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Figure DR1. Low-Temperature susceptibility

Normalized reciprocal magnetic susceptibility (ko/k) as a function of temperature. Ideal ferromagnetic curve show no change in susceptibility with temperature, ideal paramagnetic curve is a straight line described by the Curie-Weiss law (k_{para} = C/T - θ where C = Curie constant, θ = paramagnetic Curie temperature; T = temperature in Kelvin). The near temperature independent susceptibility on warming from 77K indicates that the AMS fabrics is carried and defined by a ferromagnetic phase with no contribution by the paramagnetic silicate minerals.

Figure DR2. Hysteresis Results

Mass-normalized hysteresis loops corrected for the paramagnetic contributions.

(A) Representative hysteresis loops at ambient temperature (25°C). All samples yield steep acquisition and reach saturation by 200 mT to 300 mT applied fields.

(B) Plot of M_{rs}/M_s versus B_{cr}/B_c (after Day et al. [1977]) for discrimination between SD, MD, and PSD domain states. The MD field is extended out to 35 on the x-axis.

(C) High-temperature hysteresis experiments from 25°C (273 K) to ~ 700°C (~ 870 K) from two representative samples. The Curie point is reached when the magnetization approaches zero on further heating.

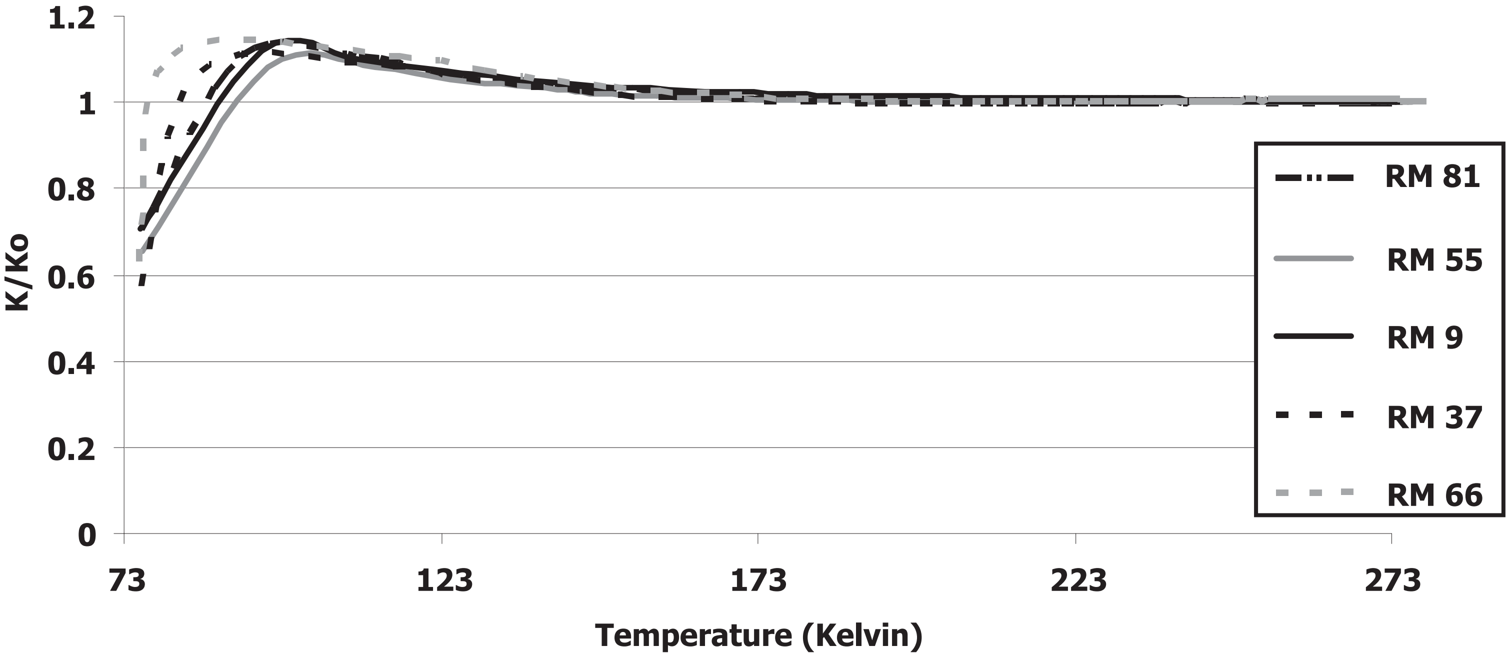
Figure DR3. Back Field IRM Results

Backfield isothermal remanent magnetization curves from representative samples. All results indicate the presence of magnetite and titanomagnetite.

Figure DR4. Anisotropy of Magnetic Susceptibility Plots

Scatter plots that compare the various susceptibility parameters. Relationship between (A) L (K1/K2) versus F (K2/K3) i.e., Flinn Plot, (B) the degree of magnetic anisotropy, Pj, and bulk susceptibility, Kmean, and (C) shape of the susceptibility ellipsoid, T and bulk susceptibility, Kmean. Black diamonds are sites from the RM1 granite phase and grey squares are from the sites in the RM2 granite phase.

Fig. DR1



1.2
1
0.8
0.6
0.4
0.2
0
K/Ko
73
123
173
223
273
Temperature (Kelvin)
RM 81
RM 55
RM 9
RM 37
RM 66

