# scale

SCANDIUM ALUMINIUM EUROPE

# Sc HAS SUPERPOWERS!

Sc achieves superior results than Y in material applications


## SOLID OXIDE FUEL CELLS

Sc-stabilized Zirconia has **lowered operational temperatures** facilitating the **commercialization** of the technology

## LASERS WITH Sc GARNETS

have **3 times higher efficiency** than Y garnets

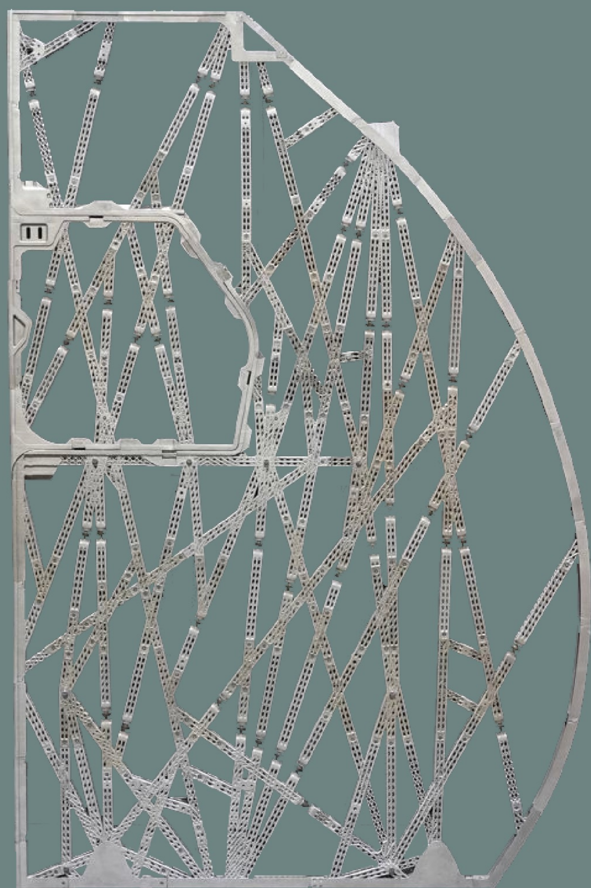
## NATURAL LIGHT

Sc compound is used as phosphors for **high intensity 'natural' light** - close to solar optical spectrum

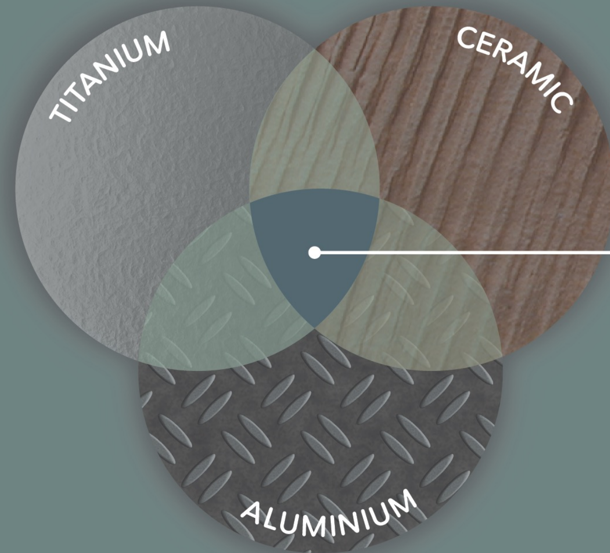
# Sc GOES WELL WITH Al

Sc+Al

**Sc** drastically improves **Al** alloys, increasing strengh, corrosion resistance & allowing welding...



Scalmalloy® 3D Printing




**$Al_{20}Li_{20}Mg_{10}Sc_{20}Ti_{30}$**

as strong as titanium
as light as aluminium
as hard as ceramic

The Al-Sc-Mg alloy powder is used in 3D printing by AIRBUS

# scale

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Bauxite
Residues
TiO2 Pigment
Acid Wastes

mg/kg

## EXTRACTING

Sc from waste

g/kg

## REFINING

Sc
concentrates

$Sc_2O_3$

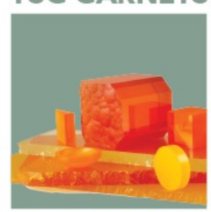
## PRODUCING

Sc Metal

# SCALE:

Production of
Sc compounds &
Sc-Al alloys from
European metallugrical
by-products

LASERS:
YSG GARNETS



II-VI

SSZ LAYER
SOLID OXIDE
FUEL CELLS

AL-SC ALLOY

KBM AFFILIPS MASTER ALLOYS

SCALMALLOY
3D PRINTING

AIRBUS

# A BARRIER-BREAKING MODEL

A viable process, from extraction to production

## Sc EXTRACTION

BREAKTRHOUGH TECHNOLOGIES

Extracting Sc from low grade and complicated resources and by-products

TECH BARRIER

## Sc REFINING

OPTIMIZATION TECHNOLOGIES

Multi stage S-X processing

Use of HF(g)

MARKET BARRIER

## Sc PRODUCTION

BREAKTHROUGH TECHNOLOGIES

High processing costs

Small production scales

**SCALE:** AN RTD PROJECT DEDICATED IN DEVELOPING A NOVEL Sc SUPPLY CHAIN

Horizon 2020

4 year project

€ 7,000,000.00

AoG demo plant

# EU MARKET POTENTIAL

- **Alumina Sector:** up to 500 t/y of Sc
- **Titania Sector:** up to 140 t/y of Sc

## SCALE RAW MATERIAL SOURCES

**AoG Bauxite Residue:**
130 g/t Sc; 750,000 t/y

**AOS Bauxite Residue:**
93 g/t Sc; 900,000 t/y

**TRONOX acid waste filter cake:**
150 g/t Sc; 50,000 t/y

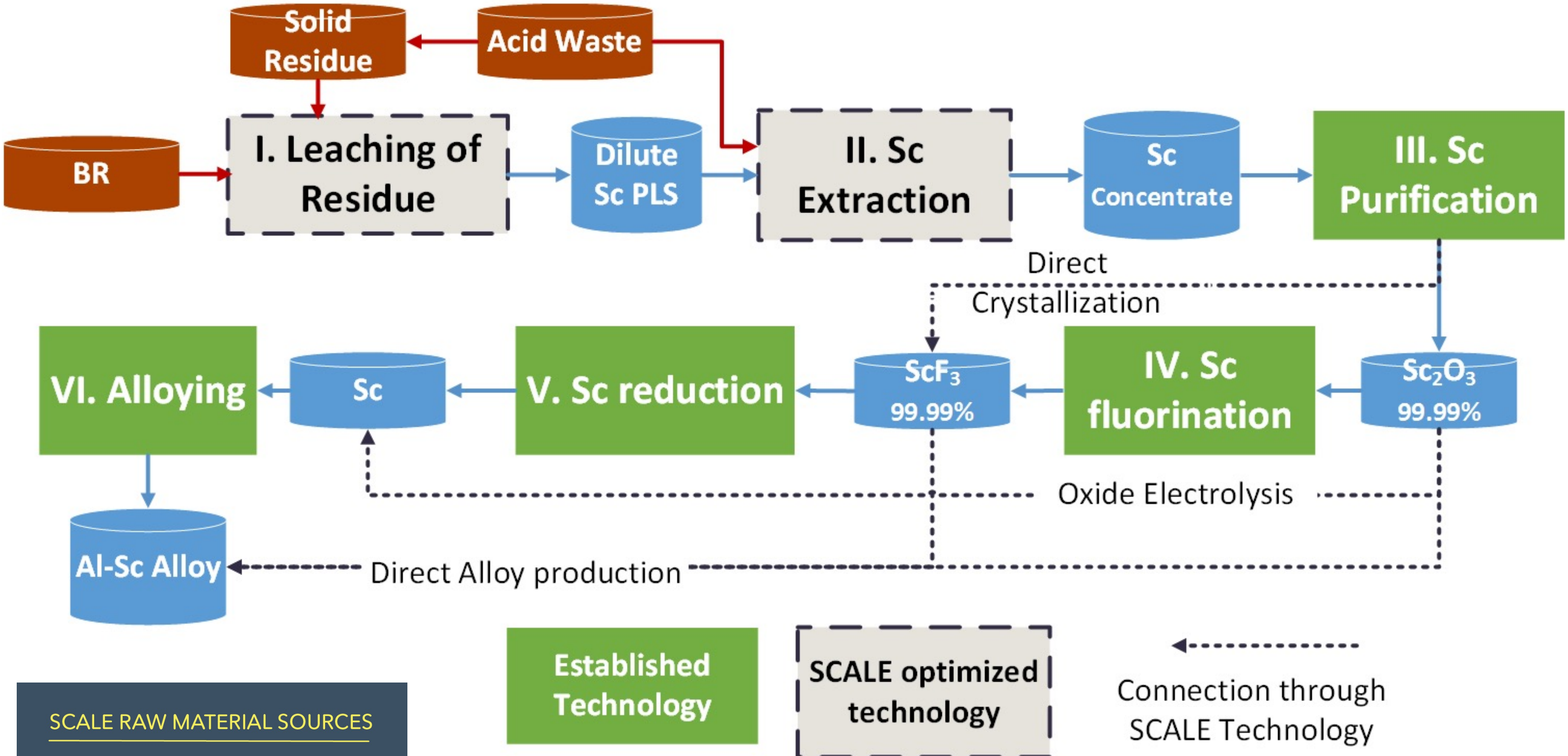
The research leading to these results has been performed within the SCALE project and received funding from the European Community's Horizon 2020 Programme (H2020/2014-2020) under grant agreement n° 730105.

