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Identification of behavior and damage mechanism in fatigue of ferrite-pearlite steel with microstructure gradient

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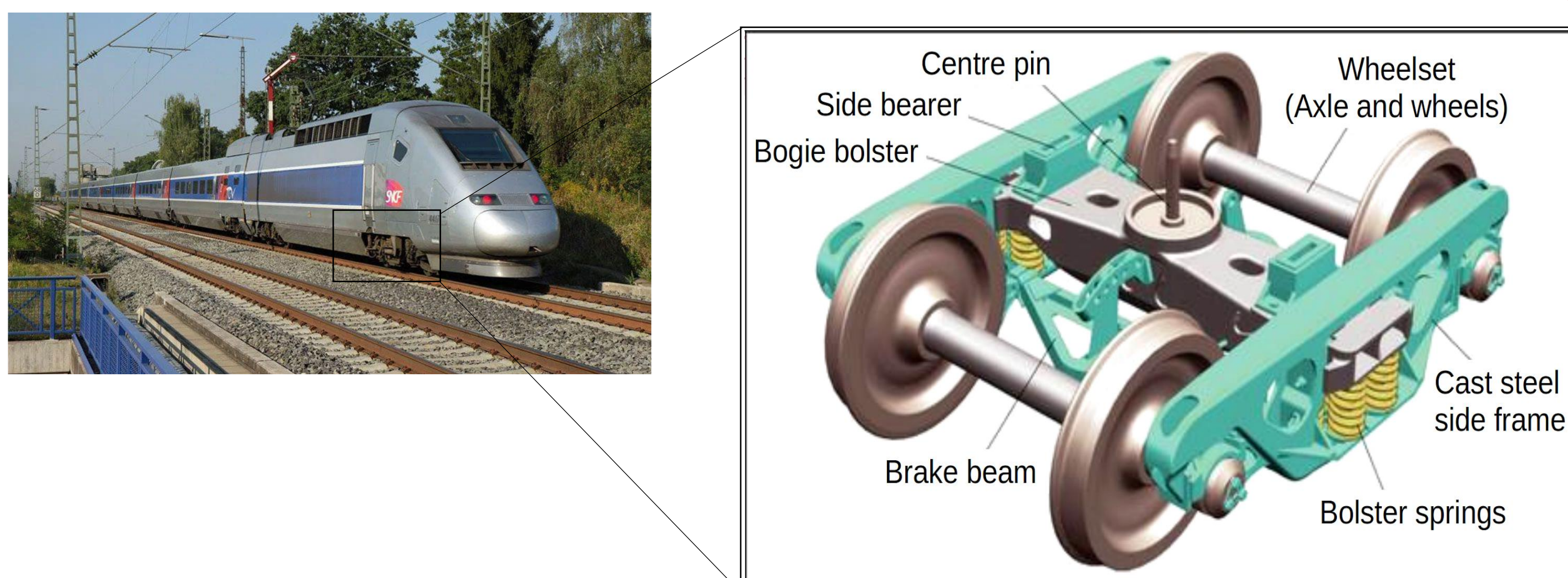
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Identification of behavior and damage mechanism in fatigue of ferrite-pearlite steel with microstructure gradient.

