expert Group (EGS MREG) operates a Task Team to streamline the harmonization of mineral resources classification and to co-operate with the UNECE Expert Group on Resource Classification (EGRC). A questionnaire was distributed to survey the EGS member country status concerning data harmonization and the legislative implementation of international and national standards. The survey includes information on the availability of inventories and datasets that can be used for determining the certainty of geological knowledge, (UNFC-G axis), economic and social viability (E) and feasibility (F) of mineral development projects. Our presentation introduces the results of this survey including different approaches and project results relating to the harmonization of mineral resources classification.
The intention for harmonization between national inventories, classification systems and international standards has increased in the last years in the raw material community. EGS Members agree that harmonization is essential for national resource management.

For solid minerals, the CRIRSCO-aligned standards (e.g. PERC, JORC) are the most widely used and accepted. Compared to the CRIRSCO standards, the United Nations Framework Classification (UNFC) is more comprehensive and more suitable to be used by governments as it covers solid and fluid resources, renewables and injection projects. UNFC may also be applicable for secondary resources, a point that was raised by the COST Management at the 7th session of the EGRC in Geneva. Both the UNFC and CRIRSCO standards can be applied at national level.

National Geological Surveys have an interest to develop a concept of harmonization and support collaboration projects. Harmonized terminology (e.g. “resources” and “reserves”) should be adopted from international standards. The harmonization of national classification systems and inventories with the UNFC system can be done by Bridging Documents provided by UNECE-EGRC.

The results of the work on primary minerals carried out by the EGS MREG Task Team, as well as some national projects, are likely to contribute to the objectives of the COST-MINEA project concerning secondary resources classification.

Harmonization of primary resources - example of the Hungarian mineral resource inventory

Katalin Sári, Geological and Geophysical Institute of Hungary (MFGI)

The Hungarian State Inventory of Minerals and Geothermal Energy maintained by the Hungarian Office for Mining and Geology consists of 5 parts (ores, coals, non-metallic minerals, hydrocarbons and geothermal energy) and the registered resources are classified according to the "Russian" classification system. Since 2013 the Hungarian Office for Mining and Geology co-operates with the Geophysical and Geological Institute of Hungary to modernize the national mineral resources inventory, which includes its harmonization with international classification systems.

During this research project several international resource classification systems have been analysed (UNFC, CRIRSCO aligned standards, SPE-PRMS, Australian Geothermal Code). For solid minerals CRIRSCO standards and the UNFC framework can be applied. With help of the UNFC Guidelines on the Alignment of the Russian minerals reporting standards, and the CRIRSCO Template with the bridging document between CRIRSCO and the UNFC classification, resources of the Hungarian inventory can be converted into CRIRSCO (PERC) and UNFC categories.

This presentation aims to demonstrate the algorithm applied when converting Hungarian resources into CRIRSCO and UNFC categories, to present the challenges and possible solutions, and to provide some case studies for solid minerals.

Government mineral inventories and reporting: The Geological Survey perspective.

Mark Simoni, Geological Survey of Norway (NGU)

To accommodate the growing human population ever more resources are needed, but the question is: just how much, and where from?

Rising economies like China and India have an insatiable hunger for energy, raw materials and arable land. By 2050, 66 % of the global population will be living in cities (UNPD, 2014), and it is estimated that "60 per cent of the built environment required to accommodate the earth's population by 2050 remains to be built" (UNEP, 2013).

This urban growth is the main driver for consumption of raw materials. While national geological surveys maintain public inventories for geological (primary) resources, anthropogenic (secondary) resources are usually not inventoried at all. Reliable estimates of future recyclable quantities (potentials for mining the anthroposphere) are still missing. This lack of information makes it difficult to anticipate the future need for mining; it is almost impossible to set reasonable national circular economy targets, unclear in what (recycling or mining?) and where to invest, and difficult to assess how and where the environmental impacts can be minimized.

National Geological Surveys are intensively working on building national mineral resource databases. They collect, harmonize, aggregate and report mineral resource information on a national level, for instance to safeguard the future availability of construction materials for urban development, to reduce environmental impacts by better use of mineral waste, and to diminish of risks of unsustainable resource exploitation.

