Low CO2 emission ALuminium alloy BAttery cells produced from SCRAP (BAALSCRAP)

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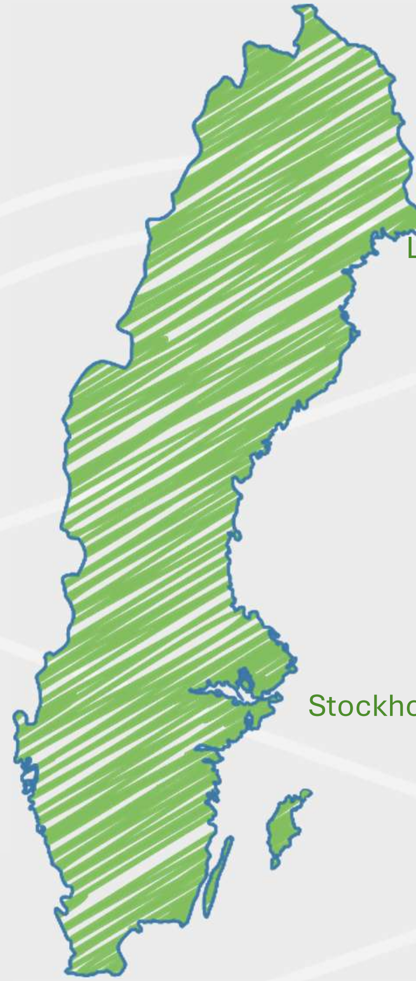
SWERIM

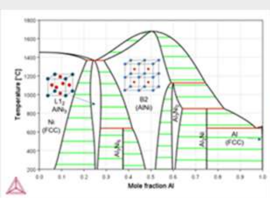
Swerim in short

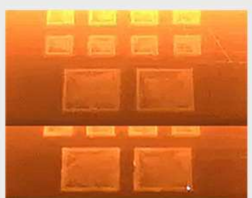
Research institute for metal and mining
> 100 years old

- Independent research institute
- Approximately 190 employees
- Located in Luleå and Stockholm
- Turnover approximately SEK 250 million
- Unique test and demonstration facilities
- Customers from all over the world
- Owners: Industry (80%) and the Swedish state through RISE (20%)

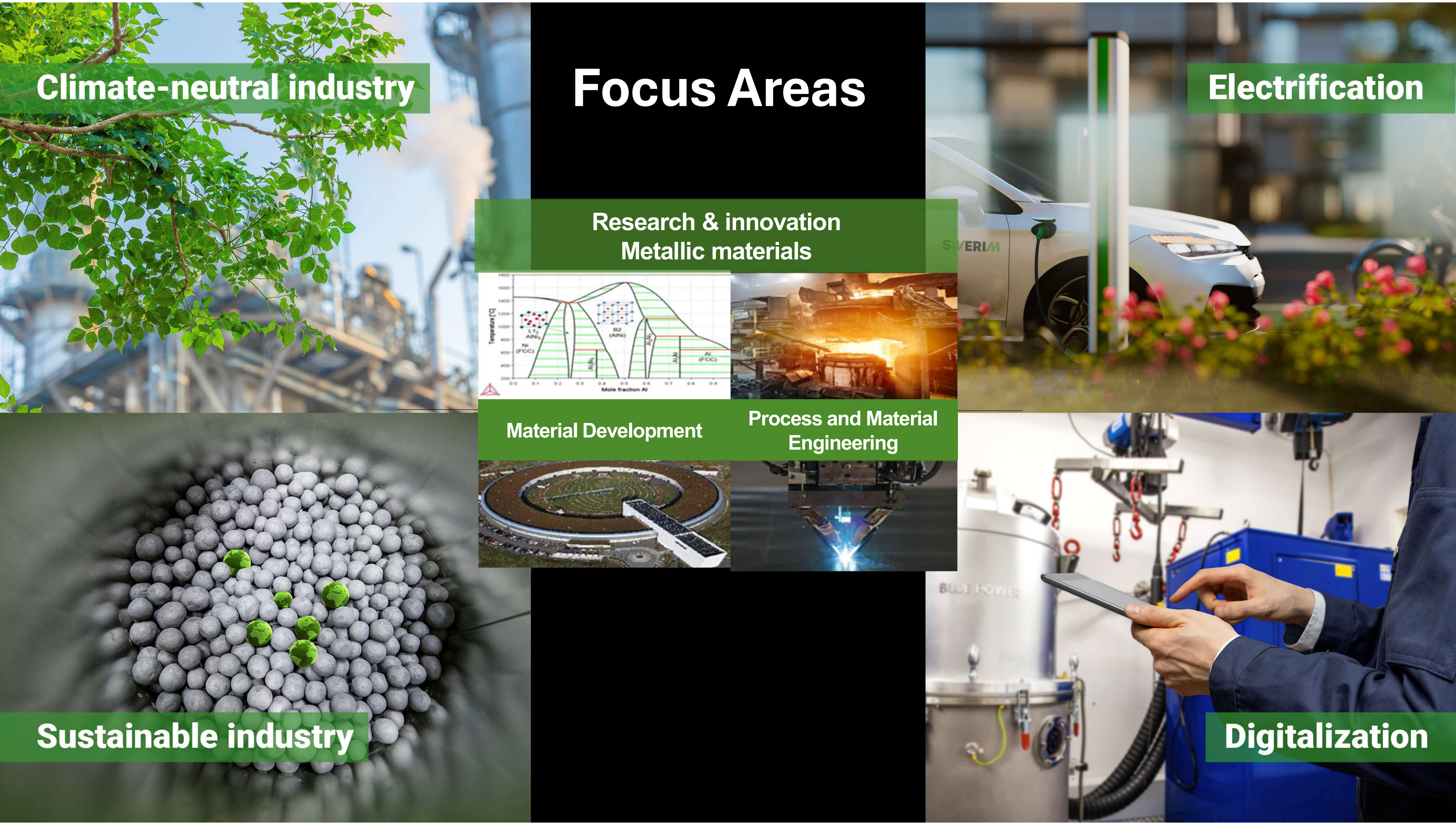


Long tradition – the oldest part was established in 1921 (Metallografiska institutet) and MEFOS (1963)





Alloy development → Processing → Manufacturing → Characterization → Application of product


Focus Areas
Climate-neutral industry
Electrification
Research & innovation
Metallic materials
Material Development
Process and Material
Engineering
Sustainable industry
Digitalization

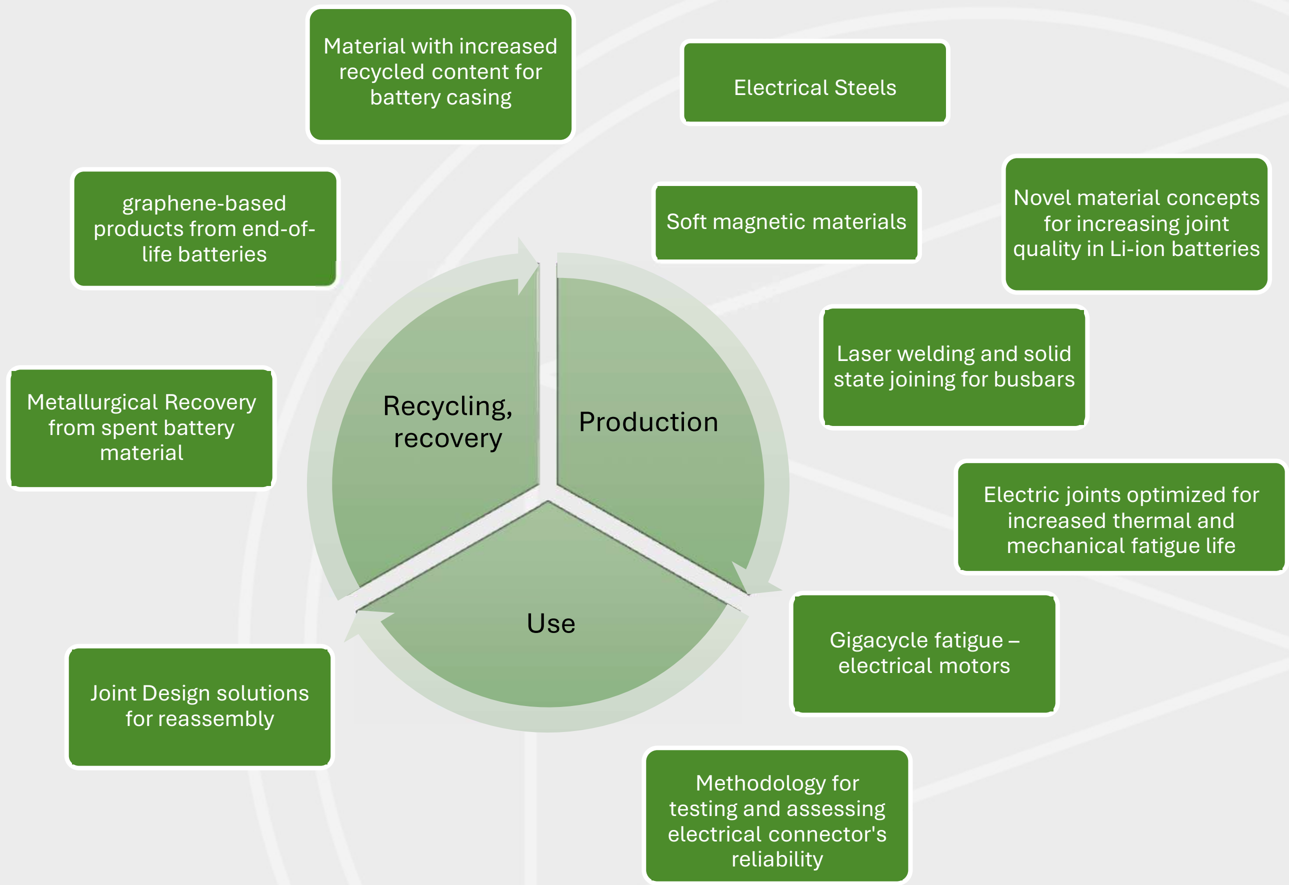
Swerim activities related to electromobility

