Ferrite Precipitation in Fe-0.09C-4.6Mn (wt. %)

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Contents

- Literature Review (low, medium, high Mn containing steels)
- Experiments in Fe-0.09C-4.6Mn
- Results
- Interpretation

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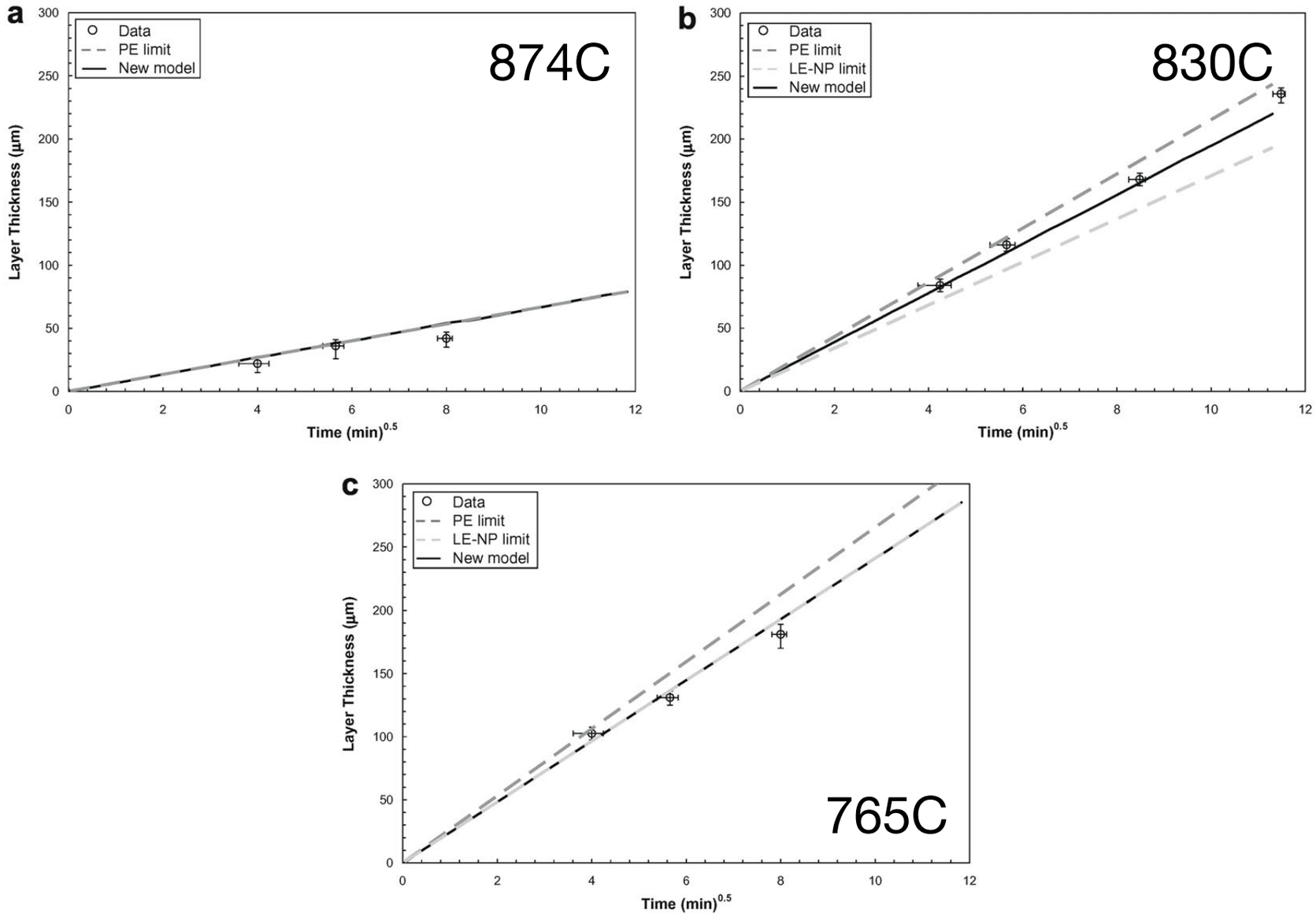
Literature Review

Subjective categorization of Mn contents into low (<1%), medium (1-3%) and high (>3%).

Restrict ourselves to ternary Fe-C-Mn and isothermal experiments available in the literature.

Literature Review: low Mn (<1%Mn)

Fe-0.57C-0.47Mn (wt. %): Decarburization conditions



Zurob et al. Acta materialia, 2008, 2009

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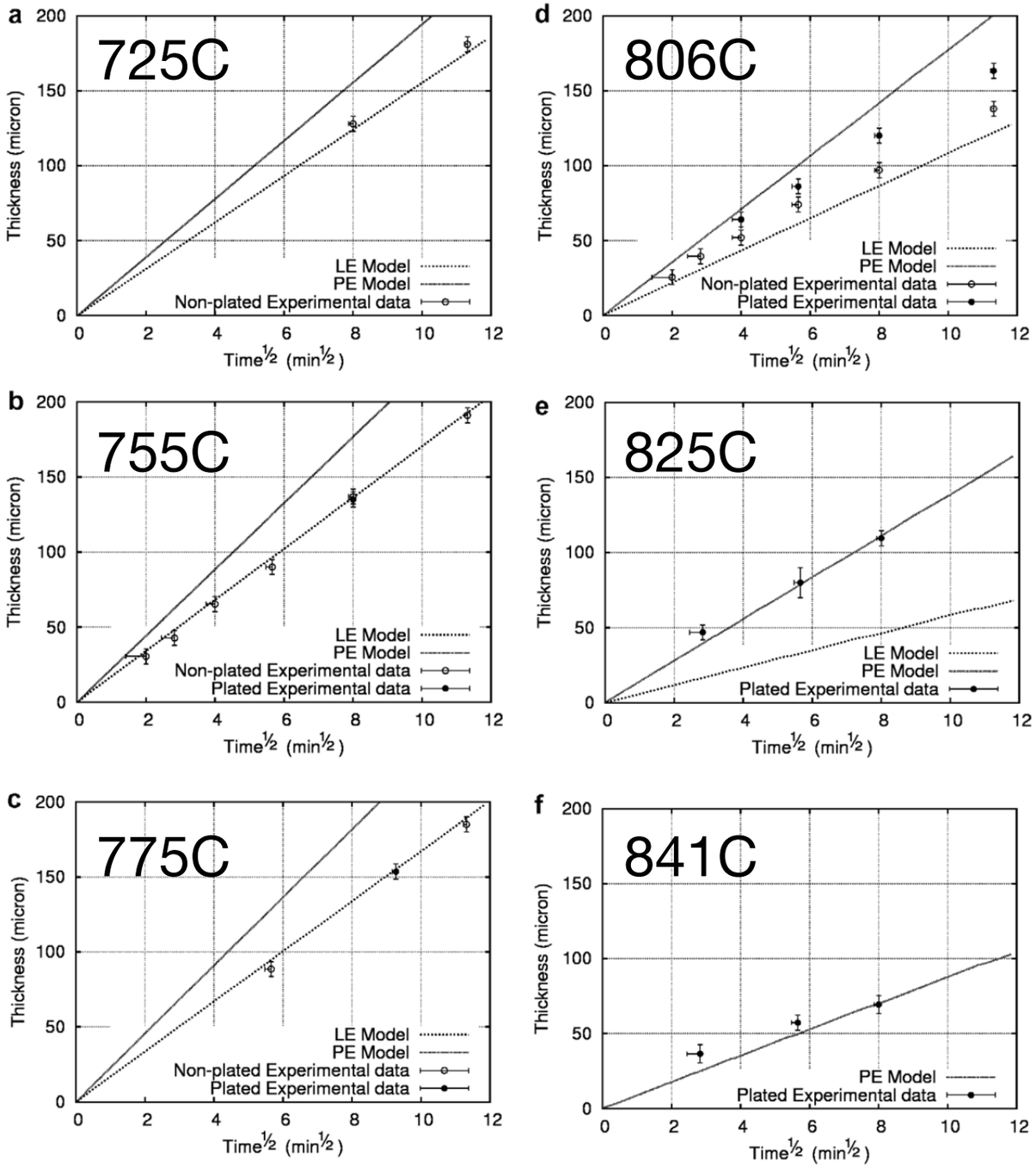
Literature Review: low Mn (<1%Mn)

Fe-0.57C-0.94Mn (wt. %): Decarburization conditions



Zurob et al. Acta materialia, 2008, 2009

- LENP to PE transition with increase temperature
- Long-lived, parabolic intermediate states

