

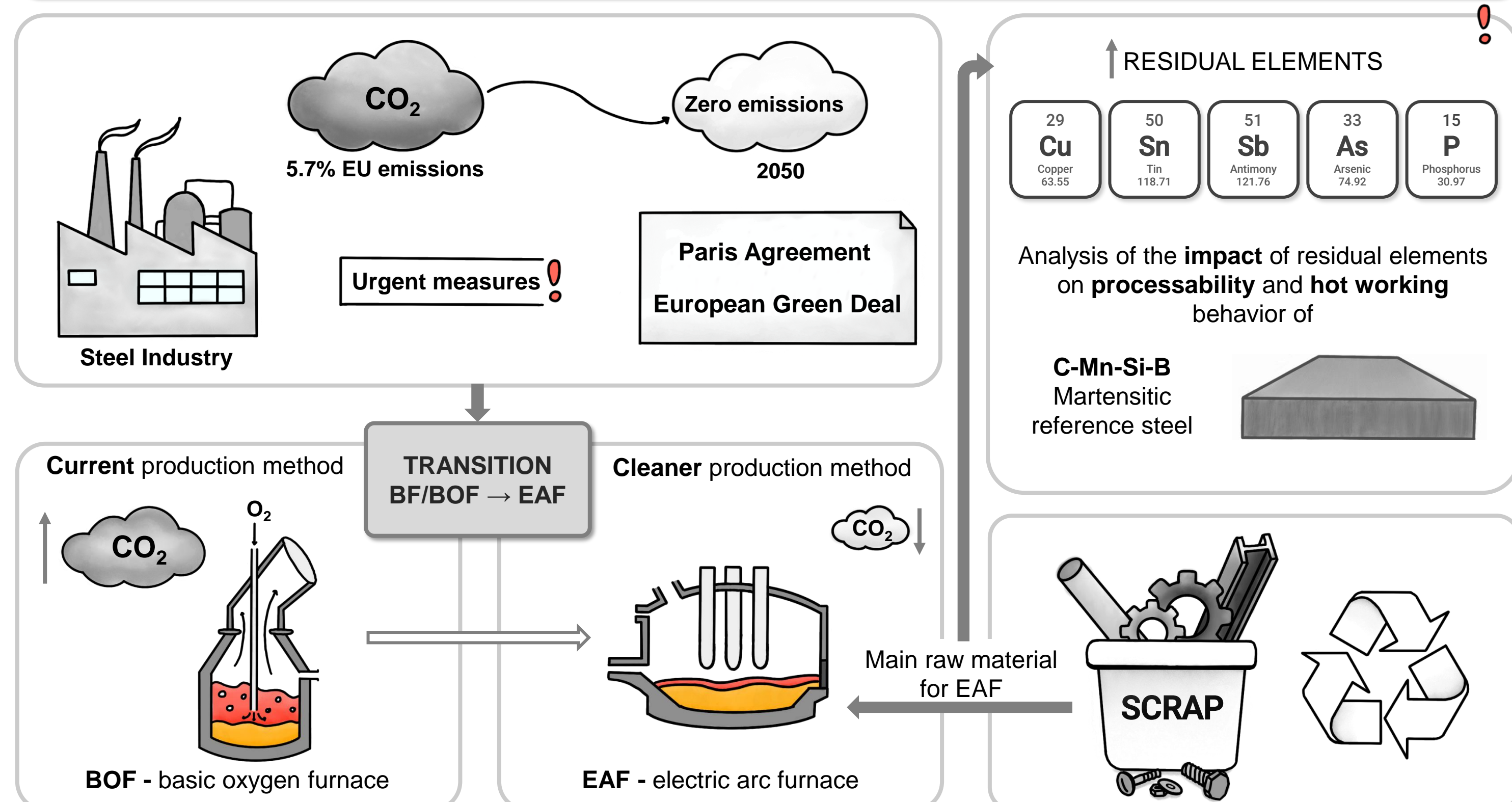
# Toward sustainable steelmaking: impact of residual elements on processability and hot working behavior of martensitic steels