Material development

Joining & manufacturing

Electrical connectors

Battery recycling



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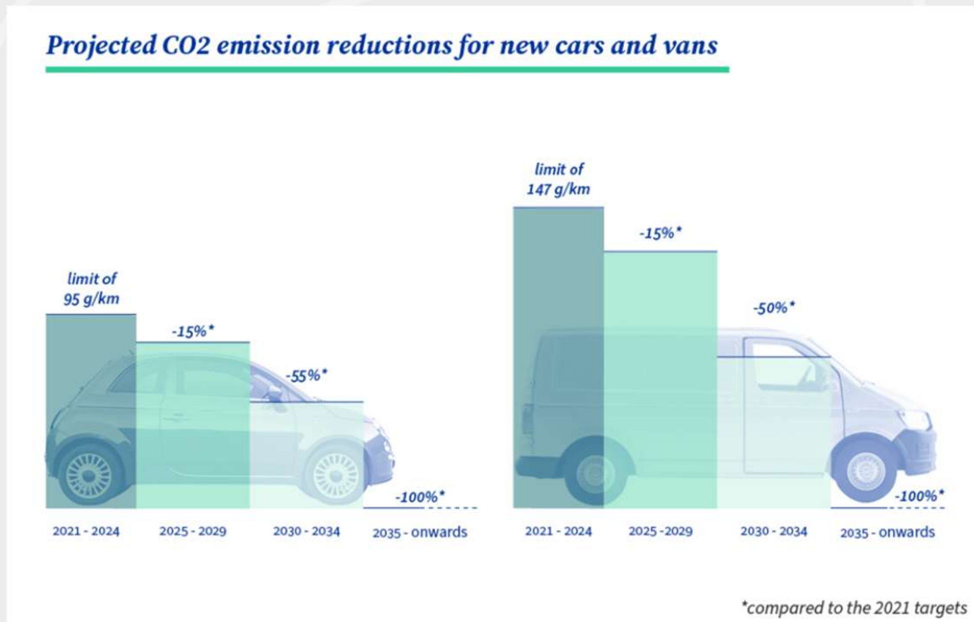
Transition ICE to BEV – emission change

Use-phase emissions drops dramatically

- ICE heavy vehicles generate 80-90+% of their lifetime emissions from tailpipe exhaust alone.
- BEVs produce **zero tailpipe emissions**, and their use-phase footprint depends entirely on the electricity mix. In Sweden and the Nordics very low (20 g/kWh).
- With today's average European grid, BEVs already reduce total life-cycle emissions by **~65–70%** compared to diesel heavy vehicles. In the Nordics **80-90%**
- As grids decarbonize, BEV use-phase emissions continue to fall, increasing the gap.



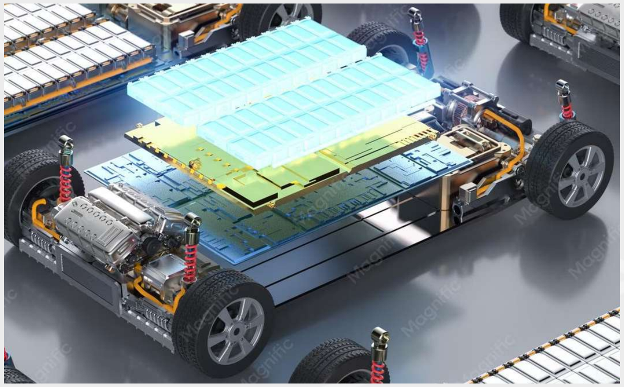
Transition ICE to BEV – emission change

Manufacturing emissions increase mainly due to batteries

BEV manufacturing emissions **2–3× higher** than ICE manufacturing emissions because battery production is energy-intensive. Average material-related emissions:

ICE: ~25-50 t CO_2

BEV: ~50-150 t CO_2 (Driven largely by battery minerals and cell production.)



Lifetime emissions still favor BEVs:
“Break even” 80.000 - 150.000 km, then BEV outperform ICEs as they accumulate mileage

European Industrial Battery Value Chain

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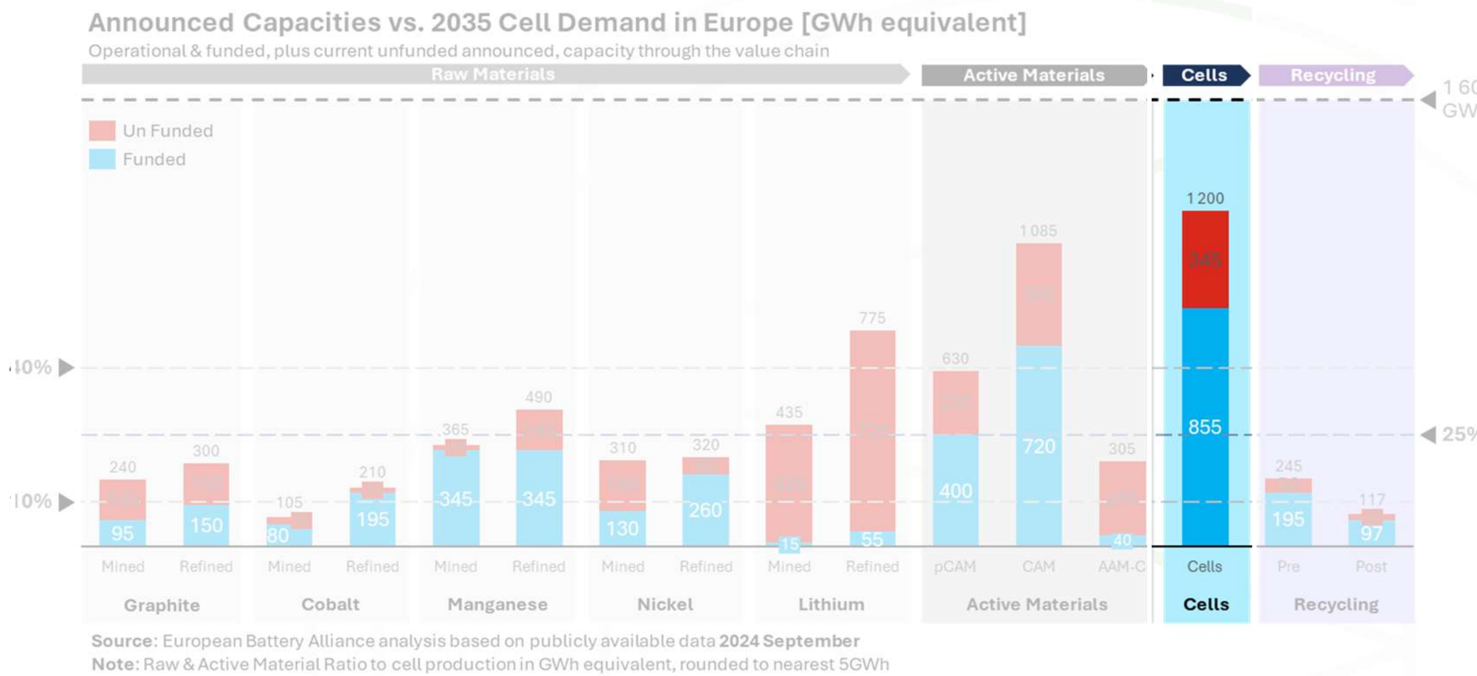
Use of aluminum – increase

Use of recycled aluminum is limited to up to 30% of total demand today

Projection is that with EV the demand will increase 4-5 times until 2035

1 TWh (2024) → > Up to 6.8 TWh by 2035

Typical EV battery ≈ 60–80 kWh



Today: EU imports about **6.5 million tonnes** of raw (primary) aluminium per year

Slide from: InnoEnergy | EBA250 – Electromobility seminar at Swerim November 2025

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Battery cells production chain in Sweden – prismatic cells

Gränges

1. Casting and rolling

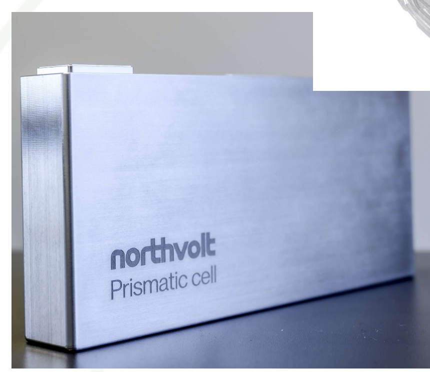
Challenges: defects, intermetallic, mechanical properties etc.

Kedali

2. Deep drawing and forming

Challenges: being able to form without damage, uniform thickness after forming, mechanical properties,

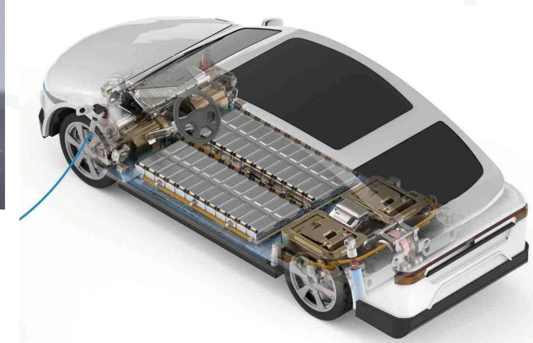
Northvolt (Lyten)/Novo Energy



3. Welding

Challenges: weldability, weld geometry, mechanical properties of weld, fatigue

Scania
Volvo



4. Application

Corrosion, Fatigue, mechanical properties, Stress, etc.

About this project

Net zero industry strategic project

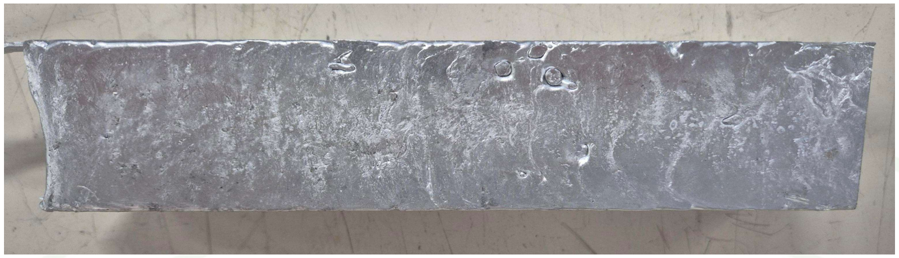
The idea from Gränges: current limitation on battery casing product replies on virgin aluminium with no tolerance for any type of recycle: this limit for Mg+Zn < 0.03 %

At start of this project no partner along the production chain was aware of the reason behind this.

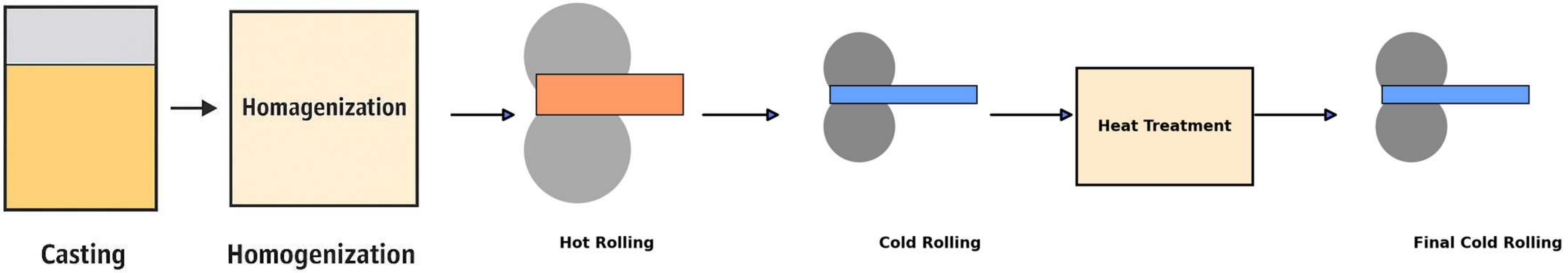
We started with project with a purpose to understand what this actual limit is and why and how the production will be affected if it is more circular.

