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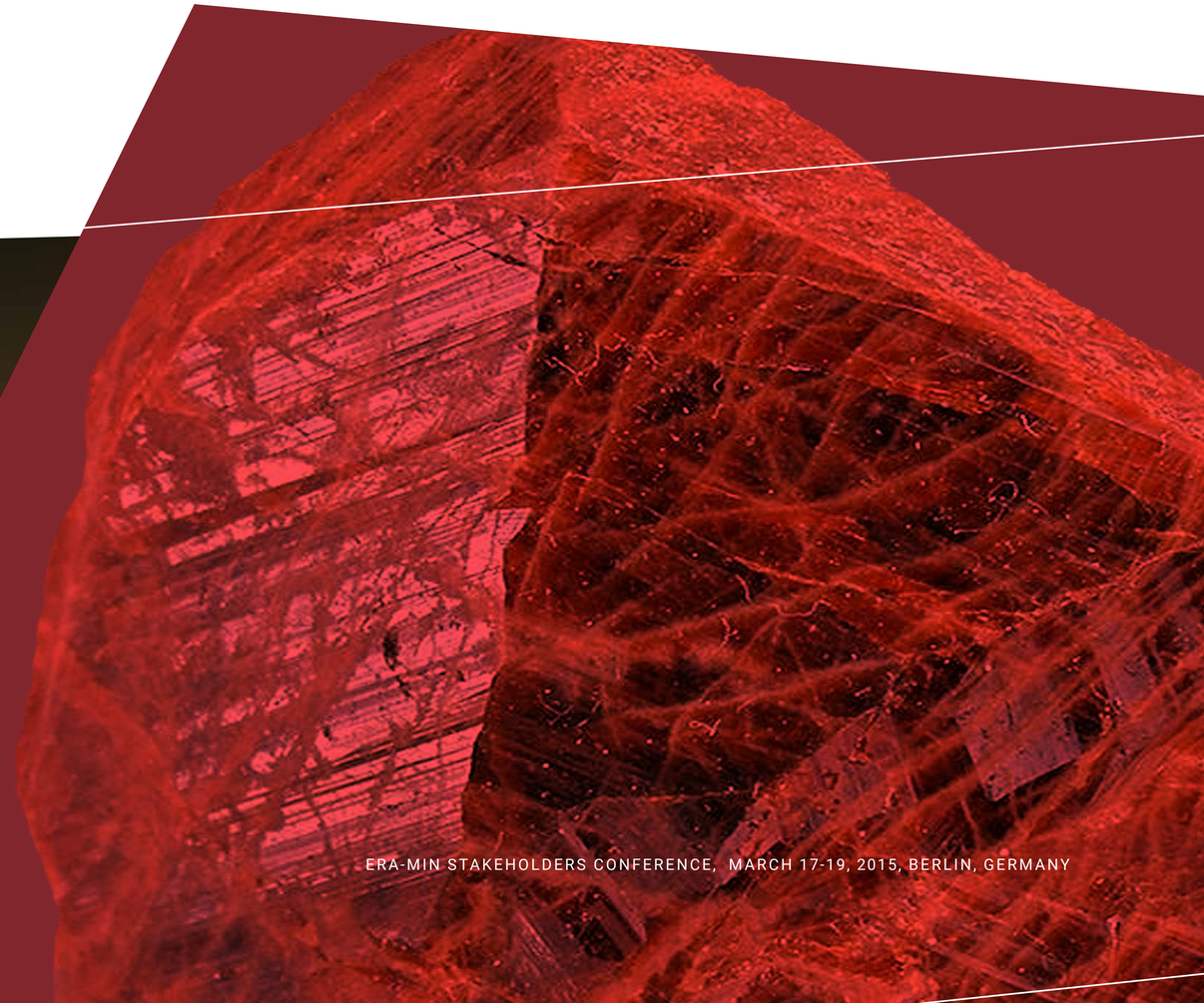
environmentally friendly and efficient methods for extraction
of rare earth elements from secondary sources

PROJECT SUMMARY

ERA•MIN
NETWORK ON THE INDUSTRIAL HANDLING
OF RAW MATERIALS FOR EUROPEAN INDUSTRIES



ERA-MIN STAKEHOLDERS CONFERENCE, MARCH 17-19, 2015, BERLIN, GERMANY

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background

Rare Earth Elements identified as Critical Raw Materials by EU Raw Materials Initiative

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ree classification

	Metal	**Grouping**
Rare Earth Elements	Scandium	Scandium
	Lanthanum, Cerium, Praseodymium, Neodymium, Samarium	Rare Earth Elements – Light (LREE)
	Europium, Gadolinium, Terbium, Dysprosium, Erbium, Yttrium, others (Holmium, Erbium, Thulium, Ytterbium and Lutetium)	Rare Earth Elements – Heavy (HREE)