Fig. DR2A

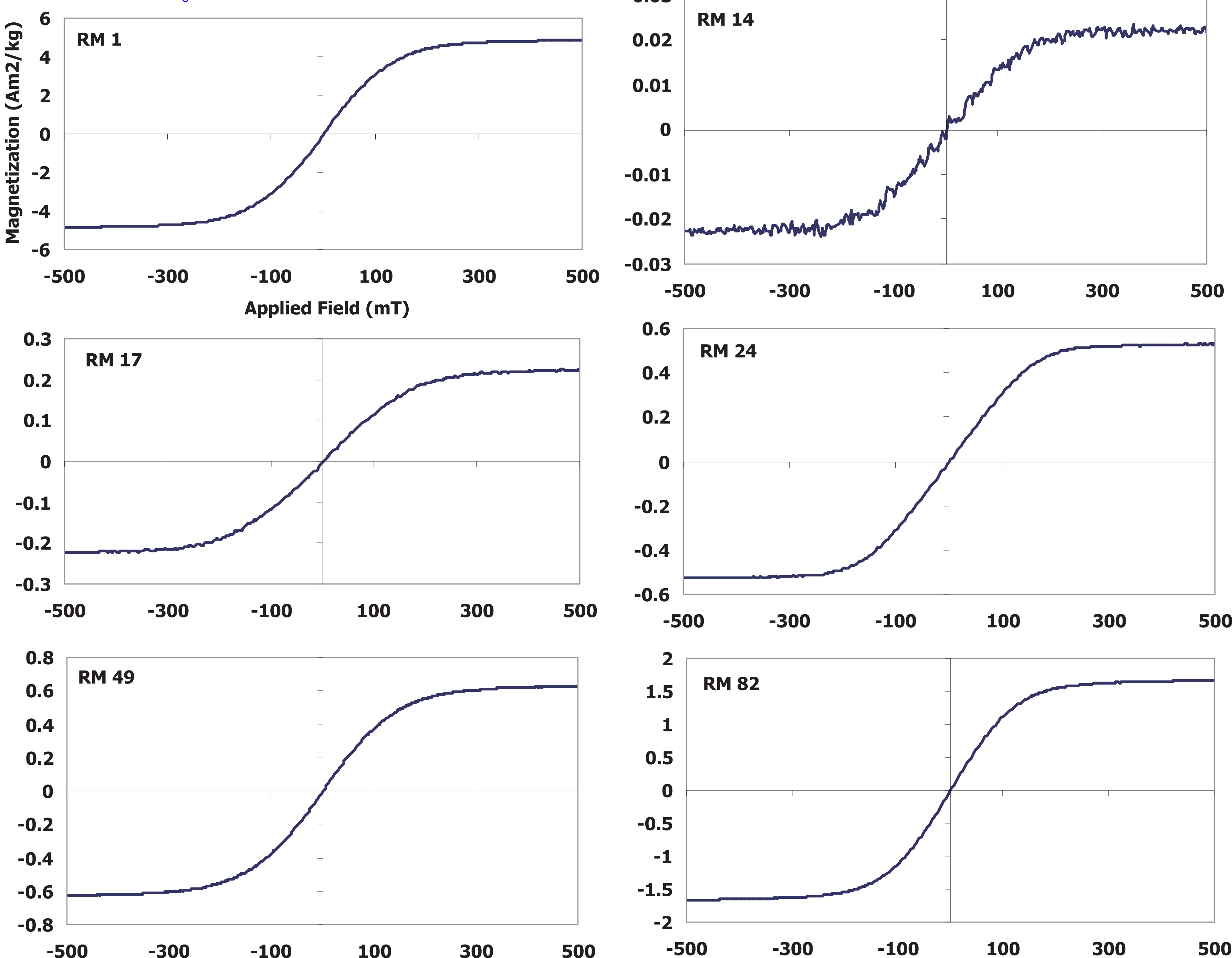
