Lecture 11

- Environmental toolkit
- Applications

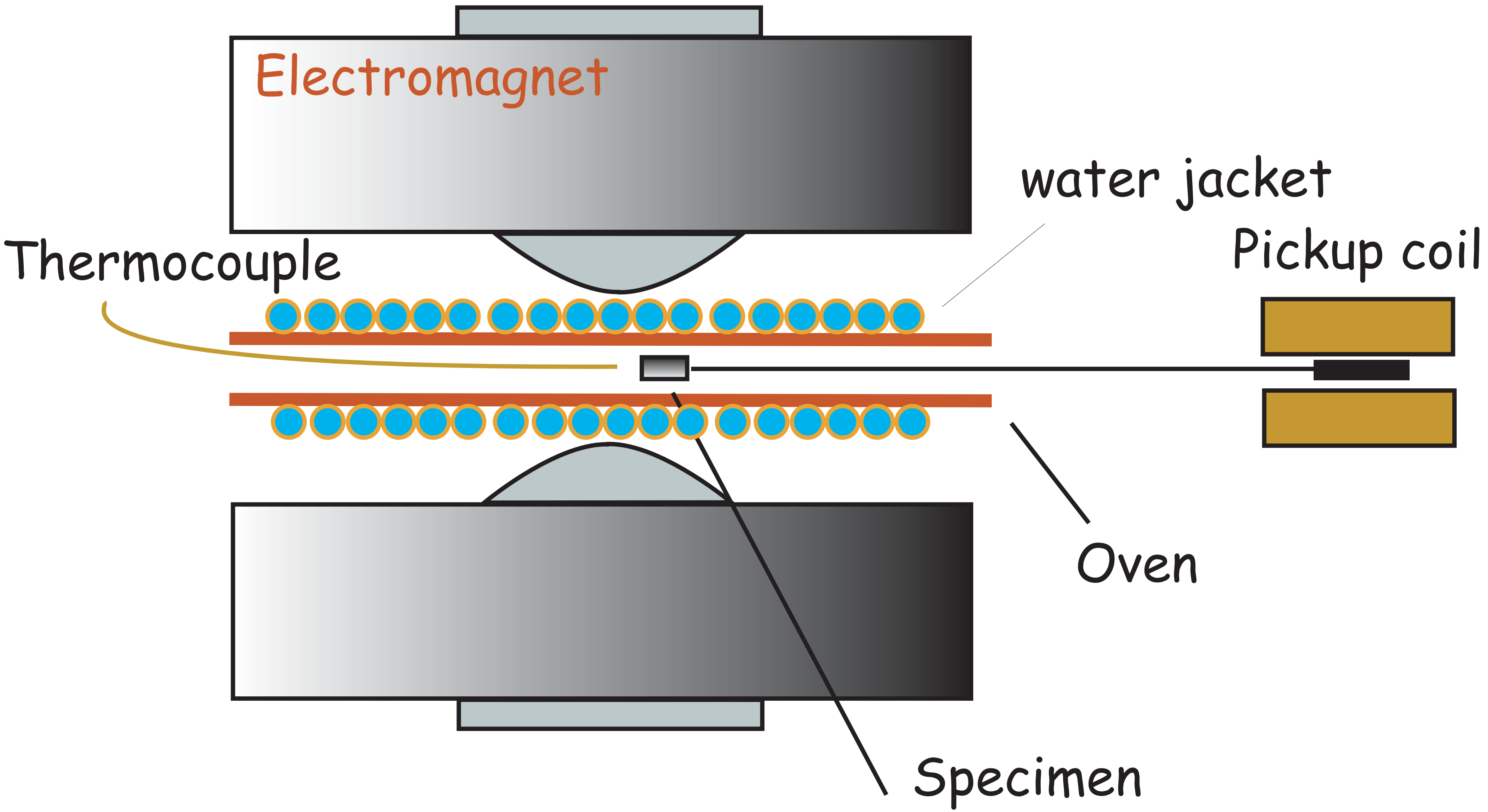
Toolkit

- Images (a picture is worth 1000 words)
- Critical Temperatures (Curie, Verwey, etc.)
- Magnetic susceptibility
- Remanent magnetizations
- Ratios

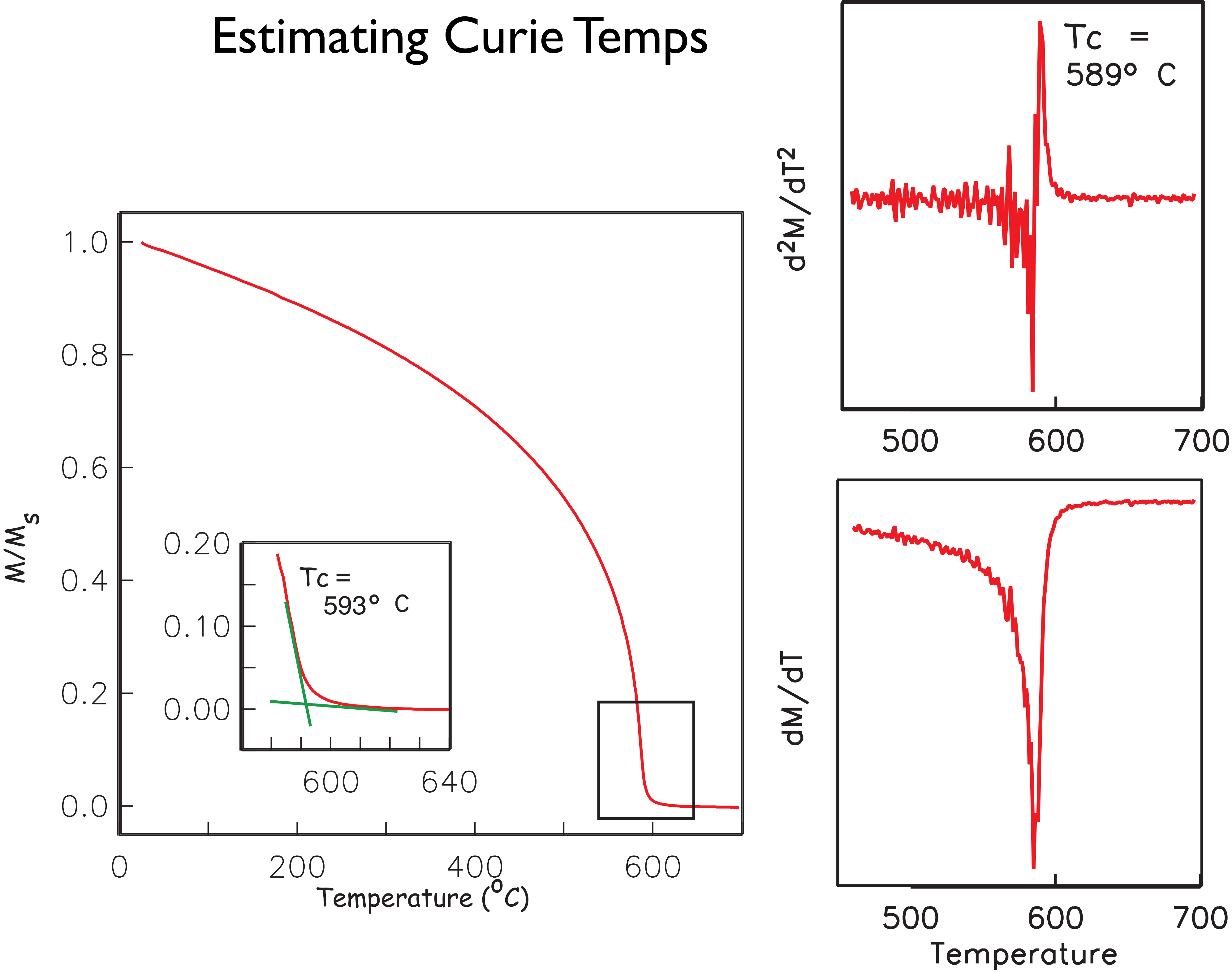
Critical temperatures (Table 8.1)

- Curie (Neel) temperature (Tc)
- Blocking temperature (Tb) and Median destructive temperature (MDT) [and Hc and Median destructive field while we are at it.]
- Hopkinson effect
- Various crystallographic transition temperatures

