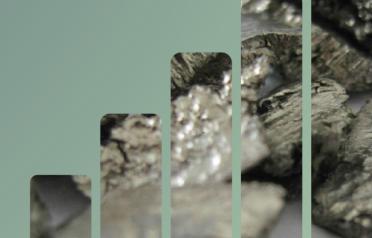


# SCALE project results – year 3

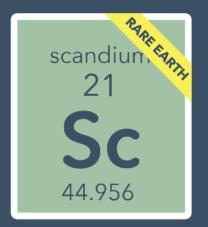
Efthymios Balomenos, Mytilineos S.A.









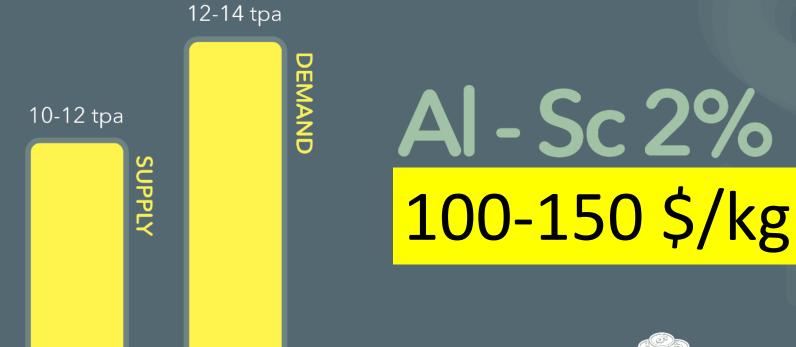


# GLOBAL PRODUCERS

**Sc** is produced in a handful of places globally



# THE ECONOMY OF Sc











Sc VALUE CHAIN: 0.9 \$/g

Sc<sub>2</sub>O<sub>3</sub> 99%

5 \$/g

Sc<sub>2</sub>O<sub>3</sub> 99,99%

253 \$/g

ScF3 99,99%

206 \$/g

Sc Metal

## WHERE IS Sc FOUND?

Viable sources of **Sc** today



Bauxides and nickel laterite ores are proposed as the most promising **Sc** resources for future large scale production; **Parnassos/Greece could well be a worldwide resource for Sc!** 

