A new furnace design to improve the thermal demagnetization in paleomagnetism

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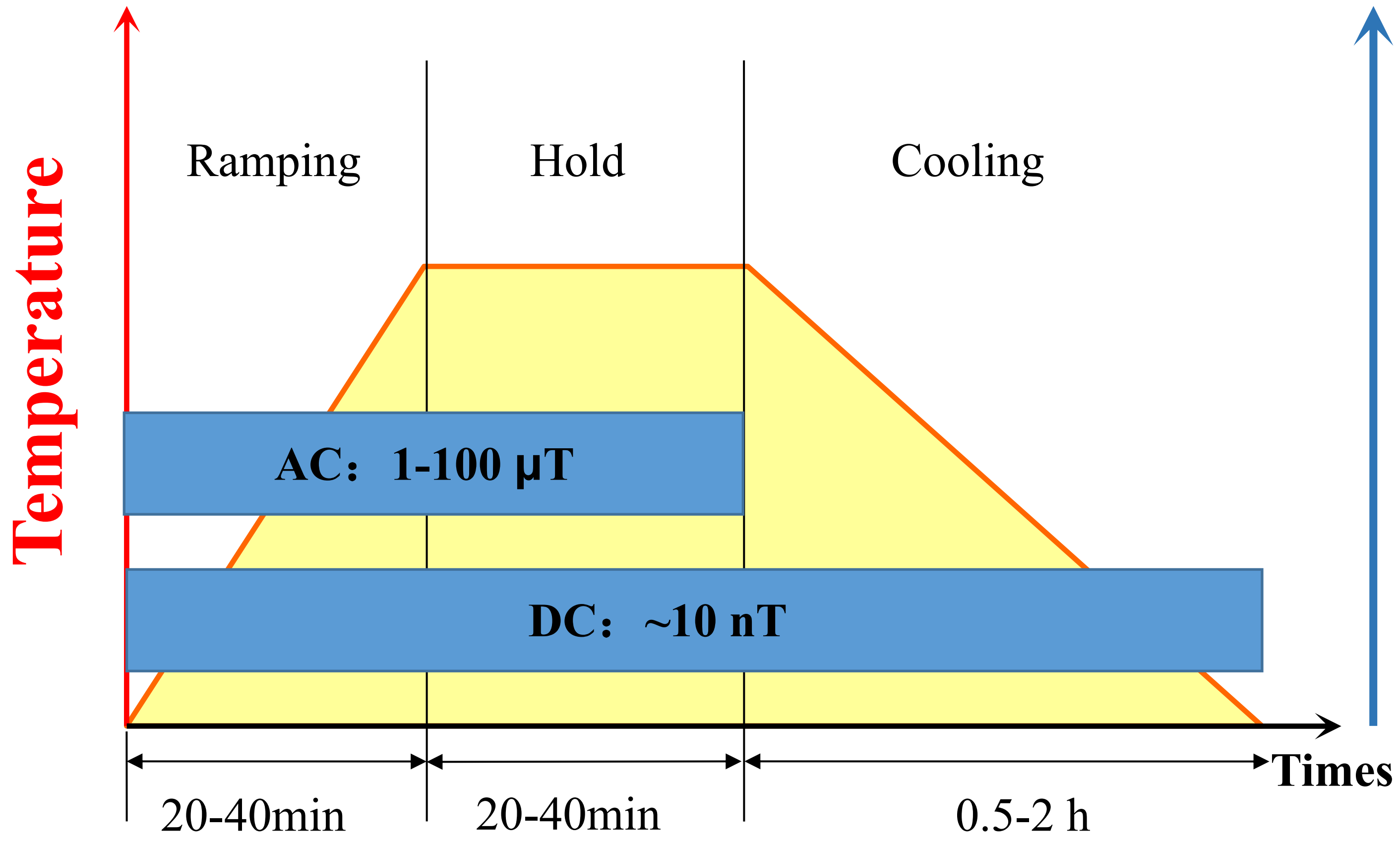
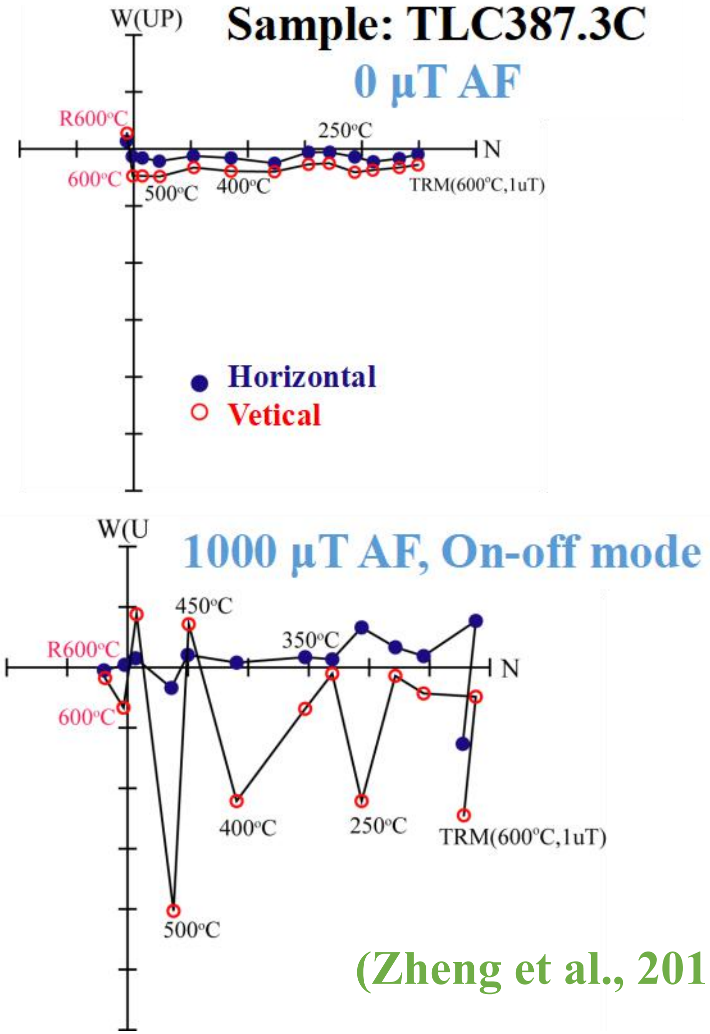
Imperfect thermal demagnetization