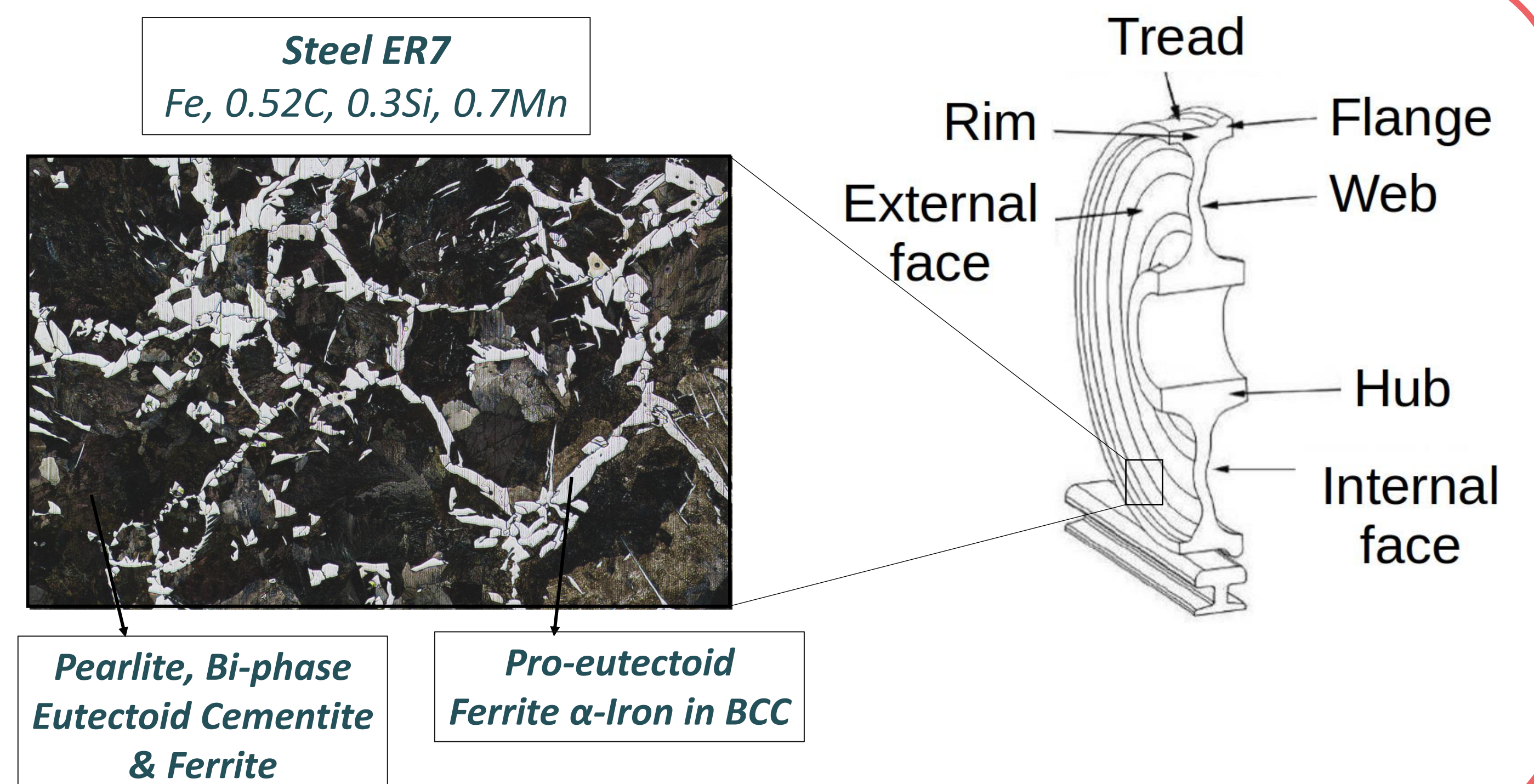
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General Context



Purpose -> Reduce maintenance cost & improve lifecycle
Complex stresses -> Increased understanding -> Better Design
Analysis of Material-Structure performance.