Curie balance in the SIO lab



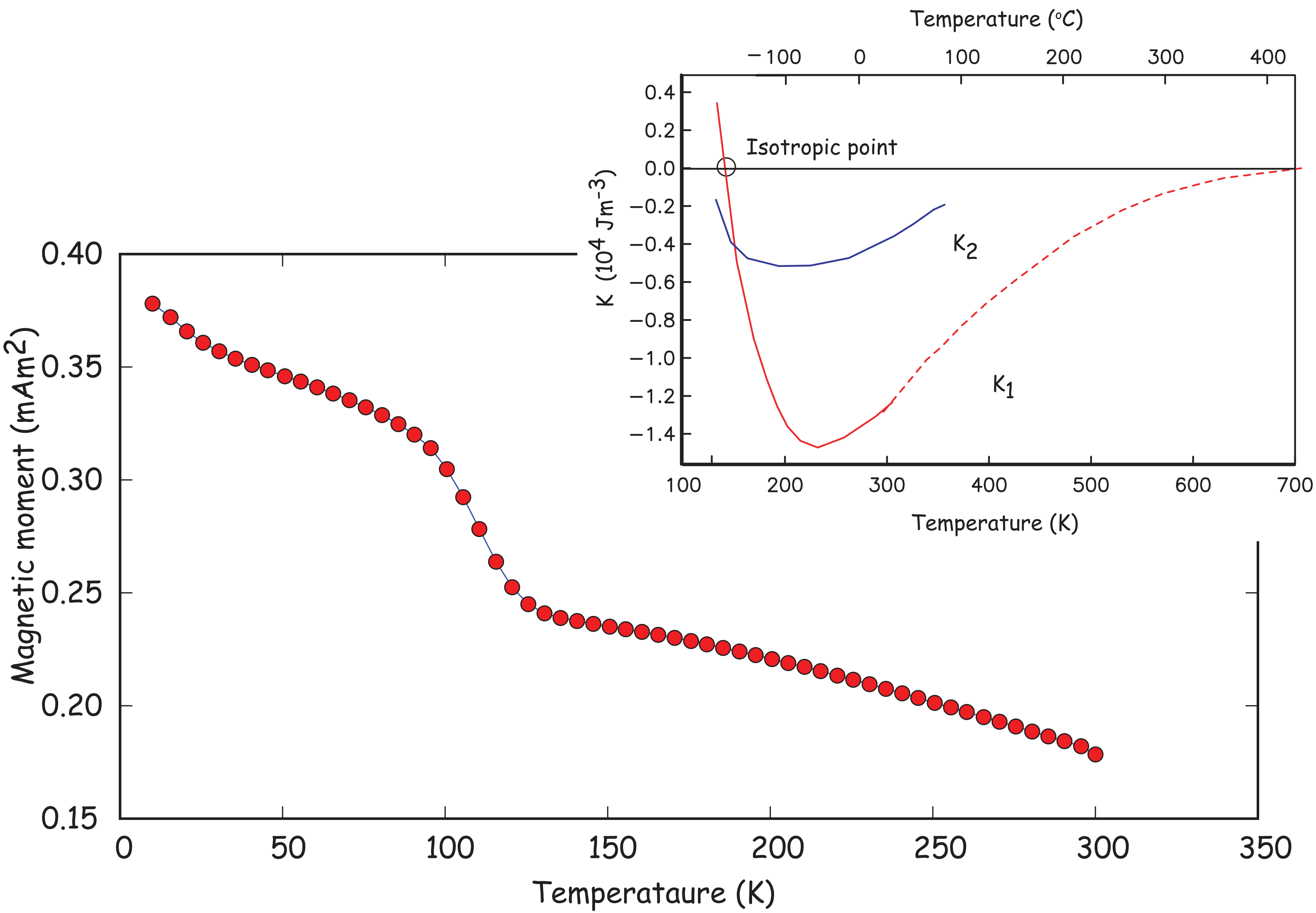
Estimating Curie Temps



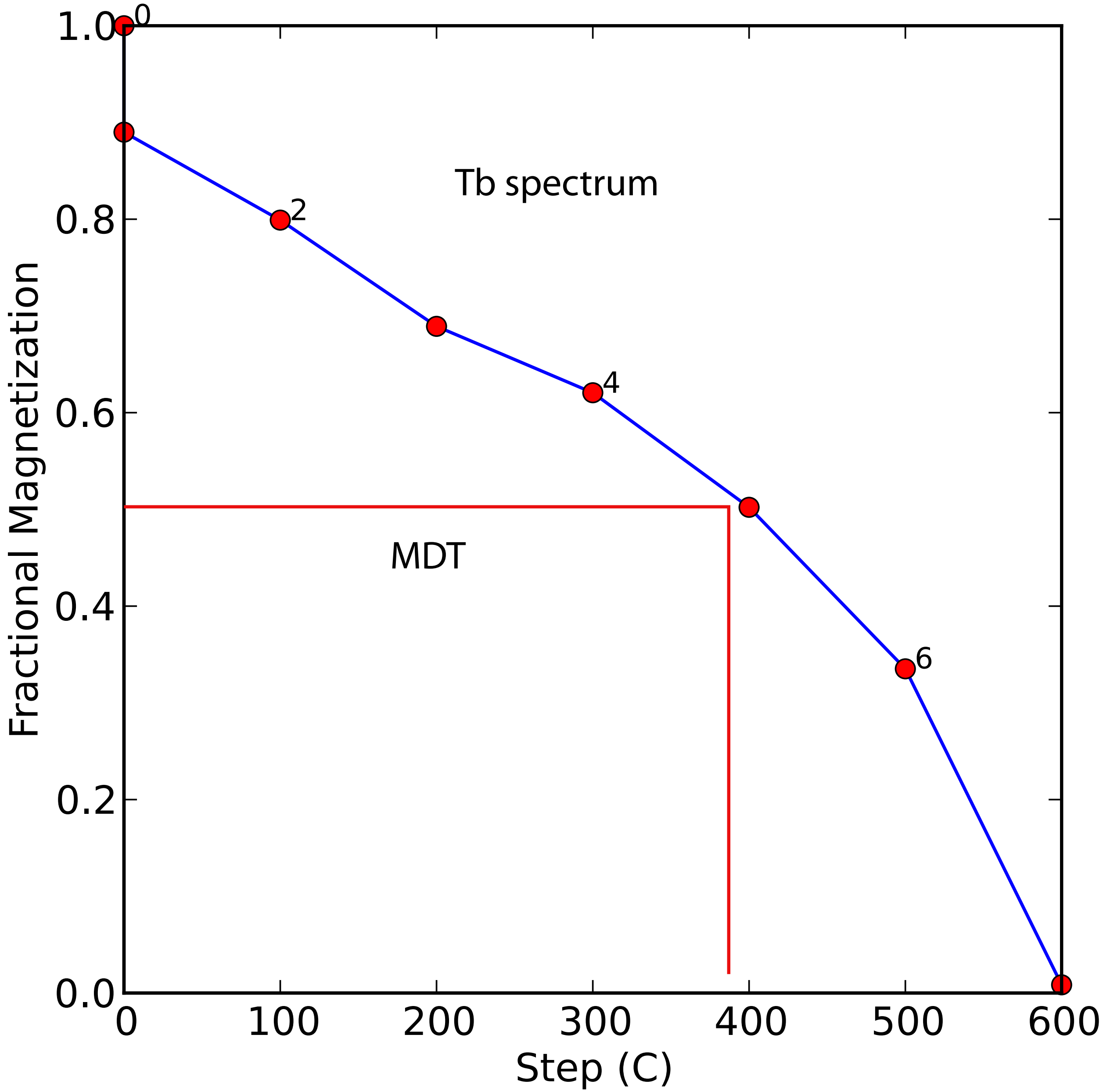
Know your Curie Temperatures!

Listed in Table 6.1

Verwey Temp (from Chapter 4)

