UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Paleomagnetic study of diabasic dikes and miscellaneous granitic gneisses in St. Lawrence and Jefferson Counties, New York

by

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with

Foreword and footnotes

by

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Foreword

by

C. Ervin Brown

Geologic situation

Fine-grained mafic dikes that are generally vertical, narrow, and undeformed are exposed in roadcuts near Gouverneur, N.Y. and others were noted by geologists at several places in the vicinity. A particularly notable group of dikes are on Grindstone Island in the St. Lawrence River near Clayton, N.Y. and many more are nearby in Ontario. These have been mapped and described by various workers (Cushing and others, 1910; Smyth, 1894), but those in New York have aroused only slight geologic notice.

In the late 1960's I mapped a dike that is 12 - 18 m (40-60 feet) wide throughout its mapped extent of more than 16 km (10 miles) in the Beaver Creek drainage basin of St. Lawrence County. Parallel but narrower dikes within about 3 km (2 miles) were also mapped.

The dikes show chilled borders, have amygdaloids, are undeformed, and have undergone some saussuritization. The large dike has diabasic texture but is an alkalic, sub silicic, olivine and analcite-bearing rock (Brown, 1975). Dikes on both sides of the St. Lawrence intrude all rocks of Precambrian age in the Lowlands. At no place do they intrude the patchy remnants of overlying sedimentary rocks of Upper Cambrian age. In fact, the dikes show deep weathering where exposed close to the pre Upper Cambrian unconformity. They certainly appear to have been truncated by that erosional event.

Most of the dikes in the area including those near Beaver Creek trend to the northeast. A few dikes to the west and southwest trend to the north or northwest and are different petrologically in that they are not undersaturated and are less altered. Similar trending dikes also occur nearby in Ontario.

Age problem

K-Ar dates on pyroxene and feldspar on the large northeast-trending dike are 405 $\pm$ 11 m.y. and 440 $\pm$ 10 m.y., respectively (Brown, 1975). Unfortunately, these dates do not agree within the limits of the analytical uncertainty, but the pyroxene date does agree with two K-Ar whole-rock ages of 407 $\pm$ 23 m.y. and 411 $\pm$ 23 m.y. reported on a northwest-trending dike nearby in Ontario (Park and Irving, 1972). These dates are clearly not compatible with the Pre-Upper Cambrian age required by the field relations. Ages in the 600 - 800 m.y. range for other dikes in Ontario reported by Park and Irving are probably closer to the actual time of intrusion. Because of the discrepancy between isotopic dates and field relations, a paleomagnetic study was suggested to determine pole positions during crystallization of the dike rock. Comparison with polar wandering curves could aid speculation on the approximate age of intrusion and enable correlation with similar data on the dikes in Ontario (Park and Irving, 1972). Also polar data could aid in determining whether dikes of different trend and composition are of separate magmatic events.

This geologic situation was the incentive for the paleomagnetic study that is the subject of this report by Kenneth G. Books prepared in 1978 before his retirement.

Paleomagnetic study of diabasic dikes and miscellaneous granitic gneisses in St. Lawrence and Jefferson Counties, New York

by

Kenneth G. Books

Introduction

Magnetic property measurements on samples[1/] from diabase dikes in St. Lawrence and Jefferson Counties, N.Y. were done in an effort to relate ages of the dikes and the Upper Cambrian Potsdam Sandstone. Sample collections were also made on a Precambrian "phacolith" and "granite intrusion"[2/] (fig. 1).

Previous work by Park and Irving (1972) on dikes in the Gananoque area, Ontario, Canada had shown differing paleomagnetic field directions for the north-, northeast-, and northwest-trending dikes. According to their data, radiometric measurements indicate a minimum age of 800 m.y. for northeast-trending dikes and minimum of 407 ± 23 m.y., 411 ± 23 m.y., and 434 ± 75 m.y. for northwest-trending dikes (see Foreword). An age of 675 m.y. was estimated for a north-trending dike by comparison of the magnetic pole with that of the Franklin diabase (Fahrig et al., 1971).

[1/] Sampling was done during brief visits to the field in 1972, 1975 and 1976. Oriented cores were collected by Books and Brown assisted by John Windolph in the spring of 1972, in 1975 with the assistance of Harold Hubbard, and on Grindstone Island by Ken Books and William Huff in the spring of 1976. C.E.B.

[2/] Samples were collected from the Hyde School "phacolith" of Buddington (1929). Now believed to be a domical upwarp of metamorphosed and recrystallized ash-flow tuffs ranging from diorite to alaskite in composition (Carl and Van Diver, 1975) and representing some of the oldest rocks of the region.

The "granite intrusion" is a peneconcordant sheet of granite that invades metasediments of the Grenville Complex 4 km (2.5 mi) north of North Gouverneur, N.Y. C.E.B.