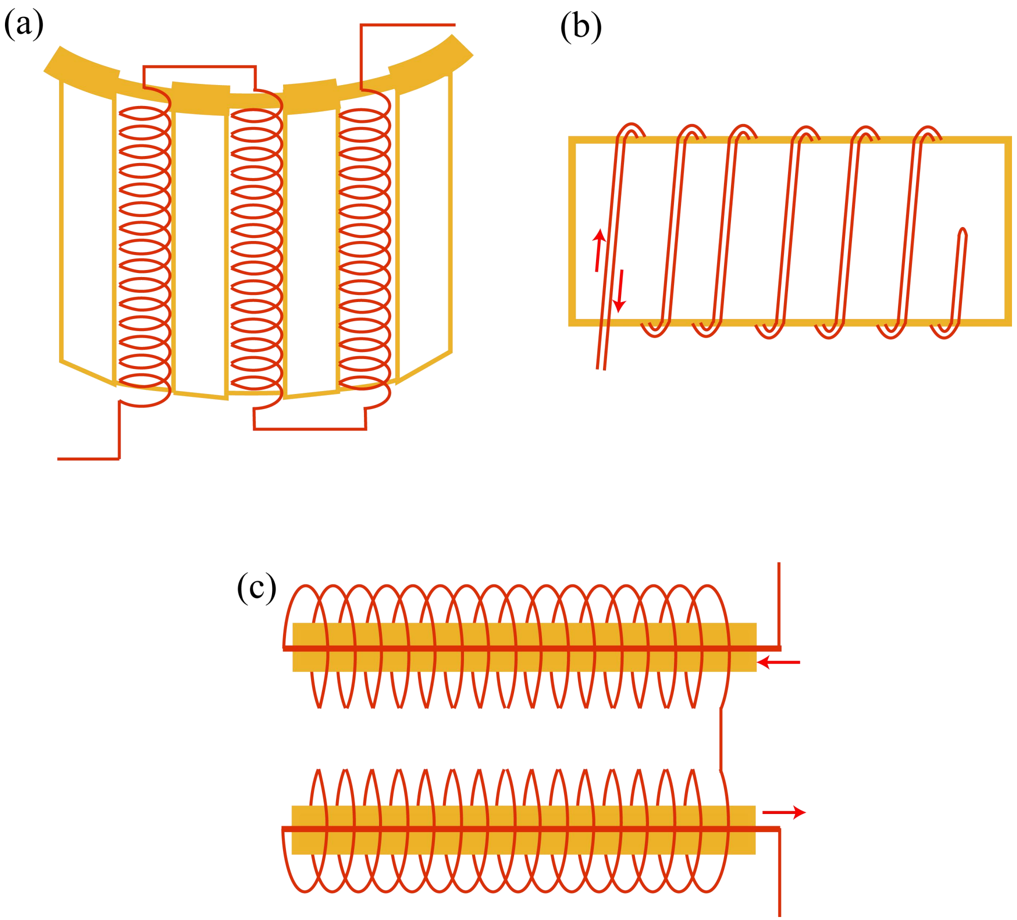


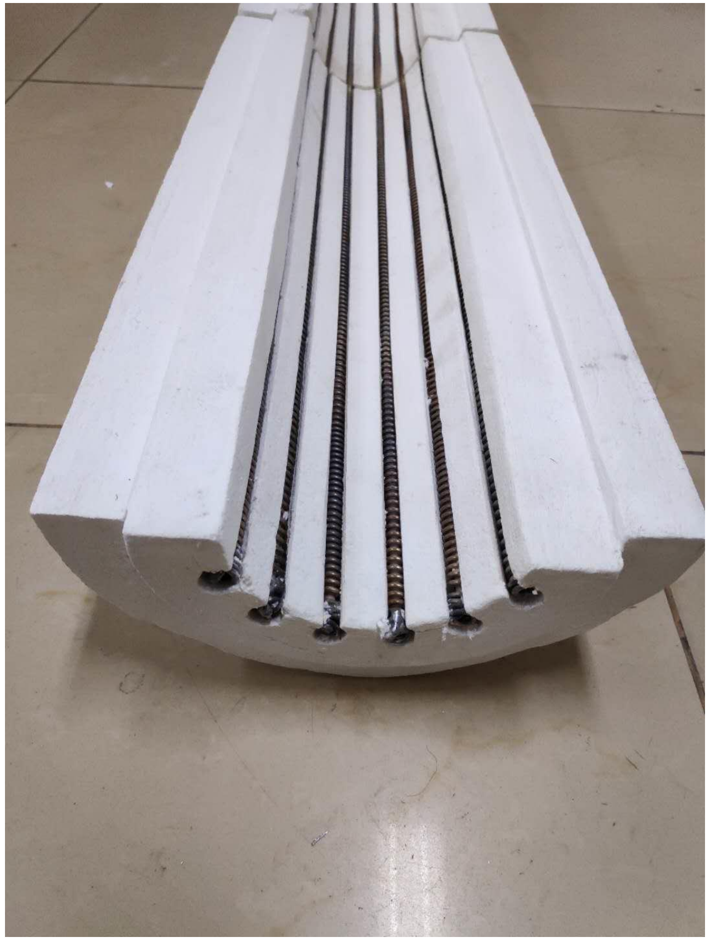


(Zheng et al., 2010)

The samples should be in **zero magnetic field** during thermal demagnetization. However, magnetic field noise, including residual magnetic fields of material and induced fields caused by the heating current in the furnace are always present.

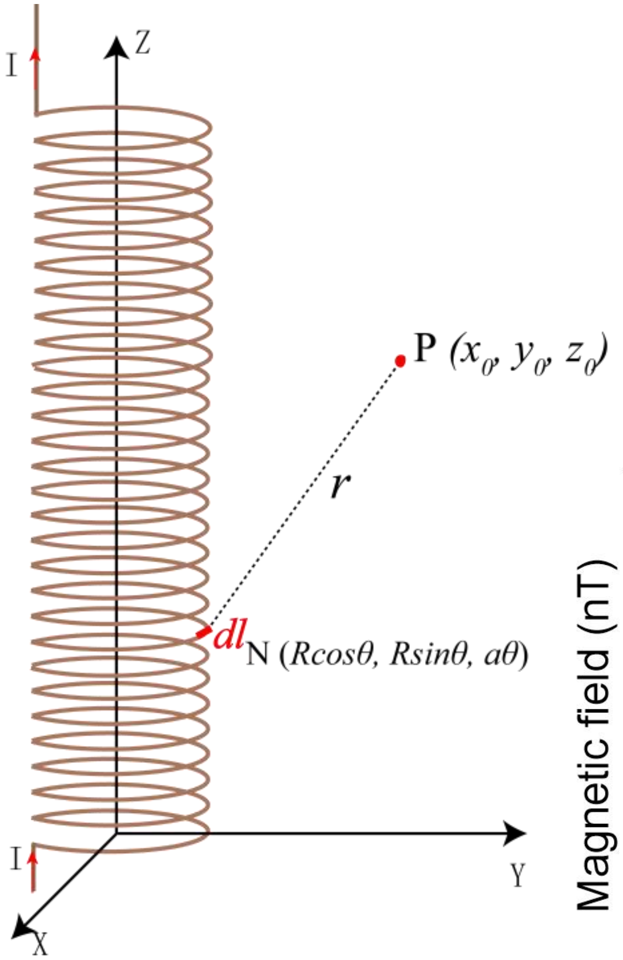
Configuration of non-inductive heating wires





solenoids arranged in opposite direction (a), a bifilar solenoid wrapped (b) and new heating element made by solenoid and connected with a straight wire in series at one end for new developed demagnetizing furnace (c).

Simulation of solenoid magnetic field



Solenoid:

$$dB_x = \frac{\mu_0 I}{4\pi}\frac{\left[(z_0 - a\theta)R\cos\theta - (y_0 - R\sin\theta)a\right]d\theta}{\left[(x_0 - R\cos\theta)^2 + (y_0 - R\sin\theta)^2 + (z_0 - a\theta)^2\right]^{3/2}}$$

$$dB_y = \frac{\mu_0 I}{4\pi}\frac{\left[(z_0 - a\theta)R\sin\theta + (x_0 - R\cos\theta)a\right]d\theta}{\left[(x_0 - R\cos\theta)^2 + (y_0 - R\sin\theta)^2 + (z_0 - a\theta)^2\right]^{3/2}}$$

$$dB_z = -\frac{\mu_0 I}{4\pi}\frac{\left[(y_0 - R\sin\theta)R\sin\theta + (x_0 - R\cos\theta)R\cos\theta\right]d\theta}{\left[(x_0 - R\cos\theta)^2 + (y_0 - R\sin\theta)^2 + (z_0 - a\theta)^2\right]^{3/2}}$$

