DENSITY AND MAGNETIC SUSCEPTIBILITY OF WISCONSIN ROCK

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ABSTRACT

Density and magnetic susceptibility values were determined for a suite of specimens from Wisconsin and northern Michigan that provide a sample of a wide variety of cover and basement rock types in the northern Midcontinent. In addition, we summarize a large number of previously published values. In general, the densities of Midcontinent rock agree with the normal range of densities for any given rock type, and therefore, the assumed density values used in most geopyhysical studies are valid. One significant exception is the Keeweenawan mafic rock suite, which shows a lower density contrast with granitic basement rock than has heretofore been assumed in many studies. Magnetic properties, which depend largely on magnetite content, show no simple correlation with rock type, but the overall pattern observed is consistent with the usual assumptions made in magnetic studies: cover rock is essentially nonmagnetic, mafic rock is generally magnetic, and granite is highly variable. The Wolf River Batholith has susceptibility of 100 to 1000 x 10^{-6} cgs units, whereas the rhyolite and epizonal granite of south-central Wisconsin are highly magnetic, with susceptibility over 1000 x 10^{-6} cgs units. Similar susceptibility has been previously reported for the younger rhyolite and epizonal granite of the St. Francois Mountains in southeastern Missouri. The possibility, therefore, exists that the widespread rhyolite and epizonal granite of the eastern Midcontinent is generally magnetic.

INTRODUCTION

Although many structural studies of the buried Precambrian basement of the central United States have been published in recent years (Dutch, 1983; Klasner and King, 1986; Sims and Peterman, 1986), there is as yet little published data on physical properties of Midcontinent rock, such as density or magnetic susceptibility. This study is an effort to fill part of that gap.

Since 1976 the senior author has been assembling a reference collection of Wisconsin rock. Wisconsin is particularly well situated for purposes of this study because every major Precambrian rock suite in the eastern Midcontinent except for the Eastern Rhyolite-Granite suite (1420-1500 Ma; Bickford and others, 1986) is exposed in or near Wisconsin (See Anderson, 1983; Sims and Peterman, 1983; 1986 for additional overviews of regional geology). Wisconsin also has a well-exposed and nearly complete lower Paleozoic section. The reference collection, at the time this study was done, numbered 236 specimens, of which 204 were measured for density. Magnetic susceptibilities were determined for 114 specimens, including most of the Precambrian specimens and a representative sampling of cover rock. Results are presented in tables 1-3, along with published data from other sources. The sample collection has been assembled as opportunity permitted, and is not exhaustive; Archean and Keeweenawan rock is particularly under-represented. Nevertheless, the data published here should serve a useful purpose in reducing uncertainties in geophysical interpretation and perhaps in inspiring additional data gathering. Density values from previous studies (about 1000 values) aid greatly in filling gaps in our own sample collection.

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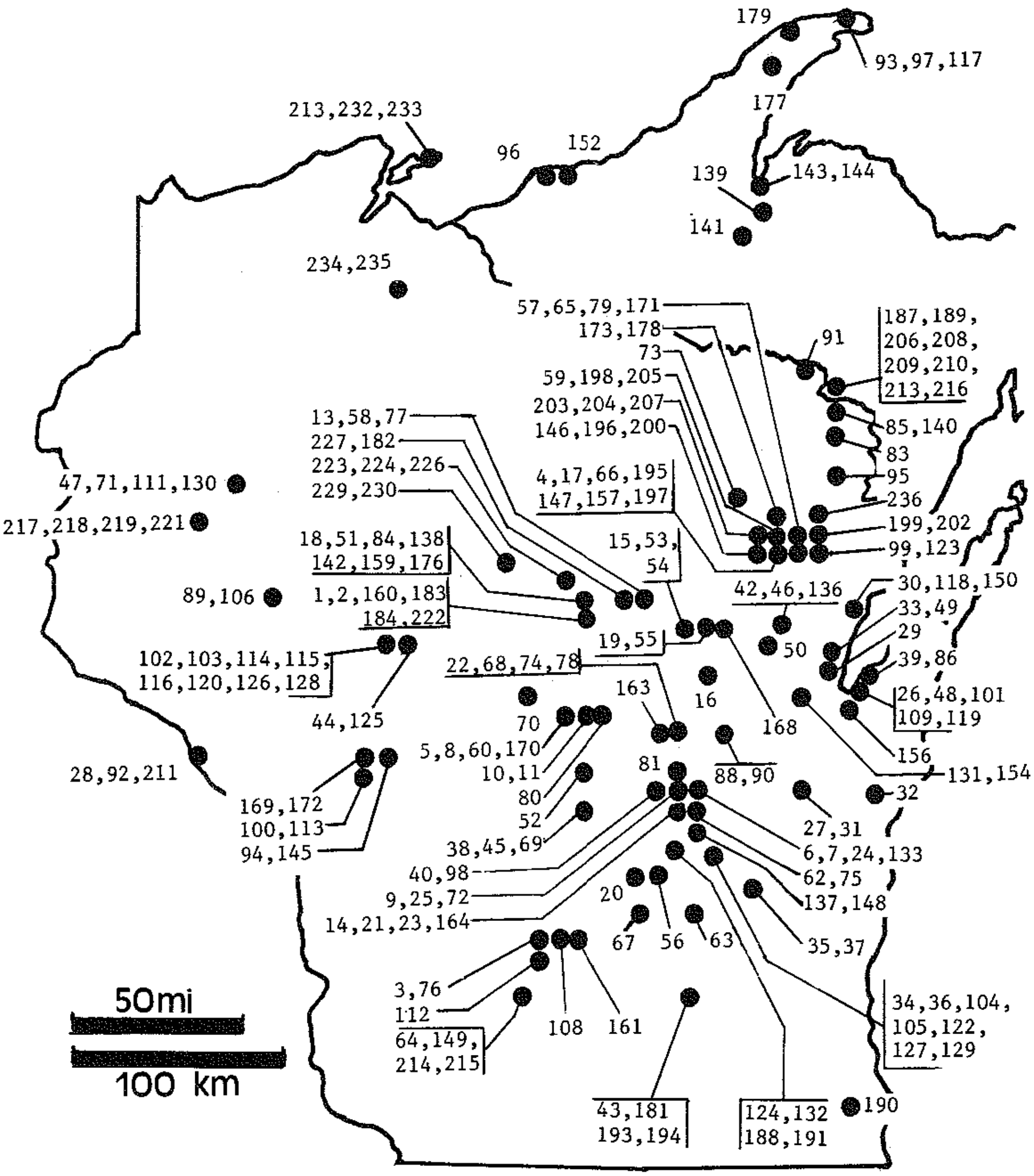

Figure 1. Map of Wisconsin and northern Michigan showing localities of samples measured by authors.