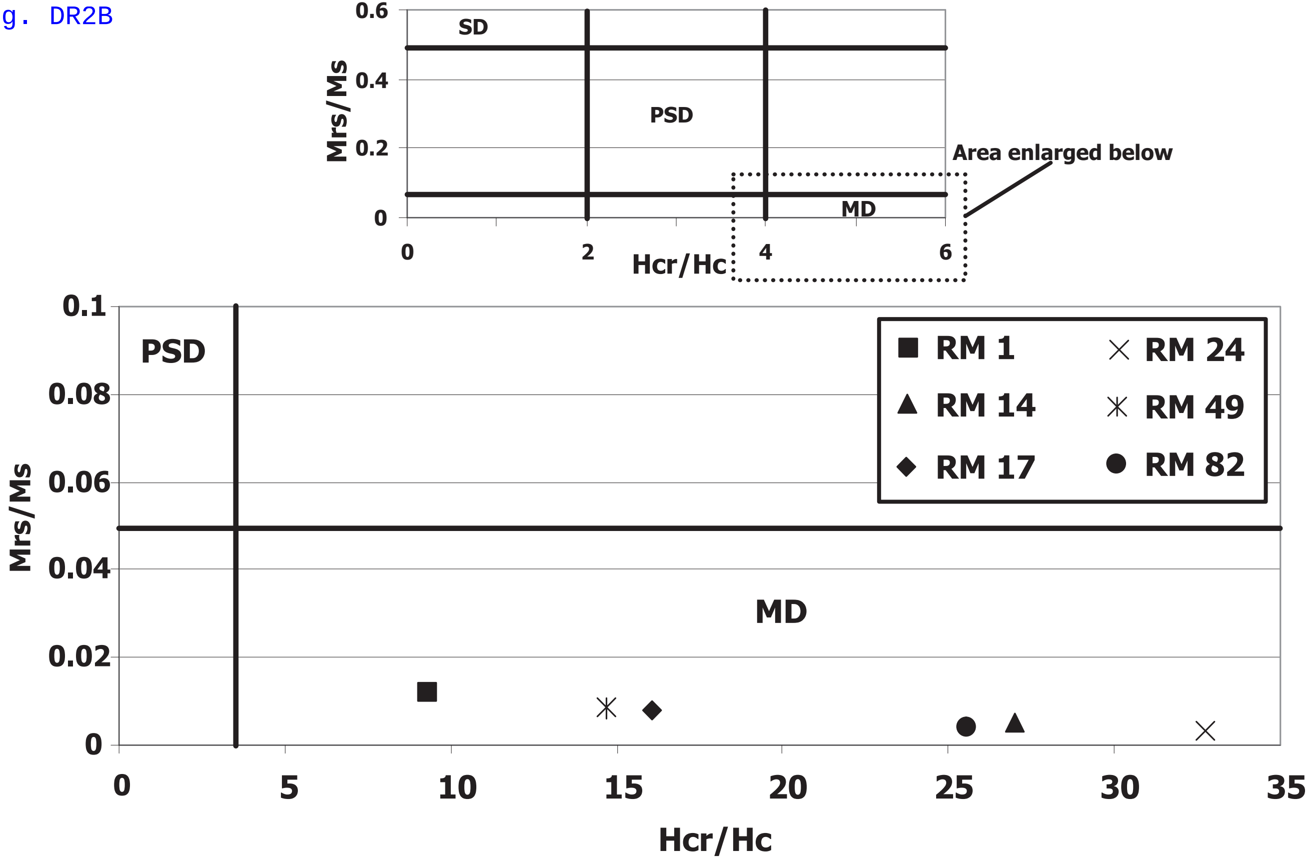