- Even with low Mn and high T, Mn has some tricks up its sleeve

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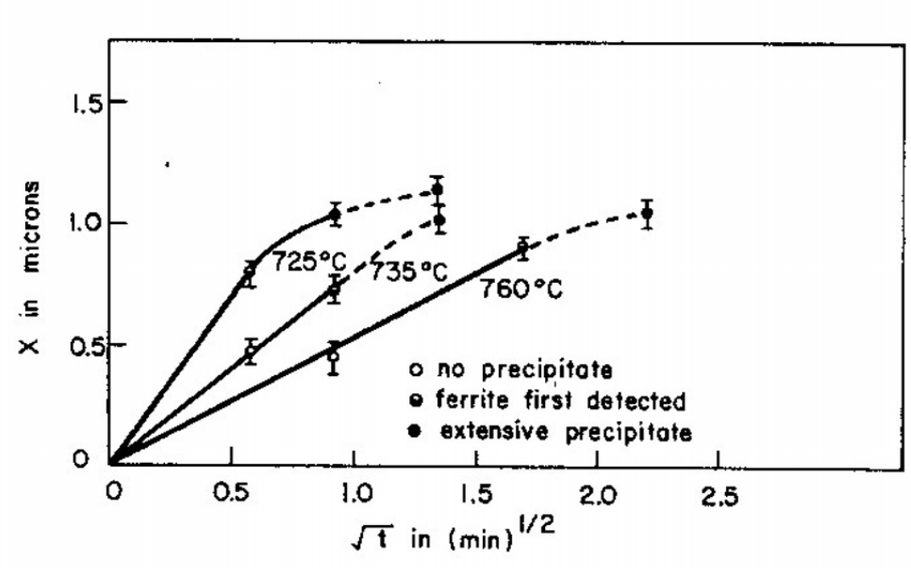
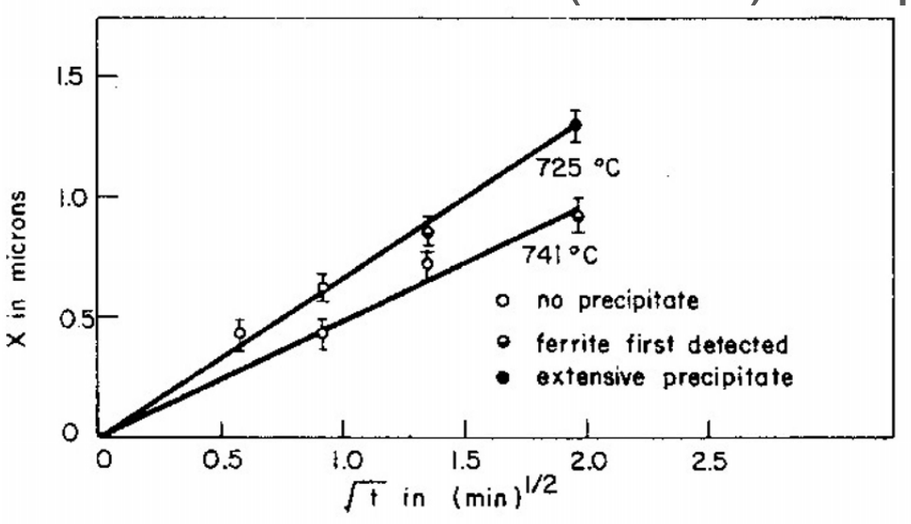
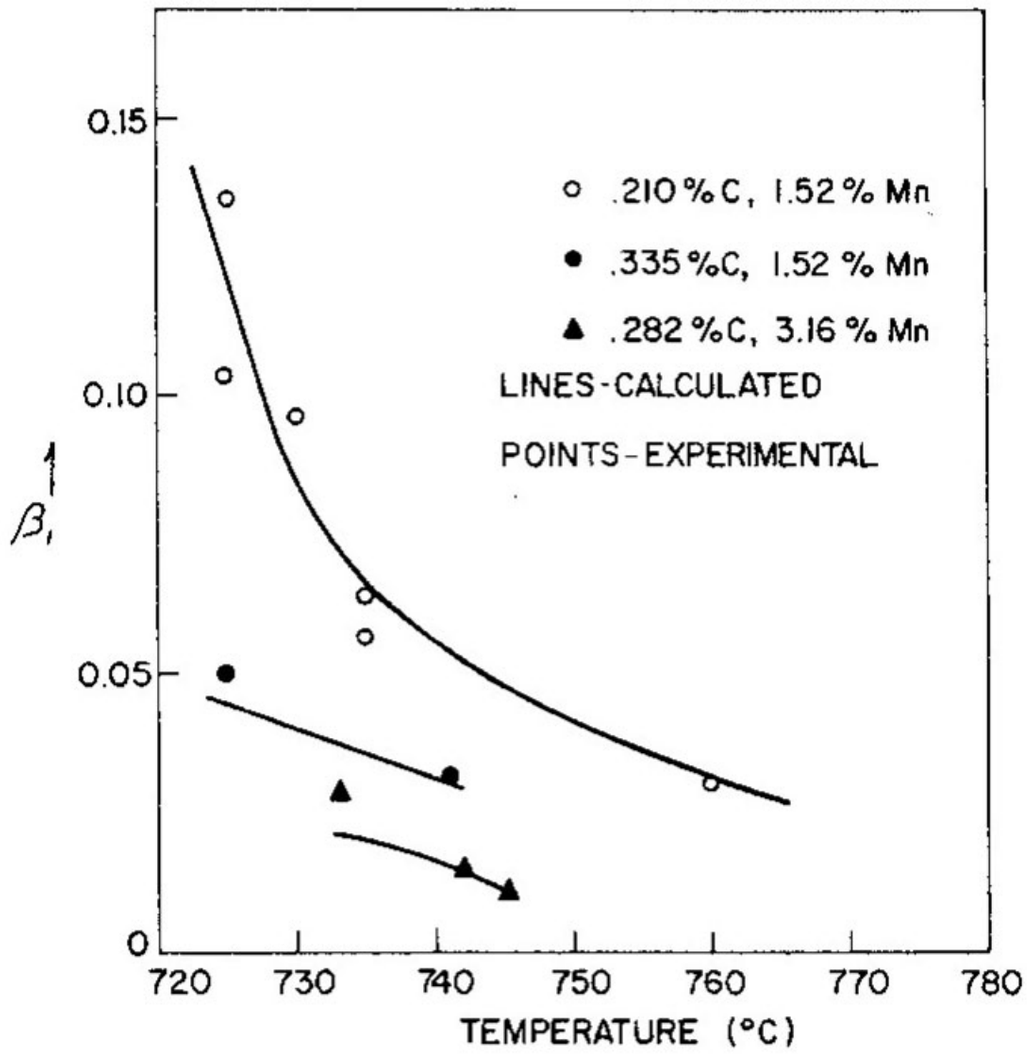
Literature Review: medium Mn (1-3%Mn)

Fe-0.21C-1.52Mn (wt. %): Fe plated



Fe-0.335C-1.52Mn (wt. %): Fe plated





Purdy et al. Trans AIME, 1964

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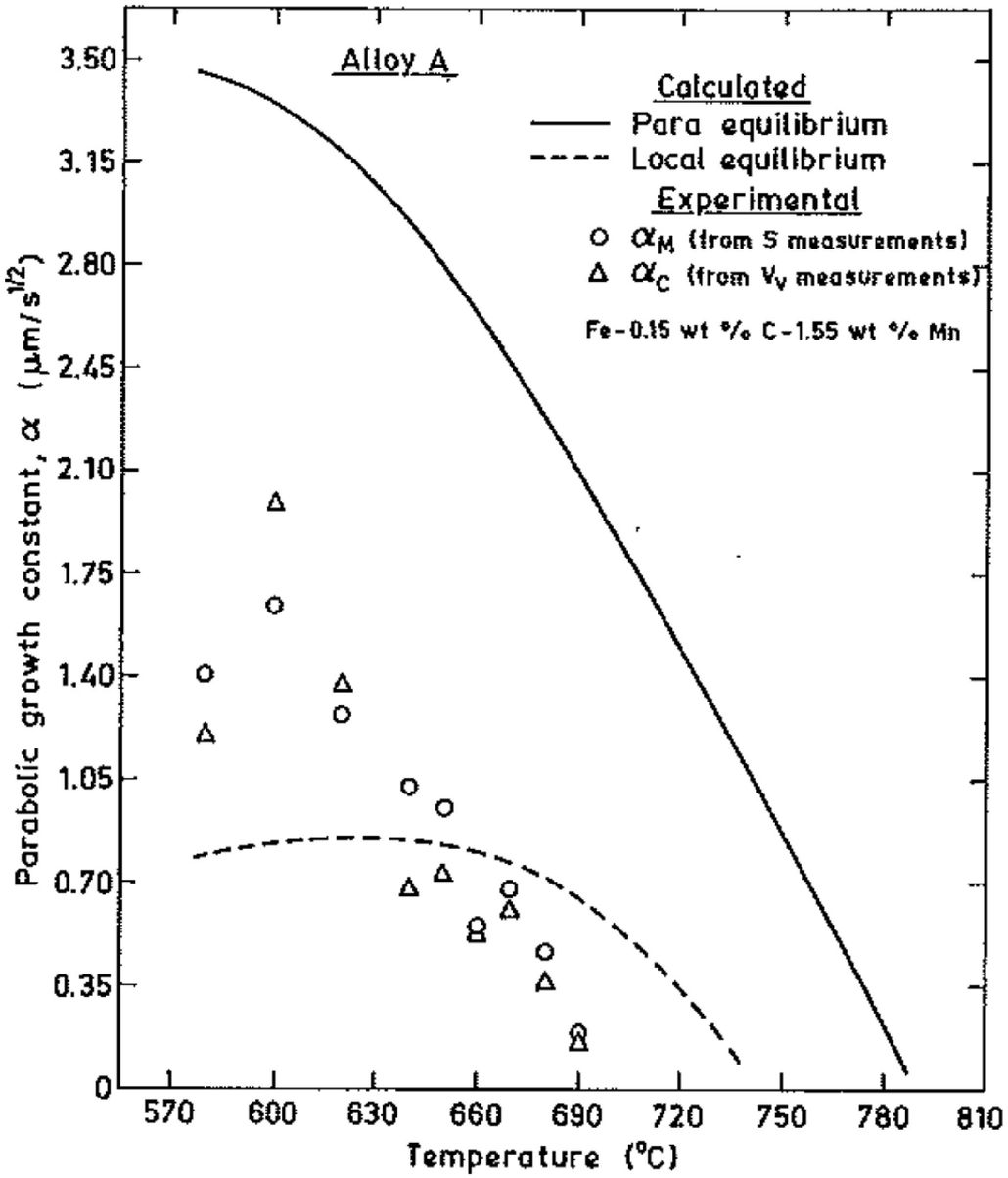
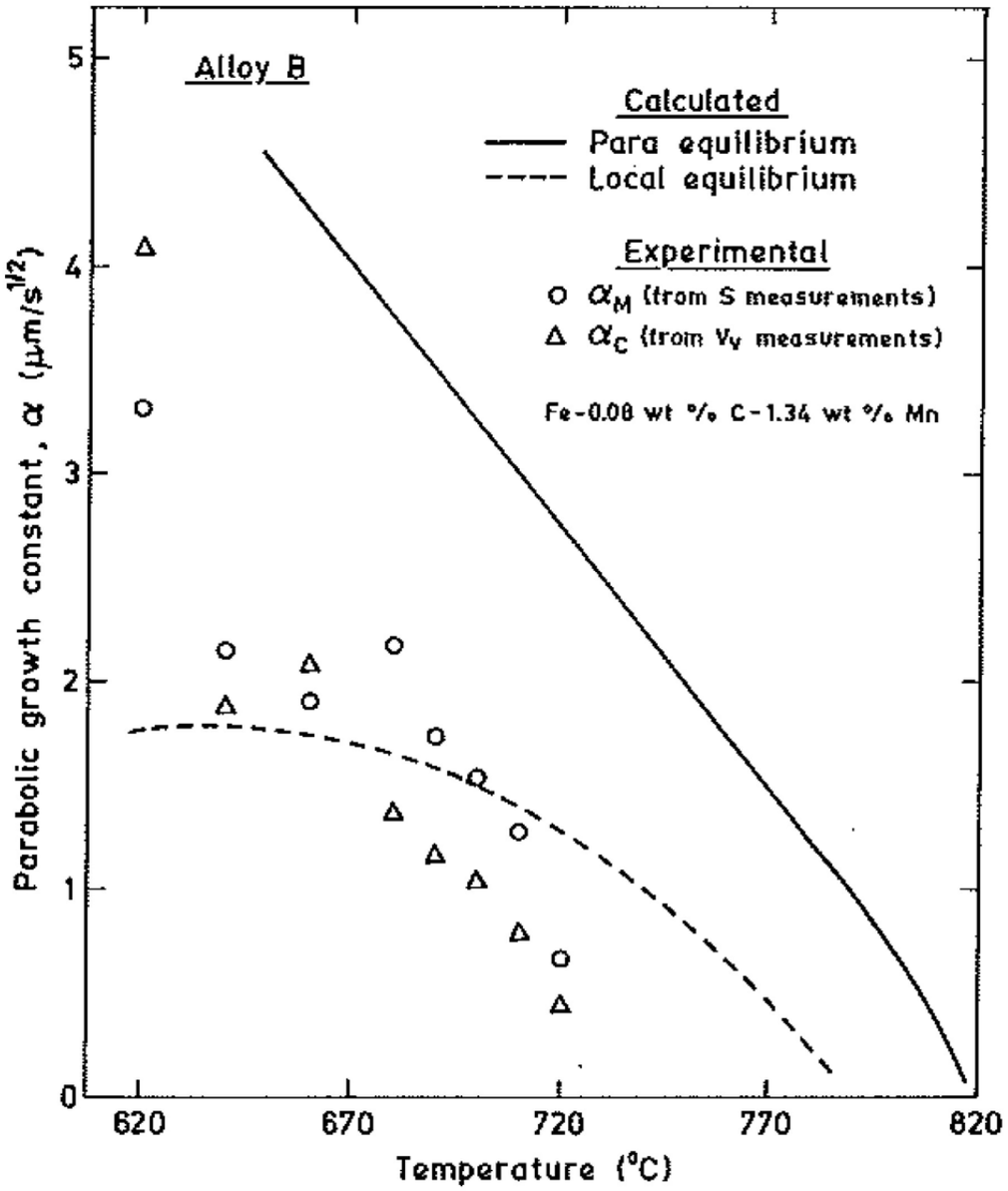
Literature Review: medium Mn (1-3%Mn)