# 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

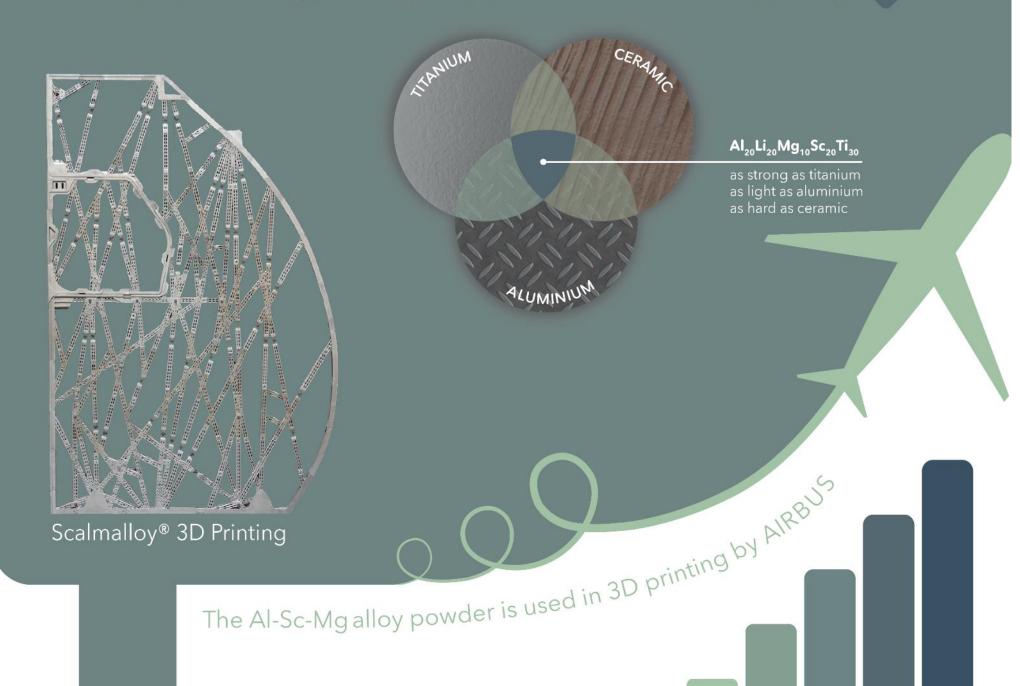
### **NATURAL LIGHT**

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

Sc GOES WELL WITH A



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





Bauxite Residues TiO2 Pigment Acid Wastes mg/kg

### **EXTRACTING**

Sc from waste





### SCANDIUM ALUMINIUM EUROPE









## **SCALE:**

Production of Sc compounds & Sc-Al alloys from

European metallugrical

by-products



LASERS: YSG GARNETS



SSZ LAYER SOLID OXIDE **FUEL CELLS** 



AL-SC ALLOY



SCALMALLOY **3D PRINTING** 



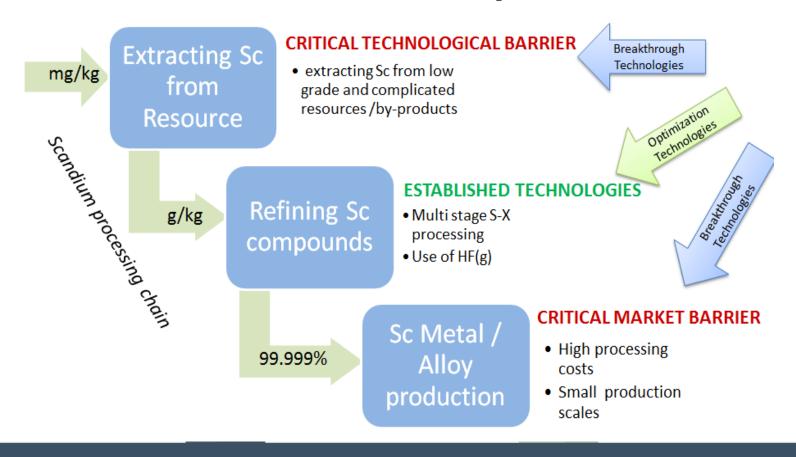








### **Scandium Production today**



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





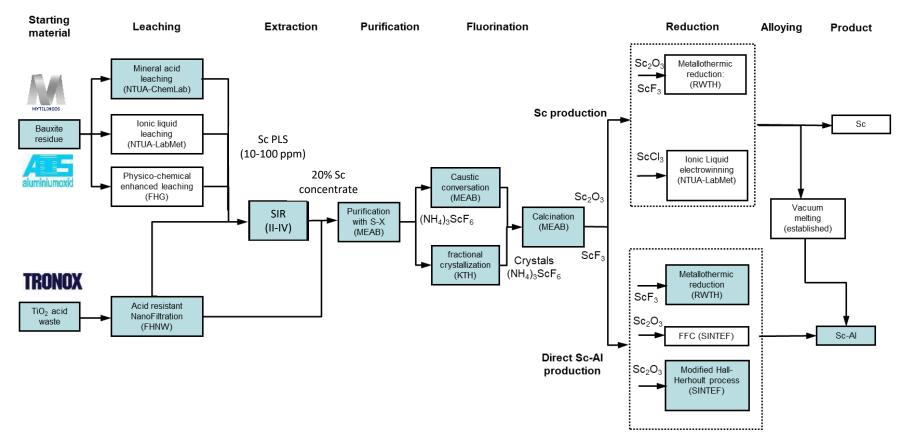








### The SCALE technology map



In highlight technologies to be demonstrated in pilot/bench scale









































### **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.
- 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 Dimitrios Panias

Show Details



2019 Light Metals Subject Award -Alumina/Bauxite Panagiotis Davris

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".