ALUMINIUM OF GREECE · II-VI · TRONOX · io·li·tec Ionic Liquids Technologies · KTH · RWTH AACHEN UNIVERSITY · MŰEGYETEM 1782 · n|w University of Applied Sciences and Arts Northwestern Switzerland · BAM

aluminiumoxid · LCM less common metals · ITRB CONSULTING · Kurt Salmon · KBM AFFILIPS MASTER ALLOYS · MEAB · Fraunhofer · SINTEF

Project objectives

# European by-products as Sc resources

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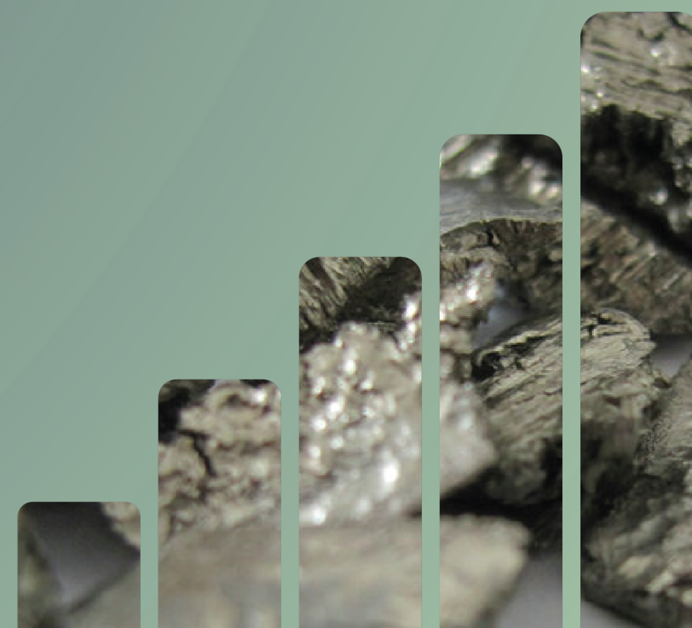
**TRONOX acid waste filter cake:**
150 g/t Sc; 50,000 t/y

# The Case of Acid Waste from TiO2 production



scale
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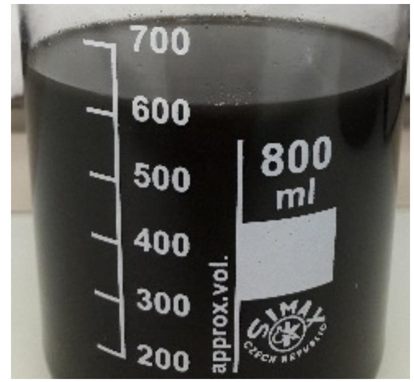
# Acid Waste (AW) from TiO2 Chloride production

- Acid Waste is the by-product of ilmenite (and other raw material) digestion to extract Ti
- The Sulfur route dissolves Ti through digestion with $H_2SO_4$ leaving as a by-product the un-reacted ore sludge
- The Chloride route uses Cl(g) and coke to extract $TiCl_4$, leaving as a by-product the Acid Waste an iron chloride solution with suspended unreacted ore and coke particles
- The AW from the chloride route is preferable Sc resource as the Sc is already dissolved in the stream
- AW is a hazardous waste due to U,Th levels as wells as high acidity.
- More than 1,4 Mt of AW from chloride route produced annually in Europe , USA, Canada and Australia




Chloride ~ 180 g/L ~ 5 M HCl

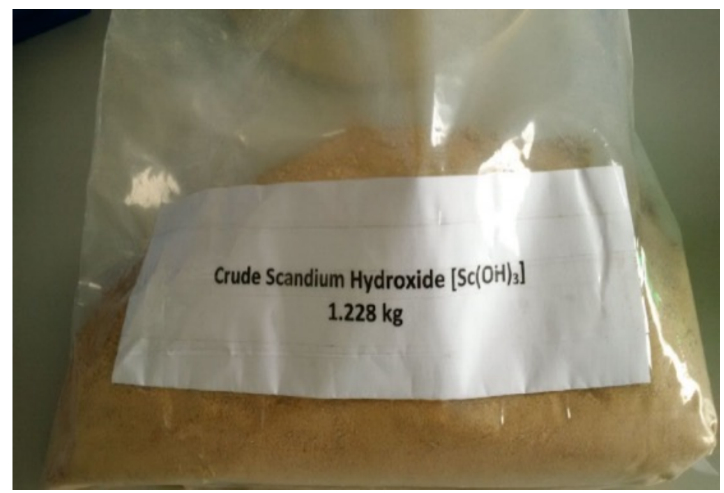
| Element | ppm |
|---|---|
| Fe | 47800 |
| Mn | 7000 |
| Al | 5200 |
| Mg | 2200 |
| Na | 2000 |
| Cr | 900 |
| Ca | 180 |

| REE Element | ppm |
|---|---|
| Ce | 138 |
| **Sc** | **82** |
| La | 60 |
| Nd | 60 |
| Y | 37 |
| Pr | 15 |
| Sm | 12 |
| Gd | 9 |
| Dy | 8 |
| Yb | 6 |
| Er | 5 |

Overall Project highlights

# Sc extraction from Acid Waste using SIR

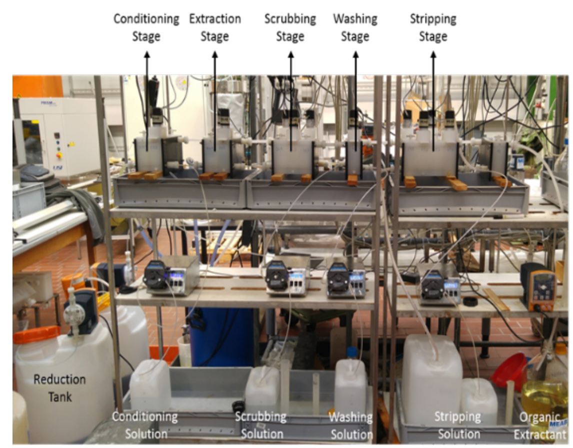
- Extracting Sc from AW has been demonstrated in pilot scale – **1.23kg of crude 19% Sc concentrate** produced from 2 m3 of AW.



Overall Project highlights

# Sc extraction from Acid Waste using Nanofiltration and innovative Solvent extraction -crystallization


- AW Sc nanofiltration has been developed and demonstrated in pilot scale, processing 800 lt with 81 ppm of Sc to 100 l of nano-filtered PLS with 130 ppm of Sc and >99.9 % of Ti, Zr, Nb, Th, U and 74 % of Fe impurities removal.
- The final filtered AW PLS was treated in bench scale with the MEAB/KTH SCALE flowsheet resulting in 8 l of Sc bearing strip liquor with a purity of >95%. **Overall Sc was up concentrated from 0.12 g/L to 1.5 g/L in the strip liquor.**
- The recovery of Sc as (NH4)3ScF6 with purity 99.2 to 99.5%. from real strip liquor streams using novel cooling and anti-solvent (AS) crystallization techniques has been achieved. Calcination of the (NH4)3ScF6 solid, produced ScF3 with an average purity of 99.12 ± 0.16 %. **This flowsheet has eliminated the need for HF gas in $ScF_3$ production.**

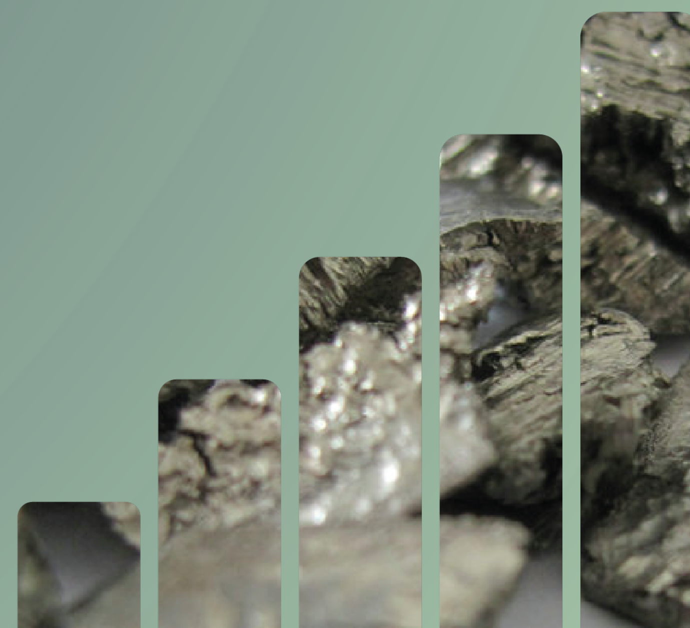



University of Applied Sciences and Arts Northwestern Switzerland
School of Life Sciences

MEAB

KTH VETENSKAP OCH KONST

# The Case of Bauxite Residue from $Al_2O_3$ production



# Bauxite Residue (BR) from alumina production

| wt% | | | | | | | ppm | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| $Fe_2O_3$ | $Al_2O_3$ | $SiO_2$ | CaO | $Na_2O$ | $TiO_2$ | LOI | Ce | La | Y | **Sc** |
| 39.16 | 16.53 | 9.90 | 8.40 | 3.46 | 4.67 | 10.10 | 657 | 110 | 132 | **71** |

| | Boehmite | Diaspore | Hematite | Goethite | Anatase | Rutile | Calcite | Quarz | Chamosite | Gibbsite | Hydrogarnet | Cancrinite | Perovskite | Portlandite |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **BR (%)** | 2 | 13 | 31 | 7.5 | 0.6 | 0.7 | 5 | 0.3 | 3.7 | 2.5 | 14.5 | 11 | 4 | 0.8 |

- Bauxite Residue is produced during the digestion of bauxite ore with soda for alumina production
- Mytilineos process a mixture of Greek (Karstic) and Tropical (Lateritic) Bauxite
- The Greek BR produced contains 70-100 ppm of Sc
- Each year 800,000 t of BR are produced at Mytilineos containing 60 – 80 t of Sc
- Previous Studies have shown that the Sc is mainly associated with iron mineral phases –originating from the Greek [Karstic] Bauxite
- Karstic Bauxite (“Sc -rich” bauxite) is used mainly in Greece, Russia and China.

