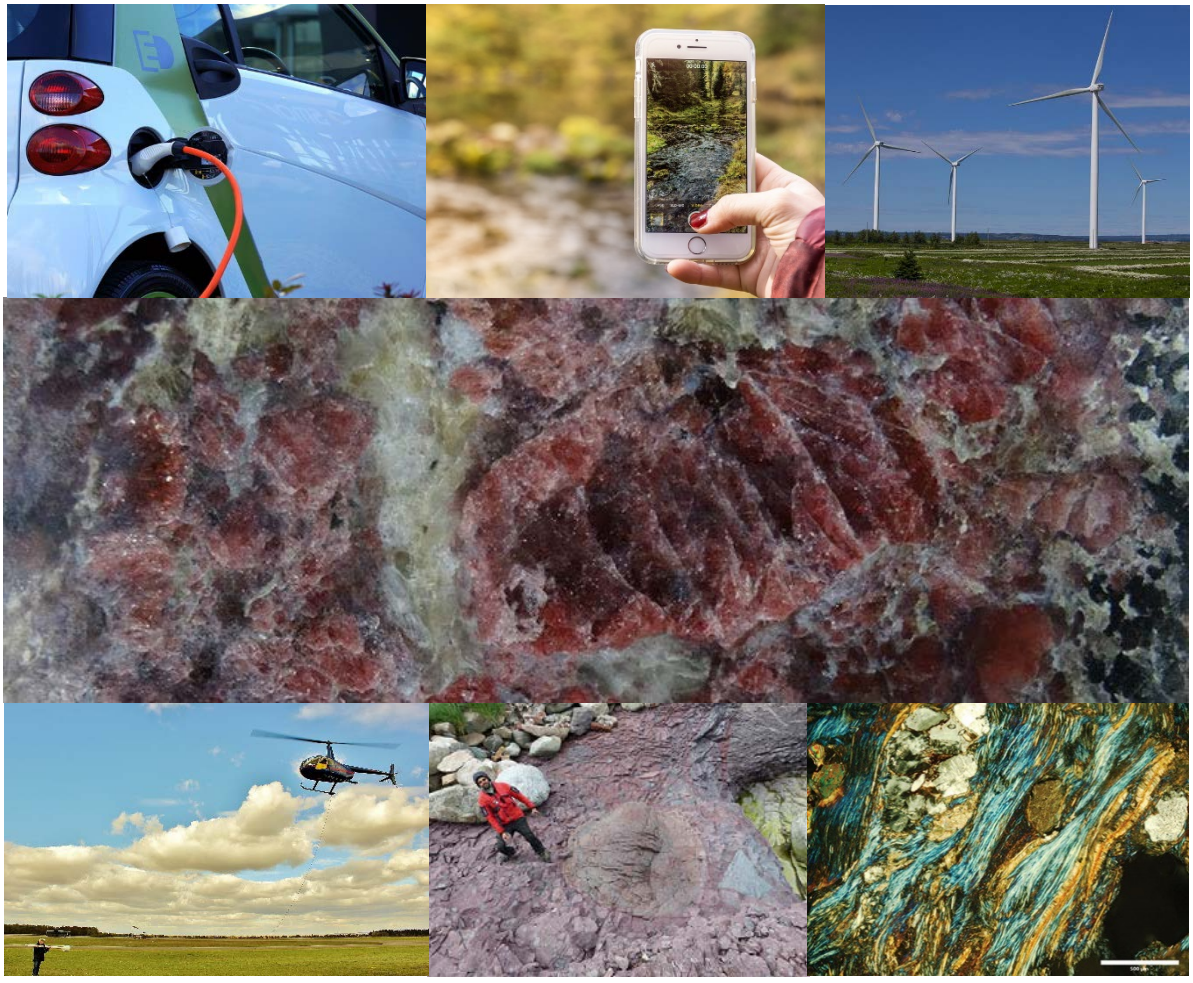
Critical raw materials and our green future



HiTech AlkCarb and SoS RARE celebratory and results launch event - Programme

26th and 27th November, London

Flett Lecture Theatre, Natural History Museum

and

Kohn Centre, Royal Society, London

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Workshop introduction

Day 1 (26th November at the Natural History Museum) will be a workshop to focus on the scientific advances from our projects and future challenges that we can work on as a scientific community, and will involve a day of keynote and contributed scientific presentations and discussions. Presentations will include results from HiTech AlkCarb and SoS RARE, as well as scientific contributions from researchers across the broader community.