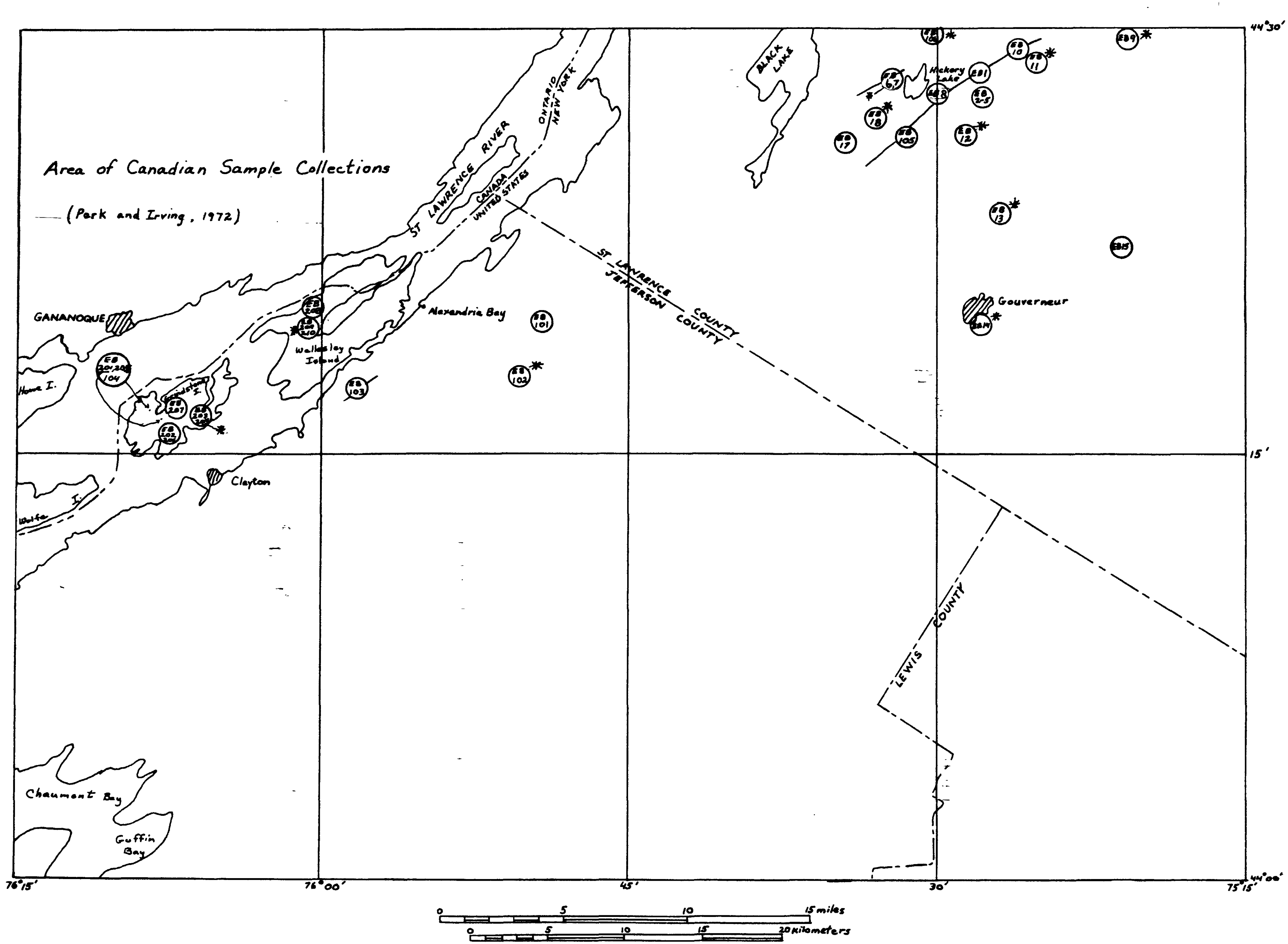


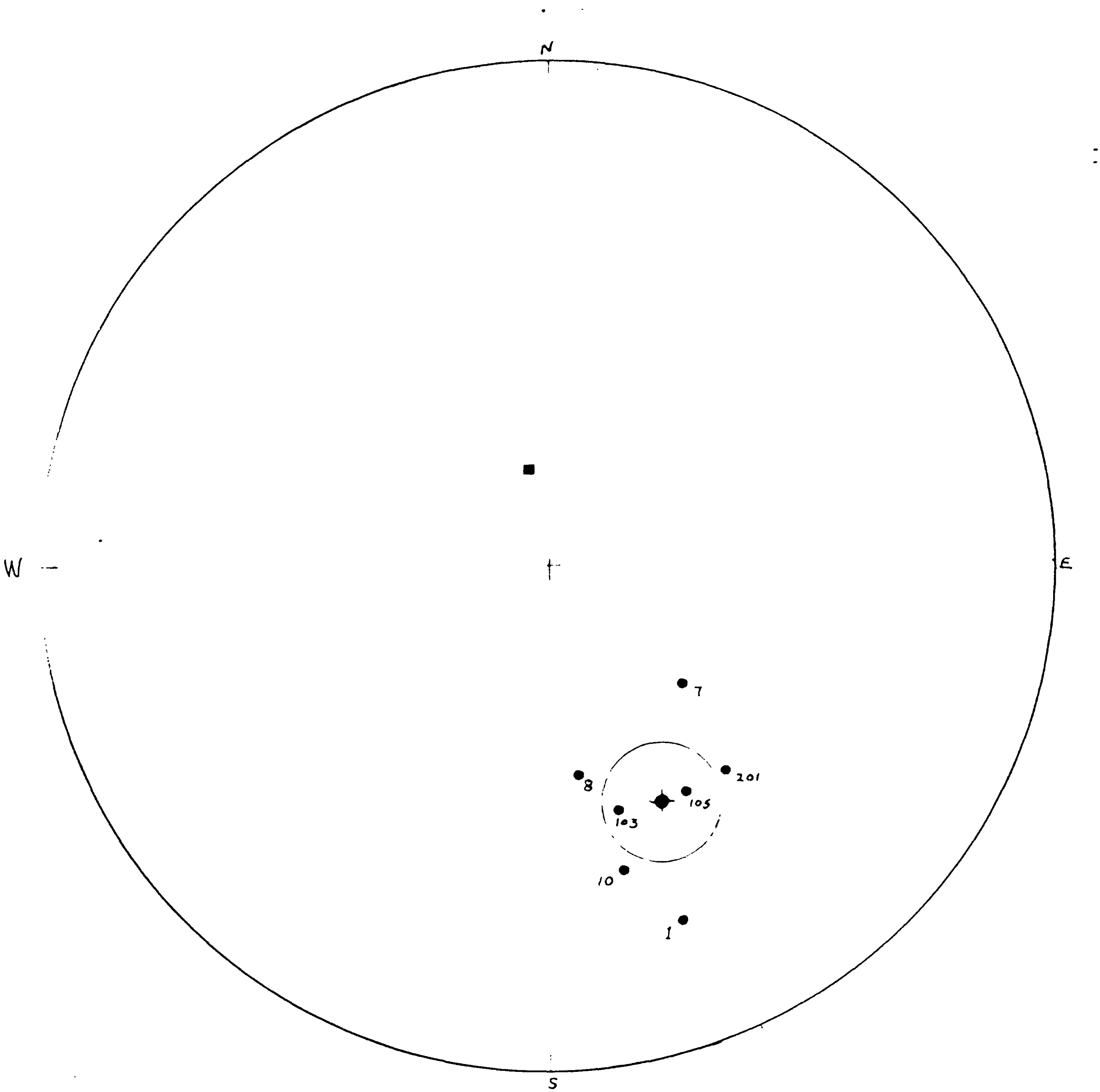
Figure 1.—Paleomagnetic sample collection sites. Asterisk indicates samples having magnetic directions too scattered to use.

Although relative ages of the dikes and Potsdam Sandstone could not be resolved because of poor precision for the sandstone samples, the dike, granite intrusion, and gneissic phacolith sample data are worth discussing. Magnetic property measurements on all samples were made in the U.S. Geological Survey's Magnetic Properties Laboratory in Reston, Va. All data were reduced with computer programs and are presented in terms of declination (D), measured in degrees east of geographic north, and inclination (I), measured in degrees below the horizontal. In the various figures, remanence results are plotted on the lower hemisphere of an equal-area net to permit direct comparison of directions on a single plane, regardless of polarity. Solid circles represent polarization north-seeking down and open circles represent polarization south-seeking down.

Discussion of results

The collection sites consist of five granites, one gneiss, and 24 sites on diabase dikes. Of these, one of the granite, one of the gneiss, and nine of the diabase dike sample sets[1/] had their directions of magnetization too scattered to be used after partial demagnetization in AC (alternating current) fields up to 1000 oersteds. The useable data for the 15 dikes are shown in Figures 2a and 2b.