Mineral Resource Classification is fundamental for long-term mineral resource management. Universities, industry and government can exploit synergies by collaborating on the development of a comprehensive resource information system that has the ability to integrate both primary and secondary resources. COST MINEA provides an essential building block in the strategic decision making chain: it facilitates long-term planning and safeguarding the resources for building the infrastructure, cities, and urban ecosystems of the next century.

UNPD (2014). World Urbanization Prospects: The 2014 Revision, Highlights. Population Division of the Department of Economic and Social Affairs of the United Nations. New York, United Nations, 27.

UNEP (2013). City-Level Decoupling: Urban resource flows and the governace of infrastructure transitions. A Report of the Working Group on Cities of the International Resource Panel. Swilling, M., Robinson, B., Marvin, S. and Hodson, M. Nairobi, United Nations Environment Programme, 95.

Procedures to report mineral resources and reserves to support mining investment)

Mark Howson, Pan-European Reserves and Resources Reporting Committee (PERC)

Companies that explore for, or mine, solid minerals need to demonstrate the value of their mineral assets to justify major investments to bring a product to market. Increasingly, they do so by reporting their mineral resources and reserves in accordance with one of the international CRIRSCO standards. These include the Australasian JORC, the Canadian NI 43-101 and the European PERC.

These codes and standards are all based on the same template, but differ according to the requirements of local stock exchanges, language, and with regard to guidelines for working with specific mineral products that are important in the region. Guidelines for a particular product group may assist its industry in attracting investment by applying a standard that investors are familiar with. Figures of mineral resources and reserves reported under one of these standards should be materially the same as under any other.

Basic requirements for reporting are that the mineral must be characterized and quantified with a minimum level of confidence, have reasonable prospects for eventual economic extraction, and be signed-off by one or more named Competent or Qualified Persons. These experts compile a document providing details of the supporting technical studies and data, including quality and frequency of sampling, how sample data was transferred to the large quantities reported, and how levels of confidence were assigned for resource categories.

A commitment to mining, implied by the reporting of mineral reserves, is supported by mining, processing, economic, marketing, legal environmental infrastructure, social and governmental factors. The work-flow to achieve this may be illustrated in a series of study phases with graduated investment to develop a mining operation from a mineral find, and which may also apply to extraction from mining residues.

CGI - geostandards - EarthResourceML and GeoSciML with related vocabularies.

Juoni Vuollo, Geological Survey of Finland (GTK)

EarthResourceML as well as GeoSciML are the CGI[3] community developed exchange formats for providing detailed information on earth resources including mining wastes as a secondary resource. They both have served as the basis for the INSPIRE Geology / Mineral Resource core data models. Both community standard data models will be used to extend the scope and detail of the INSPIRE core data models to address additional requirements mainly from the EU Raw Materials Initiative and the Mining Waste Directive or other EU activities.

GeoSciML is an XML–based data transfer standard for the exchange of digital geoscientific information. It accommodates the representation and description of features typically found on geological maps, as well as being extensible to other geoscience data such as drilling, sampling, and analytical results. GeoSciML provides a standard data structure for a suite of common geologic features (e.g., geologic units, structures, earth materials) and artefacts of geological investigations (e.g., boreholes, specimens, measurements). Supporting objects such as the geological timescale and vocabularies are also provided as linked resources, so that they can be used as classifiers for the primary objects in the GeoSciML standard.

EarthResourceML is an XML–based data transfer standard for the exchange of digital information for mineral occurrences, mines and mining activity. EarthResourceML describes the geological characteristics and setting of mineral occurrences, their contained commodities, and their mineral reserve, resource and endowment. It is also able to describe mines and mining activities, and production of concentrates, refined products, and waste materials.

To facilitate semantic interoperability, the use of controlled vocabularies is embedded in the data model. The resulting set of code lists and their values is based on the INSPIRE Core Data Models for Geology and Mineral Resources. For the additional vocabulary – not covered by INSPIRE - several interoperability activities and project results have been evaluated and accepted so far.