Shah et al. Z. Metallkd, 1983

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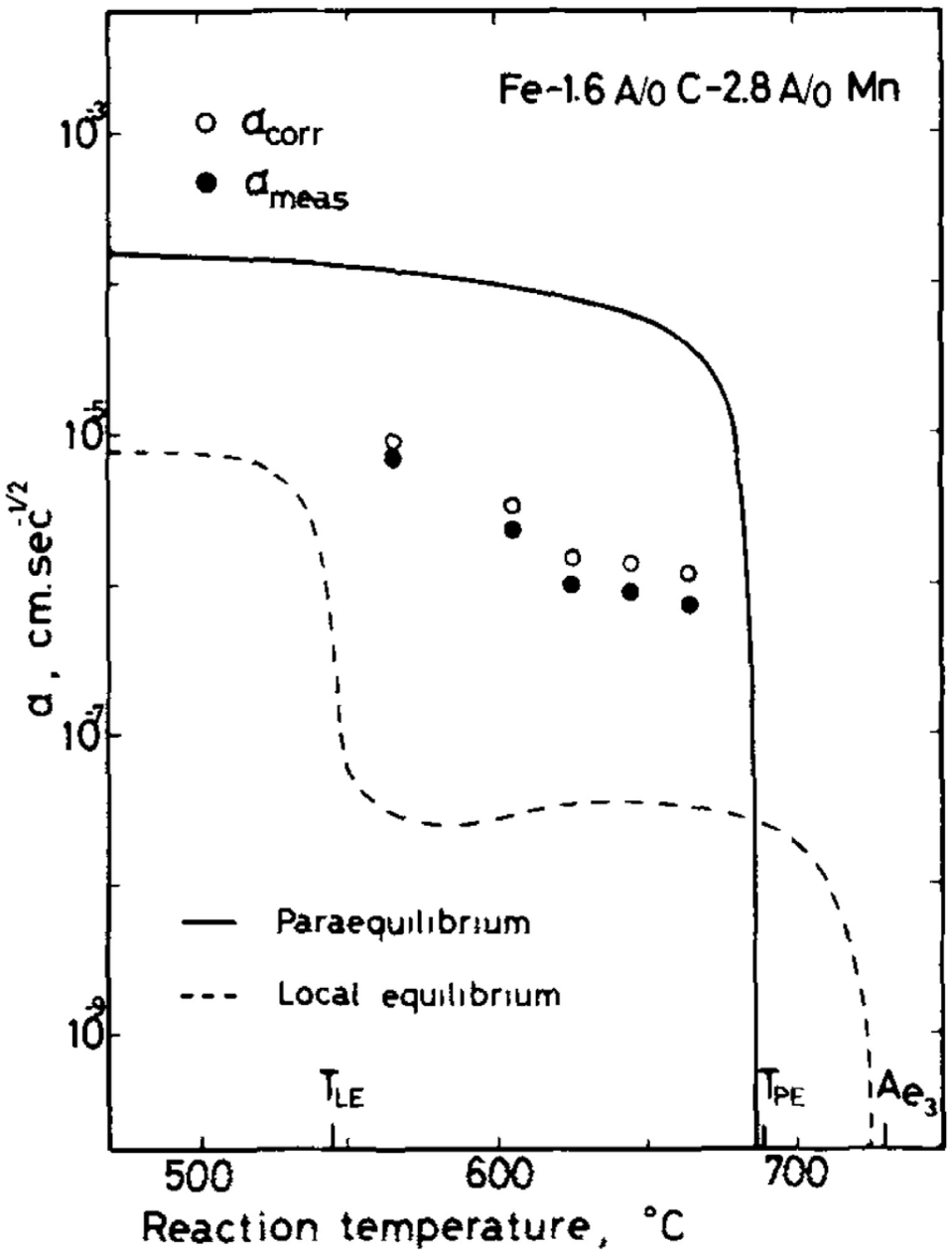
Literature Review: medium Mn (1-3%Mn)



Enomoto and Aaronson. Met Trans A, 1987

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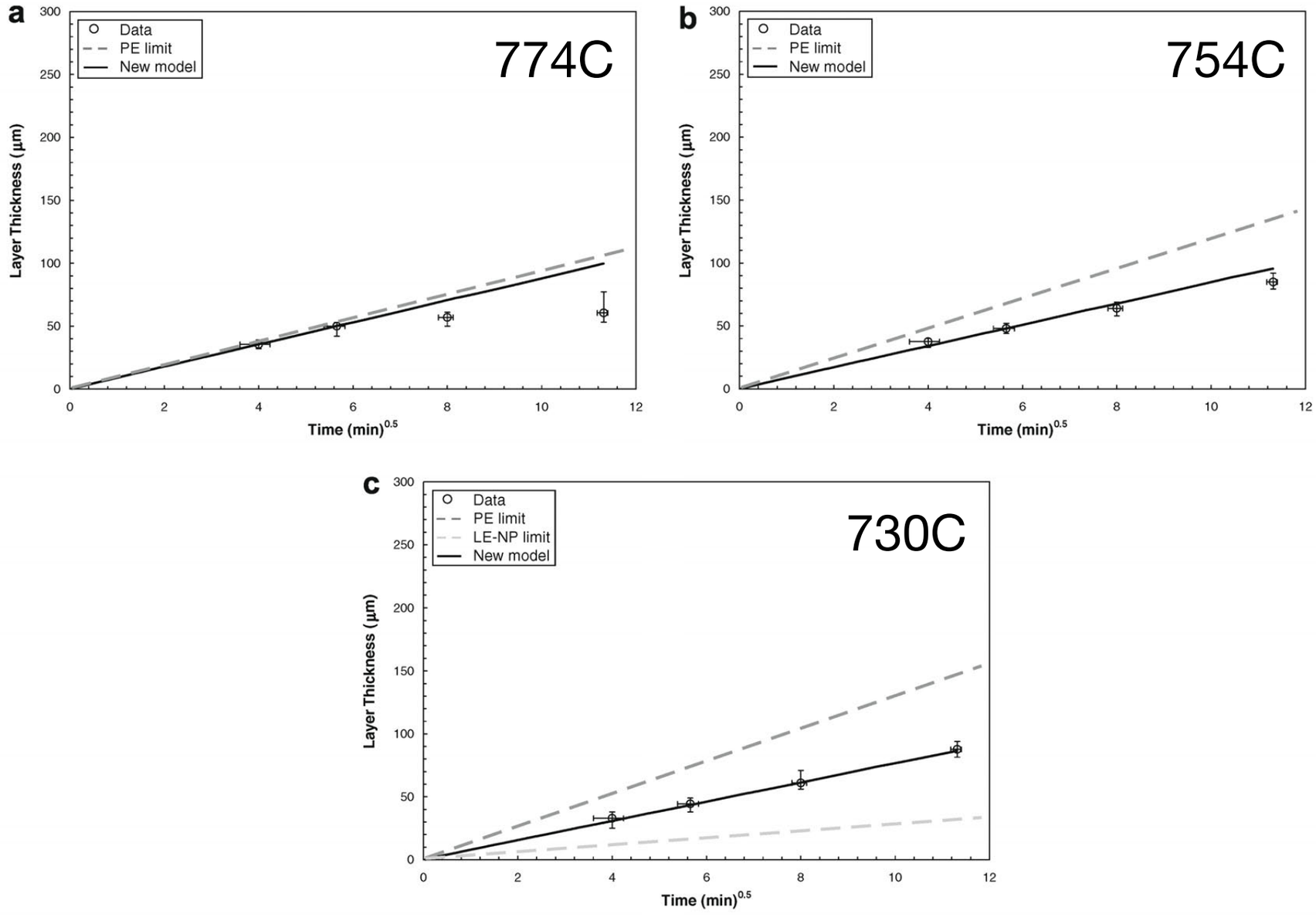
Literature Review: medium Mn (1-3%Mn)