METHODOLOGY

Density was determined by two methods. About 80 samples were measured by differential weighing in water and in air (Jolly balance method) with porous rock like sandstone being soaked for several hours before weighing in air. There was no significant difference in density between samples soaked for 24 hours and samples of the same rock soaked for one or two hours, so we conclude that the effect of trapped air is negligible. The coarseness of most Wisconsin sandstone accounts for the high permeability of the specimens. In addition, the full sample suite was measured by volumetric displacement. In general, densities determined by the two methods agreed to within 0.5 percent.

The apparatus for determining sample volume consisted of a pair of identical water-filled basins connected by a siphon. A sample was placed in one basin and displaced water ran through the siphon to the second basin, which was situated on a digital laboratory scale. The weight of water added to the second basin is proportional to the volume displaced by the specimen. The total volume of the sample is twice the volume of water displaced into the second basin. The apparatus was calibrated by adding known volumes of water from a volumetric flask to the sample basin; this calibration accounted for both instrumental errors and temperature corrections for the density of water.

The method described above offers several advantages: it is considerably faster and more convenient than the conventional method of using a balance with two pans. It seems to be much more suitable for large specimens (almost all samples weighed over 100 g, most were about 500 g), and large specimens are more likely to be representative of the rock as a whole. Finally, some sources of error, such as adhering water and sample loss in handling, are easier to control using our technique.

Magnetic susceptibility was determined using a Bison Model 3101 magnetic susceptibility meter. Samples were crushed to 1 cm or smaller and placed in glass or plastic vials (which measurements showed to have zero magnetic susceptibility). The instrument is calibrated for cylindrical (core) samples 2.54 cm in diameter by 7.62 cm long, and samples of other sizes must be corrected for length and cross-sectional area. In addition, corrections for void spaces in crushed samples are necessary. The full corrections are:

$$(1)\quad k = R\,(7.62/L)\,(2.54/D)^2\,(C/W)$$

where k is the true magnetic susceptibility, R is the reading from the instrument, L is the length of the sample in cm, D is the sample diameter in cm, C is the density of the rock and W the bulk density of the crushed sample. We can multiply numerator and denominator by $\pi/4$ and combine terms to obtain:

$$(2)\quad k = R\,C\,(\pi/4 * 2.54^2 * 7.62)/M$$

or

$$(3)\quad k = 38.611\,R\,C/M$$

where M is the weight of the sample. Even though all length terms have vanished in equation (3), it is still based on the assumption of a cylindrical specimen and should not be uncritically applied to irregular specimens.

The magnetic susceptibility meter is an inductance bridge. Susceptibility is read on a dial in terms of 10^{-6} cgs units. In this paper, magnetic susceptibilities will be reported as multiples of 10^{-6} cgs units. SI and cgs units differ only by a simple constant:

$$(4)\quad k(SI) = 4\ k(cgs) = 12.566k(cgs)$$

Repeated measurements on specimens suggest that the measurements are repeatable to about 10^{-5} cgs units or about 10 dial gradations. This level of error is insignificant for most crystalline rock but is significant for weakly magnetic cover rock. Because the Bison instrument drifts, the meter was re-zeroed for each measurement.

Statistical summaries of density and magnetic susceptibility of major rock suites are presented in tables 2 and 3. For density, table 2 tabulates minimum, mean, and maximum values. Magnetic susceptibility is much more variable than density; it can vary significantly within a single outcrop, be greatly reduced by weathering or alteration, or be increased greatly by small increases in magnetite content. Magnetic susceptibility readings showed such wide scatter that the arithmetic mean is not a suitable measure of central tendency because it can be greatly skewed by outliers. Accordingly, magnetic susceptibility data are tabulated in table 3 in terms of the median and logarithmic mean. For larger sample collections, quartile values are also tabulated.

PREVIOUSLY PUBLISHED DATA

There is a large amount of published density data for Midcontinent rock in early reports of state geological surveys. These data were collected primarily in connection with reports on the dimension stone and aggregate industries. In some cases as well, it appears that density distinctions were also used to separate fine-grained igneous rock types before the advent of widespread thin-section analysis. The determination of density (usually by the Jolly balance or differential-weighing method) is straightforward and there is no reason to doubt that these values compare favorably in quality with contemporary measurements. The more recent data of Cain (1964), Leney (1966) and Carlson (1972) was collected for geophysical or petrographic studies.

Magnetic susceptibility values are not nearly as abundant in the literature, and tend to have been collected for two purposes: modelling a specific magnetic anomaly or determining the range of susceptibilities of various rock types. There seem to be few surveys of susceptibility aimed at tabulating reference values for regional geophysical interpretation. One such survey (Allingham, 1964) will be discussed later.

Table 1. Density and magnetic susceptibility of rocks from Wisconsin and northern Michigan. Density in gm/cm^3, susceptibility in 10^{-6} cgs units. All localities in Wisconsin unless otherwise noted.