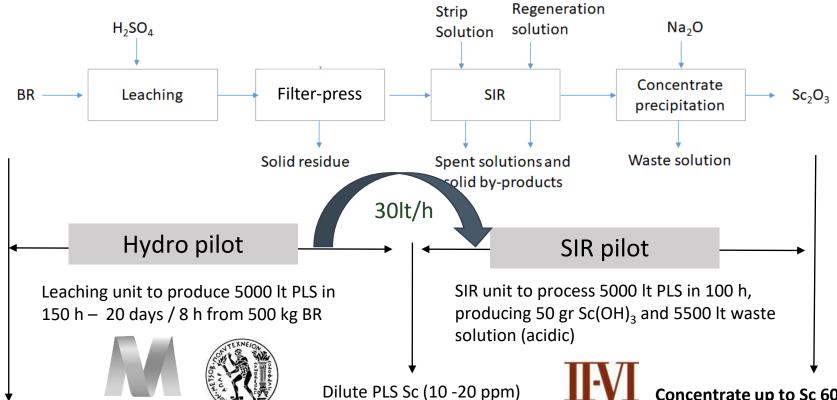
Using a novel organic solvent, the team was able to selectively recover the 'trace amounts' of Scandium found in the Greek Bauxite Residue and produce concentrated scandium bearing solutions that can be used for Scandium production.

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





### Basic Design on the SCALE BR pilot



KB Sc 0.1 gr/kg

BR	ppm (mg/kg)
Sc	104
Fe	298,108
Al	132,811
Ti	28,885
Na	14,833

Precipitate up to 0.4 gr/kg

Sc Conc.	ppm
Sc	405
Fe	172,515
Al	131,688
Ti	9,833
Na	41,696

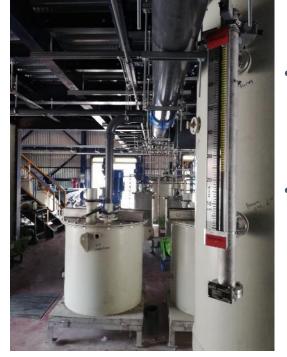
### Concentrate up to Sc 60 gr/kg

Sc conc.	ppm
Sc	59,791
Fe	857
Al	391
Ti	5,265
Si	3,524



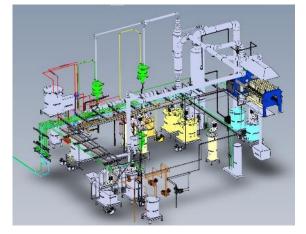
## **SCALE pilot @ MYTILINEOS**







- Operations to begin in the coming days
- Leaching of at least 500 kg of Bauxite Residue is foreseen

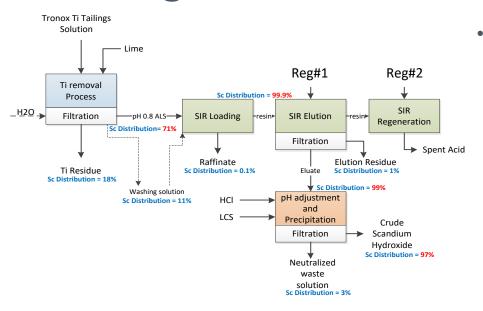








### **Extracting Sc from TiO2 Acid Waste**



Prototype SIR extraction plant successfully commissioned and operated with 2 m<sup>3</sup>

Tronox AW, producing 1.2 kg of Sc concentrate with 80% efficiency (SIR process efficiency 95%)