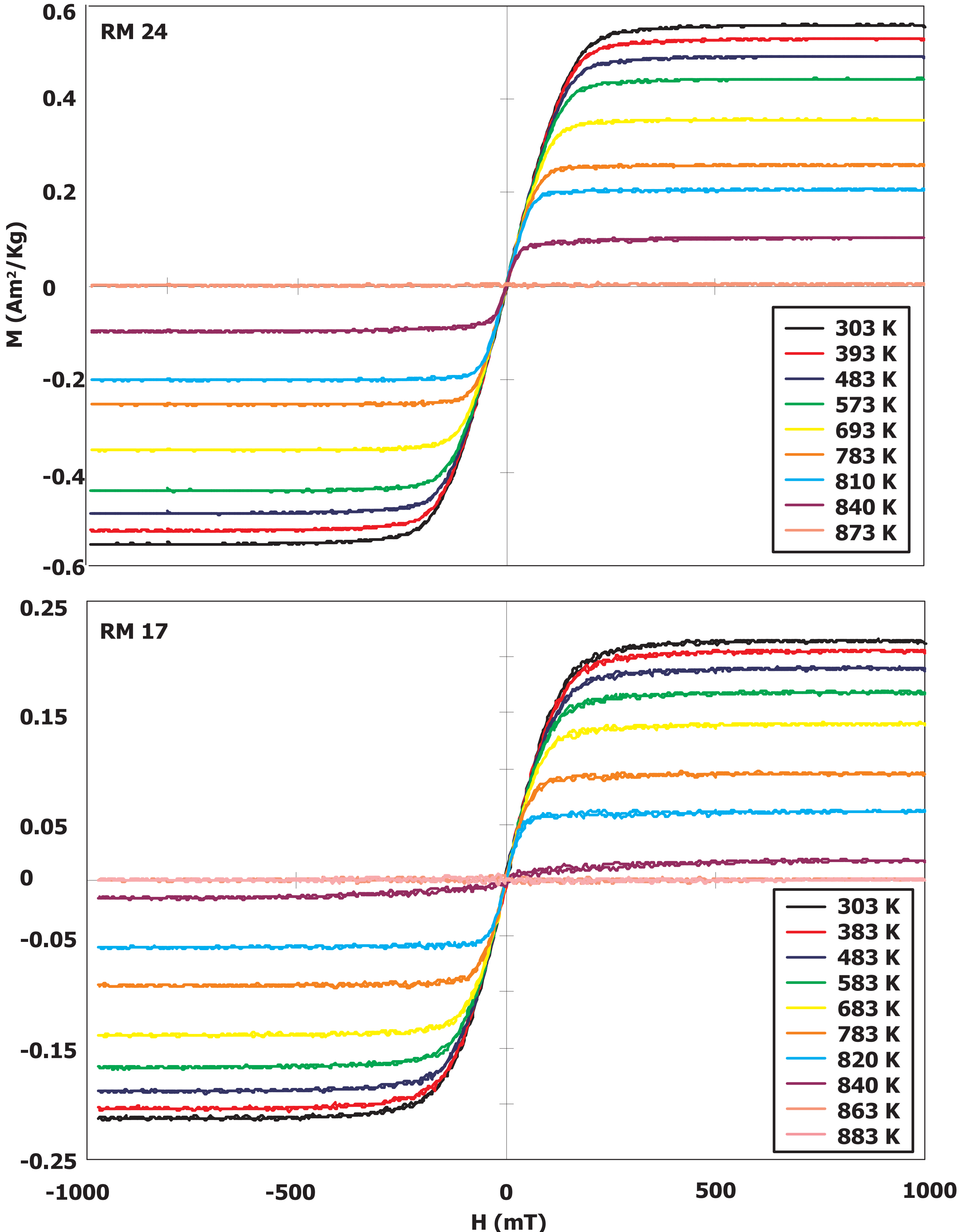