Currently Gränges, Kedali and Traton are in the project together with Swerim.

Summary of lab materials

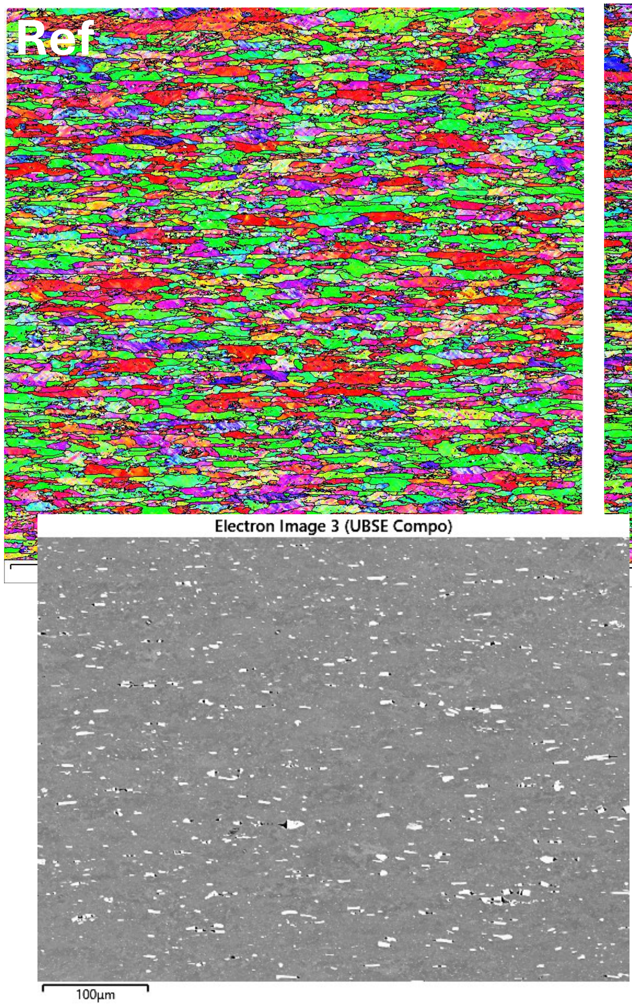


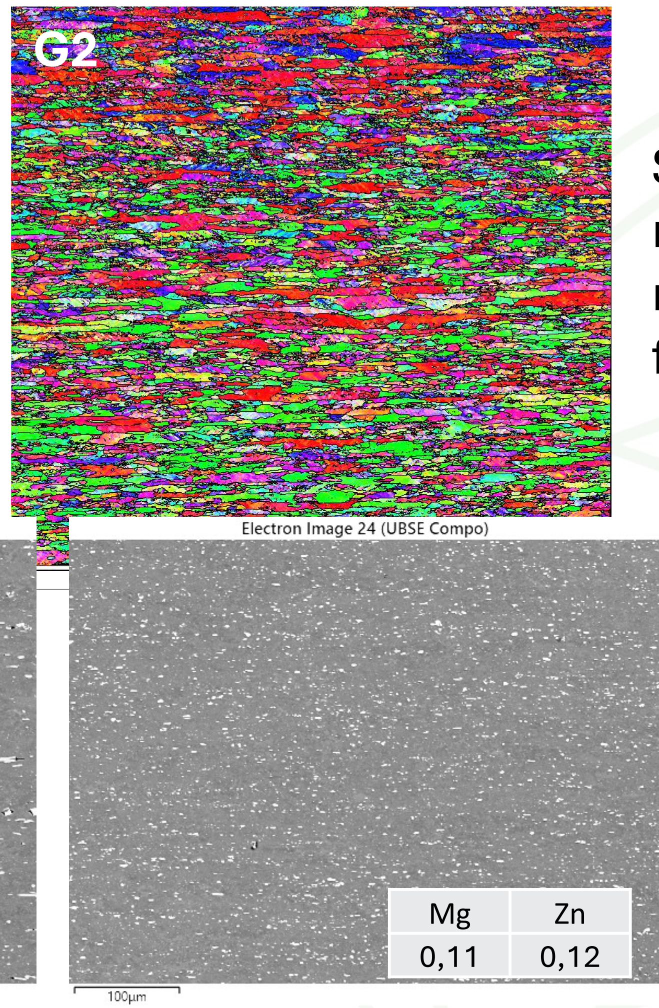
16 alloys varying Mg and Zn between 0 – 0.25 wt.%
primarily focus: weldability and formability



Such capabilities allow us to mimic tons of industrials trials on only 5-10 kg samples: 1-1.5M sek trial cost can be reduced to 50-100k sek tests

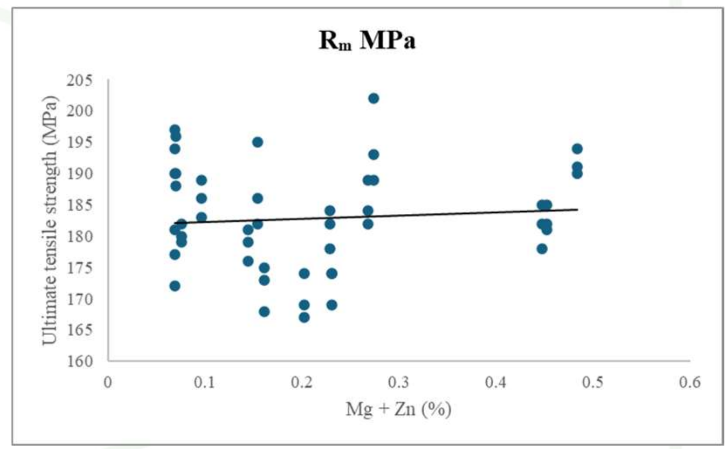
Materials screening and characterization





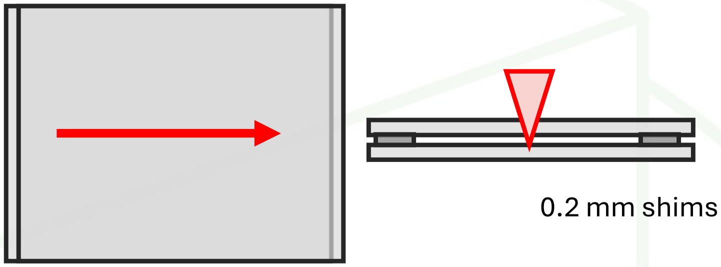
Mg	Zn
0,11	0,12

Similar mechanical properties and microstructure as the industrial materials. Slight differences due to faster cooling of lab materials...

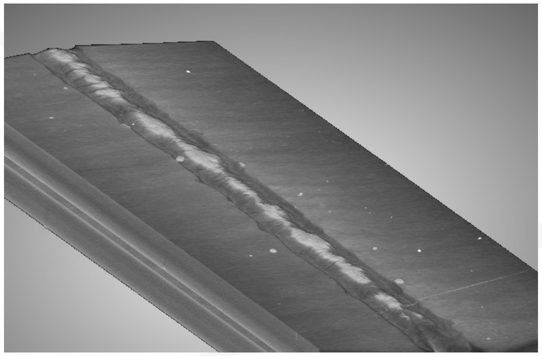


Welding parameters and condition

- Laser welding trials like the industrial processes (single laser)
- Parameters adjusted on penetration for reference materials thickness and composition
- Same parameters applied all 16 alloys



