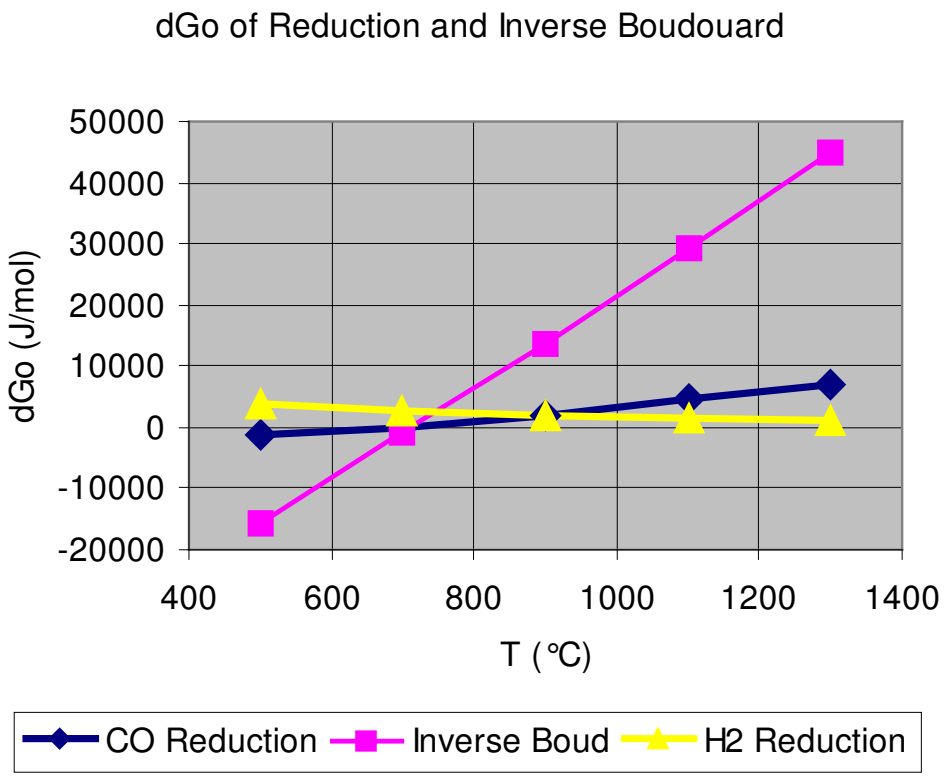
Gas reduction in Factsage

influence of reductant and pressure to reduction of FeO

Kees Verweij at GTT Herzogenrath

dGo of reduction reactions



- $FeO + CO = Fe + CO_2$
- $FeO + H_2 = Fe + H_2O$
- $2\ CO = CO_2 + C$

CO :

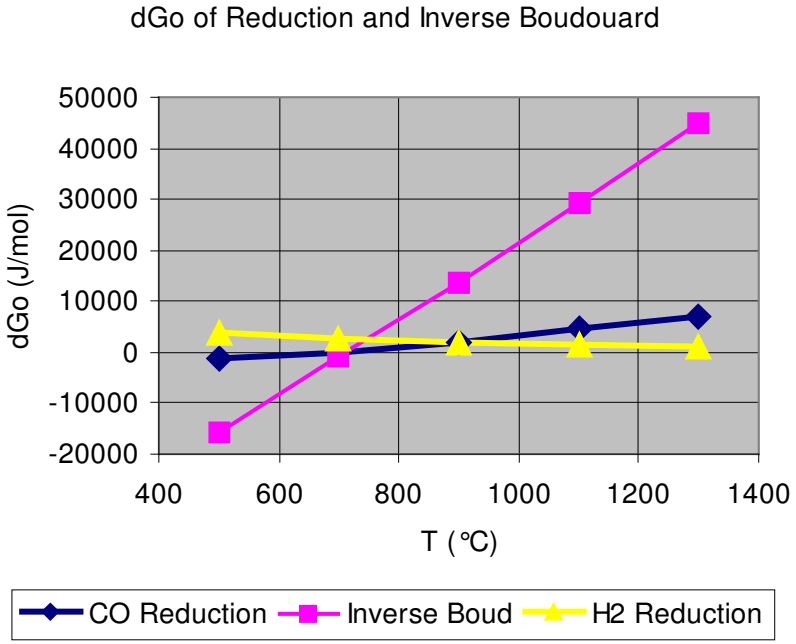
below 700 °C preference for the Boudouard reaction

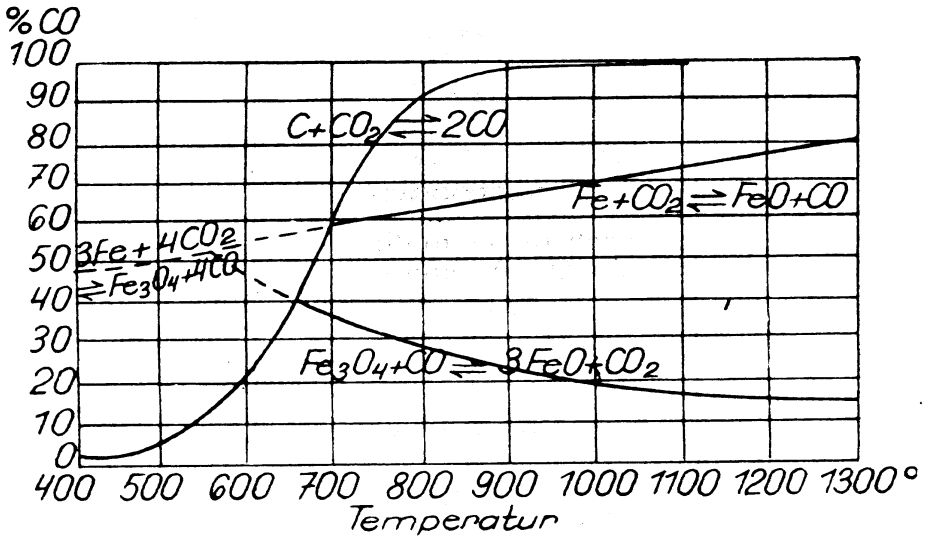
beyond 700 °C preference for reduction

H_2 :

