Sustainable Production of Scandium Products in Europe

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MEAB

eit RawMaterials
Connecting matters

Co-funded by the European Union

Contents

Background

Abundance

- Sc concentration in the earth's crust: 22 ppm
- Rare or not?
- Scarcity of scandium-containing ores[1-2]

Metal	Concentration (ppm)
Co	18
Pb	16
Tn	2.5
Li	18
Ag	0.07
Au	0.004

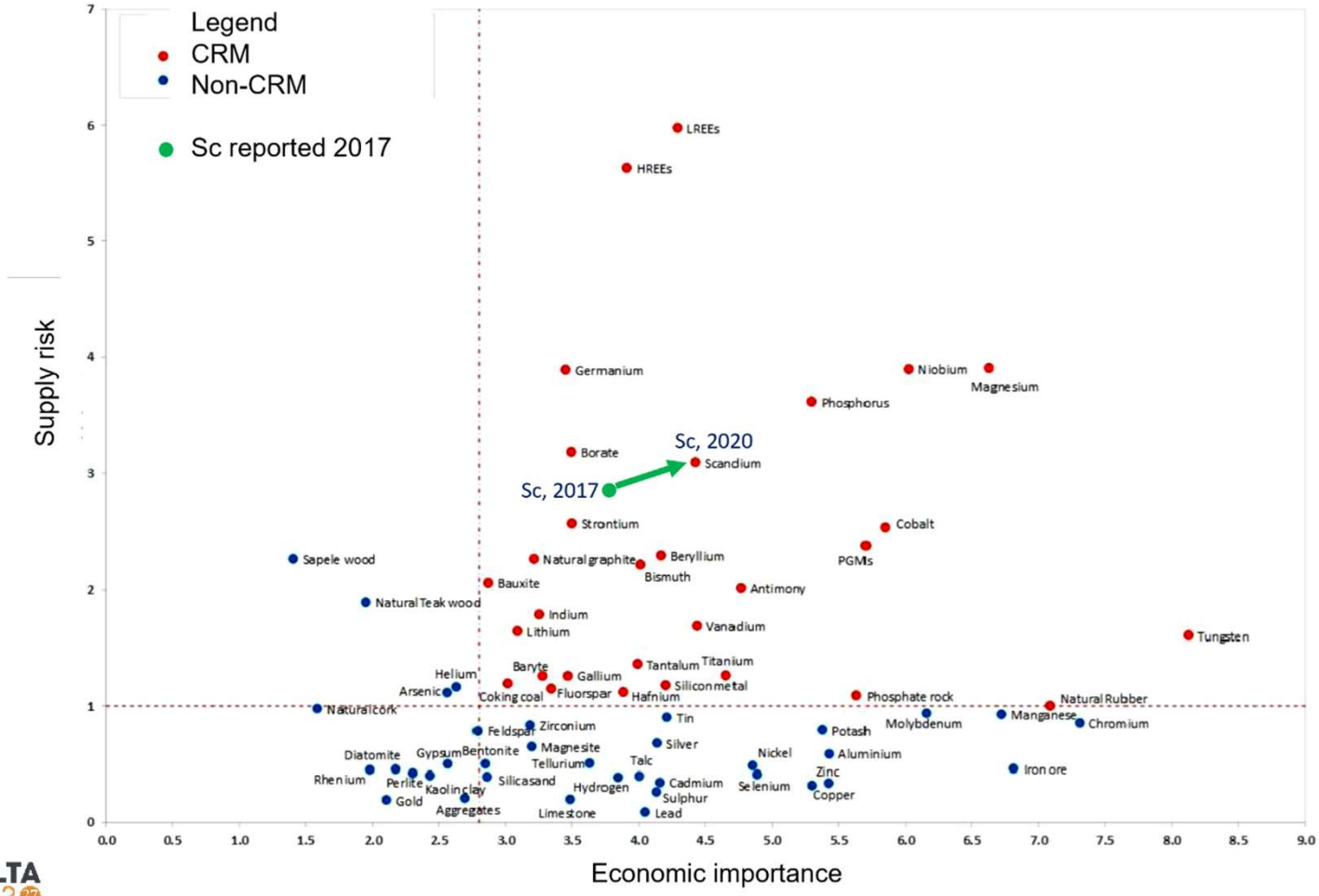
Background

Applications[3,4]

- Al-Sc alloys < 2 wt. % Sc (Aviation industry)
- Solid Oxide Fuel Cells (SOFCs) & Solid Oxide Electrolyzer Cells (SOECs)
- 5G thin films (Al-Sc-N)
- Ceramics
- Lighting
- Lasers
- Electronics
- 3D printing

