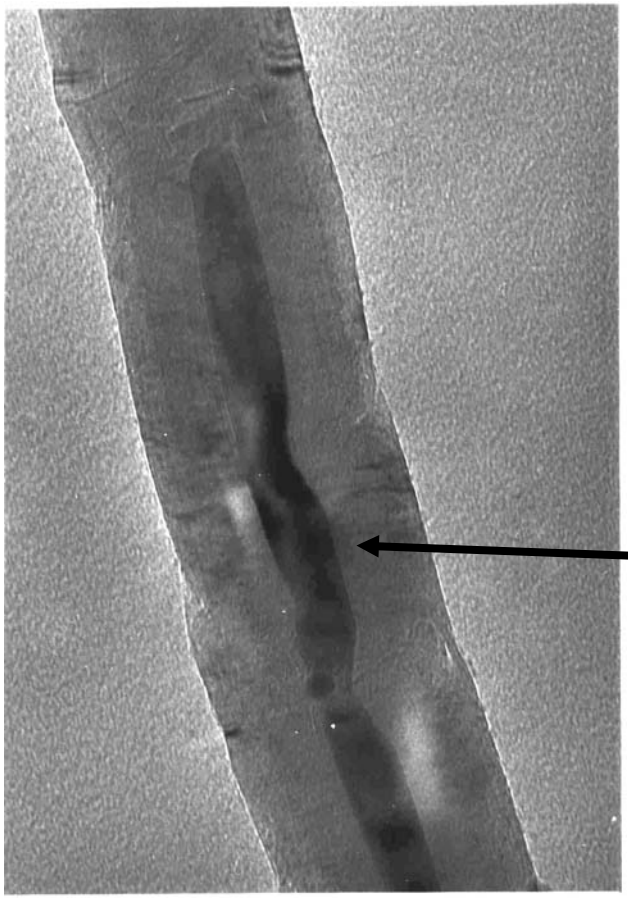
Properties of Small Metallic Particles

Helen Chappell
Aikaterina Plati
Yi Shen

Carbon nanotube with iron particle in the middle



blobby iron particle

Kinloch, 2002

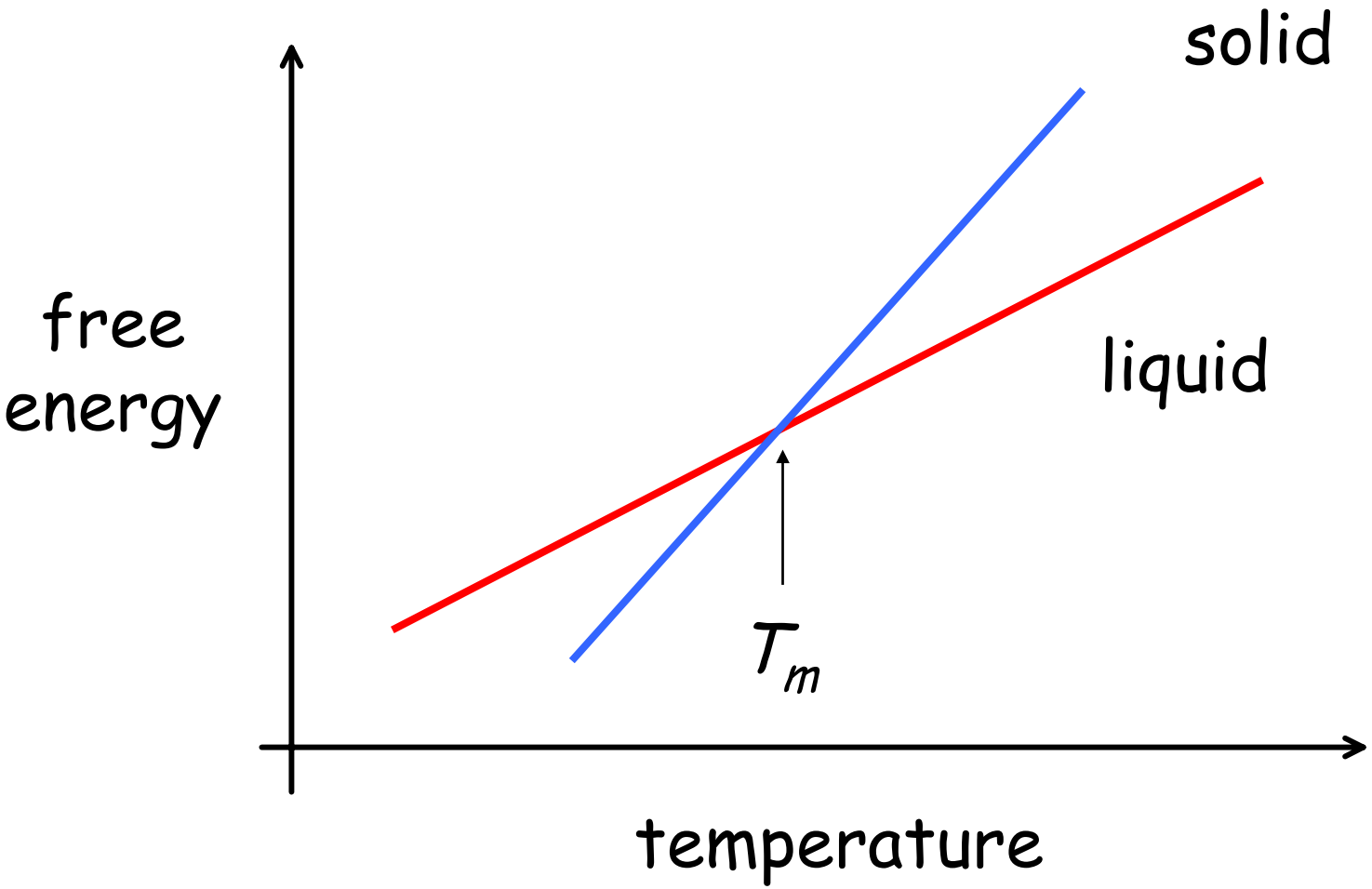
What we did…

- Iron particles
- 10-wt% nickel-iron alloy particles
- Varied shape, size and composition
- Statistical sampling of 'homogeneous' alloy