SAMPLE NO.		LITHOLOGY	LOCALITY	T	R	DENSITY	k
ARCHEAN							
Black River Falls Area							
94		IF	Black River Falls	21N	03W	3.04	1968
145		GGN	Black River Falls	21N	03W	2.60	120
169		GN	Black River Falls	21N	04W	2.64	341
172		GR	Black River Falls	21N	04W	2.61	67
South-Central Wisconsin							
10		MIG	W of Stevens Point	23N	07E	2.63	
11		MIG	W of Stevens Point	23N	07E	2.66	448
60		GR	Biron	23N	06E	2.73	881
5		(1)	Biron	23N	06E	2.61	
8		(1)	Biron	23N	06E	2.60	273
80		(2)	Whiting	23N	08E	2.63	61
Northern Wisconsin and Michigan							
234		GAB	S of Mellen	44N	02W	2.98	766
	High Bridge	GR	(B)	45N	03W	2.67	
		GGN	MI (L12, Mean of 5)	40N	30W	2.63	
PENOKEAN SUPRACRUSTAL ROCK							
Northern Michigan Metavolcanic and Metasedimentary Suite							
139		MB	Alberta MI	49N	33W	2.77	188
141		MB	Covington, MI	48N	34W	2.83	140
	Michigamme	SL	MI (L2, Min. of 98)	40N	30W	2.17	
	Michigamme	SL	MI (L2, Mean of 98)	40N	30W	3.00	
	Michigamme	SL	MI (L2, Max. of 98)	40N	30W	3.72	
187	Vulcan	IF	Groveland Mine MI	40N	30W	3.19	
189	Vulcan	IF	Groveland Mine MI	40N	30W	3.35	
208	Vulcan	IF	Groveland Mine MI	40N	30W	3.53	
208	Vulcan	IF	Groveland Mine MI	40N	30W	3.05	
	Vulcan	IF	MI (L2, Min. of 103)	40N	30W	2.87	
	Vulcan	IF	MI (L2, Mean of 103)	40N	30W	3.44	
	Vulcan	IF	MI (L2, Max. of 103)	40N	30W	3.87	
206	Felch	(3)	Groveland Mine Mi	40N	30W	2.94	
	Felch	QZ,Phy	MI (L2, Min. of 48)	40N	30W	2.22	
	Felch	QZ,Phy	MI (L2, Mean of 48)	40N	30W	2.72	
	Felch	QZ,Phy	MI (L2, Max. of 48)	40N	30W	3.22	
210	Randville	(4)	Groveland Mine MI	40N	30W	2.89	
	Randville	(4)	MI (L2, Min. of 32)	40N	30W	2.67	
	Randville	(4)	MI (L2, Mean of 32)	40N	30W	2.86	
	Randville	(4)	MI (L2, Max. of 32)	40N	30W	3.07	
Quinnesec Volcanics and related rocks							
83	Quinnesec	MGR	Pembine	37N	20E	2.86	357
		MR	(C2, Mean of 2)	37N	20E	2.75	
		(20)	(C2)	37N	20E	2.95	
	Quinnesec	MB	(C2, Mean of 15)	37N	20E	2.97	

SAMPLE NO.		LITHOLOGY	LOCALITY	T	R	DENSITY	k
	Quinnesec	MB	(C2, Mean of 14)	35N	17E	3.00	
	Quinnesec	MB	(C2, Mean of 3)	41N	14E	2.89	
	Quinnesec	MB	(C2, Mean of 2)	41N	13E	2.94	
		MB	(C2, Mean of 2)	36N	11E	2.97	
		MR	(C2)	36N	11E	2.65	
	Quinnesec	MR	(C2)	36N	19E	2.77	
85	Quinnesec	(5)	S of Niagara	38N	20E	2.80	152
91	Quinnesec	MB	W of Niagara	40N	18E	2.69	115
140	Quinnesec	MB	S of Niagara	38N	20E	2.94	124
	Badwater	MB	(C2)	40N	17E	2.97	
Waupee Volcanics							
12	Waupee	MB	Butler rock	31N	18E	2.84	80
197	Waupee	MB	Mountain	31N	17E	2.82	
147	Waupee	MB	Mountain	31N	17E	2.91	
157	Waupee	MB	Mountain	31N	17E	2.76	
	Waupee	MB	(C2, Mean of 6)	31N	17E	3.06	
	Waupee	MB	(C2, Mean of 2)	31N	17E	2.63	
174	Waupee	MB	Butler Rock	31N	18E	2.78	
	Waupee	(20)	(C2, Mean of 4)	32N	18E	3.06	
Marathon County Mafic Suite							
13		(6)	Eau Claire Dells	29N	10E	3.00	2713
223		MB	Little Chicago	30N	06E	2.76	225
226		(7)	Little Chicago	30N	06E		91
227		MB	SW Eau Claire Dells	29N	09E	2.94	115
229		AM	Goodrich Dells	31N	03E	2.94	168
Marathon County Felsic Suite							
58		(8)	Eau Claire Dells	29N	10E	2.66	704
77		(8)	Eau Claire Dells	29N	10E	2.54	2430
224		MR	Little Chicago	30N	06E	2.65	65
Post-Volcanic Sediments							
51	Marshall Hill	MCG	Brokaw	29N	07E	2.84	3518
159		(9)	Brokaw	29N	07E	3.01	
176	Marshall Hill	MCG	Brokaw	29N	07E	2.78	3633
Penokean (?) Mafic Intrusive Rocks							
		AM	(C2, Mean of 5)			2.93	
		GAB	(C2)	33N	18E	2.99	
		GAB	(C2)	33N	18E	2.77	
		GAB	(C2)	31N	17E	3.01	
		DIO	(C2, Mean of 2)	33N	18E	2.91	
		DIO	(C2, Mean of 2)	31N	17E	2.90	
		DIO	(C2, Mean of 3)	35N	20E	2.77	
		MD	(C2)	35N	17E	2.93	
		MD	(C2, Mean of 3)	36N	15E	3.04	
		MD	(C2)	36N	11E	2.83	
		AM	(C2, Mean of 3)	33N	12E	2.99	

SAMPLE NO.		LITHOLOGY	LOCALITY	T	R	DENSITY	k
Penokean Gneissic Rocks							
	Dunbar	GGN	(C2, Mean of 4)			2.62	
	Dunbar	GGN	(C2, Mean of 4)			2.72	
	Dunbar	GGN	(C2)	37N	16E	2.70	
	Dunbar	GGN	(C2, Mean of 4)	38N	16E	2.64	
	Dunbar	GN	(C2, Mean of 3)	38N	16E	2.98	
	Dunbar	GGN	(C2, Mean of 2)	39N	15E	2.59	
	Dunbar	GGN	(C2, Mean of 3)	39N	14E	2.65	
	Dunbar	GGN	(C2, Mean of 3)	38N	13E	2.77	
	Macauley	GGN	(C2)	31N	17E	2.69	
		GN	(C2, Mean of 4)	37N	10E	2.80	
		AM	(C2, Mean of 3)	37N	10E	2.90	
		AM	(C2, Mean of 3)	36N	15E	2.90	
		GN	(C2, Mean of 2)	37N	13E	2.71	
		AM	(C2, Mean of 4)	40N	15E	2.88	
Penokean Granitic Rocks							
95	Amberg	QMZ	Amberg	35N	20E	2.63	
216							
	Amberg	QMZ	(C2, Mean of 6)	35N	20E	2.67	
199		GR	Johnson Falls Dam	32N	19E	2.68	
202		GR	Johnson Falls Dam	32N	19E	2.67	
230		(1)	Goodrich Dells	31N	03E	2.63	
366							
236	Pomeroy	GR	Middle Inlet	33N	19E	2.64	
1057							
	Marinette	QD	(C2, Mean of 5)	38N	20E	2.71	
	Newingham	GRD	(C2, Mean of 4)	38N	20E	2.71	
	Newingham	GRD	(C1, Min. of 53)	38N	20E	2.66	
	Newingham	GRD	(C1, Mean of 53)	38N	20E	2.70	
	Newingham	GRD	(C1, Max. of 53)	38N	20E	2.74	
	Hoskin Lake	GR	(C2, Mean of 16)	38N	19E	2.67	
	Twelvefoot F.	QD	(C2, Mean of 2)	36N	19E	2.90	
	Athelstane	QMZ	(C2, Mean of 3)	35N	20E	2.64	
	Athelstane	QMZ	(C2, Mean of 9)	33N	20E	2.74	
		GR	(C2, Mean of 2)	34N	18E	2.64	
		GR	(C2, Mean of 3)	34N	16E	2.69	
		GR	(C2, Mean of 2)	34N	17E	2.69	
		GR	(C2)	34N	18E	2.72	
	Undivided	GR	(B, Mean of 6)			2.68	
	St Cloud, MN	GR	(B, Mean of 3)			2.68	
POST-PENOKEAN RHYOLITE-EPIZONAL GRANITE TERRAIN							
Metaluminous Granites							
88	“Cactus Rock”	GR	New London	22N	14E	2.55	
490							
90	“Cactus Rock”	GR	New London	22N	14E	2.56	
22		GR	Waupaca	22N	12E	2.64	