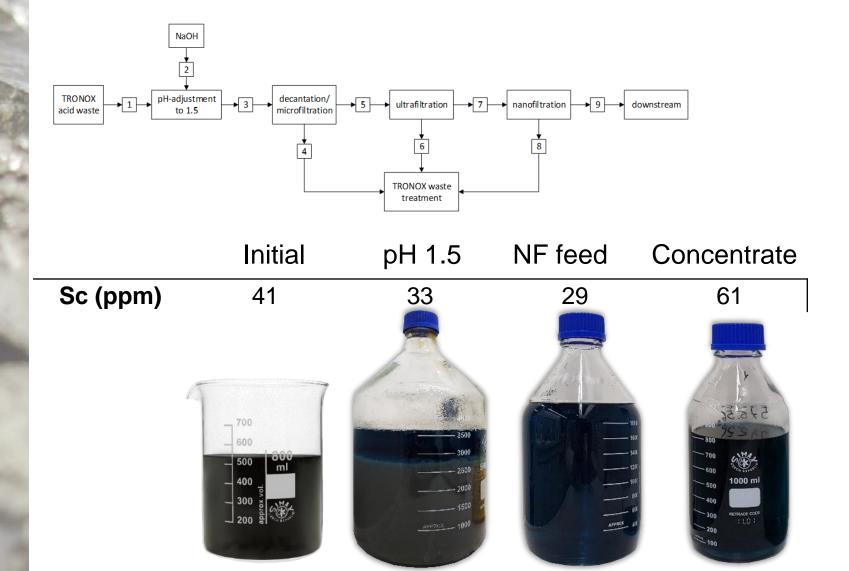






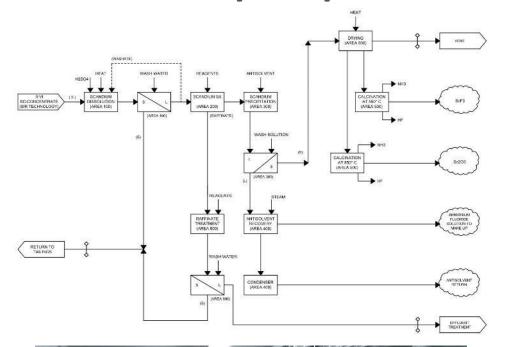
### **Acid Waste Nanofiltration**







### **New S-X and precipitation route**



- A new flowsheet has been developed for Sc compound production:
- It allows for direct and pure (NH<sub>4</sub>)<sub>3</sub>ScF<sub>6</sub> production without use of HF gas.
- The (NH<sub>4</sub>)<sub>3</sub>ScF<sub>6</sub> can be then converted to ScF<sub>3</sub> or Sc(OH)<sub>3</sub>

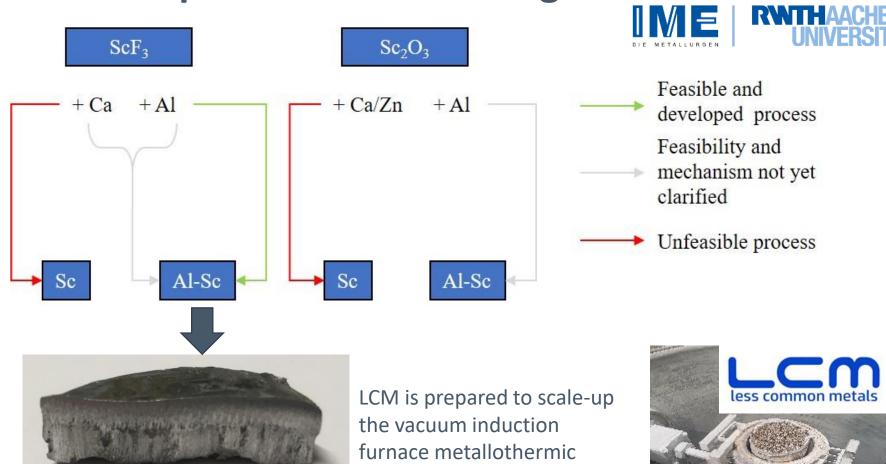








### Sc metal production technologies



	Al [wt%]	Sc [wt%]
Тор	82.1	14.1
Bottom	78.1	16.4

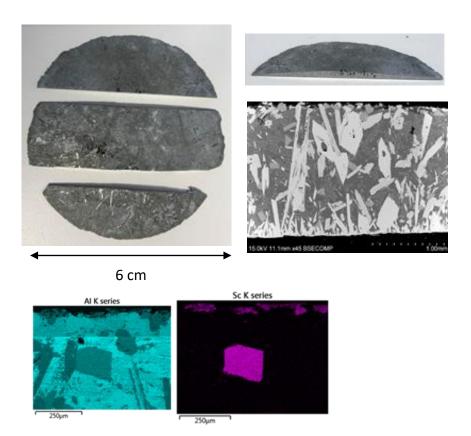
technology for production of Sc and Al-Sc alloy at a 5kg batch scale.