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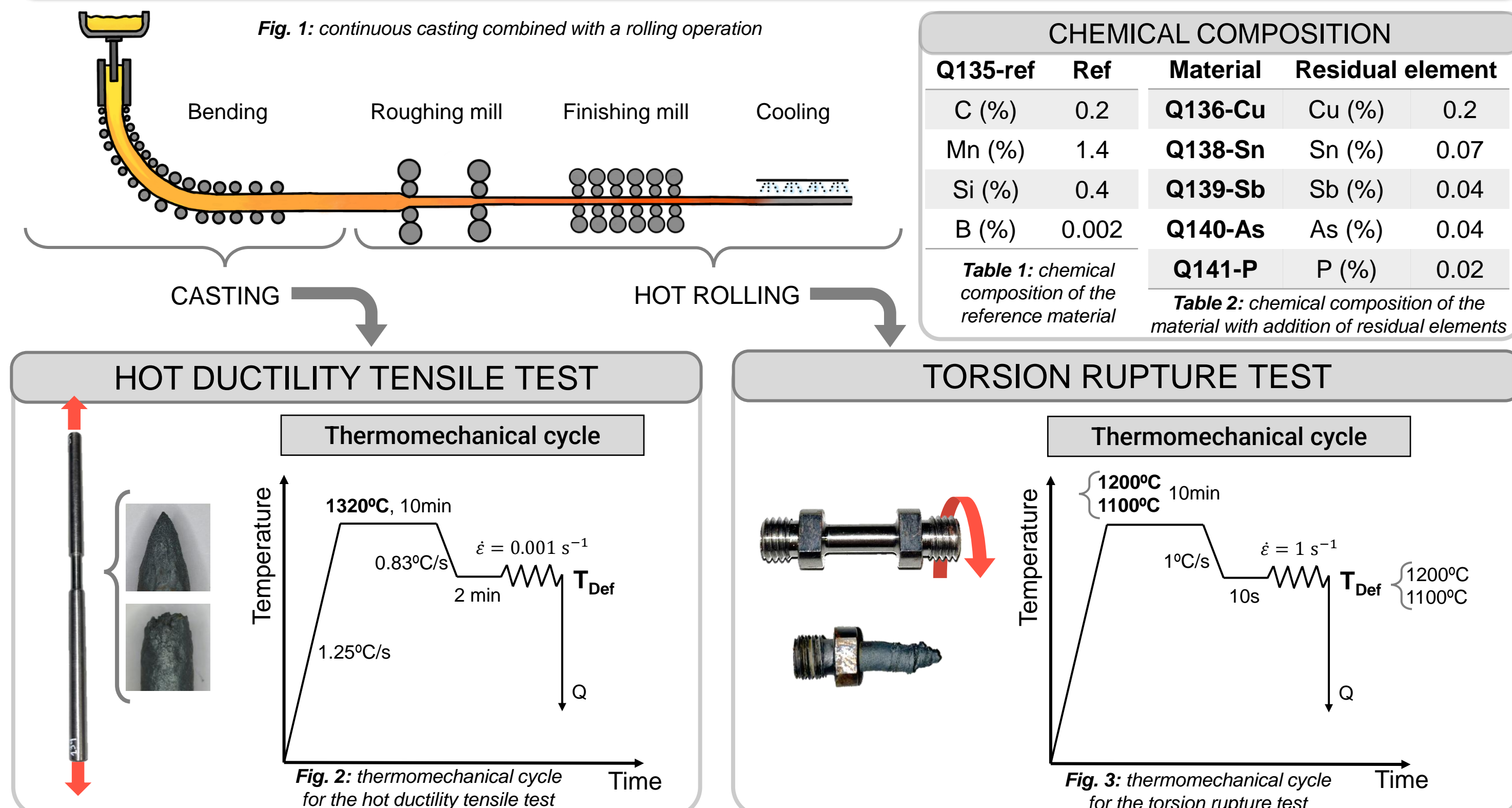