SAMPLE NO.		LITHOLOGY	LOCALITY	T	R	DENSITY	k
159							
24		GR	Poy Sippi	19N	13E	2.65	573
6		CGR	Poy Sippi	19N	13E	2.61	
7		CGR	Poy Sippi	19N	13E	2.70	1179
72		GR	Pine River	19N	12E	2.69	2258
9		CGR	Pine River	19N	12E	2.63	2024
81		GR	Saxeville	20N	12E	2.57	603
25		GR	Mount Morris	19N	12E	2.66	220
21		GR	Redgranite	18N	12E	2.56	300
164		GR	Redgranite	18N	12E	2.64	2268
14		MD	Redgranite	18N	12E	3.04	138
23		MD	Redgranite	18N	12E	2.85	161
		GR	Waushara (B, 2 samples)			2.64	
20		GR	Montello	15N	10E	2.63	490
		GR	Montello (B, 2 samples)			2.64	
Metaluminous Rhyolites							
75		(10)	Berlin	17N	13E	2.45	149
62		RHY	Berlin	17N	13E	2.71	2388
		RHY	Berlin (B, mean of 4)			2.64	
63		RHY	Utley	13N	13E	2.68	1681
161		RHY	NE of Baraboo	12N	07E	2.62	1411
		RHY	NE of Baraboo (H)	12N	07E	2.66	
Peraluminous Rhyolites							
56		RHY	Marquette	15N	11E	2.59	1939
		RHY	Marquette	15N	11E	2.65	
67		RHY	Marcellon	13N	10E	2.57	445
Unclassified							
68		RHY	Waupaca	22N	12E	2.72	2668
74		RHY	Waupaca	22N	12E	2.78	3489
78		(11)	Waupaca	22N	12E	2.53	142
	Baxter Hollow	GR	(H, mean of 3)	11N	06E	2.63	
	Denzer	DIO	(H, 2 samples)	10N	05E	2.83	
POST-PENOKEAN EPICRATONIC QUARTZITES (BARABOO INTERVAL)							
McCaslin Syncline							
4	Baldwin	CGL	Mountain	31N	17E	2.69	
66	Baldwin	CGL	Mountain	31N	17E	2.65	310
73	McCaslin	QZ	Carter	34N	15E	2.57	108
82		(12)	Mountain	31N	17E	2.55	
79	Thunder Mtn	MGR	Thunder Mtn	32N	18E	2.70	150
173	Thunder Mtn	QZ	Thunder Mtn	33N	17E	2.64	462
178	Thunder Mtn	QZ	Thunder Mtn	33N	17E	2.68	
	Thunder Mtn	QZ	(C2, Mean of 3)	33N	17E	2.68	
Rib Mtn							
1	Rib Mtn	QZ	Rib Mtn	28N	07E	2.61	93
2	Rib Mtn	QZ	Rib Mtn	28N	07E	2.67	112
160	Rib Mtn	QZ	Rib Mtn	28N	07E	2.63	

SAMPLE NO.		LITHOLOGY	LOCALITY	T	R	DENSITY	k
Barron							
47	Barron	QZ	Cameron	34N	10E	2.59	111
71	Barron	QZ	Cameron	34N	10E	2.58	
Central Wisconsin							
52	Hamilton Mound	QZ	Hamilton Mound	20N	07E	2.65	44
70	Powers Bluff	QZ	Bethel	24N	04E	2.56	71
Baraboo							
3	Baraboo	QZ	Rock Springs	12N	05E	2.62	
76	Baraboo	(13)	Rock Springs	12N	05E	2.72	86
	Baraboo	QZ	(H, mean of 5)			2.66	
	Dake	QZ	(H, mean of 3)	12N	06E	2.68	
	Freedom	SL,IF	(H, 2 samples)	11N	05E	2.64	
Southeastern Wisconsin							
43	Waterloo	QZ	Hubbleton	09N	13E	2.64	
181	Waterloo	MCG	Portland Quarry	09N	13E	2.66	67
193	Waterloo	QZ	Portland Quarry	09N	13E	2.66	
194	Waterloo	PHY	Portland Quarry	09N	13E	2.81	
WOLF RIVER BATHOLITH							
Northern Felsite Suite							
17	Hagar	(14)	Mountain	31N	17E	2.56	481
57	Hagar	(14)	High Falls Dam	32N	18E	2.60	186
59	Hagar	FSP	Crooked Lake	32N	17E	2.65	293
198	Hagar	FSP	Crooked Lake	32N	17E	2.64	
205	Hagar	FSP	Crooked Lake	32N	17E	2.64	
	Hagar	FSP	(C2)	32N	17E	2.67	
	Hagar	FSP	(C2)	32N	17E	2.78	
Northern Batholith							
146		GR	Mountain	31N	16E	2.64	213
171	High Falls?	GR	High Falls Dam	32N	18E	2.60	329
195		GR	Mountain	31N	17E	2.61	
196		GR	Chute Pond	31N	16E	2.61	
200		GR	Mountain	31N	16E	2.61	
	Belongia	GR	(C2, mean of 2)	31N	16E	2.64	
203		GR	Lakewood	32N	16E	2.67	
204		GR	Lakewood	32N	16E	2.77	
207		GR	Lakewood	32N	16E	2.68	
Central Batholith							
16	Wolf River	QMZ	Marion	25N	13E	2.60	53
	Wolf River	QMZ	(C2, mean of 3)	30N	15E	2.68	
19		GR	Bowler	27N	13E	2.60	500
55		GR	Bowler	27N	13E	2.72	162
163	Waupaca	QMZ	Waupaca	22N	11E	2.69	270
	Waupaca	QMZ	(B, 2 samples)	22N	11E	2.68	
	Waupaca	QMZ	(C2)			2.71	
	Red River	QMZ	(C2, mean of 3)			2.66	