Fe-0.59C-1.96Mn (wt. %): Decarburization conditions



Zurob et al. Acta materialia, 2009

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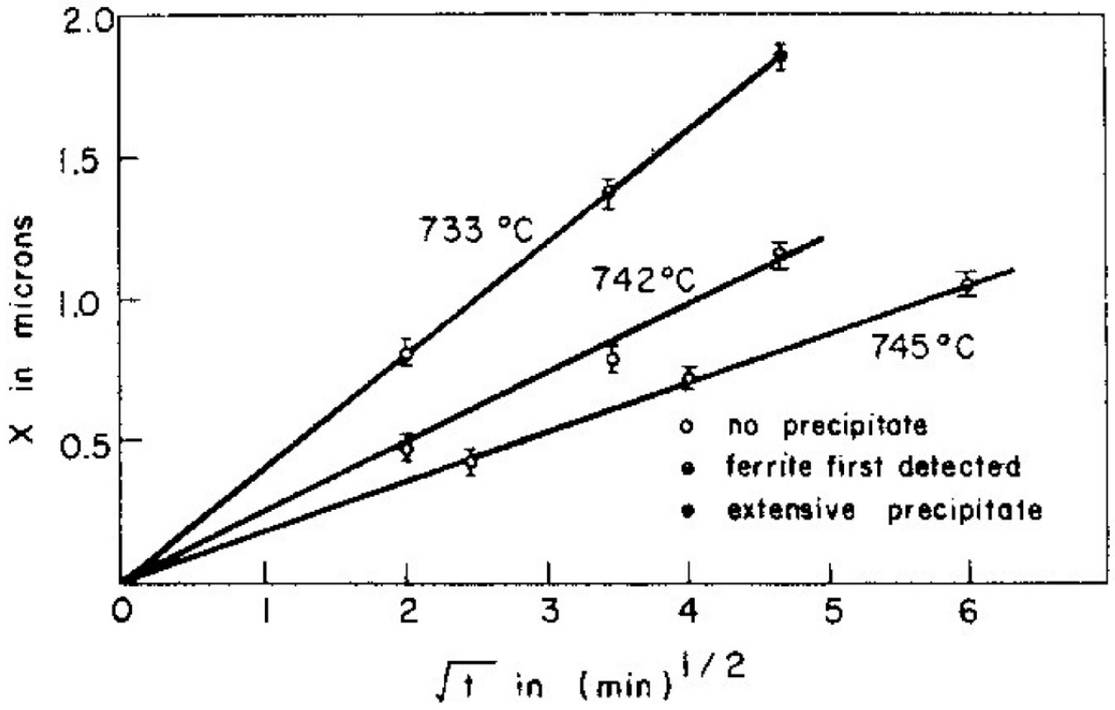
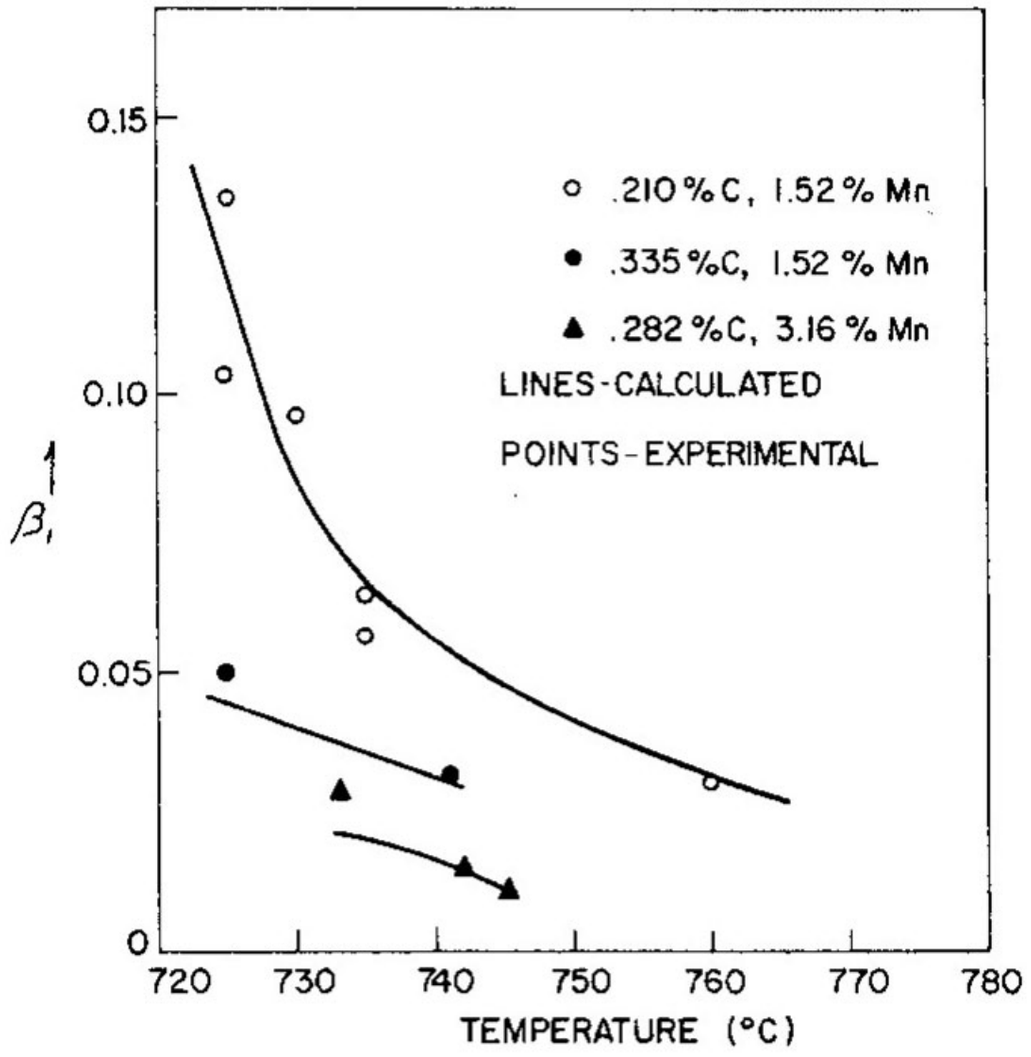
Literature Review: high Mn (> 3%Mn)

Fe-0.282C-3.16Mn (wt. %): Fe plated





Purdy et al. Trans AIME, 1964

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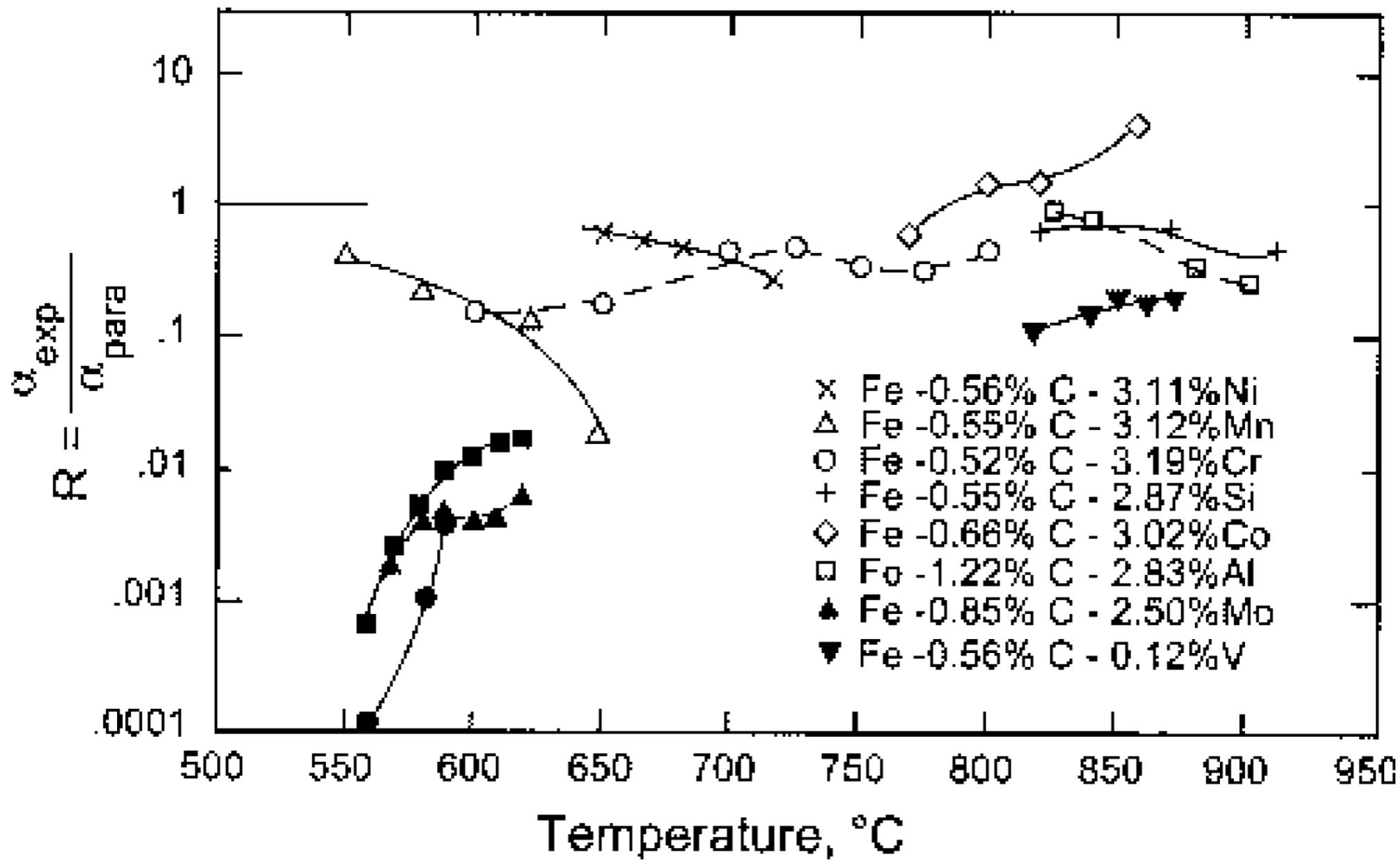
Literature Review: high Mn (> 3%Mn)

Fe-0.55C-3.12Mn (at. %)



Bradley and Aaronson, Met Trans A, 1981
Aaronson et al. Met Trans A, 2004

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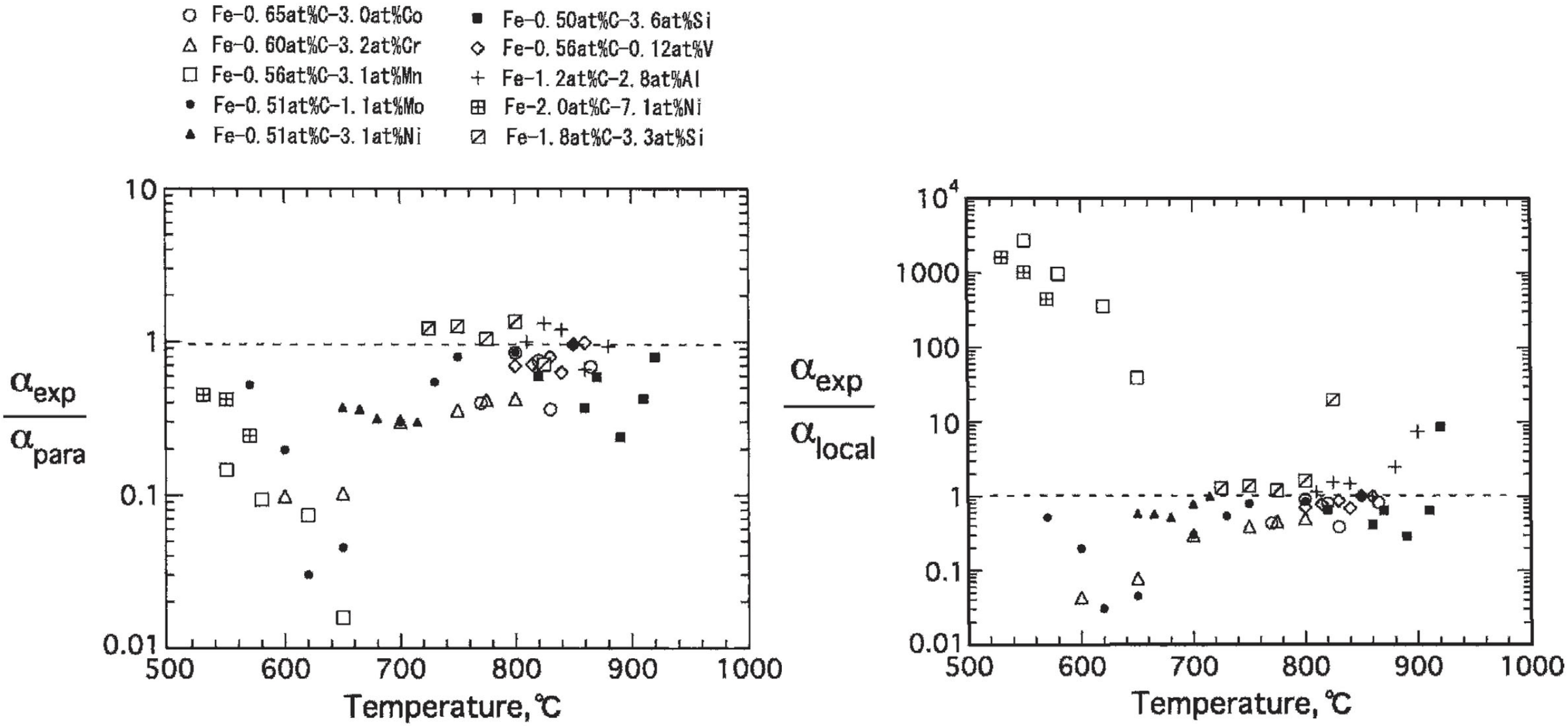
Literature Review: high Mn (> 3%Mn)

Fe-0.56C-3.1Mn (at. %)



Enomoto, Met Trans A, 2006

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Literature Review: Summary

There are a large number of cases where the kinetics in Mn containing steels agree very well with LENP model predictions or fall in between LENP and PE predictions and can be described by ‘transition’ type models.