Source: Report on Critical Raw Materials for the EU

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ENERGY PRODUCTION			ENERGY REDUCTION			ENERGY EFFICIENCY			LIFESTYLE		
Petroleum refining			UV filters in glass			New generation vehicles			Colour screen LCDs/PDPs		
	La			Ce		Nd	Sm		Eu	Tb	Y
High-powered electric motors			Reducing fuel consumption			Rechargeable batteries			Components to hardware		
Nd	Dy	Tb		Nd			La			Nd	
New generation vehicles			Lighter vehicles – improved performance			Energy-efficient lighting			Medical services		
	La			Dy		Pr	Eu		Nd	Gd	Ce

La (Lanthanum), **Nd** (Neodymium), **Dy** (Dysprosium), **Tb** (Terbium), **Ce** (Cerium), **Sm** (Samarium), **Pr** (Praseodymium), **Eu** (Europium), **Y** (Yttrium), **Gd** (Gadolinium)

Source: Arafura Resources

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ree production

Estimated world mine production in tonnes of rare earth oxides, 2012, ± 15% +

	China	USA	Australia*	India	Russia*	Total	%
Lanthanum	29,320	2,661	1,040	169	700	33,890	26
Cerium	41,875	3,934	2,040	363	1,436	49,648	38
Praseodymium	5,700	347	160	42	95	6,344	5
Neodymium	19,750	960	600	139	220	21,669	17
Samarium	2,470	64	72	20	24	2,650	2
Europium	340	8	16	-	3	367	0
Gadolinium	2,215	14	40	9	5	2,283	2
Terbium	340	2	4	-	2	348	0
Dysprosium	1,350	2	8	-	2	1,362	1
Erbium	860		8	-	2	870	1
Yttrium	9,915	8	2	-	-	9,925	8
Ho, Tm, Yb, Lu	1,715		10	8	11	1,744	1
Total	115,85	8,000	4,000	750	2,500	131,100	-

Source: Roskill Information Services / Dudley Kingsnorth, IMCOA (March 2013) & *USGS Data for Australia † This reflects uncertainty related to Chinese mineral and metal production statistics

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ree in Europe

- **EU net importer of cca 8,000 tonnes of rare earths every year (excluding REE in products) – Europe imports about 14% of the total REE production of China**

SOURCES: **primary** **recycling** **other secondary sources**

- **no rare earth production is currently located within the EU – but being developed in Norra Kärr (Sweden), some development Germany, Greenland and Turkey. Silmet plant in Estonia uses Russian materials for production.**

- **tailings and other by-products from previous mining activities in EU hold sometimes significant amount of REE**
- **research needed to find technically, economically and environmentally viable solutions for such secondary sources**

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- **ERA-MIN 2nd Joint Call project**
- **selected for funding and launched in January 2015**
- **coordinated by Christian Ekberg,** Chalmers University of Technology, Gothenburg, Sweden
- **11 partners from 8 countries**
- **planned for 3 years**

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enviree research topics

EXTRACTION

Integrated processes and system approach and Innovative waste management.

MINERAL PROCESSING

Processing of low grade and complex materials in the most efficient and sustainable way; Energy efficiency in the processing (grain size optimization, efficient leaching)

METALLURGY

Treatment of metallurgical by-products and waste with the complete recovery of metal value; New technologies for recovery of accompanying and critical metals for better utilization of natural resources; Tackling the existing challenges in extractive metallurgy.

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enviree objectives

- **develop novel and environmentally friendly leaching processes for different waste materials.**
- **develop environmentally friendly and economical separation processes**
- **ensure that the above processes comply with normal process optimization,** e.g. grain size, solid to liquid ratio etc. and all possible chemicals like extraction and leaching agents will be recirculated
- **asure environmental and economic feasibility of the processes**
- have an extensive **education, training and dissemination activity**
- bring the research results to the market through **interaction with the target groups.**

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enviree work structure

WP6 Project Management (Chalmers)

WP5 Training, education, dissemination and market uptake (IST-ID)

WP2
Leaching of the selected materials (CEA)

WP3
Separation of the REE (Chalmers)

WP1 Assesment of available materials and their charakterization (AICU)

WP4 Evaluation of envinronmental impact and economic feasibility (AGH)

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enviree materials

Material provider	Type of material provided
Boliden, Sweden	Tailing containing REE
Council for Geoscience, South Africa	Different secondary materials and mine residues from South Africa mines and processing plants where REE has been identifies as potential by-product
EDM, Portugal	Waste rock and tailing potentially containing REE
Rio Tinto, Australia	By-product from the mineral sand operations with potentially hight content of REE and Th
ZNP SAV s . r . o . Slovakia	Red mud from abandoned alumina production (from bauxite)
DIAMO-GEAM a.s., Czech Republic	a) samples from uranium production b) samples from tailing ponds c) mine water from Zlate hory area d) samples from waste rock pile
Hellenic copper mines LTD, Cyprus	Tailings from copper mining and processing
AGH, Poland	Tailings from copper ore processing – post flotation waste
	Tailings from zinc and lead ore processing – post floation waste
	Tailings from sculpture ore processing – post flotation waste
TERAMED Ltd., Czech Republic	Mining waste from different locations in the Czech Republic