[1/]The dike samples with scattered magnetic directions are from the following sites EB-6, 9, 11, 13, 14, 102, 106, 204, 209 and 210. Although not explaining the scatter of magnetization, it is interesting that these include all samples from very narrow (<10 feet wide) fine-grained dikes (11, 13, 14, 102, 106)--that are also strongly saussuritized. In addition, 9, 102, 209, and 210 are from well-weathered rock all close vertically to the pre-Upper Cambrian unconformity and thus were exposed to oxidation at that time as well as now. These factors possibly contributed to the erratic scatter of magnetization directions. C.E.B.



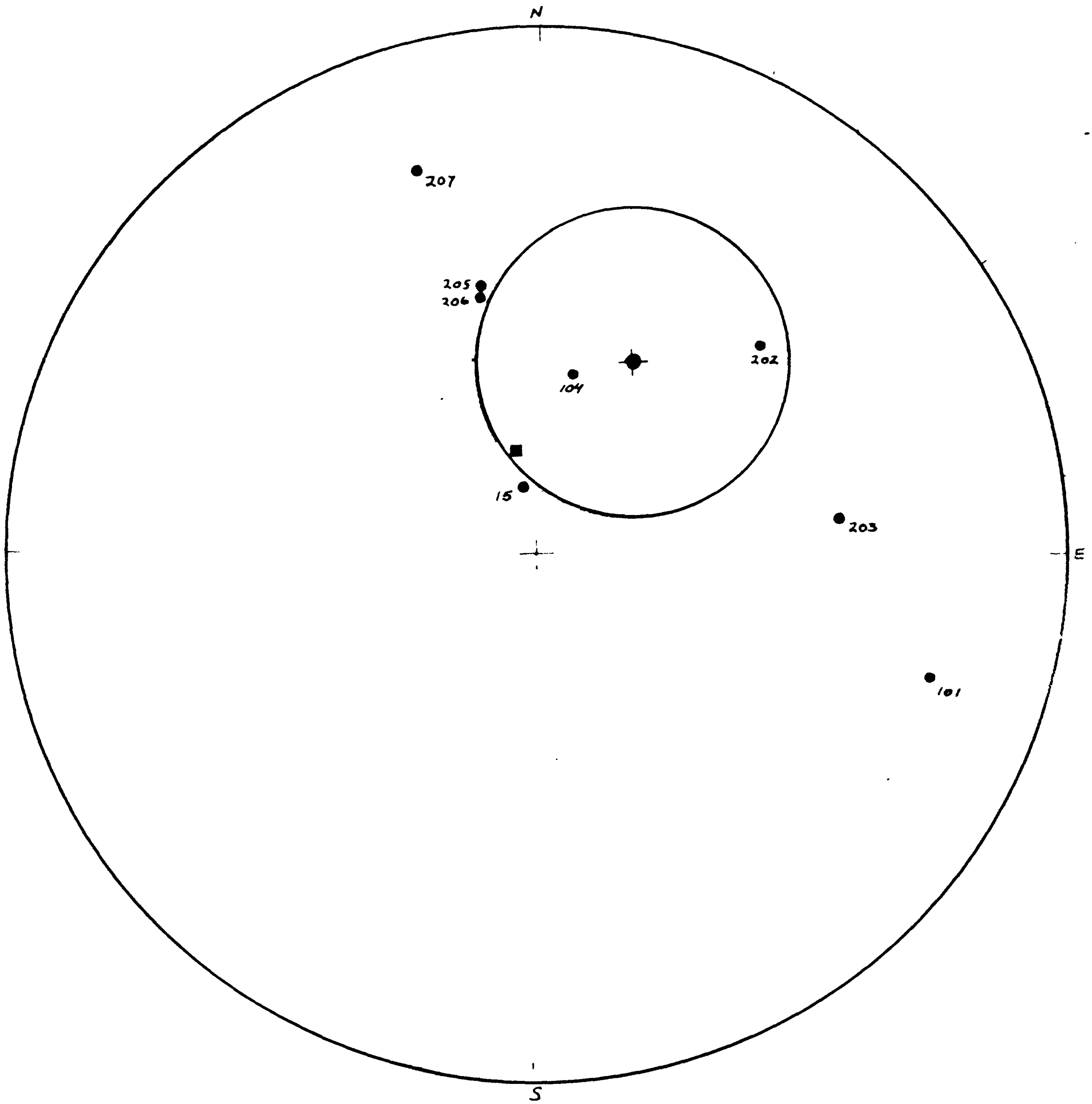
EXPLANATION

Mean of site-mean direction of magnetization. North-seeking polarization, lower hemisphere.

Site-mean directions of magnetization. North-seeking polarization, lower hemisphere.

Direction of axial dipole component of present geomagnetic field

Figure 2a.--Mean of site-mean directions of magnetization for northeast-trending dikes.



EXPLANATION

Mean of site-mean direction of magnetization. North-seeking polarization, lower hemisphere.

Site-mean directions of magnetization. North-seeking polarization, lower hemisphere.

Direction of axial dipole component of present geomagnetic field

Figure 2b.--Mean of site-mean directions of magnetization for northwest-trending dikes.

Northeast-trending dikes

These are the most common dike trends in the area of collection in St. Lawrence and Jefferson Counties. Although precision is not great, the dikes include the more closely grouped directions of magnetization, both within and between sites. Of the 13 dikes sampled, only seven had useable data, and of the seven, one was of mixed polarity and the south-seeking component vanished above the 400 oersted demagnetizing field. Figure 2a shows the north-seeking magnetization for these dikes grouping in the southeast quadrant of an equal-area net.[1/]

Northwest-trending dikes

Site magnetic directions for these dike samples, most of which are from Grindstone Island north of Clayton, N.Y., are shown in Figure 2b. Scatter for magnetic directions is large, both within and between sites. Of seven sites utilized, three have a mixed polarity. The north-seeking magnetization for these dikes clusters in the northeast quadrant of the equal-area net.

Granite and gneissic phacolith

Magnetic directions for four sites on a granite intrusion southeast of Hickory Lake in St. Lawrence County are somewhat scattered as are directions for one site on a gneissic "phacolith" southwest of Hickory Lake. All five sites have their magnetization initially north-seeking but quickly become south-seeking during partial AC demagnetization in fields up to 500 oersteds.

[1/]The seven samples from northeast-trending dikes also have the following common characteristics (see Table 1 and Figure 2a): Sample sites EB-1, 8, 10, and 105 are all on the same northeast-trending dike. EB-7 is from a parallel dike 9000 feet to the northwest. EB-103 is from a wide northeast-trending dike exposed in roadcuts along Interstate route 81 about 22 miles to the southwest nearly on trend of the above dikes. EB-201 is on a large irregularly shaped dike on Grindstone Island, possibly having a northeast trend. Thus, except for possibly EB-201, they appear to form a long narrow northeast-trending belt. Unlike the samples from narrow chilled dikes that gave mixed unusable results, these are all from wide dikes, mostly more than 30 feet, that internally are well crystallized and are phaneritic with diabasic texture.