To me there are two clear signs that Mn is not all it seems:

- Shah et al. (1983) report that the ferrite growth kinetics in both Fe-0.15C1.55Mn and Fe-0.08C-1.34Mn, measured over the T range 580-720C, are consistently slower than LENP. (It seems unusual that the deviation increases with increasing T?)

- Zurob et al. (2008, 2009) report observations of PE at high T and long-lived parabolic states between PE and LENP (the latter cannot be decribed by simple transition models)

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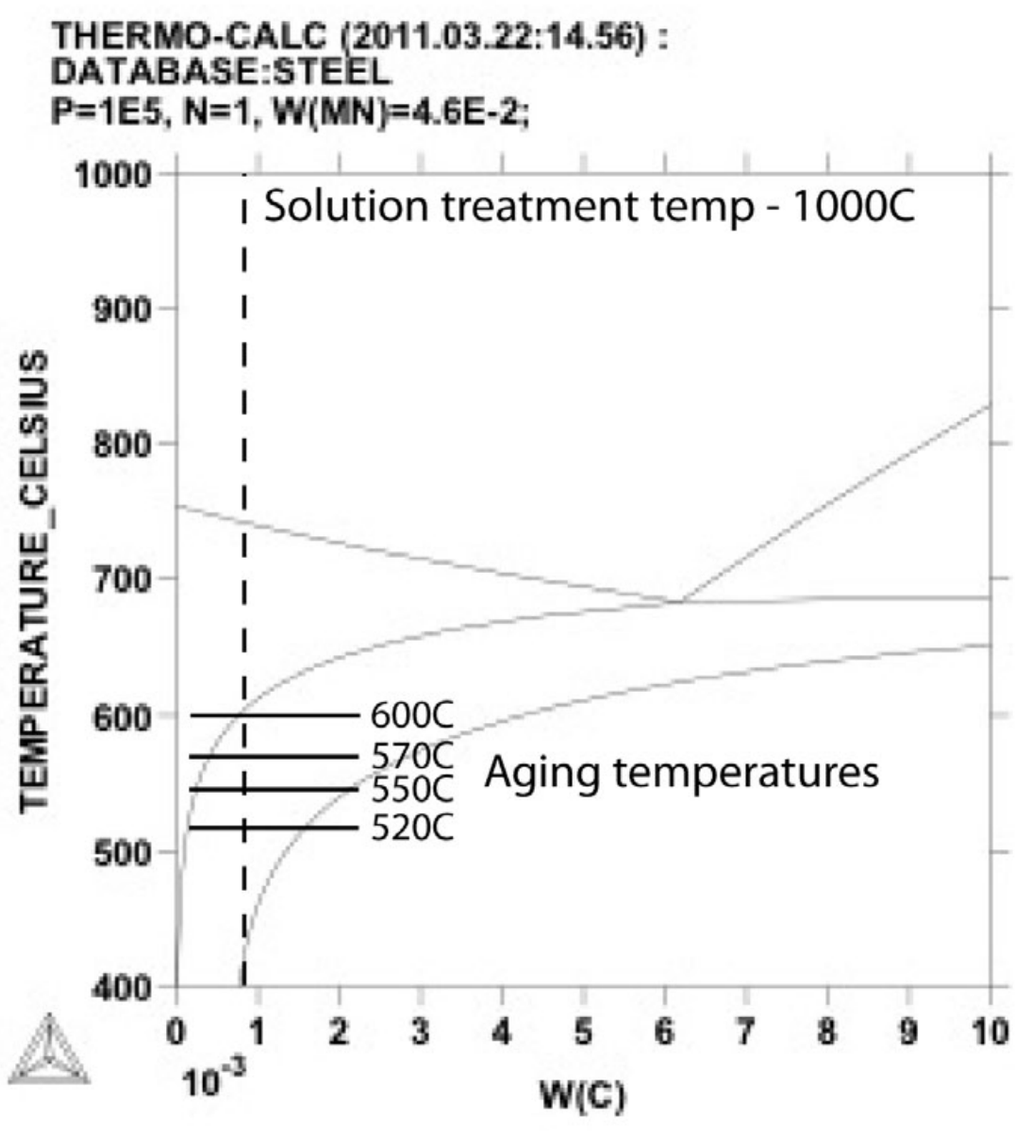
Experimental Procedure

- Alloy of composition Fe-0.09C-4.6Mn (wt. %) was supplied by ArcelorMittal (rolled sheet ~2mm in thickness)



- Solution treatment 20min 1000C
- Transformed isothermally at 4 temperatures
- Metallographic observation of fractions transformed

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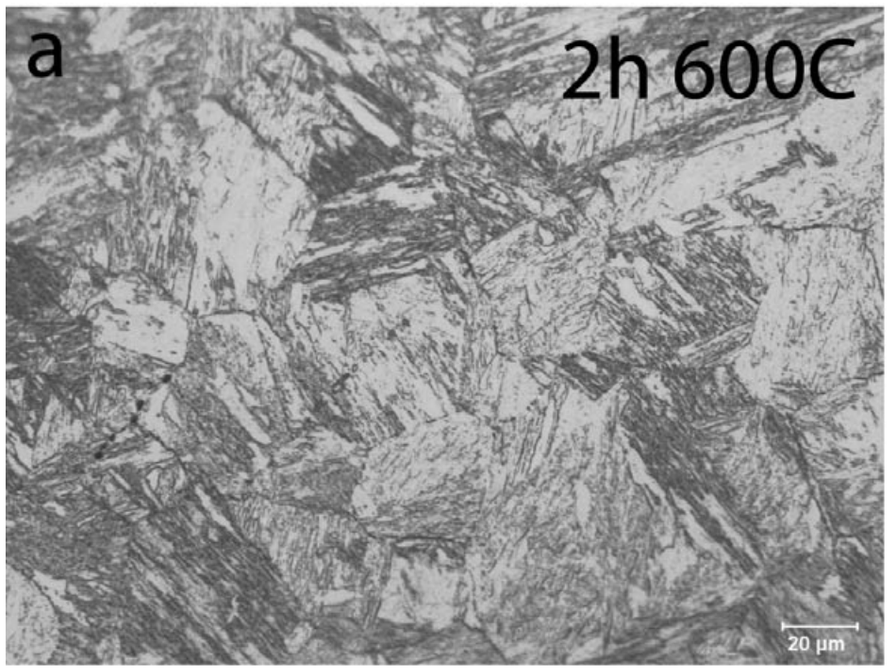
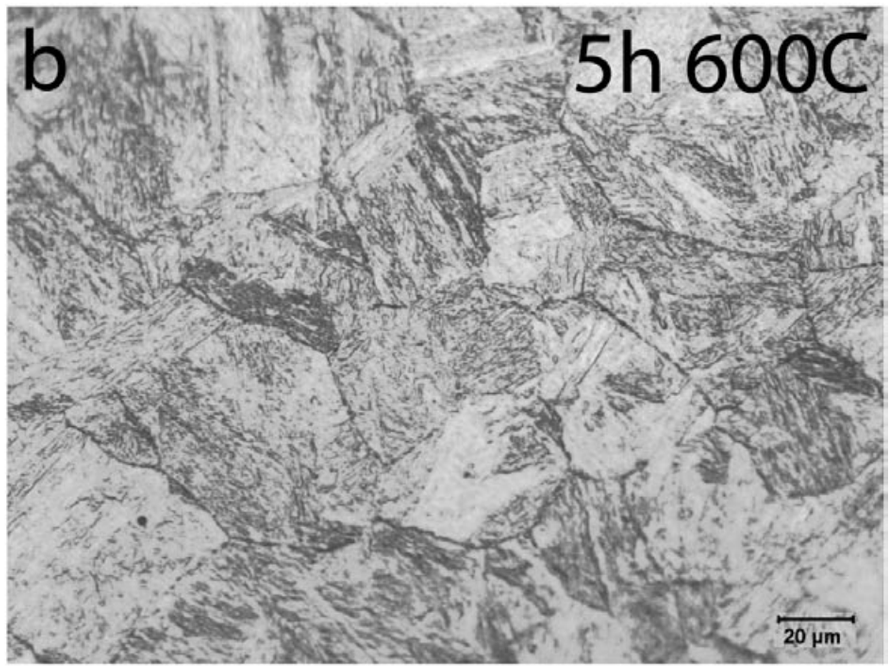
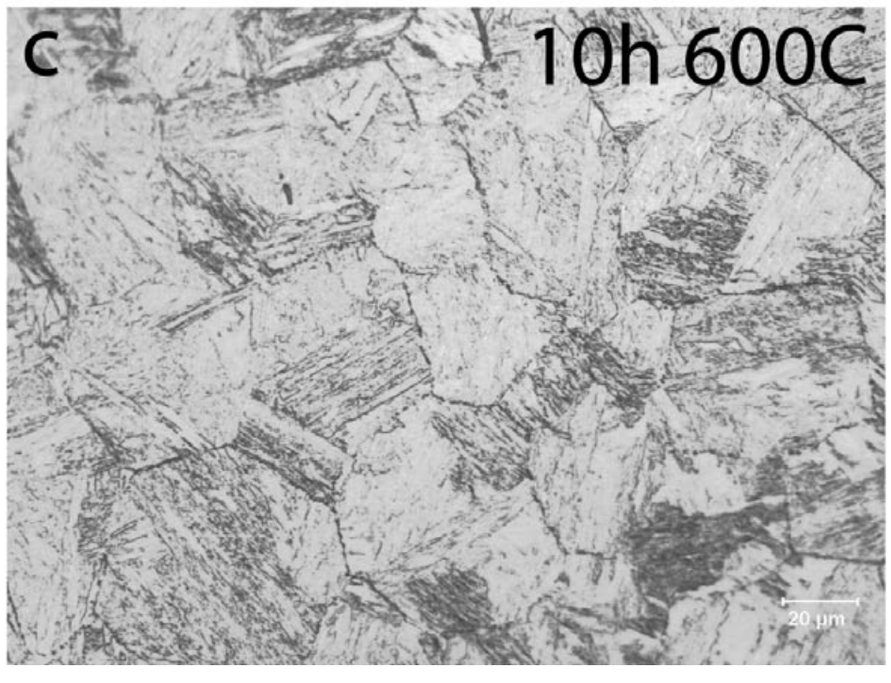
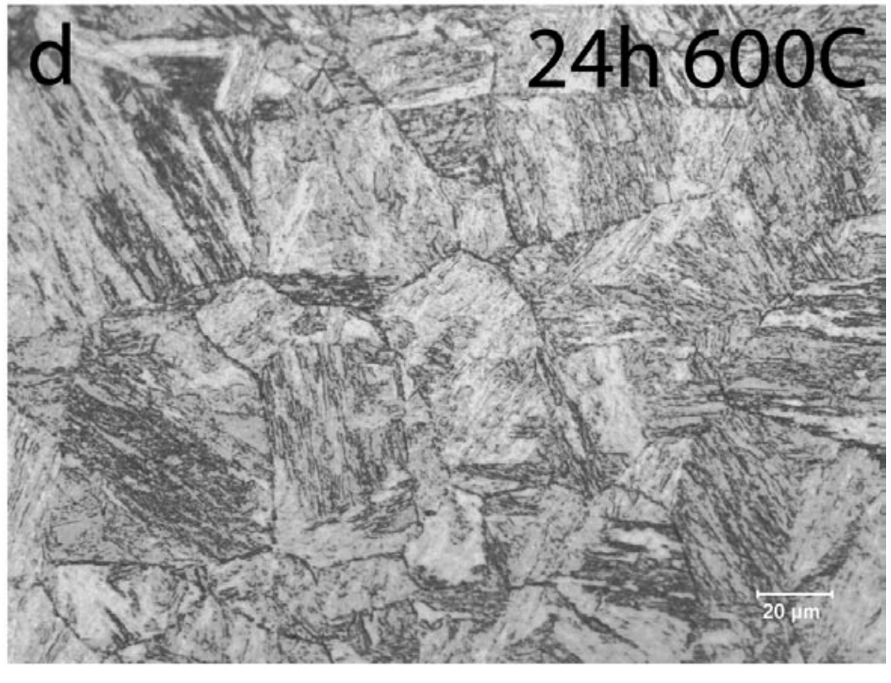
Results – 600C