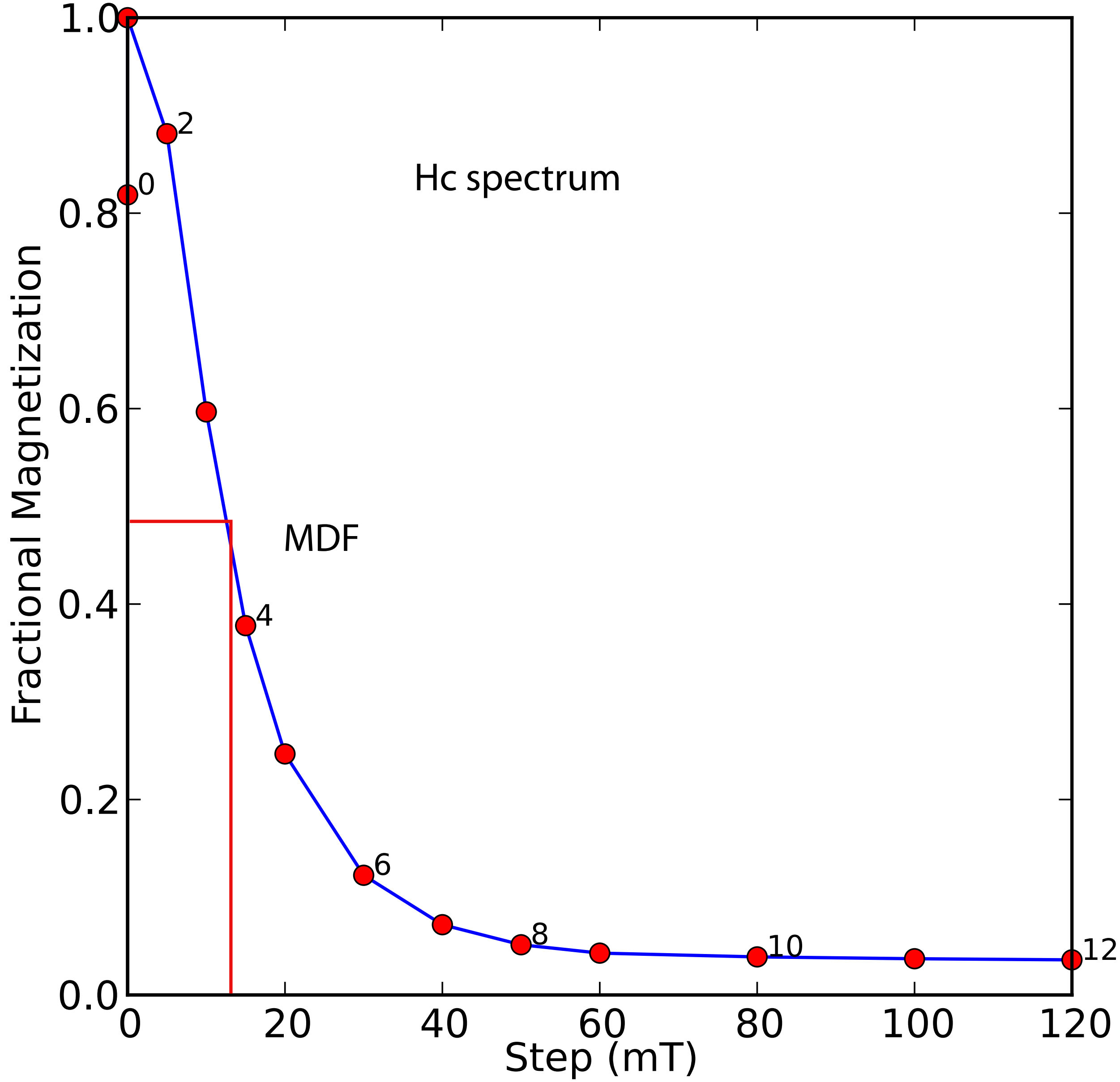


Tb and MDT

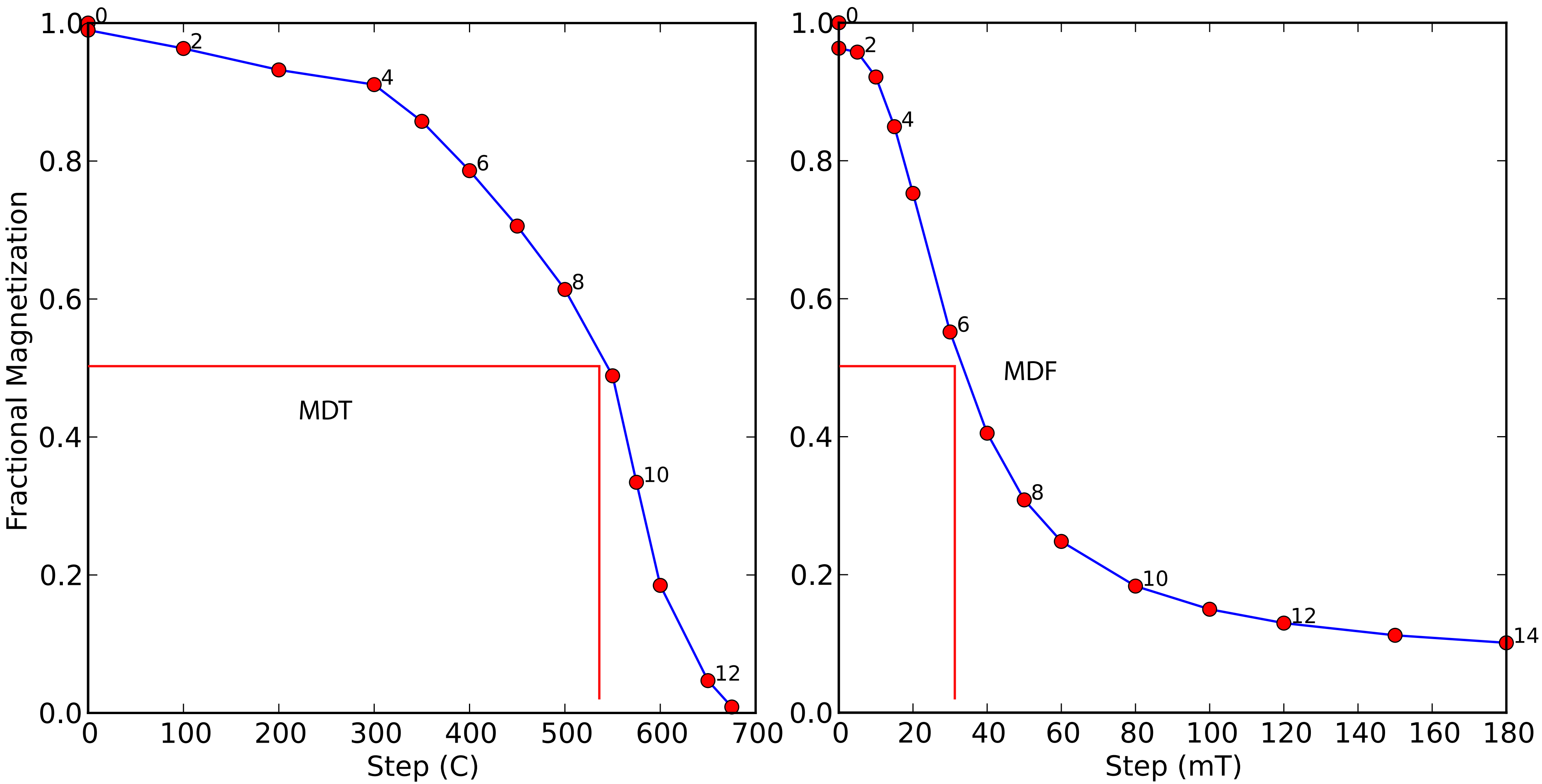


Tb spectrum
MDT
Fractional Magnetization
Step (C)
0
2
4
6
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
500
600

coercivity spectrum and MDF for sister specimen



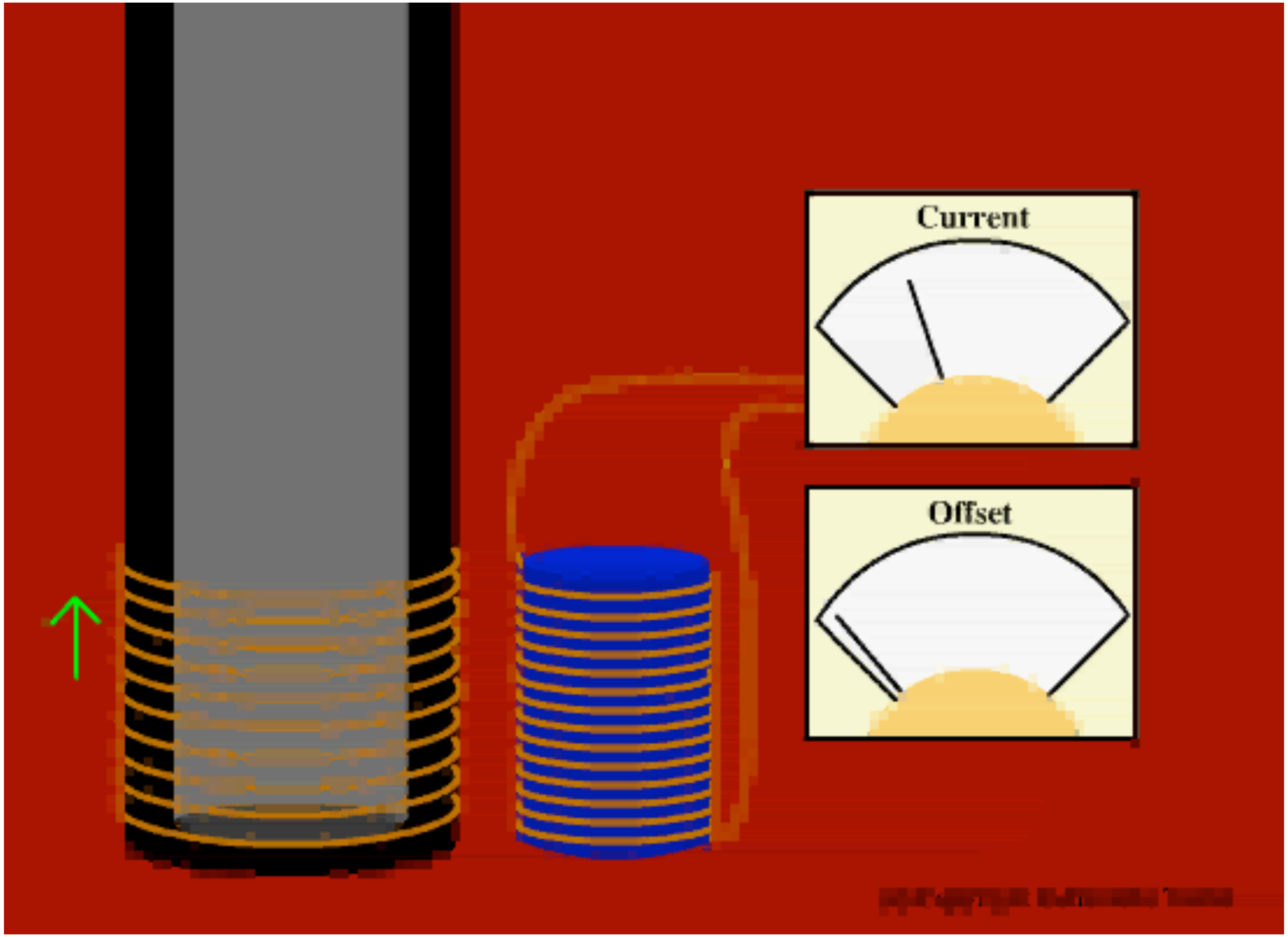
Guess which mineral this is....