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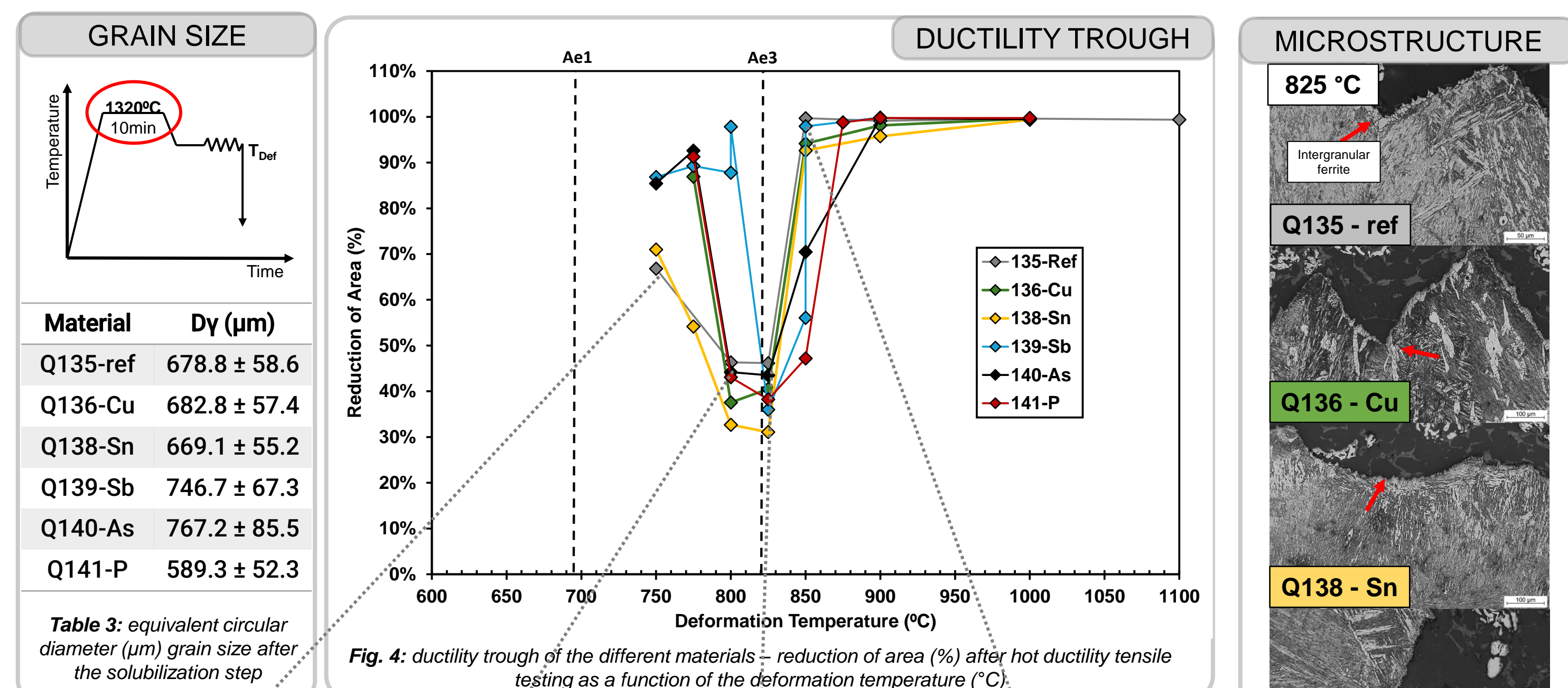
## INTRODUCTION