These GeoSciML and EarthResourceML geoscience data standards are endorsed across the world as the geoscientific data transfer standard and are used by various data sharing initiatives. The OneGeology project is currently demonstrating the use of GeoSciML Web Feature Services and GeoSciML-Lite Web Map Services in its portal for world-wide geological map data. The inclusion of geology and mineral resources in the European INSPIRE Directive is based on the GeoSciML and EarthResourceML work and facilitates the use of geological and mineral resource information by other thematic communities. This guarantees geoscience data interoperability among countries of the European Union. The EU-FP7 project Minerals4EU demonstrates the implementation of these global/INSPIRE geostandards to deliver mineral resource data from 17 EU national geosurveys. The Australian AuScope project is using GeoSciML to deliver borehole data from state and territory agencies, and EarthResourceML to deliver mineral resource data. The US Geoscience Information Network (USGIN) is using GeoSciML-Lite and GeoSciML to share geological data between governmental agencies, educational and private institutions. The Canadian Groundwater Information Network uses an extension of GeoSciML – GroundwaterML – to integrate water well information from multiple jurisdictions.

[3] Commission for the Management and Application of Geoscience Information (CGI) of the International Union of Geological Sciences (IUGS).

A paradigmatic case of proper sequential utilization of primary and secondary resources by a mineral-based industry.

Rafael Garcia-Tenorio, Department of Applied Physics II, University of Seville

Europe is full of industries working in different strategic sectors, and their operational procedures often involve the treatment of different minerals as raw materials/primary resources. In the context of the production process, wastes and by-products are generated. In an ample number of cases these are either accumulated/stored in big deposits or directly released to the environment, without taking into consideration a key point: the comprehensive management of resources, i.e., the mined resources should be managed in such a way that the final return is maximized and not focussed only on obtaining just the primary target commodity. This comprehensive management of resources should be supported by a comprehensive mining extraction policy: if you propose to mine at all, is better when you disturb only once.

In this presentation the production process of a paradigmatic industry devoted to the production of titanium dioxide pigments as a primary commodity is presented with special focus in to show its evolution over time and the important role of secondary resources in its economical balance. In particular, it will highlight how the amount of generated wastes was diminished through innovative ideas, and how over time new commodities with a defined market appeared after the treatment of the secondary resources.

The European industries should take this and other similar cases as examples to follow, leaving the traditional rigidity in their production processes and opening them to the treatment of the secondary resources generated during the production of the primary commodities.

End-of-waste in the United Kingdom

Julia Stegemann, University College London, UCL CircEL (The Circular Economy Lab)

Article 6 of European Directive 2008/98/EC on waste (the Waste Framework Directive) provides legal conditions for identifying when a waste material that has undergone a recovery/recycling operation has become a product and no longer needs to be regulated as a waste, in particular:

a) the substance or object is commonly used for specific purposes;
b) a market or demand exists for such a substance or object;
c) the substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products; and
d) the use of the substance or object will not lead to overall adverse environmental or human health impacts.

In all EU countries, a material can be considered to be a non-waste product if it falls under one of the EU End-of-Waste Regulations, which exist for iron, steel, aluminium and copper scrap, and glass cullet (European Commission 2016). In the UK, if a regulation does not exist, a waste can become a non-waste 1) if it complies with a "Quality Protocol" or 2) as the outcome of an individual assessment.

Quality Protocols for 13 materials have been developed jointly by the Environment Agency (EA) and the Waste and Resources Action Programme (WRAP). They are intended: *to ensure the product made from waste does not pose an unacceptable risk to human health or the environment, increase market confidence in the quality of products made from waste and their potential value*, and *encourage greater waste recycling and recovery* (Environment Agency May 2016). A waste derived material that complies with a Quality Protocol is considered a non-waste product that is no longer subject to waste controls (Environment Agency 2014).

If no Quality Protocol exists for a waste, an individual assessment must be made on the basis of the relevant case law, which presently holds that *It should be enough that the holder has converted the waste material into a distinct, marketable product, which can be used in exactly the same way as a [non-waste material], and with no worse environmental effects* (R ex parte OSS Group Ltd v EA and Department of Environment, Food and Rural Affairs 2007).

It must therefore be demonstrated that the waste has been turned into a completely new product, different from the original waste, with a genuine market. Further, the UK EA has issued a series of "material comparator" reports for non-waste fuels and materials for land application, construction or animal bedding, to provide data on physical and chemical properties, and microbiological contamination that can be used to help assess whether a candidate end-of-waste material might reasonably have similar environmental effects as non-waste materials, and whether an end-of-waste application or further processing may be appropriate (Environment Agency August 2016). A self-assessment may also be conducted using the "IsitWaste Tool". Ultimately, an individual end-of-waste case must be submitted for review by a national "Definition of Waste" panel.