Background

Supply vs. Demand[4]



- Supply risk and economic importance of Sc increased from 2017 and 2020

Background

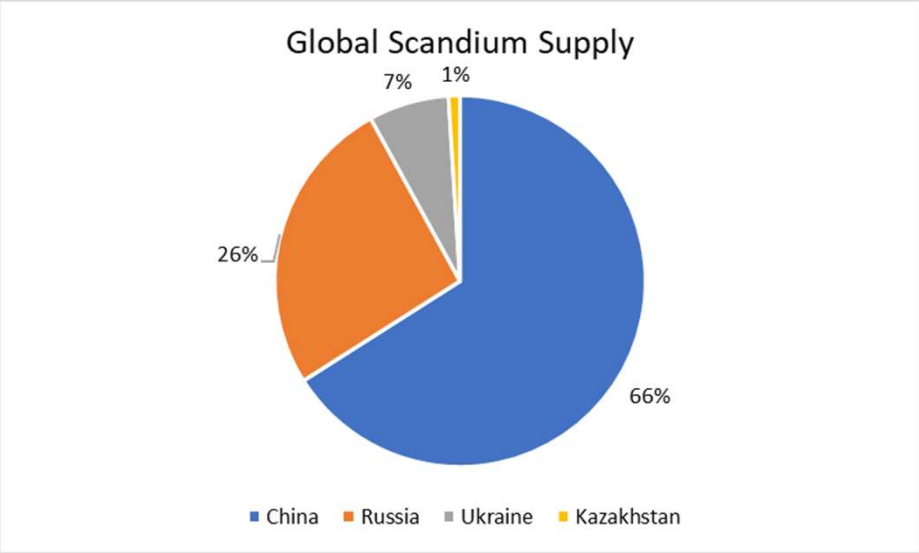
Trade

- Current prices:[3]

Product	$US per gram (2022)
ScF_3 99.9% pure	250
Sc_2O_3 99.99% pure	2.1
Sc Ingot	150

- Current global Sc supply: 15 – 25 t/yr
- EU currently relies on 100% imports

[4]



Scandium Primary and Secondary Resources

Primary

- Thortveitite & Kolbeckite ores ($(Sc,Y)_2Si_2O_7$: < 45% Sc_2O_3; Madagascar and Norway[1,5,6]
- Wolframite ores (0.1% Sc) [1]
- Fe-Nb REE deposit (Bayan Obo, China: 0.006 – 0.016% as Sc_2O_3)[1]
- Elk Creek Carbonitite Nb ore, Nebraska (65.7 ppm Sc) [3,5,7]
- Ni-Co laterite ores (0.005 – 0.06% Sc): Nyngan, NSW, Australia[5,8], SCONI project, Queensland[6]

Secondary

- Bauxite Residue (red mud)
- TiO_2 acidic waste
- Waste from U, apatite, Tungsten, tin, Ni-Co laterite processing
- Coal ash

European Scandium Secondary Resources

Bauxite Residue[9,10,11,12]

- Composition 30 – 230 g Sc/t dry basis
- 1 – 1.5 t red mud/t of bauxite ore
- Annual production: 150M t/y
- Europe: 7M t/yr (dry basis) [13]
- Sc: 95% of economic value of REEs

Fe_2O_3 (%)	Al_2O_3 (%)	SiO_2 (%)	TiO_2 (%)	CaO (%)	Na_2O (%)	Sc (ppm)
41	16	9.6	8.8	8.6	4.5	30 - 230

Origin	Sc, ppm
Greece	121
Australia	54
Canada	31
Russia	73 – 228
China	158

European Scandium Secondary Resources

TiO_2 Acidic Waste

- Composition 5 – 20 g Sc/t dry basis
- Annual production: 6 – 8 t of acidic waste / t of TiO_2 produced [14]
- EU produces about 1.5M tons of TiO_2 pigments annually
- Landfilled as filter cakes at high costs [15]
- SCALE project

[16]

Sc, g/L	Ti, g/L	Fe, g/L	V, g/L	Mn, g/L	Al, g/L	Ca, g/L	Mg, g/L	H_2SO_4, g/L
0.02	3.53	30	0.2	2.4	1.33	0.24	0.29	227

Scale project (Sc-Al Europe: 2017 – 2020)