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enviree consortium

The Nuclear Chemistry / Industrial Materials Recycling group at Chalmers University, Sweden (CHALMERS)

University of Science and Technology (AGH), Krakow, Poland

Alexandru Ioan Cuza University of Iaşi (AICU), Romania

Instituto Superior Técnico for Research and Development (IST-ID), Lisboa, Portugal

Karlsruhe Institute of Technology (KIT), Germany (with own funding)

Primus.inter.pares AS (PIPAS), Norway

Empresa de Desenvolvimento Mineiro, SA, (EDM), Portugal

Commissariat à l'énergie atomique et aux énergies alternatives (CEA), France

The Council for Geoscience (CGS), South Africa

Savona Project s.a. (SAVONA), Poland

Bureau de Recherches Geologiques et Minieres, (BRGM), France

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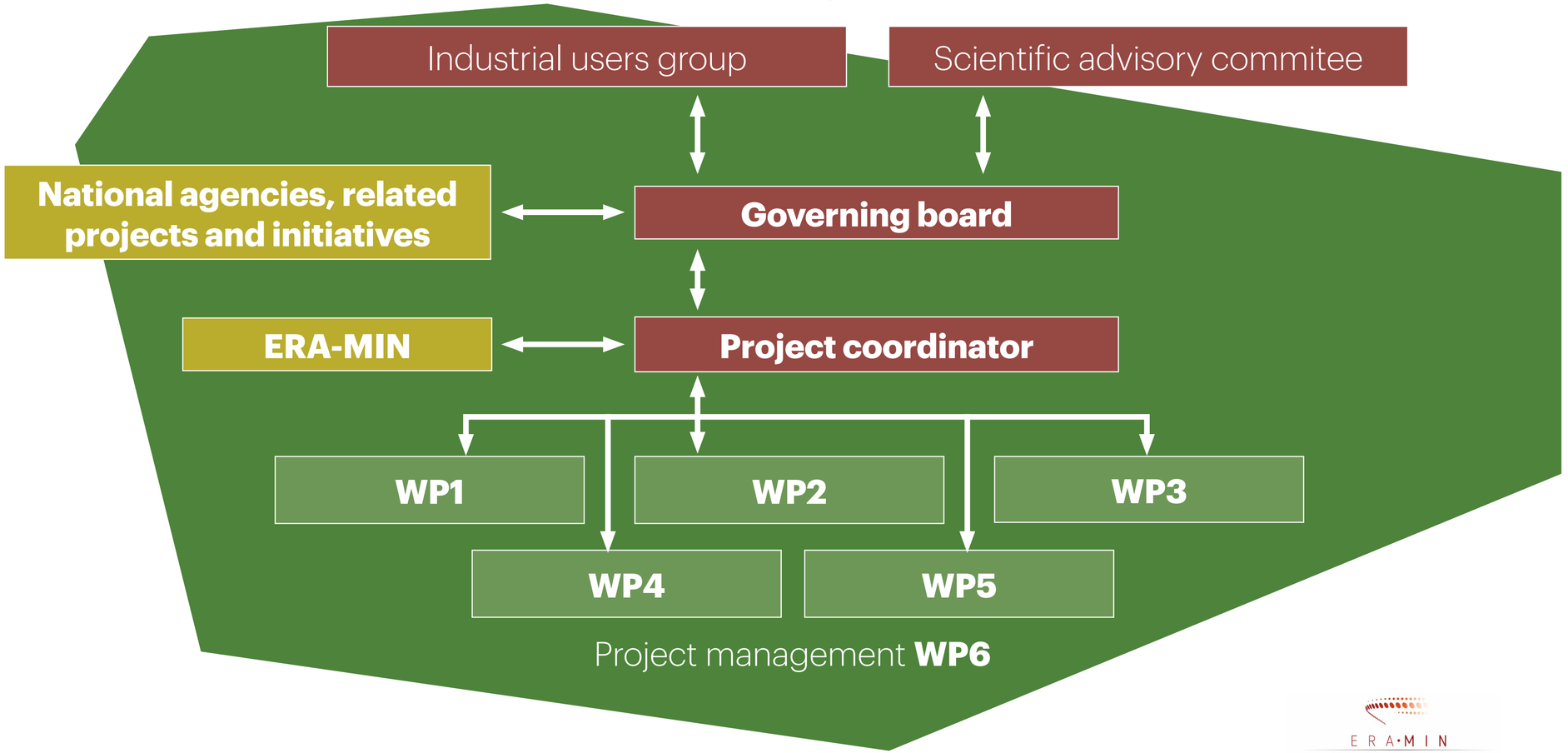
enviree organisation