SAMPLE NO.		LITHOLOGY	LOCALITY	T	R	DENSITY	k
168	Wolf River	GR	W of Shawano	27N	14E		142
182		GR	W of Aniwa	29N	09E		266
Wausau Syenite							
18	Wausau	SY	Wausau	29N	07E	2.72	
84	Wausau	SY	Wausau	29N	07E	2.66	497
138	Wausau	SY	Wausau	29N	07E	2.69	
142	Wausau	SY	Wausau	29N	07E	2.71	
Ninemile Pluton							
183	Ninemile	(15)	W of Wausau				24
184	Ninemile	GR	W of Wausau	28N	07E	2.63	119
222		MD	W of Wausau	28N	07E	2.66	500
	Wausau	GR	Wausau (B, 5 samples)			2.63	
Anorthosite and Gabbro							
15	Tigerton	ANO	E of Wittenberg	27N	12E	2.64	68
53	Tigerton	ANO	Bowler	27N	12E	2.68	639
54	Tigerton	ANO	Bowler	27N	12E	2.72	967
	Tigerton	ANO	(C2)			2.74	
65		GAB	High Falls Dam	32N	18E	2.71	761
KEEWEENAWAN							
Igneous Rocks							
152		(20)	Porcupine Mtns MI	51N	42W	2.60	188
179		(16)	Eagle River MI	58N	31E	2.70	92
235		BAS	Copper Falls St Pk	44N	02W	2.81	2703
		BAS	Calumet, MI (L1, min. of 68)			2.76	
		BAS	Calumet, MI (L1, mean of 68)			2.89	
		BAS	Calumet, MI (L1, max. of 68)			2.76	
		(16)	Calumet, MI (L1, min. of 50)			2.70	
		(16)	Calumet, MI (L1, mean of 50)			2.85	
		(16)	Calumet, MI (L1, max. of 50)			3.09	
Sedimentary Rocks							
93		CGL	Copper HBR MI	58N	28W	2.67	176
96		SS	Lake of Clouds MI	51N	43W	2.55	83
97		SS	Copper Hbr MI	58N	28W	2.36	142
117		CGL	Copper Hbr MI	58N	28W	2.67	
177		(17)	Calumet MI	56N	32W	2.97	178
231	Bayfield	SS	Madeline Is	50N	02W	2.21	31
232	Bayfield	CGL	Madeline Is	50N	02W	2.24	31
233	Bayfield	SS	Madeline Is	50N	02W	2.23	
		SS	WI (B, min. of 14)			2.62	
		SS	WI (B, mean of 14)			2.63	
		SS	WI (B, min. of 14)			2.65	
		SS	WI (B, min. of 14)			2.62	
		CGL	MI (B, min. of 10)			2.62	
		CGL	MI (B, mean of 14)			2.74	
		CGL	MI (B, max of 10)			2.84	

SAMPLE NO.		LITHOLOGY	LOCALITY	T	R	DENSITY	k
LATE PRECAMBRIAN							
143	Jacobsville	SS	L'Anse MI	50N	33W	2.21	85
144	Jacobsville	SS	L'Anse MI	50N	33W	2.23	
	Jacobsville	SS	MI (B)			2.16	
	Jacobsville	SS	MI (B)			2.29	
CAMBRIAN							
40	Undivided	SS	Mount Morris	19N	11E	2.50	57
89	Undivided	BCG	Chippewa Falls	28N	08W	2.32	
98	Undivided	SS	Mount Morris	19N	11E	2.22	
99	Undivided	SS	W of Pound	31N	19E	2.29	
100	Undivided	SS	Black River Falls	20N	04W	2.14	16
102	Undivided	SS	Fort Mc Coy	17N	03W	2.33	125
103	Undivided	SS	Fort Mc Coy	17N	03W	2.33	
106	Undivided	SS	Chippewa Falls	28N	08W	2.09	
108	Lodi	SH	Baraboo	12N	06E	2.41	34
111	Undivided	SS	Cameron	34N	10W	2.20	
112	Galesville	SS	Larue	11N	05E	2.18	
113	Undivided	SS	Black River Falls	20N	04E	2.16	
114	Undivided	SS	Fort Mc Coy	17N	03W	2.37	
115	Undivided	SS	Fort Mc Coy	17N	03W	2.41	
116	Undivided	SS	Fort Mc Coy	17N	03W	2.08	20
120	Undivided	SS	Fort Mc Coy	17N	03W	1.95	
123	Undivided	SS	W of Pound	31N	19E	2.31	
124	Jordan	SS	St Marie Quarry	16N	12E	2.09	
126	Undivided	SS	Fort Mc Coy	17N	03W	2.31	
128	Undivided	SS	Fort Mc Coy	17N	03W	2.03	
130	Undivided	BCG	Cameron				61
132	Jordan	SS	St Marie Quarry	16N	12E	2.05	
133	Jordan	SS	Poy Sippi	19N	13E	2.49	
136	Undivided	SS	Cecil	27N	17E	2.44	
137	Undivided	BCG	Berlin	17N	13E	2.10	
148	Undivided	BCG	Berlin	17N	13E	2.50	
170	Undivided	SS	W of Stevens Point	23N	06E	2.51	
211	Undivided	SS	Alma	21N	13W	2.06	
213	Undivided	SS	Groveland Mine MI	40N	30W	2.03	
216	Undivided	SS	Groveland Mine MI	40N	30W	2.47	
	Undivided	SS	MI (L2, Min. of 37)	40N	30W	2.17	
	Undivided	SS	MI (L2, Mean of 37)	40N	30W	2.42	
	Undivided	SS	MI (L2, Max. of 37)	40N	30W	2.82	
217	Undivided	SS	Ridgeland	32N	12W	2.52	
221	Undivided	SS	Ridgeland	32N	12W	2.30	
	Undivided	SS	WI (B, min. of 12)			2.50	
	Undivided	SS	WI (B, mean of 12)			2.59	
	Undivided	SS	WI (B, max. of 12)			2.63	
	Undivided	SS	MN (B, min. of 3)			2.34	
	Undivided	SS	WI (B, max. of 3)			2.38	
ORDOVICIAN							
Prairie du Chien Group							
28	Pr. Du Chien	DOL	Alma	21N	13W	2.45	
42	Pr. Du Chien	DOL	Cecil	27N	17E	2.68	52