# BR leaching approaches

- Leaching the Sc ppms from BR without co-dissolution of the major metals is the main challenge
- Selectivity in Sc leaching over Fe and Ti are especially crucial for the downstream extraction; silical gel formation is also an issue
- SCALE tested in labscale
  - Mineral acid leaching resulting up to 50% Sc extraction with less than 3% Fe co-extraction; this means a PLS of ~ 5 mg/l of Sc and ~1-2 g/l of Fe, 1.3-1.8 g/l of Ti
  - Physicochemical leaching with mineral acid resulted in higher Sc extraction but also higher Fe and Ti leaching
  - Ionic Liquid leaching resulted in high selectivity against Si, Ti and Fe with final PLS >25 mg/l Sc and 6 g/l Fe and <2.5 mg/l Ti . This method however comes with a high reagent cost

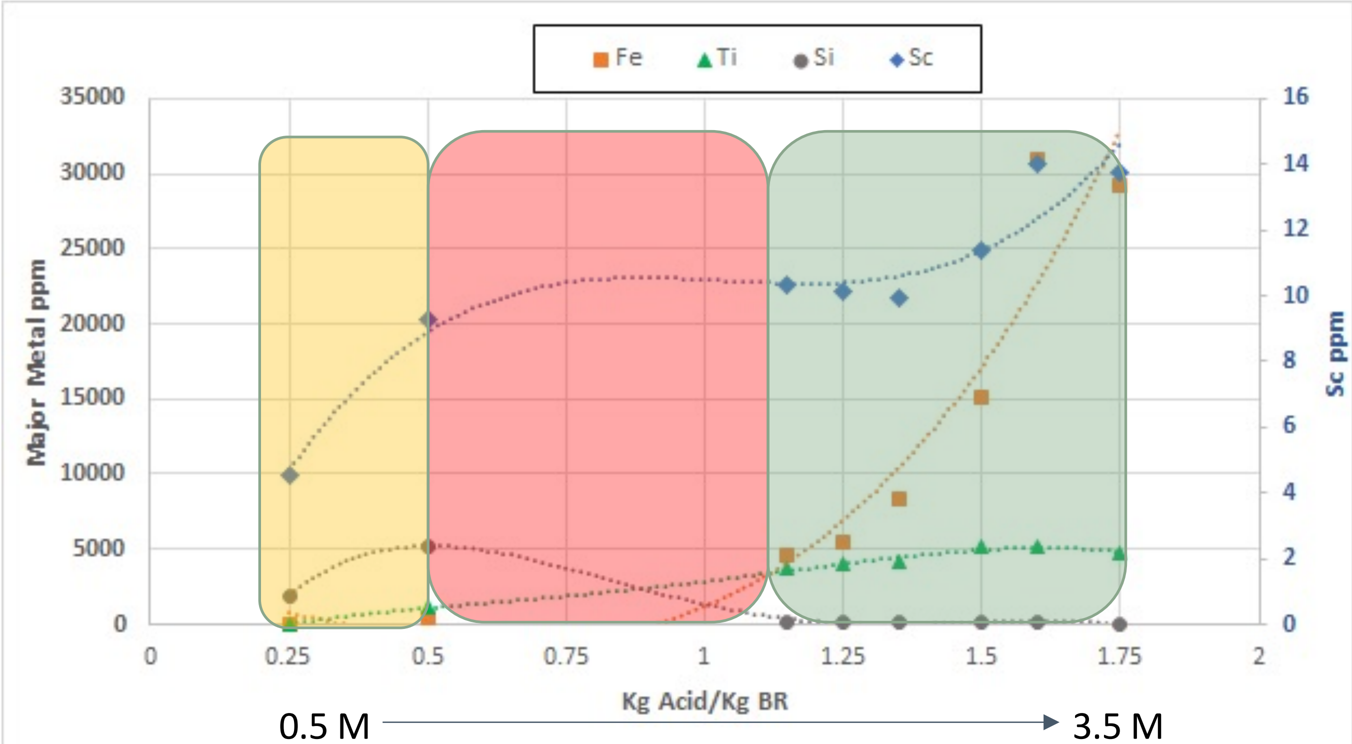
# LabScale Conclusions

- ✓ Leaching has been tested with various acids, ionic liquids and physicochemical methods. In terms of Sc leaching yields all methods achieve similar results.
- ✓ In terms of selectivity of Sc leaching against Fe the trend of $HNO_3$>$H_2SO_4$>HCl has been reported.
- ✓ Higher Temperature seem to favors higher Sc leaching while in some conditions also accelerating the removal of impurities like Ti, Si, Al through secondary precipitations.
- ✓ The PLS produced has low Sc content and significant impurities that hinder IX such as Fe+3, Ti and Si

# Upscaling Choice

- ➢ The use of an inorganic acid as leaching agent is preferred for the economy of the process.
- ➢ H2SO4 is selected as it is cheaper and easier to handle then HNO3, while more selective against HCl.
- ➢ The leaching will take place at 85-95°C to avoid use of autoclaves
- ➢ Selecting low acid leaching to minimize impurities in conjunction with SIR flowsheet development

# Leaching behavior of BR with H2SO4




| | | |
|---|---|---|
| - Low Sc Recovery,<br>- Metastable silica gel<br>- High selectivity | Silica gel formation | **- High Sc recovery,<br>- Silica precipitation,<br>- Low selectivity** |

*This region is economic in terms of acid consumption and 'compatible with SIR'*

Lab Leaching tests at:

- 85 oC,
- 20% pulp density
- 4 h retention time

*Increasing acid concentration leads to + 2-4 ppm of Sc but also + several g/l of Fe and Ti*

MYTILINEOS

# Sc extraction from BR using Acid Leaching & SIR

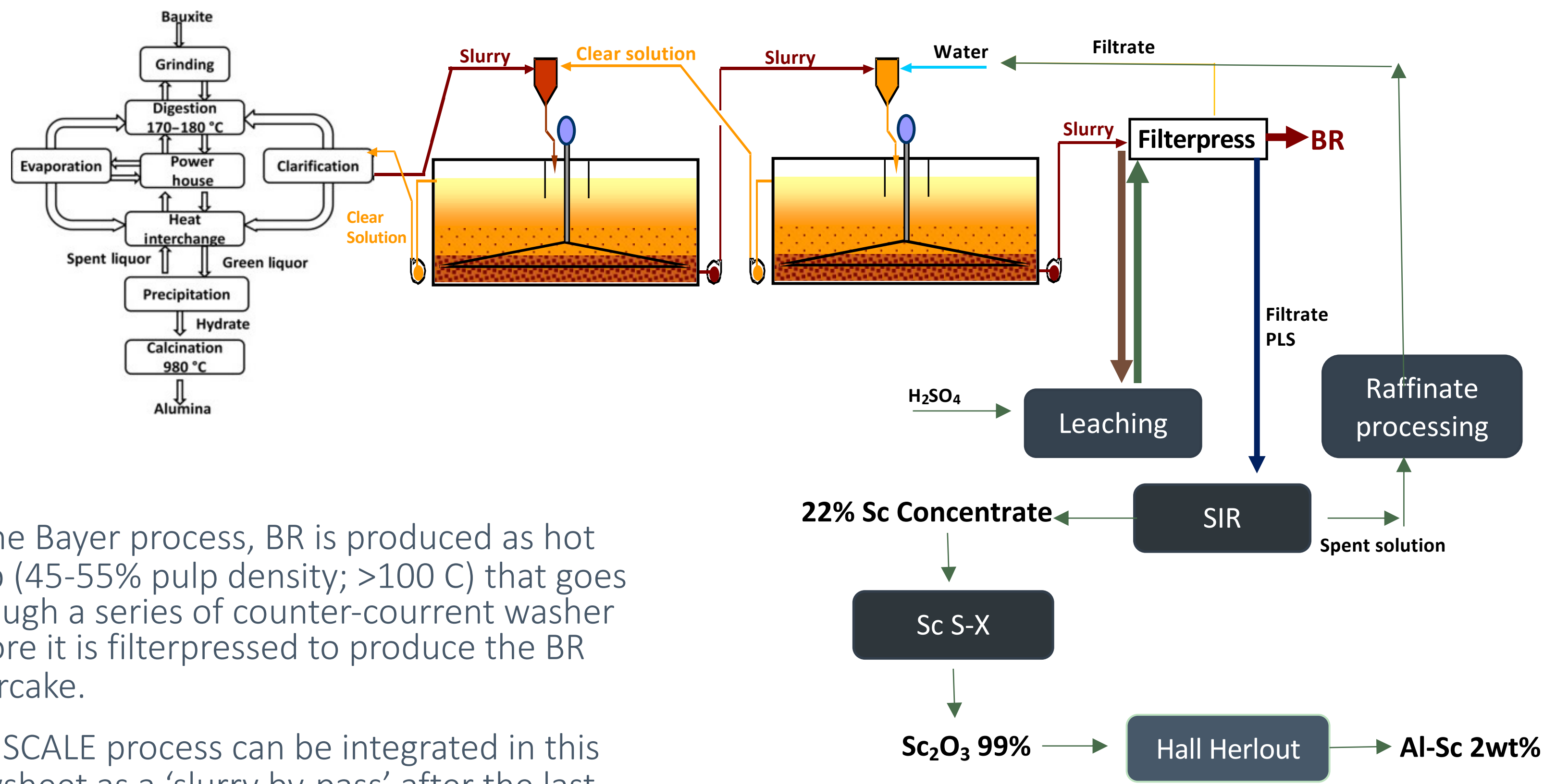
Overall Project highlights

- 10 t of BR have been leached at MYTILINEOS, producing 14 m3 of PLS. **On average 1 t BR 17,15g Sc are dissolved into PLS consuming 0.27t of $H_2SO_4$.**
- The PLS was processed in the II-VI SIR pilot, where loading of the 15 lt column resin reached 3,500 mg Sc/l, without the resin reaching its exhaustion point (full loading capacity is estimated at 4,500 -5,000 mg/l). The elution of the resin provided a solution with 865 ppm Sc, resulting in app **200 g of a crude 22wt% Sc** (or 34% wt Sc2O3) **concentrate**. **Sc was concentrated more than 2500 times from the initial BR to the crude Sc concentrate**