Day 2 (27th November at the Royal Society) is aimed at a broad audience with interest in a green future, environmentally sustainable exploration and mining and hi-tech manufacturing. During the day we will discuss the big picture of our research and the need for critical raw materials, and we will highlight the key results of our work over the last few years and consider a vision for the future. In the evening we will hold a drinks reception to celebrate the past 4.5 years of work and launch some of our 3d project models.

This meeting has been organised by Emma Humphreys-Williams of the Natural History Museum, Pete Siegfried of GeoAfrica and Kate Smith and Frances Wall of Camborne School of Mines, University of Exeter, with the support of the HiTech AlkCarb and SoS RARE project teams.

26th November, Natural History Museum, Talks programme

St. time	Session	Lead speaker	Title
09:00	Coffee and Pastries		
09:20	Intro	Frances Wall	Welcome
09:30	Session 1	**Alan Woolley**	**KEYNOTE: Alkaline rocks, carbonatites and the lithosphere**
10:00		Will Hutchison	New isotopic constraints on the source and physico-chemical evolution of alkaline magmatic fluids: implications for REE prospecting and mineraliszation
10:15		Adrian Finch	Magmatic roof zones: where chemical and thermal gradients cause mineralisation
10:30		Gianluigi Rosatelli	Italian Carbonatites from mantle to ore deposits
10:45		Wei Chen	Geochemistry of magnetite from carbonatite-related complexes
11:00	BREAK Poster session		
11:20	Session 2	Marcelo Andrade	The role of rare earth elements in the discovery of Brazilian new minerals
11:35		Martin Smith	The Role of Hydrothermal Processes In Carbonatite-Related REE Deposits
11:50		Graham Banks	The alkaline igneous REE-HFSE mineral system: a new approach for global exploration targeting, and the next generation research questions.
12:10		Charles Beard	Geomodels for Hi-tech raw materials in alkaline-silicate and carbonatite systems
12:30		Emma Humphreys-Williams	The Alkaline Rocks and Carbonatites of the World Database and website - how to use and how to contribute!
12:45	LUNCH Poster session		
13:45	Session 3	**Jock Harmer**	**KEYNOTE: Exploration vectors for REE deposits in magnesian carbonatites derived from integrated field, petrological and experimental data**
14:15		Michael Anenburg	Late REE mobility in carbonatites controlled by alkali carbonates
14:30		Megan Barnett	Microbiology of REE deposits
14:45		Mbili Tshiningayamwe	Distribution, Petrology and chemistry of apatite from the Epembe carbonatite dyke, NW Namibia and other accessory minerals
15:00		Ed Loye	Responsible near-term REE production from Southern Africa - an example from Namibia
15:15		Robert Möckel	The Nam Xe REE-Project in Vietnam - From Mineralogy to Possible Processing Routes

15:30	BREAK Poster session		
15:50	Session 4	Yan Liu	Development of REE mineralization in the giant Maoniuping deposit (Sichuan, China)
16:05		Nicholas Arndt	PACIFIC - passive seismic applied to mineral exploration
16:20		Panel discussion	The future of understanding economic, mineral-forming processes in alkaline rocks and carbonatites: tectonics, redox and new depths to explore
17:30		Finish	

26th November, Natural History Museum, Talk summaries in chronological order

SESSION 1

09:30 Alan Woolley, Natural History Museum, UK

KEYNOTE: Alkaline rocks, carbonatites and the lithosphere: Alkaline rocks, carbonatites and the lithosphere. The crucial role played by the lithosphere in the spatial distribution and temporal ranges of the alkaline rocks and carbonatites will be emphasised. Carbonatite-bearing occurrences are overwhelmingly restricted to the continental cratons and have increased markedly with time, probably reflecting continuing metasomatism of the continental lithosphere. The roles of lithosphere focussing and repetition of activity in restricted provinces will be discussed. The alkaline rocks have also increased but the reason for this is more problematic resulting not only from continuing lithosphere metasomatism but also to a huge increase in magmatism with time in oceanic intraplate areas the reason for which is not absolutely clear.

10:00 Will Hutchison, University of St. Andrews, UK

New isotopic constraints on the source and physico-chemical evolution of alkaline magmatic fluids: implications for REE prospecting and mineraliszation: New isotopic constraints on the source and physico-chemical evolution of alkaline magmatic fluids: implications for REE prospecting and mineraliszation I'll speak mostly about S isotope results from HTAC project - what these tell us about alkaline and carbonatite magma sources, and how we can use these methods to unravel their temperature-pressure-redox evolution.