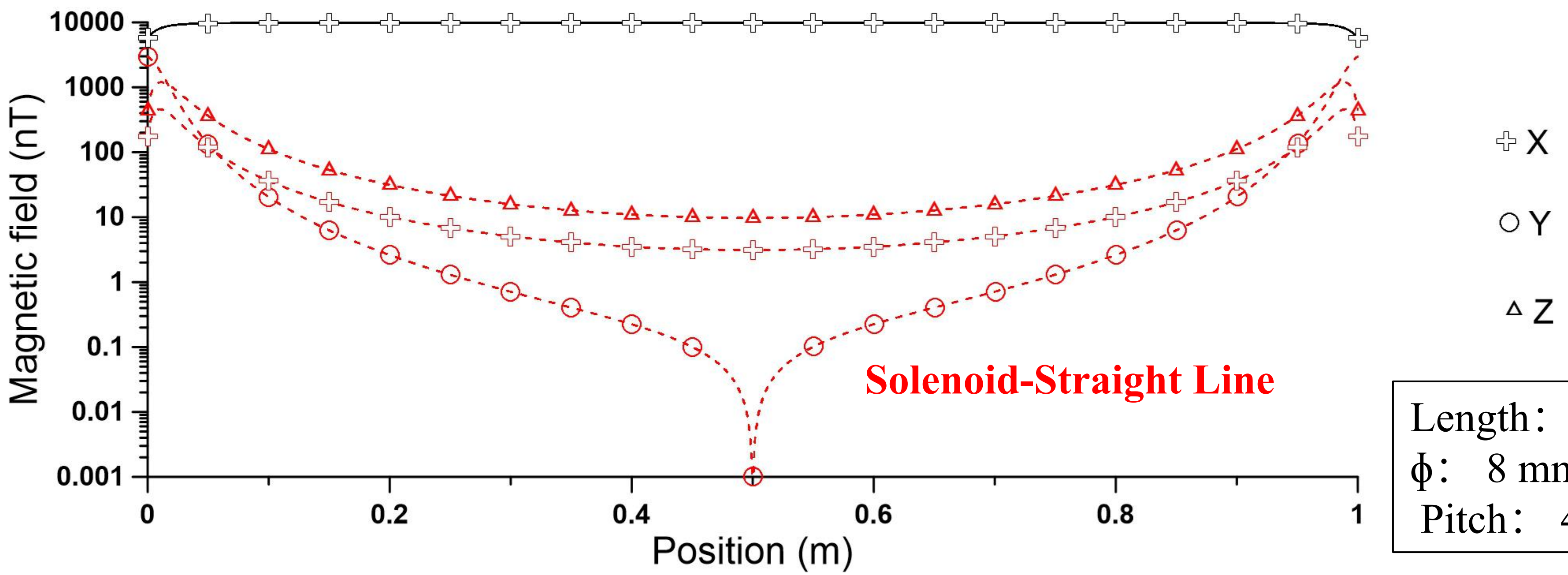
$-$

Straight Line:

$$dB_x = -\frac{\mu_0 I}{4\pi}\frac{y_0 a\, d\theta}{\left[x_0^2 + y_0^2 + (z_0 - a\theta)^2\right]^{3/2}}$$

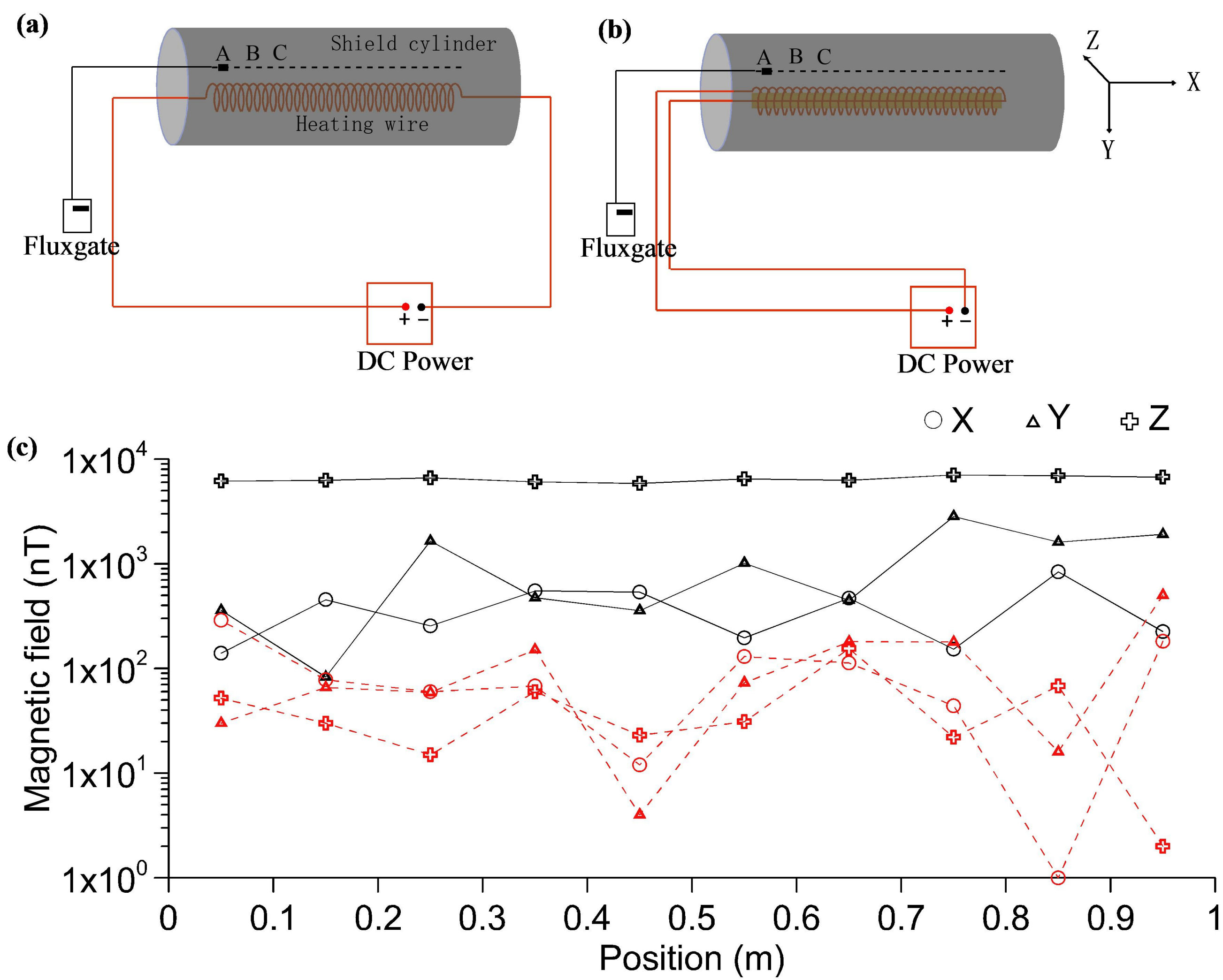
$$dB_y = -\frac{\mu_0 I}{4\pi}\frac{x_0 a\, d\theta}{\left[x_0^2 + y_0^2 + (z_0 - a\theta)^2\right]^{3/2}}$$