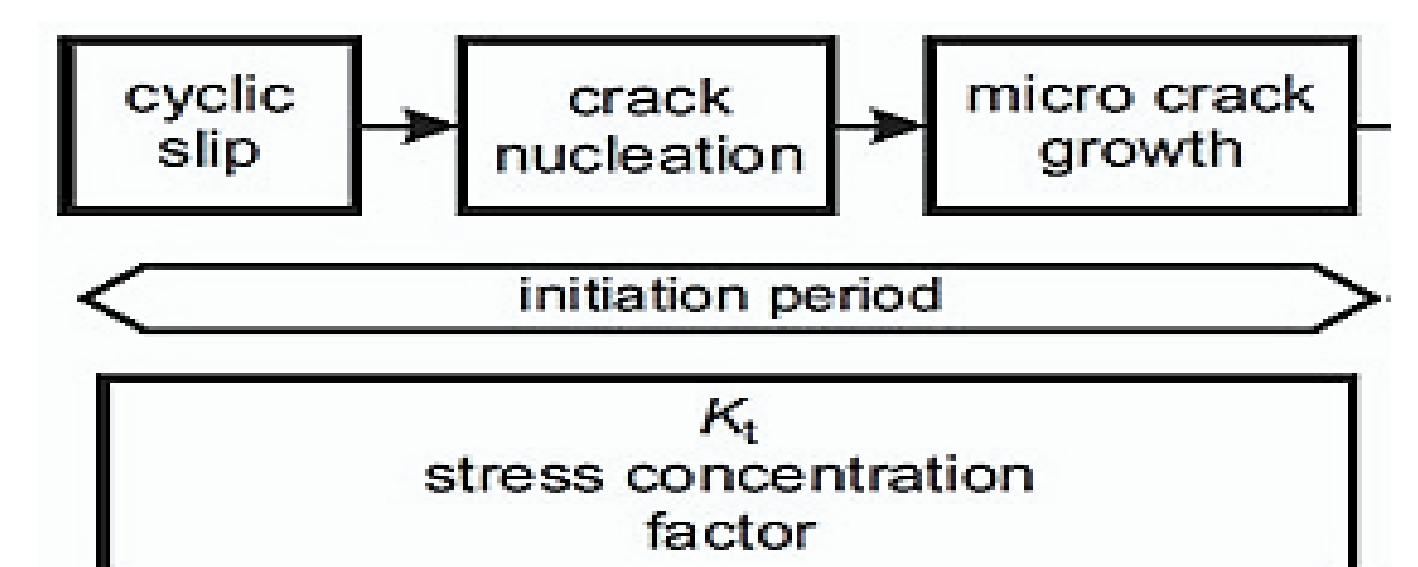
Railway wheel



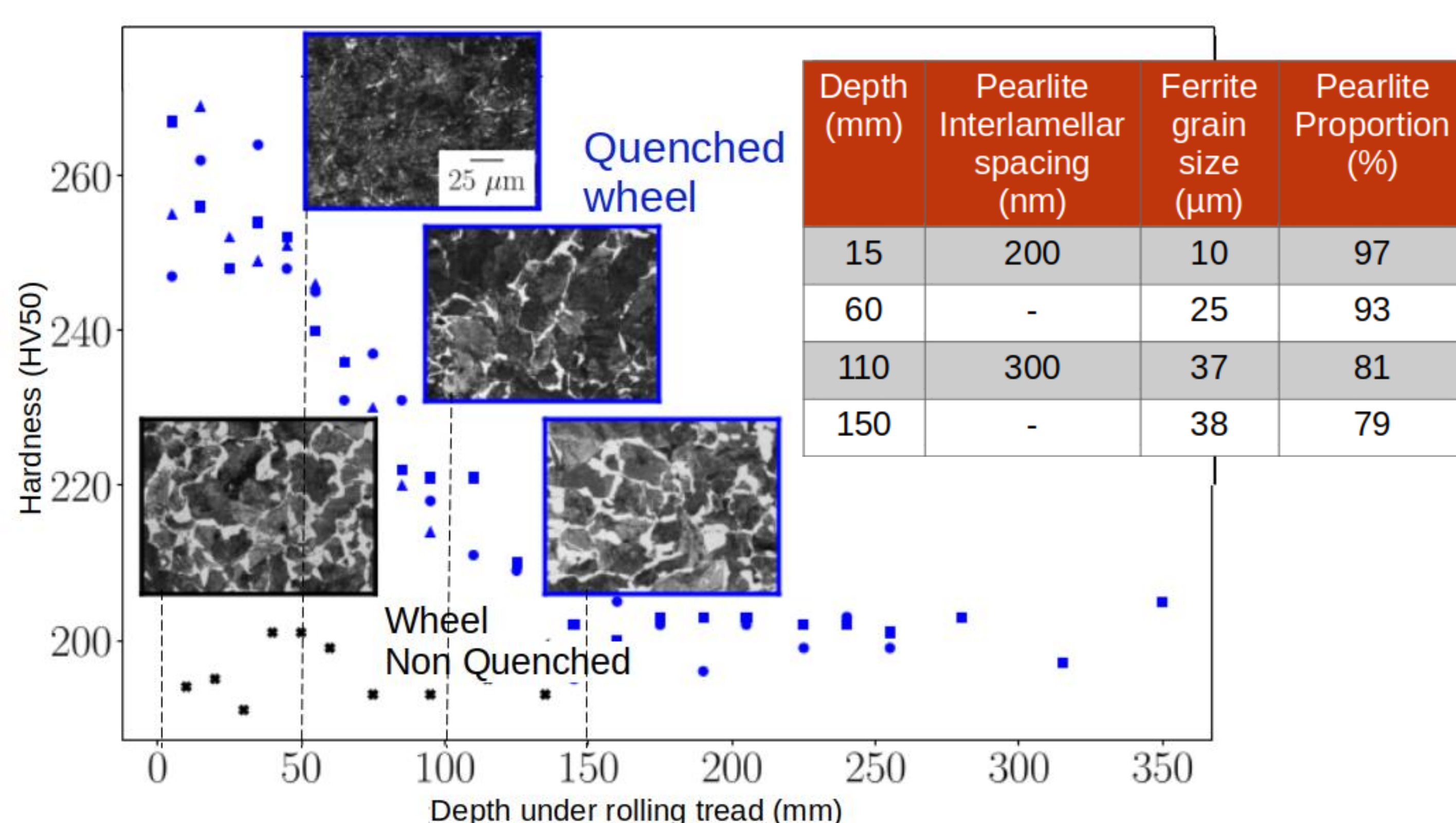
Scientific problem and objective

To examine the influence of the microstructure gradient on fatigue crack initiation and micro-crack growth.