10:15 Adrian Finch, University of St. Andrews, UK

Magmatic roof zones: where chemical and thermal gradients cause mineralisation: Magmatic roof zones are unique environments, in which magma composition and physical properties can be radically different to those in the main reservoir. The most evolved melts and volatiles concentrate in the roof and in many cases late-stage roof zone processes are implicated in rare element mineralisation. We present data from fieldwork in magmatic roof zones from Greenland where three-dimensional slices through magma bodies are preserved. New sulfur isotope (δ34S) data (Hutchison, this conference) constrain the origins and evolution of roof zone fluids. Together, the new geochemical and geological observations of roof zone processes provide insights into the processes that contribute to rare element mineralisation and we discuss the pointers that may indicate a mineralised roof zone at depth.

10:30 Gianluigi Rosatelli, University G. d'Annunzio, Italy

Italian Carbonatites from mantle to ore deposits: Italian Carbonatites from mantle to ore deposits Presentation of the new Italian carbonatite occurrences and the multi-stage petrogenetic process: 1-orthomagmatic, 2-carbothermal, 3-hydrothermal they depict.

10:45 Wei Chen, China University of Geosciences, China

Geochemisty of magnetite from carbonatite complexes (e.g., Mushgai Khudag), and implications for ore genesis.

SESSION 2

11:20 Marcelo Andrade, University of Sao Paulo, IFSC, Brazil

The role of rare earth elements in the discovery of Brazilian new minerals: The characterization of new minerals is challenging. However, it can provide insights about the geological conditions and formation of rare-earth ores. It is worth knowing a bit more about the analysis techniques used for the characterization of the most recent Brazilian minerals that contain rare earths.

11:35 Martin Smith, University of Brighton, UK

The Role of Hydrothermal Processes In Carbonatite-Related REE Deposits: The influence of hydrothermal processes on grade in REE deposits including the importance of fluid chemistry.

11:50 Graham Banks, Geological Survey of Denmark and Greenland, Denmark

The alkaline igneous REE-HFSE mineral system: a new approach for global exploration targeting, and the next generation research questions: This presentation will talk us all through the entire mineral system for alkaline igneous-associated REE and HFSE commodities (to my knowledge the first time its been constructed), through continental to prospect scales. I'll place that within the exploration business framework to show how research and industry stakeholders are needed to populate it. Then we'll discuss the major knowledge gaps and suggest next generation research questions, to help the REE-HFSE sector systematically build, risk and rank REE-HFSE projects globally.

12:10 Charlie Beard, British Geological Survey, UK

Geomodels for Hi-tech raw materials in alkaline-silicate and carbonatite systems: A review of geological, mineral processing, exploration targeting and environmental factors pertinent for the development of critical metal resources hosted by carbonatite and alkaline-silicate magmatic systems. We present two interactive 3D geomodels at the prospect-scale (ca. 15 km lateral) that place mineralisations within a depth and horizontal reference frame.

12:30 Emma Humphreys-Williams, Natural History Museum, UK

The Alkaline Rocks and Carbonatites of the World Database and website - how to use and how to contribute!: I will give an introduction to the website we have created of alkaline rocks and carbonatites. I will detail how the website works and what you can do with the data.

SESSION 3

13:45 Jock Harmer, Rhodes University, South Africa

KEYNOTE: Exploration vectors for REE deposits in magnesian carbonatites derived from integrated field, petrological and experimental data: Experimental data on the evolution of carbonatite magmas at shallow crustal depths, coupled with field, petrographic and geochemical data on a range of carbonatite complexes - dolomitic, and composite calcitic-dolomitic - are used to derive an internally-consistent petrological model that provides useful constraints for exploration targeting of both magmatic/hydrothermal and supergene style REE deposits.

14:15 Michael Anenburg, Australian National University, Australia

Late REE mobility in carbonatites controlled by alkali carbonates: Experimental results showing how Na and K in carbonatites make REE incompatible and concentrate as soluble species in late hydrothermal fluids.