$$dB_z = 0$$

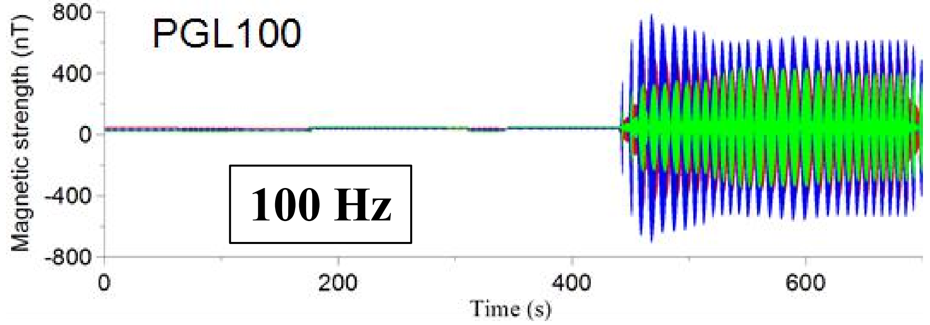


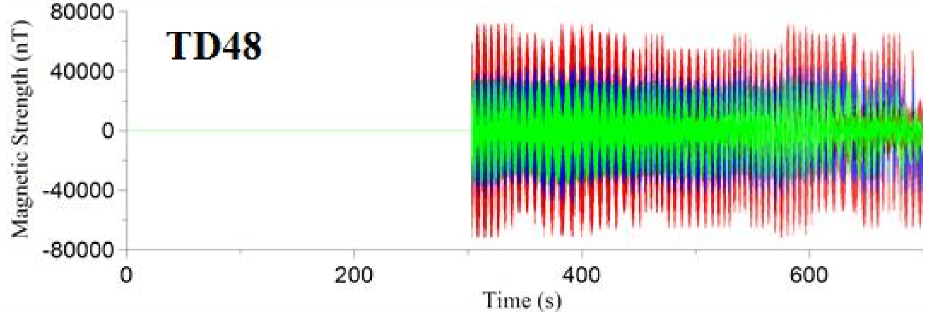
Length： 1 m
ϕ： 8 mm
Pitch： 4 mm

Magnetic field measurement

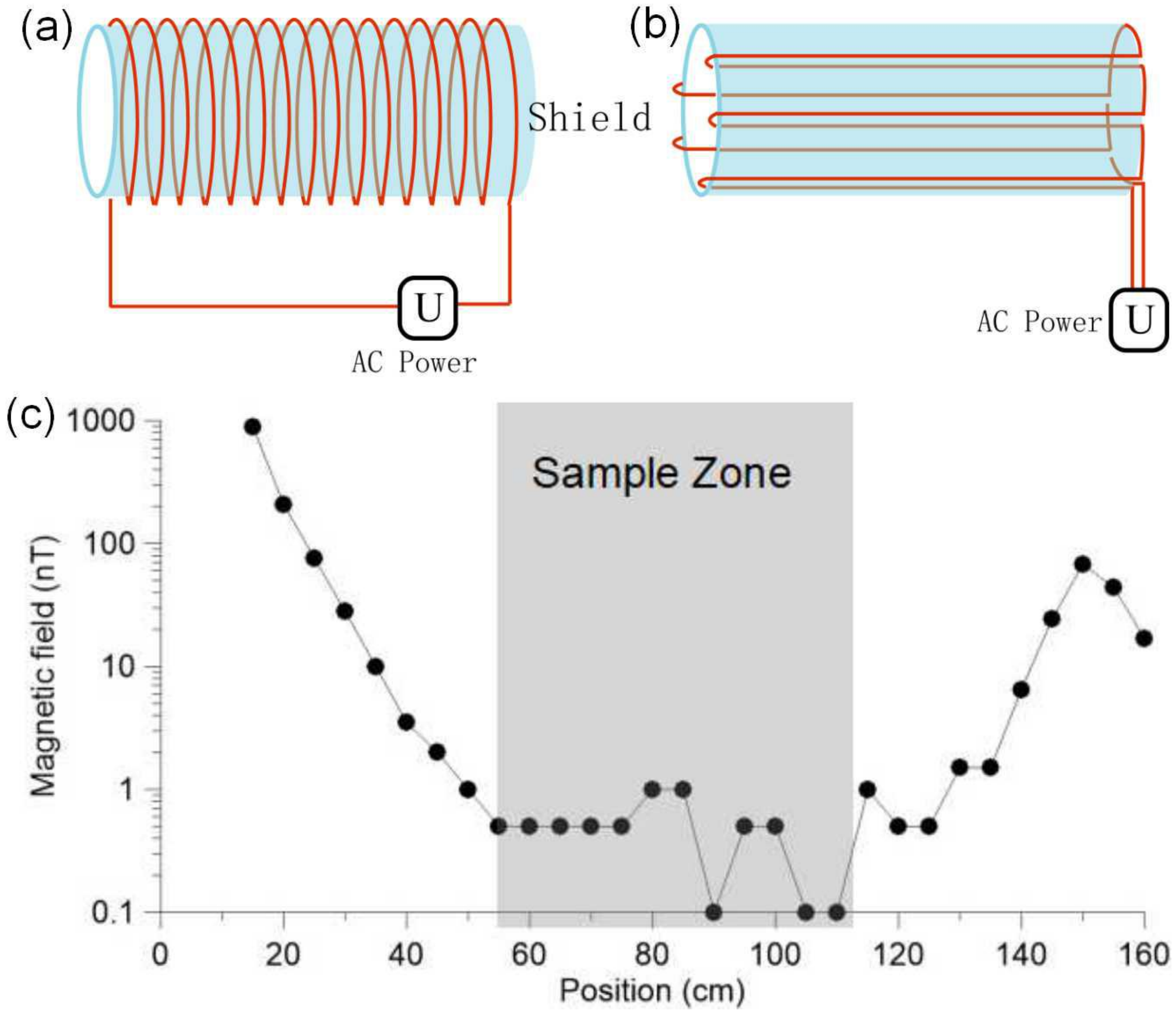


Model	Induce field （nT/A）
Sogo-fine-TD	260
ASC-TD48	9260
MMTD80	840
TD-PGL100	130