Melting Temperature

- Flat interface, $G_L = G_S$

Melting Temperature

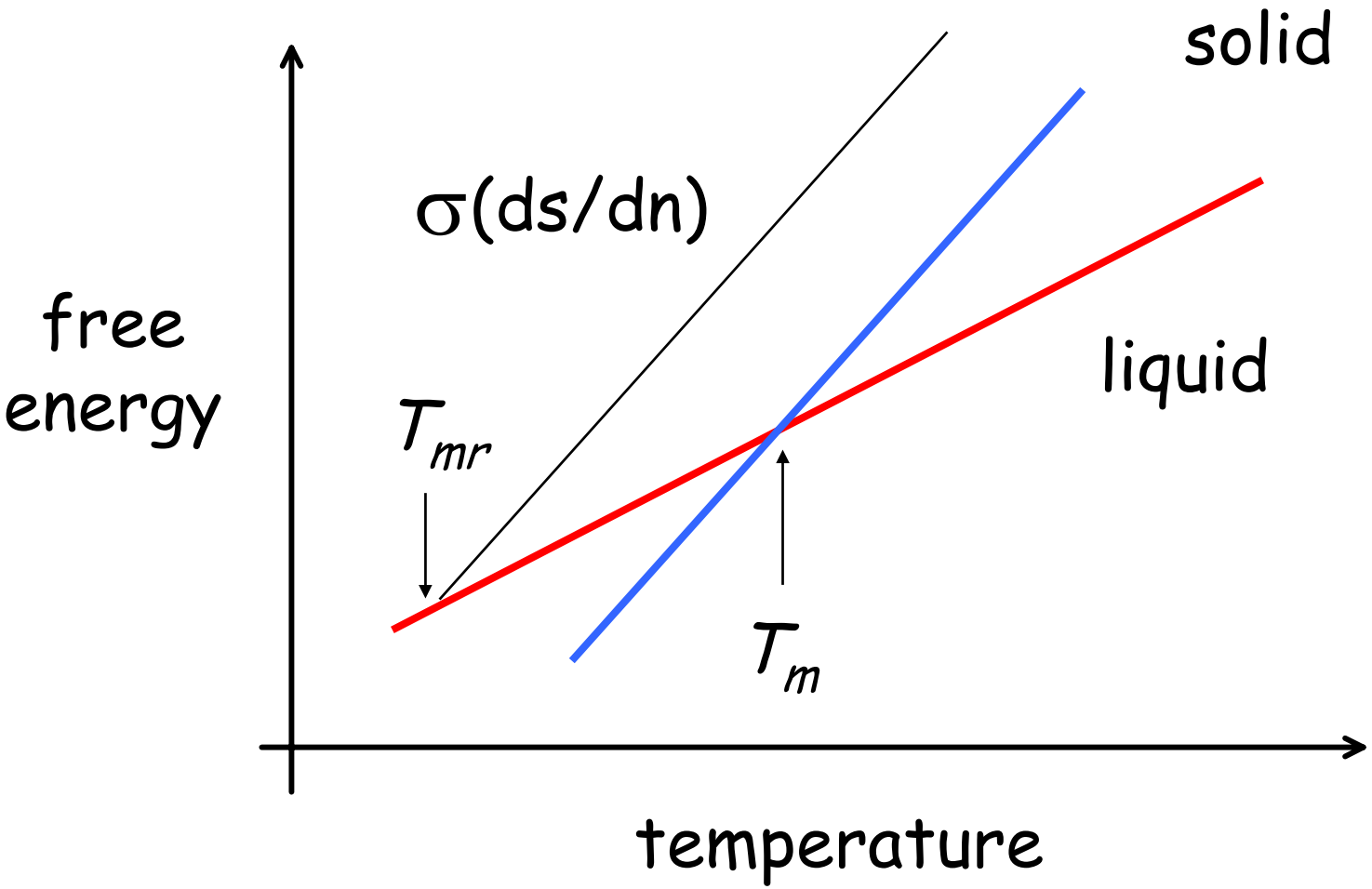


Melting Temperature

- Flat interface, $G_L = G_S$

Curved interface, $G_L = G_S + \sigma \, ds/dn$

Melting Temperature



Process

- Mt data (G_L , G_s)