14:30 Megan Barnett, British Geological Survey, UK

Microbiology of REE deposits: Biotechnology Potential of Critical Metals: the rare earth elements Part 1. A brief introduction to the current commercial bioleaching operations and types of material currently targeted by bioleaching and those in research phase. Part 2. A summary of the work completed as part of WP4 of SoS RARE (leaching of non-conventional resources), looking at laterites and bauxites using different bioleaching techniques. Part 3. An overview of some of the other possible uses of biotechnology critical raw materials research, including leaching of other targets, separation and remediation.

14:45 Mbili Tshiningayamwe, Wits University and University of Namibia, Namibia

Distribution, Petrology and chemistry of apatite from the Epembe carbonatite dyke, NW Namibia and other accessory minerals: The talk will cover the occurrence and character of apatite and other related accessory minerals in different carbonatite rocks based on cathodoluminescence and backscattered electron imaging. In addition the major, minor and trace elements including halogens obtained from EPMA and LA-ICPMS will be presented. The results will be discussed in the context of apatite petrogenesis, carbonatite crystallization, and post-magmatic hydrothermal events.

15:00 Ed Loye, University of Exeter, UK

Responsible near-term REE production from Southern Africa - an example from Namibia: There have been attempts to diversify the supply chain for REE since the price spikes of 2011. However, many burgeoning mining companies around the world have struggled to get to production primarily because of challenging deposit characteristics (despite lauding high grade/high tonnages) and/or logistical remoteness. Lessons learnt have revealed important metrics to consider when assessing the viability of a REE prospect:

1. Deposit composition - high grade, conventional/proven REE ore mineral e.g. bastnäsite and/or monazite, with low actinide (Th, U) content. A high proportion of magnet metals Nd & Pr.
2. Mining mechanics – well constrained deposit, efficient beneficiation and high recovery.
3. Deposit accessibility - geography, topography, political stability, tax regime, proximity to infrastructure i.e. road/rail, water, electricity, shipping port.
4. Off-take agreement for product in place.
Could Southern Africa be the best region today to facilitate near-term, low cost and responsible REE supply?

15:15 Robert Möckel, Helmholtz-Institute Freiberg for Resource Technology, HZDR, Germany

The Nam Xe REE-Project in Vietnam - From Mineralogy to Possible Processing Routes: The Nam Xe deposit in northern Vietnam is a promissing REE prospect. A German-Vietnamese cooperative project included massive pre-mining environmental monitoring, detailled mineralogical investigation and processing experiments. Outcomes were detailled mapping results of radioactive elements and a first suggestion for a processing route of the REE ore, including sensor sorting and a two stage flotation scheme.

SESSION 4

15:50 Yan Liu, Institute of Geology, Chinese Academy of Geological Sciences, China

Development of REE mineralization in the giant Maoniuping deposit (Sichuan, China): Maoniuping carbonatite-related REE deposits is located in the eastern Tibet (Sichuan, China) and formed at about 25 Ma. Ore vein system developed in this deposit. Low-grade stockworks of multiple veinlets and breccias in the lower part of the orebody grade upwards into progressively thicker veins (up to 12 m in width) that are typically zoned and comprise ferromagnesian micas, sodium clinopyroxenes, sodium amphiboles, K-feldspar, fluorite, barite, calcite, and bastnäsite. The latter four minerals are most common in the uppermost 80 m of the Dagudao section and represent the climax of hydrothermal activity. Hydrothermal REE transport was probably controlled by F−, (SO4)2−, Cl−, and (CO3)2− as complexing ligands.

16:05 Nicholas Arndt, Sisprobe, Frances

PACIFIC - passive seismic applied to mineral exploration: PACIFIC is an H2020 project that is developing advanced passive seismic methods for mineral exploration. Participants include geoscientists from two major universities and research organisations, a geological survey and three companies. At the Marathon PGM-Cu deposit in Canada the body-wave reflection seismic method is being tested and at the Kallak Fe deposit in Sweden a combination to down-hole and surface arrays are being deployed. The project also includes experiments to monitor public perception of the minerals industry.