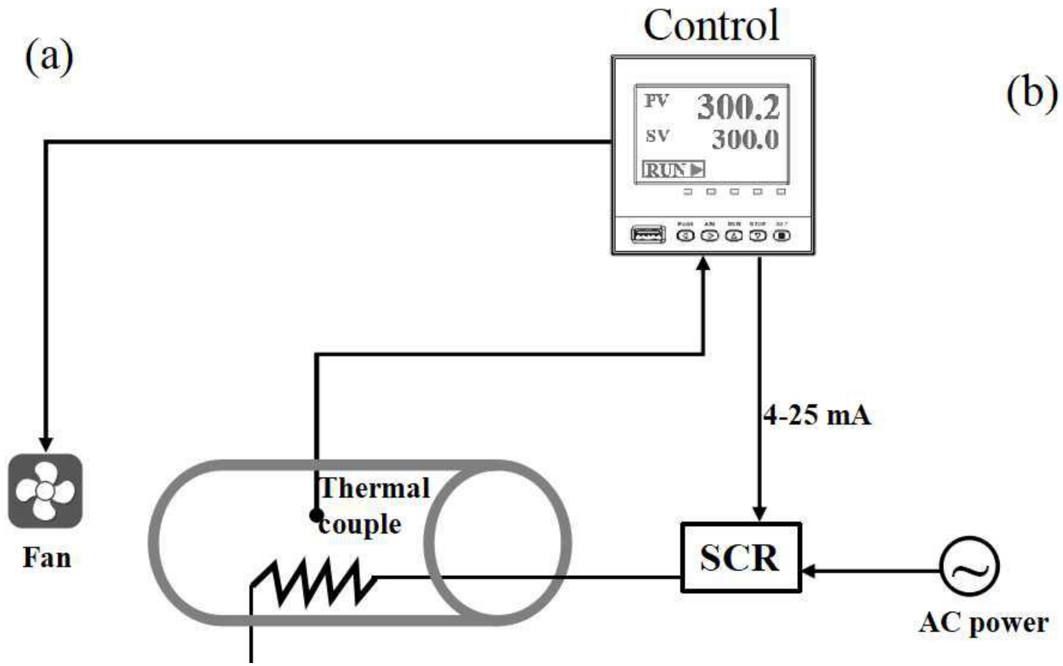


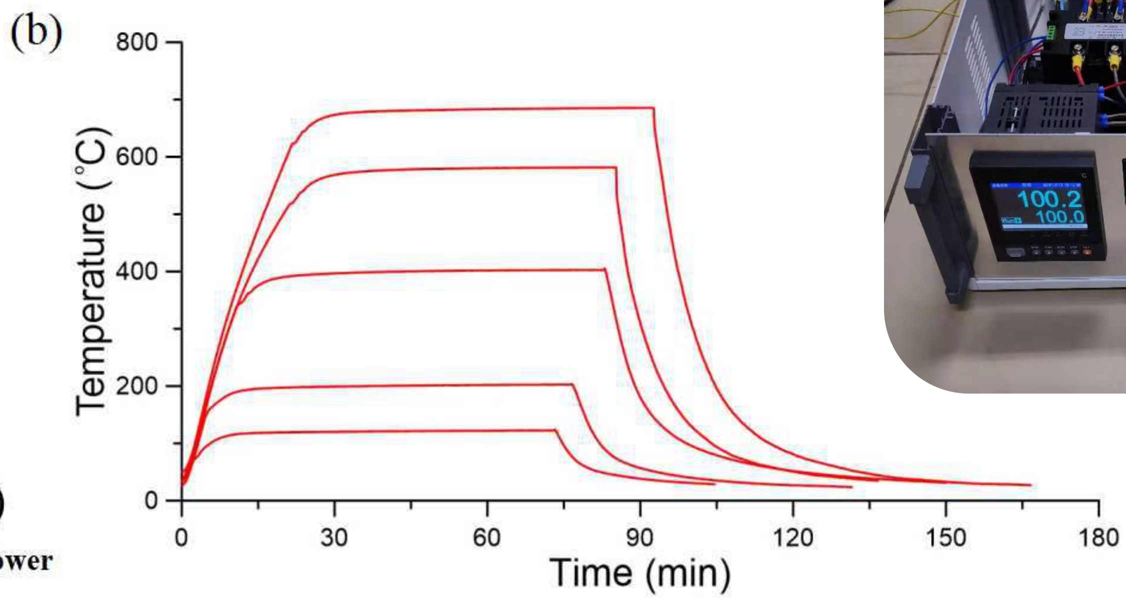
Degaussing the shield cylinder

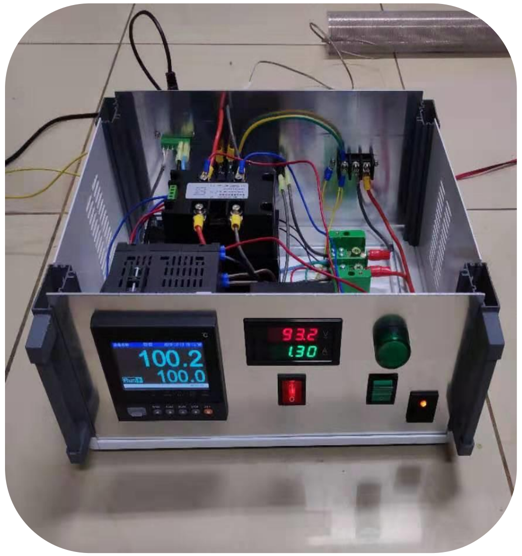


A solenoidal (a) and toroidal (b) degaussing coil embody the shield cylinder, and residual field in in shielding cylinder after demagnetization (c) with winding method according to figure (b). After demagnetization with this procedure, the residual magnetic field in the sample region can be less than 1 nT .

Temperature control

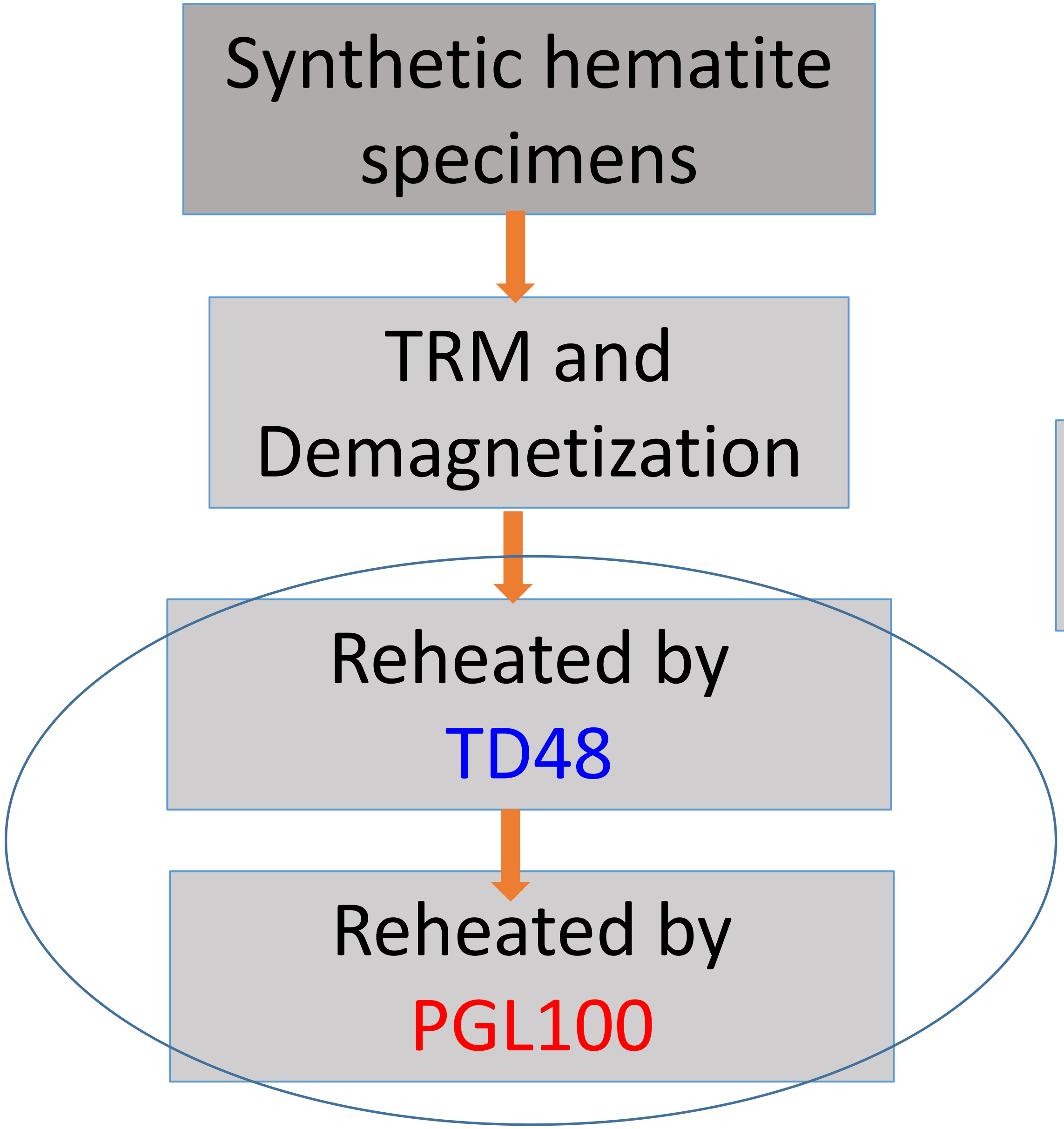


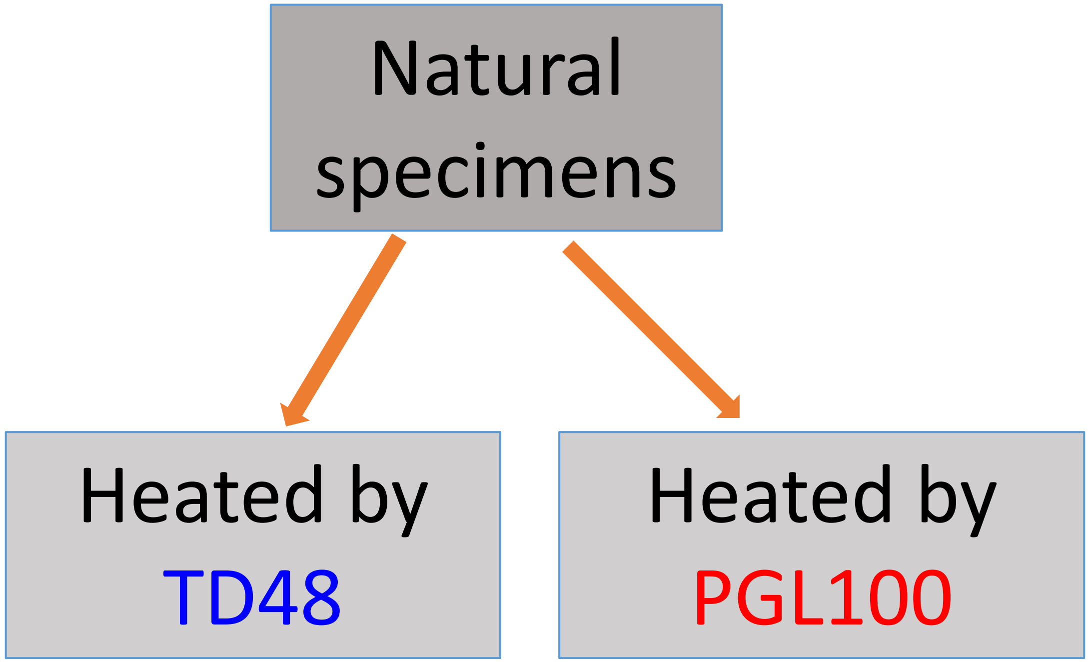




The heating current can be adjusted by Single-phase Voltage Module, which can reduce the current when approaching the target temperature. Its advantage is to ensure temperature stability and reduce the induced magnetic field. The temperature of heating process can be recorded in USB memory.