RM 1
RM 14
RM 17
RM 24
RM 49
RM 82
Magnetization (Am2/kg)
Applied Field (mT)
-500
-300
-100
100
300
500

Fig. DR2B



SD
PSD
MD
Mrs/Ms
Hcr/Hc
Area enlarged below
0.6
0.4
0.2
0
0
2
4
6
PSD
MD
RM 1
RM 14
RM 17
RM 24
RM 49
RM 82
0.1
0.08
0.06
0.04
0.02
0
0
5
10
15
20
25
30
35
Mrs/Ms
Hcr/Hc

Fig. DR2C



RM 24
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
M (Am²/Kg)
303 K
393 K
483 K
573 K
693 K
783 K
810 K
840 K
873 K
RM 17
0.25
0.15
0.05
0
-0.05
-0.15
-0.25
303 K
383 K
483 K
583 K
683 K
783 K
820 K
840 K
863 K
883 K
-1000
-500
0
500
1000
H (mT)

Fig. DR3

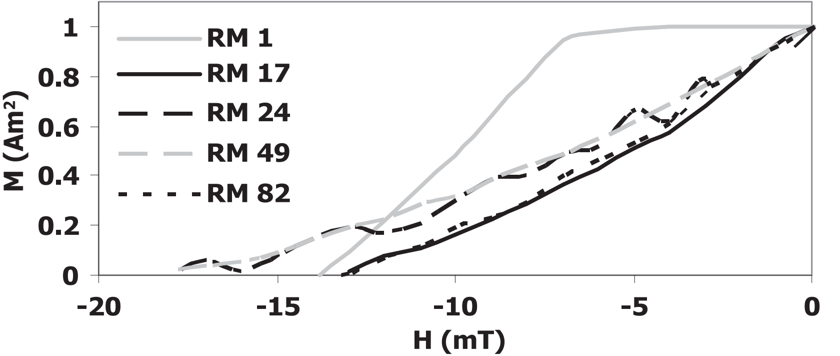
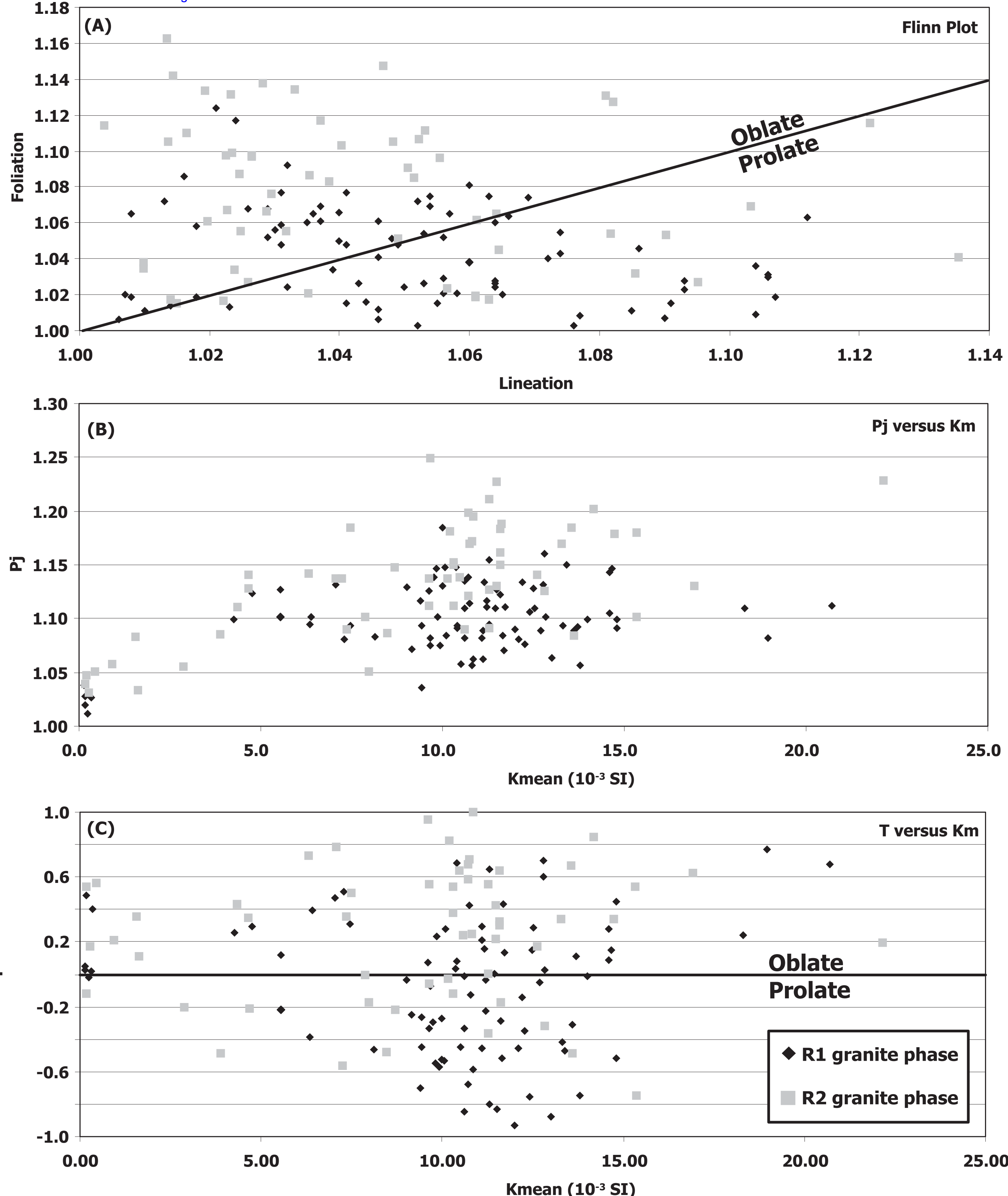


Fig. DR4


(A)
Flinn Plot
Foliation
Lineation
Oblate
Prolate
1.00
1.02
1.04
1.06
1.08
1.10
1.12
1.14
1.16
1.18
(B)
Pj versus Km
Pj
Kmean (10^{-3} SI)
0.0
5.0
10.0
15.0
20.0
25.0
1.00
1.05
1.10
1.15
1.20
1.25
1.30
(C)
T versus Km
T
Kmean (10^{-3} SI)
Oblate
Prolate
R1 granite phase
R2 granite phase
1.0
0.6
0.2
-0.2
-0.6
-1.0
0.00
5.00
10.00
15.00
20.00
25.00