Goal: simple welding to compare the effect of materials chemistry



Analysis of welds

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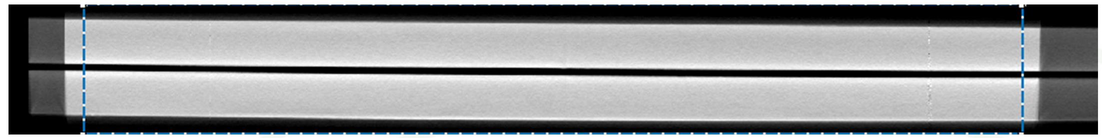
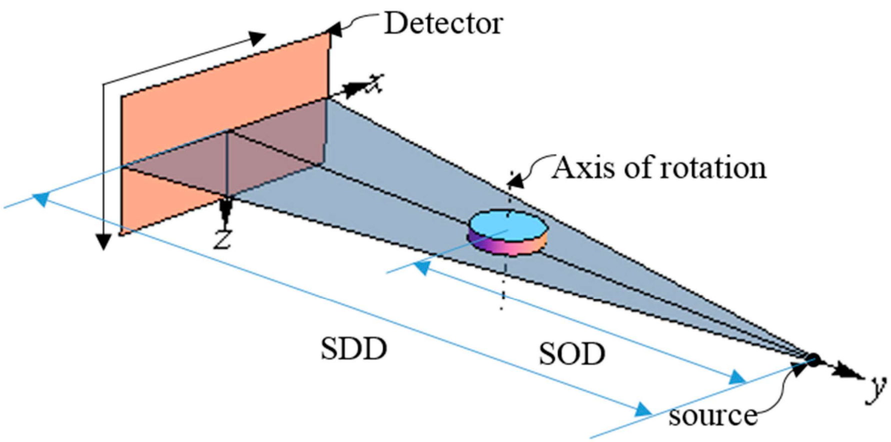
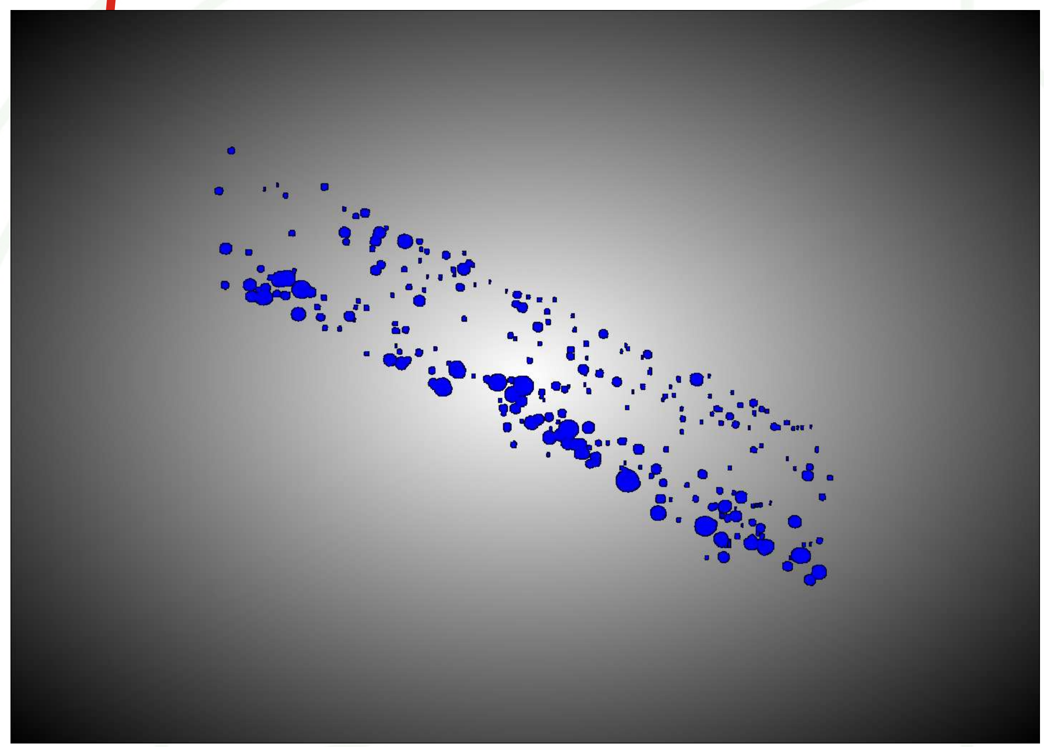
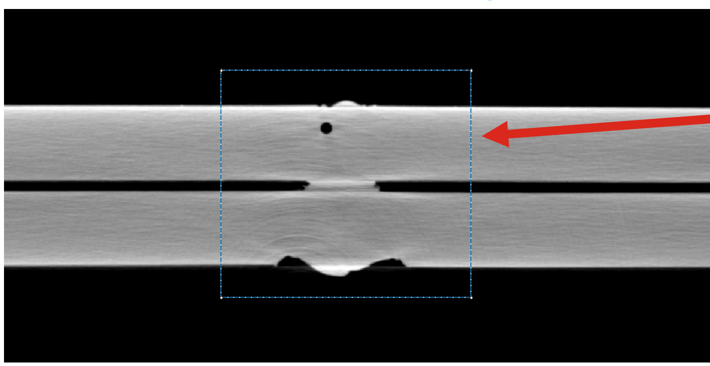
Low resolution X-ray tomography (3D) for pore analysis – 20 µm voxel size

yz plane









xy

Analysis of welds

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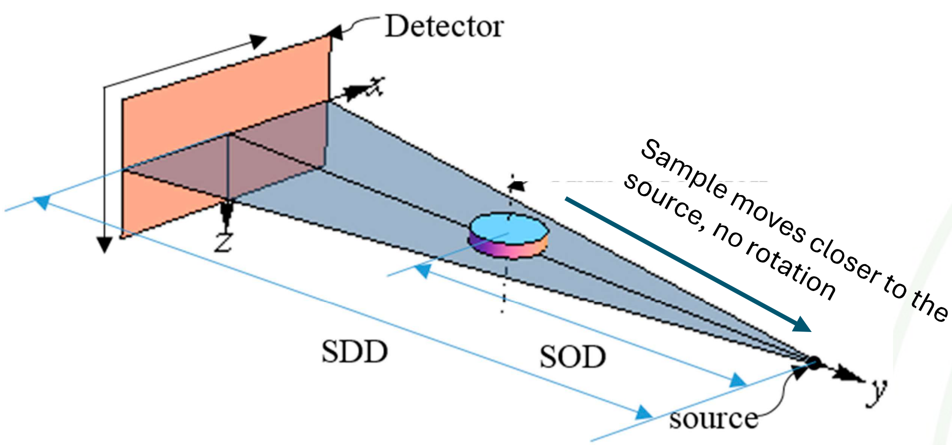
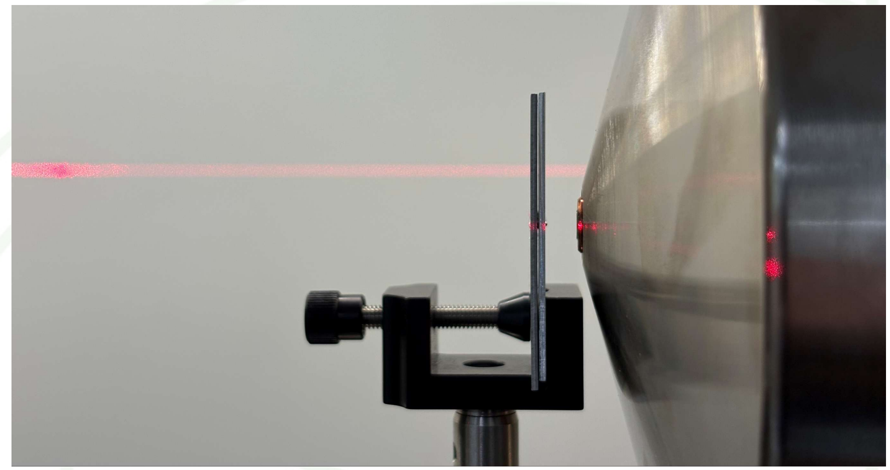
High resolution X-ray radiography (2D) for pore analysis – 0.5 µm pixel size





Analysis of welds

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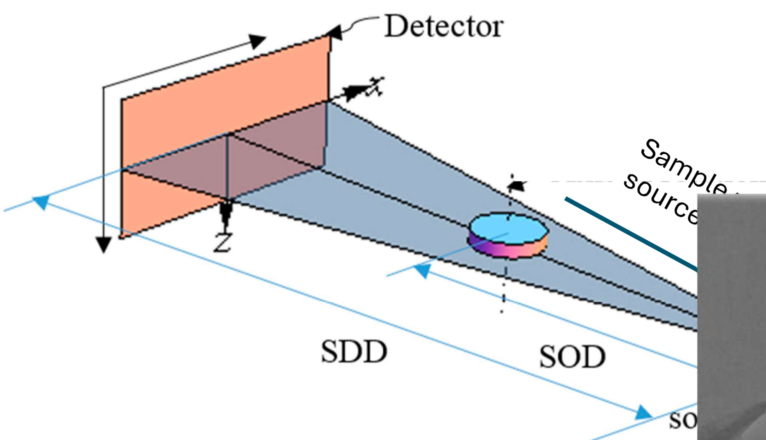
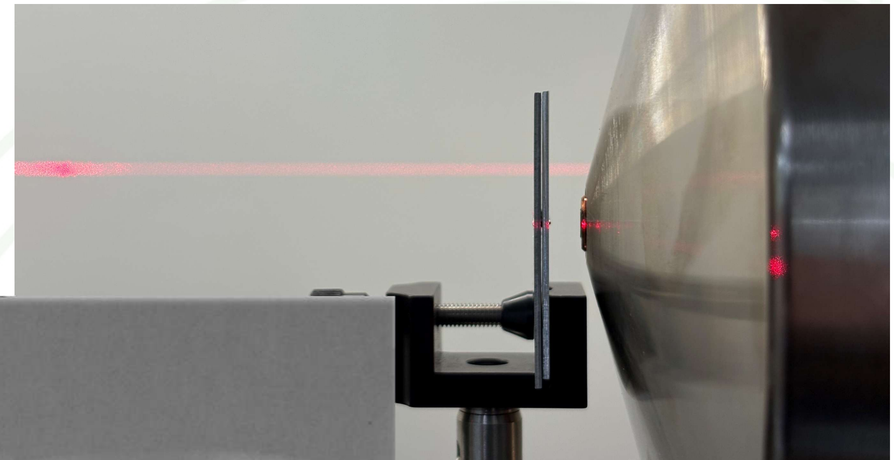
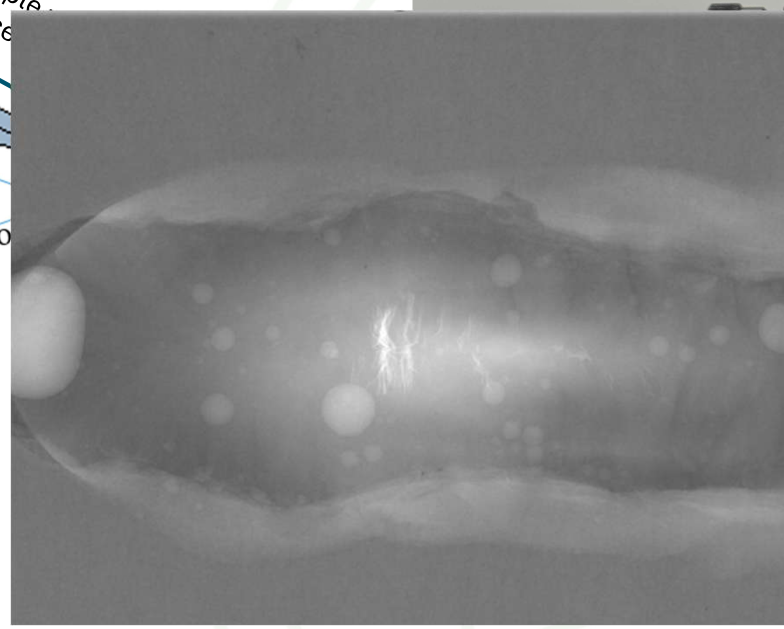
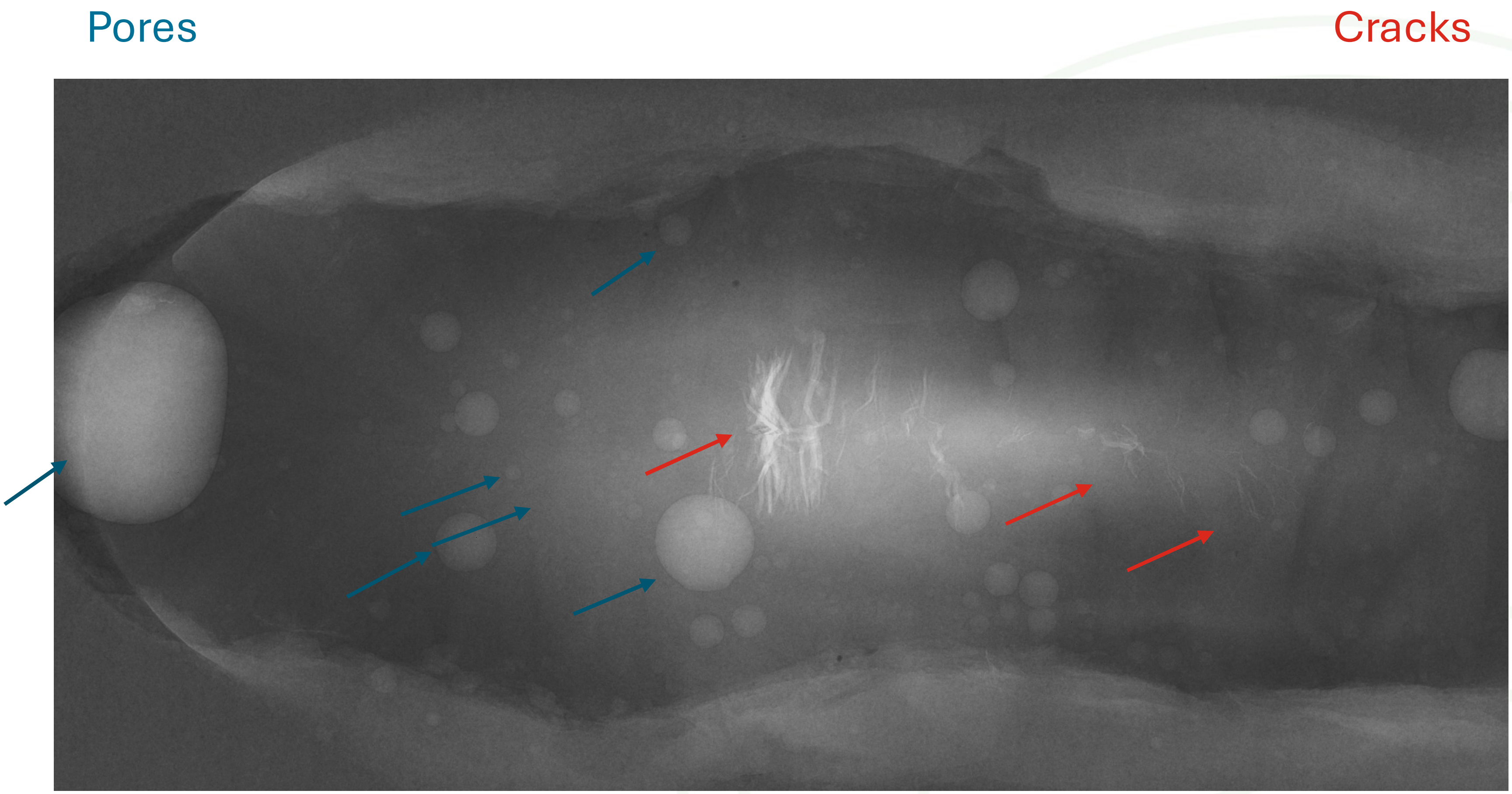
High resolution X-ray radiography (2D) for pore analysis – 0.5 µm pixel size