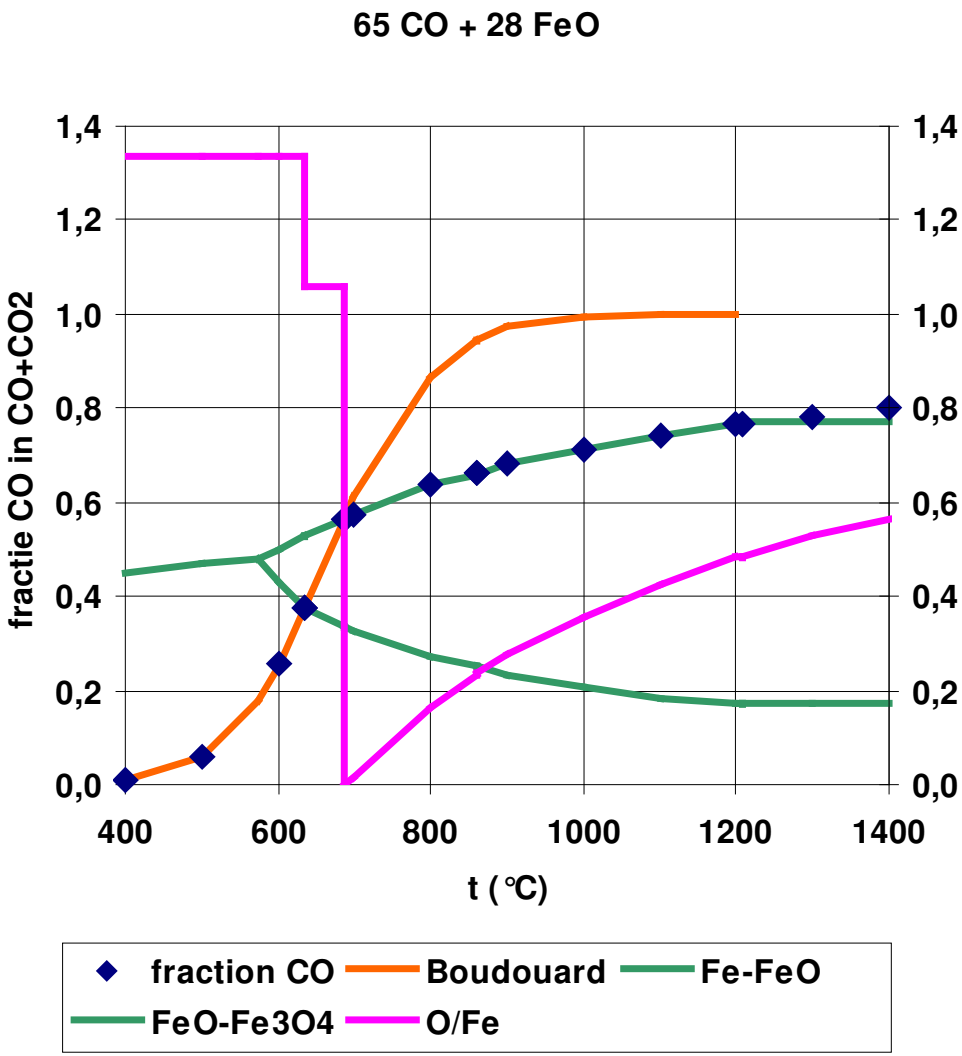
reduction with H_2 at all temperatures, but improves at increasing temperature

How does dGo fit to the old presentation ?





Bauer Gläsener diagram



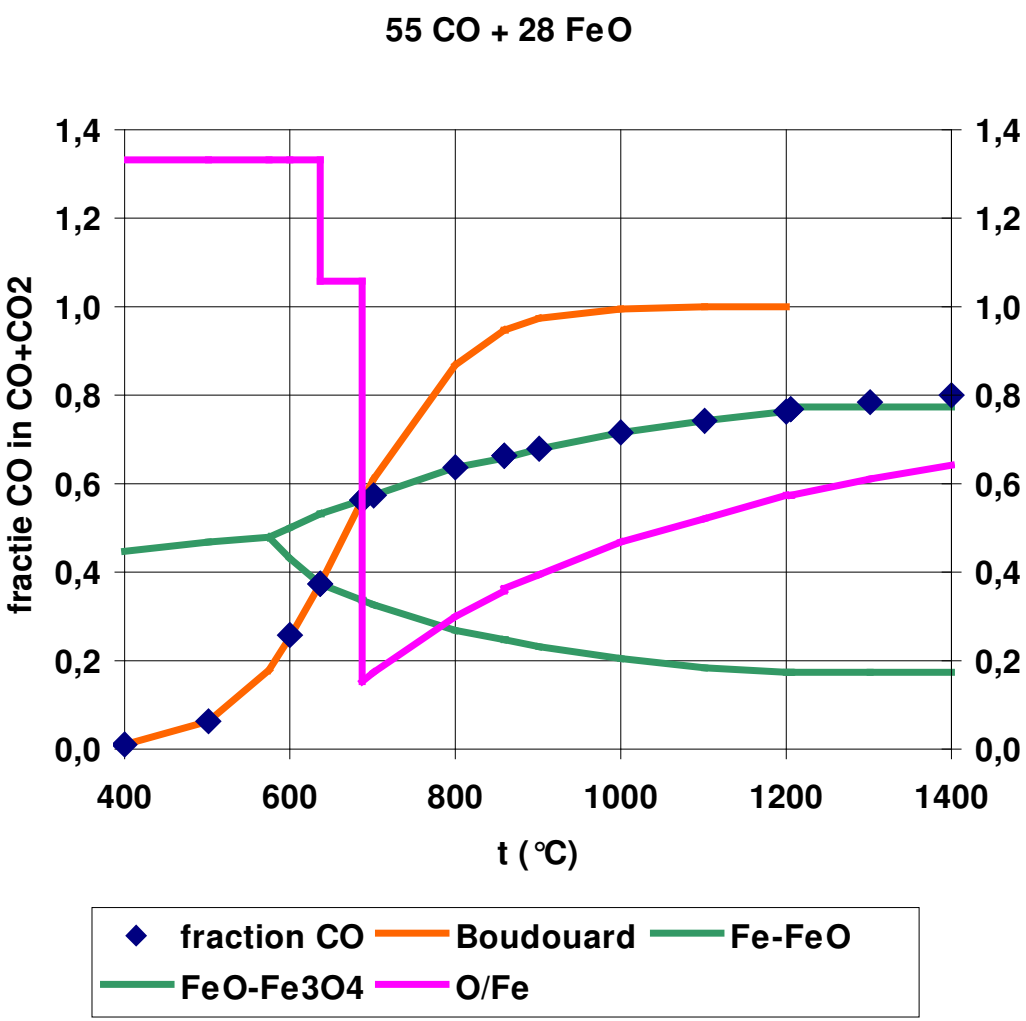
base case :

- includes O / Fe line
- Boudouard curve

100 % reduction at 700 °C

gas equilibria follow Boudouard and FeO-Fe line

Shortage of CO



reduction at 700 °C below 85 %

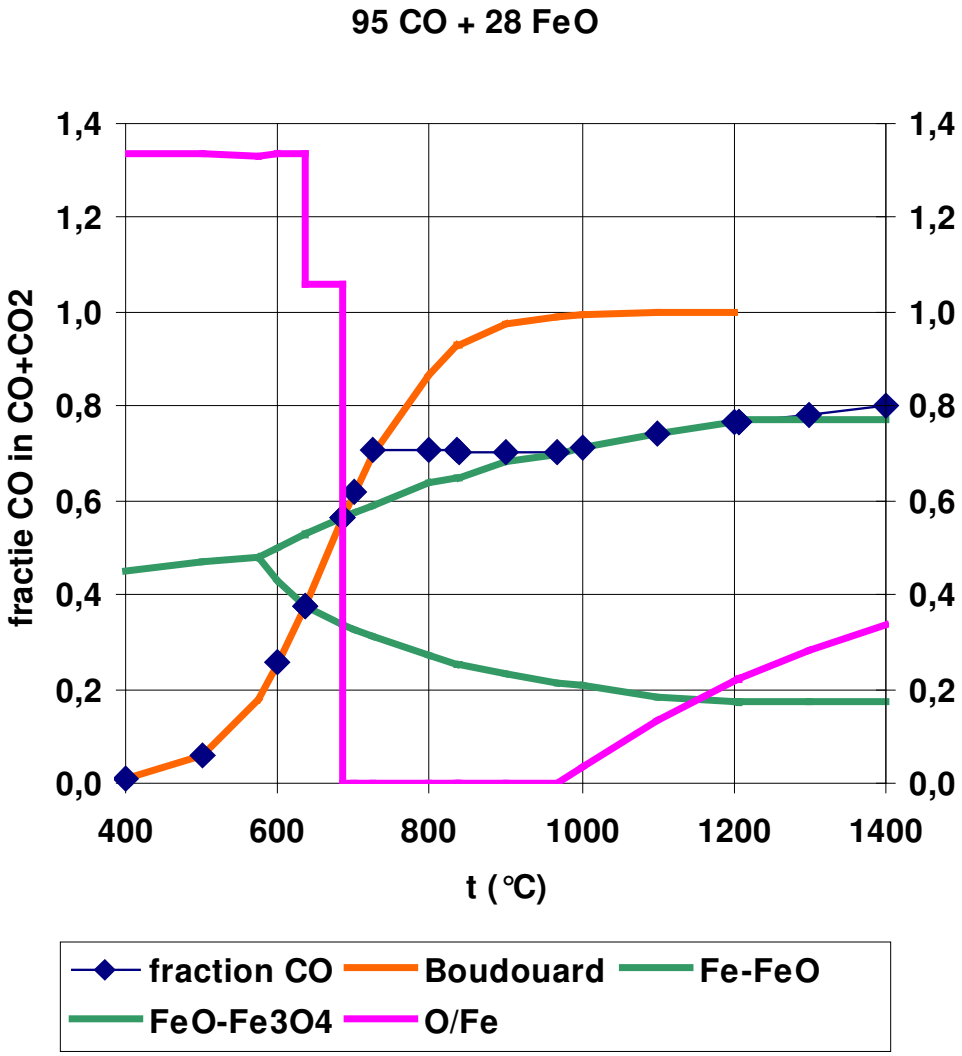
O / Fe line increases with increase in temperature :