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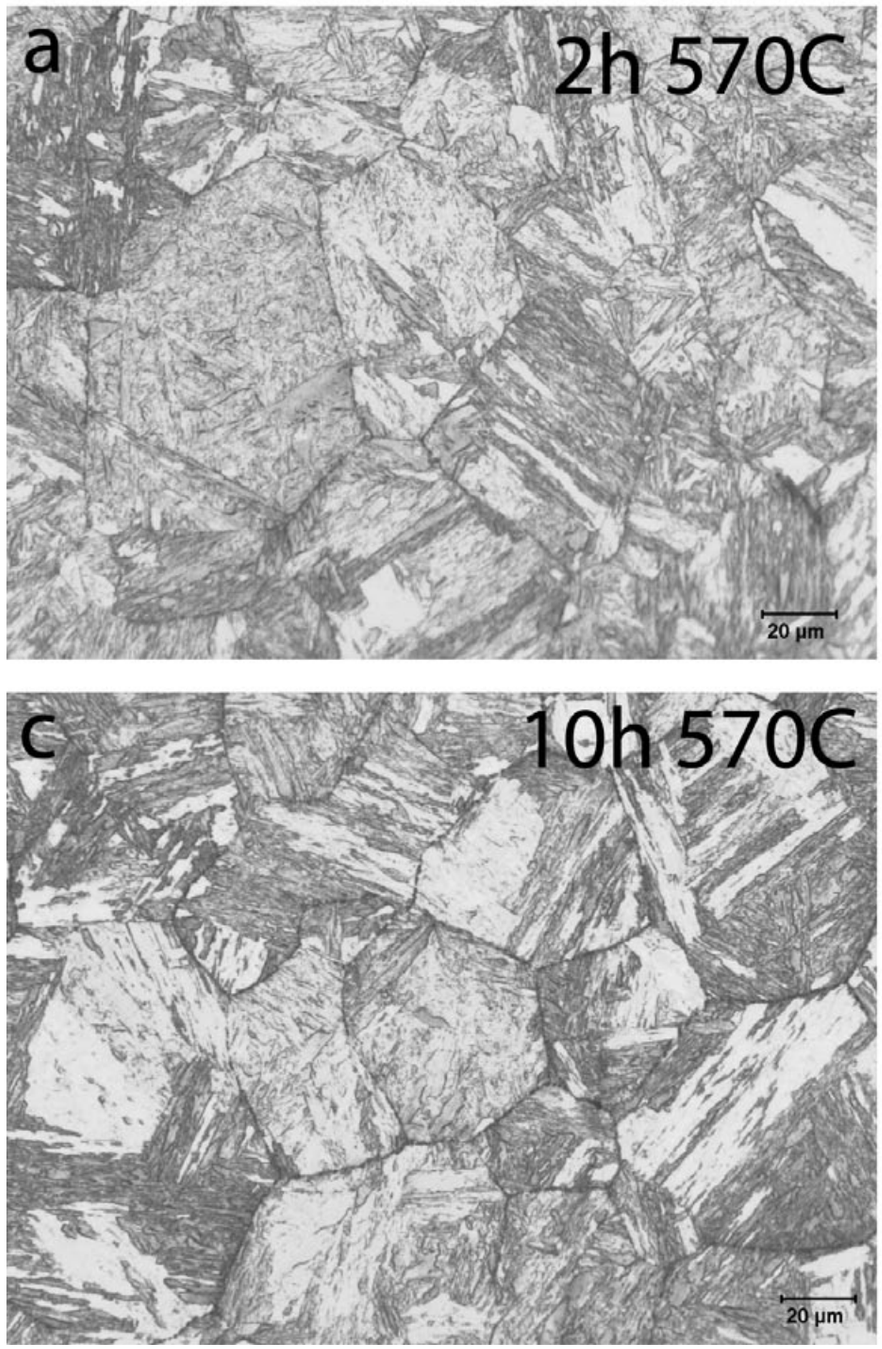
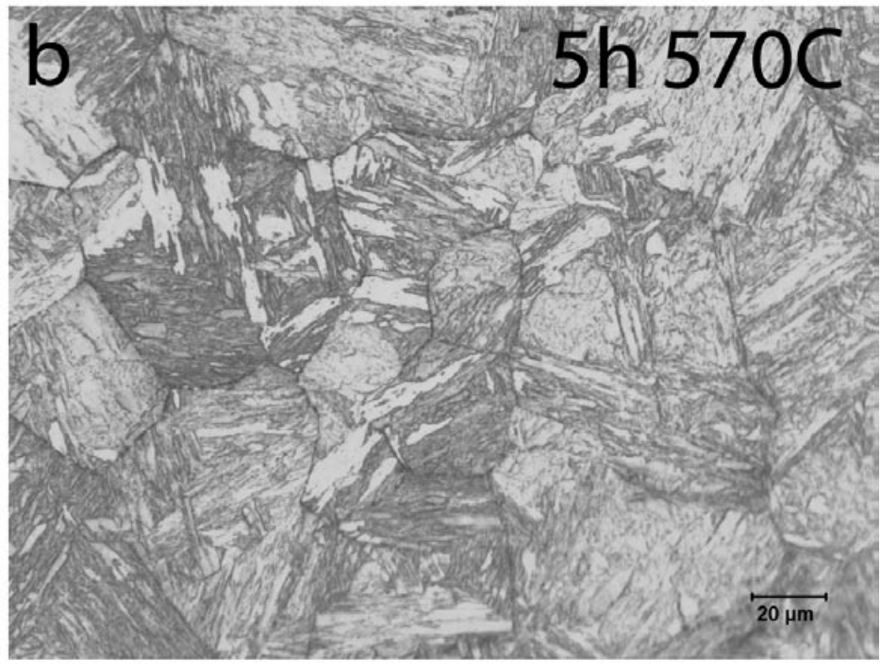
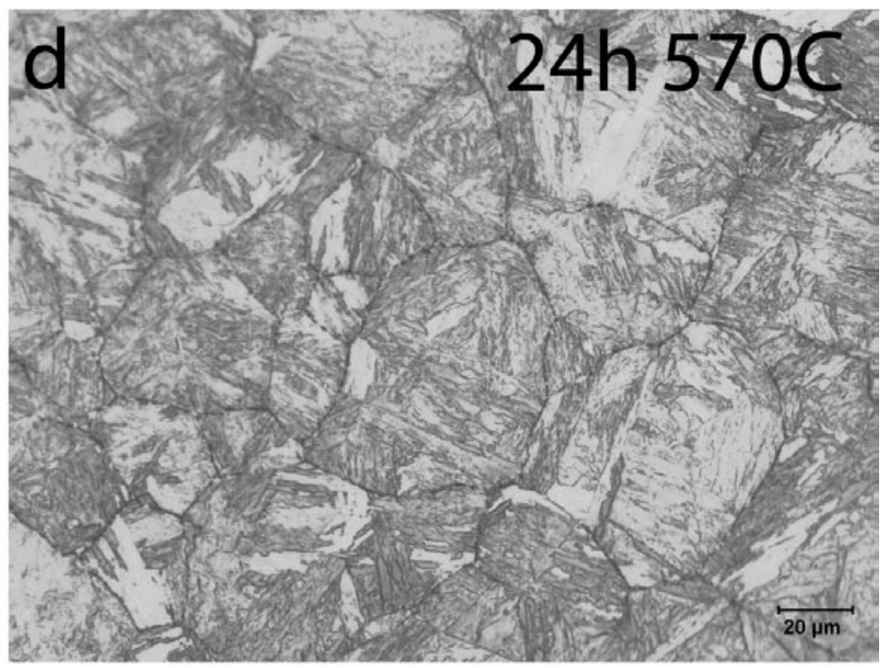
Results – 570C