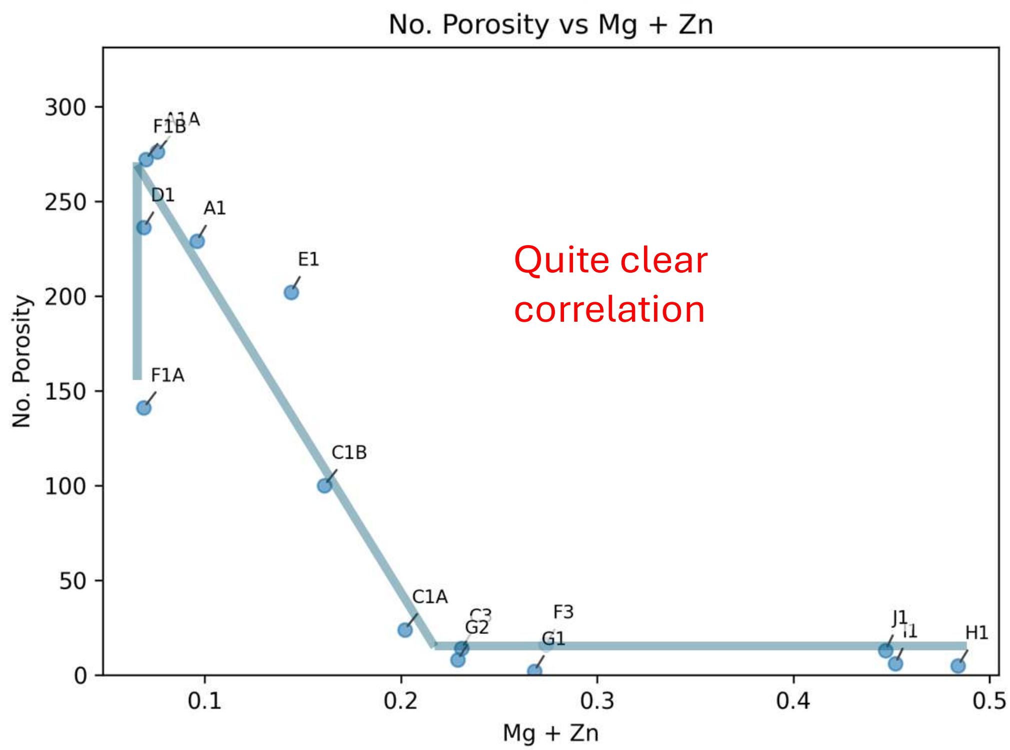




Pores
Cracks

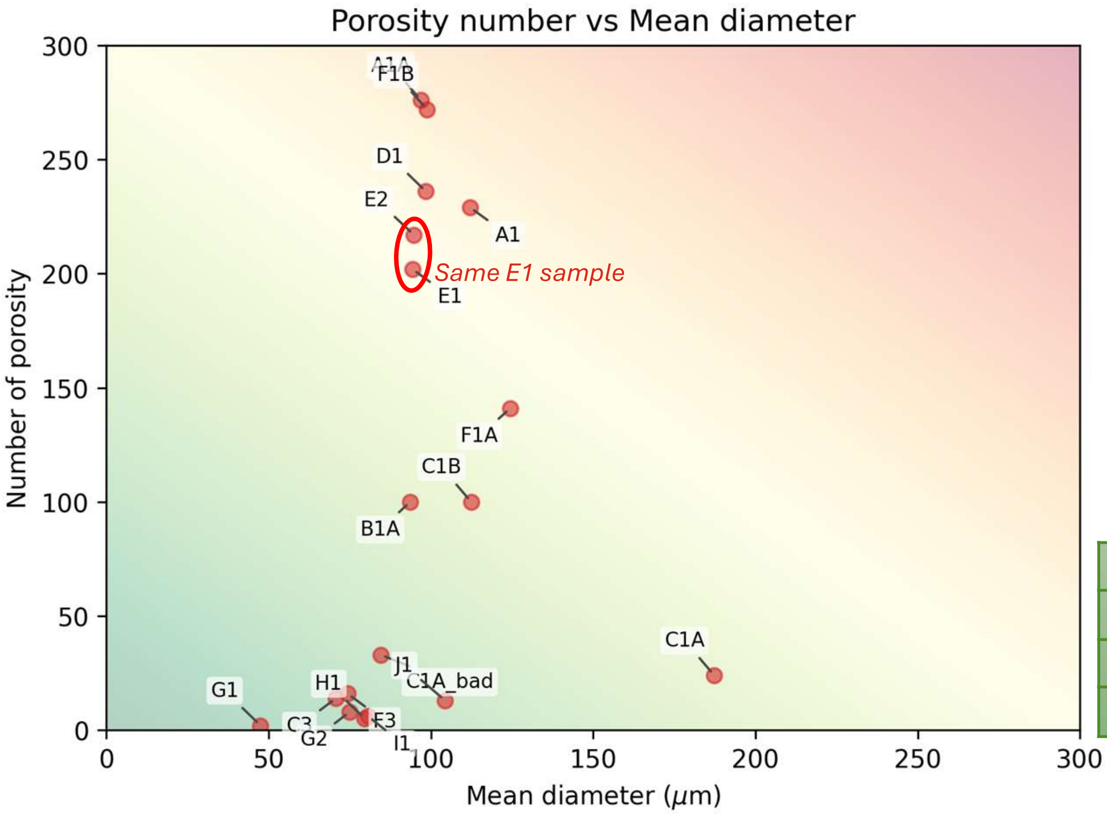
Results – analysis of pores

Number of pores vs alloy chemical compositions shows less pores and defects in the weld at high Mg and Zn content



Results – analysis of pores

Porosity number vs alloy chemical compositions



G1 shows the best results

G2, H1, C3, F3 are also good

A1A and F1B are the worst samples

Alloys	Si	Fe	Cu	Mn	Mg	Zn	Ti
G1	0.166	0.54	0.102	1.002	0.13	0.138	0.023
A1A	0.17	0.53	0.098	0.997	0.019	0.057	0.023
F1B	0.14	0.57	0.1	1.01	0.034	0.036	0.023

Pore formation mechanism

We found 1 reference focused on much higher Mg containing alloys where they showed:

Higher Mg content increases the recoil pressure in the keyhole, making the keyhole more stable and reducing the frequency of keyhole collapse (the phenomenon that creates the majority of pores in laser welding).

The paper reflects only on Mg content but Zn with its high vapor pressure should have a similar effect

We need to visually observe this!