MYTILINEOS

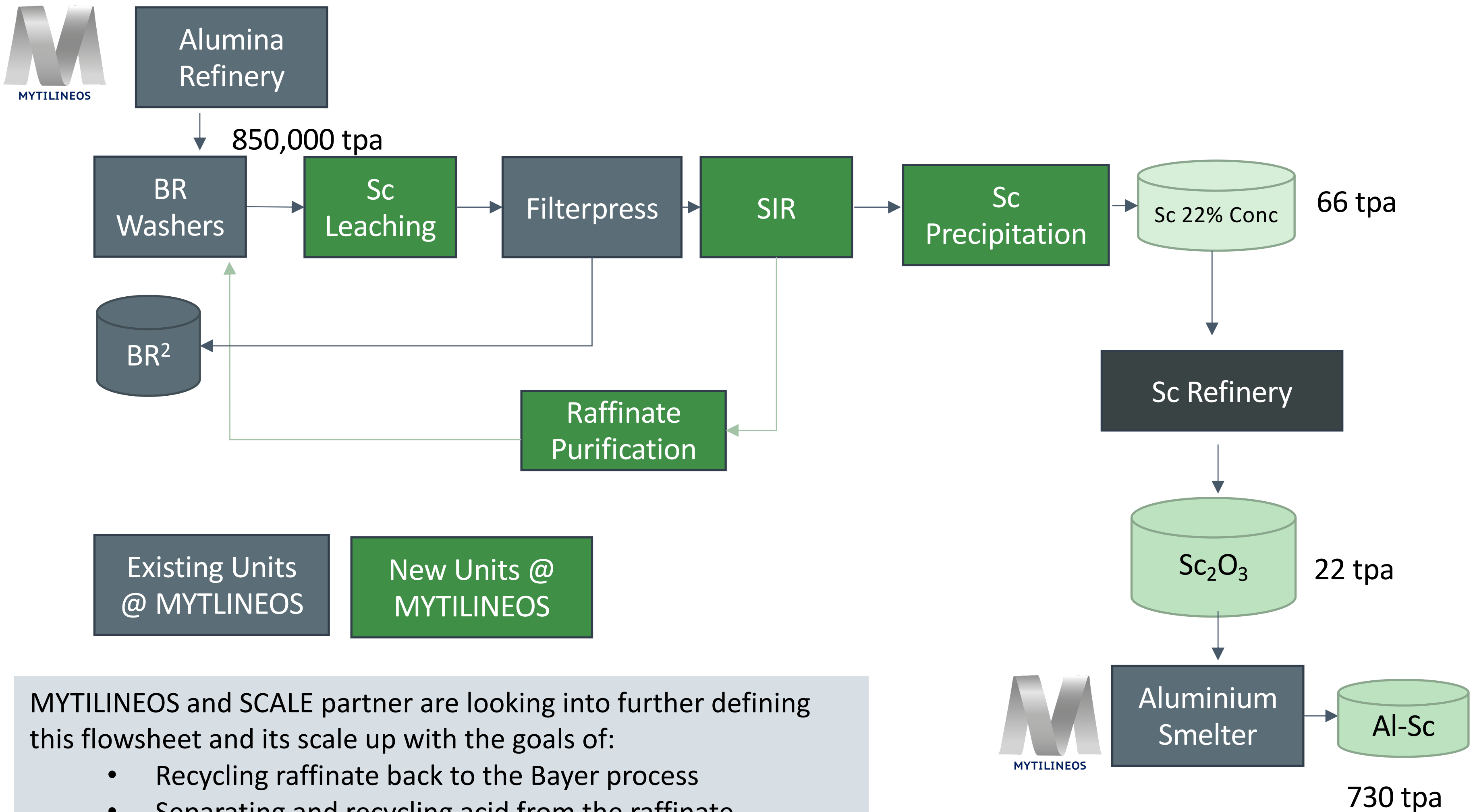
II-VI

# Sc extraction integration into the Alumina plant




- In the Bayer process, BR is produced as hot pulp (45-55% pulp density; >100 C) that goes through a series of counter-courrent washer before it is filterpressed to produce the BR filtercake.
- The SCALE process can be integrated in this flowsheet as a 'slurry by-pass' after the last washer and before the filterpress
- This integration would save substantial heating energy as the slurry is already hot.

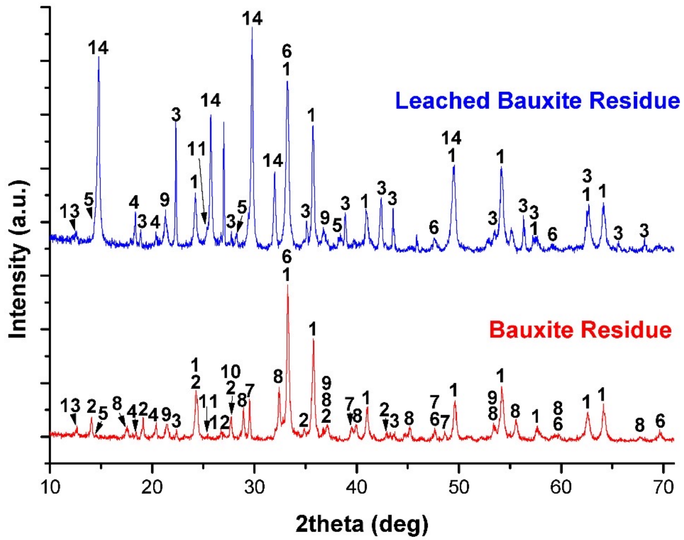
# From BR to Al-Sc2%




MYTILINEOS and SCALE partner are looking into further defining this flowsheet and its scale up with the goals of:

- Recycling raffinate back to the Bayer process
- Separating and recycling acid from the raffinate
- Validating Modified Hall-Herlout in industrial pilot scale

# What about the rest of the BR ?

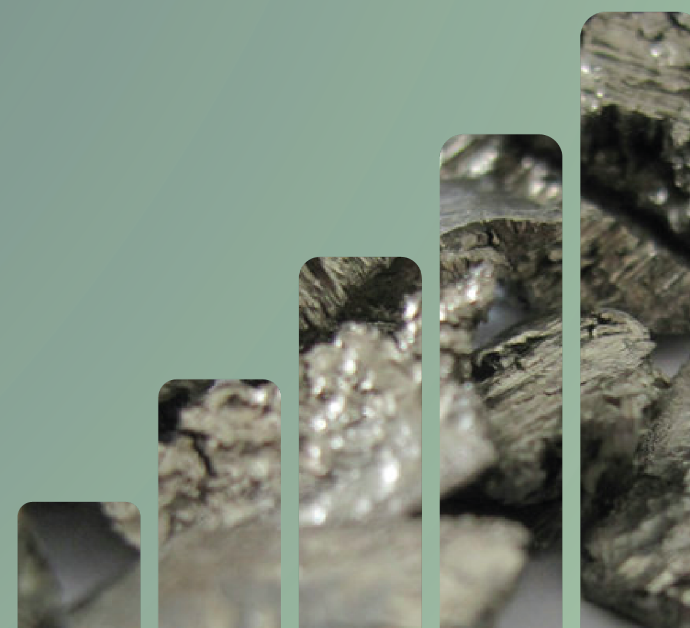



- Missing phases: Cancrinite, Katoite, Calcite
- New Phases: Bassanite Ca2(SO4)2(H2O)
  (and Diaspore phases with higher intensity)

| %wt | $Al_2O_3$ | $Fe_2O_3$ | $SiO_2$ | $TiO_2$ | CaO | $Na_2O$ | $SO_3$ |
|---|---|---|---|---|---|---|---|
| Initial BR | 24.1 | 38.07 | 7.6 | 4.67 | 8.4 | 3.46 | |
| Filtercake | 17.28 | 38.26 | 7.22 | 4.53 | 8.17 | 0.38 | 6.85 |

- The process dissolves an ‘insignificant’ fraction of BR.
- The new filtercake produced is depleted in Na and enriched in $CaSO_4$
- This makes it an excellent alternative raw material for cement clinker production.