- Fitted polynomial equations to the data

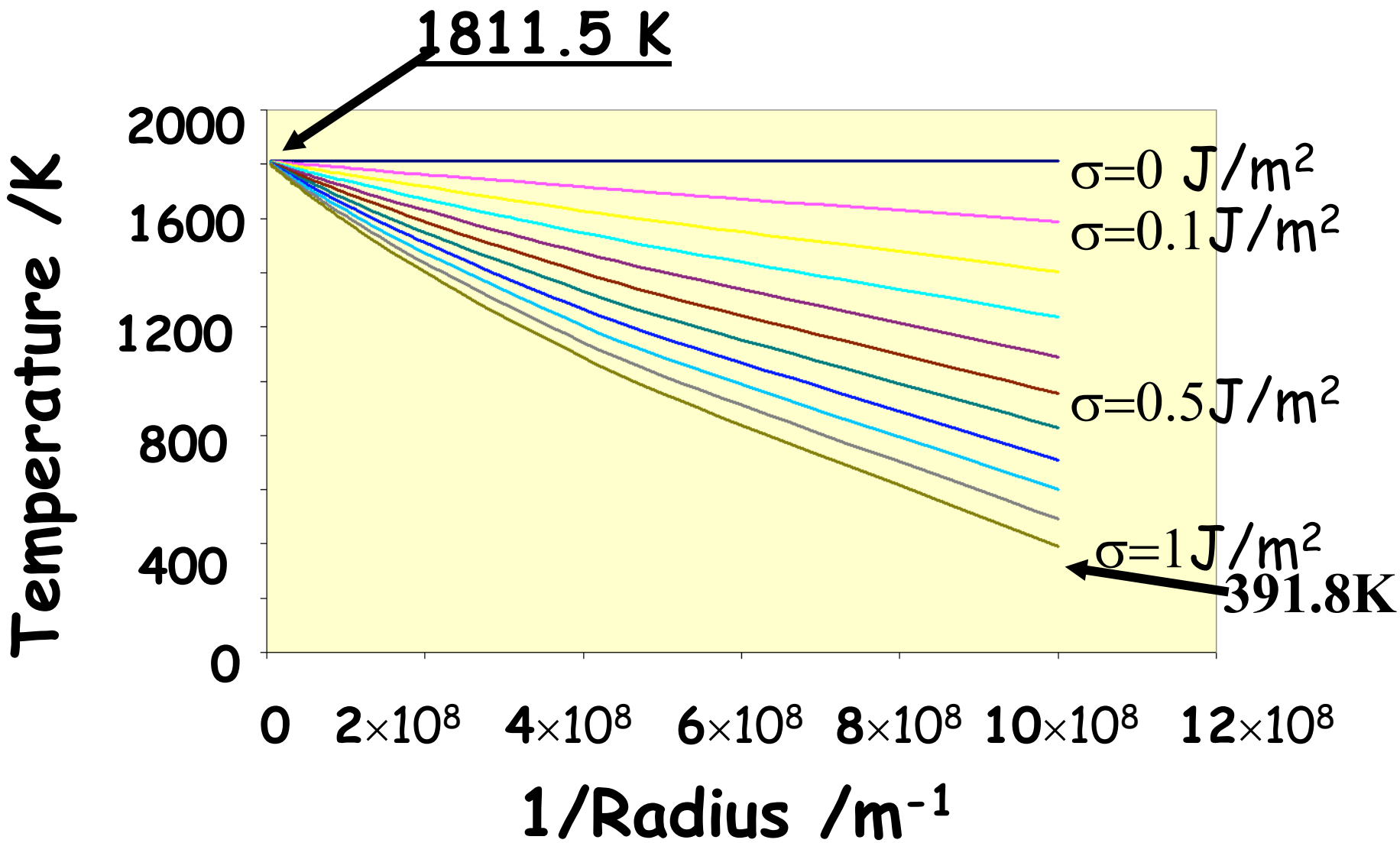
$$G_L = AT^2 + BT + C$$

$$G_s = DT^2 + FT + L$$

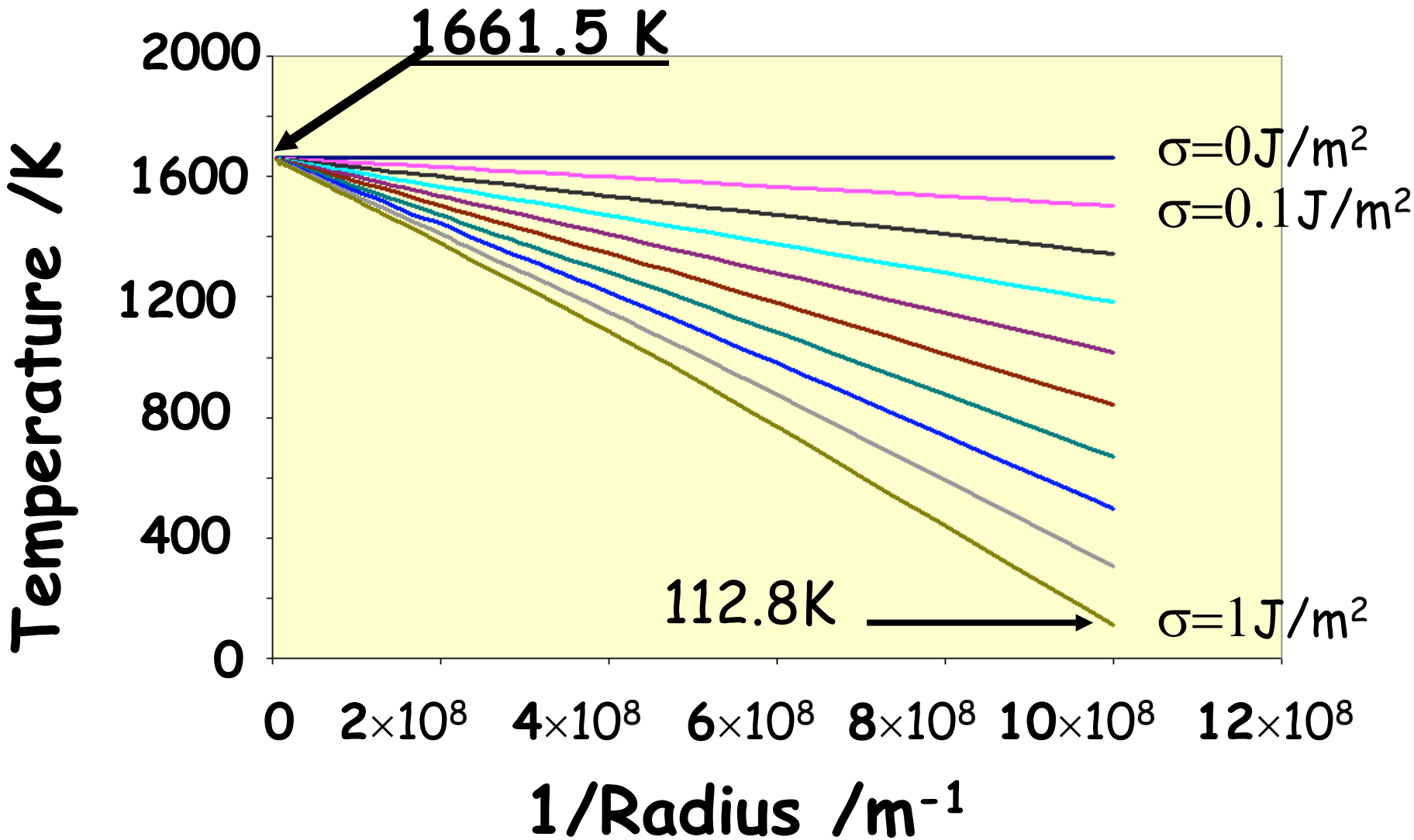
$$G_{SR} = G_S + \sigma\, ds/dn$$