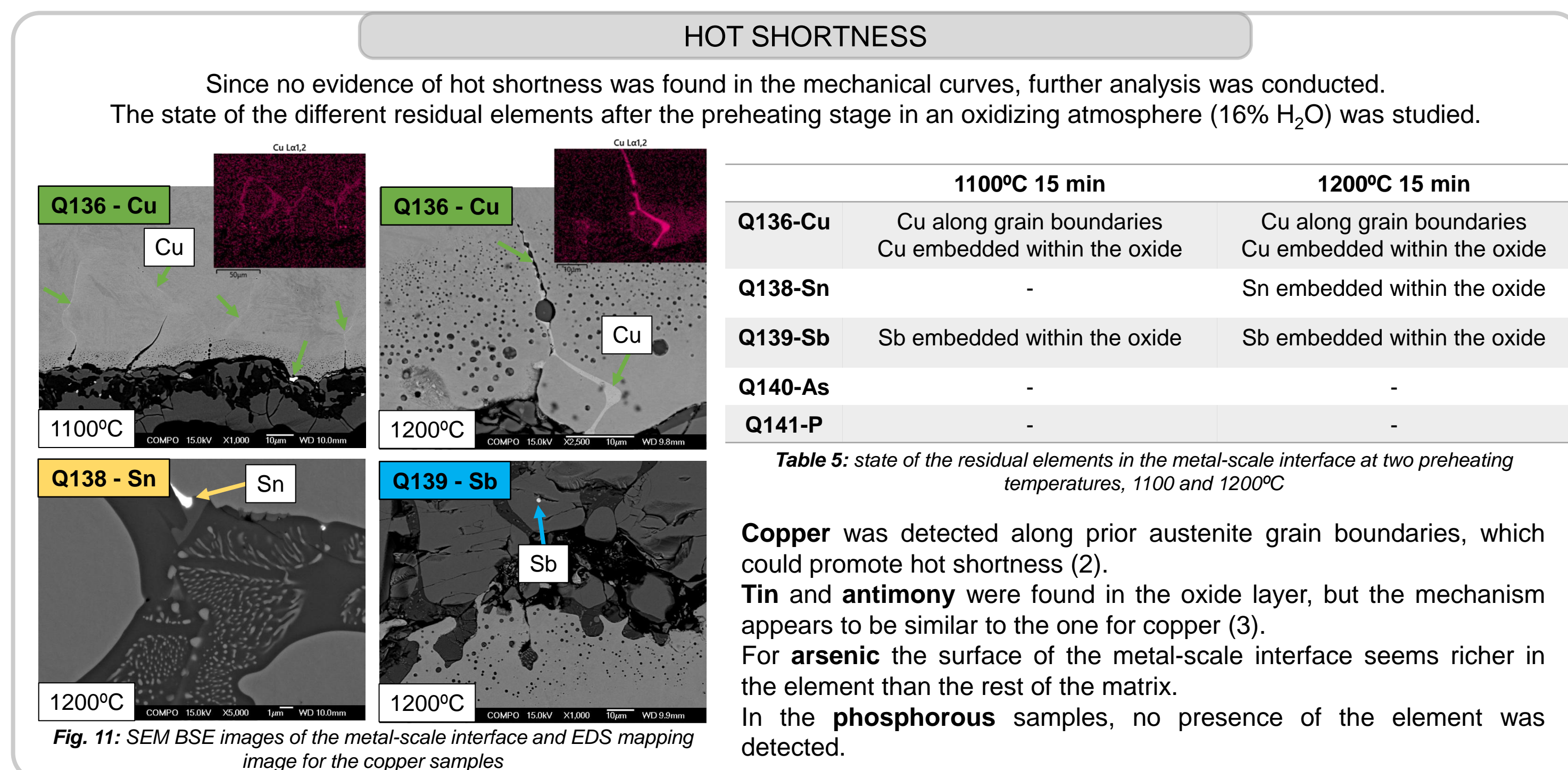
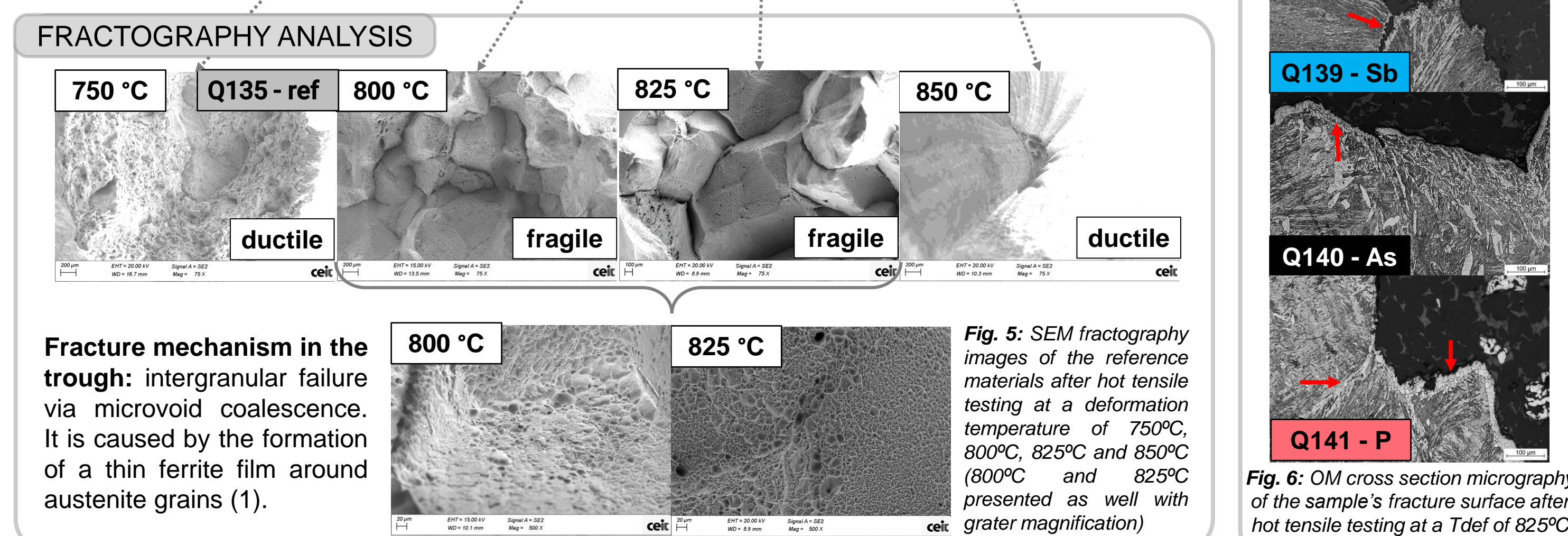
