Case 7: Nb-, V- and Ti- carbide and nitride precipitation in microalloyed steels
Microalloyed steels are used for special high-strength applications such as pipelines. In order for the steel to acquire good mechanical properties, it needs to be thermo-mechanically treated. FactSage can help in finding the correct temperatures for treating these steels.

The steel is annealed in the austenite region and then cooled through the temperatures Ar3 and Ar1 temperatures (continuous cooling austenite to ferrite transformation start and finish).

The goal of this study is to find the ideal annealing temperatures to avoid precipitation of Nb carbonitrides and promote precipitation of NbC.
Carbide and Nitride precipitation in microalloyed steels

1. A typical microalloyed steel composition is entered (For more information, refer to J. Calvo et al. / Materials Science and Engineering A 520 (2009) 90–96)

2. Select only the FSstel database.
Carbide and Nitride precipitation in microalloyed steels

1. We are interested in carbide, nitride and carbonitride precipitation, so we will select all the solids...

2. ... all the carbide phases (select I-option, possible two-phase immiscibility)

3. ... and select J-option (possible 3-phase immiscibility) for the FCC, BCC and HCP phases. This is because carbonitrides have similar structure to austenite.

4. We will select a range of temperature encompassing the whole austenite phase.
Carbide and Nitride precipitation in microalloyed steels

1. Plot g vs T(C) for all solids and solutions having a maximum weight greater than 0
1. From the graph, we can deduce equilibrium transformation temperatures from austenite to ferrite.

2. We should also look at the very low compositions, since all the microalloyed elements will be present in very small quantities.
1. Using a log scale is very convenient for looking at the microalloyed elements.

2. It is clearly seen that the FCC#1, #2 and #3 phases are forming. In this case, they are probably carbides and nitrides. We can check this by plotting their composition with temperature.
Carbide and Nitride precipitation in microalloyed steels

1. We will first select all the species in FCC#1 and see how they are distributed.
1. In the austenite region, the FCC\#1 phase is composed mostly of iron (Fe\textsubscript{Va}).

2. But below Ae3, the dominant species are MoC, VC and NbC.
Carbide and Nitride precipitation in microalloyed steels

1. The FCC#2 phase is composed mainly of TiN and NbN at austenite temperatures...

2. … and of NbC below Ae3
1. Finally, the FCC#3 phase is composed of Nb(C,N) at the austenite temperatures and of TiN below Ae3.
1. We also note that there is an HCP#1 phase present, which appears only below Ae3 and is composed primarily of Mo2C and Mn2C.
1. Now that we know what each phase is composed of, it would be convenient to plot the species that interest us the most, namely (Nb,Ti,V)(C,N).

2. Copying the amounts of NbC, TiC, ... species contained in FCC#1, FCC#2 and FCC#3 as well as the carbide and cementite phases to Excel, the following graph is obtained.

3. In summary, we can now figure out what the equilibrium precipitates will be at each temperature for designing the thermal treatment needed.