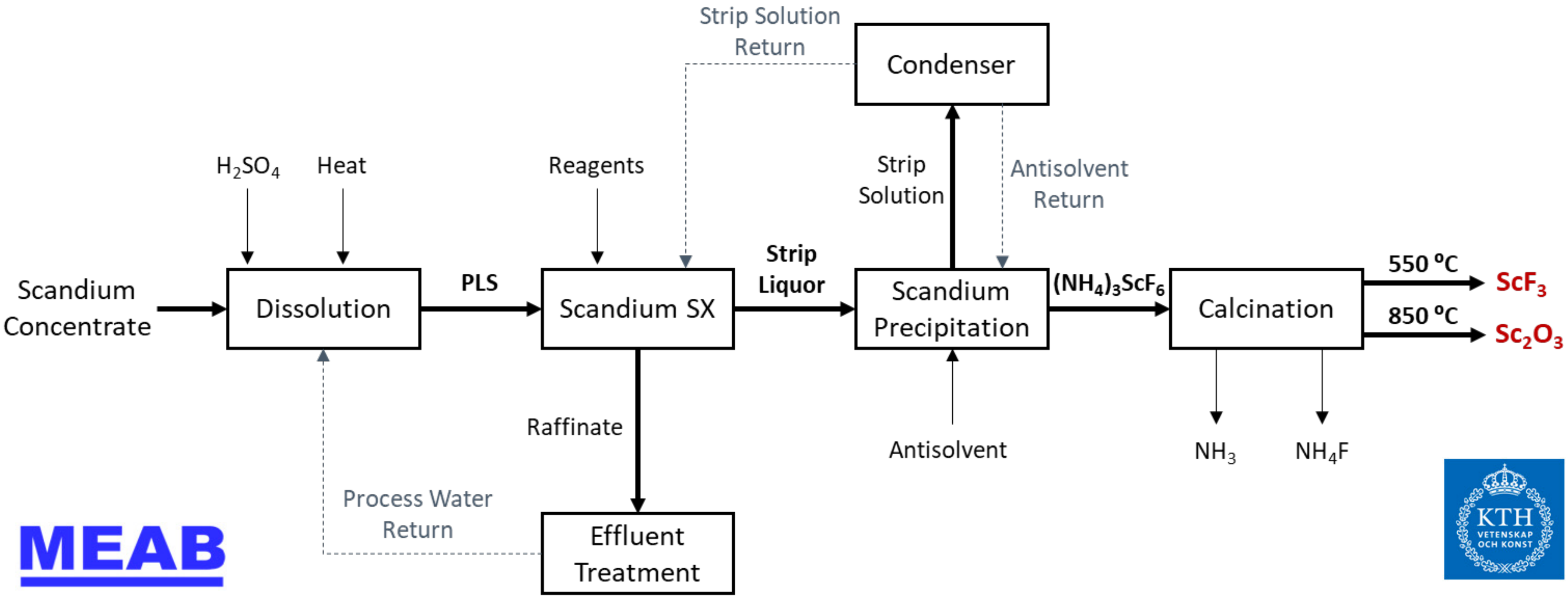
# Purification/Separation Technology



# New $ScF_3/Sc_2O_3$ production technology

*A new flowsheet has been developed for Sc compound production:*

- *Hydrometallurgical processing route*
- *Direct and pure $(NH_4)_3ScF_6$ production without the use of HF gas*
- *Low chemical loss due to antisolvent precipitation and chemical recycling*
- *Flexible products via calcination conditions*
- *> 99% purity for the products*




MEAB

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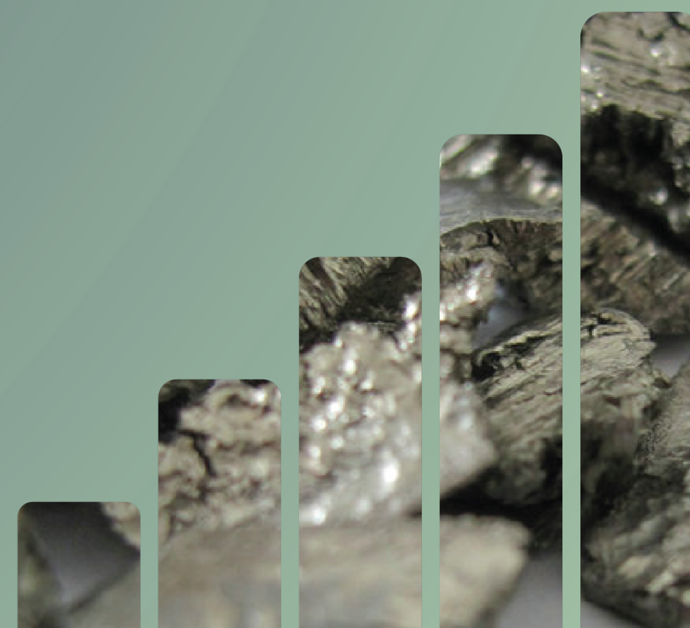
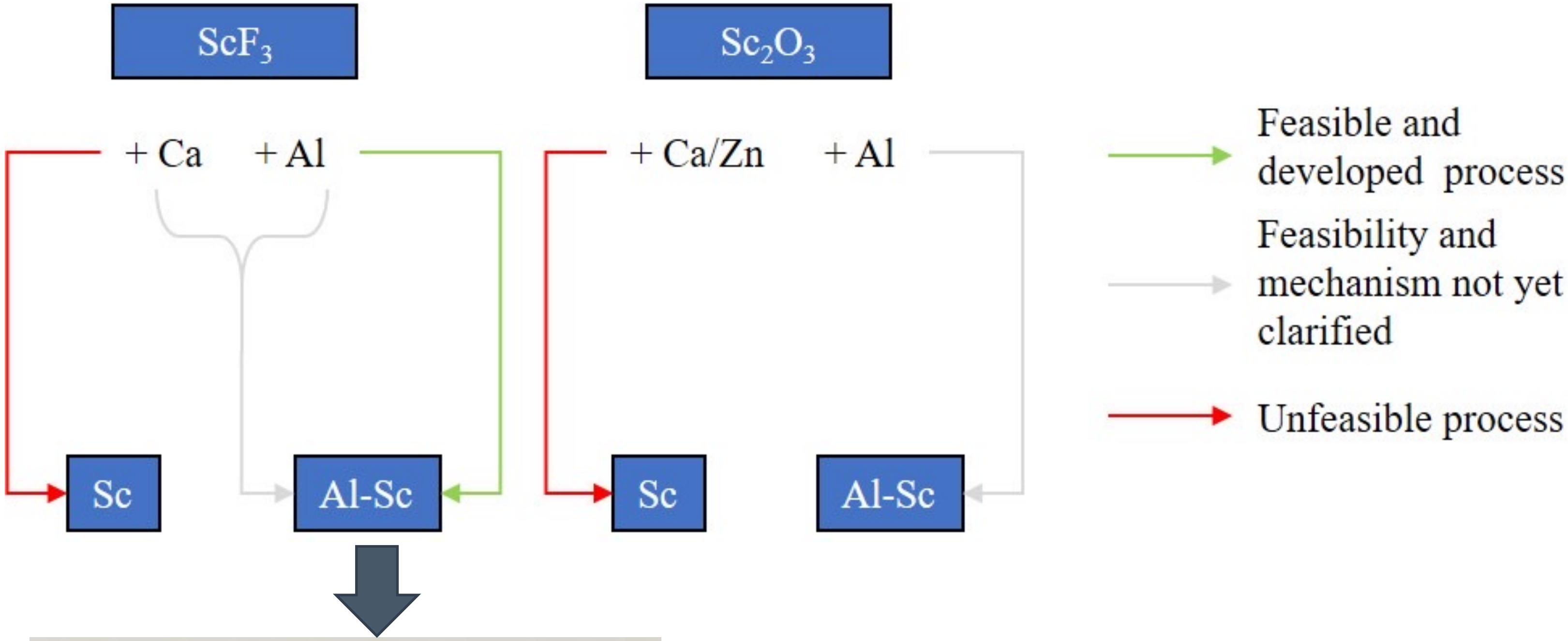
# Metal production



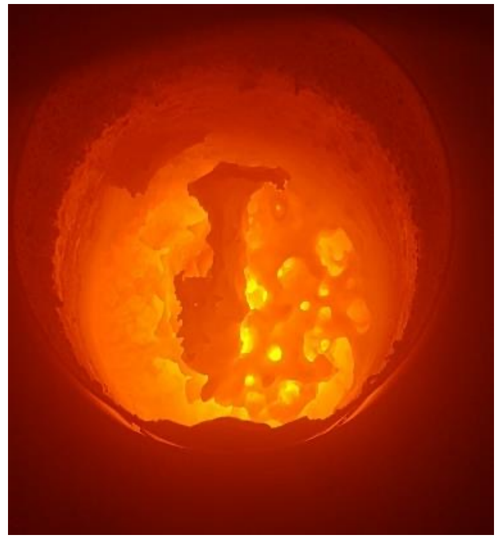
# Sc metal production technologies




| | Al [wt.-%] | Sc [wt.-%] |
|---|---|---|
| Top | 82.1 | 14.1 |
| Bottom | 78.1 | 16.4 |

# Sc metal production and 3D printing

- Pilot scale demonstration of aluminothermic reduction of ScF3 has been conducted at industrial scale in LCM, **7kg of Sc-Al alloy with about 4% Sc have been produced.** KBM has subsequently process the Sc-Al alloy **producing 7 kg of SCALMALLOY®** suitable for atomization and 3D printing**; a demonstration of the established 3D printing technology by AIRBUS followed.**




LCM less common metals

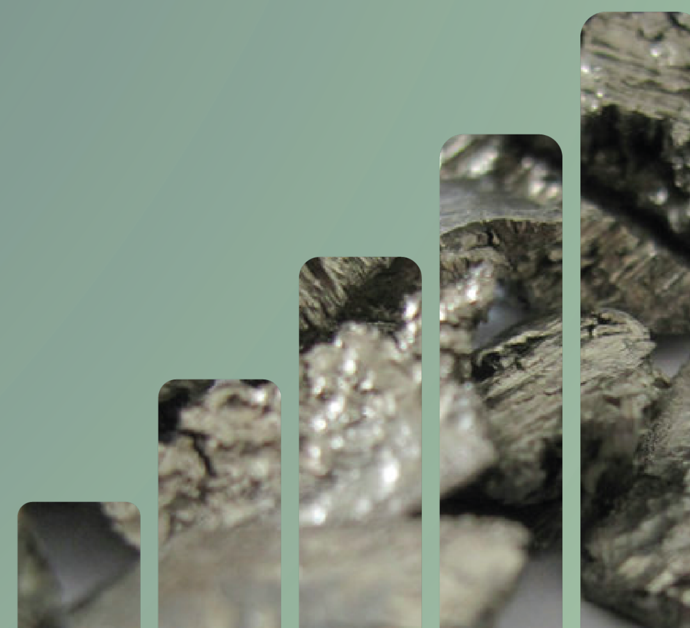
KBM AFFILIPS MASTER ALLOYS

# " Modified" Hall Heroult process

- **It is possible to obtain Al with Sc by the "modified" Hall-Heroult process** using a cryolite melt (CR=2.2), upon $Al_2O_3$ + $Sc_2O_3$ additions, T= 980 °C
- Metal product is aluminium matrix containing **1-2 wt% Sc**
- Long term electrolysis (up-scaling) trial was carried out by SINTEF using $Sc_2O_3$ material from Partner II-VI , and ca. **750 g metal product was obtained**
- **It is possible to use dross residues from the Al-Sc master alloy** production from Partner KBM, as feed (dross= $Al_2O_3$ and $Sc_2O_3$ source)
- The dross material can be valorised in a process that is already industrially implemented aluminium production, thus demanding low CAPEX investments