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enviree expected results and impacts

- **competitive, environmentally friendly recovery techniques** for secondary mineral sources involving **holistic approach** to the given problem
- **existing test bed at CHALMERS involved** in order to optimize the processes and bring it closer to industrial application - **industrially relevant focus** as assured also through involvement of end users
- **competitiveness and environmental impacts of the suggested approaches addressed**
- **extensive training and education programme applied**

Placing EU among those possessing techniques for a sustainable and resource efficient recovery of REE from sources normally not used in this context and spreading both generic and specific industrial knowledge among relevant target groups

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Thank you for your attention!

enviree contacts

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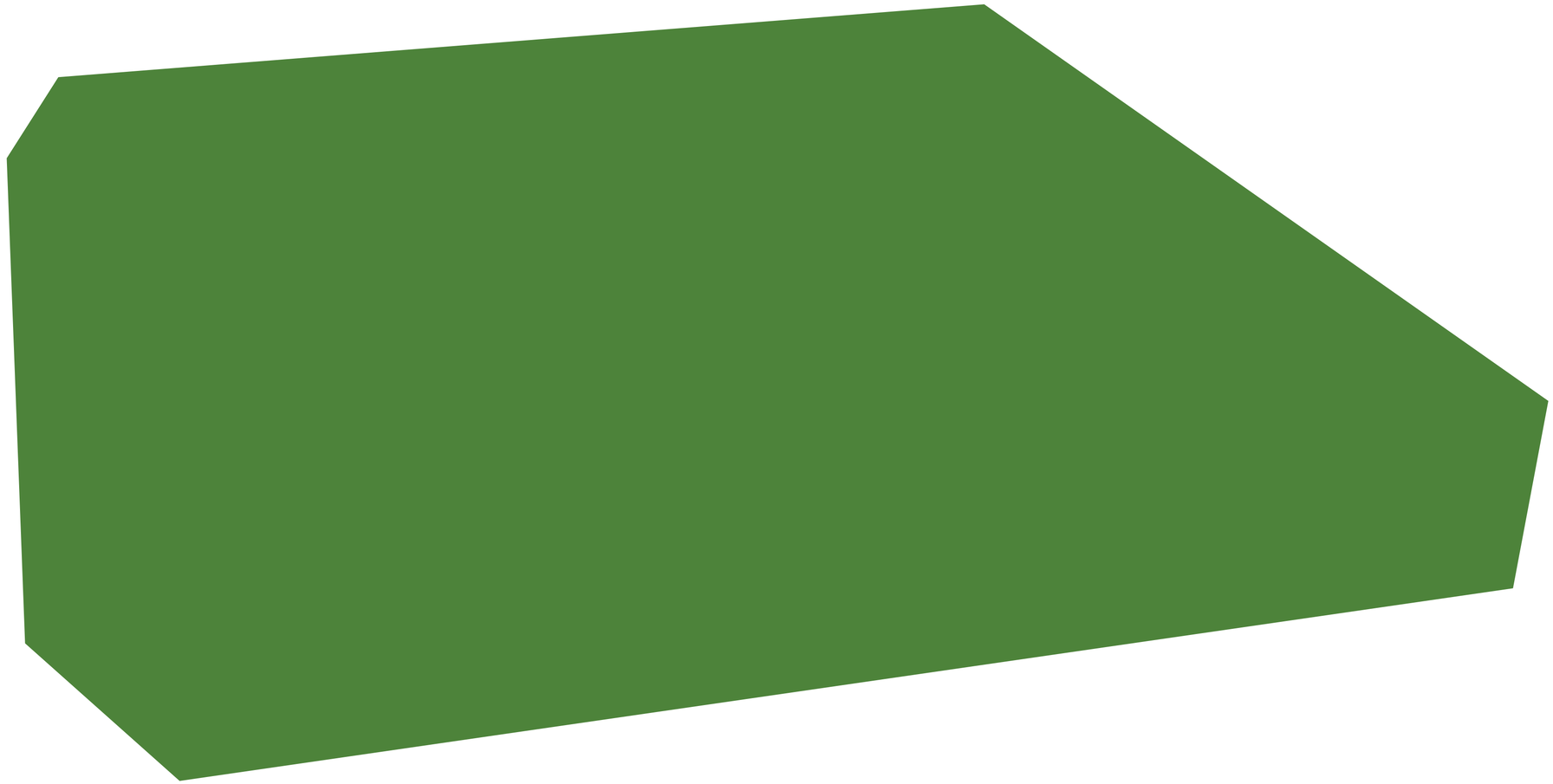

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