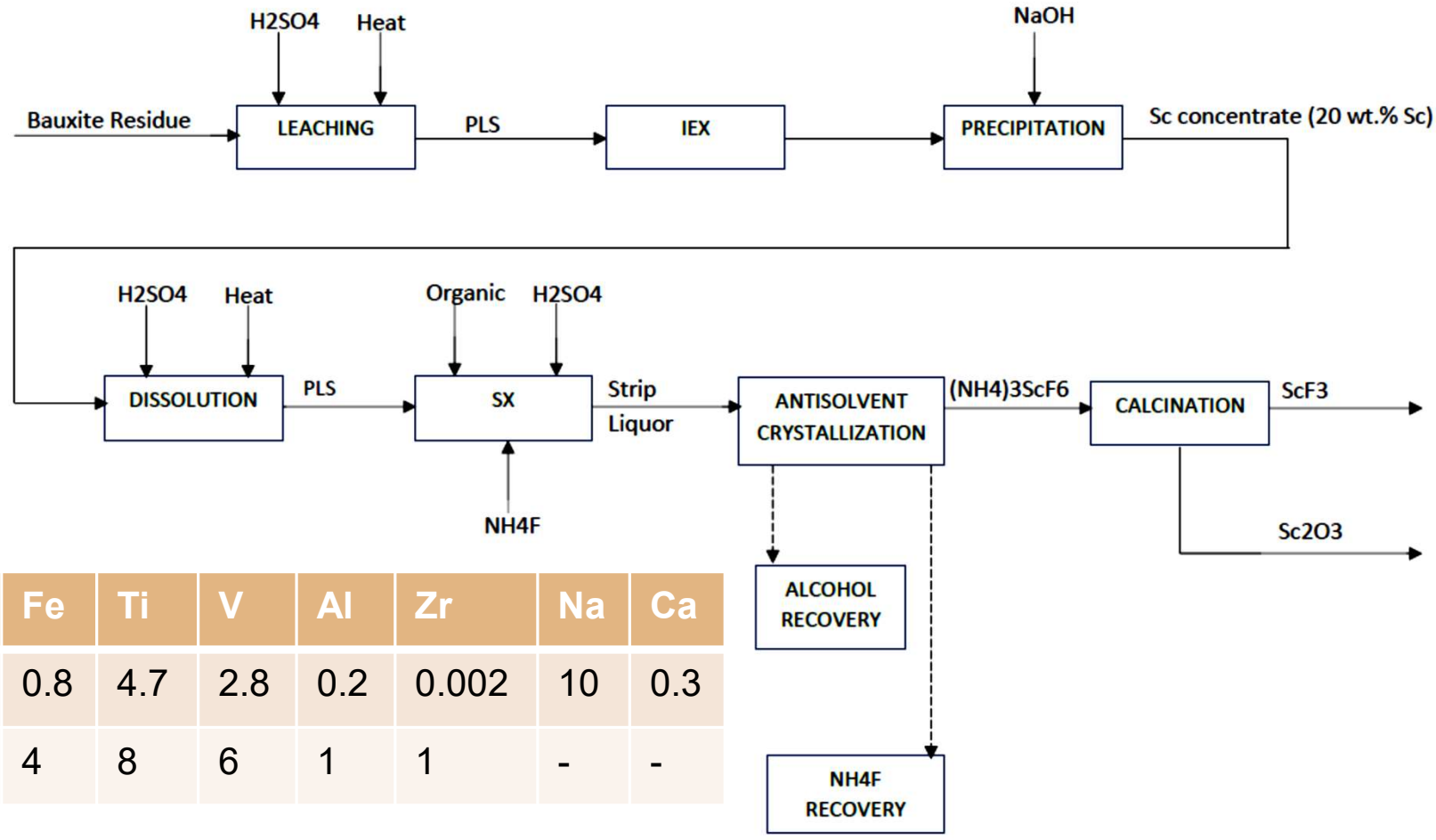
Flowsheet based on bench-scale testwork

- Funded by Horizon2020 Research and Innovation Programme
- SCALE developed innovative technologies to economically and sustainably extract Sc from secondary resources
- Validated at appropriate laboratory and industrial environments
- TRL 6
- Developed a flowsheet (Leaching, ion exchange, solvent extraction, crystallization, calcination)

Scale project (Sc-Al Europe: 2017 – 2020)