Magnetic susceptibility

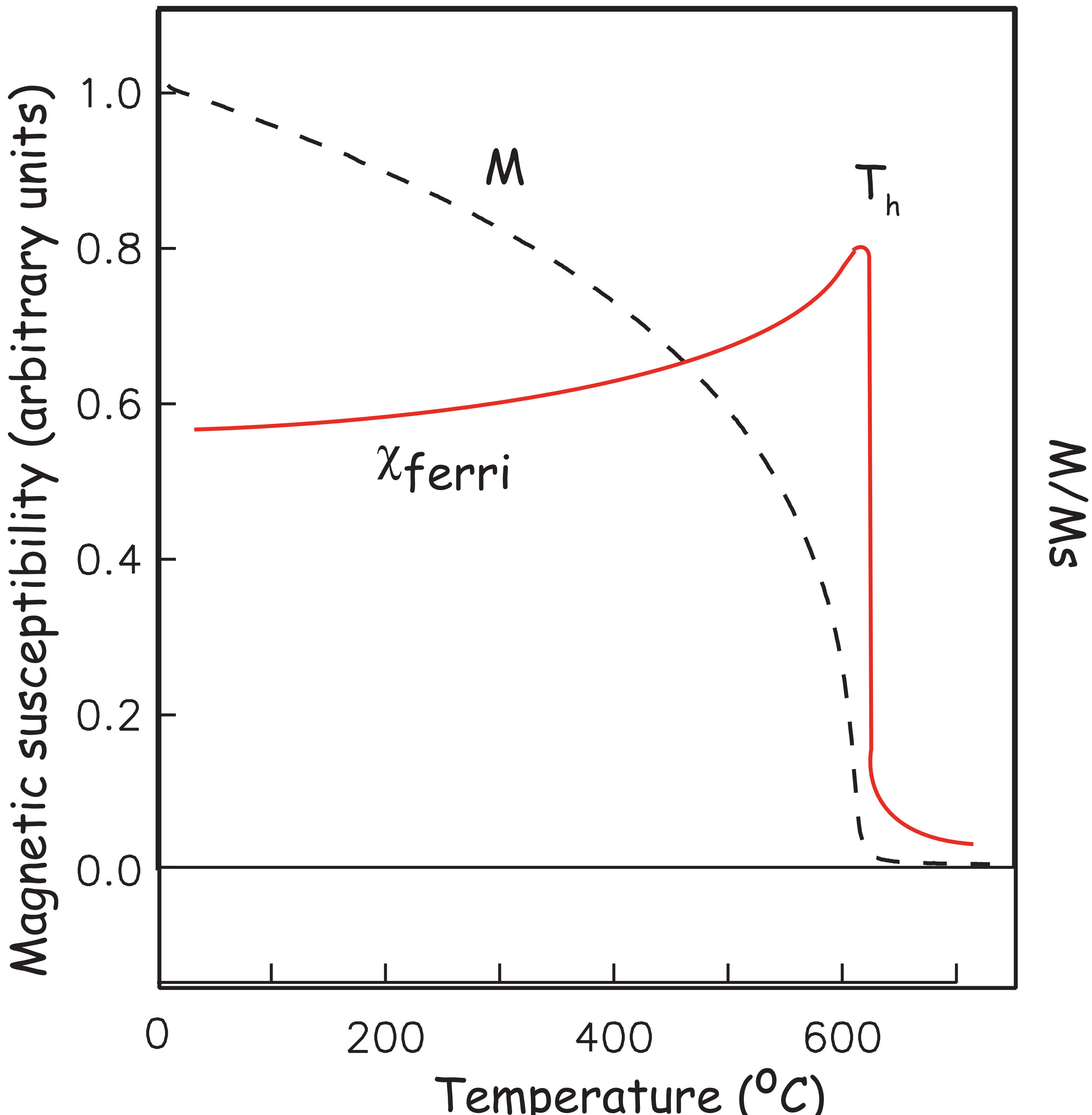
- Measurement
- Directional dependence (anisotropy - see Chapter 13)
- Temperature dependence
- Frequency Dependence

Magnetic susceptibility



Temperature dependence

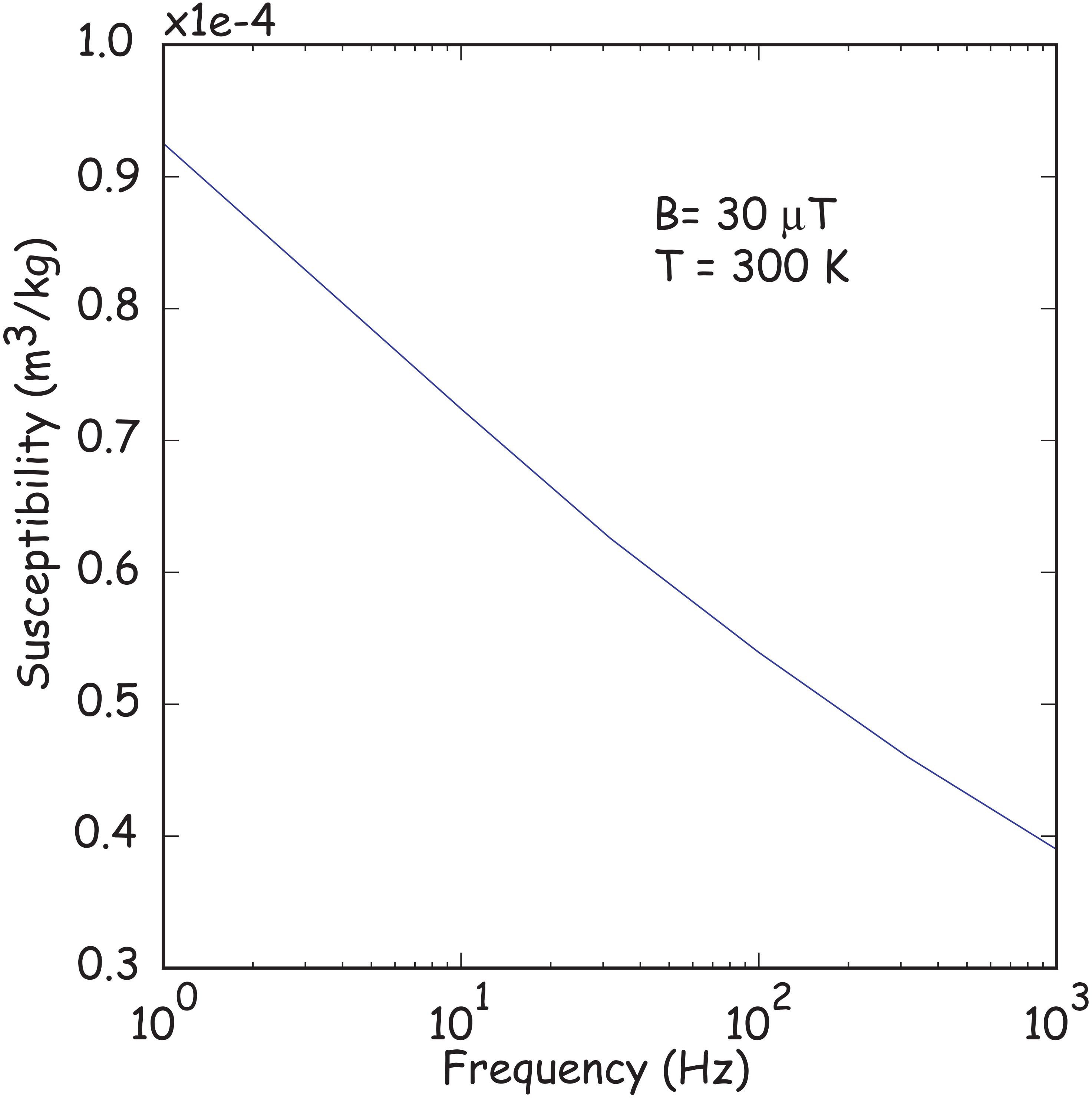
- Diamagnetic (none)
- Paramagetic (1/T)
- ferromagnetic (depends on domain state (SP/SD/MD)
- Biggest effect is change from SD=>SP (jumps by factor of 27) known as Hopkinson effect