SAMPLE NO.		LITHOLOGY	LOCALITY	T	R	DENSITY	k
46	Pr. Du Chien	DOL	Cecil	27N	17E	2.60	
0	Pr. Du Chien	DOL	Shawano	26N	16E	2.66	
92	Pr. Du Chien	DOL	Alma	21N	13W	2.35	59
	Pr. Du Chien	DOL	WI (B, min. of 4)			2.74	
	Pr. Du Chien	DOL	WI (B, max. of 4)			2.81	
	Pr. Du Chien	DOL	MN (B, min. of 3)			2.64	
	Pr. Du Chien	DOL	MN (B, max. of 3)			2.74	
188	Oneonta	DOL	St Marie Quarry	16N	12E	2.81	
191	Oneonta	DOL	St Marie Quarry	16N	12E	2.82	
Saint Peter Ss							
104	Saint Peter	SS	Ripon	16N	14E	2.32	126
105	Saint Peter	SS	Ripon	16N	14E	2.18	
122	Saint Peter	SS	Ripon	16N	14E	2.27	
127	Saint Peter	SS	Ripon	16N	14E	2.36	32
129	Saint Peter	SS	Ripon	16N	14E	2.32	
131	Saint Peter	SS	Seymour	24N	18E	2.28	39
	Saint Peter	SS	WI (B, 2 samples)			2.66	
Sinnipee Group							
30	Platteville	DOL	Stiles Junction	28N	21E	2.67	
34	Platteville	DOL	Ripon	16N	14E	2.72	85
36	Shakopee	DOL	Ripon	16N	14E	2.61	113
38	Platteville	(21)	Glovers Bluff	17N	08E	2.65	
45	Platteville	(21)	Glovers Bluff	17N	08E	2.50	83
69	Platteville	(21)	Glovers Bluff	17N	08E	2.75	
118	Platteville	SHD.	SE of Lena	28N	21E	2.47	
150	Plattev/Galena	DOL	SE of Lena	28N	21E	2.67	
154	Platteville	DOL	Seymour	24N	18E	2.75	
29	Galena	DOL	Suamico	25N	20E	2.78	
33	Galena	DOL	Brookside	26N	20E	2.74	
49	Galena	DOL	Brookside	26N	20E	2.67	80
	Plattev/Galena	DOL	WI (B, min. of 4)			2.78	
	Plattev/Galena	DOL	WI (B, max. of 4)			2.84	
	Plattev/Galena	DOL	MN (B, 2 samples)			2.77	
Maquoketa							
48	Maquoketa	DOL	Edgewater Beach	24N	21E	2.59	108
101	Maquoketa	SH	Wequiock	24N	21E	2.73	
109	Maquoketa	DOL	Green Bay	24N	21E	2.53	79
119	Maquoketa	SH	Edgewater Beach	24N	21E	2.67	
SILURIAN							
156	Neda	(18)	Kolb Corners	23N	21E	2.91	
86	Neda	(19)	Bayshore Cty Pk	25N	22E		110
26	Mayville	DOL	Wequiock	24N	21E	2.67	49
27	Mayville	DOL	High Cliff	19N	18E	2.83	76
35	Mayville	DOL	Oakfield	14N	16E	2.74	
39	Stalactitic	DOL	Bayshore Cty Pk	25N	22E	2.66	
31		DOL	Stockbridge	19N	18E	2.82	
32	Byron	DOL	Grimms	19N	22E	2.73	
37	Byron	DOL	Oakfield	14N	16E	2.70	

SAMPLE NO.		LITHOLOGY	LOCALITY	T	R	DENSITY	k
190	Racine	DOL	Racine	03N	21E	2.30	
	Undivided	DOL	WI (B, min. of 14)			2.70	
	Undivided	DOL	WI (B, mean of 14)			2.82	
	Undivided	DOL	WI (B, max. of 14)			2.86	
POST-PALEOZOIC (CRETACEOUS-TERTIARY?)							
44	"Windrow"	DUR	Fort Mc Coy	17N	02W	2.33	
125	"Windrow"	DUR	Fort Mc Coy	17N	02W	2.75	
64		DUR	N of Spring Green	09N	04E	2.72	132
149		DUR	N of Spring Green	09N	04E	2.79	
214		DUR	N of Spring Green	09N	04E	2.76	
215		DUR	N of Spring Green	09N	04E	2.85	
218		DUR	Ridgeland	32N	12E	2.52	
219		DUR	Ridgeland	32N	12E	2.58	

Table includes samples from previous studies, with source indicated under locality. These samples are not shown on Figure 1 but their location may be estimated by reference to plotted samples. Township locations determined from locality descriptions in original sources.

Explanation of Lithology Abbreviations used in table.

