GSA Data Repository 2015352

Paleomagnetic evidence for ~4000 km of crustal shortening across the 1 Ga Grenville Orogen of North America

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DATA REPOSITORY

The Data Repository comprises six Tables (DR1-6) that support data and interpretations expressed in the main text.

Table DR1

Table shows details of the seven studies that together form the mean direction of magnetization **P**, summarized in Figure 2.

Tables DR2 and DR3

Tables summarise results from 18 studies from southeast of the ABT, the mean directions of which are shown in Figure 3A, and constitute magnetization **A**.

Table DR4

Table shows results from southeast of the ABT that define magnetizations that have lower unblocking temperatures and coercivities, compared to magnetization **A.** Stereonet summaries of these components (**B** and **C**) are shown respectively in Figures 3B and 3C.

Table DR5

Table gives average ages based on the map compilation by Tohver et al. (2006) across the southwestern Grenville province according to both the method used and the sample locality from which they come. This table forms the basis of the summary Table 1 with the caveat that in Table 1 extra lines (in italics) have been inserted to report mean ages per terrane where the data used are restricted to those within the main area of paleomagnetic sites; blank spaces indicate lack of data.

Table DR6

Table gives the details of the paleomagnetic pole positions that are used in the Apparent Polar Wander Path of Figure 4.

TABLE DR1

NORTHWEST OF ABT: PALEOMAGNETIC DIRECTIONS, MEANS AND POLE POSITIONS FOR DIFFERENT STUDIES AND UNITS

STUDY		N	D'[°]	I'[°]	k	α_{95} [°]	PLAT[°N]	PLON[°E]	dp[°]	dm[°]	REF
RVA	RIVER VALLEY ANORTHOSITE	8[14]	123.5	17	98	5.6	-16.2	340	2.9	5.7	24
SD	METAMORPHOSED SUDBURY DYKES	10[12]	112.2	28.8	139	4.1	-4	344.5	2.5	4.5	24
FLA	FALL LAKE ANORTHOSITE	3[3]	118.2	27.4	170	9.5	-8.4	340.6	5.5	10.2	4
FRA**	FRENCH RIVER ANORTHOSITE	14[19]	129.2	27	ND	4.1	-15	332	2.3	4.4	20
MIG	MICHAEL GABBRO	21[21]	118.6	23.8	161	2.5	-10.3	341.6	1.6	2.8	21
BI	BUSTARD ISLANDS GNEISS	6[12]	121.8	30.3	141	5.1	-9.2	336.7	3	5.6	22
SL*	SEAL LAKE SILLS, VOLCANICS	8[14]	123.4	32.5	79	6.3	-9	334.6	4.2	7.3	23
MEAN		7[7]	121.1	26.8	136	5.2	-10.3	338.6	3.1	5.6	

* Only the lowest inclination sites are used, as they are considered by the authors as less contaminated by a steep component.

** Only the mean of 14 sites was quoted, but in the absence of individual site data no stereonet appears in Figure 2. D', I' : declination, inclination of magnetization calculated for a common site at 45°N, 79°W.

PLAT, PLON: latitude and longitude of paleomagnetic pole derived from D', I'; dp,dm are semi-axes of 95% confidence ellipse about the pole.

k, α95, are Fisher (1953) precision parameter and radius of 95% confidence circle about the magnetization direction.

N = Number of sites/ samples used to calculate poles [total number of sites/samples studied].

REFERENCES: 4- Palmer & Carmichael, 1973; 20- Stupavsky & Symons, 1981; 21- Fahrig & Larochelle, 1972; 22- Halls et al., 2015; 23- Roy & Fahrig, 1973; 24- results based on unpublished data by H.C.Halls and A. Lovette.

