

# Scarcity of resources in Europe. Can Norway help?

### By Dag Øistein Eriksen University of Oslo, March 6<sup>th</sup>, 2018

www.hydromet.no d.o.eriksen@kjemi.uio.no

# A couple of economic definitions concerning ores:

• Reserve:

An economic concept which shall be close to the amount of valuable ore available for extraction at current technology

• *Resource*:

An estimated amount of ore available for extraction at current or future technology

*Reserve and resource* are concepts used by stock market listed companies

# What are the challenges?

#### **Globally:**

- Population growth
  - Growth of welfare
- Climate changes
  - Energy production with with low CO<sub>2</sub>-emissions
  - Food production
  - Ocean levels increase
- Natural resources are exhausted or threatened
- China is dominating the international access of metals
- Prices and offers are lacking transparency



Responsible Resource Management for a Sustainable World:



FINDINGS FROM THE INTERNATIONAL RESOURCE PANEL

#### Global material extraction in billion tons, 1900 to 2005.



A greeting in Norwegian from the UN vice secretary for the Environment

### Need for Resource Security is Accelerating



**The Past is No Guide to the Future**: the metal demands of current and emerging technologies represents a shift from crustally abundant elements with many sources, to trace metals. These are rarely found in high concentrations; rarely form individual minerals; have high barriers to entry due to technology hurdles; and customers require high purities.

# The future will need more of many different and special metals



Rohstoffe für Zukunftstechnologien 2016

»Auftragsstudie«

Im Auftrag der Deutschen Rohstoffagentur in der Bundesanstalt für Geowissenschaften und Rohstoffe, Berlin



# What are the main future use of the metals?

Metal	Demand <sub>20xx</sub> /Production <sub>2013</sub>		Emercing technologies
	2013	2035	Emerging technologies
Lithium	0.0	3.9	Lithium-ion batteries, lightweight airframes
HREE (Dy/Tb)	0.9	3.1	Magnets, e-cars, wind power
Rhenium	1.0	2.5	Super alloys
LREE (Nd/Pr)	0.8	1.7	Magnets, e-cars, wind power
Tantalum	0.4	1.6	Micro-capacitors, medical technology
Scandium	0.2	1.4	SOFC fuel cells
Cobalt	0.0	0.9	Lithium-ion batteries, XTL.
Germanium	0.4	0.8	Fibre optic, IR technology
Platinum	0.0	0.6	Fuel cells, catalysts
Tin	0.6	0.5	Transparent electrodes, lead-free solders
Palladium	0.1	0.5	Catalysts, seawater desalination
Indium	0.3	0.5	Displays, thin layer photovoltaics
Gallium	0.3	0.4	Thin layer photovoltaics, IC, WLED
Silver	0.2	0.3	RFID
Copper	0.0	0.3	Electric motors, RFID
Titanium	0.0	0.2	Seawater desalination, implants



Source: European Commission (2017c) Study on the review of the list of Critical Raw Materials 2017, Executive summary. 8



#### 06.03.2018

## "Resources" are more than economy

- Legal right and access to mineral deposit
- Infrastructure to bring ore to processing plant and export product
- Safe handling of waste material
- Knowhow on how to extract the valuables from the ore
- Chemical and environmental infrastructure
- Clean energy available
- Knowledge of markets and societal needs and requirements
- Capital

#### Examples of need for infrastructure: Avalon Ventures, Ganada Thor Lake Project Location Rae Yellowknife Lutsel'ke Thor Lake® N Fort Resolution Hay River kilometres Pine Point Edmonton Atlas 1080 km chnologies .... Google **PROPERTY LOCATION MAP** rraMetrics avy, NGA, GEBCO Eye alt 2531.74 km 65°45'55.77" N 125°01'12.51" W elev 428 m