SUPPLEMENTAL INFORMATION 1. ROCK MAGNETISM METHODS

High-temperature low-field susceptibility measurements were carried out in a stepwise heating/cooling fashion from 25°C to 700°C in an Argon atmosphere using an AGICO KLY2 and MFK1-A susceptibility meter with a CS2 and CS4 furnace attachment, respectively. These experiments allow for an evaluation of the magnetic mineral composition based on Curie point estimates and assist with revealing mixtures of magnetic phases within a given sample. Low-temperature susceptibility measurements were conducted on an in-house built cryogenic measurement system at the New Mexico Highlands University (NMHU) paleomagnetic - rock magnetism laboratory and involved cooling samples to 77 K and measuring susceptibility every 15 seconds with an AGICO MFK1-A during warming to 298 K. Ideal ferro/ferrimagnetic materials yield a warming curve that is of zero slope (no change in susceptibility with temperature) while a pure paramagnetic material yields a warming curve described by the Curie-Weiss law. Complete hysteresis curves were measured on rock chips up to a maximum field of 1.5 Tesla (T) using the Micro- Mag2 Princeton Measurements Corporation vibrating sample magnetometer (VSM). Hysteresis experiments at room (273 K) provide information on the prevailing magnetic grain size distribution, an estimate of the coercivity spectra, and the saturation remanence which is related to the magnetic phase composition. High (273K to 840K) temperature hysteresis experiments attempt to characterize the magnetic moment and remanence measurements as a function of temperature to aid with magnetic mineral identification, magnetic grain size determinations, and the temperature interval at which the samples lose all ferromagnetic remanence. Back-field measurements give information on the coercivity of remanence of the sample. High-temperature low-field susceptibility, on most samples, and all hysteresis and back-field measurements were conducted at the Institute for Rock Magnetism, University of Minnesota. The remaining low- and high-temperature low-field susceptibility measurements were conducted at the NMHU paleomagnetic-rock magnetic laboratory.

SUPPLEMENTAL INFORMATION 2. PRINCIPAL OF ANISOTROPY OF MAGNETIC SUSCEPTIBILITY

All statistical AMS parameters were calculated following the methods of Jelinek (1978) and Jelinek (1981). Anisotropy of magnetic susceptibility (AMS) is controlled mainly by the preferred orientation of magnetic grains in a rock, principally the ferromagnetic (s.l.) (e.g. magnetite, titanomagnetite) and paramagnetic mineral phases (e.g., biotite, hornblende) (Bouchez, 1997). An AMS measurement of one rock specimen yields a second order tensor that may be viewed as an ellipsoid of magnetic susceptibility (K) defined by the length and orientation of its three principal axes, K1 > K2 > K3, which are the three eigenvectors of the susceptibility tensor (Tarling and Hrouda 1993). The magnitude of susceptibility parameters are usually reported in terms of “size”, “shape” and “strength” (or ellipticity) of the ellipsoid. The AMS technique facilitates the definition of the degree of magnitude of the linear (L=K1/K2) and planar (F=K2/K3) fabric components (Jelenik, 1981). The technique also quantifies the corrected degree of anisotropy, Pj = exp (2[(η1 – η)2 + (η2-η)2 + (η3-η)2]1/2), for ellipticity; T = (2 η2 - η1 - η3) / (η1 - η3) for shape where η1 = ln K1, η2 = ln K2, η3 = ln K3, and η = ln (K1 + K2 +K3)1/3. Using these parameters, Pj=1 describes a perfectly isotropic fabric and a Pj value of 1.15 describes a sample with 15% anisotropy. Given the above, Pj values of 0-5% indicate a weak anisotropy, 5-10% moderate anisotropy, 10-20% a strong anisotropy, and >20% a very strong anisotropy. The shape of the susceptibility ellipsoid (Tj) [with Tj = (2lnk2 - lnk1 - lnk3) / (lnk1 - lnk3); Jelinek, 1981)] ranges from +1 where purely foliated (oblate) to –1 where purely lineated (prolate) and is triaxial between both end-members. The shape parameter can be further broken down into linear and planar components using L=K1/K2 and F=K2/K3.