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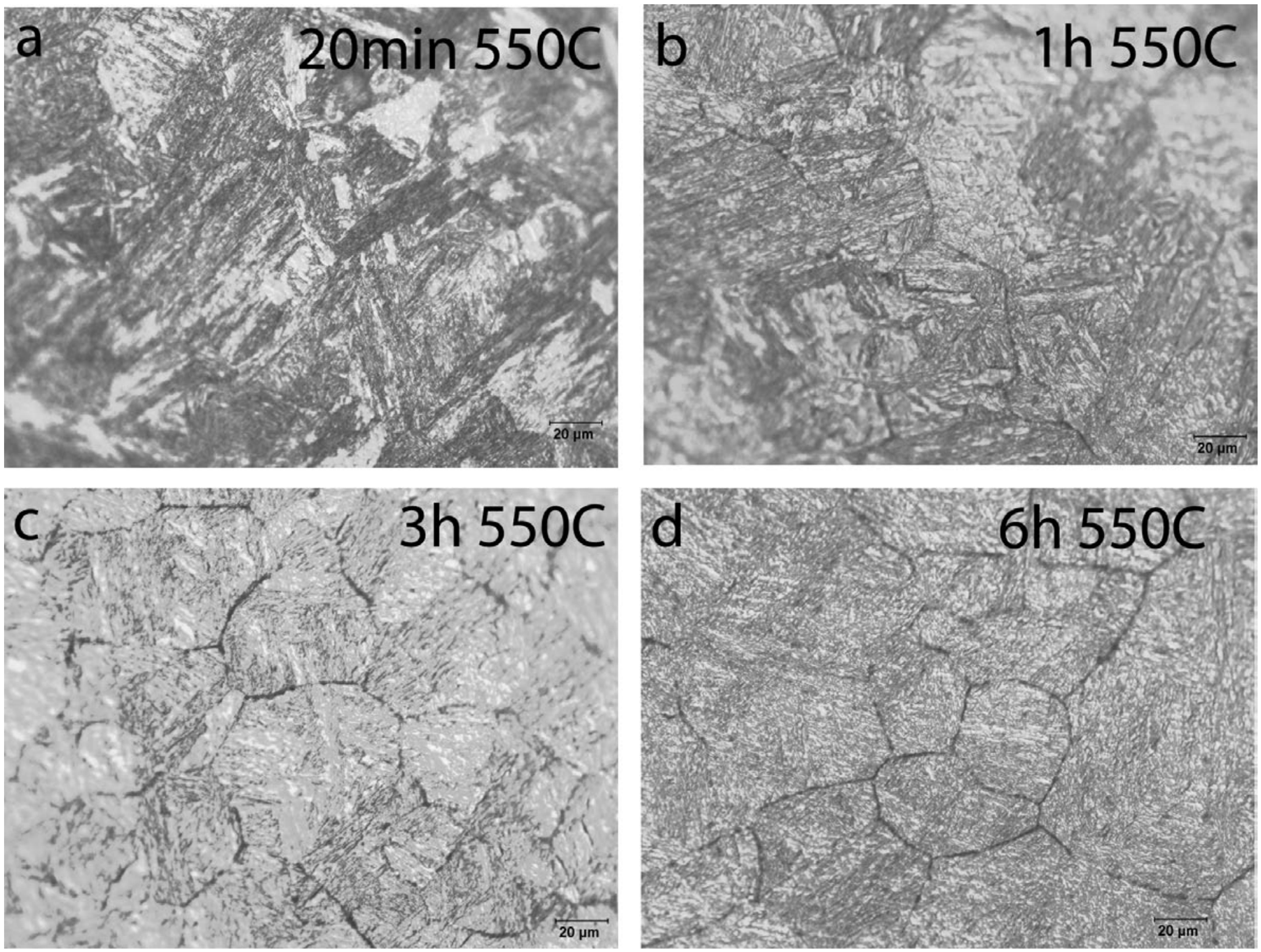
Results – 550C



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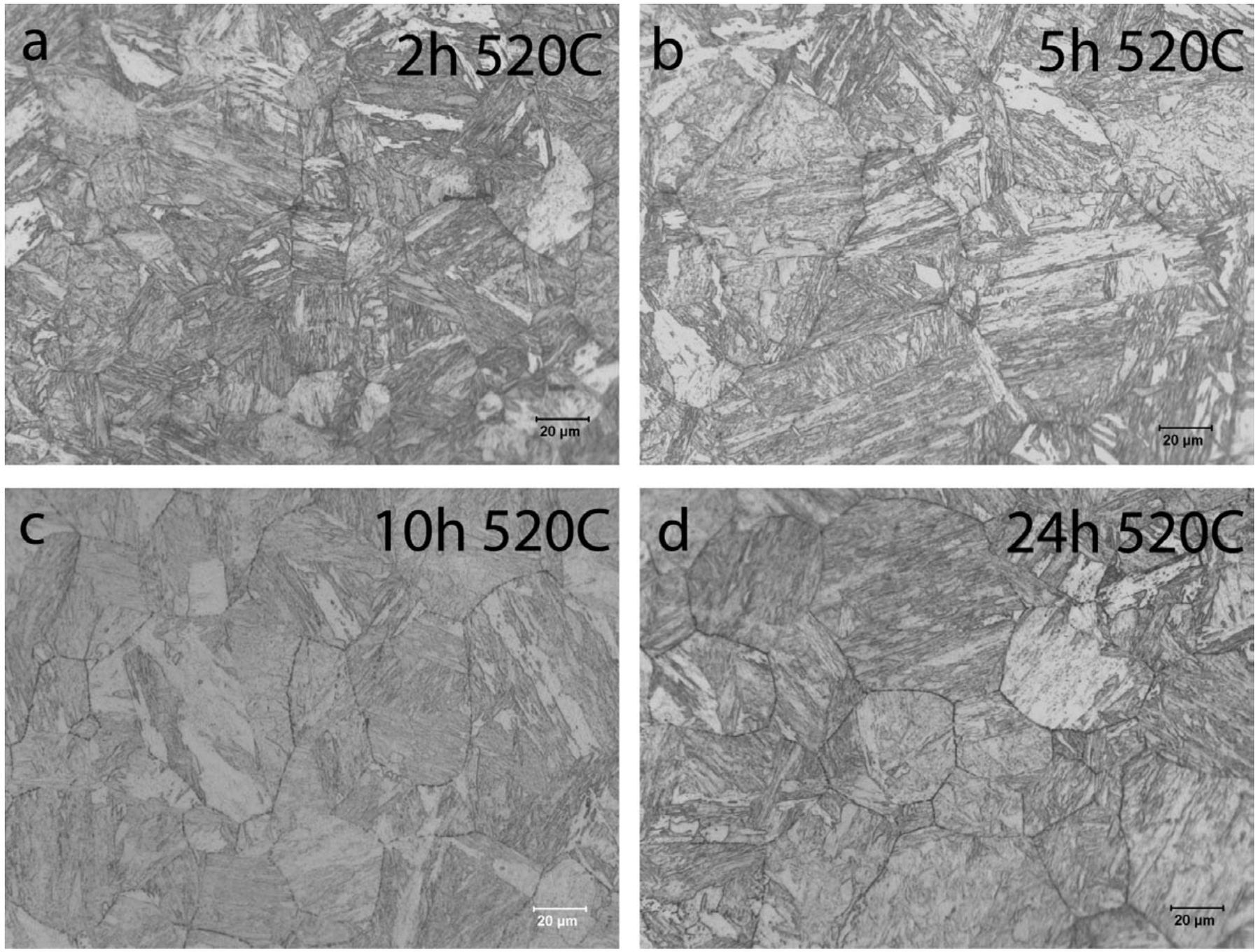
Results – 520C



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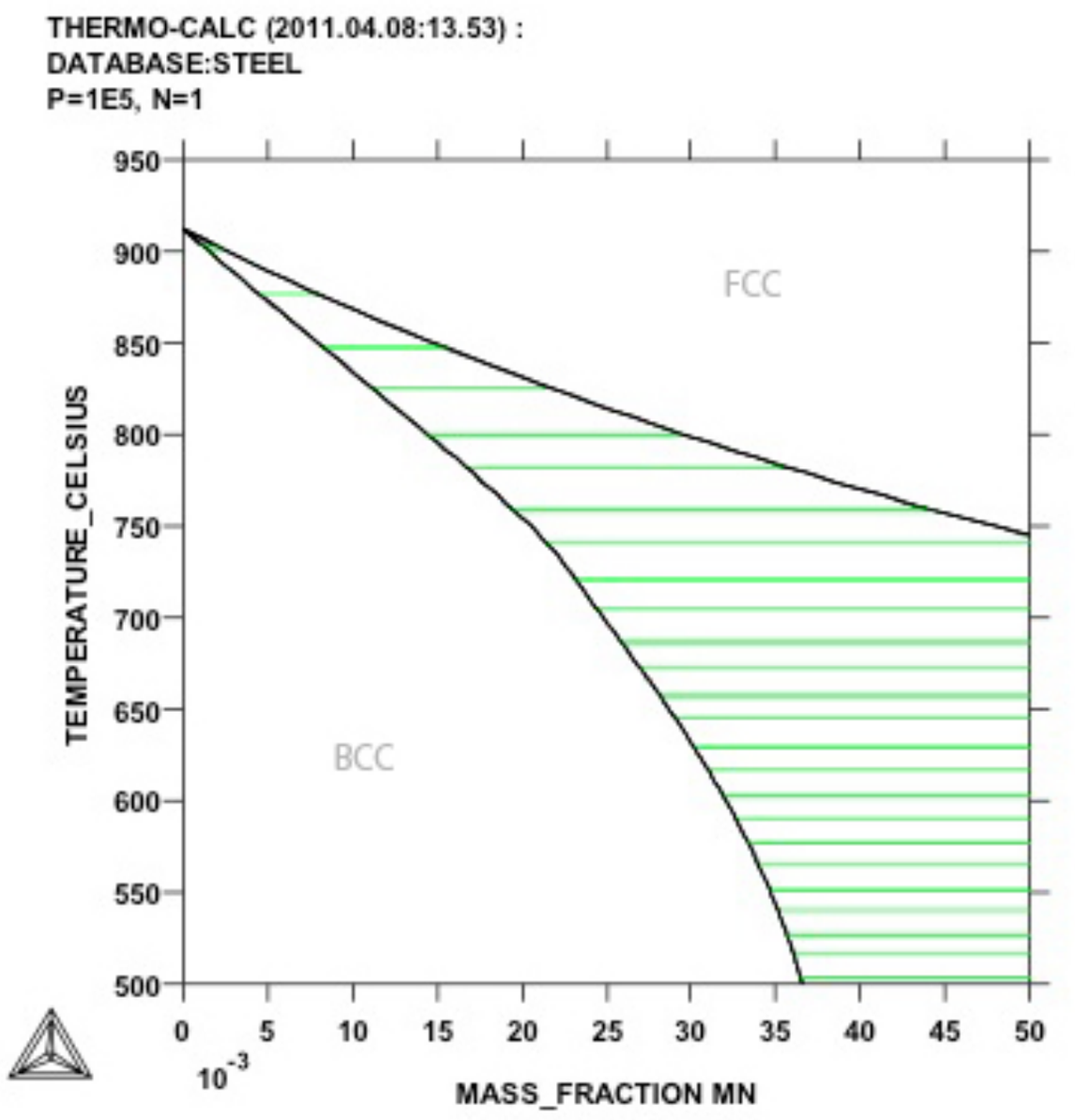
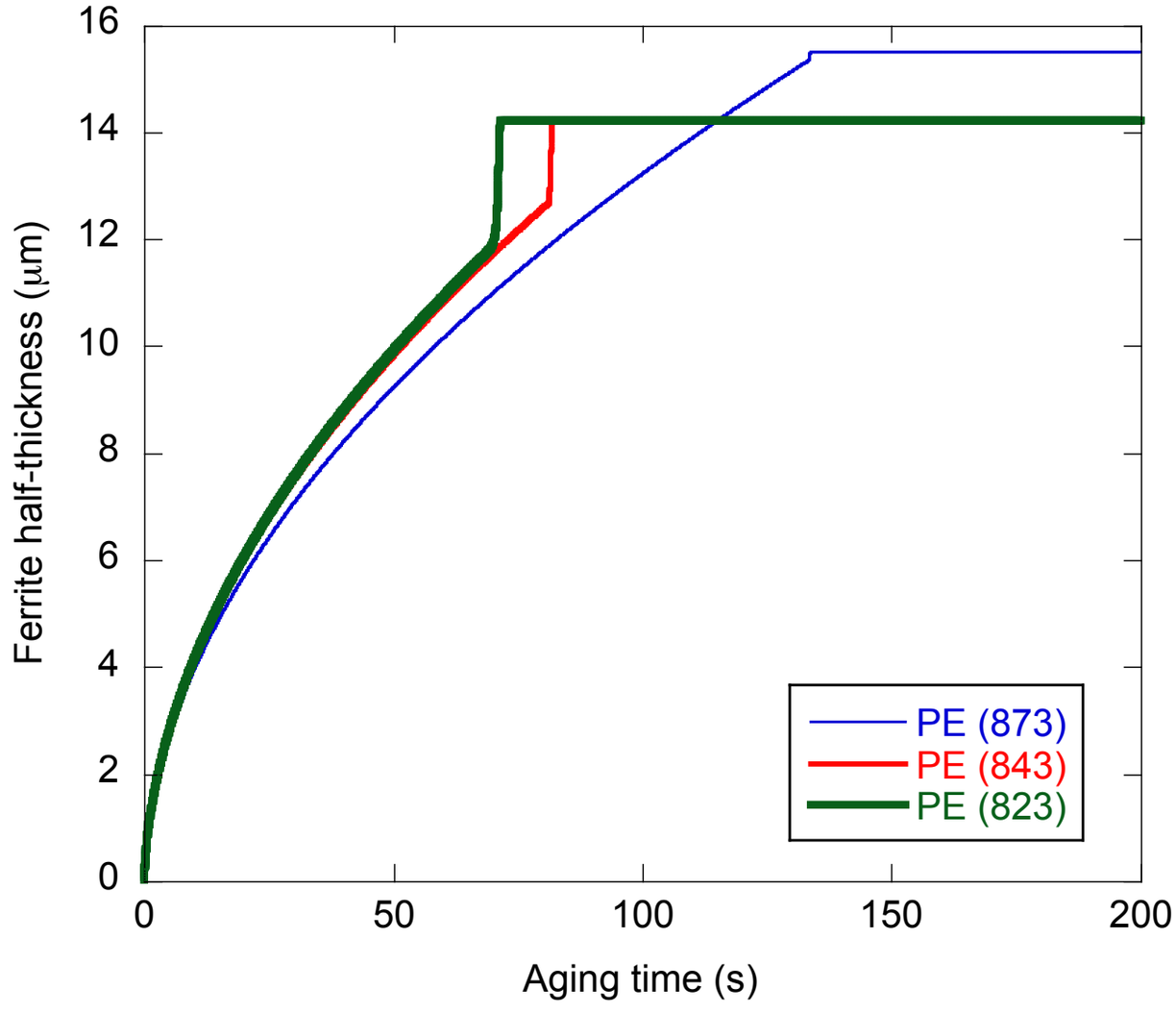
What do we expect?