this is due to increase in dGo

➔ equilibrium shifts to the left of reaction 1

➔ gas usage decreases

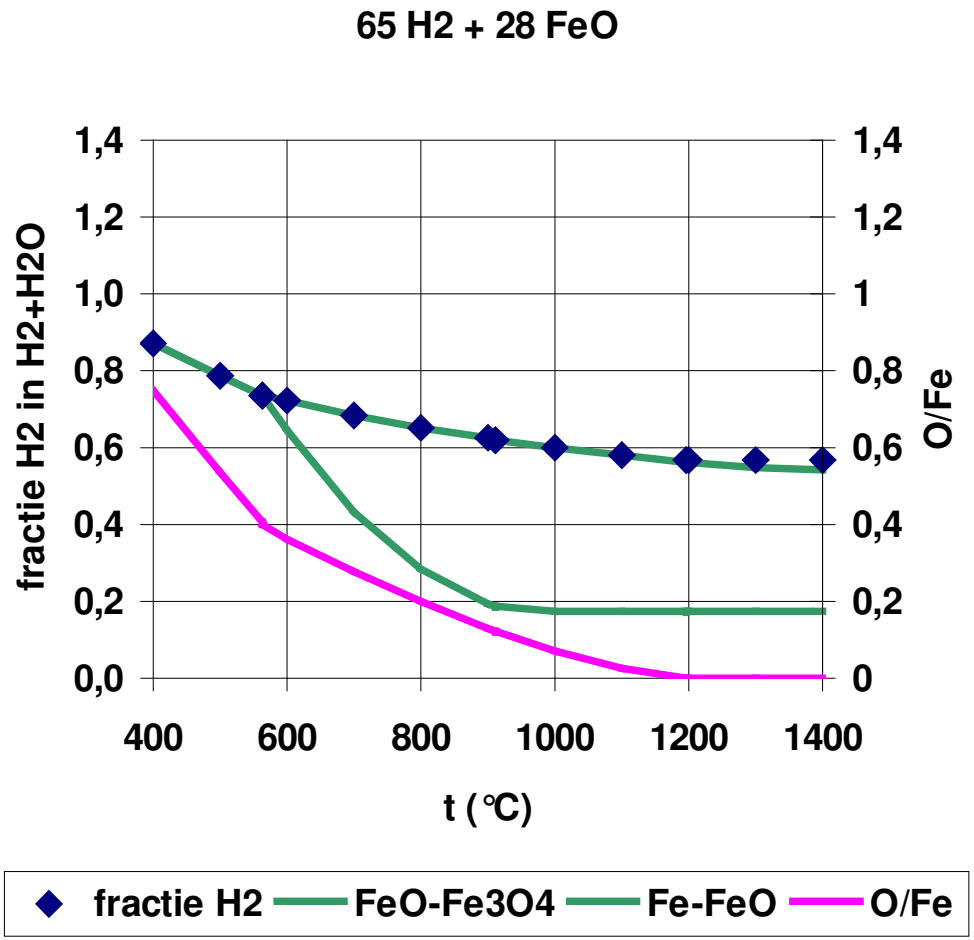
Surplus of CO



the full reduction is achieved over a broader temperature range

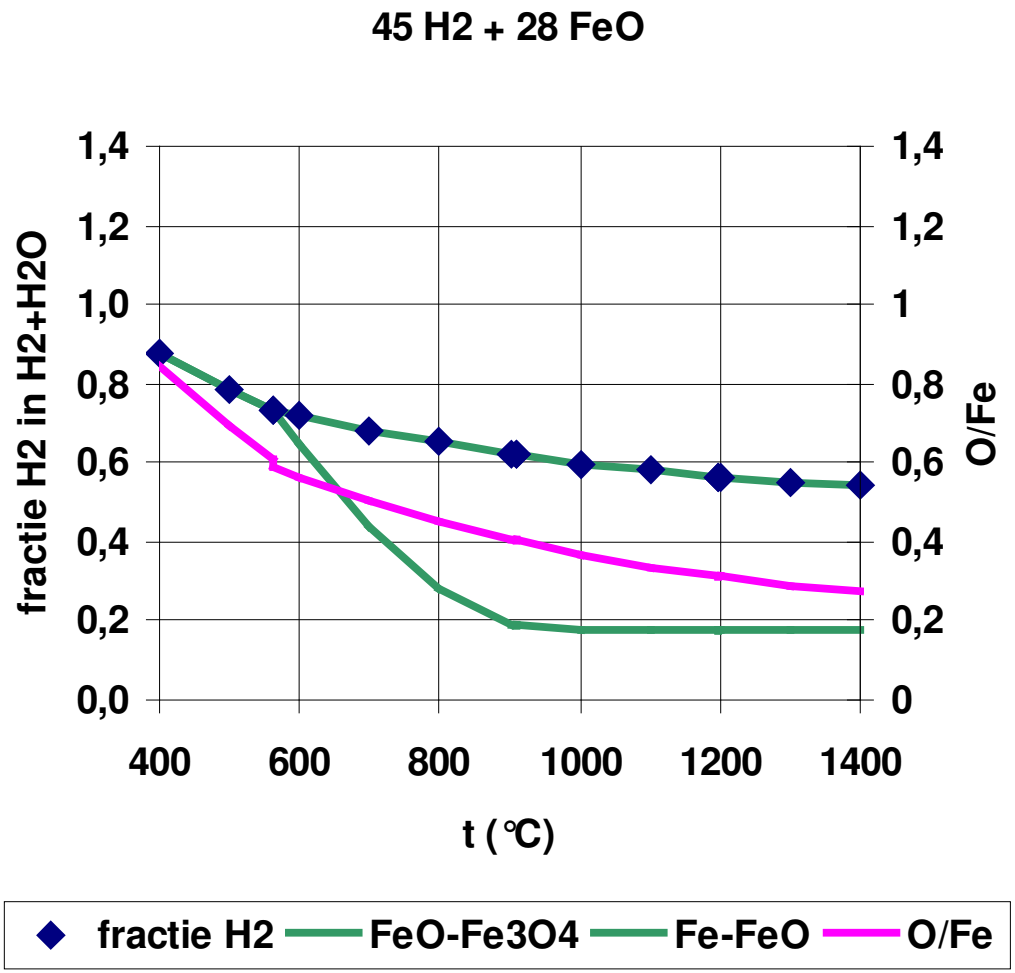
around 700 – 900 °C not all CO is used and equilibria deviate from green FeO-Fe line