Experimental Method





the remanent magnetization of completely demagnetized specimens would remain unchanged during re-demagnatization

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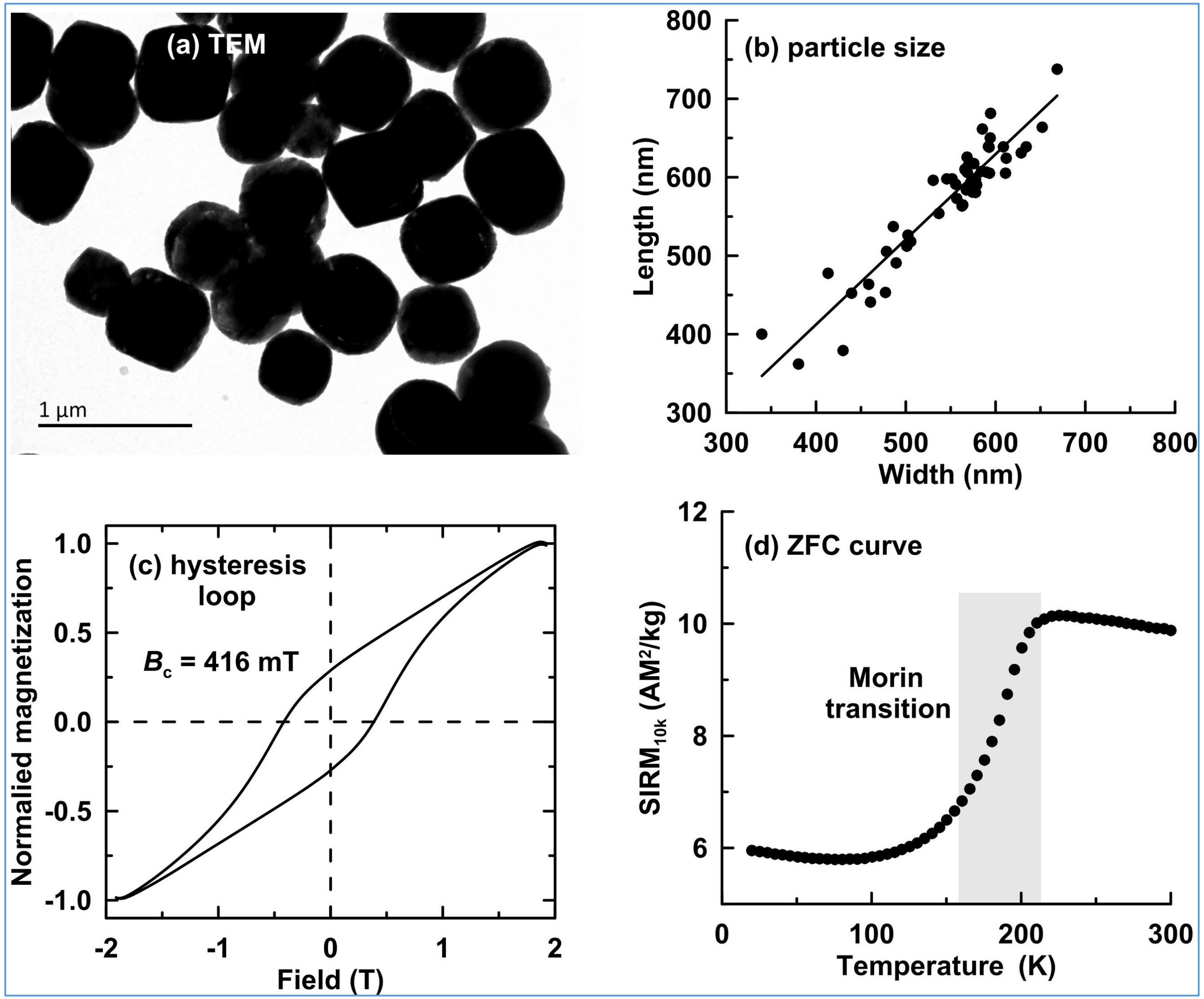
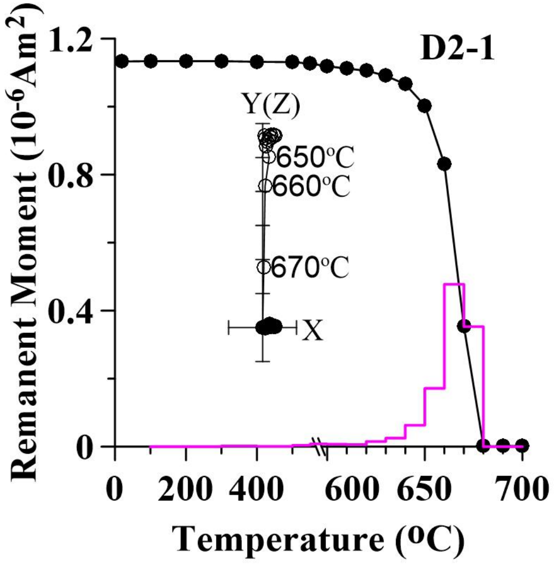
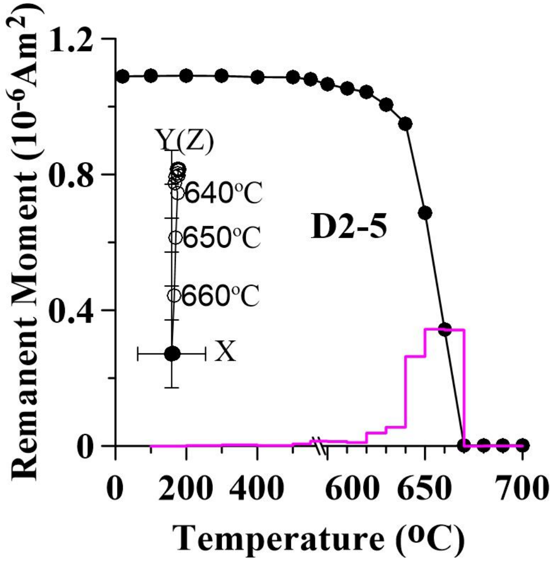
Specimen and Demagnetization of TRM