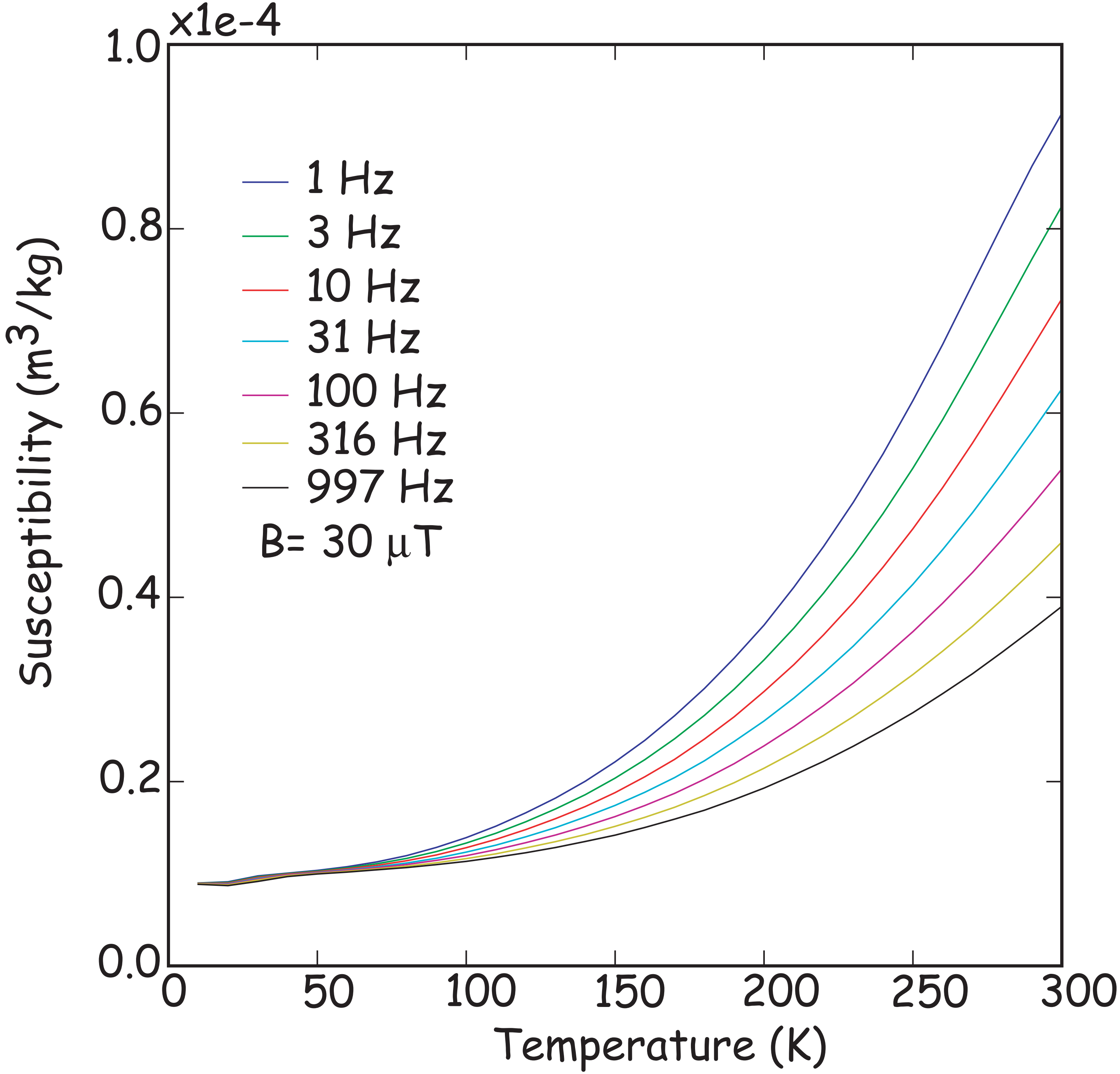


Magnetic susceptibility (arbitrary units)
1.0
0.8
0.6
0.4
0.2
0.0
M
T_h
χ_{ferri}
M/Ms
0
200
400
600
Temperature (°C)

Frequency dependence

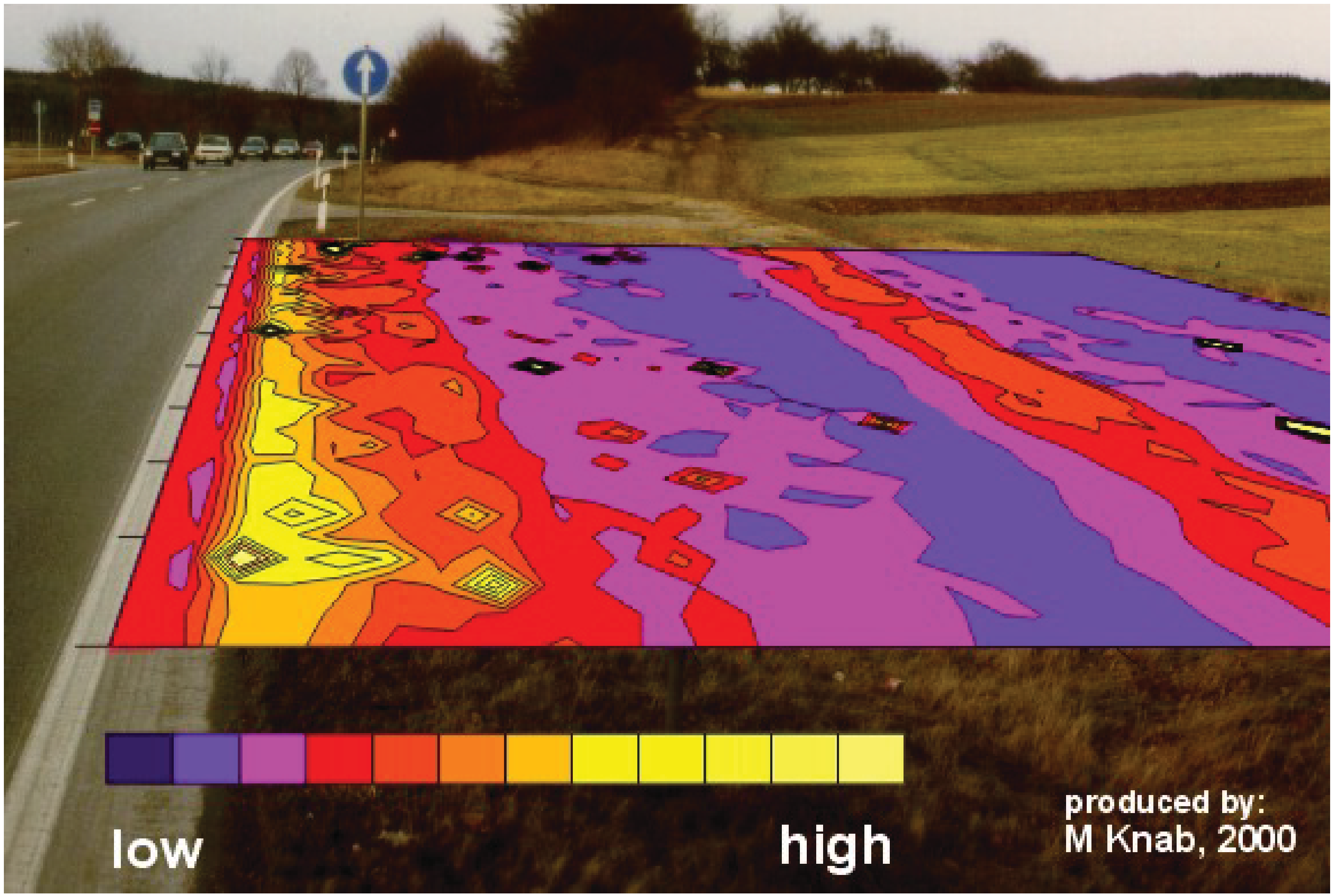
- Because the definition of SP depends on time scale, can go from SD to SP by lengthening time span of observation.
- Measure susceptibility fast, could behave as stable (low susceptibility)
- Measure same specimen slow, could behave as SP (high susceptibility)