Possible connection between closed mining waste facilities – potential assessment of secondary mineral raw materials and classification issues (Hungarian case study)

Csaba Vigh, Geological and Geophysical Institute of Hungary (MFGI)

In Hungary, it can be estimated that approximately 5000-6000 mining waste rock heaps and tailing ponds exist on sites that had been exploited in the past or are still active mining sites. Among them about 2000 have been surveyed based on reports of mining waste cadastres in the 1980s, and were selected according to the size of the facilities.

The Directive 2006/21/EC of the European Parliament prescribes for the Member States that closed and abandoned mining waste facilities which can cause significant environmental impacts are to be registered. An inventory including a risk-based ranking has been developed by the Hungarian Geological and Geophysical Institute, and it is available to the public via Hungarian Office for Mining and Geology. It contains more than thousand records registering the name and the coordinates of the facilities, as well as their size (area, height, volume) and their raw material contents (e.g. inert rocks, ores, bauxite residues or coal waste).

Risk-based ranking for tailings (Z1, Z2, Z3, Z4) and waste rock heaps (M1, M2, M3, M4) were established, based on their size, the topographic slope and the phase of the remediation. These categorizations may be used for the development of classification scheme for secondary resources (mainly mining waste) or those landfilled materials which have environmental impacts.

All these data are important parameters in the estimation of the potential of these resources. Heaps and tailings contains large amount of raw material that is suitable for inert constructional and building materials or valuable major/minor elements can be extracted by metallurgical/hydrometallurgical methods. The utilization of different mining waste is determined by the physical and chemical properties of the landfilled (usually mixed) material.

Currently an on-going project evaluates mining waste as secondary raw materials and updates the inventory of mining waste facilities with geochemical data other useful information regarding material contents.

System of Environmental-Economic Accounting (SEEA): methodology, application, implications and case studies

Julian Hilton, Aleff Group

Against the background international agreement to adopt the policies and principles of sustainable development, both international accounting and banking bodies are working hard to create a suitable framework for the realisation of sustainable management and use of both primary and secondary mineral resources, across their whole life-cycle.

On the accounting side, the International Accounting Standards Board (IASB) has introduced the definition of a new term, "economic resource", to capture the tangible and intangible value of "new economic resources" generated from materials such as tailings and residues on the balance sheet.

On the banking side, supported by the UN, the World Bank, European Commission, IMF, FAO and OECD have promoted the development of the System for Environmental-Economic Accounting Central Framework 2012 (SEEA) (2014) and its companion publication, the SEEA Experimental Ecosystem Accounting System (2014) to bridge between investment decision-making regarding projects using new economic resources, and accounting devices for recording project progression and performance. All these efforts trace their origins explicitly back to the publication of Our Common Future (1987) also known as the Brundtland Report.

The foundations of SEEA consist of a small number of key terms, notably "residuals", "revaluation" and "residuals release", which are tightly linked. Residuals is used to define any mineral or biological resource that has been used, but that, subject in some instances to reprocessing, can be reused, including land and water resources. The outcome of applying this definition is that many resources previously regarded as wastes with no further potential for use and hence of zero or negative value, can now be subject to revaluation as assets. This is of course not an arbitrary process or a matter of opinion, it is an evidence-based reappraisal of the value of the residual grounded in scientific, technical and economic appraisal. Hence the revaluation process can lead to a key objective of applying SEEA "residuals release". Building on that resource progression model, this presentation will propose the concept of "value release" from all secondary resources (residuals).

Value release as a concept can then be applied in two significant ways, first, to bridge to the United Nations Framework Classification (UNFC) (2009) and secondly, to respond to the resurgence of interest in the mining and processing sector in co-products and by-products (Malensek, 2016), leading to the adoption of flow-sheets based on "comprehensive extraction". When these approaches find points of convergence – as is increasingly the case – they can provide the basis of an integrated and transparent mineral resource management toolkit suited to the pursuit of the UN Sustainable Development Goals (September 2015) and policies such as the circular economy and zero waste.

Two examples will be given of how SEEA is being applied by Aleff Group to ongoing major projects for which it is responsible. (1.) Against the background of the growing emphasis on the role of co- and by-products in the financial assessment and performance reporting of mining and processing projects, the publication of the International Atomic Energy Agency Safety Report of the Phosphate Industry (SR 78) (2013), defines phosphogypsum as a co-product of wet process phosphoric acid production not as previously a "waste". This IAEA Report and its consequences for phosphogypsum use worldwide has become a benchmark for "residuals value release", illustrated by the ongoing revaluation process of phosphogypsum stacks in many markets. (2.) The procedure is applicable methodologically to secondary resources generated from both tailings and processing residues generated by a wide range of minerals industries. An example of a major phosphate tailings remediation and revaluation project in Jordan will be shown to illustrate value release from both mineral and land residuals.