- Created Curvefit3 $\longrightarrow$ $G_{sr}, T_{m(r)/x,\sigma}$
- Plotted results in Excel

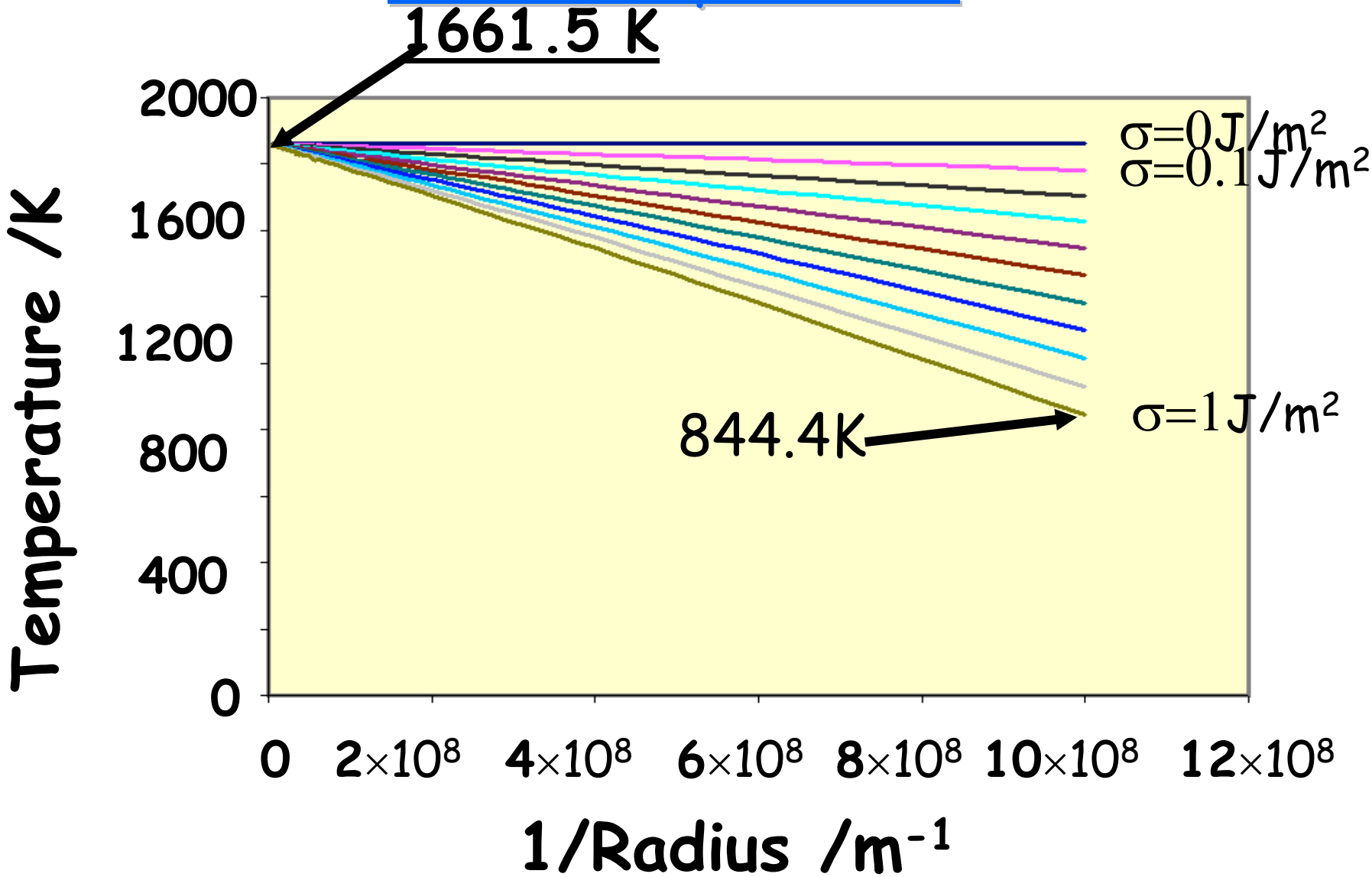
Melting temperature for spherical ferrite particles