The relatively tight grouping of north-seeking poles shown on Figure 2a probably is the most significant result of this study. Books has not been able to match this with Parke and Irving's data (1972) or the Logan Loop recorded from rocks in the Lake Superior region (Pesonen and Halls, 1979). If the average pole position of the NE-trending dike were south-seeking rather than north-seeking it would match closest to the pole for Sioux quartzite (Books, personal commun., 1982). C.E.B.

South-seeking magnetization

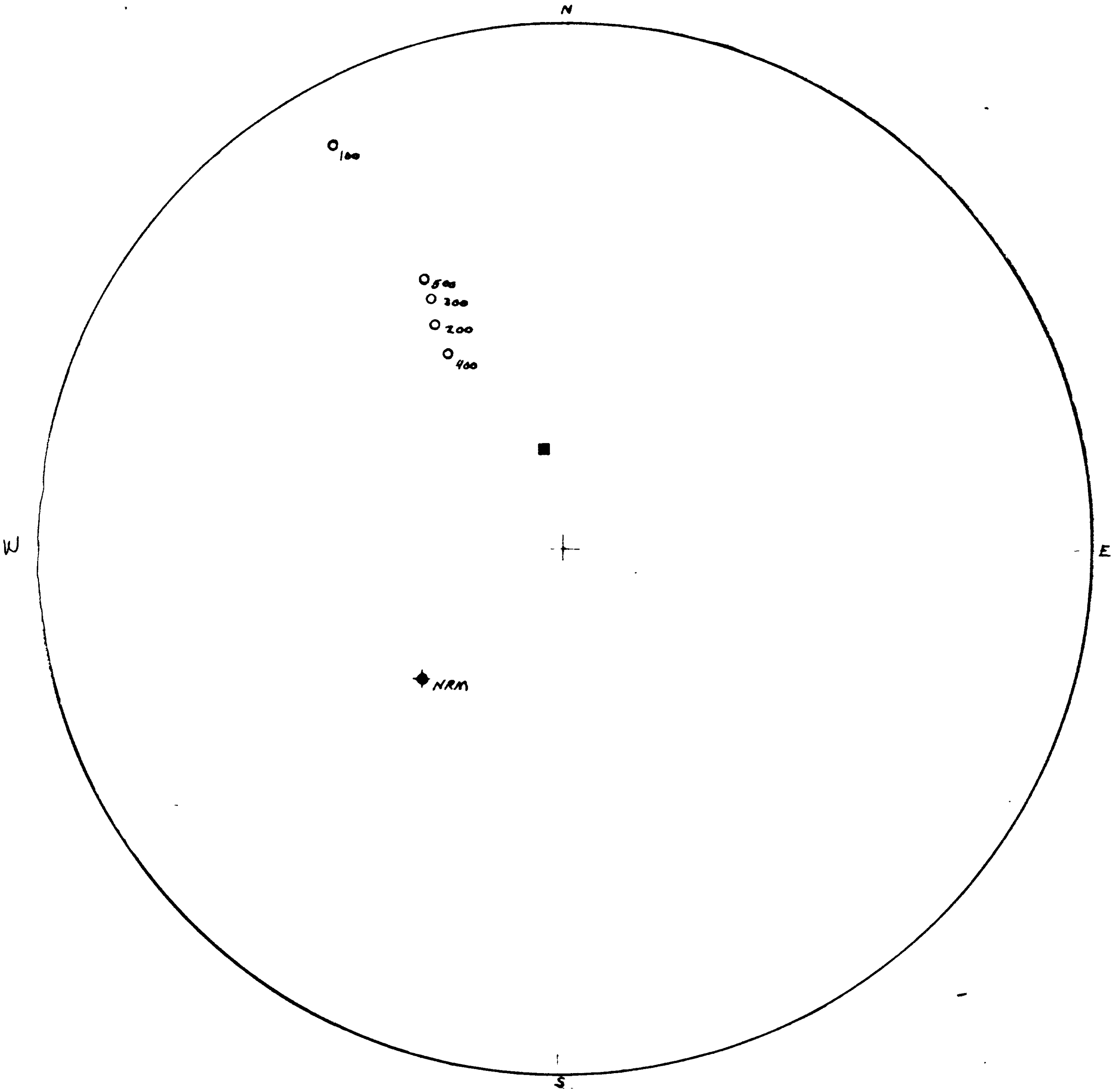
At about half of the sites, the directions of magnetization are north-seeking down, but at five of the 15 diabase dike sites and all of the granite and gneiss sites, the magnetization is either initially partly south-seeking or becomes south-seeking as the samples are partially demagnetized. Figures 3a-3d illustrate these characteristics. Site EB2 (fig. 3a) is representative of the one gneiss and five granite sites. These have their natural remanent magnetism north-seeking down, but become south-seeking at the 100 oersted demagnetization step and have little appreciable movement in direction of magnetization from 200 to 500 oersteds.

Site EB101 is a northwest-trending diabase dike and initially has its magnetization north-seeking down at the 100 to 300 oersted "cleaning" steps, as shown in Figure 3b. At higher fields (400 oersteds and up), the magnetization becomes south-seeking.

Site EB104, a northwest-trending dike, is of a mixed polarity and has two discretely different directions of magnetization. Both remain quite consistent up to the maximum "cleaning" level of 1000 oersteds. This is shown in Figure 3c.

Finally, site EB202, a northwest-trending dike, has an initial mixed magnetization, the south-seeking component of which becomes weak and disappears at AC partial demagnetization fields above 400 oersteds. The north-seeking component is still present at the 700 oersted level (fig. 3d).

Unlike the north-seeking down direction of magnetization, which appears to be related to dike trends having different ages, the south-seeking component seems unrelated to either rock type, dike orientation, or age difference as it occurs in both the older granite and gneiss and in the younger diabase rocks, as well as in dikes of different trends. Plotted directions for the south-seeking magnetization are shown in Figure 4.