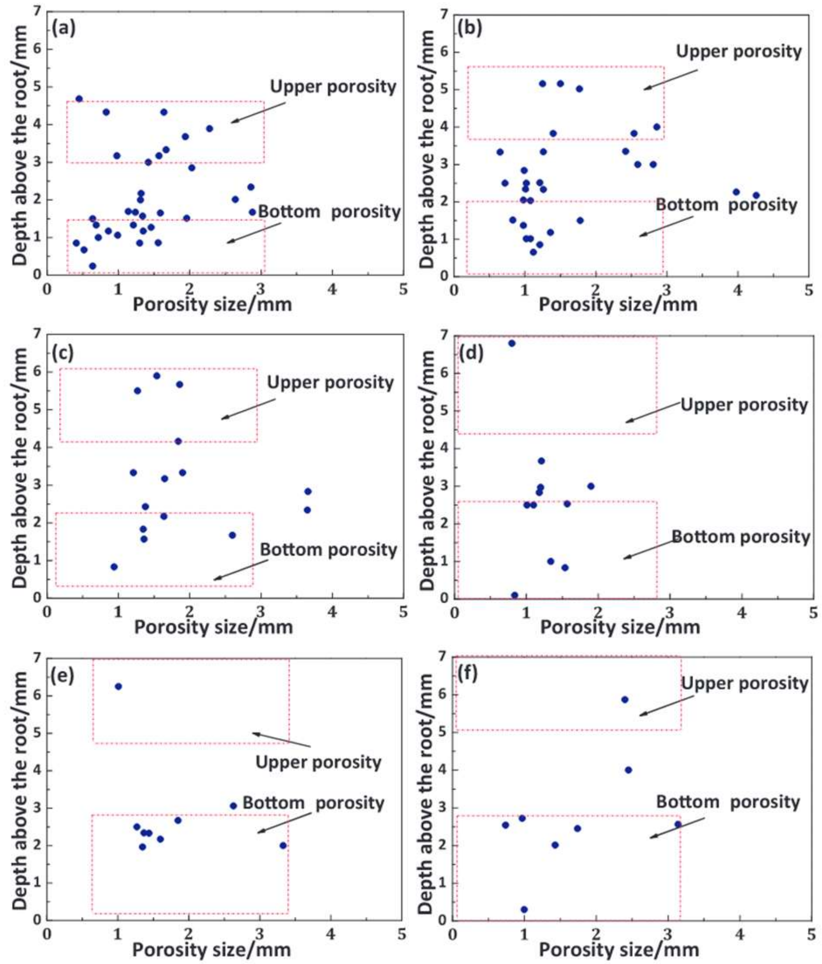
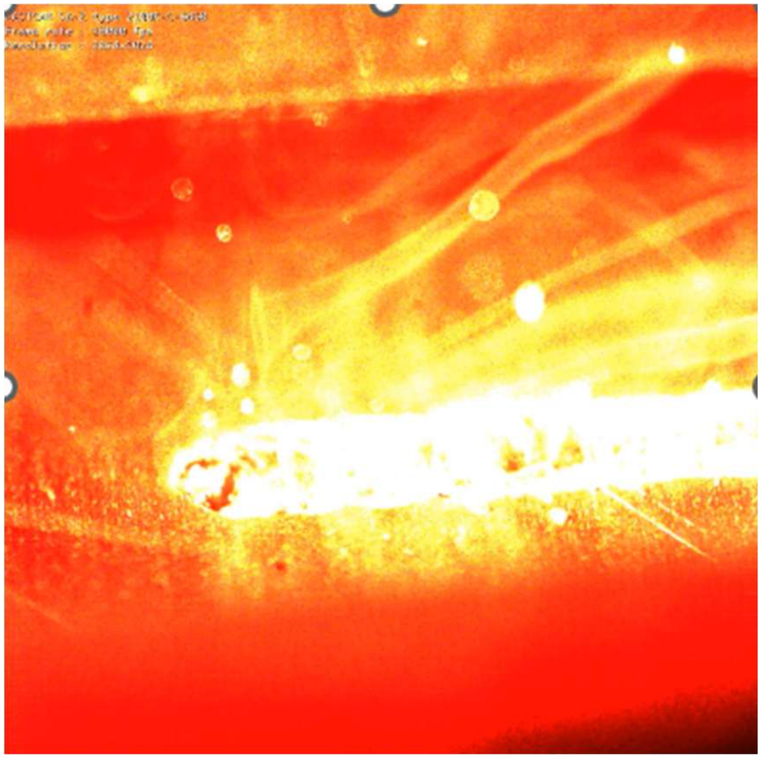


Fig. 16. Location and porosity size generated in the welds correspond to Fig. 4: (a) 1050 (b) 6061 (c) 2A12 (d) 5754 (e) 5083 (f) 5A06.