Reduction with H_2



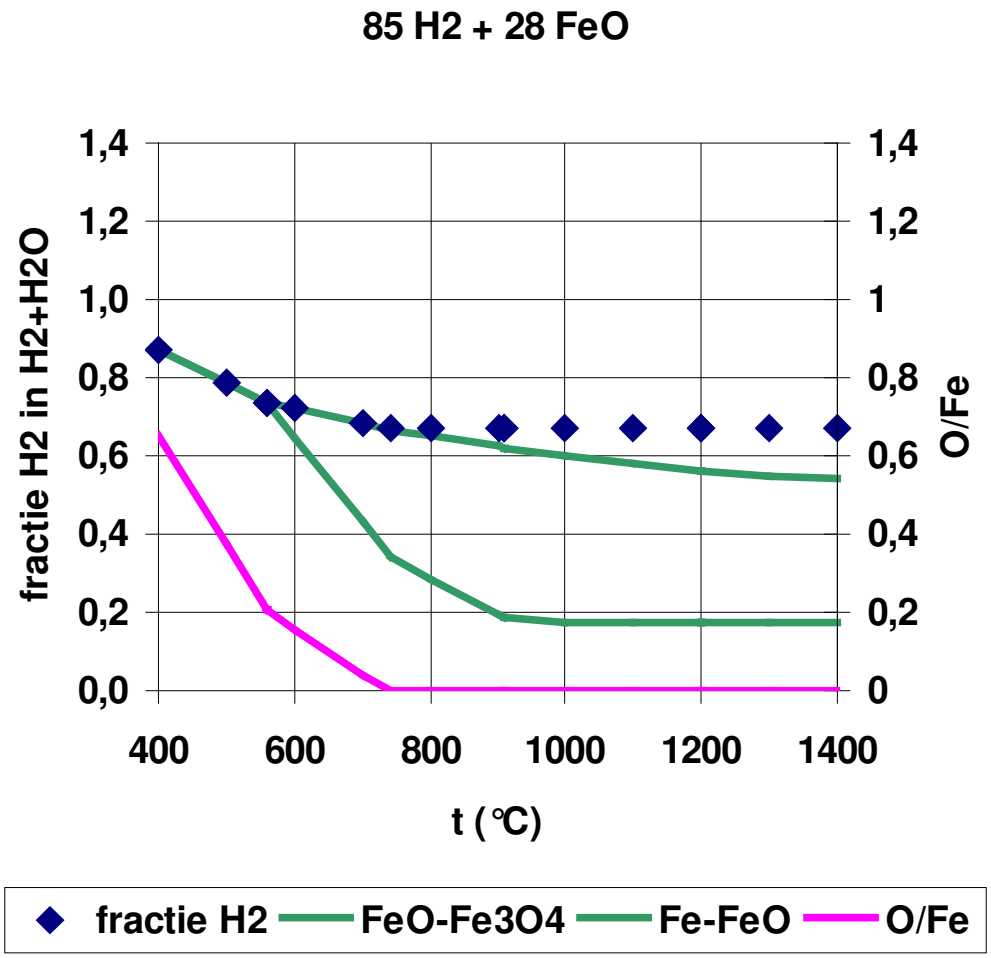
100 % reduction is achieved beyond 1150 °C