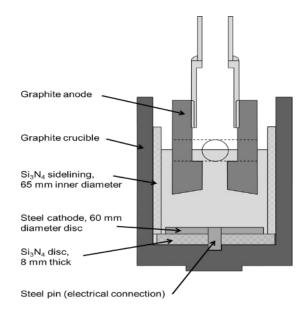


### "Modified" Hall Heroult process





- Using similar electrolysis cell as today's industrial aluminium production (Hall-Heroult)
- Sc<sub>2</sub>O<sub>3</sub> as raw material

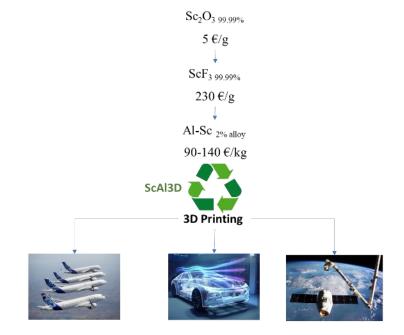


Al with 2.6 wt% Sc is produced upon Sc<sub>2</sub>O<sub>3</sub> addition in the cryolite-based melt



### 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 <sup>®</sup> case CuSO<sub>4</sub> slurry used





#### Acknowledgement of receipt

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

Country DE

Method of dissolution and separation of critical raw materials (CRM)

Documents submitted package-data.xml
application-body.xml

SPECEPO-1.pdfH68287
specification.pdf (25 p.)

ep-request.xml ep-request.pdf (4 p.) 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
 90:C4:B6:8E:CD:DB:D0:30:66:24:C2:E1:B7:7A:3B:6B:6D:88:E8:CA

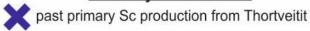


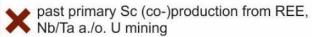


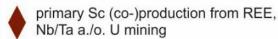
### Putting Sc on the map



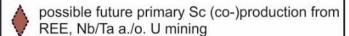
### **Primary Production**











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



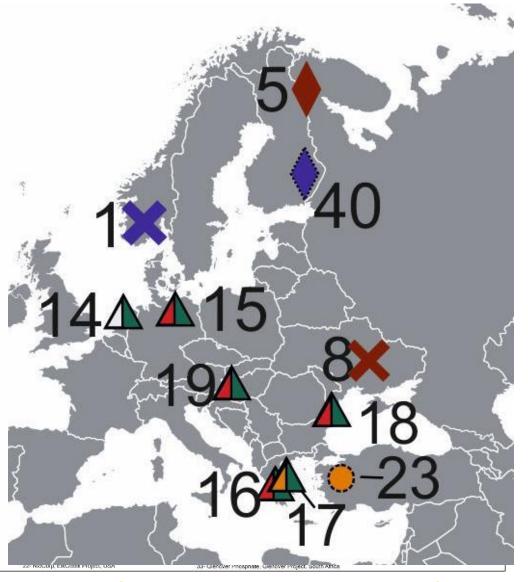
secondary Sc production from uranium mining

secondary production/ recovery from titanium dioxide production

secondary production/ recovery from bauxite residue (or during alumina production)

possible secondary production/ recovery from Ni/Co-, Cu-production

possible resource identified/investigated in SCALE





### Putting Sc on the map

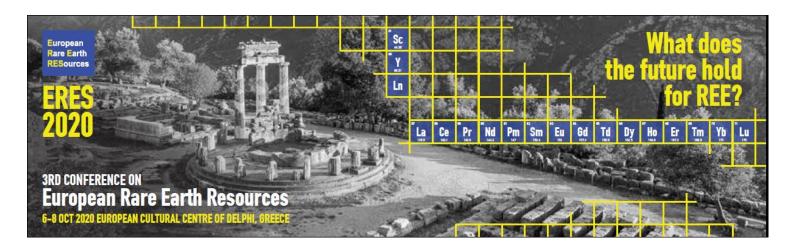
- 57 conference/Workshop presentations
- 8 publications in Journals
- 1 international award (TMS 2019)
- 1 patent application
- In 2018 SCALE Organized 2-day WS with 50 Sc stakeholders from Europe and beyond





Light Metals Subject Award - Alumina/Bauxite

➤ Will organize an international conference for REE/Sc (ERES2020)





## **Putting Sc on the map**



JRC SCIENCE FOR POLICY REPORT

Recovery of critical and other raw materials from mining waste and landfills

> State of play on existing practices

Blengini, G.A.; Mathieux, F.; Mancini, L.; Nyberg, M.; Vieges, H.M. (Editors)



Scale presented at Indo-European Meet

NAME AND ADDRESS OF THE SOURCE STATE ASSESSMENT ASSESSM

On the 18, 19 and 20 September 2019, SCALE, together with the EnsuraAl and RemovAl projects, was presented at the Partnership Instrument EU-REI event "Indo-European Meet on Resource Efficiency in the Allumini mindustry with a Focus on Effective Utilization of Red Mud (Bausde Residue)". After a first round of meetings with the highest levels of the Indian Government and Industry.