TABLE DR2

PALEOMAGNETIC DIRECTIONS FOR SITES SOUTHEAST OF ABT

SITE	LAT° N	LONG° W	N	D	I	k	α_{95}	UNIT	REFERENCE
MMG	46° 1'	80° 0.2'	8	284	-58	42	9	Mememesing Lake diorite	24
RV25	45° 55'17''	79°56'34''	6	292	-61	219	5	Port Loring dyke	24
MT	45° 43'	79° 41'	23	302	-73	51	4	Magnetawan gneiss	1
MAT	46.25°	78.18°	30	312	-72	66	3	Mattawa Gneiss	2
WA	45° 39.5'	79° 52'	5	285	-56	96	8	Whitestone anorthosite	3
WD	45° 39.5'	79° 52'	4	292	-67	223	6	Whitestone Diorite	3
WP	45° 7'	78° 15'	3	295	-59	365	7	Wilberforce pyroxenite	4
HI	44° 57'	78° 26.5'	15	272	-73	38	6	Haliburton Intrusions	5
TG*	44° 45'	77° 41'	8	326	-46	132	5	Tudor gabbro	6
ND	44°44.5'	77° 10'	6	303	-65	68	8	Northbrook dyke	24
MU	45° 08'	79° 36'	6	268	-68	76	8	Muskoka sites	7
CMB	44° 42'	76° 45'	8	286	-52	40	9	Central Metasdimentary Belt sites	8
MA	46° 00'	74° 15'	24	266	-77	32	5	Morin Anorthosite	9
LA	48° 20'	70° 57'	12	301	-66	46	7	Lac St. Jean Anorthosite	10
AA	51°	63°	4	297	-79	88	10	Allard Lake Anorthosite	11
IHA	48.5°	58.25°	5	311	-59	30	14	Indian Head anorthosite	12
CG	44.5°	77.75°	*30*	295	-56	24	10	Cordova Gabbro	13
OI	45.7°	76.24°	7	280	-66	98	6	Ottawa Intrusions	14
AH	44.2°	74.0°	*36*	288	-68	32	4	Adirondack Highlands	15

REFERENCES: 1- McWilliams & Dunlop, 1975; 2- Hyodo & Dunlop, 1993; 3 Ueno et al., 1975; Palmer & Carmichael, 1973; 5- Buchan & Dunlop, 1976; 6- Dunlop et al., 1985; 7- Constanzo Alvarez & Dunlop, 1998; 8- Brett & Dunlop, 2008; 9- Irving et al., 1974; 10- Buchan et al., 1982; 11- Hargraves & Burt, 1967; 12- Murthy & Rao, 1975; 13- Dunlop & Stirling, 1985; 14- Irving et al., 1972; 15- Brown & McEnroe, 2012; 24- result based on H.C.Halls & A. Lovette, Unpublished Data.

D, I: Declination, Inclination of magnetization, not corrected for common site comparison.

Other symbols: see Table DR1.

* TG was not included in the mean for magnetization **A** because, at ~1240 Ma (U-Pb on titanite), it appears to be older than the Ottawan orogen.

TABLE DR3

PALEOMAGNETIC POLES FOR SITES SOUTHEAST OF ABT

SITE	PLAT[°N]	PLON[°E]	dp	dm	λ	D	I
MMG	18	333	9.8	13.2	-38.6	284	-58
RV25	16.8	326	5.9	7.7	-42	293	-62
MT	24.6	309.4	6.4	7.1	-59	303	-74
MAT	20.7	307.5	4.7	5.3	-57	309	-72
WA	16.3	334.2	8.3	11.4	-37	286	-57
WD	22	320.6	8.2	9.9	-50	293	-68
WP	12.9	327.4	7.8	10.4	-40	295	-59
HI	36.2	321.7	9.6	10.7	-59	272	-73
ND	14.6	319.2	10.4	12.9	-47	302	-65
MU	34	329.5	11.2	13.4	-51	270	-69
CMB	12.3	339	8.4	12.3	-33	285	-51
MA	42.3	320.2	8.7	9.3	-65	278	-75
LA	19.3	326.1	9.4	11.4	-47	291	-64
AA	38.4	321.3	18	18.9	-69	271	-74
CG	10.1	330	10.3	14.3	-37	294	-55
IHA	8.3	337.7	15.5	20.8	-40	290	-49
OI	26.9	331.3	8.1	10	-48	277	-64
MMA	34.5	359.3	8.3	10.5	-33	289	-51
AH	23.2	327.2	6.1	7.2	-50	285	-65

PLAT, PLON are Latitude, Longitude of the paleomagnetic pole; dp, dm: semi-axes of the 95% confidence ellipse about the pole; λ: Paleolatitude [+°N]

D, I are Declination, Inclination of magnetization computed for a common site at Lat.45°N, Long.79°W

MEAN of D', I' : D= 288.1, I= -64.4, N = 18, k=79, alpha = 3.9. Note slight streaking in WNW direction.

PLAT = 21°N, PLON = 325.8°E dp = 5°, dm = 6.2°. PALEOLATITUDE = -46°

MMA not included in mean because 8 of the 11 sites had positive inclinations to the ESE.