Shortage of H_2



reduction is worse than 70 %

Surplus of H_2

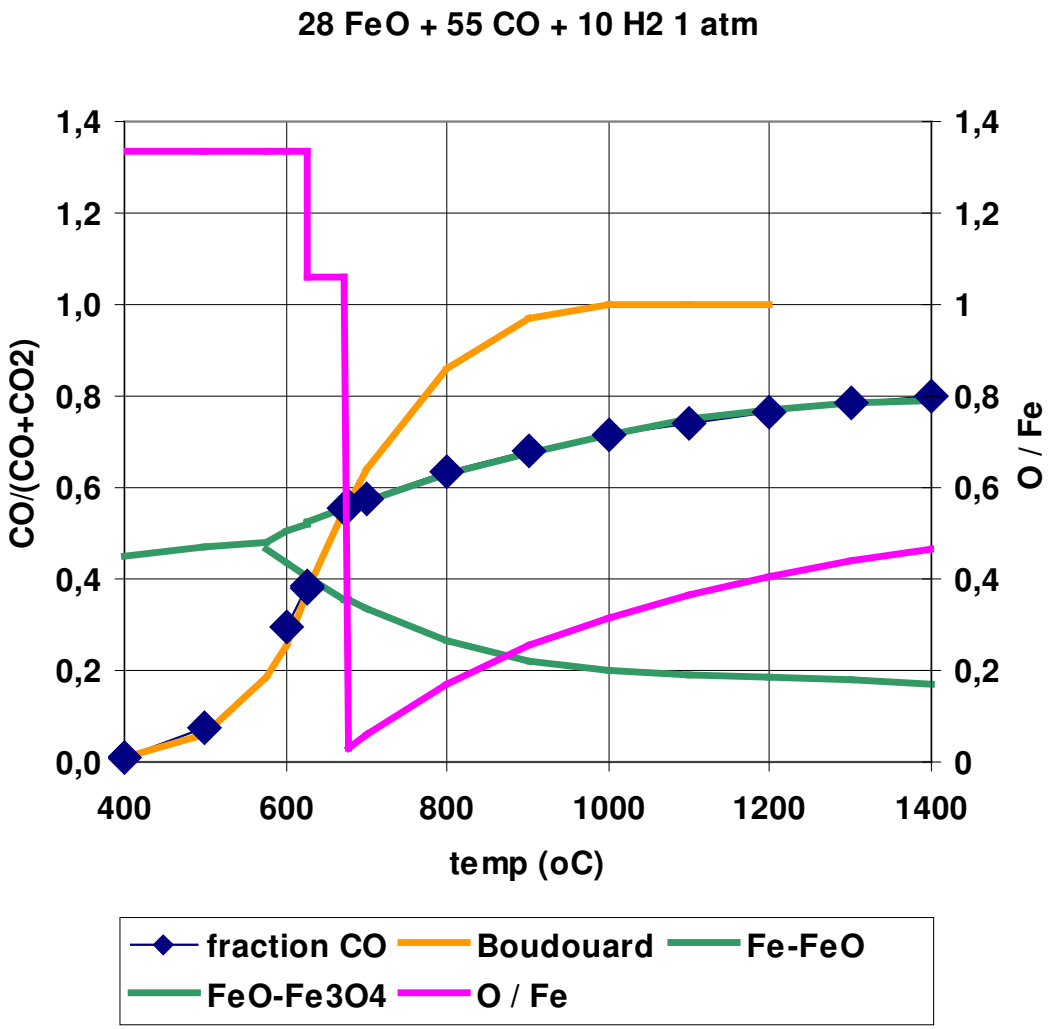


reduction achieves 100 % beyond 750 °C

beyond 750 °C there is surplus of H_2 available

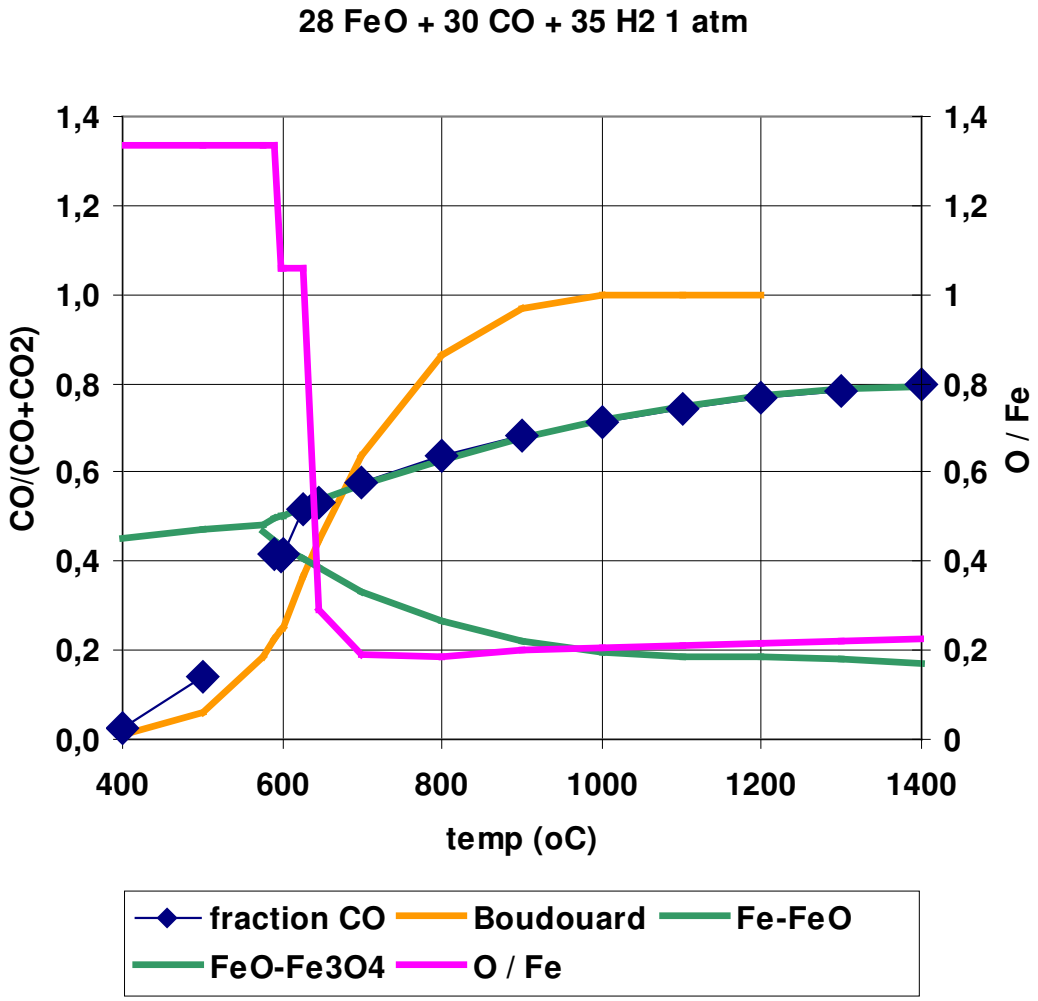
➔ equilibria deviate from FeO – Fe line

Replacement of CO by H_2



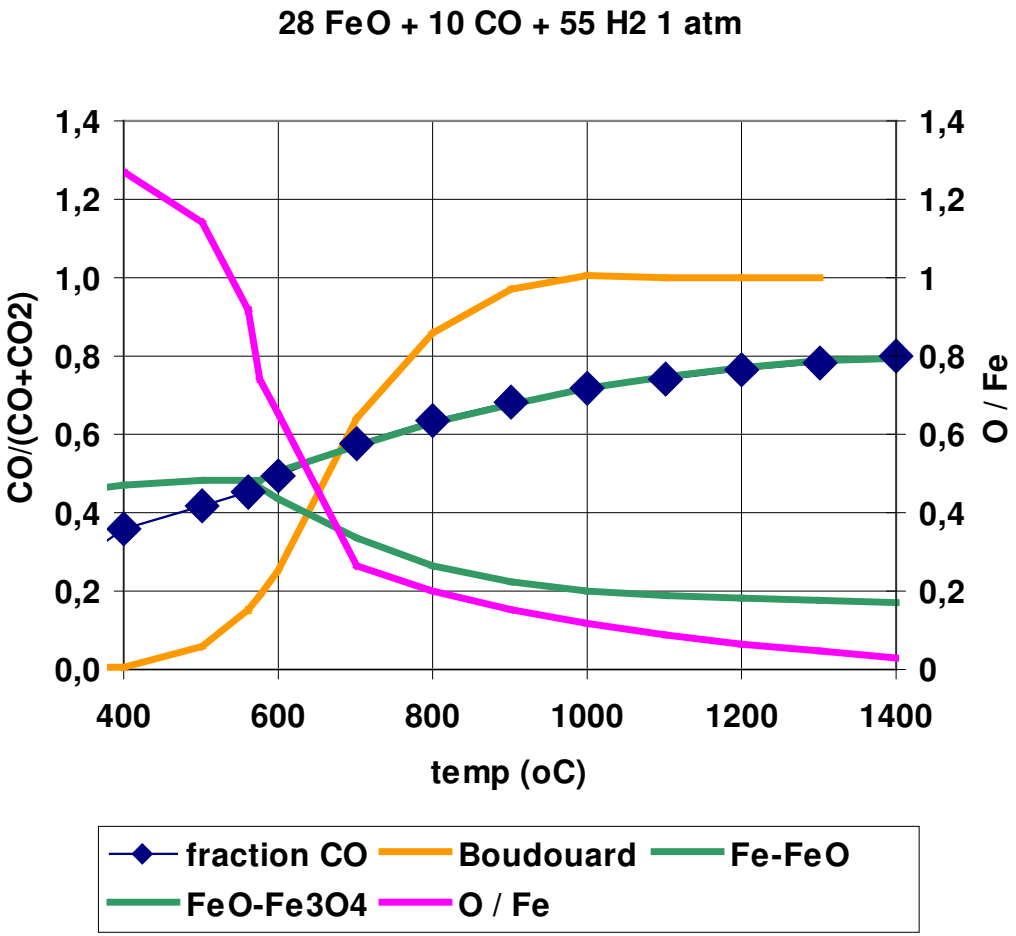
maximum reduction
at 700 °C is 95 %

Replacement of CO by H_2



maximum reduction of 80 % over the temperature range is possible

Replacement of CO by H_2

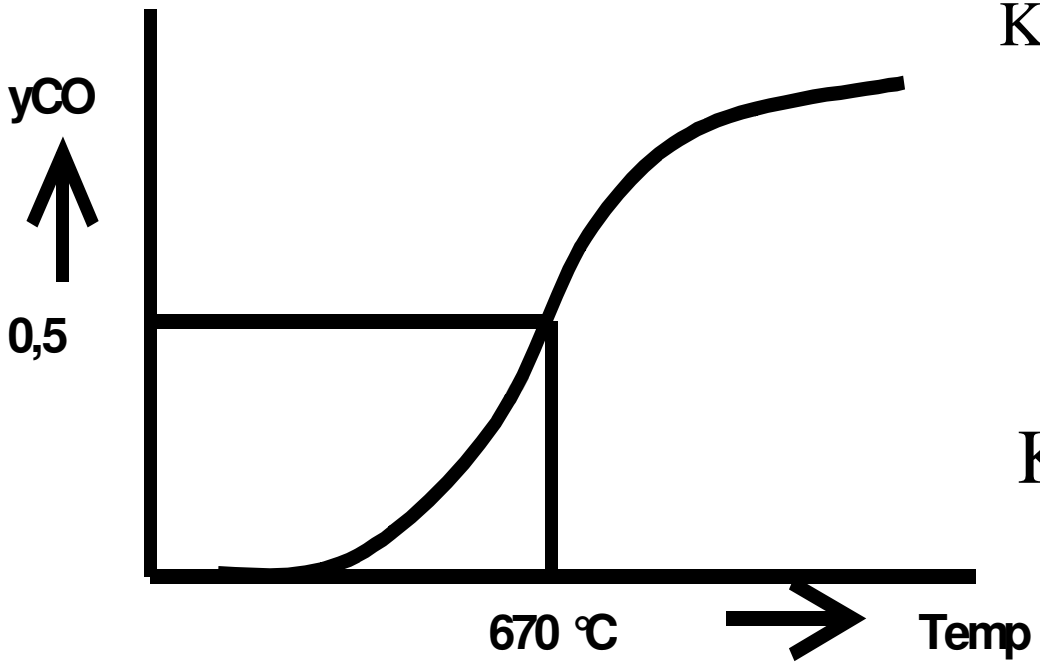


O / Fe starts to resemble that of pure H_2

Boudouard 1 : influence of p

$2\ CO = CO_2 + C$