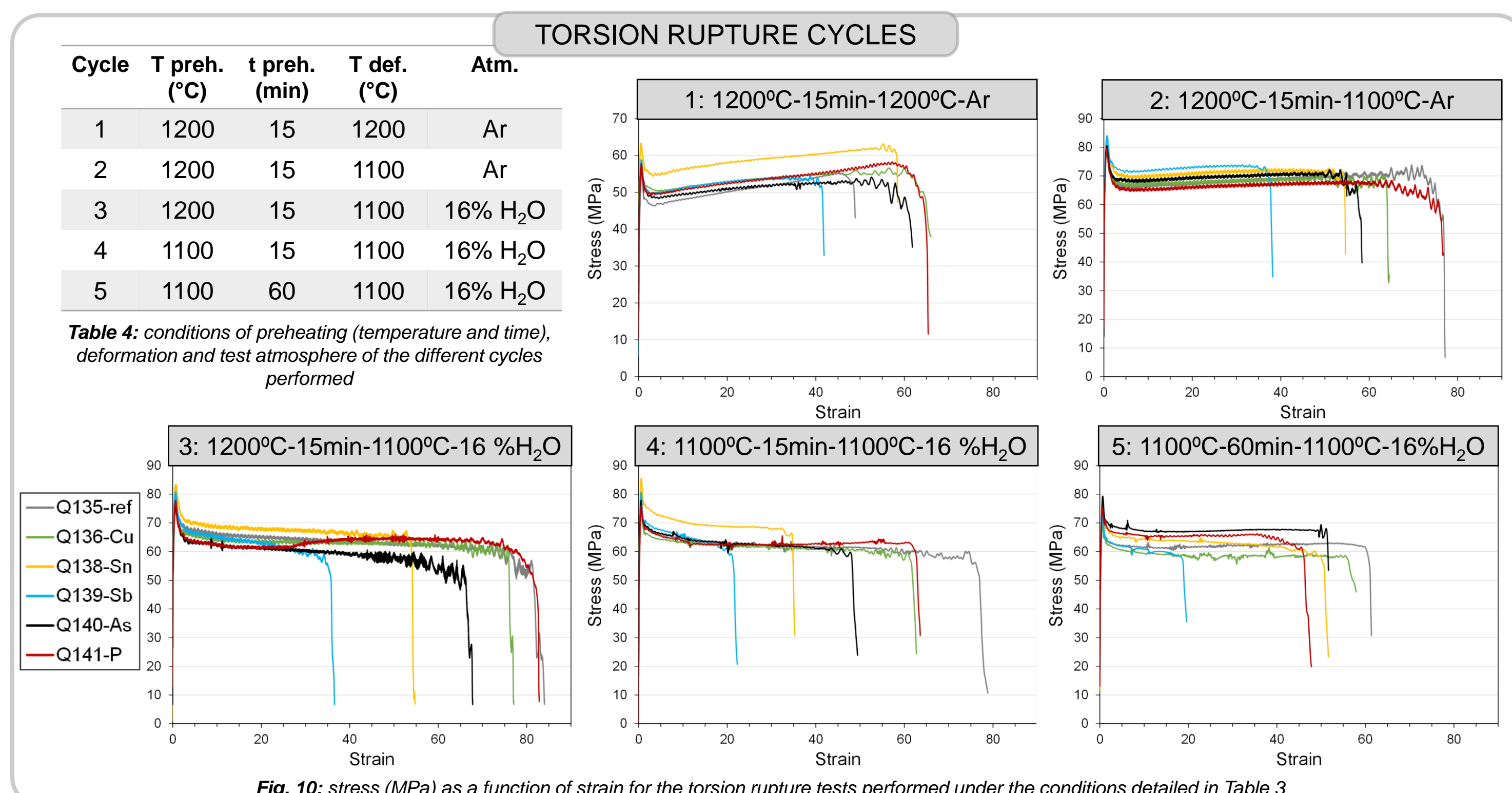
## MATERIALS AND PROCEDURE