Flowsheet based on bench-scale testwork

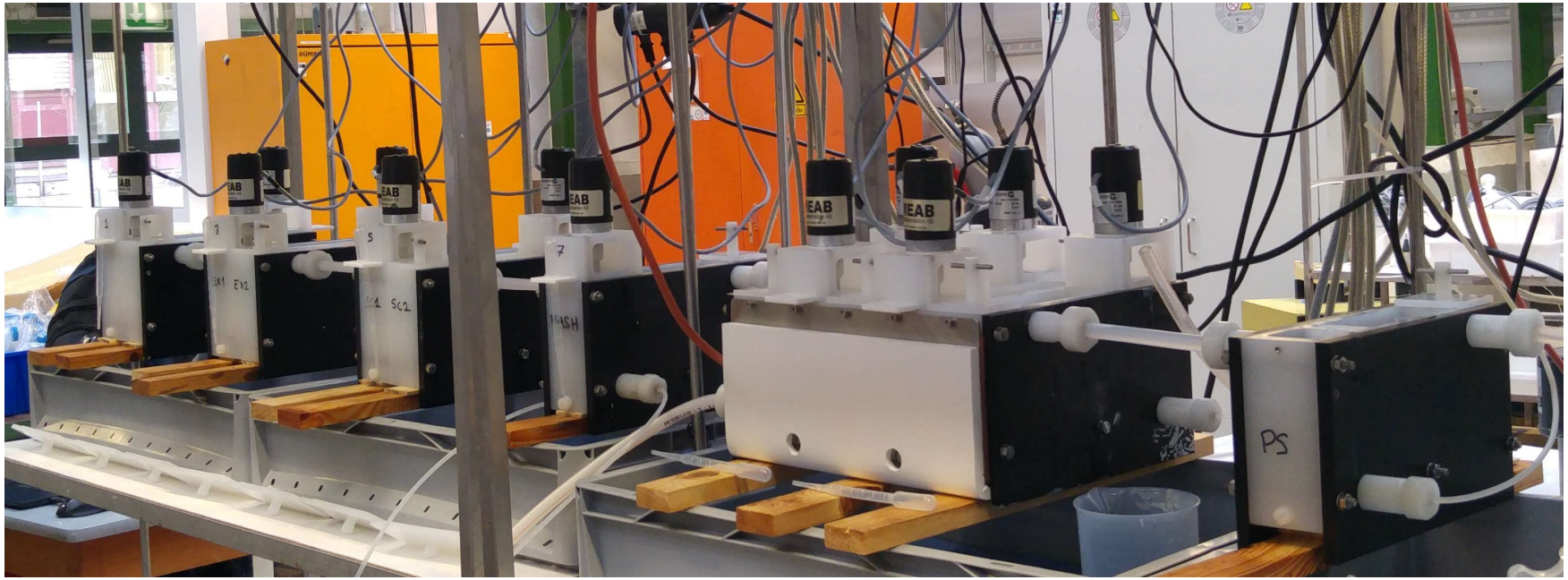
- Strip Liquor: 2.5 g/L Sc
- $(NH_4)_3ScF_6$: > 99%
- ScF_3: > 99%



	Sc	Fe	Ti	V	Al	Zr	Na	Ca
Sc concentrate, %	20	0.8	4.7	2.8	0.2	0.002	10	0.3
Strip Liquor, mg/L	2500	4	8	6	1	1	-	-

Scale project (Sc-Al Europe: 2017 – 2020)

Solvent extraction pilot campaign



- Mixer-settler units MSU 0.5 designed by MEAB Metallextraktion AB, Sweden
- Pilot consisted of 12 stages + post settler
- Strip liquors containing ca. 2.5 g/L Sc were obtained

Scaleup project (2022 – 2024)

- Funded by European Institute of Innovation and Technology (EIT) Raw Materials
- Follow-up to the SCALE project
- Demonstrates a commercialization-ready flowsheet for producing Sc-products from Bauxite Residue.
- TRL 7 – 8
- Engineering scale-up study
- Leads to commercialization and production of Sc-products in Europe (Sc_2O_3, ScF_3, Al-Sc alloy)
- Website (https://scaleup.tesmet.gr/)

Scavanger project (2021 – 2024)

- Funded by European Institute of Innovation and Technology (EIT) Raw Materials
- Follow-up to the SCALE project
- Demonstrates a commercialization-ready flowsheet for producing Sc-products from liquid residues from chloride-based TiO_2 plants.
- TRL 8 – 9
- Vanadium and niobium by-products
- Engineering scale-up study
- Leads to commercialization and production of Sc-products in Europe (Sc_2O_3, ScF_3, Al-Sc alloy)
- Website (https://www.scavanger.eu/)

Future Outlook

- SCALEUP and SCAVANGER projects are expected to lead to commercialization of Sc extraction technologies from secondary resources in Europe
- Expected to produce 22 t/yr Sc_2O_3, which represents 2/3 of the expected EU consumption in 2028.

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