Melting temperature for spherical austenite particles



Melting temperature for cylindrical austenite particles



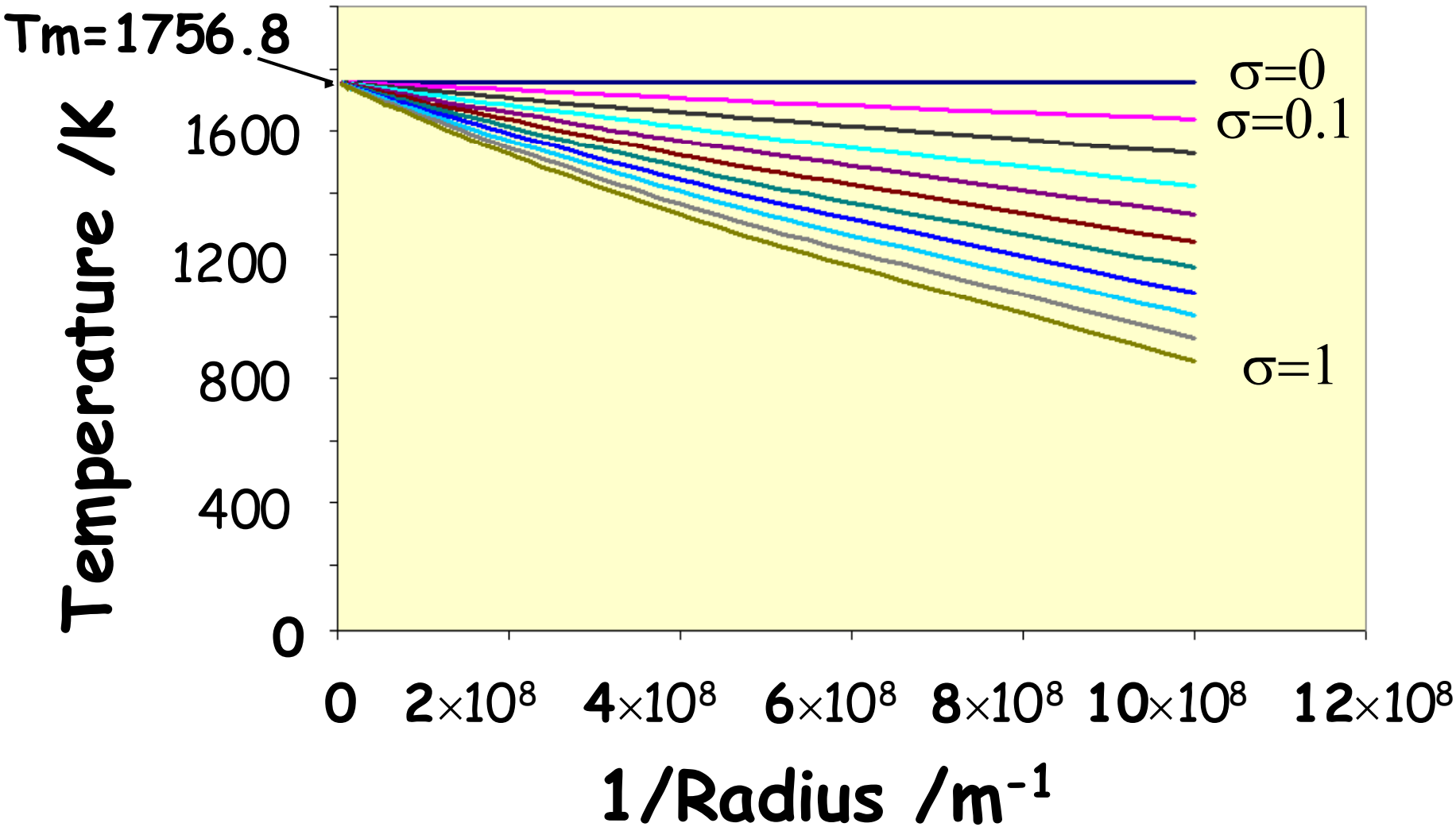
Nickel-iron particles

- *Gs*-ferrite
  $y = -0.0172T^2 - 35.564T + 7602.5$

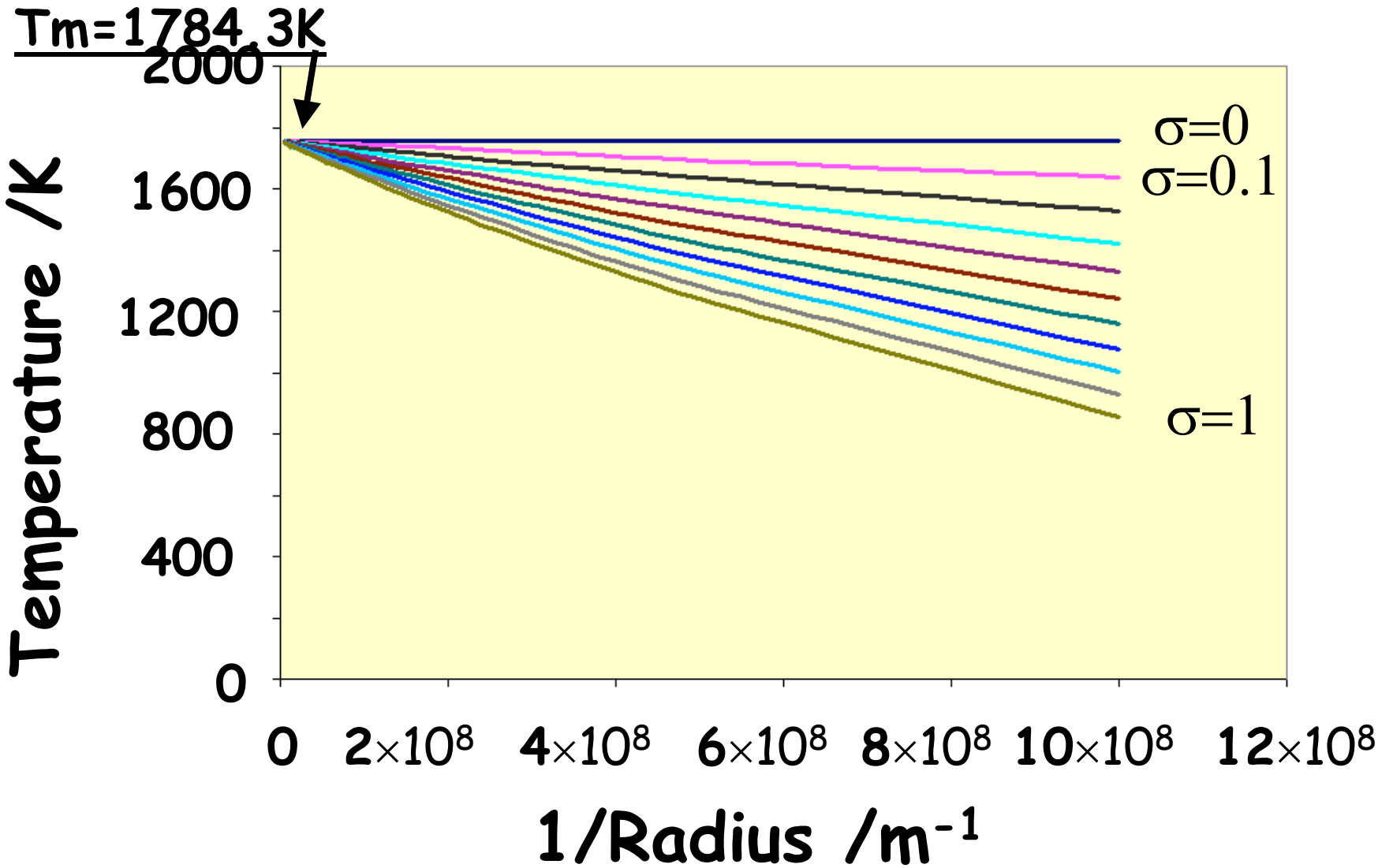
- *Gs*-austenite
  $y = -0.0141T^2 - 44.14T + 12886$