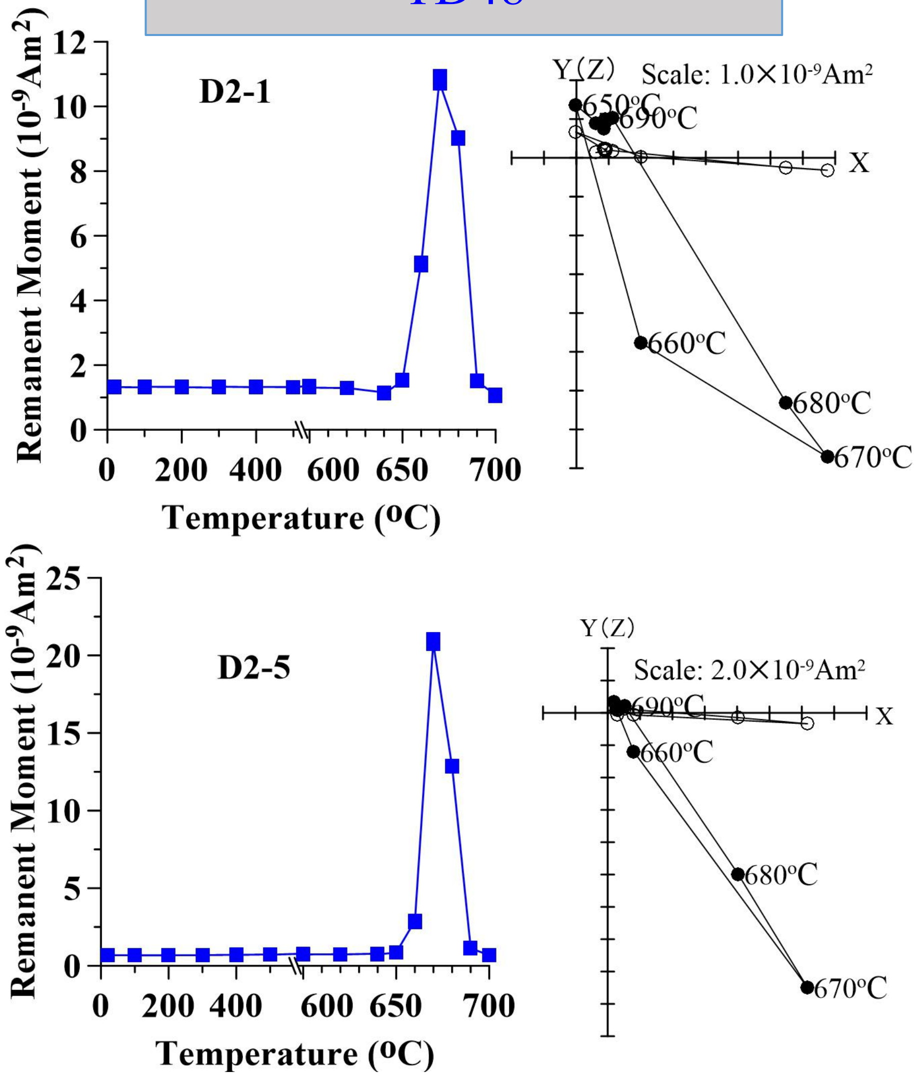




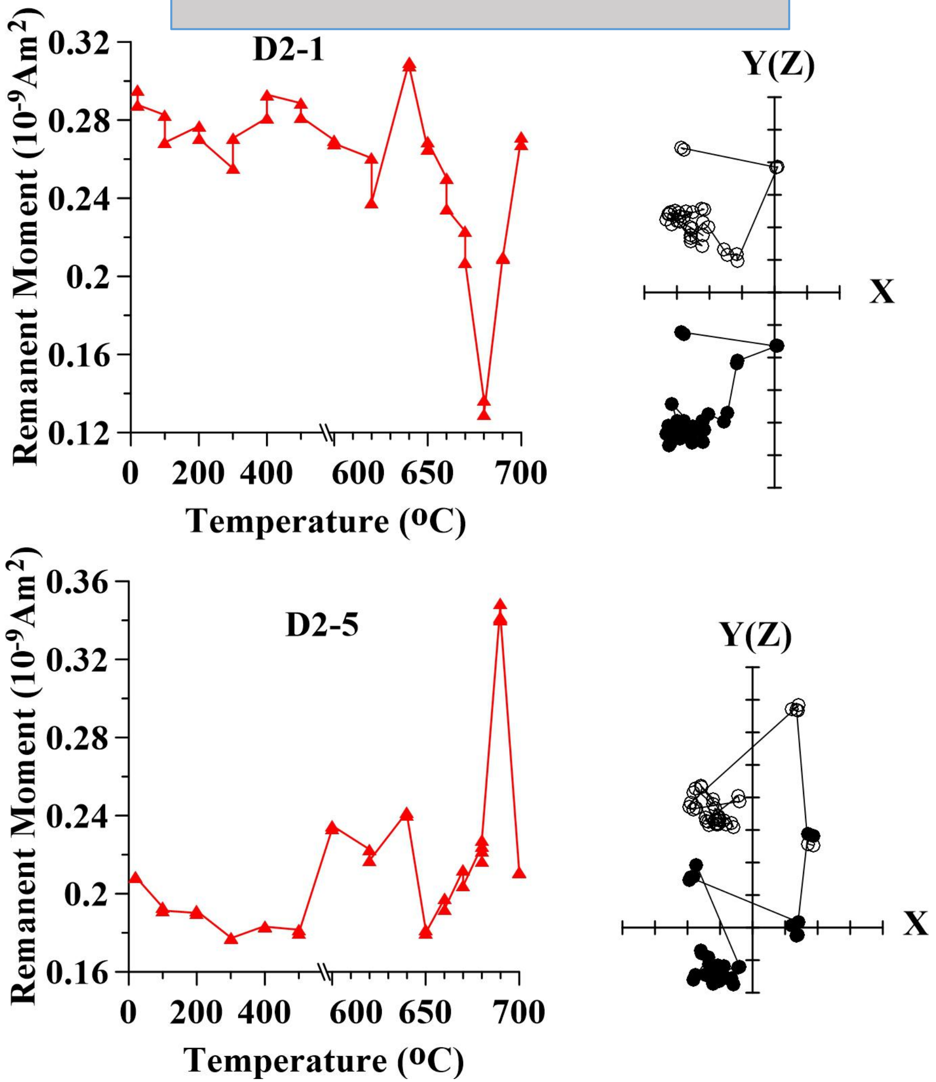


Re-demagnetization of Synthetic specimens

TD48

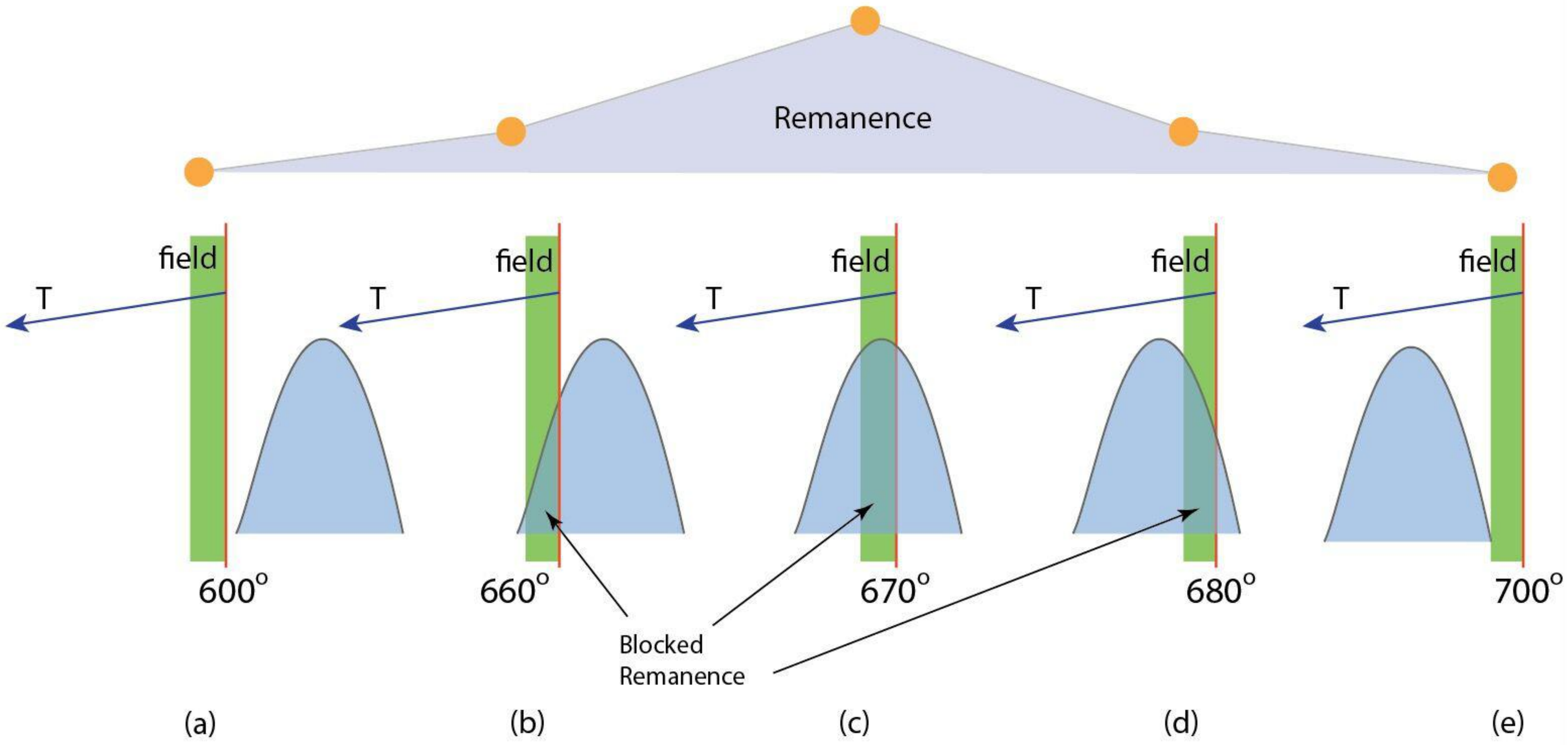


PGL100

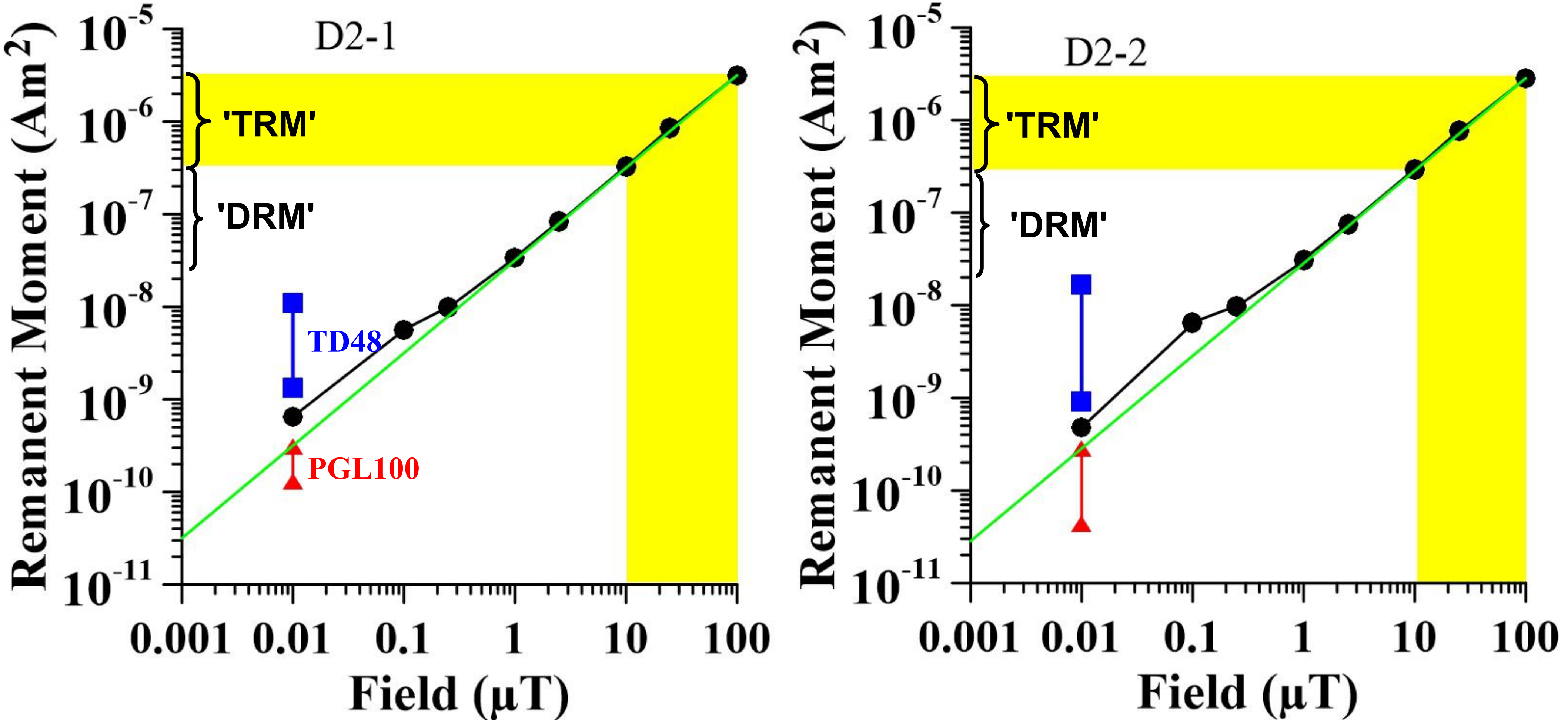


It proved that the extra undesirable remanence acquired during the thermal re-demagnetization process

Reason for obtaining remanence

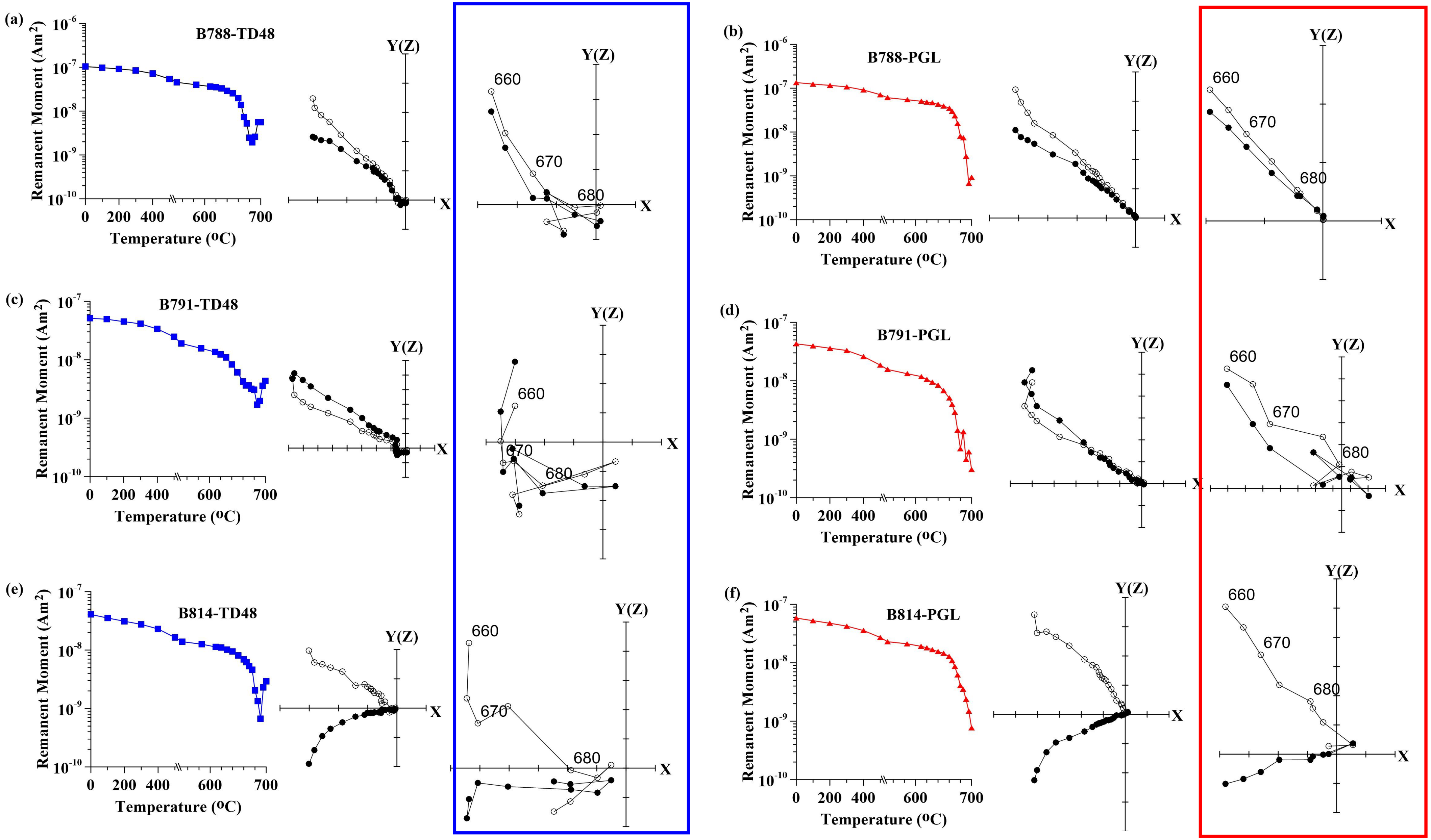


Nosie Remanece Vs NRM ('TRM', 'DRM')



Suppose that detrital remanence (DRM) is typically an order of magnitude weaker than TRM, nosie fields in furnace may have a large impact on thermal demagnetization data obtained from sedimentray rocks

Thermal demagnetization of natural specimens



Conclusions

1. The new heating element design can significantly reduce magnetic field noises in thermal demagnetizer
2. The experiments confirm that magnetic field noise in various furnaces can have an observable and detrimental impact on demagnetization behavior
3. The new furnace represents an important improvement in the design of thermal demagnetizers and allows for extremely weak specimens to be successfully measured.

Acknowledgements

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