$$\Delta G_{reaction} = \Delta G^0 + RT * \ln K$$



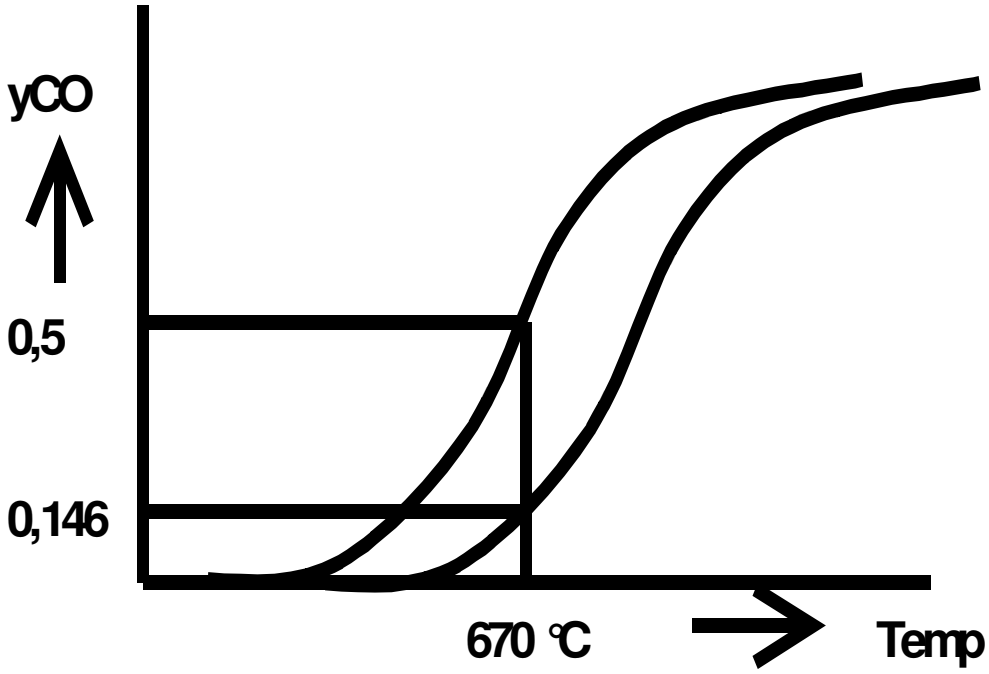
$$K = \frac{a_C * y_{CO2} * P_{total}}{y_{CO}^{\ 2} * P_{total}^{\ 2}} = \frac{y_{CO2}}{y_{CO}^{\ 2} * P_{total}}$$

$yCO = 0,5$

$$K = \frac{y_{CO2}}{y_{CO}^{\ 2} * 1} = \frac{0,5}{0,25 * 1} = 2$$

Boudouard 2 : influence of p

$2\,CO = CO_2 + C$



$yCO = 0{,}5$

$$K = \frac{y_{CO2}}{y_{CO}^{\,2} * 1} = \frac{0{,}5}{0{,}25 * 1} = 2$$

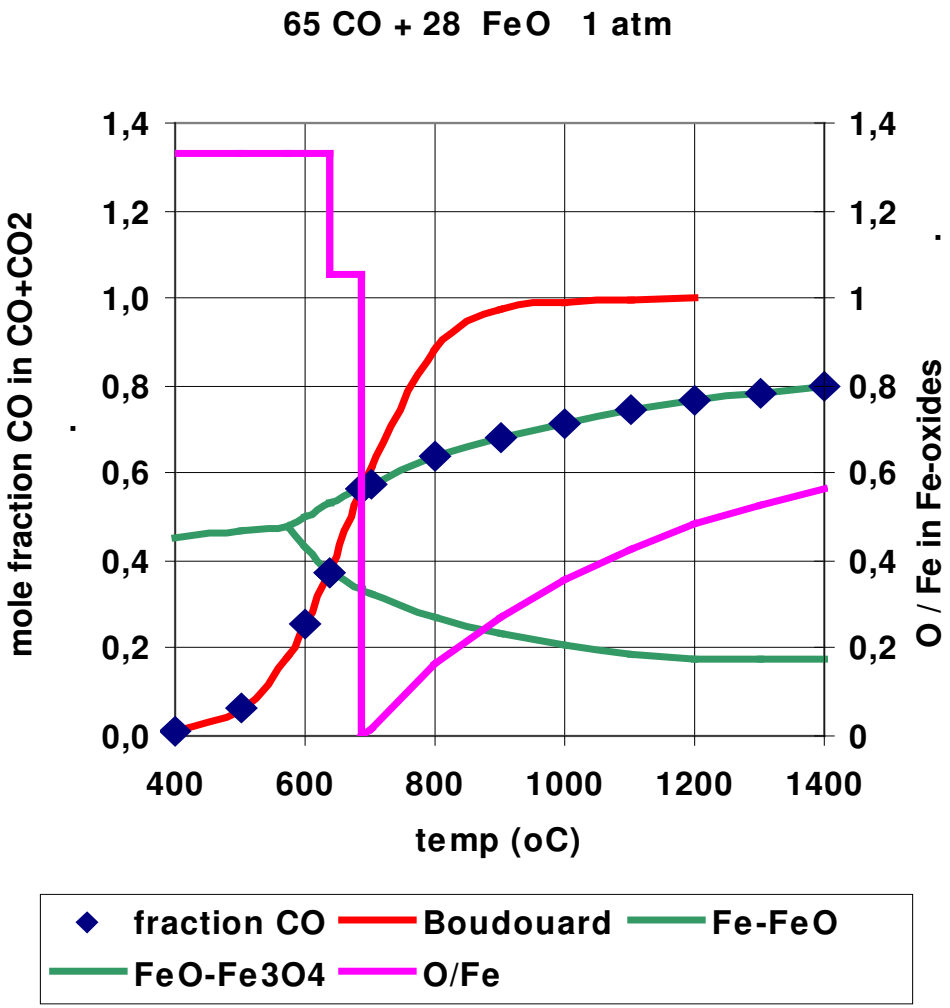
ΔGo **(1 atm)** $= \Delta Go$ **(20 atm)** ➔

$RT*\ln K$ **(1 atm)** $= RT*\ln K$ **(20 atm)**

$$K = \frac{y_{CO2}}{y_{CO}^{\,2} * 20} = \frac{1 - y_{CO}}{y_{CO}^{\,2} * 20} = 2$$