- G_L
  $y = -0.0146T^2 - 50.209T + 25307$

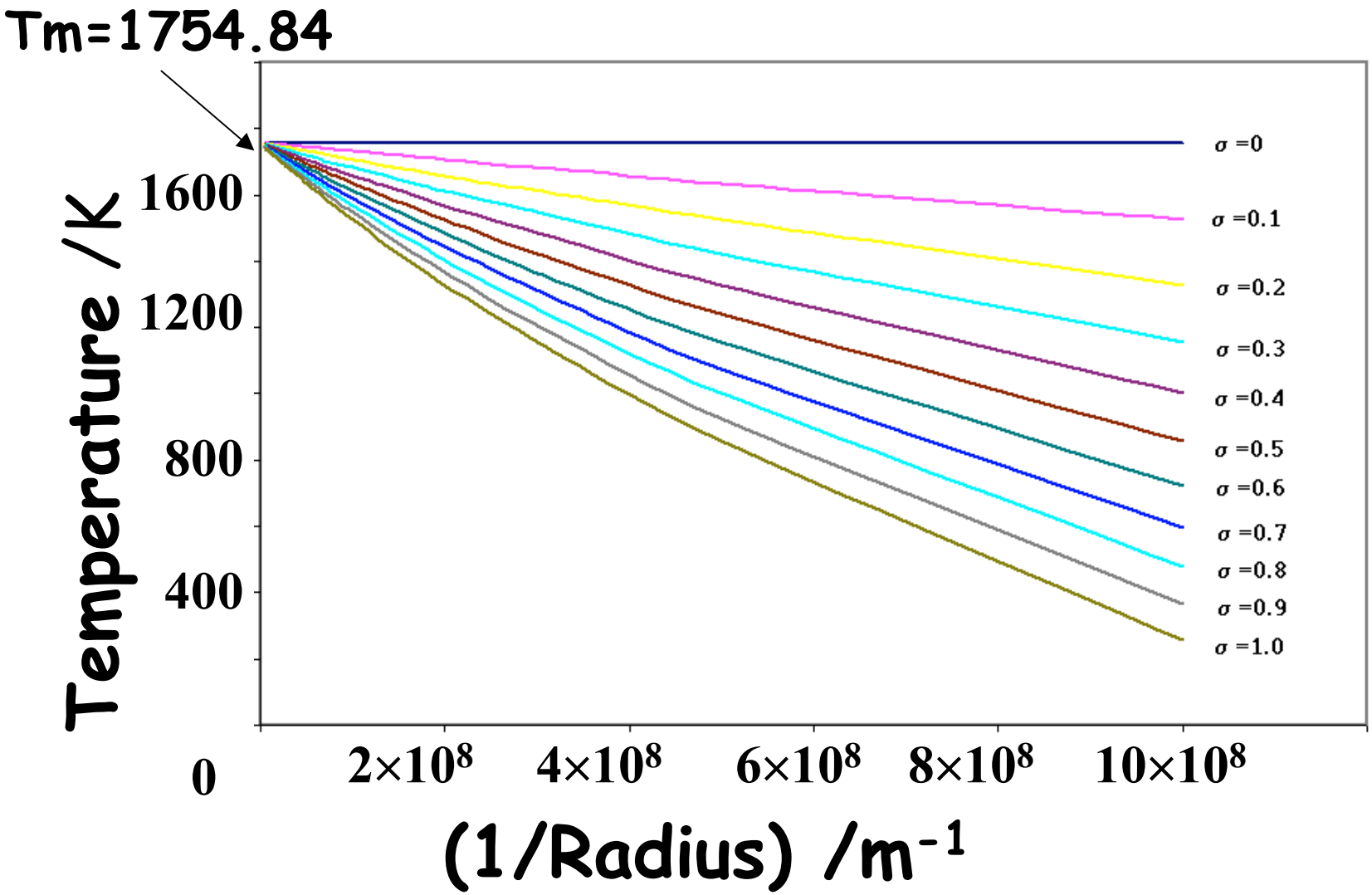
Melting temperature for cylindrical ferrite particles in alloy (10%Ni)