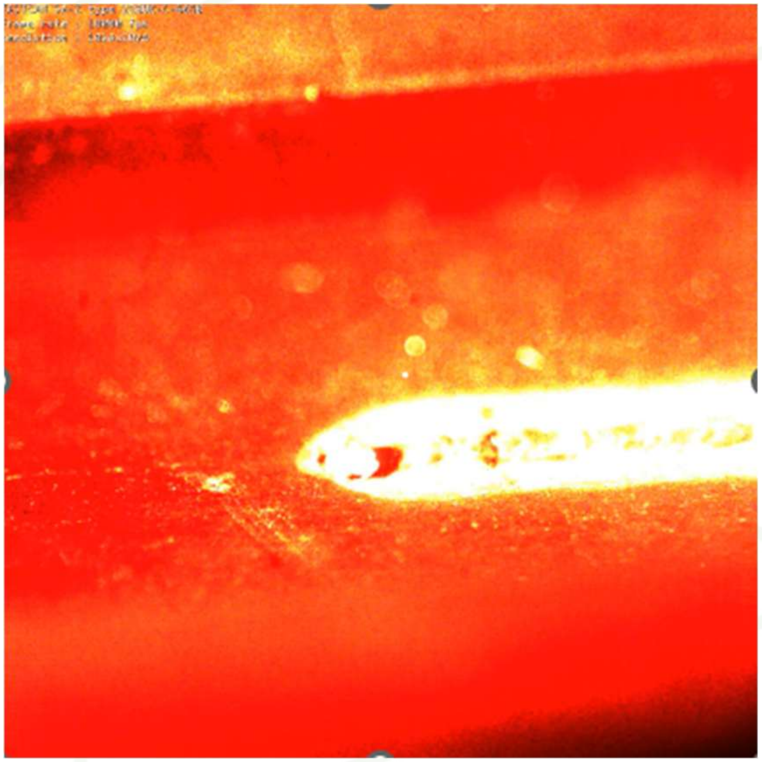
Effect of Zn and Mg

	Si	Fe	Cu	Mn	Mg	Zn	Ti
Refrence alloy	0,14	0,45	0,11	1,16	0,02	0,01	0,03

	Si	Fe	Cu	Mn	Mg	Zn	Ti
H1 alloy	0,166	0,53	0,103	1,037	0,244	0,24	0,026



Reference alloy→ More spattering

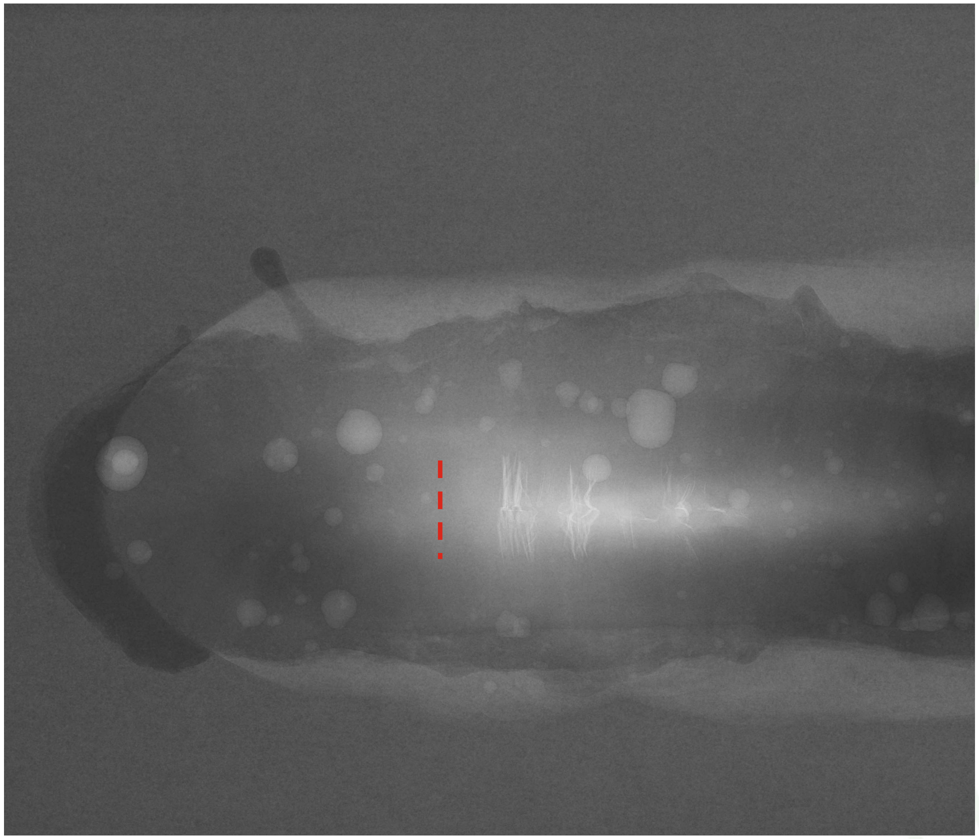


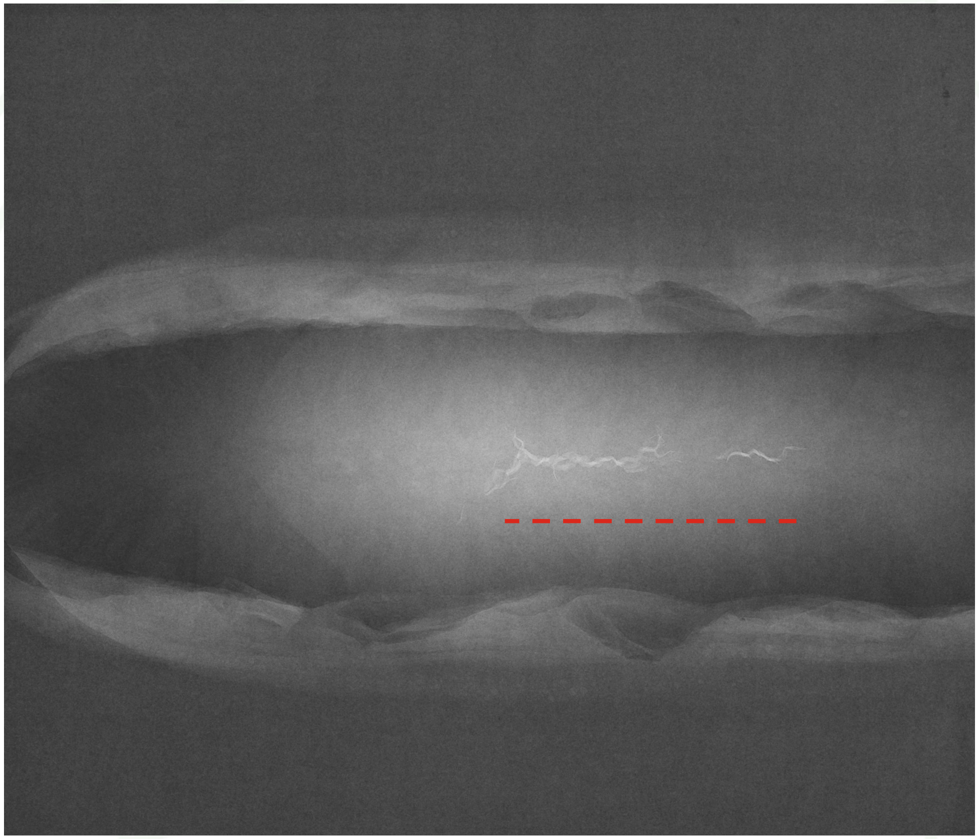
Highest Zn and Mg → More stable

Analysis of results - cracks

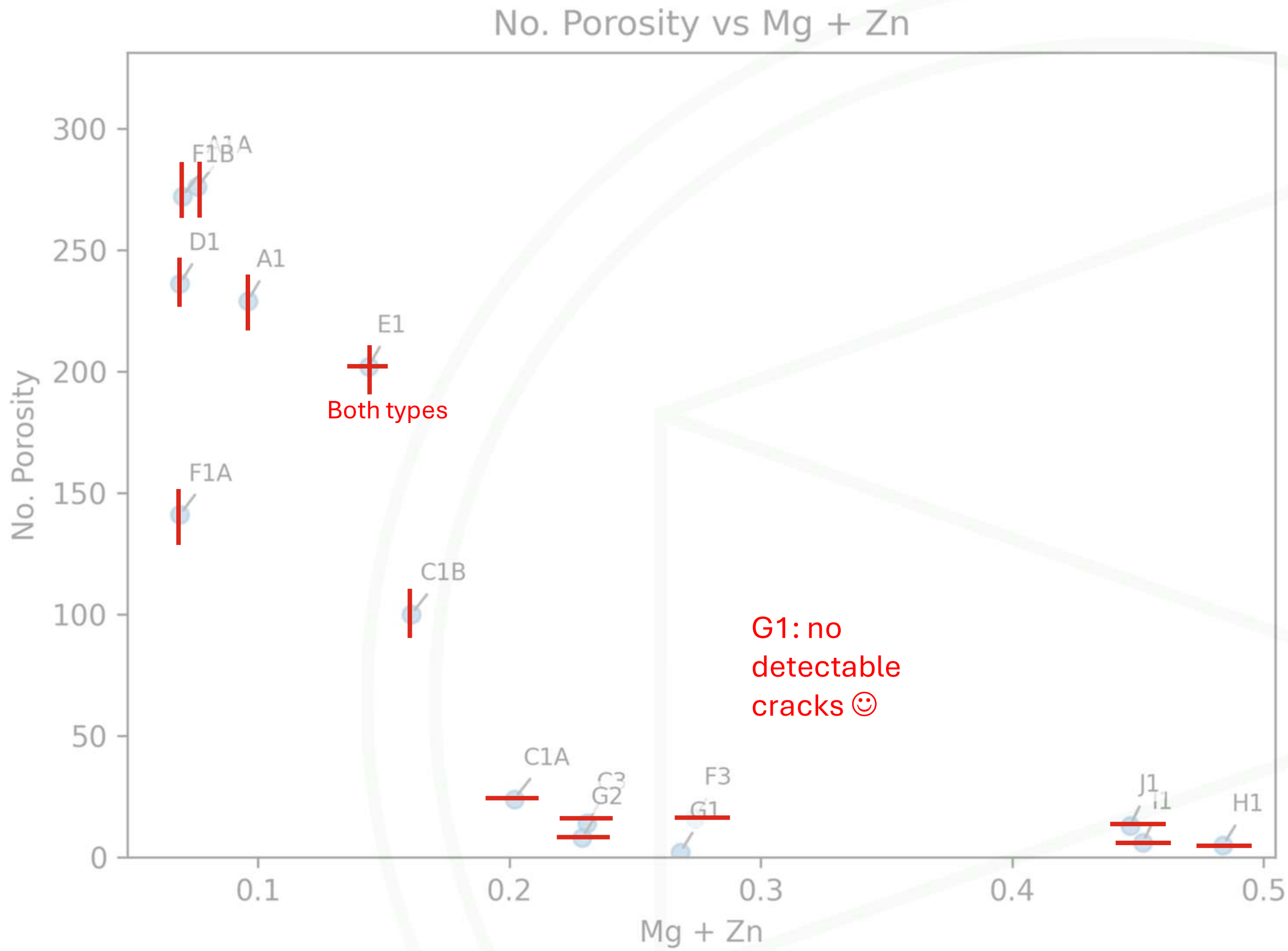
	Si	Fe	Cu	Mn	Mg	Zn	Ti
Refrence alloy	0,14	0,45	0,11	1,16	0,02	0,01	0,03

	Si	Fe	Cu	Mn	Mg	Zn	Ti
H1 alloy	0,166	0,53	0,103	1,037	0,244	0,24	0,026





Crack direction



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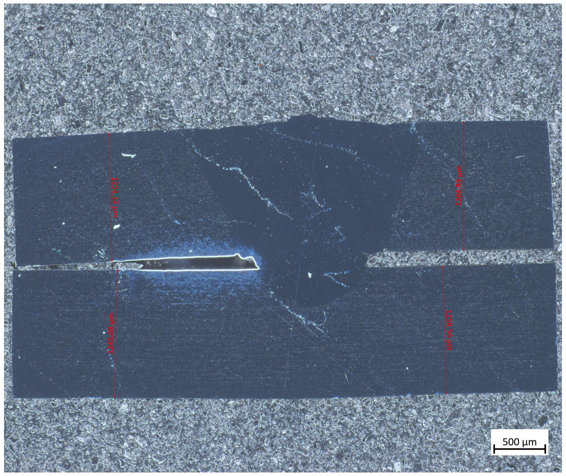
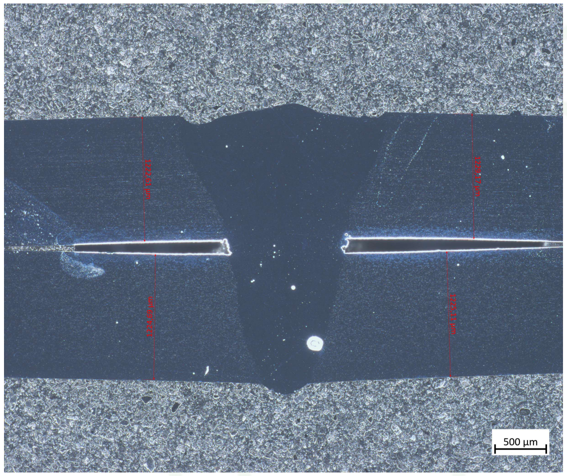
Penetration depth of weld is slightly different – due to approximately differences Mg makes in Thermal conductivity