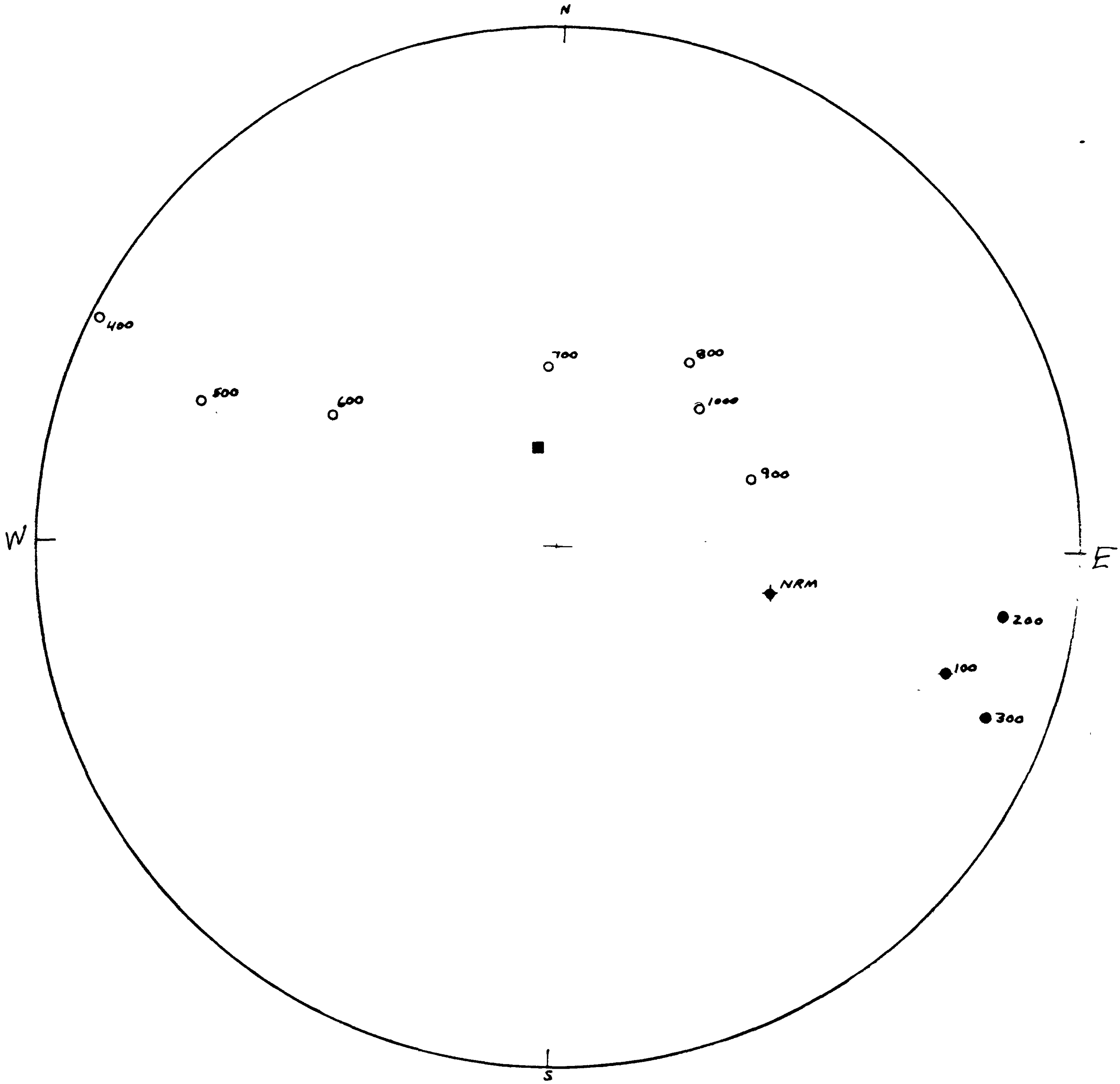
EXPLANATION

●
Site-mean direction of magnetization. North-seeking polarization. Lower hemisphere.

○
Site-mean direction of magnetization. South-seeking polarization. Lower hemisphere.

■
Direction of axial dipole component of present geomagnetic field.

Figure 3a.--Site-mean directions of magnetization for A.C. (alternating current) partial demagnetization steps of Site EB2. NRM is the direction of natural remanent magnetization.



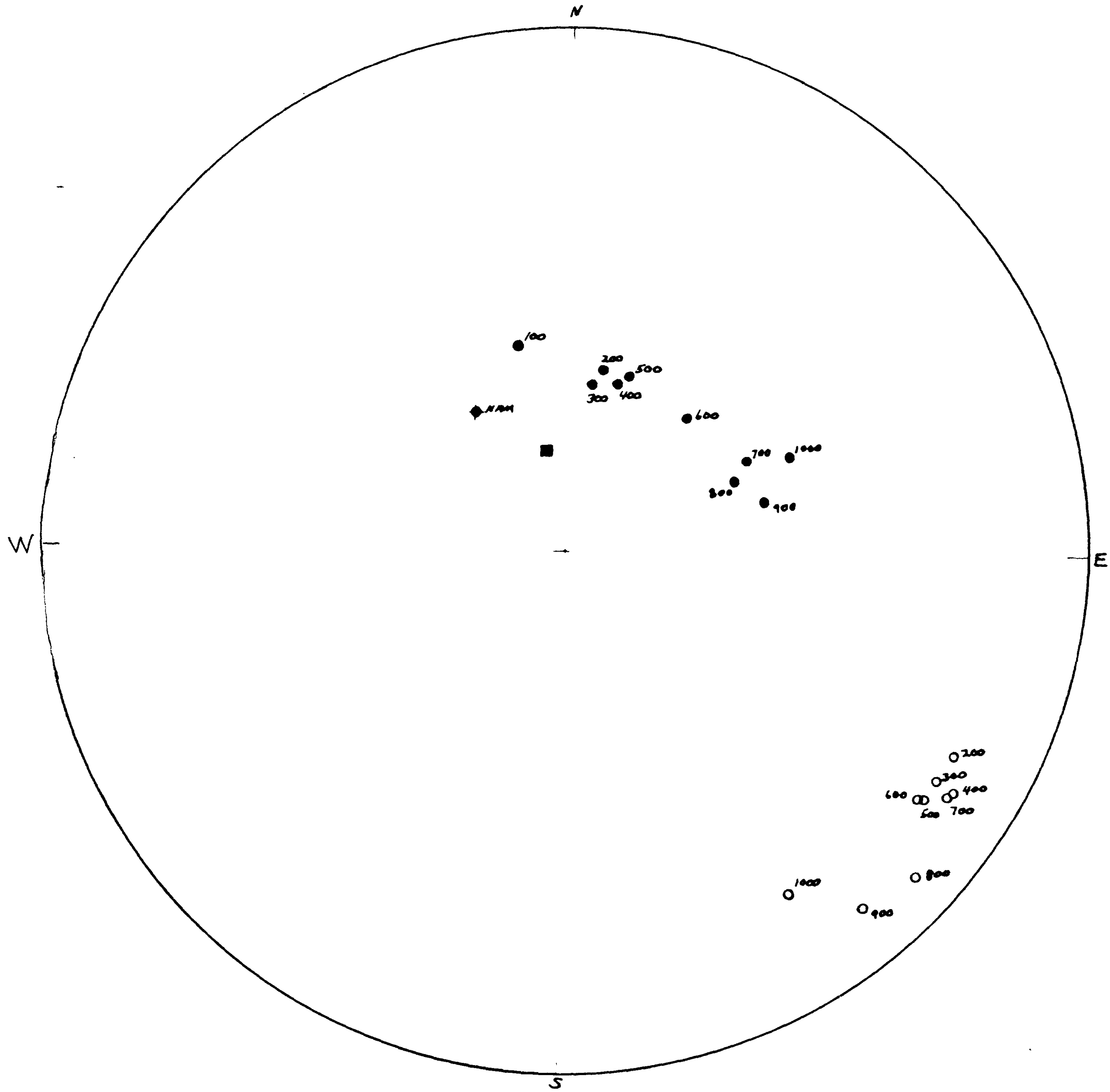
EXPLANATION

● Site-mean direction of magnetization. North-seeking polarization. Lower hemisphere.