Systems analysis of the anthropogenic metabolism as a first step to integrate primary and secondary resource classification

Daniel B. Müller, Norwegian University of Science and Technology (NTNU)

Neither primary nor secondary resources alone are able to satisfy the needs of a growing global population. A sustainable use of materials therefore involves that the use of different primary and secondary resources are combined and adjusted to the specific circumstances, which may vary in space and time.

This presentation aims at demonstrating that (i) a joint analysis of primary and secondary resources is not meaningful if the different characteristics of primary and secondary resources are not captured adequately, (ii) that the common and different physical characteristics of primary and secondary resources can in principle be captured using material flow analysis (MFA) as a "common language", but (iii) that this language needs to be expanded in several dimensions, physical and non-physical, and (iv) that a common systems analysis offers an opportunity to add important context for the evaluation of individual resources, and thus adding policy relevance.

Using aluminium as a case study, this presentation demonstrates how traditional MFAs can be expanded to become more relevant for different stakeholders. Important aspects include the differentiation of stock and flow resources, the analysis of the linkage of metals at different stages of their cycles, as well as the spatial and temporal resolution. The presentation includes elements of the planned H2020 project MinFuture, which is expected to start at the end of 2016.

EU raw materials policy perspective

Dominic Wittmer, European Commission Joint Research Centre (JRC)

The presentation will give an overview on the EU policy on raw materials, the European Innovation Partnership on Raw Materials, the state of play of the work to build up an EU Raw Materials Knowledge Base, the need for circular economy and the relevance of secondary raw materials, some relevant research projects funded by the Horizon 2020 programme as well as some European Commission expectations on the assessment of anthropogenic resource potentials in a European-wide perspective.
It will highlight the comprehensive EU raw materials policy and its main components and stress the need for further development of EU-wide data and information on raw materials stocks and flows in the context of the EU Circular Economy Action Plan through the EU Raw Materials Information System (RMIS) managed by the Joint Research Centre of the European Commission."

Abstracts as contribution for discussions

Investigating stocks and flows of the non-residential building sector

Liselotte Schebek, Technische Universität Darmstadt

In industrial societies the largest amounts of anthropogenic resources are stored in buildings and infrastructures. Up to now, most studies investigating material stocks have focused on residential buildings. However, non-residential buildings seem of special interest, because shares of technical equipment and metals can be expected to be higher compared to residential buildings. In addition, for recovery of valuable resources information is needed not only on stocks but also on future flows of materials from the building sector. Here, dynamics of re-use, renovation and demolition is faster for non-residential compared to residential buildings.

In our research, we investigate material stocks and flows of the non-residential sector based on empirical data gathered in the Rhine-Main-Area. Our methodological approach combines building related information from surveys of real-estate and from on-site visits of single buildings with statistical data and cadastral land registers. By means of scenarios for the real estate market and a Material Flow Model, future flows from demolition can be calculated. As a first step, the present stock of the Rhine-Main-Area has been assessed (Schebek et al. 2016). Main findings from our research include: we showed the general feasibility of combining spatial and building related information for assessing regional material stocks. However, several restrictions exist, i.a. the present lack of detailed spatial data on building type and age-classes for NRB. Notably, as to specific values for material contents, a high variability between individual buildings was found. In order to identify representative values for building types or age classes, more empirical research and the evaluation of data from existing studies is desirable. For this, common terminologies could facilitate the use of data from different sources considerably and enhance validity of values for average material contents of buildings.

Schebek, L., Schnitzer, B., Blesinger, D., Köhn, A., Miekley, B., Linke, H.-J., Lohmann, A., Motzko, Chr., Seemann, A., 2016. “Material Stocks of the Non-residential Building Sector: the Case of the Rhine Main Area”, in: Resources, Conservation & Recycling, Special Issue “Anthropogenic Stocks”.