SCALE participated in MIREU's SLO workshop

| Dyadolo ||| Commerciani

SCALE was presented at the 3nd SLO Workshop Ensuring SLO is Adaptive and Resilient (5-6 June 2019, Brussels, Belgium), within the context of the MIREU project. The referent essents with regard to SLO, as well as additional appears which affect the market deployment of the new technologies developed by SCALE, were presented to and discussed with a mailterine committee (parther surrently).



SCALE AT THE WORKSHOP ON SOCIAL ACCEPTANCE IN THE EUROPEAN RAW MATERIALS SECTOR



CAPTURE | TANK OF COMMENTS

Note an imposed with workshop or nodel acceptance in the bisopper nemnatorials south. The critical continuously is acceptance with location of the continuously in the continuously in the acceptance with location of the acceptance with a continuously in the acc



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SCALE PRESENTED AT HEQUE INNOVATION FORUM



MINOR L'BIANC | IN Communité

On October 4th 2018 SCALE both partiet in the total 2000 through France advanting event, bit ging together HCCOD projects, but also policy make a, and cases and industry normalizations make the producting private and policy make a and in route the 2012.

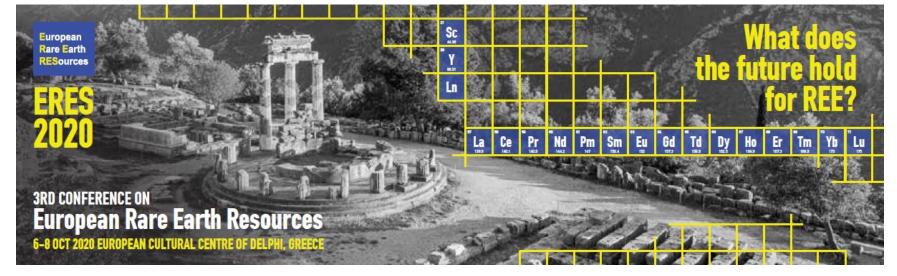
Two March and an idea in a Communication of war access SLE which couldn't suck a power to a advance and year Mill made, activities seek the could full in section, respect section, means, we see:



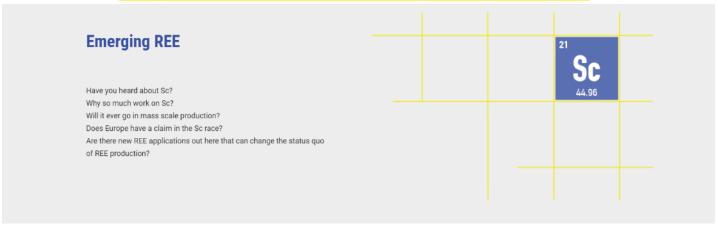
## **Overall Project status/highlights**

- Leaching and extracting Sc from BR has been achieved in lab scale and will be demonstrated in pilot scale
- Extracting Sc from AW has been demonstrated in pilot scale 1kg of crude Sc concentrate produced.
- A new flowsheet for Nano-filtration and Solvent-Extraction has been achieved in lab scale and will be demonstrated in pilot scale.
- A patent has been filed for an innovative process on SCALMALLOY underspray powder recycling.
- Multiple routes for Sc and Al-Sc alloy production have been investigated in lab scale. Pilot scale demonstration to be conducted.
- A worldwide map of Sc resources has been compiled.
- Detailed LCA/LCCA and environmental impact analysis is under way.
- The SCALE single entry point is been designed as incubator for SCALE business plan.
- SCALE paper has received the TMS subject award-Alumina/Bauxite.





### http://eres2020.eres-conference.eu/.



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