○ Site-mean direction of magnetization. South-seeking polarization. Lower hemisphere.

■ Direction of axial dipole component of present geomagnetic field.

Figure 3b.--Site-mean directions of magnetization for A.C. (alternating current) partial demagnetization steps of Site EB101. NRM is the direction of natural remanent magnetization.



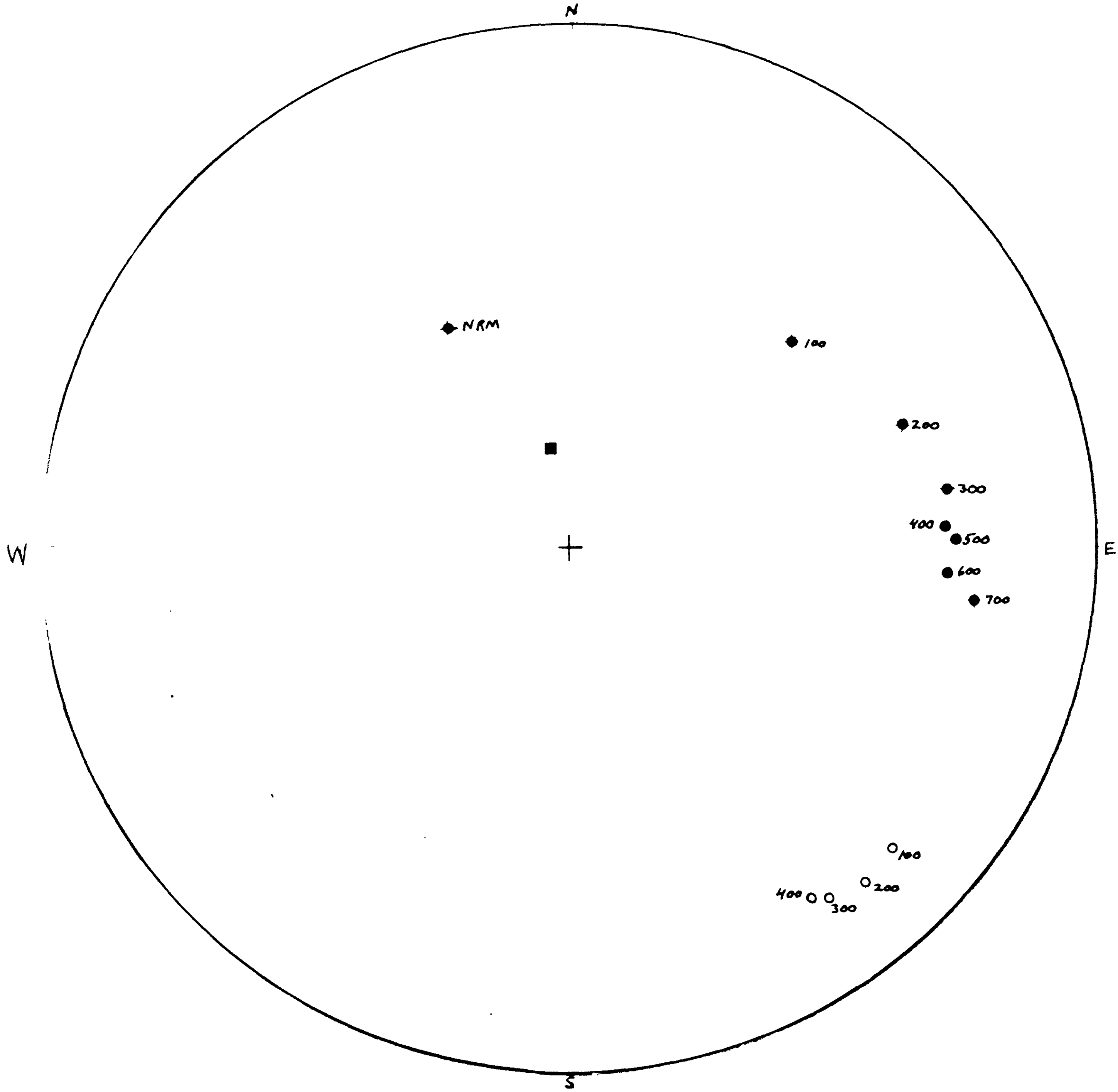
EXPLANATION

●
Site-mean direction of magnetization. North-seeking polarization. Lower hemisphere.

○
Site-mean direction of magnetization. South-seeking polarization. Lower hemisphere.

■
Direction of axial dipole component of present geomagnetic field.

Figure 3c.--Site-mean directions of magnetization for A.C. (alternating current) partial demagnetization steps of Site EB104. NRM is direction of natural remanent magnetization.