Mines of tomorrow – evaluating and classifying anthropogenic resources: A new methodology

Andrea Winterstetter, Technische Universität Wien

Various recent policy initiatives indicate an increasing need for a comprehensive overview of potentially extractable anthropogenic resources, in order to compare them with geogenic resources. Therefore, a new methodology for the evaluation and classification of anthropogenic resources, i.e. for waste flows and material stocks, in analogy to existing concepts used for geogenic resource deposits was established.

This study presents how anthropogenic resources can be systematically integrated into the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC-2009). The main goal is to illustrate different settings of anthropogenic resource classification, and to provide specific criteria to map different types of anthropogenic resources within the three dimensions of UNFC-2009, i.e. "knowledge on composition and extractable material content", "technical and project feasibility" and "socioeconomic viability". In order to account for the heterogeneity of anthropogenic resources, the newly developed method was applied to case studies for landfill mining (obsolete stocks), recycling of obsolete personal computers (PC waste flows) and recovering materials from in-use wind turbines (in-use stocks). The economic results depend on the respective scenarios, where the timing of mining is varied, different organizational and societal settings are compared and different choices for technological options are made. While landfill mining under current conditions is not economically viable, the final result might look different in the future with changing key modifying factors, such as increasing secondary raw material prices. Mining materials from obsolete PCs and from permanent magnets in in-use wind turbines would both yield positive economic results for all investigated scenarios. On the scenario level, the economic result is better for PC recycling in a high-income EU member state than in a low-income EU member state, due to higher collection and source separation rates and in spite of higher labour costs. In case of the permanent magnets from wind turbines the re-use scenario is economically clearly to be preferred over the hydrometallurgical extraction.

Winterstetter, A., Laner, D., Rechberger, H., Fellner, J., 2015. Framework for the evaluation of anthropogenic resources: A landfill mining case study–Resource or reserve? Resources, Conservation and Recycling 96, 19-30.

Winterstetter, A., Laner, D., Rechberger, H., Fellner, J., 2016. Integrating anthropogenic material stocks and flows into a modern resource classification framework: Challenges and potentials. Journal of Cleaner Production 133, 1352-1362.

Winterstetter, A., Laner, D., Rechberger, H., Fellner, J., 2016a. Evaluation and classification of different types of anthropogenic resources: The cases of old landfills, obsolete computers and in-use wind turbines. Journal of Cleaner Production

Mining waste classification using mining and mineral processing activities - the ProSUM approach

Anders Hallberg, Geological Survey of Sweden (SGU)

Mining waste has for a long time resided in the grey zone between the mining industry and environmental protection authorities – and has always been regarded as a problem. In recent years, and with the Raw Materials Initiative, the potential of mining waste as a resource and the possibility to reducing mining waste production has been widely discussed.

As a first step in that discussion, we need to agree on a common ground for how to describe mining waste. For that purpose, the ProSUM project has developed data models and code lists making it possible to get a comprehensive picture of secondary raw materials in the mining sector, to relate those to primary raw materials and also make comparison with other waste streams in society, e.g. used cars, waste electronics and batteries.

The ProSUM data model for mining waste will be an extension of the primary resources data model developed in the Minerals4EU-project and incorporated in the INSPIRE Mineral Resource data model. Mining waste is defined by the process that generated the waste, in the data model called Processing Transformation Activity. A code list to this activity, based on an examination of published data for >20 mines and processing plants around the world, has been developed. Using this approach, it is possible to relate the mining waste to the mine where the ore came from. Ore composition can then be used to characterize the generated waste.

We have not found it necessary to make code lists for reserves & resources of mining waste since a mineable mining waste deposit will have to be described and classified in the same way as a primary mineral resource, thus existing codes can be used. Code lists for qualitatively different methods to estimate size and grade of a mining waste deposit have been developed.

The role of raw material accessibility in developing a common ontology for resource classification

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There is increasing recognition for the need to develop a common ontology of raw material supply from geological and anthropogenic deposits. For this, key elements are different resource classification frameworks, such as UNFC-2009, PERC or JORC. However, existing resource classification frameworks rarely cover non-geological deposits (e.g. end-of-life products), for which data are currently scarce. Simultaneously, the integration of sustainability issues, such as consideration of social and environmental impacts, into the UNFC-2009 framework is currently underway. To integrate non-geological deposits and a broad sustainability evaluation, it has been argued that such frameworks should be broader in scope and cover raw material 'accessibility' as well as their 'availability'. A systematic investigation of raw material 'accessibility' and 'availability' in relation to geological and anthropogenic raw material supply has not yet been undertaken.