AM	Amphibolite
ANO	Anorthosite
BAS	Basalt
BCG	Basal Conglomerate
CGL	Conglomerate
CGR	Cataclastic Granite
DIO	Diorite
DOL	Dolomite
DUR	Duricrust
FSP	Feldspar Porphyry Felsite
GAB	Gabbro
GGN	Granitic gneiss
GN	Gneiss
IF	Iron formation
MB	Metabasalt
MCG	Metaconglomerate
MD	Mafic Dike
MGR	Metagreywacke
MIG	Migmatite
MR	Metarhyolite
PHY	Phyllite
QD	Quartz Diorite
QMZ	Quartz Monzonite
QZ	Quartzite
SH	Shale
SHD	Shaly Dolomite
SL	Slate
SS	Sandstone
SY	Syenite

(1)	Foliated Tonalite
(2)	Lineated Gneiss
(3)	Biotite Schist
(4)	Dolomite Marble
(5)	Cataclastic Metasediment
(6)	Sheared Amphibolite
(7)	Metabasalt Fault Breccia
(8)	Cataclastic Metarhyolite
(9)	Epidote
(10)	Weathered Metarhyolite
(11)	Fragmental Rhyolite
(12)	Vein Quartz
(13)	Quartzite Breccia
(14)	Quartz Porphyry Felsite
(15)	Granite Grus
(16)	Amygdaloidal Basalt
(17)	Copper Conglomerate
(18)	Oolitic Iron Formation
(19)	Iron-rich Clay
(20)	Mafic Tuff
(21)	Dolomite Breccia, possibly impact crater fallback

References:

B. Buckley, 1896, Table V, p. 400-403 and XI, p. 413-414
L1. Lane, 1911, p. 98-99
L2. Leney, 1966, p.402
H. Hinze, 1959, p. 420
C1. Cain, 1964, p. 535
C2. Carlson, 1974, p. 20-22

About 25 samples of various lithologies from this study were also measured by David Crimley at the University of Illinois-Champaign/Urbana using a Barrington surface probe. His measurements substantially agreed with this study for samples with large values of k (over 100), but were considerably lower for those samples with low k. Values of k on the order of a few tens are at the lower limit of sensitivity of the Bison instrument used in this study, and should be viewed as accurate to an order of magnitude only. The comparison measurements suggest that k values in the range of 0 to 50 reported in this study probably are systematically high. Some high values of k in Paleozoic cover rock might be due to detrital magnetite, especially in lower Cambrian units, or to pyrrhotite in shale and carbonate units.

Table 2. Density Ranges of Principal Midcontinent Rock Types

AGE OR FORMATION	STATE	N	MIN.	MEAN	MAX.	STD	REF.
ARCHEAN							
gneiss, granite	MI,WI	15	2.61	2.64	2.73	.035	D,B1,L2
PENOKEAN (1800 MY)							
Michigamme slate	MI	98	2.18	3.00	3.72	.281	L2
Vulcan iron fm	MI	103	2.88	3.44	3.88	.247	L2
Felch Formation	MI	49	2.22	2.72	3.57	.266	L2
Randville dolomite	MI	32	2.67	2.86	3.07	.082	L2
undivided granite	WI	114	2.63	2.69	2.74	.028	D,B1,C1,C2
St. Cloud Granite	MN	3	2.63	2.68	2.71	.044	B1
mafic metavolcanic	WI	58	2.70	2.95	3.06	100	D,C2
felsic metavolc.	WI	7	2.55	2.67	2.77	.074	D,C2
post-volc. metased.	WI	2	2.79		2.85		D
RHYOLITE/EPIZONAL							
granite terrain	WI	34	2.54	2.64	2.78	.052	D,B1,H1
BARABOO INTERVAL							
quartzites	WI	28	2.55	2.65	2.72	.042	D,H1,C2
WOLF RIVER (1500 MY)							
granitic rocks	WI	36	2.57	2.65	2.72	.025	D,B1,C2
Wausau Syenite	WI	2	2.67	2.70	2.72	.015	D
anorthosite/gabbro	WI	5	2.65	2.69	2.72	.030	D,C2
KEEWEENAWAN (1100 MY)							
ss and cgl	MI,MN,WI	29	2.36	2.65	2.89	NA	D,B1,L1
massive basalt	MI	70	2.61	2.88	3.09		D,L1
amygdaloidal basalt	MI	51	2.70	2.85	3.09		D,L1
Bayfield Ss	WI	3	2.21	2.23	2.24	.002	D
PRECAMBRIAN Z							
Jacobsville Ss	MI	4	2.16	2.22	2.29	.035	D,B1
Jacobsville Ss	MI			2.77			H2
CAMBRIAN							
undivided ss	MI,MN,WI	82	1.96	2.39	2.83	.183	D,B1,L2
Mount Simon Ss	MI			2.58			H2
Eau Claire Fm	MI			2.67			H2
Dresback Ss	MI			2.69			H2
Franconia Ss	MI			2.72			H2
Trempeleau Fm	MI			2.82			H2
CAMBRO-ORDOVICIAN							
undivided ls	MO	7	2.77	2.79	2.80	.013	B2
ORDOVICIAN							
Prairie cu Chien	MI			2.70			H2
Prairie du Chien	MN,WI	14	2.36	2.69	2.83	.137	D,B1
Saint Peter	MI			2.63			H2
Saint Peter	WI	8	2.19	2.38	2.66	.054	B1
Glenwood Fm	MI			2.54			H2
Black River Fm	MI			2.71			H2

AGE OR FORMATION	STATE	N	MIN.	MEAN	MAX.	STD	REF.
Trenton Fm	MI			2.70			H2
Utica Shale	MI			2.71			H2
Sinnipee Group	MN,WI	18	2.51	2.72	2.84	.083	D,B1
Galena	IL	17	2.45	2.66	2.75	.071	K
Platteville	IL	21	2.52	2.70	2.79	.068	K
Maquoketa/Richmond	IL	5	2.66	2.72	2.79	.053	K
Maquoketa Fm	WI	4	2.54	2.63	2.74	.0088	D
SILURIAN							
Cataract Fm	MI			2.59			H2
Niagaran, Edgewood	IL	71	2.39	2.65	2.71	.082	K
Niagaran	MI			2.71			H2
Evaporites	MI		2.16	2.25	2.34		H2
Salina Fm	MI			2.79			H2
Bass Island Dol	MI			2.89			H2
undivided dolomite	WI	22	2.29	2.77	2.86	.124	D,B1
undivided ls	MO	2	2.71	2.74	2.76	.022	B2
DEVONIAN							
Bois Blanc Fm	MI			2.64			H2
Dundee Ls	MI			2.81			H2
Bell Shale	MI			2.59			H2
Traverse Fm	MI			2.71			H2
Antrim Shale	MI			2.48			H2
Berea Ss	MI			2.62			H2
MISSISSIPPIAN							
Sunbury Shale	MI			2.45			H2
Coldwater Shale	MI			2.63			H2
Marshall Ss	MI			2.48			H2
undivided ls	MO	10	2.62	2.69	2.76	.039	B2
Burlington Fm	IL	8	2.54	2.62	2.66	.040	K
St Louis/Salem Fm	IL	17	2.56	2.68	2.72	.037	K
St Geniveve Fm	IL	5	2.69	2.69	2.70	.005	K
Menard Fm	IL	4	2.63	2.67	2.70	.031	K
PENNSYLVANIAN							
undivided ls	MO	4	2.45	2.61	2.69	.094	B2
undivided ss	MO	5	2.457	2.65	2.70	.097	B2
McLeansboro Fm	IL	6	2.60	2.66	2.71	.039	K
undivided ss	IL	2	2.70		2.79		K
JURASSIC							
undivided	MI			2.47			H2

All Michigan data are for the northern peninsula except for those of Hinze and others, 1978.