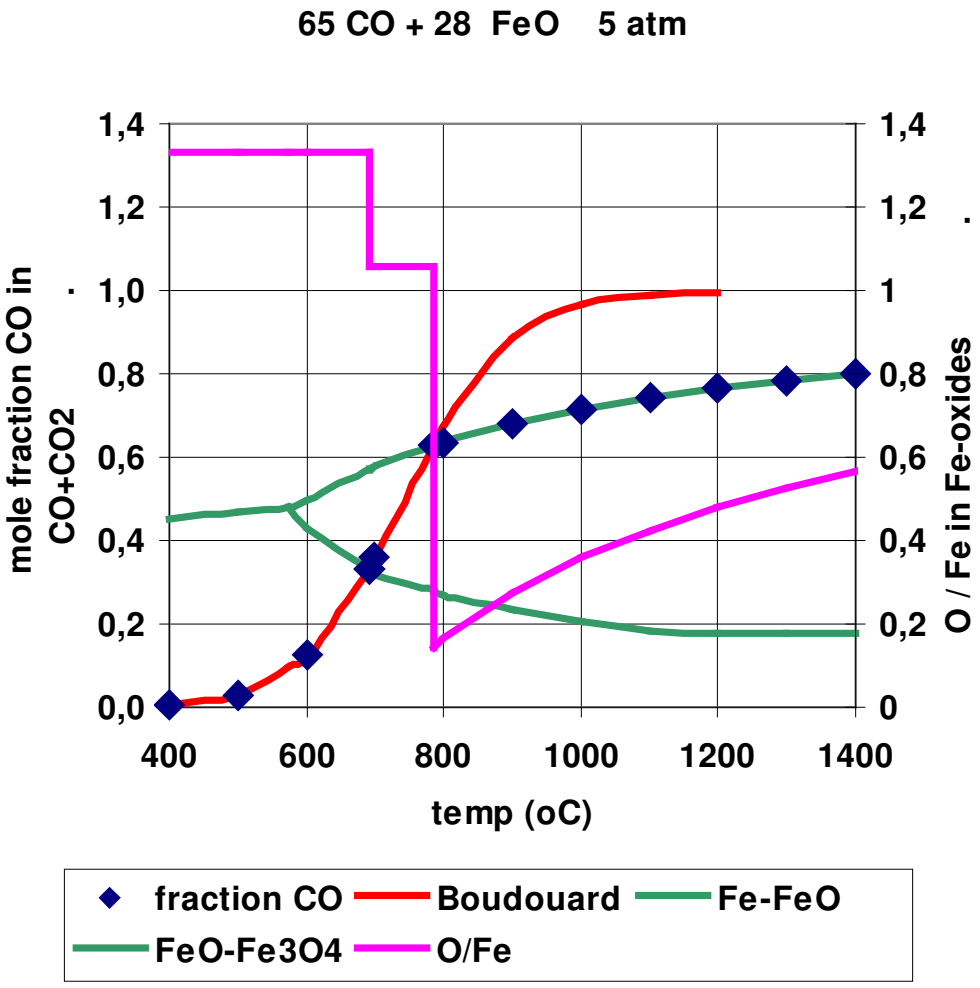
➔ $yCO = 0{,}146$

Base case at 1 atm



100 % reduction at 700 °C

CO at 5 atm



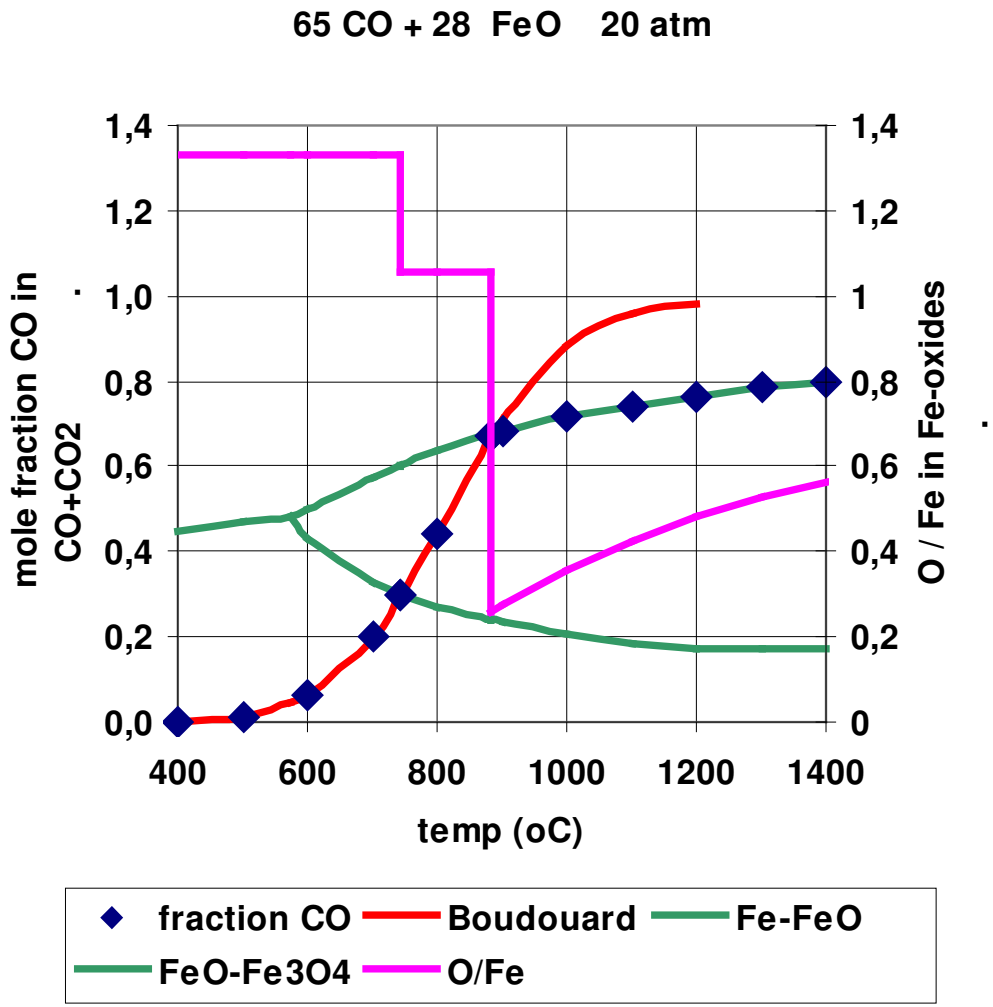
reduction of FeO reduces from 100 % at 700 °C to 85 % at 780 °C

