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Analysis of Precipitates in the Base Metal and HAZ of a 2.25Cr-1Mo Steel

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Steels with 2.25% Cr and 1% Mo are widely used for high temperature applications in the fossil and nuclear power generation and in the petrochemical industries [1]. Research by Nutting [1] and by Depinoy et al. [2] investigated at the formation of carbide precipitates during heat treatment and service that will affect the high temperature properties of this steel. This work is part of a study comparing carbide precipitation in the base metal and in the weld heat-affected zone (HAZ) of a 2.25%Cr -1%Mo steel.

The composition of the analyzed steel is shown in Table 1. Extraction replicas of normalized and tempered base metal and of simulated HAZ, which underwent five reheats to 785oC, were made by Nital etching. These replicas were then examined in a FEI/ThermoScientific Tecnai F20 TEM/STEM with a windowless EDAX SDD detector. The analysis of the precipitates was done with a combination of STEM EDX and microdiffraction techniques. Initial EDX spectra were acquired from a large number of precipitates using the EDAX TEAM and particle analysis software packages. Individual particles were then selected and tilted to a zone axis. A zone-axis microdiffraction pattern and an EDX spectrum were acquired to identify the precipitate.

A typical precipitate from the base metal is shown in Figure 1 with the corresponding composition shown in Table 2 (#1). There is significantly higher Mo and Cr in the M23C6 precipitates than in the M3C precipitates shown in Table 2 (#2 & #3). The M23C6 type are characterized by a distinct rod-like morphology. Hence identification of M23C6 precipitates is straightforward by their morphology. The base metal contains a large number of M23C6 type precipitates which aren't seen in the HAZ material. Within the HAZ, the precipitates are dominated by the M3C type as shown in Figures 2 & 3. Unlike the M23C6 precipitates, the M3C precipitates in the HAZ have various morphologies. Extensive observation hasn't shown the presence of rod-like precipitates in the HAZ. This, in combination with EDS and diffraction data suggests that the M23C6 are very rare or absent in the HAZ. This agrees with the thermodynamic calculations of the precipitation reactions [3]. [4]

C	Mn	P	S	Cu	Si	Ni	Cr	Mo	V	Ti	B	Al	Nb	Sb	As	Sn
0.13	0.52	0.016	0.009	0.17	0.21	0.12	2.25	0.94	0.004	0.003	0.0001	0.033	0.001	0.005	0.003	0.007

	Si	Cr	Mn	Fe	Ni	Mo
#1	0.6	25.6	2.3	58.2	.8	12.5
#2	0.5	16.7	1.4	76.5	1.8	1.3
#3	0.2	10	1.1	83.7	2.2	2.7

Figure 1. Top - Bulk steel compositionBottom - composition of 3 particles in figure 2

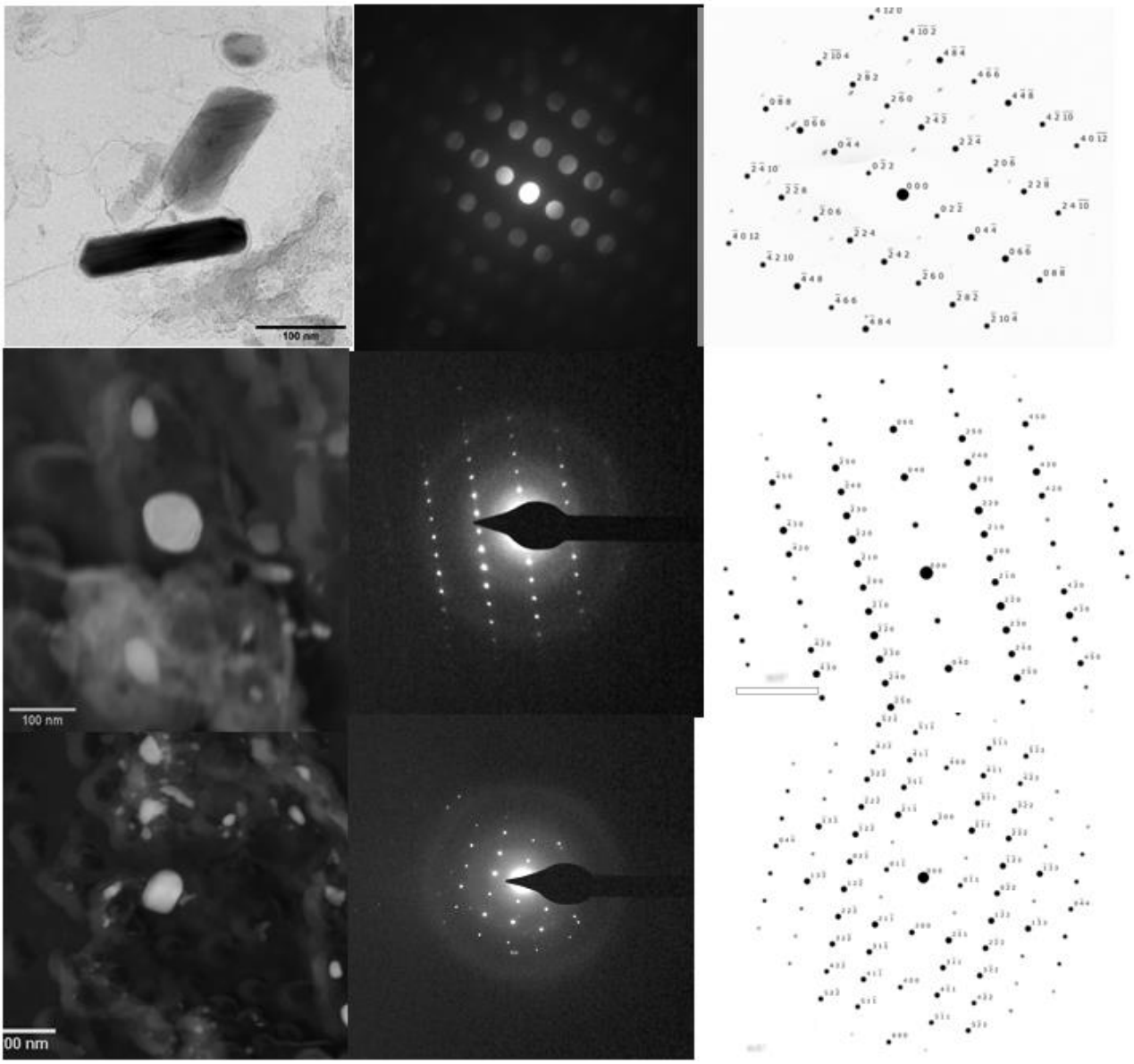

Figure 2. Top - M23C6 precipitate from bulk material with recorded and calculated [311] DPMid - M3C precipitate from HAZ with recorded and calculated [001] DPBottom - M3C precipitate from HAZ with recorded and calculated [011] DP

References
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[3] Sarich, C., unpublished results
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