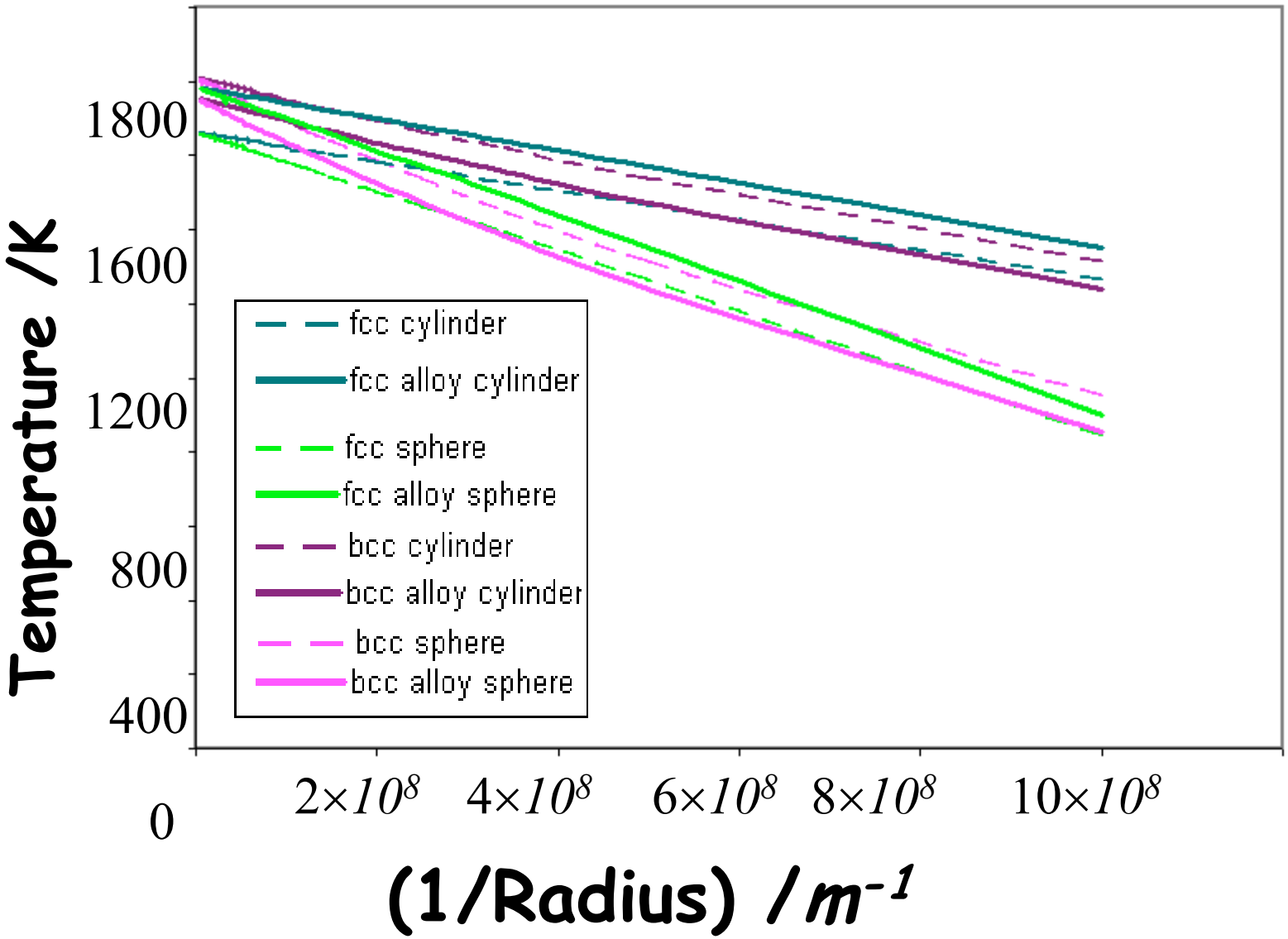
Melting temperature for cylindrical austenite particles in alloy (10%Ni)



Melting temperature for spherical ferrite particles in alloy(10% Ni)