Mueller et al., (2015) presented a novel framework for establishing synergies between geological and anthropogenic mining processes and applied this framework to evaluate the confidence level of determining the quantities (geological knowledge) of three products containing rare earth elements (REE). Building on this framework, this study addresses the following research questions: (i) how can accessibility and availability be conceptualised in the context of raw material supply? (ii) how can this then be translated to address the accessibility of End-of-Life products and the Earth's crust? and (iii) to what extent can the accessibility of geological and anthropogenic raw materials be quantified?

We applied a quantitative linguistic approach to systematically clarify the use of accessibility and availability for evaluating the raw material supply. Following this, a novel, consistent framework that focuses on evaluating the raw material accessibility was developed. To demonstrate the framework's application, we evaluated the accessibility at four deposits: one anthropogenic (computer hard drive disks) and three geological (Mt. Weld, Bayan Obo, and Mt. Pass). We investigate further how multi-dimensional sustainability considerations can influence the accessibility of raw materials.

Mueller, S.R., Wäger, P.A., Widmer, R. and Williams, I.D., 2015. A geological reconnaissance of electrical and electronic waste as a source for rare earth metals. Waste Management, 45, pp.226–234.

The challenge of transboundary movement of wastes for the circular economy

Julia A. Stegemann, University College London (UCL) and Ashima Suchdev, Ellen MacArthur Foundation

The Ellen MacArthur Foundation (EMF) was founded in 2010, to accelerate the transition to a Circular Economy by working with business, government and academia. The EMF convenes the "Circular Economy 100" (CE100) multi-stakeholder network of 100 leading organisations from around the globe, including corporations, governments and cities, to enable them to develop new opportunities and realise their circular economy ambitions faster. UCL is one of 7 Pioneer Universities who are members of the CE100, with a formal agreement to further the collective understanding of a circular economy and enable a transition to it through insights and skills development.

Two-day acceleration workshops held with the CE100 twice a year focus on promoting cross-company and cross-sector collaboration. Members create Collaborative Projects (Co.Projects) to address key aspects of the transition towards a circular economy. A recent Co.Project was formed to focus on regulatory enablers for the Circular Economy, with membership from Apple, Antea Group, Cranfield University, Dell, DHL, Globechain, HP, Michelin, Philips, Renault, Rochester Institute of Technology, Suez, Tarkett, Teleplan, UCL and Zero Waste Scotland. Initial meetings rapidly established that a key regulatory issue is control of transboundary movement of wastes under the Basel Convention. A survey of concerns was undertaken to establish barriers and opportunities in association with this issue. Responses will inform three case studies that are being undertaken to illustrate the issues for movement of materials within the EU, in imports to the EU, and as exports from the EU.

SMART GROUND: SMART data collection and inteGRation platform to enhance availability and accessibility of data and infOrmation in the EU territory on SecoNDary Raw Materials

Antoniettan Pizza, ENCO srl

Steady Raw Materials supply is essential for the EU economy and is increasingly under pressure to sustain the businesses and industries demand. The supply of raw materials is not only a matter of availability of primary but also secondary raw materials (SRM). As such, we need to consider both the scarcity and raising prices of Raw Materials and the EU waste management policies aiming at reducing the environmental and health impacts of waste. To improve Europe's resource efficiency, a higher level of recycling and the minimisation of the extraction of natural resources is needed. A zero-waste production must be reached, finding a new market for each fraction deriving from processing activities, moving from a linear to a circular economy approach.

In Europe there are between 150,000 and 500,000 landfills, thus the SRM potential is significant. Nevertheless, there is to date no inventory of SRM at EU level. SMART GROUND aims to facilitate the availability and accessibility of data and information on SRM in the EU, as well as creating synergy and collaboration between the different stakeholders involved in the SRM value chain. In order to do so, the SMART GROUND consortium is carrying out a set of activities to integrate all the data from existing sources into a single EU database and expand it with new information retrieved from pilot landfills as progress is made. Such a database will enable the exchange of contacts and information among the relevant stakeholders, and raise interested in providing or obtaining SRM. The project will further spin out the SRM economy and employment by delivering targeted training on the feasibility of SRM recovery from landfills, and by establishing a dedicated network of stakeholders committed to cost-effective research, technology transfer and training.