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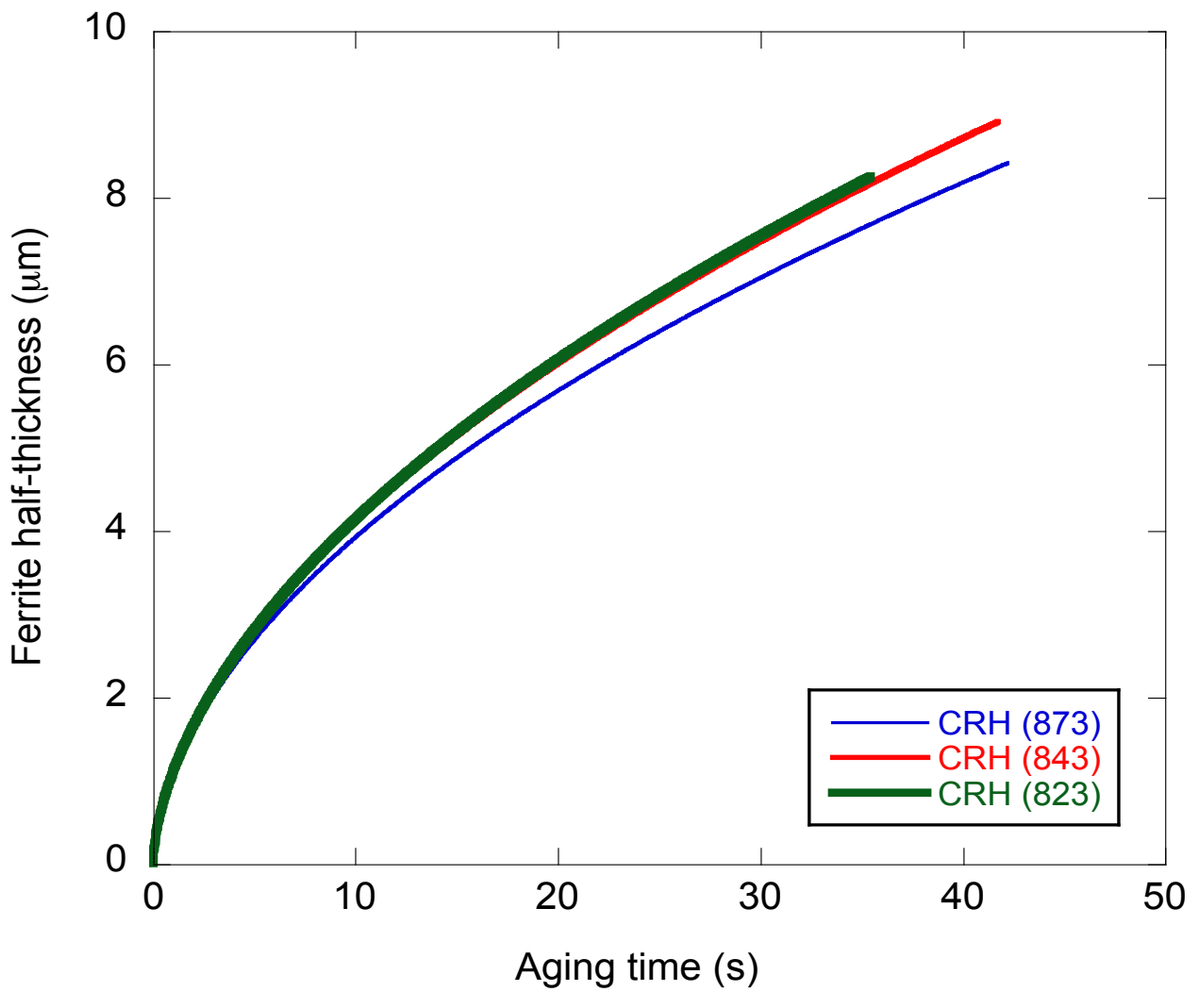
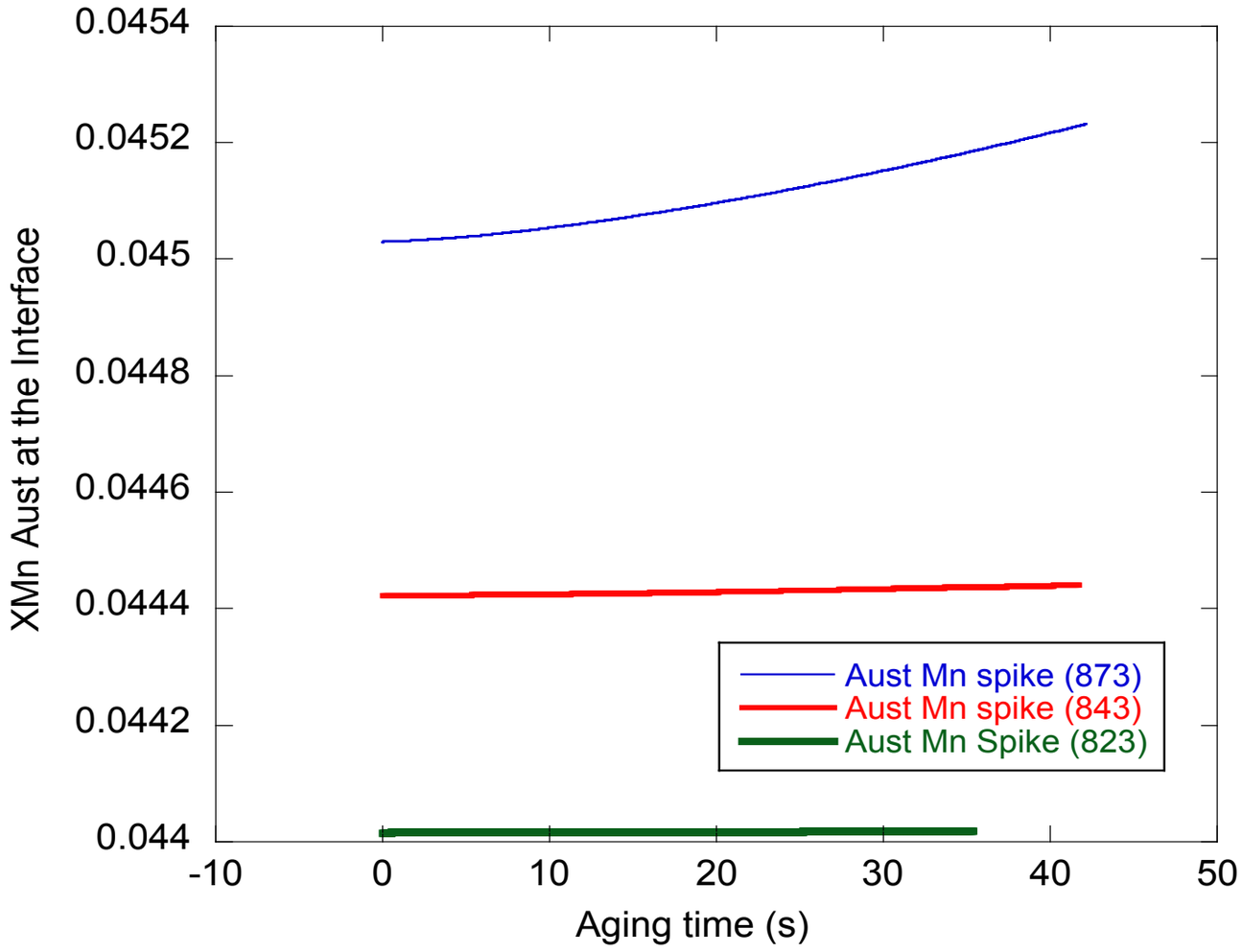
How about a transition model?

- Using a trans-interface coefficient equal to the geometric means in α and γ





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A caveat: Microsegregation?

- M. Goune: micro-segregation of Mn on the scale of 1-5μm occurs in this system. This may have some unexpected effects.

- Diffusion distance of Mn during austenitization: 1-2μm

Discussion and possible explanations

There are a number of possible origins that immediately come to mind:

- The trans-interface diffusivity we are using is much too small. Any guidance the atomistic guys can give on the T dependence of the effective transfer coefficient would be fantastic

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- The classic picture of diffusional dissipation of free energy in the interface requires ‘diffusion in the interface’. If the trans-interface diffusivity is very much enhanced this might contribute very significantly.

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- The classic picture of diffusional dissipation of free energy in the interface requires ‘diffusion in the interface’. If the trans-interface diffusivity is very much enhanced this might contribute very significantly.

- We must also have a structural rearrangement FCC to BCC. We usually lump the dissipation for this together into the intrinsic mobility and assume it is a constant (relatively independent of composition). Perhaps this is not true. Another effect of solute on boundary motion might be through an effect on attachment kinetics (perhaps not important for very dilute alloys but more important in higher concentrations)

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