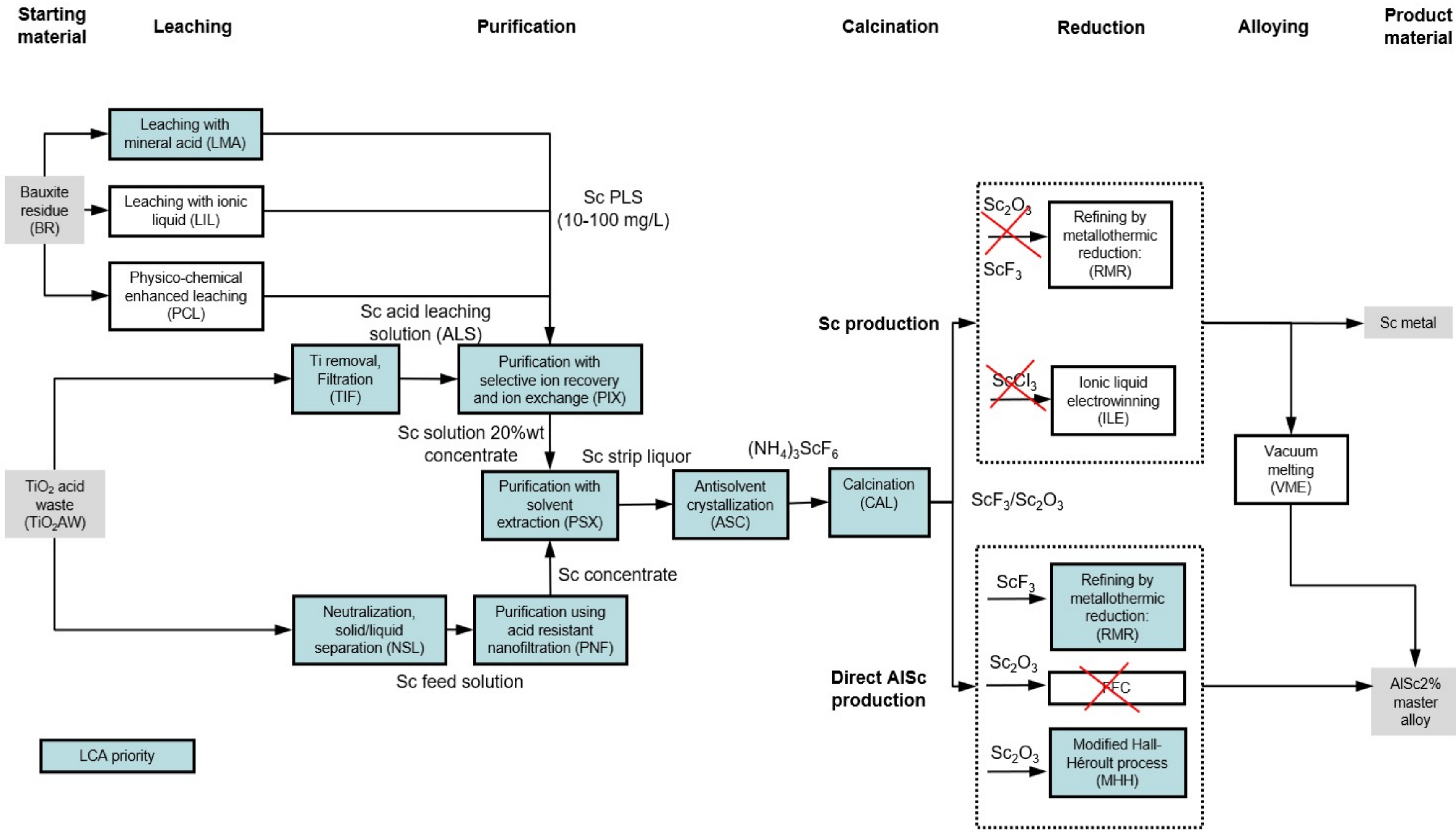
SINTEF

# Novel SCALE flowsheets



Overall Project highlights

# The SCALE technology map




- 11 technologies developed in lab scale at all stages of the value chain
- **5 pilot demonstrations (TRL 5-6) performed** (10 t of BR and 2.8 m3 of AW processed)
- LCA, LCC performed for 3 complete routes : BR to Al-Sc2%, AW to Al-Sc2% with SIR and AW to Al-Sc2% with NF

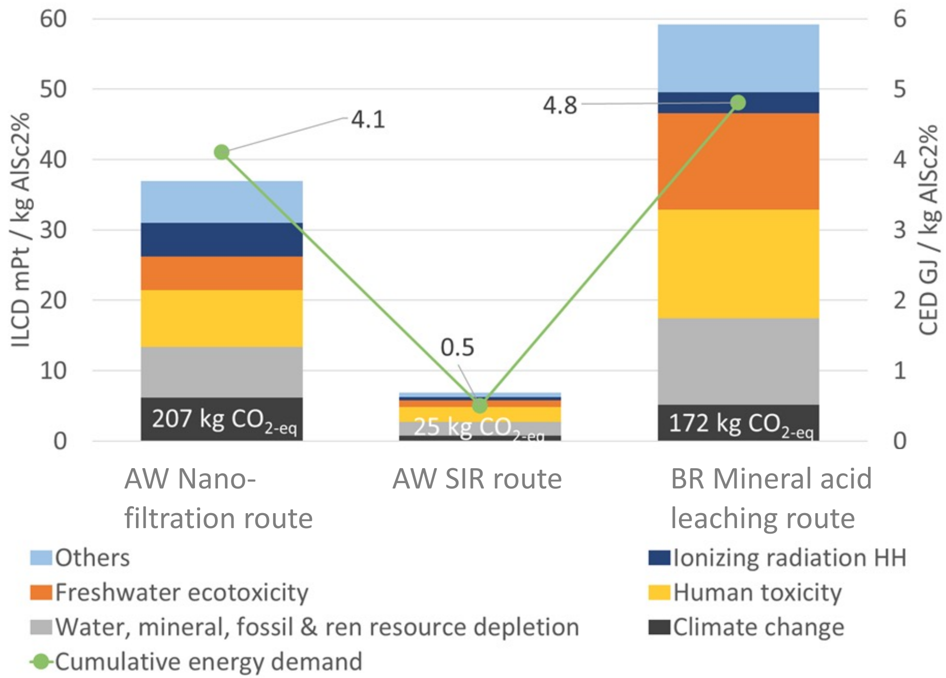
# Cumulative Energy Demand (CED), $CO_2$ , International Reference Life Cycle Data (ILCD) Impacts / kg AlSc2%

- In the SCALE LCA, an **AlSc2% master alloy** is produced **by metallothermic reduction (MR) of $ScF_3$** in the presence of **Al.**. $ScF_3$ is produced equally to $Sc_2O_3$.

- LCA of the **AW-SIR route** indicates **lowest environmental impact** of the three routes. Costs and impact of lime used to neutralize AW prior Sc extraction are zero and count to $TiO_2$ production. At $TiO_2$ production, AW needs to be neutralized before disposal anyway.

- **All impact indicators** for the **AW Nanofiltration route** are **higher by a factor of 7 to 8** than for the SIR route. To neutralize the AW not lime but NaOH is required, which counts to the route and has a significant share on the impact: As already mentioned, a major **potential to reduce electricity consumption** at upscaling.

- The **BR route** show the **highest CED and ILCD impact**, but the $CO_2$ impact is within the 97.5% confidential interval of the value of the AW Nanofiltration




**Comparison of the CED impact in GJ, ILCD category impacts (mPt) and $CO_2$ impact per kg of AlSc2% in the SCALE production routes.**

- It is expected that after a full **integration** of the **energy and material flows** of the **BR route** into **an aluminium plant, environmental impacts and costs can be reduced.** The valorization of the **filter cake** from mineral acid leaching in cement-clinker production reduces the amount of land-filled BR / filter **cake and contributes to reduce freshwater ecotoxicity and human toxicity** caused by leaching to water bodies. Furthermore, the use of the filter cake in the **cement industry saves primary resources**.

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# $CO_2$ impact of $Sc_2O_3$ production

- **BR route:** $H_2SO_4$, steam and electricity consumption contributes 80% to the total $CO_2$ value. Mineral acid leaching consumes most of these resources.
  The $CO_2$ value is 50% lower than the estimated value of $Sc_2O_3$ extraction from REO deposits in China.

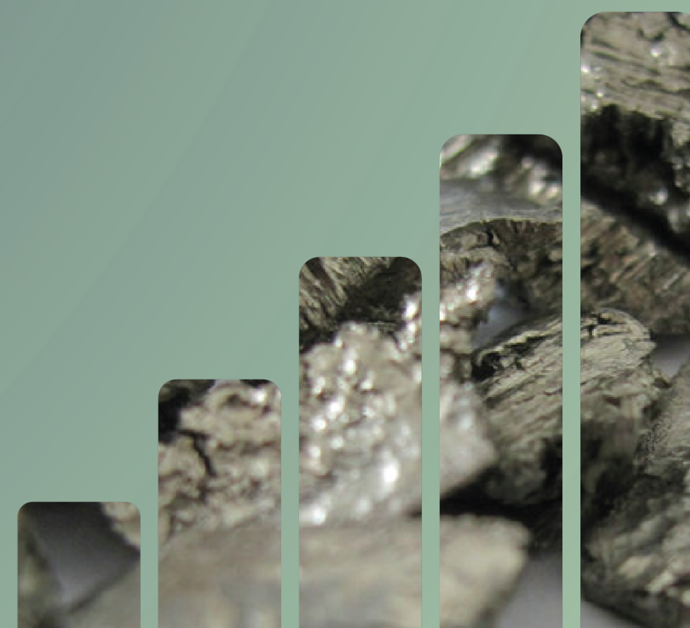
- **AW NF route**: NaOH and electricity consumption mainly at the initial nanofiltration step, contributes 90% to the total $CO_2$ value. This step applied at lab scale consumes most of the resources but has a major potential to reduce electricity consumption.
  It is expected that the $CO_2$ value which is higher by a factor of 8.5 than the published value for $Sc_2O_3$ extraction from $TiO_2$ acid waste in China, will be reduced.

| Sc source | $Sc_2O_3$ production route | t $CO_2$/kg $Sc_2O_3$ | Comparison |
|---|---|---|---|
| Bauxite residues | **BR route:** Mineral acid leaching – SIR – solvent extraction – crystallisation – calcination | 5.06 | 50% |
| REO deposits | State of the art (China)* | ~11** | 100% |
| Acid waste | AW NF route: Nanofiltration – solvent extraction – crystallisation – calcination | 6.32 | 850% |
| Acid waste | AW SIR route: SIR – solvent extraction – crystallisation – calcination | 0.43 | 60% |
| Acid waste | State of the art (China)** | 0.74 | 100 % |

*Value estimated with data vom Koltun and Tharumarajah (2014) and Talens Peiró and Villalba Méndez (2013), **Zhang et al. (2019),

**AW SIR route**: Electricity, heat, HCl consumption and the disposal of solvent regeneration residues contribute ~70% to the total $CO_2$ value. Solvent regeneration and the disposal of the sludges have the major shares. The $CO_2$ value is 60% of the published value for $Sc_2O_3$ extraction from $TiO_2$ acid waste in China.