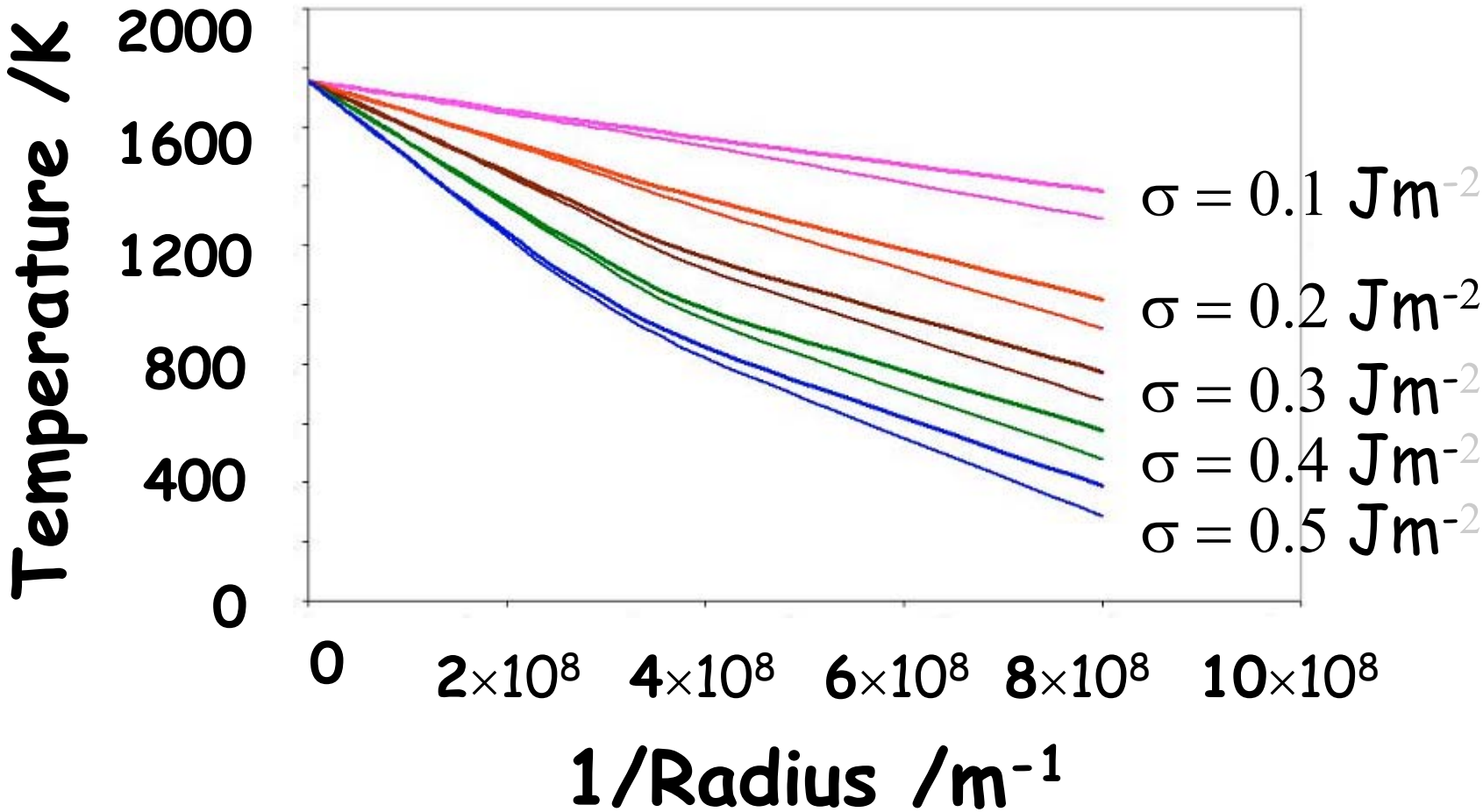
Melting temperature of austenite and ferrite particles in pure iron and alloy(10%Ni) σ=0.5



Statistical Analysis

- Fixed volume
- $N_p \times N_a$ = constant
- $\sigma_x = \sqrt{N_a \times f(1-f)}$, $f=0.1$
- $N_a = (4/3\ \pi\ r^3)/V_m \times N$

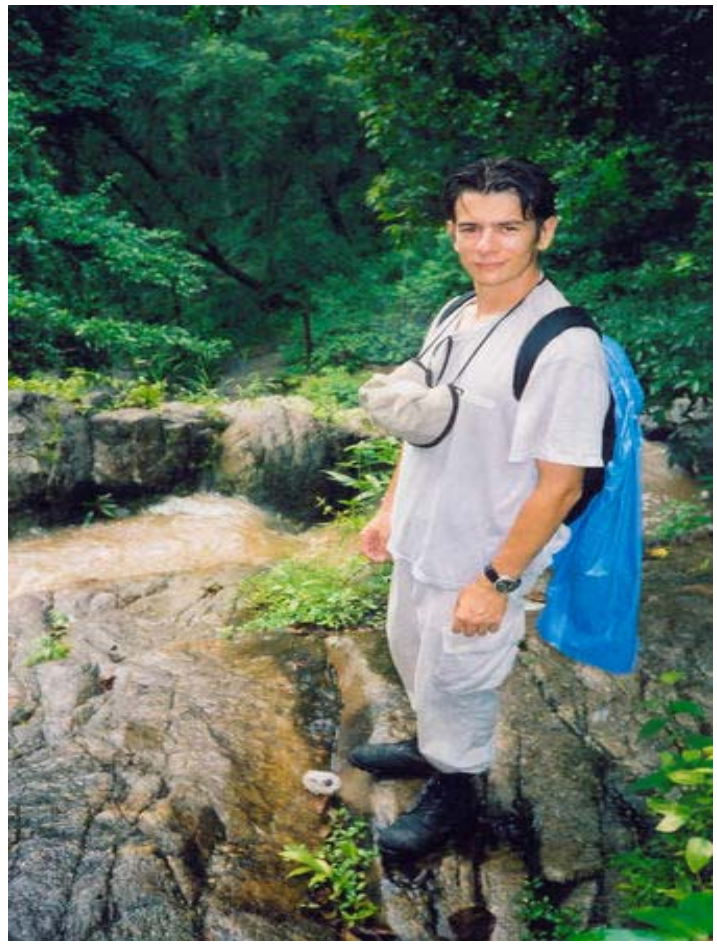
Statistically derived melting temperature for Fe - Ni particles



Summary of Results

- Spherical particles reduce T_{mr} by greatest amount
- Cylindrical particles reduce T_{mr}
- Small particles, large σ - reduces T_{mr}
- Iron - austenite largest reduction in T_{mr}
- Alloy - ferrite largest reduction in T_{mr}
- Extremely small particles - composition influences melting temperature

That's all folks!



The change in ds/dn

- Sphere = $2V_m / r$
- Cylinder = V_m / r

MT-DATA

- Thermodynamic data – SGTE database
- Minimises Gibbs free energy
  - Equilibrium Composition
  - Volume fractions of phases
- Phases can be suppressed
- No kinetic information