x1e-4
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
Susceptibility (m3/kg)
B= 30 μT
T = 300 K
10^0
10^1
10^2
10^3
Frequency (Hz)



x1e-4
1.0
0.8
0.6
0.4
0.2
0.0
0
50
100
150
200
250
300
Susceptibility (m3/kg)
Temperature (K)
1 Hz
3 Hz
10 Hz
31 Hz
100 Hz
316 Hz
997 Hz
B= 30 μT

outcrop measurement of susceptibility



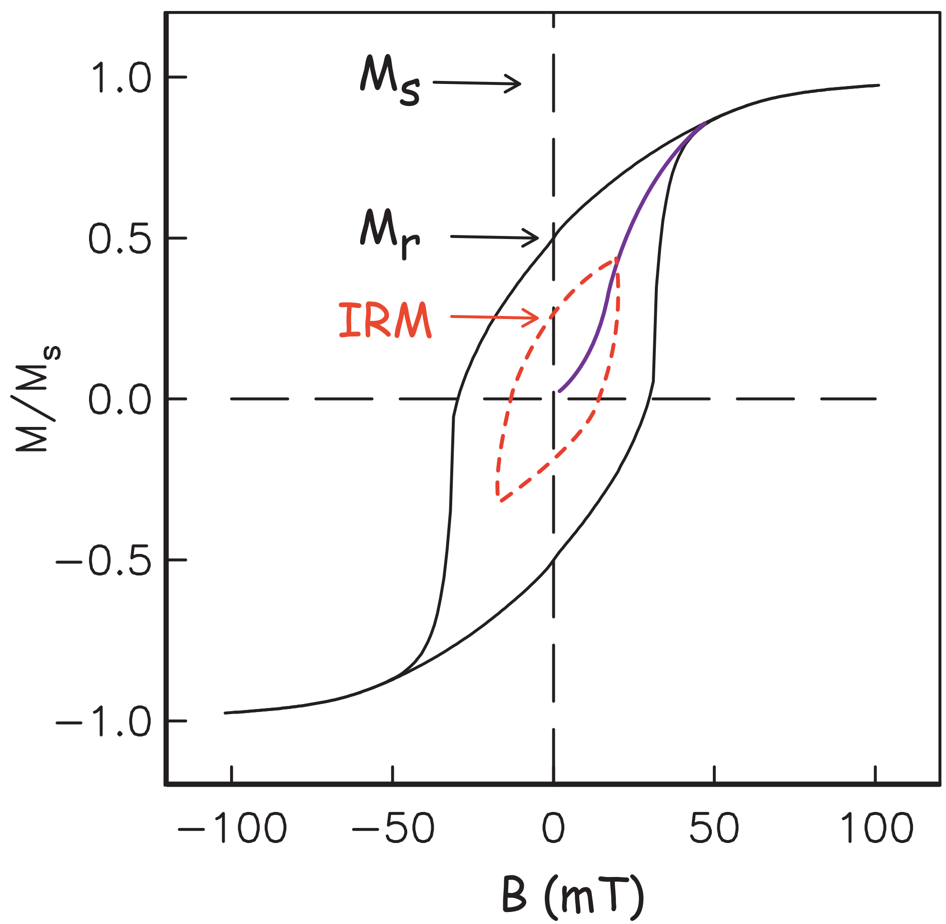
Magnetic remanences

- Isothermal remanence (IRM)
- Anhysteretic remanence (ARM)
- Gyromagnetic remancence (GRM)

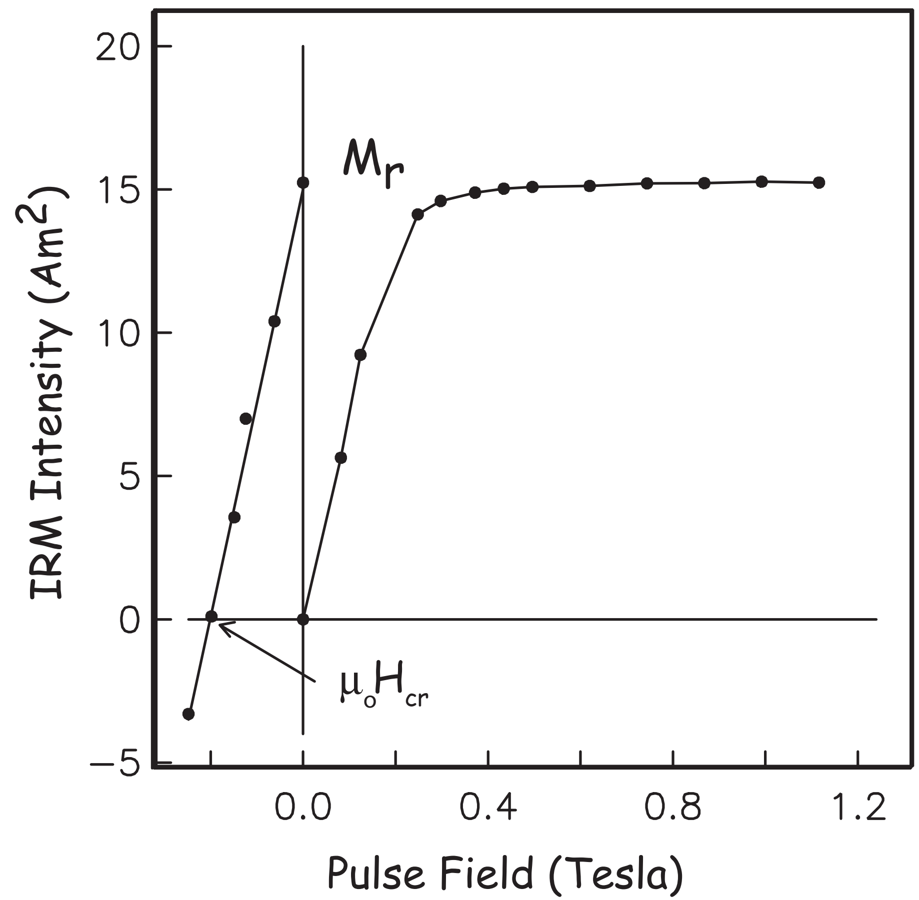
The joys of IRM

- Acquisition
- Destruction
    - DC fields
    - AC fields
    - thermal demagnetization