# Other SCALE Results

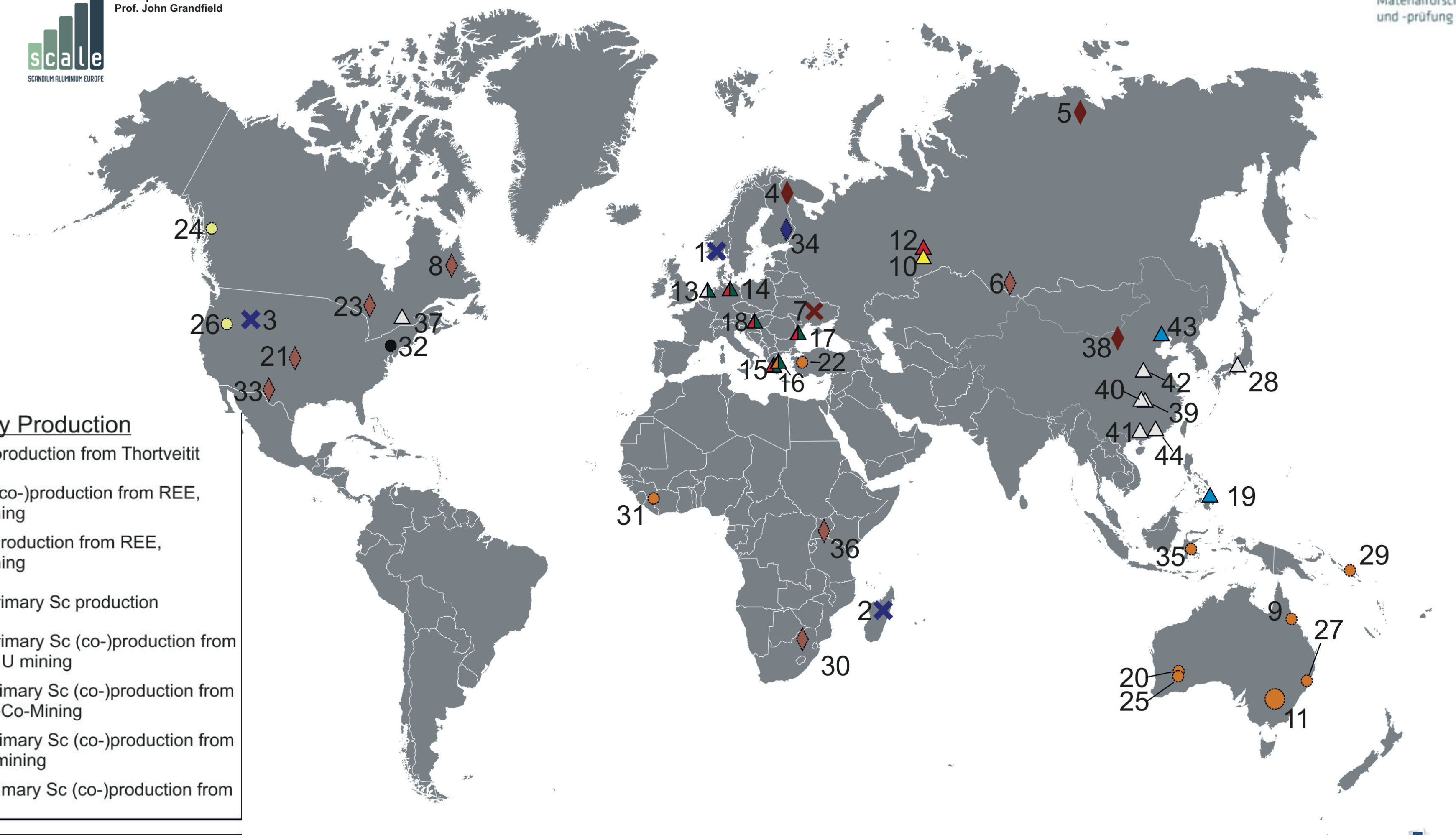


# Scandium Resource Inventory

SCANDIUM ALUMINIUM EUROPE

in cooperation with
Prof. John Grandfield

BAM
Bundesanstalt für Materialforschung und -prüfung




## Primary Production

- past primary Sc production from Thortveitit
- past primary Sc (co-)production from REE, Nb/Ta a./o. U mining
- primary Sc (co-)production from REE, Nb/Ta a./o. U mining
- possible future primary Sc production
- possible future primary Sc (co-)production from REE, Nb/Ta a./o. U mining
- possible future primary Sc (co-)production from laterite mining/Ni-Co-Mining
- possible future primary Sc (co-)production from Au,Cu,Ag or Mn mining
- possible future primary Sc (co-)production from coal mining

## Secondary Production

- by-product Sc production from uranium mining
- by-product Sc recovery from titanium dioxide production/Zirconia production
- by-product/ Sc recovery from bauxite residue (or during alumina production)
- by-product/ Sc recovery from Ni/Co-, Cu-production
- possible resource identified/investigated in SCALE

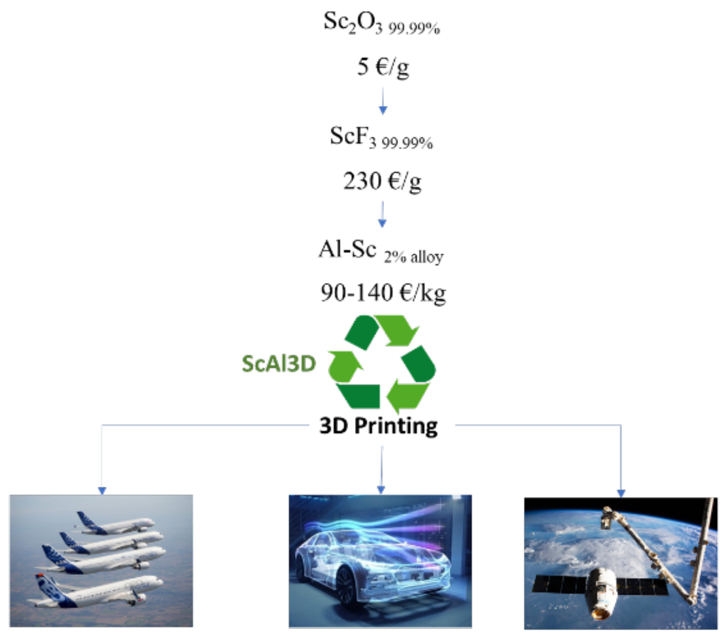
The SCALE project has received funding from the European Union's Horizon 2020 Research and Innovation program under Grant Agreement No 730105

11-New South Wales Projects
Scandium Int. mining, Nyngan Project, Australia
Clean TeQ, Sunrise Project, Australia
Australian Mines, Flemington Project
Platina Ressources, Owendale Project, Australia
12- RUSAL's: Kamensk-Uralsky,Russia
13- TRONOX $TiO_2$ Production, the Netherlands
14- AOS Stade, Germany
15- MYTILINEOS (AOG), Greece
16- LARCO, Greece
17- ALUM, Romania
18- MAL Hungarian Aluminium, Hungary
19- Sumitomo Metal Mining Ltd., Mindanao Island, Phillipines
20- GME, NiWest Project, Australia
21- NioCorp, ElkCreek Project, USA
22- Meta Nickel Cobalt, Gördes Turkey
23- Pele Mountain Resources, Elliot Lake, Canada
24- Romios Gold, Ken Zone, Canada
25- Ardea Resources, Goongarrie, Australia
26- Bayhorse Inc., Bayhorse silver mine, USA
27- MinRex Ltd. Pacific Express Project, Australia
28- Ishihara Sangyo Kaisha, Yokkaichi Plant, Japan
29- Axiom Mining, San Jorge Project, Solomon Islands
30- Glenover Phosphate, Glenover Project, South Africa
31- SRG Graphite, Gogota Project, Guinea
32- Texas Mineral Resources, Pennsylvania Anthracite, USA
33- Texas Mineral Resources, Round Top Project, USA
34- Scandium International, Kiviniemi Project, Finnland
35- PT Vale Indonesia, Sorowako, Indonesia
36- Ionic rare earths, Uganda
37- Rio Tinto Fer et Titane (RTFT) Quebéc, Canda
38- Bayan Obo deposit China
39- Hunan Oriental Scandium, China
40- Taojiang Ruilong Metal New Material, Hunan, China
41- Guangxi Maoxin Technology, China
42- Jiaozuo Rongjia Scandium, Henan, China
43- MCC New Material, Hebei, China
44- Huizhou Top Metal Material, Guangdong, China

https://www.scaletechnology.eu/scandium-inventory-world-map/

# Scandium from SCALMALLOY® Powder

- New method to recycle Sc, REEs, Mg, Co, Ni and Li
- Environmentally friendly, simple and sustainable
- Developed by MEAB in Aachen
- Patent application (No: EP19160176.4 - filed in 2019)
- For SCALMALLOY® case $CuSO_4$ slurry used