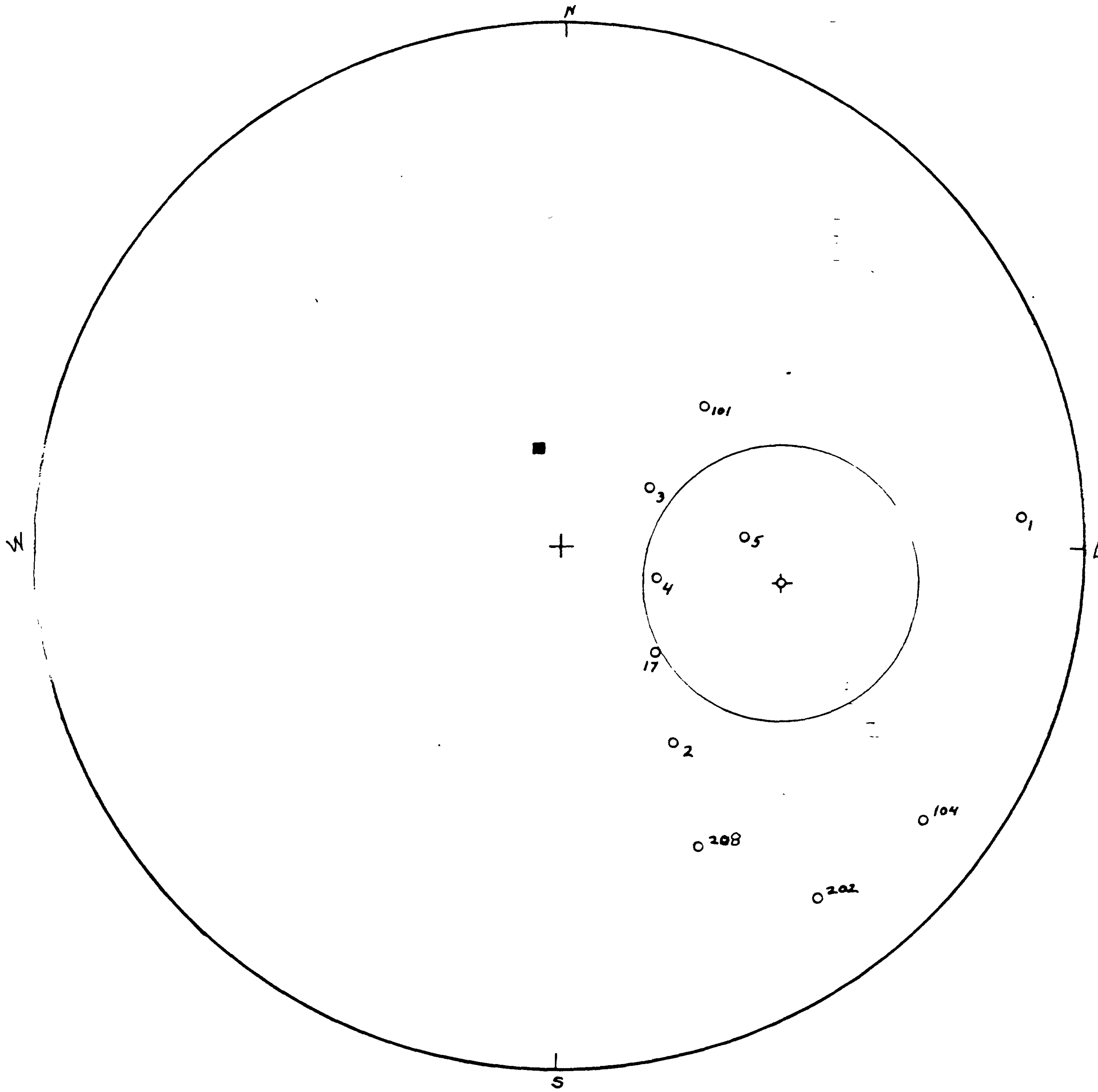
EXPLANATION

● Site-mean direction of magnetization, North-seeking polarization. Lower hemisphere.

○ Site-mean direction of magnetization. South-seeking polarization. Lower hemisphere.

■ Direction of axial dipole component of present geomagnetic field.

Figure 3d.--Site-mean directions of magnetization for A.C. (alternating current) partial demagnetization steps of Site EB202. NRM is direction of natural remanent magnetization.



EXPLANATION

Mean of site-mean direction of magnetization. South-seeking polarization, lower hemisphere.

Site-mean directions of magnetization. South-seeking polarization, lower hemisphere.

Direction of axial dipole component of present geomagnetic field.

Figure 4.--Mean of site-mean directions of magnetization for the south-seeking component of magnetization at the various sites.

Conclusions

Because of a wide variation in results, the data from the rocks of this investigation probably do not warrant firm conclusions. However, the northwest- and northeast-trending dikes do have significantly different directions of magnetization for the north-seeking component. Because differently trending dikes (northeast and northwest) have different ages, as indicated by radiometric data, it would suggest the north-seeking polarity, by virtue of different direction of magnetization, is the more stable or original direction of magnetization in the area rocks. It is also significant that half of the sample sites have a south-seeking component of magnetization that is present in some degree in the oldest to the youngest rocks. Although scattered, the directions do show a general similarity for all sites and may indicate a later or secondary component of magnetization that is younger than the youngest dike rocks.[1/]

[1/]The diabase dikes are obviously much younger than the Grenville metasediments that show a 1 b.y. age of metamorphism. The south-seeking component occurring in both the metasediments and dikes suggests a late wide-spread thermal event affecting the entire region. Only two mineralization events are known here that are younger than the diabase dikes. These are mineralization phases 3 and 4 described by me (Brown, 1982; and Brown, in press). Phase 3 produced oxidation of iron-bearing minerals and hydrothermal alteration close to the Precambrian-Paleozoic unconformity. The iron deposits typified by those mined at Antwerp, N.Y., in the 1800's are a result. Ore minerals are hematite and minor amounts of magnetic minerals such as maghemite and magnetite. This phase also produced barite and a wide range of secondary minerals where the pre-existing Balmat zinc deposits were affected by it. Phase 4 produced the vertical galena-bearing veins previously mined near Rossie and Macomb, N.Y. This type vein is composed mainly of calcite with galena, sphalerite and fluorite. Similar calcite and sulfide veins are in rocks as young as Middle Ordovician in Ontario. Some hydrothermal alteration along joints in gneisses that locally produced epidote, reddened feldspar and quartz is also believed by me to be related to this mineralization stage.

The south-seeking component, prevalent in many of the samples, if it represents a regional magnetic feature, could explain the large regional negative magnetic anomalies in the Grenville lowlands shown on the aeromagnetic maps of the region (U.S. Geological Survey, 1975; Isachsen and others, 1979). C.E.B.

TABLE 1. - Summary of results

N is the number of sites for which Fisher (1953) analyses have been computed, D and I are declination and inclination of the mean direction of magnetization, K and α_{95} are Fishers estimate of precision and circle of confidence. In column 9, N is North latitude and S is south latitude, δm and δp are semiaxes of the confidence oval about a virtual pole and are respectively perpendicular and parallel to the virtual paleomeridian. A.F. is the cleaning field in oersteds