Review of two ways to give IRMs

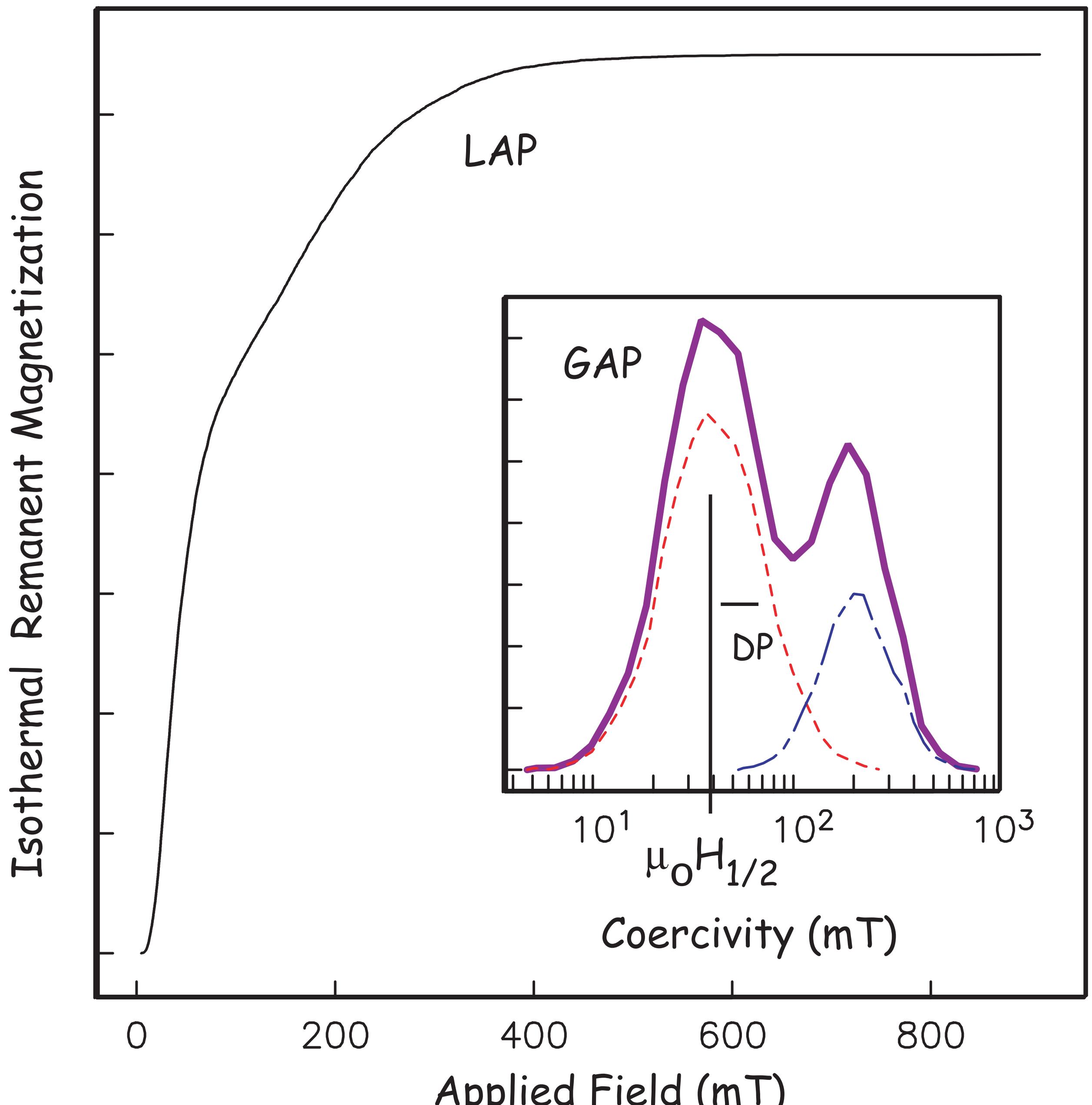


Chapter 5

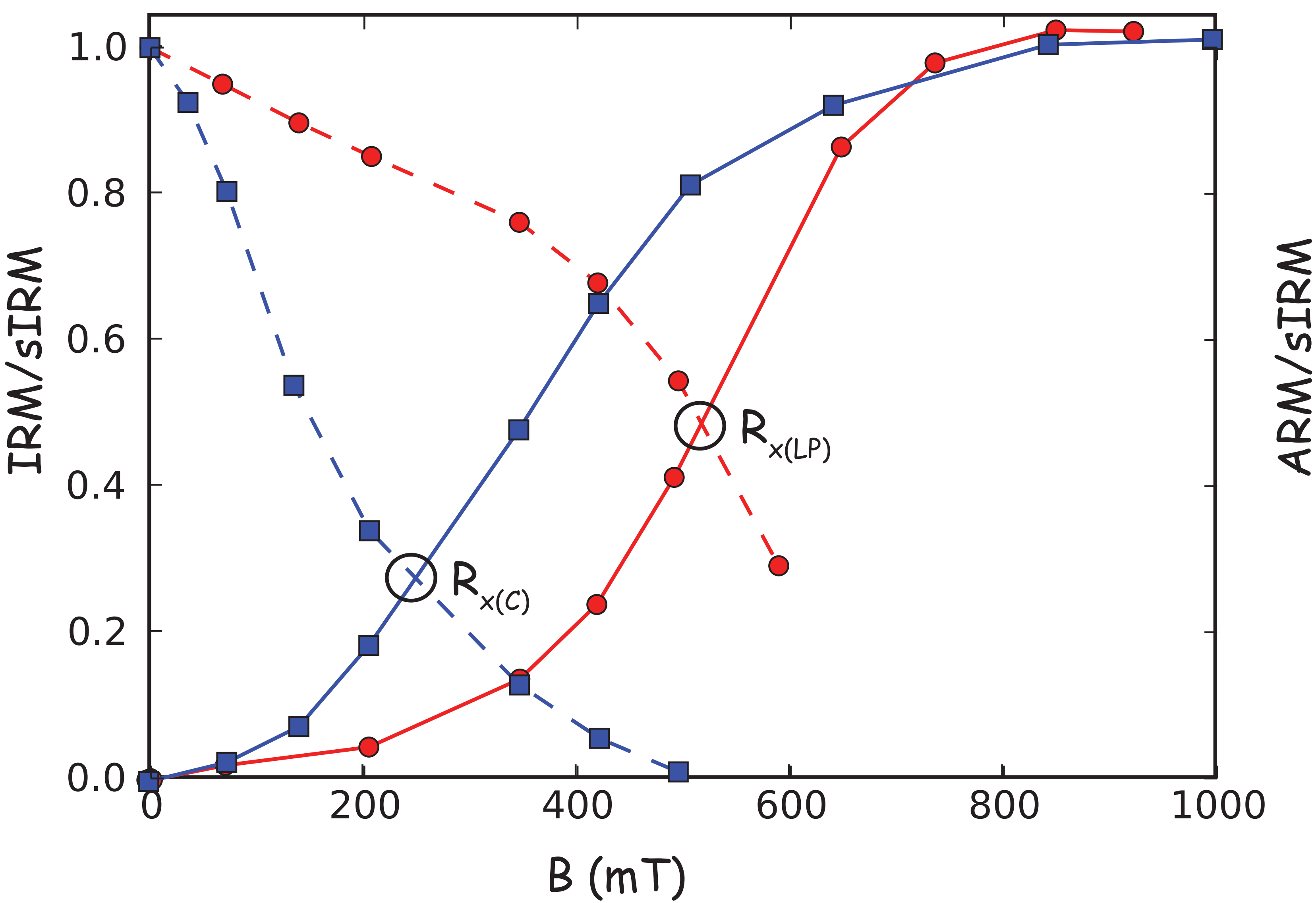


Chapter 7

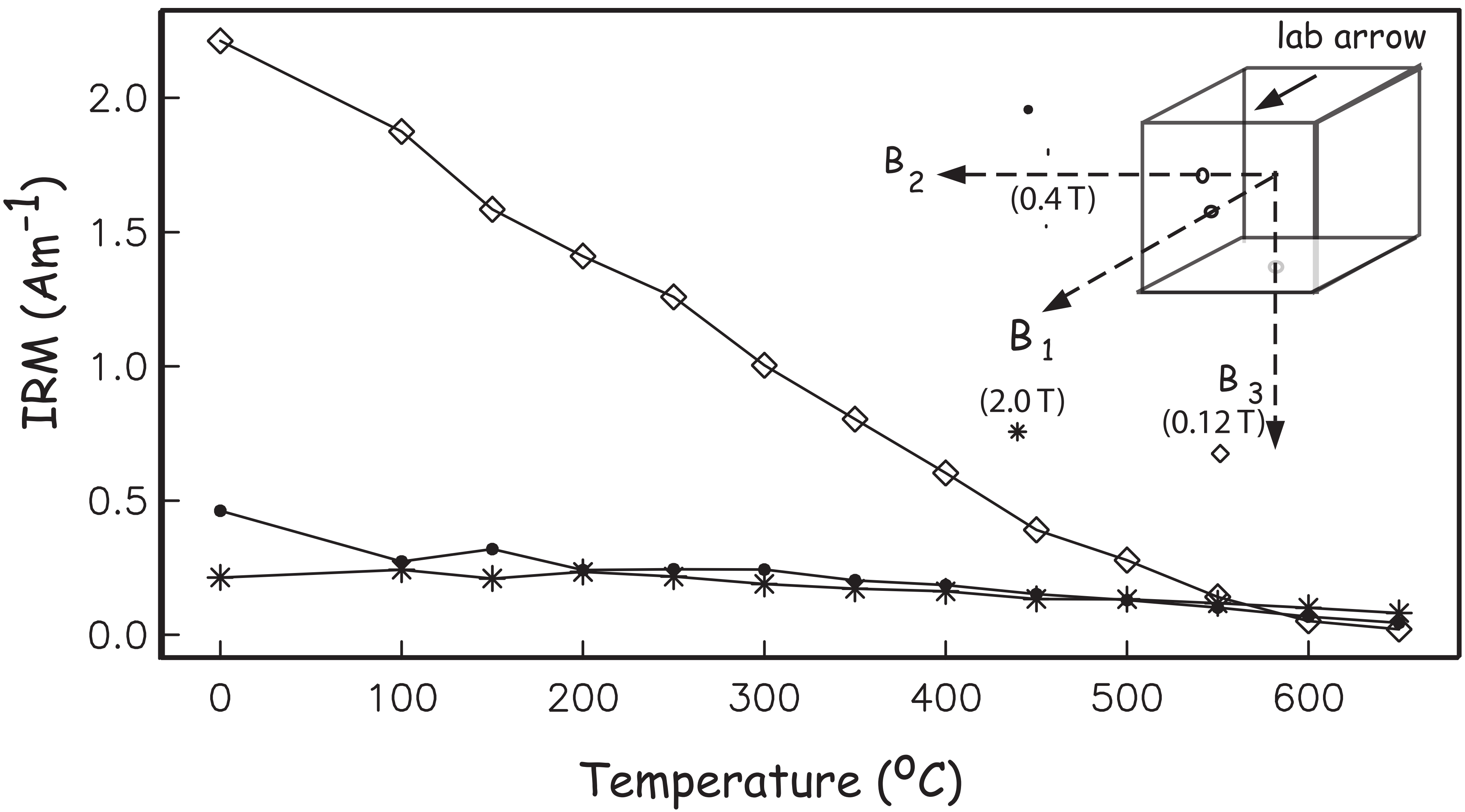
Neat application



crossover: non-interacting SD versus interacting (MD)