due to shift of Boudouard curve

reduction equimolecular in gas

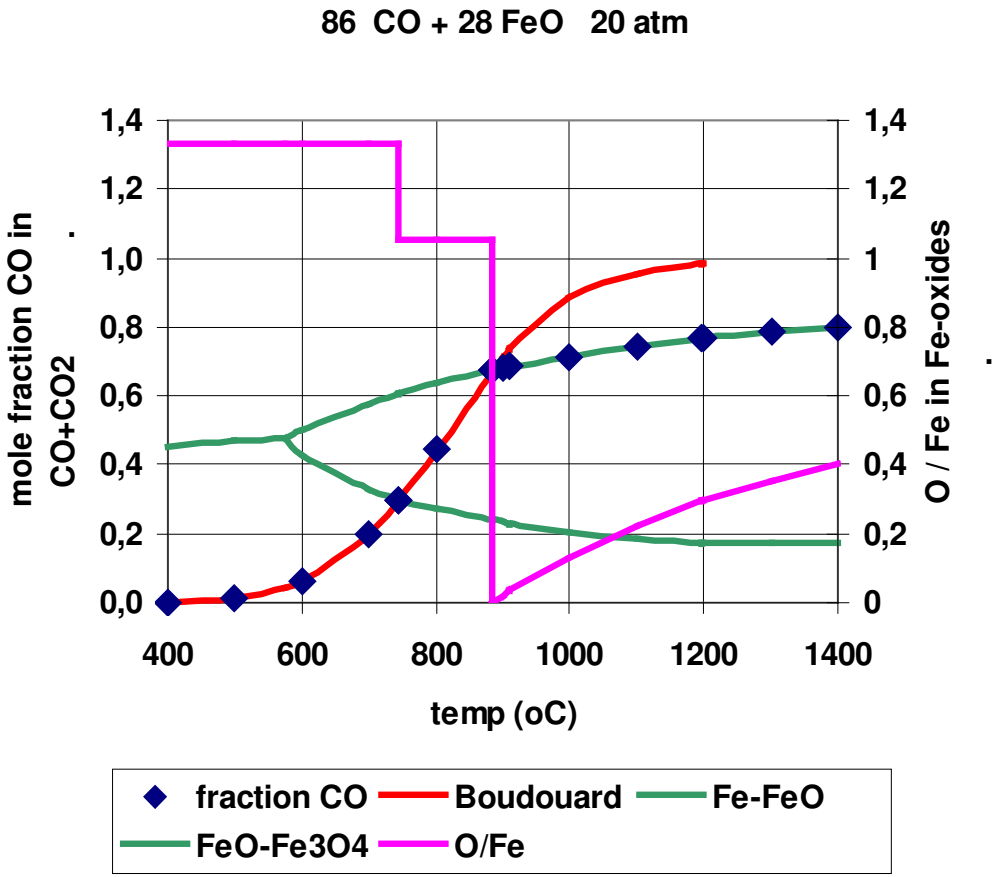
➔ no shift in FeO-Fe line

CO at 20 atm



reduction less than 80 %

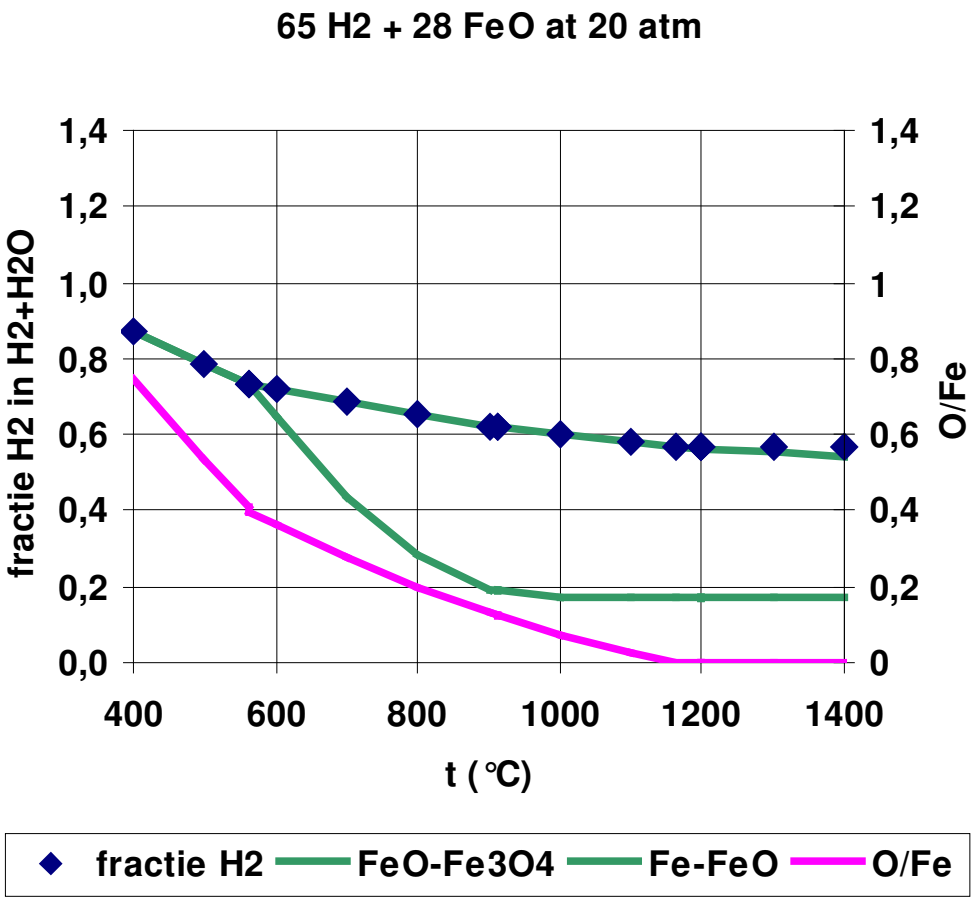
Reduction back to 100 %



reduction back to 100 % due to surplus of CO

(86 instead of 65 moles of CO)

H_2 at 20 atm



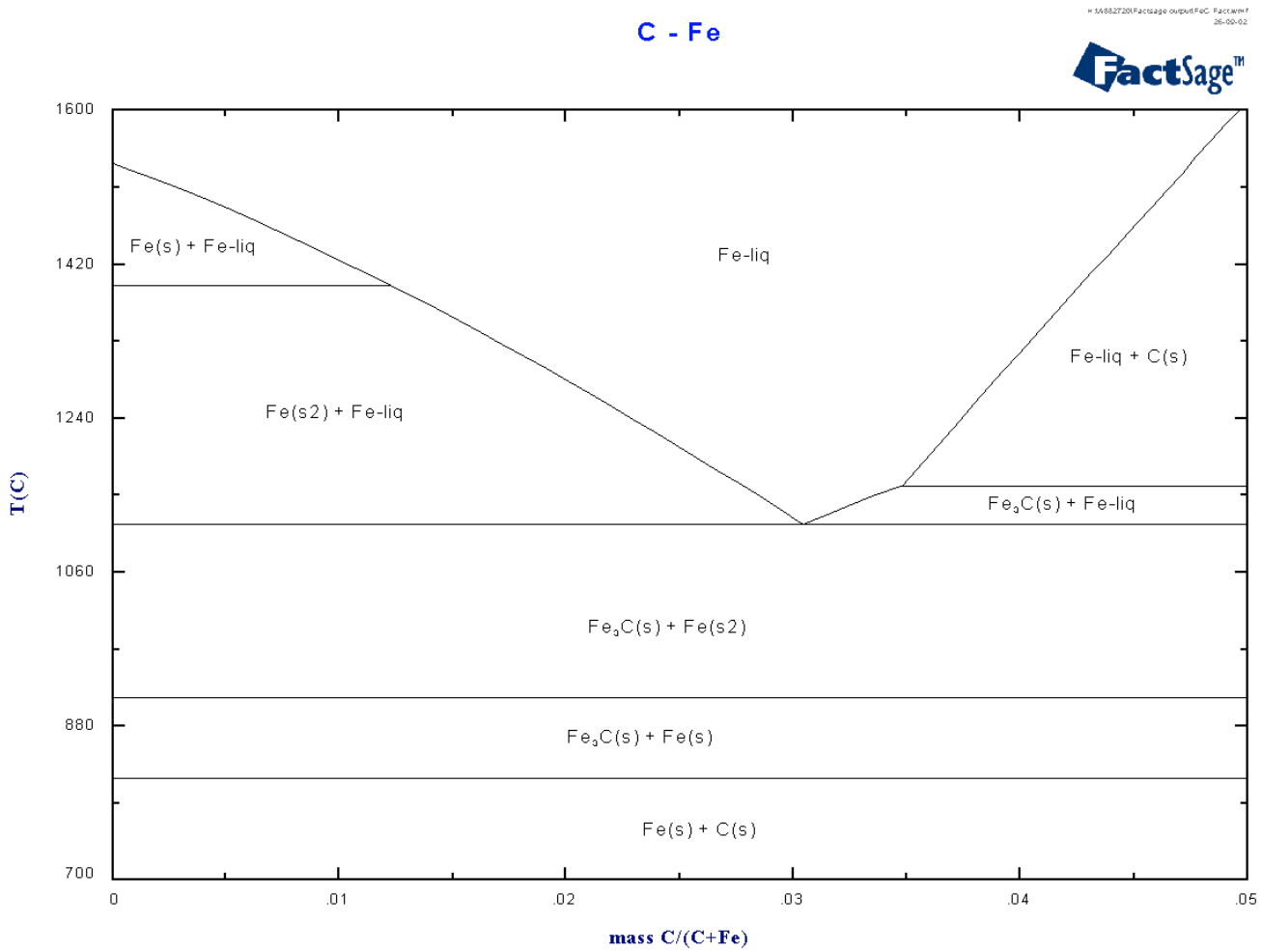
no Boudouard

equimolecular reaction

➔ no P_{total} in K

no change in K due to change in pressure

Fe C diagram FS50 data



Fe C diagram 9148C10G data