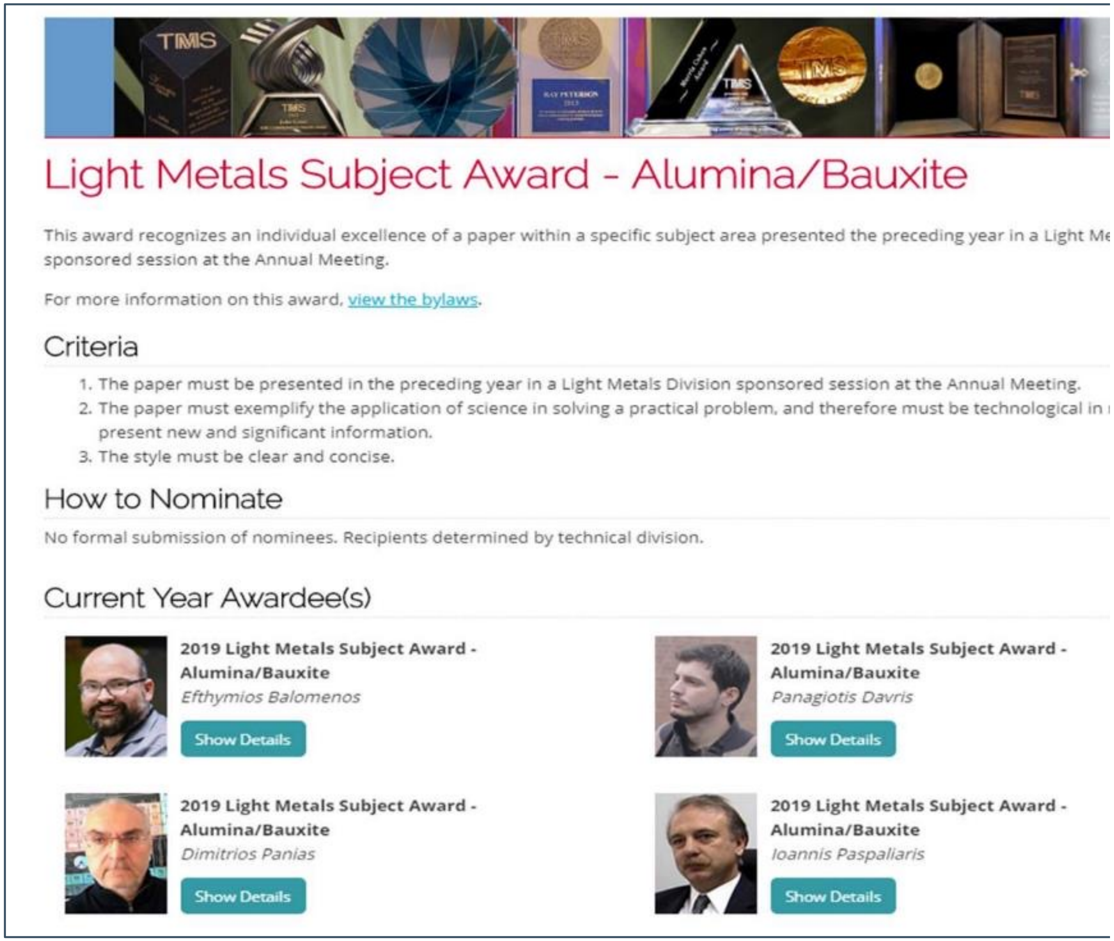

**Acknowledgement of receipt**

We hereby acknowledge receipt of your request for grant of a European patent as follows:

| | | |
|---|---|---|
| Submission number | 7241224 | |
| Application number | EP19160176.4 | |
| File No. to be used for priority declarations | EP19160176 | |
| Date of receipt | 01 March 2019 | |
| Your reference | H68287-mat | |
| Applicant | MEAB Chemie Technik GmbH | |
| Country | DE | |
| Title | Method of dissolution and separation of critical raw materials (CRM) | |
| Documents submitted | package-data.xml<br>application-body.xml<br>SPECEPO-1.pdf\H68287 specification.pdf (25 p.) | ep-request.xml<br>ep-request.pdf (4 p.)<br>f1002-1.pdf (1 p.) |
| Submitted by | CN=Dirk Broecher 11899 | |
| Method of submission | Online | |
| Date and time receipt generated | 01 March 2019, 09:05 (CET) | |
| Message Digest | 9D:C4:B6:8E:CD:DB:D0:3D:66:24:C2:E1:B7:7A:3B:6B:6D:88:E8:CA | |

MEAB

# TMS Light Metals Subject Award 2019



Light Metals Subject Award - Alumina/Bauxite

This award recognizes an individual excellence of a paper within a specific subject area presented the preceding year in a Light Me
sponsored session at the Annual Meeting.

For more information on this award, view the bylaws.

Criteria

1. The paper must be presented in the preceding year in a Light Metals Division sponsored session at the Annual Meeting.
2. The paper must exemplify the application of science in solving a practical problem, and therefore must be technological in
present new and significant information.
3. The style must be clear and concise.

How to Nominate

No formal submission of nominees. Recipients determined by technical division.

Current Year Awardee(s)

2019 Light Metals Subject Award - Alumina/Bauxite
*Efthymios Balomenos*
Show Details

2019 Light Metals Subject Award - Alumina/Bauxite
*Panagiotis Davris*
Show Details

2019 Light Metals Subject Award - Alumina/Bauxite
*Dimitrios Panias*
Show Details

2019 Light Metals Subject Award - Alumina/Bauxite
*Ioannis Paspaliaris*
Show Details

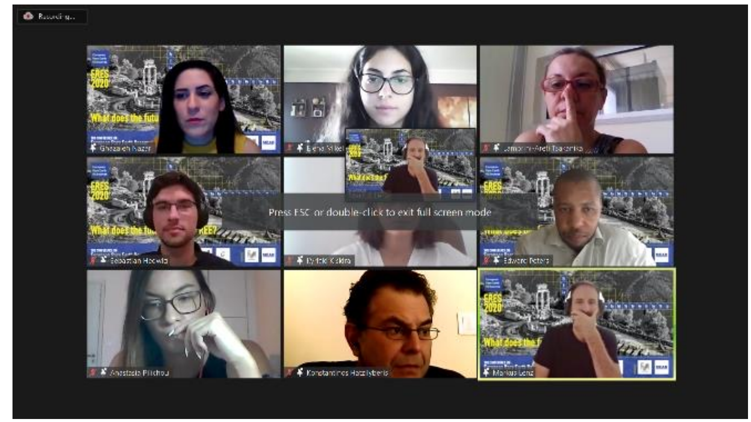
***"Developing a new process for selective extraction of Rare Earth Element from Bauxite Residue based on factionalized ionic liquids".***

Using a novel organic solvent, the team was able to selectively recover the 'trace amounts' of Scandium found in the Greek Bauxite Residue and produce concentrated scandium bearing solutions that can be used for Scandium production.

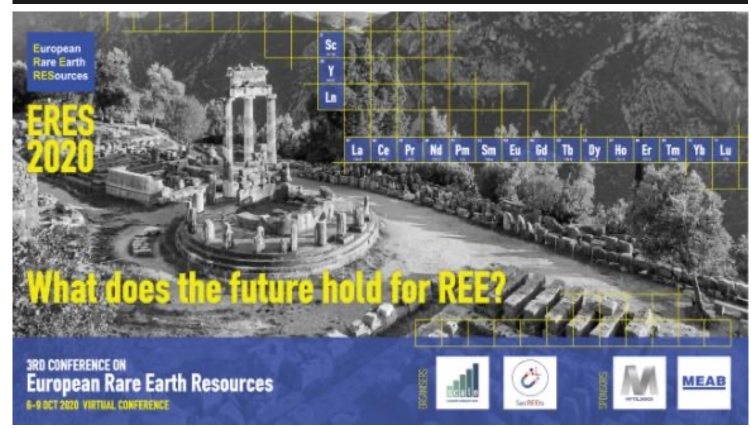
This work was presented in the TMS conference in 2018 and has been published in Light Metals 2018, The Minerals, Metals & Materials Series.

# SCALE results

- SCALE organized **a Sc workshop in 2018** (20 presentations, 48 participants in 2-day event) as well as the **3rd European Rare Earth Resources** (ERES) conference in 2020 (46 presentations -105 registered participants in a 3-day online event).
- 13 publications in Journals, 52 presentations in conferences
- 2 public videos on SCALE technologies
- Participation at the 2019 Raw Materials Week in Brussels, European Researcher nights and others.





Adam Christian
Albert Boehlke
Ajexandro Simon De Dios
Ana Maria Martinez
Anna Lisa Bachmann
Arturio Sanabria
Asterios Delipaltas
Bengi Yagmurlu
Bernd Friedrich
Betty Tsakanika
Boyan Illiev
Carsten Dittrich
Chris Hall
Christina Dalla
Christoph Hugi
Dimitris Panias
Dirk Hengevoss
Edward Peters
Efthymios Balomenos
Egil Skybakmoen

Elena Mikeli
Emese Vaszita
Eva Ujaczki
Evangelos Bourbos
Fernadno Marin
Francesca Di Carolo
Francisca Gaona
Frank Diekmann
Frederic Brinkmann
Gert Homm
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Henk Van der Laan
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Wen-Qing Xu

https://www.scaletechnology.eu/

http://www.circulary.eu/project/scale/

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The research leading to these results has been performed within the SCALE project (http://scale-project.eu/) and received funding from the European Community's Horizon 2020 Programme (H2020/2014-2020) under grant agreement n° 730105.