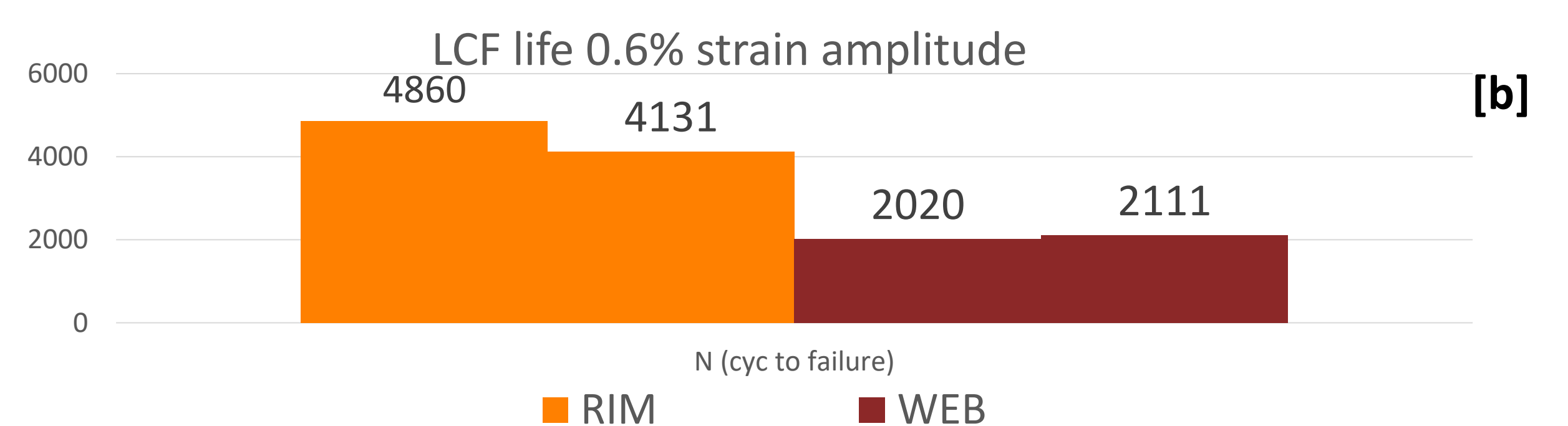
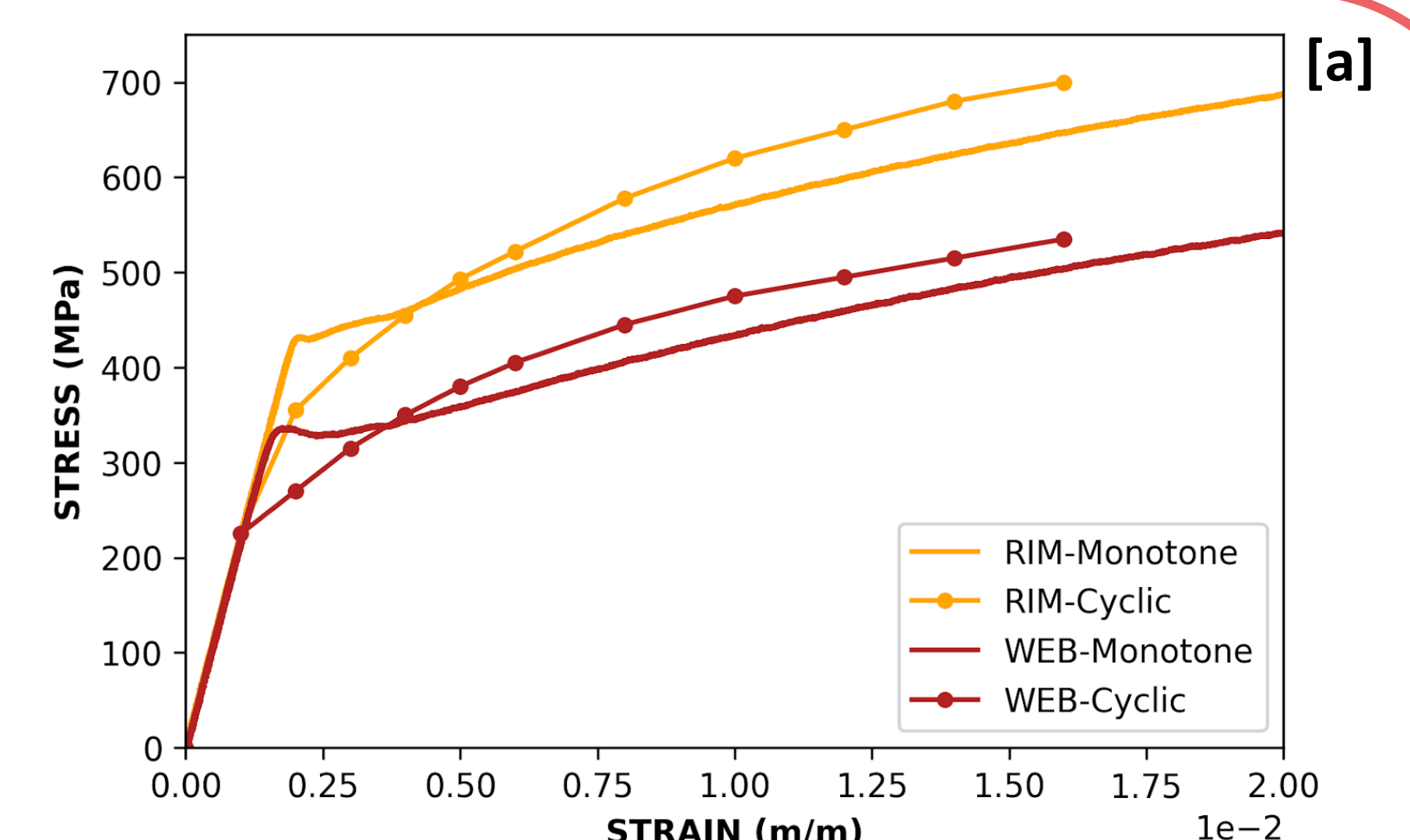
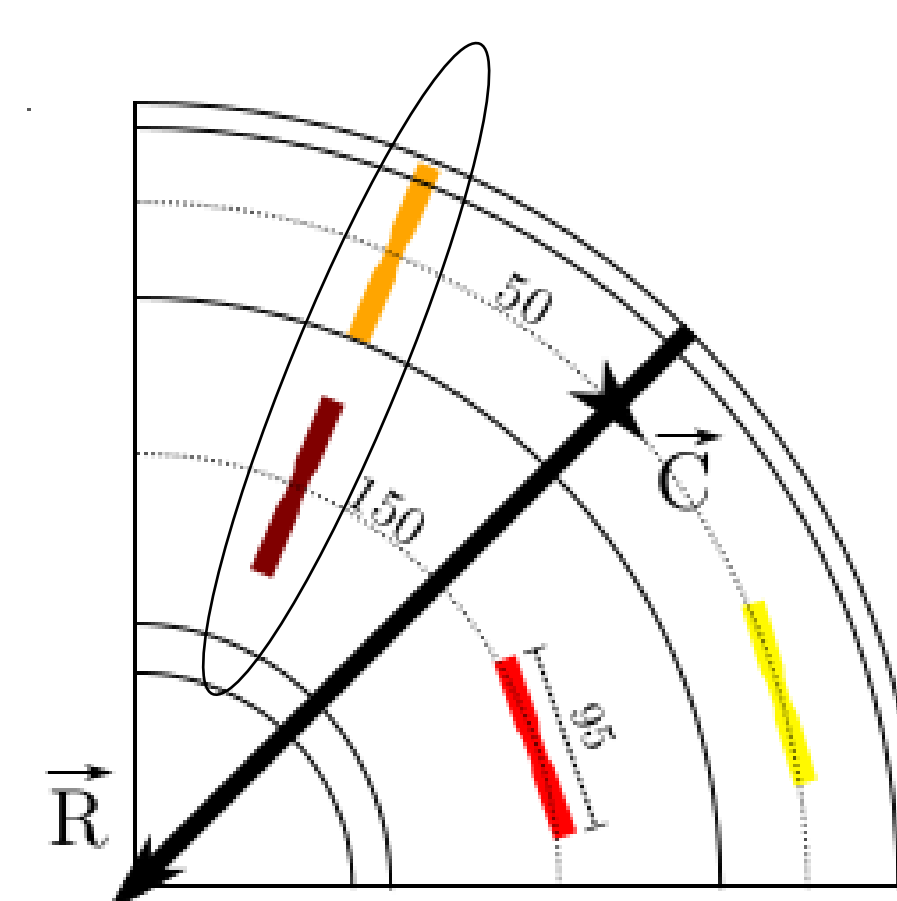
- ✓ Characterization of macroscopic behaviour and observation of fatigue mechanism according to microstructure.
- ✓ Relation with microstructure and damage mechanism at local deformation sites.