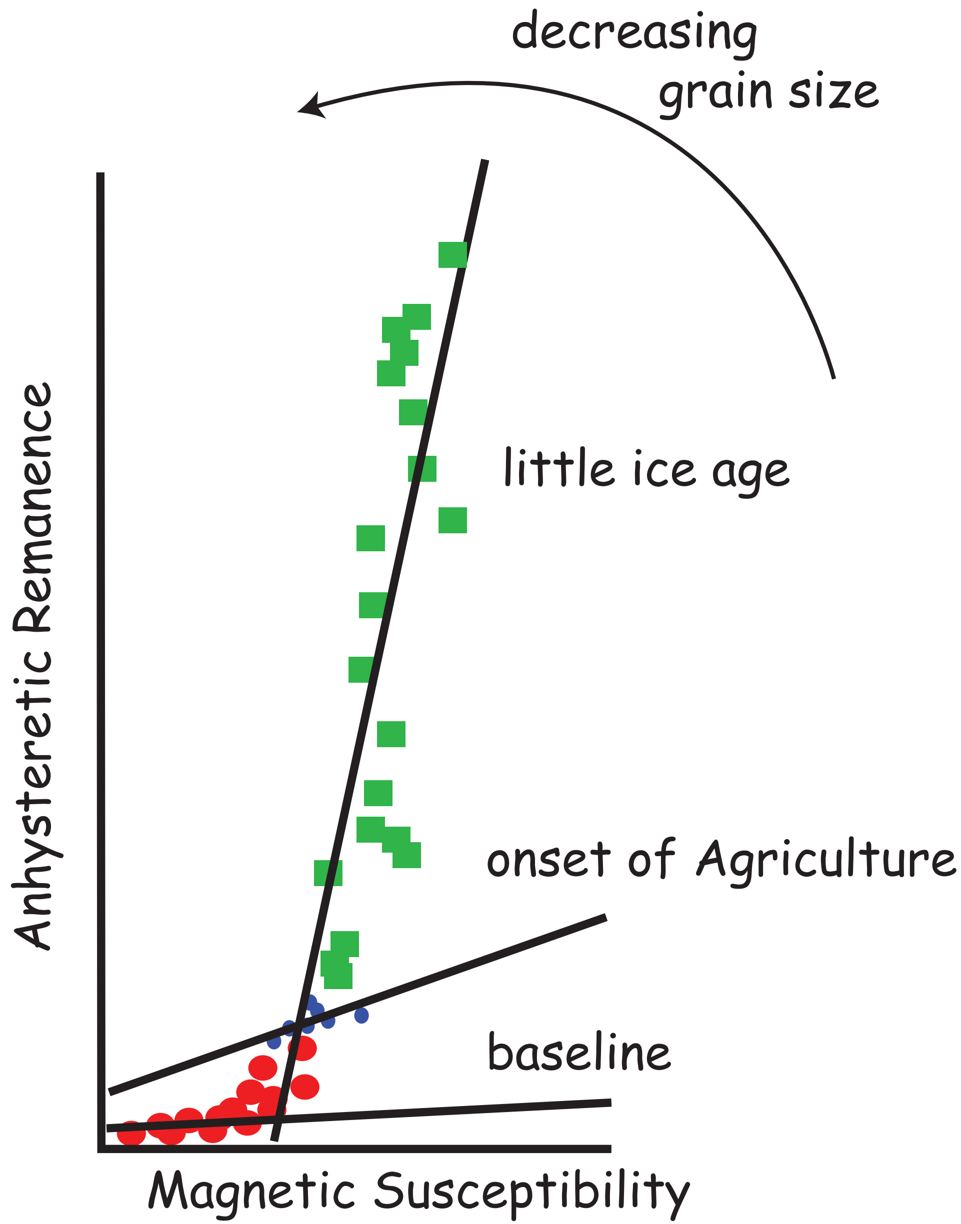


3D IRM technique

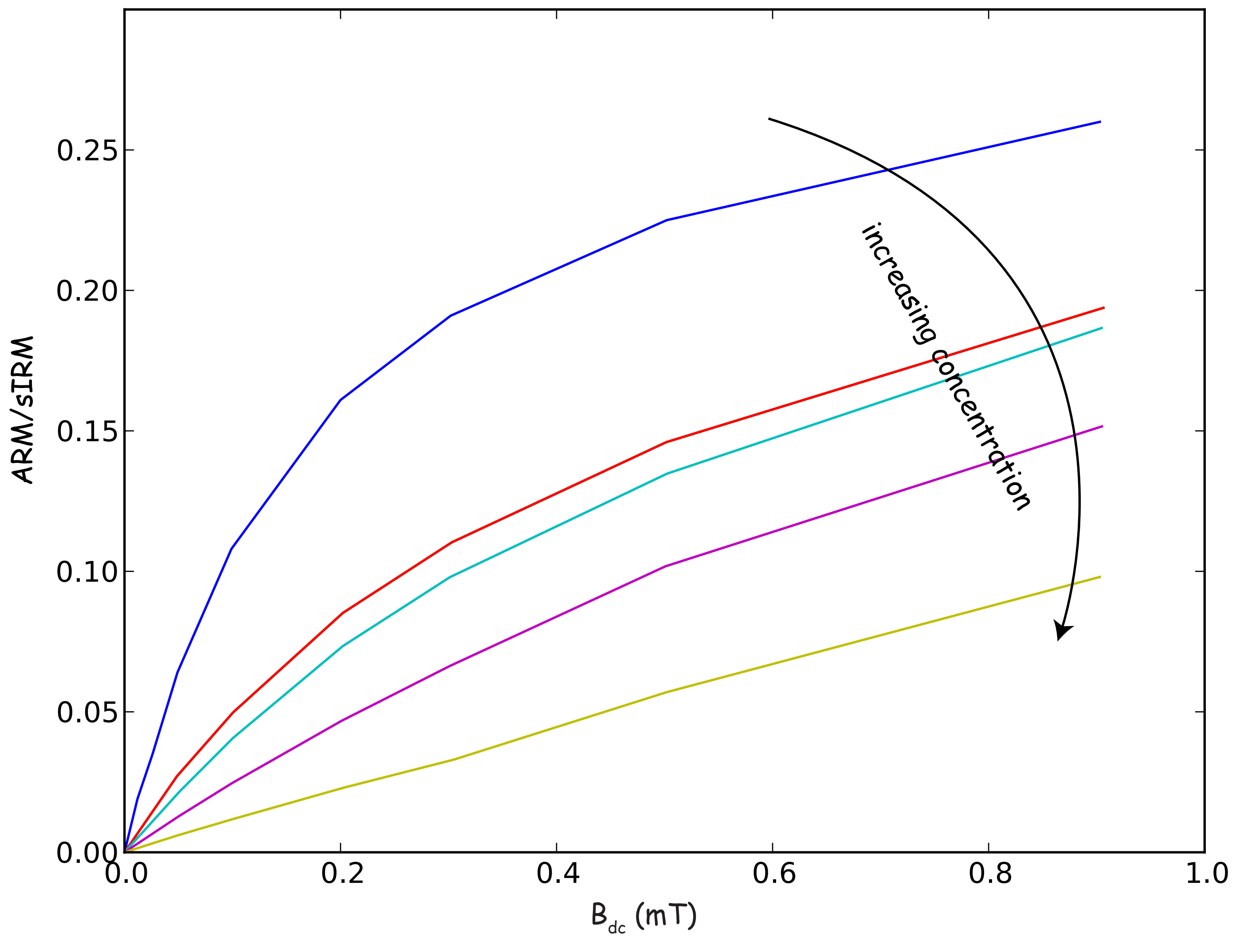


ARM – what’s it good for

- Strong function of grain size
- Strong function of concentration (particle interaction)



Banerjee et al., 1981


0.25
0.20
0.15
0.10
0.05
0.00
0.0
0.2
0.4
0.6
0.8
1.0
ARM/sIRM
B_{dc} (mT)
increasing concentration

Ratios (and differences)

- Mr/Ms versus Hcr/Hc (Day plot)
- ARM versus magnetic susceptibility (Banerjee plot)
- see Table 8.2 in the book for more....

Lots more applications in Chapter 8

See also review by Liu et al., Environmental magnetism: Principles and Applications, Reviews of Geophysics, 50, doi: 10.1029/2012RG000393, 2012.

Assignment

- Problems 8.1 and 8.3 in Chapter 8 of Essentials of Paleomagnetism