26th November - Posters (listed by first author)

First Name	Last name	Title
Anouk	Borst	Hydrothermal Alteration of Eudialyte-Hosted Critical Metal Deposits: Fluid Source and Implications for Deposit Grade
Sam	Broom-Fendley	Geology of the Eureka carbonatite complex, Namibia: a progress update.
Rosemary	Fayjaloun	PACIFIC : Passive Seismic Techniques for Mineral Exploration
Ester Panduleni	Kapuka	Distribution of Rare Earth Elements in the Epembe Carbonatite Dyke, Opuwo Area, Namibia
Jindřich	Kynický	Diversity of rare-earth mineralization in carbonatites of the Lugiin Gol complex, southern Mongolia.
Yondon	Majigsuren	REE deposit in Mongolia
Michael	Musialike	Zambian carbonatites
Gerel	Ochir	Rare earth mineral deposits in Mongolia
Bill	Peters	Airborne Geophysical Surveys over Carbonatite and Alkaline Volcanic Intrusions
Claudia	Pohl	From Geophysics to 3D-Geology at the REE-bearing Kaiserstuhl Volcanic Complex
Wenlei	Song	Heavy rare earth elements enrichment in carbonatites: An case study from xenotime-bearing carbonatite REE deposit in Bachu area, Xinjiang Province, China
Marie Alexandra	Speiser	Lessons learned at the Kaiserstuhl regarding environmental and social preceptions of the public
Jian	Sun	Calcium isotope systematics of carbonatites
Anatoly	Zaitsev	Pyrochlore group minerals in plutonic carbonatites from the Kerimasi volcano, Tanzania

26th November - Poster summaries (ordered by last name)

Anouk Borst, University of St. Andrews, UK

Hydrothermal Alteration of Eudialyte-Hosted Critical Metal Deposits: Fluid Source and Implications for Deposit Grade: This poster discusses hydrothermal alteration of eudialyte and its impact on ore grade and mineral processing. Eudialyte represents a potential source of heavy REE, as well as Nb, Ta and Zr and is found in large quantities in peralkaline igneous complexes. Our study focuses on alteration assemblages after eudialyte in nepheline syenites from the Ilímaussaq Complex, Greenland, one of the world's largest eudialyte-hosted REE-Zr-Nb deposits. Late-magmatic hydrothermal alteration caused partial replacement of primary eudialyte by complex pseudomorph assemblages of secondary Zr-, Nb-, and REE-minerals. We found that alteration has little effect on overall grade but preferentially separates heavy and light REE into different phases. Targeted processing of the alteration products may access individual rare earth families (heavy vs. light) and other metals (Zr, Nb, Ta) more effectively than processing the fresh rock.

Sam Broom-Fendley, University of Exeter, UK

Geology of the Eureka carbonatite complex, Namibia: a progress update.

Rosemary Fayjaloun, Université Grenoble Alpes, France

PACIFIC: Passive Seismic Techniques for Mineral Exploration: PACIFIC is developing techniques for mineral exploration, where we use the ambient noise from the nature and the human activities to generate the seismic waves in the ground. Those passive seismic waves are used to detect the different layers in the ground and eventually detect mineral deposits with high resolution. One technique relies on detecting the reflected body waves recorded on a dense array of sensors installed at the surface. (site test in Marathon - Canada). The other technique relies on detecting the seismic waves with multi-array sensors installed on the surface and vertically in existing boreholes. (site test in Kallak, Sweden). PACIFIC also studies the societal acceptance of mineral exploration.

Ester Panduleni Kapuka, Geological Survey of Namibia (GSN), Namibia

Distribution of Rare Earth Elements in the Epembe Carbonatite Dyke, Opuwo Area, Namibia: I plan to cover on the geological setting of Epembe carbonatite, local geology , the location and brief geological description/characteristics of Epemebe carbonatite. The geochemical composition of the Epembe carbonatite dyke. i will also present the new geochemical data for the Epembe carbonatite in order to describe the distribution and occurrence of rare earth elements of this dyke.Rare earth minerals at Epembe carbonatite.