Microstructure gradient & Influence



- ✓ The process of elaborating railway wheels results in **microstructure gradient**, which is primarily attributed to the **quenching** of the Rim through **spray cooling**.
- ✓ This gradient can be understood by comparing the **hardness** values between **quenched** and **non-quenched** wheels along the depth.
- ✓ Observations revealed an **increase** in the **size of ferrite grain** and decrease in the **proportion of pearlite** from **tread** to **depth**.
- ✓ The **pearlite interlamellar spacing** was found to **increase with depth**.

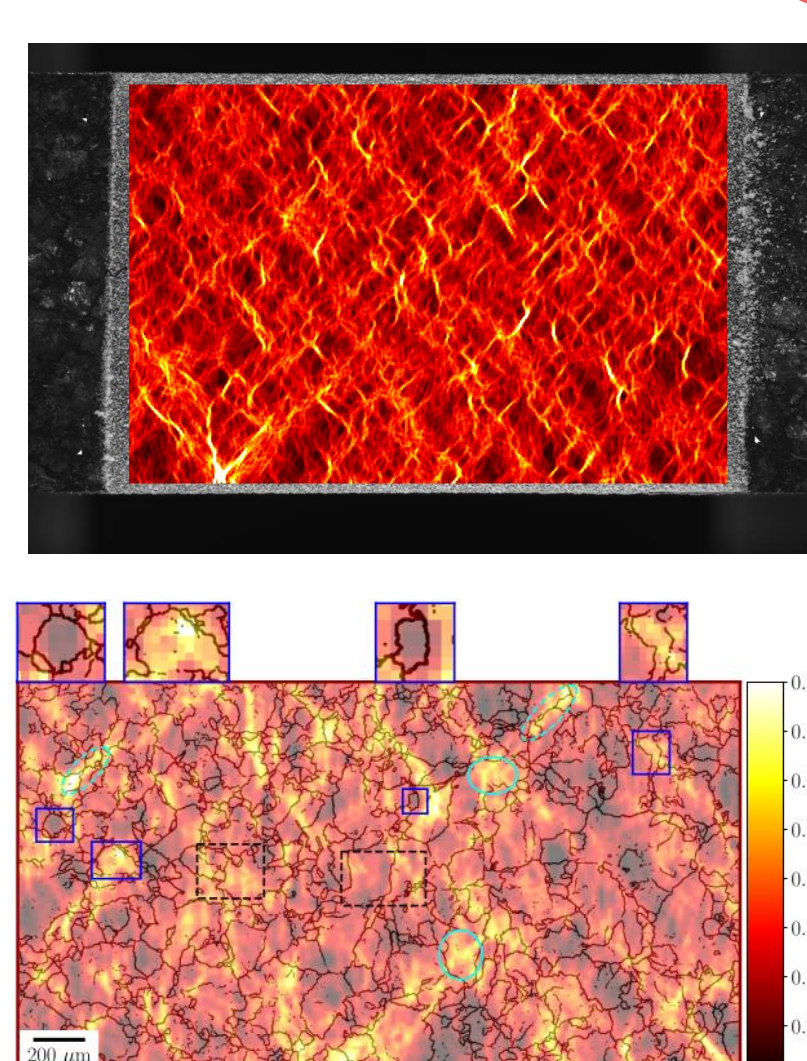


- ✓ Tests for **monotonic tensile (a)** behavior, **cyclic hardening (a)**, and **Low Cycle Fatigue (LCF) (b)** were carried out on **Rim** and **Web** specimens extracted **radially**.
- ✓ **Rim** samples exhibited **higher values of Ultimate Tensile Strength (UTS) and Yield Strength** compared to **Web** samples.
- ✓ The presence of **Yield Point Elongation (YPE)**, as well as **variations in the Upper Yield Point value and the length of the plateau** can be attributed to the **proportion of ferrite** in the microstructure.
- ✓ **Cyclic hardening behavior** was observed in both **Rim** and **Web** samples.
- ✓ An **increased LCF life** was observed in **Rim** samples characterized by a **higher proportion of pearlite** and a **smaller size of ferrite**.

Conclusions

The **basic mechanical properties** of the **wheel steel** were evaluated at **Rim** and **Web** regions, and the underlying causes with respect to **microstructure** were identified.

In a previous thesis by A. Berger [2022] under the project, instrumented monotonic tensile tests were conducted on ferrite-pearlite specimens to analyze strain heterogeneities and their respective influences of constituents, microstructure size, and pearlite interlamellar spacing.



Perspectives

Low Cycle fatigue (LCF) tests will be performed to understand **impact on deformation mechanism and fatigue life** using a newly developed experimental approach:

- ✓ During LCF loading, **local strain measurements** will be obtained along the width of the semi-circular notch in the specimen using an **in-situ optical-based Digital Image Correlation (DIC)** technique.
- ✓ The resultant **strain fields** will be mapped onto the microstructure to identify **the locations of plasticity and potential crack initiation sites**.