06.03.2018

Primus.inter.pares AS

### A look at Norwegian metal ore deposits Data from NGU



In-situ verdi av metaller, Mkr





### Høgtuva



## Høgtuva

- South of glacier Svartisen, NW of Mo i Rana. Road close by.
- Europe's largest deposit of Be. Mineral is phenakite, Be<sub>2</sub>SiO<sub>4</sub>. SiO<sub>2</sub> ca 70%, Al<sub>2</sub>O<sub>3</sub> ca 12%, TiO<sub>2</sub> ca 0,24%, other main components: Fe, Na, K
- Estimated at 400 000 tons of ore at 0,18% BeO
- Phenakite may be concentrated by floatation to 25% BeO at 80% yield (SGS, Lakefield, 1990).
- The ore contains:



## Phenakite from Høgtuva

- The fact that Y is more abundant than La and Ce indicates that ore is enriched on HREE
- REE is usually not present as silicates
- REE may therefore be selectively leached

 Be, Si, Ti, and Zr may all be transferred to volatile chlorides:

 $MO_n + C + nCl_2 = MCl_{2n} + CO_n$ n= 1 (Be) or 2 (Si, Ti, Zr)

- This will break down the silicate lattice and facilitate the further leaching of the other metals
- Fe and Th may also be leached as chlorides

# Scandium

- The Tørdal area (150 km<sup>2</sup>) consists of numerous mineralized pegmatite (intrusive igneous rock) dykes
- Tørdal has potential for numerous mineral targets that include scandium, yttrium, tantalum, niobium, beryllium, zirconium, titanium, lithium, lanthanides and tin
- Exploration rights did belong to Australian company Scandium International Mining Corp.



# Challenge with lithium

#### The Trouble with Lithium

Implications of Future PHEV Production for Lithium Demand By William Tahil, Meridian International Research, 2007:

"Analysis of Lithium's geological resource base shows that there is insufficient economically recoverable Lithium available in the Earth's crust to sustain Electric Vehicle manufacture in the volumes required, based solely on Li-Ion batteries"

#### 2015: 1 million electric cars – 2020: many more

# Production of lithium globally:

2005 - 17 500 tons



2013 - 34 000 tons



2017 – 43 000 tons

Portugal
Brasil
USA
Australia
Chile
Kina
Argonting

Australia

Argentina

Zimbabye

Chile
 Kina

- Argentina
   Zimbabye
- Portugal

Brasil

USA

- North- and South-American producers are based on salt lakes and salt springs
  - Li is a byproduct of  $K_2CO_3$
  - Dependent on ground water
- Australia and China produce Li from minerals
  - Has to be a more expensive way than from brines
- Li-minerals (spodumen) occur among other places in Finland and Sweden
- New mines are presently being planned in South-Africa, Czech Republic, and Finland

06.03.2018

## Are new open pit mines acceptable?



Telnes mine, Titania A/S. Foto: Titania AS/Linda Løvås

The gangue rocks are deposited near by on shore – Now leaking Ni(aq)

# New concepts for mining are needed

- In the oil industry directional well drilling has been developed since 1930's.
- The oil industry is fading out and service companies are looking for new areas of interest
- Also tunnels can be made by drilling,  $\emptyset > 4$  m
- Ores are often found in veins and «chimneys»
- What if mines are drilled just where the minerals are? Rock will already be crushed and grinded, and gangue material will still be in place?
- Drilling is expensive, but so is milling and depositories
- Maybe smaller resources can be upgraded to reserves by a better technology

## IMP@CT is a Horizon2020 project









### **Imperial College** London









Extracthive





# Can Norway contribute to Europe's metal resources?

- Norway has world class deposits of
  - Chalcopyrite (FeCuS<sub>2</sub>), Nussir mine under construction
  - Ilmenite (FeTiO<sub>3</sub>), Telnes Titania
  - Rutile (TiO<sub>2</sub>), Naustdal Nordic Mining, mine under construction
  - Olivine (Mg<sub>2</sub>SiO<sub>4</sub>), Åheim Sibelco
  - REE & Th, etc., Fen deposit
- Many less common metals may be extracted from smaller reserves by improved technologies

# Can Norway contribute to Europe's metal resources?

- Norway has necessary competence and capital to become Europe's metal producer
- Norway has chemical infrastructure to process ores from Sweden, Finland, Greenland, etc.
   – E.g. Yara and Boliden are doing today
- Unfortunately, Norway is lacking policy for mineral and metal extraction.
   This is the sad truth!
- Thank you for your attention!