Jindřich Kynický, Bic, The Czech Republic

Diversity of rare-earth mineralization in carbonatites of the Lugiin Gol complex, southern Mongolia: A large suite of calcite and akerite carbonatites from the Lugiin Gol complex in South Gobi, Mongolia, was examined. The samples chosen represent both new carbonatite outcrops and drill-core material (down to a depth of 1000 m) that has not been previously studied. [A1].The Lugiin Gol carbonatites are all strongly mineralized in rare-earth elements (REE). Their chondrite-normalized REE profiles have a steep negative slope and lack any anomalies. In addition, these rocks are characterized by extremely high abundances of Ba and Sr, coupled with low levels of Nb, Ta, Ti, K, Rb and Cs. Their age of emplacement has been determined by U-Pb dating of zircon as Triassic (ca. 240 Ma, i.e. post-orogenic). The carbonatites are represented predominantly by coarse-grained sövite, consisting of magmatic calcite, minor to accessory Na-Sr-REE-bearing apatite, and a plethora of rare-earth carbonates whose modal content locally reaches several per cent. The latter group is paragenetically diverse and includes both primary carbonates (burbankite–calcioburbankite series and REE fluorocarbonates) and hydrothermally or metasomatically formed phases associated with strontianite, fluorite, barite, celestine and quartz. The primary fluorocarbonates are represented by zoned synchysite-(Ce) crystals (synchysite I) with lamellae of bastnäsite-(Ce), parisite-(Ce) and röntgenite-(Ce). The primary textures and parageneses are modified and overprinted by such late-stage processes as recrystallization of calcite, alteration of apatite, break-down and replacement of burbankite and other early-crystallized carbonates, followed by precipitation of secondary carbonate parageneses. The primary burbankite is pseudomorphed by an sassemblage of synchysite II, calcite and strontianite, and the Na released at this stage is incorporated in khanneshite, carbocernaite

and cordylite-(Ce). A careful study of the minerals associated with the REE mineralization and their structural relations shows that most of the carbonatites underwent subsolidus metasomatic processes of two types: (1) high-temperature (max. T ca. 450 °C) fluoritization, accompanying the precipitation of REE carbonates and strontianite; and (2) low-temperature (T □ 150 °C) precipitation of barite, celestine and quartz. Our data demonstrate the complexity of magmatic and subsolidus processes involved in the evolution of carbonatites in post-orogenic settings.

Yondon Majigsuren, Researcher of Museum Geology and Mineral resources, Mongolia

REE deposit in Mongolia

Michael Musialike, University of Exeter, UK

Zambian carbonatites

Gerel Ochir, Mongolian University of Science & Technology, Mongolia

Rare earth mineral deposits in Mongolia: Rare earth mineral deposits in Mongolia are magmatic carbonatite and alkaline rock-related types. Carbonatite deposits formed in continental rift zones in South Mongolia and have complex mineralization, e.g. REE-P-Sr-Ba-F-Pb and Fe- REE. Deposits associated with alkali granite and syenite also have Zr-Nb-REE mineralization and formed in an active continental margin or rift environment in Western Mongolia. Other rare earth occurrences include Late Paleozoic and Mesozoic REE pegmatite associated with calc-alkaline and Li-F leucogranite, and REE-albite and REE-albite nepheline syenite deposit types. Four deposits Khalzan Buregtei, Mushgai Khudag, Khotgor, and Lugiin gol are of economic potential.

Bill Peters, Southern Geoscience Consultants, Australia

Airborne Geophysical Surveys over Carbonatite and Alkaline Volcanic Intrusions.

Claudia Pohl, terratec geophysical services, Germany

From Geophysics to 3D-Geology at the REE-bearing Kaiserstuhl Volcanic Complex.

Wenlei Song, Northwest University, China

Heavy rare earth elements enrichment in carbonatites: A case study from xenotime-bearing carbonatite REE deposit in Bachu area, Xinjiang Province, China: The Bachu carbonatite is located in the northwestern Tarim Large Igneous Province, China. The magma evolved from a dolomite- to a calcite-dominated composition and with subsequent hydrothermal REE mineralization. During this process, the HREE/LREE ratios of the rocks and corresponding carbonates have increased and large amounts of xenotimes occurred in the later calcite carbonatites. The carbonatite is rich in sulfates but poor in fluorine. We suggest that the different LREE/HREE compatibility of the calcite and dolomite during the

carbonatitic magmatic stage and the indistinguishable LREE/HREE migration capabilities of the sulfate-complexes control the HREE enrichment in carbonatites.

Marie Alexandra Speiser, A Speiser Environmental Consultants

Lessons learned at the Kaiserstuhl regarding environmental and social perceptions of the public.