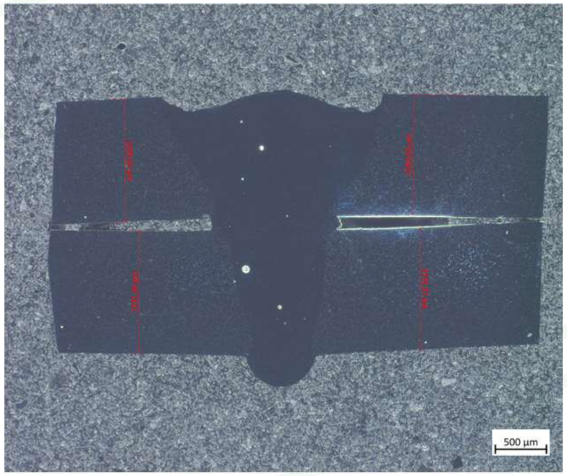
High Mg and Zn alloy



Low Mg and Zn alloy

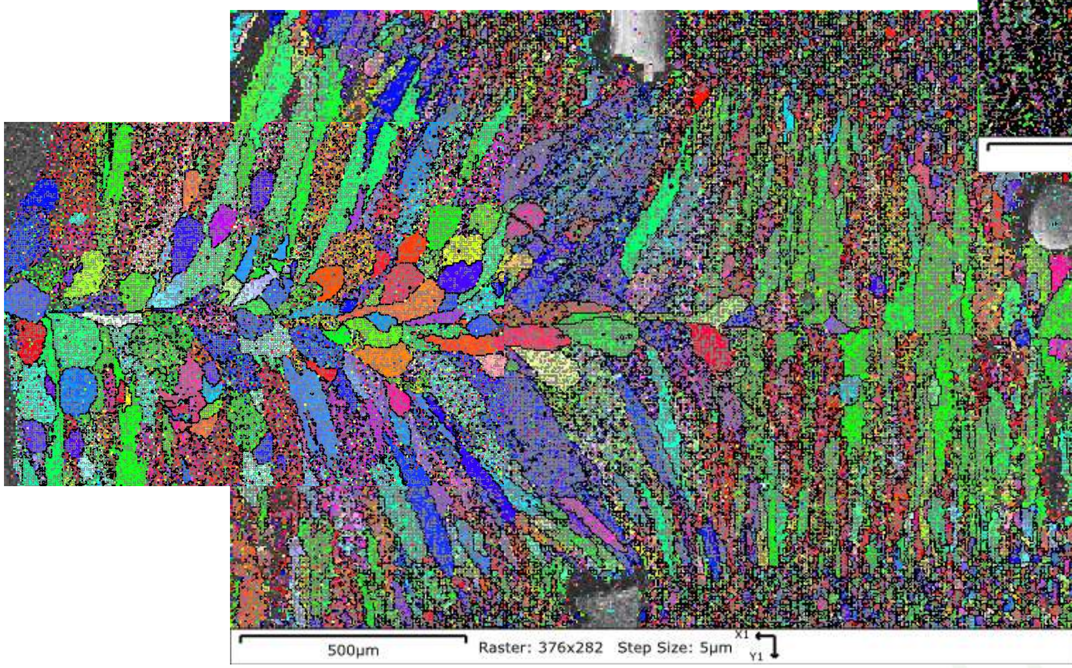


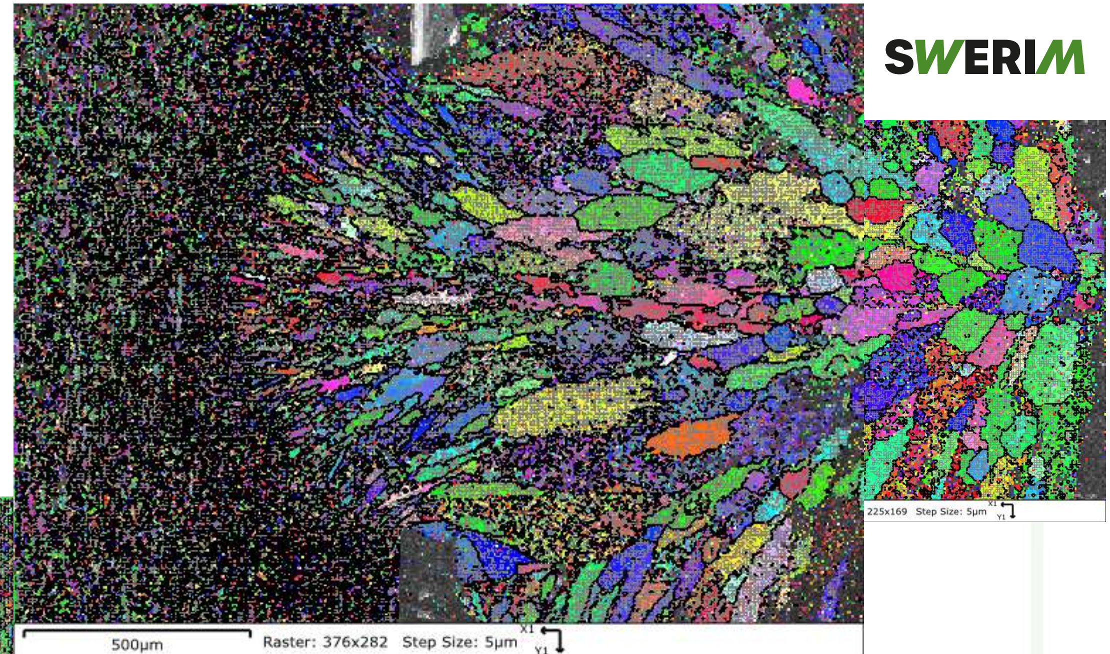
Reference



Cross-section of welds

Low Mg and Zn – Reference





High Mg and Zn

The weld to the left with low Mg & Zn has penetrated both plates completely, and the melted zone is narrow and deep. The weld above with high Mg & Zn has not penetrated both plates, the melt zone is wider compared to the weld.
The grain morphology is different with more columnar grains in the low Mg & Zn weld which has resulted in a clearer centre-line in the weld where columnar grain meet. This gives more possibilities for a crack to form between the columnar grains.
Grains contain low angle boundaries, plastically deformed.

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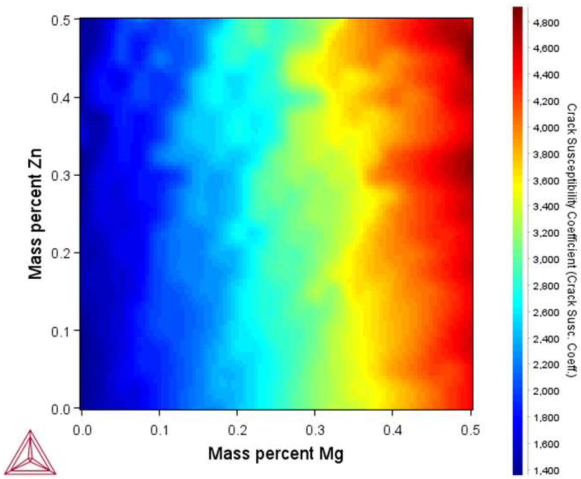
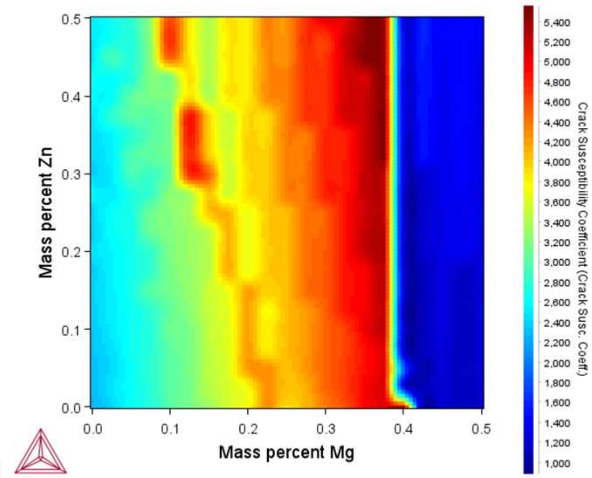
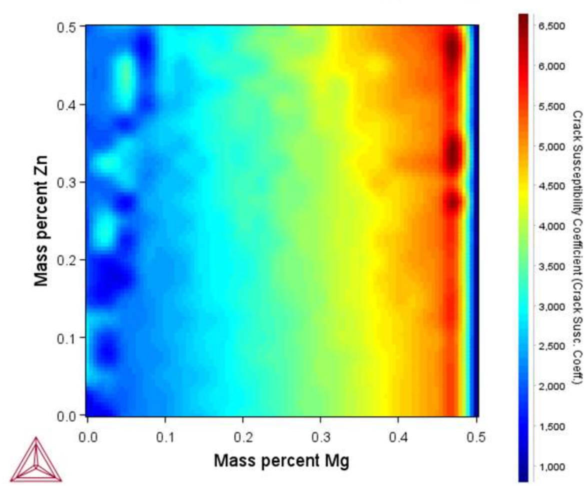
Crack susceptibility coefficient calculations by ThermoCalc



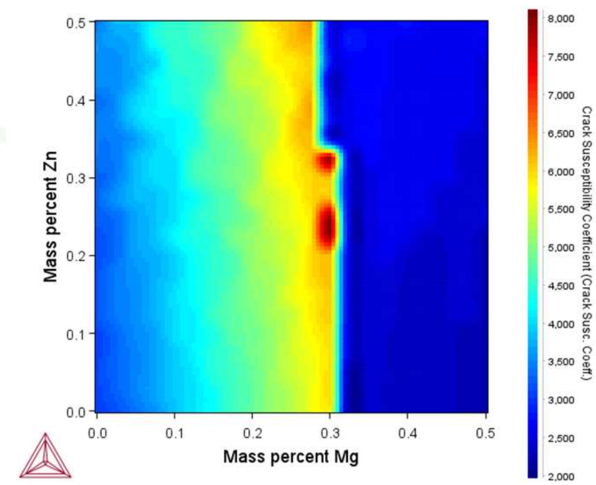
Al-**0.1Si**-0.5Fe-0.12Cu-1.15Mn



Al-**0.3Si**-0.5Fe-0.12Cu-1.15Mn



Al-**0.2Si**-0.5Fe-0.12Cu-1.15Mn

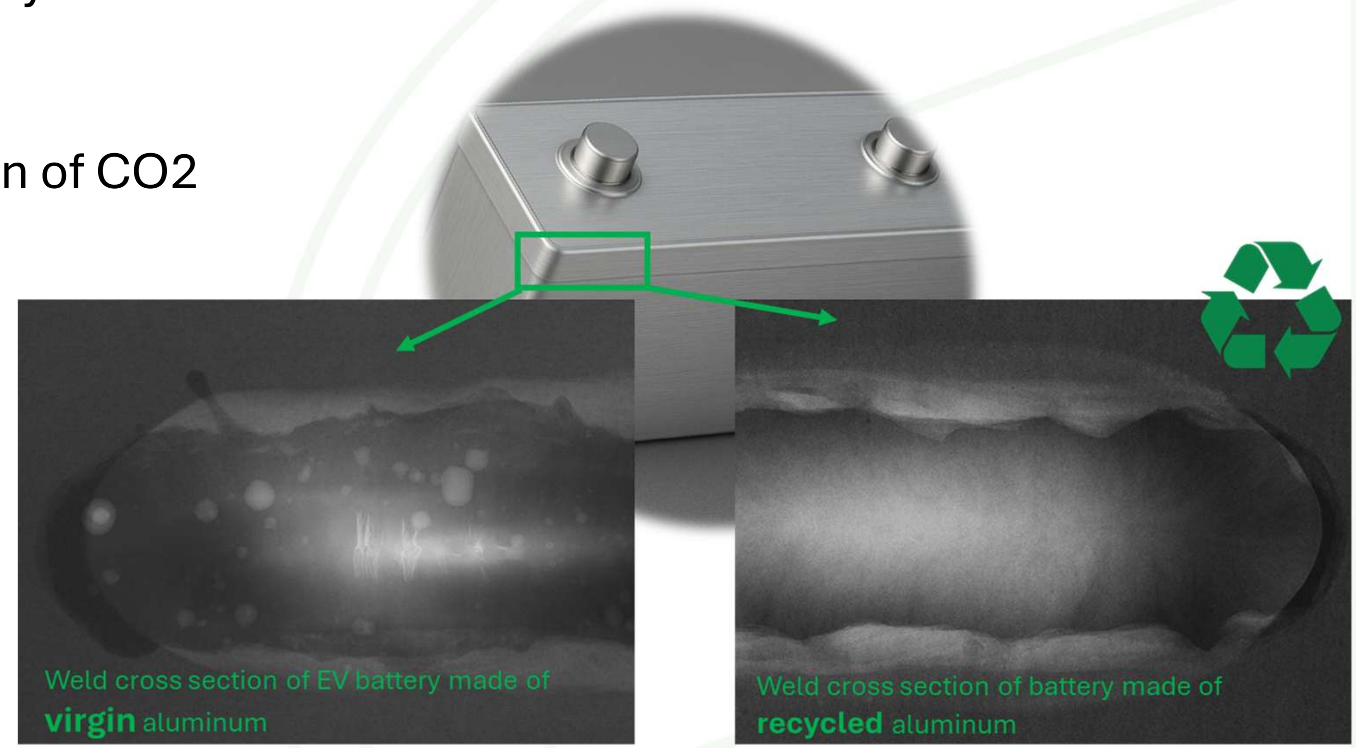


Al-**0.5Si**-0.5Fe-0.12Cu-1.15Mn

Recycled aluminium can give better properties and easier production …

Once proven industrially:

- ✓ Circularity
- ✓ Resilience
- ✓ Significant reduction of CO_2



Take away notes

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Summary:

- Laboratory trials enable cost-effective, small-scale production that mimics industrial processes, allowing systematic testing of alloy variations with different recycled content levels. Materials properties can become very similar to that of production with well controlled processes and well understood differences
- Weldability: The addition of Mg and Zn stabilizes the keyhole and reduces spattering, leading to fewer pores and improved weld quality. However, at Mg+Zn contents above ~0.2%, a change in cracking mechanism is observed, potentially shifting toward centerline segregation cracking. This behavior requires further investigation.
- Standards and requirements for battery cell casing must be reviewed allowing/enforcing higher recycled content

Recycled material additions have so far shown improved properties, while reducing CO_2 footprint by > 50% and supporting a stronger Swedish/European supply chain.

Way forward:

- Understanding crack mechanism in more details and testing different welding parameters
- Industrial trials of selected alloy: focus on forming and full production

Acknowledgment

- Gränges: Reem Rahmatalla and Claudi Martin Callizo
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- Kedali: Yu Jin and Bo Wang
- Swerim: Ethan Sullivan, Sten Wessman, Christopher Petersson and Zhangting He

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Impact Innovation - calls for proposals strategic projects

Thank you for your attention!

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