TABLE DR4

SECONDARY COMPONENTS SOUTHEAST OF ALLOCHTHON BOUNDARY THRUST (ABT)

SYMBOL	LAT[°N]	LONG[°W]	D [°]	I [°]	D' [°]	I' [°]	UNIT	REFERENCE
WA	45.39	79.87	112.4	40.8	*112.8*	*41.8*	WHITESTONE ANORTHOSITE	3
HI	44.95	78.44	105	34	*104.6*	*33.5*	HALIBURTON INTRUSIONS	5
			300	10	299.6	10.7	HALIBURTON INTRUSIONS	5
TH	44.5	77.8	308	-13	*307*	*-11.1*	THANET GABBRO	6
LA	48.3	70.95	109	45	101	39.1	LAC ST JEAN ANORTHOSITE	10
MM	53.1	60.7	300	-19	284.9	-3.1	MEALY MTS ANORTHOSITE	16
UG	44.94	77.8	100.4	44.6	*99.4*	*43.4*	UMFRAVILLE GABBRO	17
KD	44.3	76.25	103	50	*101.1*	*47.6*	KINGSTON DYKES	18
MA	46.0	74.25	114	38	*109.8*	*33.9*	MORIN ANORTHOSITE	9
CG	44.5	77.75	306	-2	305	0.04	CORDOVA GABBRO	13
SUA	47.5	70.4	113	35	*105.5*	*27.4*	ST URBAINE ANORTHOSITE	19
			309	-25	293.3	-23.3	ST URBAINE ANORTHOSITE	19

MEAN D', I' :

Magnetization B: D' = 105°, I' = 38.2°, N = 7, k = 106, α_{95} = 5.9°.
Magnetization C: D' = 298.0°, I' = -5.4°, N = 5, k = 27, α_{95} = 14.9°

D', I' are recomputed D, I for a common site location at 45°N 79°W; Numbers in italics: Magnetization **B**; Others: Magnetization **C**.

Southeast of ABT sites MG (Magnetawan gneiss), ND (Northbrook dyke), SD20 (Metadiabase dyke) and MMG (Mememesing diorite) were checked for components with unblocking temperature/coercivity lower than the characteristic one but none were found.

POLE POSITIONS:

Magnetization B: PLAT = 5.1°N PLON = 345.5°E dp = 4.1° dm = 7.0°
Magnetization C: PLAT = -17.4° PLON = 348.5°E dp = 7.5° dm = 14.9°

PLAT, PLON: Paleolatitude and paleolongitude of geomagnetic pole position; dp,dm: semi-axes of 95% confidence ellipse about the pole.

REFERENCES:

3- Ueno et al., 1975; 5- Buchan & Dunlop, 1976; 6- Dunlop et al., 1985; 9- Irving et al., 1974; 10- Buchan et al., 1982; 13- Dunlop & Stirling, 1985; Irving, 1972; 16- Fahrig et al., 1973; Symons, 1978; 18- Park & Irving, 1972; 19- Robertson & Roy, 1979.

TABLE DR5

AVERAGE AGES IN MA FROM THE GRENVILLE PROVINCE BY TERRANE [FROM FIGURE 2 OF TOHVER ET AL 2006] FOR DIFFERENT DATING METHODS

U-Pb TITANITE	AVERAGE	STANDARD DEVIATION	NUMBER OF AGES
NW OF ABT	981	18	
CENTRAL GNEISS BELT(CGB)	1026	30	6
CENTRAL METASEDIMENTARY BELT(CMB)*	1078	63	20
FRONTENAC	1151	21	28
ADIRONDACK HIGHLANDS	1055	43	10
			15
U-Pb MONAZITE			
NW OF ABT	1024	21	3
CENTRAL GNEISS BELT	1114	41	6
FRONTENAC	1158	11	7
Ar-Ar HORNBLENDE			
NW OF ABT	974	13	10
CENTRAL GNEISS BELT	980	25	19
COMPOSITE ARC BELT	984	46	33
FRONTENAC	1072	42	13
ADIRONDACK HIGHLANDS	987	38	24
Ar-Ar PHLOGOPITE			
CENTRAL METASEDIMENTARY BELT	962	49	14
Ar-Ar BIOTITE			
NW OF ABT	973	34	8
CENTRAL GNISS GNEISS BELT [NO DATA], CENTRAL METASEDIMENTARY BELT ONLY ONE DATA : 1029			
FRONTENAC	959	55	22
ADIRONDACK HIGHLANDS	907	32	5