27th November, Royal Society - Talks programme

WELCOME Location: Kohn Centre and Marble Hall	
9.15 - 10.00	Registration and welcome tea and coffee.
10.00 - 10.15	Welcome – Frances Wall, University of Exeter.
SESSION 1 *Please note this session will be live streamed on YouTube*	
10.15 - 10.35	Geology of REE deposits: what can experiments do for us, and how are they supported (or not) by evidence from the field and the microscope? **Sam Broom-Fendley**, University of Exeter and **Michael Anenburg**, Australian National University
10.35 - 10.55	Concentrating REE in the weathering zone: the ion adsorption clays, **Kathryn Goodenough**, British Geological Survey, **Martin Smith**, University of Brighton
10.55 - 11.15	The benefits of geophysics in REE exploration – A case study of the Kaiserstuhl Volcanic Complex, **Klaus Brauch and Claudia Pohl**, terratec geophysical services
11.15 - 11.35	A global catalogue of alkaline rocks and carbonatites - its construction and uses for science and industry, **Emma Humphreys-Williams and Alan Woolley**, Natural History Museum
11.35 - 11.55	Holistic workflow to aid decision quality in 'hi-tech' raw materials exploration: efficiency, uncertainty, value, risk, **Graham Banks**, GEUS
11.55 - 12.15	3D deposit models for HiTech raw materials in alkaline-silicate and carbonatite systems, **Charlie Beard**, British Geological Survey
12.15 - 13.15	Lunch and screen presentations
SESSION 2	
13.15 - 13.35	Rare earth market outlook: The engine of electrification, **Nils Backeberg**, Roskill
13.35 - 13.55	Exploration lessons and outlook, **Pete Siegfried**, GeoAfrica
13.55 - 14.15	Phosphate Fertiliser Production as a Source for Rare Earth Elements: The SecREEts Project, **Arne Ratvik**, Sintef
14.15 - 14.35	Why it pays to know your ore: mineralogy meets mineral processing, **Adrian Finch**, University of St. Andrews
14.35 - 14.55	Processing Ion adsorption deposits, **Simon Gregory**, British Geological Survey, including Computational modelling for environmentally friendly processing, **John Harding**, University of Sheffield
14.55 - 15.15	Recycling of rare earth elements, **Allan Walton**, Birmingham University

15.15 - 15.35	REE mineralization in the Fen Carbonatite complex, Telemark, Norway – A world-class exploration target for the HiTech and "Green-shift" industry? **Sven Dahlgren**, Buskerud Telemark Vestfold County Councils
15.35 - 16.00	Coffee
SESSION 3 Location: Dining Room	
16.00 - 16.20	A view of CRM from a European industrial perspective, **Maurits Bruggink**, CRM Alliance
16.20 - 16.40	Elements for 5G - **Christopher Ecclestone**, Hallgarten & Company
16.40 - 17.00	Quantifying the environmental impacts of rare earth projects during the development stages, **Rob Pell**, Minviro
17.00 - 17.20	Responsible Sourcing of Critical Raw Materials, **Blanca Racionero Gomez**, Levin Sources
17.20 - 17.40	Reaching a wider audience, **Kate Smith and Edward Loye**, University of Exeter
17.40 - 18.00	Audience participation and discussion
18.00 - 18.20	Wrap up and view to the future, **Frances Wall**, University of Exeter
18:20	**Reception**

Project information

HiTech AlkCarb

The HiTech AlkCarb project is funded under the European Union's Horizon 2020 Research and Innovation programme (grant agreement no. 689909), to develop new geomodels and sustainable exploration methods for alkaline igneous rocks and carbonatites. It has four main objectives:

- Develop new geomodels to explore for 'hi-tech' raw materials (such as the rare earth elements, scandium, niobium, tantalum, zirconium, hafnium and fluorspar) associated with alkaline rocks and carbonatites.
- Improve and develop interpretation of geophysical and downhole data in order to understand alkaline rock and carbonatite systems down to depths of approximately one kilometre.
- Build exploration expertise in hi-tech raw materials, and to ensure knowledge exchange between Europe and Africa.
- Assess environmental and socio-economic impacts of mining for these raw materials, and develop best practice.

Read more here: www.carbonatites.eu

SoS RARE

The SoS RARE project is a consortium project funded by NERC and EPSRC under the Security of Supply of Mineral Resources (SoS Minerals) science programme, running from 2015 to 2019. The research team includes 17 investigators from six UK universities and research institutes, with ten industry partners and eight core international research collaborators. The project developed from two NERC-funded catalyst grants, GEM-CREE and MM-FREE.

The project aims to improve understanding of how the rare earth elements (REE) are concentrated in natural systems, and use this information to investigate more efficient and environmentally friendly ways to extract and recover the REE. It is divided into two strands: the first concentrates on conventional bedrock deposits of the REE whilst the second focuses on ion adsorption clay deposits.

Read more here: www.sosrare.org