## HOT DUCTILITY: CASTING RELATED



## HOT SHORTNESS AND DUCTILITY: HOT ROLLING RELATED



## CONCLUSIONS

### HOT DUCTILITY RELATED CONCLUSIONS

- Existence for all the materials of a low temperature high ductility region, a high temperature high ductility region and a ductility trough between these ranges in which low ductility intergranular failure often occurs.
- Sb appears to improve ductility, as its trough is narrower, and As and P to worsen it, since their ductility drops at a higher temperature than the rest of materials. The reference steel, Cu and Sn samples show a very similar behavior.
- For all materials, the start of the ductility trough is related to the austenite to ferrite phase transformation
- The intergranular failure in the ductility trough occurs by a microvoid coalescence mechanism caused by the presence of a thin film of ferrite around the prior austenite grains.
- A study of the inclusions present in the materials was carried out since the formation of intragranular ferrite seems to be related to inclusions. The presence of MnS, Al<sub>2</sub>O<sub>3</sub> and BN predicted by the Thermocalc software was confirmed by EDS analysis.

### TORSION RELATED CONCLUSIONS

- Some general trends in the stress-strain curves obtained from torsion rupture testing are observed:
- Sb, Sn and As tend to reduce the ductility to some extent, although no signs of hot shortness or drastic ductility loss were detected under the tested conditions.
  - The most critical conditions are at 1100°C and 15 min preheating stage and a deformation temperature of 1100°C under a 16% H<sub>2</sub>O oxidizing atmosphere.
- Further analysis was conducted under oxidizing conditions in order to observe the state of the different residual elements after the preheating stage:
- Cu was detected along prior austenite grain boundaries, which could promote hot shortness.
  - The mechanism behavior of Sn and Sb appears to be similar to the Cu mechanism: the elements are liquid at that temperature and thus are able to diffuse into grain boundaries.
  - Flexion studies will be carried out in the future in order to analyse more deeply the hot shortness behaviour.

## REFERENCES AND ACKNOWLEDGEMENTS

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