METHOD	NW ABT	CGB	CMB	FRONTENAC	ADIRONDACKS
U-Pb MONAZITE	1024	1114		1158	-
U-Pb TITANITE	981	1026	1078	1151	1055
Ar-Ar HORNBLENDE	974	980	984	1072	987
Ar-Ar PHLOGOPITE			962		
Ar-Ar BIOTITE	973			959	907

NOTES: The Frontenac Terrane includes the St. Lawrence Lowlands; ABT is the Allochthon Boundary Thrust

Closure temperatures: Titanite 600-650°C; Hornblende:530±40°C, Monazite: >1000°C; Biotite: 280±40°C and Phlogopite: > 450°C

Calculations done by: www.easycalculation.com/statistics/standard-deviation.php

*Approximates the area of the composite Composite Arc Belt (Elzevir and Shawinigan Terranes) in Figure 1.

TABLE DR6

DATA FOR APPARENT POLAR WANDER PATH OF FIGURE 4

UNIT	PLAT[°N]	PLON[°E]	dp[°]	dm[°]	A [°]	P REF	AGE [Ma]	A REF
JACOBSVILLE SANDSTONE	9	363	3	6		1	~1000	1
FOND DU LAC SANDSTONE	-16	340			5	2	~1000	2
FREDA SILTSTONE	-0.7	356			6	3	>1041±32 K-Ca,Calcite vein > K-Ar Bi1062±34; >Rb-Sr 1007±25	3
NONESUCH SHALE	-3.2	356			3	3	~1050	3
LAKE SHORE TRAPS [N POLARITY]	-23.1	366			4	4	U-Pb Zr 1087±1.6	5
PORTAGE LAKE LAVAS [N POLARITY]	-26.5	361.2	1.7	2.9		6	U-Pb Zr, Bd 1094.0 ±1.5 to 1096.2±1.8*	5
NORTH SHORE LAVAS [N POLARITY]	-33.3	360.5	2.1	3.3		7	U-Pb Zr 1098.1±0.3 [Mean of 3 ages]	8
UPPER OSLER GROUP [R POLARITY]	-42.5	381.6			3.7	9	U-Pb Zr 1105±2	9
NORTH ABT [RV, SD, +5 STUDIES]**	-10.3	338.6	3.1	5.6		24	U-Pb Ti 981±18 to Ar-Ar Hb 974±13	10
PIKES PEAK GRANITE	-6	359	4	8		11	U-Pb Zr 1085± 2.5 Mean K-Ar,Rb-Sr 1020	11,12
SE ABT SECONDARY COMPONENT C	***-17.4***	***348.5***	***7.5***	***14.9***		***#***	***Ar-Ar 980±35 to Ar-Ar Mu 962±50***	***10***
SE ABT SECONDARY COMPONENT B	***5.1***	***345.5***	***4.1***	***7***		***#***	***Ar-Ar 980±35 to Ar-Ar Mu 962±50***	***10***
SE ABT CHARACTERISTIC COMPONENT A	**21**	**325.8**	**5**	**6.2**		**##**	**U-Pb Ti 1050±50 to Ar-Ar Hb 980±35**	**10**

PLAT, PLON: Latiude [°N], Longitude[°E] of Paleomagnetic Pole; dp,dm: axes of 95% confidence ellipse about the pole, A: Radius of 95% confidence about the pole†.

ABT = Allochthon Boundary Thrust

Ti= Titanite; Zr = Zircon; Bd = Baddeleyite; Hb = Hornblende, Bi = Biotite

* The two determinations come from above and below the Greenstone flow and are in correct stratigraphic order.

† dp, dm are computed when directions of magnetization are available, A is computed when only a population of poles is given.

** Mean of data shown in Table DR1

Mean of data shown in Table DR4

Mean of data shown in Table DR3

REFERENCES [P REF: Paleomagnetic reference; **A REF**: Age reference]:
1- Roy & Robertson, 1978; 2- Watts, 1981; 3 - Henry et al., 1977; 4- Kulakov et al., 2013; 5 - Davis & Paces, 1990; 6 - Halls & Pesonen, 1982; 7- Tauxe & Kodama, 2009; 8 - Davis & Green, 1997; 9 - Swanson-Hysell et al., 2013; 10 - Tohver et al., 2006; 11 - Spall, 1970; 12- Smith et al.,1999; 24 - H.C.Halls & A. Lovette, Unpublished Data.

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