Rock unit	Location of rock unit: North lat. (degrees)	Location of rock unit: West long. (degrees)	Number of samples (N)	Mean of site-mean directions of magnetization: Declination D (degrees)	Mean of site-mean directions of magnetization: Inclination I (degrees)	Precision parameter (K)	Radius of confidence circle (α_{95})	Pole position: N, North lat. S, South lat. (degrees)	Pole position: West long. (degrees)	δm	δp	A.F. (Oersteds)	Dike trend
EB 1	44.48	75.47	11	159.3	25.8	20.5	10.3	29.0 S	52.3	11.2	6.0	100	NE
EB 7	44.47	75.53	8	131.9	61.0	25.9	11.1	6.6 N	41.7	17.0	13.0	100	NE
EB 8	44.46	75.50	9	172.7	55.6	8.0	19.4	9.2 S	69.5	27.2	19.8	100	NE
EB10	44.45	75.44	7	166.3	37.9	7.6	16.1	23.1 S	61.5	19.0	11.2	100	NE
EB103	44.30	75.46	6	164.2	48.3	12.2	20.0	15.0 S	61.7	26.2	17.2	100	NE
EB105	44.43	75.53	6	148.1	47.8	39.8	10.8	11.1 S	47.4	14.0	9.1	200	NE
EB201	44.27	76.01	7	139.4	45.5	28.3	11.5	9.7 S	40.0	14.7	9.3	100	NE
Average of directions			7	155.5	47.1	30.0	11.2	13.9 S	53.3	14.5	9.4		
EB15	44.39	75.36	7	347.9	79.5	90.4	6.4	64.0 N	95.1	12.2	11.6	100	NW
EB101	44.33	75.83	6	107.7	23.2	23.9	14.0	3.8 S	6.8	15.0	7.9	100	NW
EB104	44.17	76.01	11	11.3	60.6	12.6	13.4	81.4 N	332.5	20.4	15.5	200	NW
EB202	44.27	76.01	5	46.2	41.2	12.0	23.3	47.2 N	332.7	28.3	17.3	100	NW
EB203	44.27	76.01	4	73.7	43.6	36.8	15.3	28.8 N	354.6	19.1	11.9	100	NW
EB205	44.27	76.01	8	347.2	46.3	12.7	16.2	70.4 N	220.0	20.7	13.3	100	NW
EB206	44.27	76.01	4	348.0	48.5	10.5	29.8	72.4 N	219.1	39.2	25.7	100	NW
EB207	44.28	76.01	5	342.7	24.2	22.6	16.4	55.1 N	225.5	17.6	9.4	100	NW
Average of directions			8	25.9	56.2	5.0	27.5	69.0 N	334.1	39.7	28.6		
South-seeking component of magnetization													
EB 1	44.48	75.47	8	85.9	-12.2	15.4	14.6	7.2 S	187.0	14.8	7.5	300	NE
EB 2	44.47	75.50	4	149.3	-54.5	26.3	18.3	5.8 N	230.6	25.7	18.1	400	gr.
EB 3	44.47	75.50	6	55.3	-73.4	7.4	26.3	54.1 S	209.5	47.1	42.2	400	gr.
EB 4	44.47	75.50	5	107.6	-74.9	4.8	38.8	30.9 S	223.6	70.8	64.6	400	gr.
EB 5	44.47	75.50	4	86.2	-61.1	7.1	36.9	30.2 S	196.5	56.7	43.5	400	gr.
EB17	44.47	75.54	5	137.2	-68.0	7.5	30.0	12.4 S	229.6	50.3	42.2	600	gr.
EB101	44.33	75.83	5	45.5	-58.5	11.1	23.6	56.1 S	173.3	35.0	26.0	1000	NW
EB104	44.17	76.01	5	126.5	-14.5	17.5	18.8	19.5 N	198.3	19.3	9.9	400	NW
EB202	44.27	76.01	3	144.0	-18.2	30.4	22.8	27.3 N	215.2	23.6	12.3	300	NW
EB208	44.33	76.00	4	140.9	-46.4	4.0	53.0	9.6 N	221.5	68.1	43.7	500	NW
Average south-seeking direction			10	99.1	-54.7	5.7	23.7	18.0 S	197.9	33.5	23.7		

Table 2.--Dike and location data at sample sites (CEB).

Sample No.	UTM coordinates in meters in zone 18 Easting	Northing	USGS Quadrangle (7.5')	Approximate dike trend	Comments
EB-1	463200	4924200	Richville	N 45 E	Cliff outcrop of 50 foot wide vertical dike.
EB-2 to 5	463000	4924100	Richville	----	Samples from large granite body north of Huckleberry Mt.
EB-6, 7	457700	4923600	Pope Mills	N 50 E	Vertical dike, 35 feet wide. Sample site on E-W segment of an overall N 50 E trend. 1200 feet west of Hickory Lake. EB-6 is from chilled border.
EB-8	460200	4922400	Pope Mills	N 40 E	Natural outcrop 2000 feet SE of Old State Road 55-foot wide vertical dike.
EB-9	472500	4926800	Bigelow	N 50 E	20-foot wide dike near DeKalb, N.Y.
EB-10	465200	4925500	Richville	N 50 E	Outcrop 100 feet west of Rock Island Road. Same dike as collected at EB-1, about 40 feet wide.
EB-11	466350	4925000	Richville	N 50 E	4 to 10 foot wide vertical dike in outcrop along South Fork Beaver Creek.
EB-12	462000	4920300	Richville	----	Granite lens in marble.
EB-13	463800	4915300	Richville	N 50 E	4 foot-wide dike that intrudes marble along Rock Island Road.
EB-14	462700	4907900	Gouverneur	N 55 E	3-foot dike in roadcut along State Route 58, 500 feet from Gouverneur village limits.
EB-15	471700	4914900	Bigelow	N 20 E	30-foot wide dike on hillside north of Hayden Road; shown on map by Foose (1980).
EB-17	454400	4919500	Pope Mills	----	Granite gneiss from Hyde School antiform.
EB-18	456500	4921300	Pope Mills	----	Alaskite from Hyde School antiform.
EB-101	435400	4908200	Redwood	N 10 W(?)	20-foot wide dike along Skinner Road.
EB-102	433700	4904800	Redwood	N 45 W	Narrow (<5 ft) weathered vertical dike. 1000 feet south of State Route 26B.
EB-103	422600	4904050	Alexandria Bay	N 50 E	30-foot wide dike in road cuts along U.S. Interstate 81.
EB-104,205	409500	4909800	Gananoque	N 30 W	40-foot wide vertical dike NE side of Cross Island Road on Grindstone Island.
EB-105	457900	4920100	Pope Mills	N 50 E	40-foot wide vertical dike. 3000 feet NE of Pierces Corner.
EB-106	460300	4926600	Pope Mills	N 40 E	15-foot wide vertical dike.
EB-201	409800	4902400	Gananoque	NE?	Grindstone Island. Dike of irregular shape along Cross Island Road.
EB-202	411200	4901600	1000 Island Park	N 35 W	Dike SW of Cross Island Road >40 feet wide(?). Grindstone Island.
EB-203	412100	4902200	1000 Island Park	NNW	Grindstone Island. Top of hill 600 feet north of Aunt Janes Bay.
EB-204	412900	4902400	1000 Island Park	NNW	Grindstone Island. 30-foot dike at Lower Town Landing.
EB-206	411100	4901800	1000 Island Park	N 35 W	Same dike as 202. 1500 feet NW of Upper Town Landing, Grindstone Island.
EB-207	410400	4903000	1000 Island Park	N-S	Grindstone Island. 100 NW of Base Line Road.
EB-208	420000	4908500	1000 Island Park	N-S	Wellesley Island. Dike on southeast side of highway.
EB-209,210	419600	4908150	1000 Island Park	----	"Trachyte porphyry" mapped by Paulus (1950). Possibly a heavily hematitized dike.

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