References:

B1. Buckley, 1896, Table V, pp. 400-403 and XI, pp. 413-414
B2. Buckley and Buehler, 1904, Table VII, p. 317
C1. Cain, 1964
C2. Carlson, 1974
D. This paper
H1. Hinze, 1959
H2. Hinze and others, 1978
K. Krey and Lamar, 1925, Table 5, pp. 47-62
L1. Lane, 1911, pp. 98-99
L2. Leney, 1966

Table 3. Magnetic Susceptibilities of Principal Rock Types

SUITE	MIN	1STQ	MED	LOG MEAN	3RDQ	MAX	N
Archean Granites and Gneisses	61	120	341	278	881	1968	8
Penokean Rocks							
mafic metavolc.	91	115	168	188	188	2713	13
felsic metavolc.	65		704	481		2430	3
post-volc. metased.	3518			3575		3633	2
granites	216		366	437		1057	3
Rhyolite/epizonal granite terrain	142	445	1179	1914	2268	3489	19
Baraboo Interval quartzites	44	71	108	115	150	462	11
Wolf River Batholith							
granites	53	162	266	229	329	500	13
anorthosite/gabbro	68	639		423	761	967	4
Wausau Syenite			497				1
Keeweenawan Rocks							
volcanic	92		188	360		2703	3
sediments	31			72		176	5
Jacobsville Ss			85				1
Cambrian sandstones	16	20	34	41	61	125	6
Prairie du Chien	52			55		59	2
St. Peter Sandstone	32		39	54		126	3
Sinnipee Group	80	83		89	85	113	4
Maquoketa Formation	79			92		108	2
Silurian Dolomite	49			61		76	2

DENSITY VALUES OF COVER ROCK

The dominant rock types in the cover of the Midcontinent are sandstone, shale, and carbonate. Unfortunately, no true argillaceous shale was represented in the collection analyzed in this study (the samples labelled "shale" are actually dolomitic). The friability of shale and the fine porosity make accurate density determinations difficult. The gravimeter study of Hinze and others (1978) includes several shale units, but those units are deeply buried and probably unusually dense because of compaction.

Midcontinent sandstone tends to be mature, and the upper bound of sandstone density would normally be that of pure quartz (2.67 gm/cm^3). Densities are generally lower because of pore space. Only in the case of local iron cementing does the density exceed that of quartz, and such rock is volumetrically insignificant. The effects of compaction at depth are obvious from comparing the densities of surface samples of Cambrian and Ordovician sandstones with the subsurface gravimeter results of Hinze and others (1978).

Pure carbonate rock can ideally approach the density of calcite (2.71 gm/cm^3) or dolomite (2.85 gm/cm^3) but actual values are generally significantly lower because of chert, gypsum or void space. There are a few reports of carbonate rock denser than dolomite. The extra density is likely due to sulfide minerals (pyrite, marcasite, sphpalerite or galena), dense carbonate (magnesite, ankerite, or siderite) or possibly other minerals like barite. Abnormally dense carbonate is minor in volume.

On the whole, carbonate densities are near or slightly above the average density of granite. The bulk density of the Paleozoic cover, a weighted average of the high density of carbonate and the low density of clastic rock, is probably close to the average density of the basement. The low density contrast between carbonate cover and basement rock probably accounts for the weak gravity expression of many Midcontinent basement highs and lows.

DENSITY VALUES OF BASEMENT ROCK

Densities of crystalline rock determined in this study and published in older sources contain no surprises. They agree well with values typically assumed in most gravity modelling studies. The significant exception is the Keeweenawan basalt suite. The few samples measured in this study are not definitive, but the far greater number of densities reported by Lane (1911) are, especially since they were gathered during a survey of a mine and represent a considerable section of Keeweenawan rock. These data suggest that the densities of 2.95 gm/cm to 3.0 gm/cm assumed in most models of the Keeweenawan Rift System (King and Zeitz, 1971; Hinze and others, 1982; Chandler and others, 1982) are too high, and that densities of 2.85 to 2.9 gm/cm are more nearly correct. This revision is more significant than it appears, because the gravity anomalies associated with the Keeweenawan rift are due to the density contrast between the basalt and granitic basement, and the suggested density revision reduces the density contrast on the order of 20 percent. The basalts probably become denser at depth because of compression and the closure of void spaces, but the magnitude of the change is unknown.

Keeweenawan clastic rock is reasonably close to the density of 2.3 gm/cm commonly assumed in models of the Keeweenawan rift. The clastic rock of the Keeweenaw Peninsula is systematically denser than the stratigraphically higher Bayfield sandstone.

Granitic rock generally falls in the expected range 2.65-2.70 gm/cm^3. Some is slightly lighter, perhaps due to weathering, wheras granitic rock close to the quartz dioirite composition range tends to be denser than 2.70 gm/cm^3.

Cain's (1964) study is a unique contribution to Wisconsin geophysical data and one of few detailed studies of density variations in a single rock body. Cain found that the Newingham Granodiorite varied significantly in density (from 2.66 to 2.74 gm/cm^3) in a complex pattern. This result suggests that, though it may be useful to use a single assumed density for granitic rock as a first approximation, detailed gravity modelling of granitic plutons may require careful density control for accurate results.

CAUSES OF MAGNETIC SUSCEPTIBILITY IN ROCK

Grant (1985) has summarized the factors that affect magnetic susceptibility of rock. Magnetic susceptibility is largely proportional to magnetite content, and magnetite is only marginally correlatable with lithology. Factors that tend to favor high magnetic susceptibility include:

a. High total iron content;
b. Intermediate oxidation level;
c. High grade metamorphism (as Fe-silicates decompose, they often form magnetite);
d. Silica undersaturation;
e. Pelitic protolith for metamorphic rock;
f. High aluminum content in metamorphic rock;

g. Low magnesium or titanium content; and
h. High-temperature hydrothermal alteration.

Magnetite, like all minerals, competes for cations with other mineral species, and the principal competitors of magnetite are ferromagnesian silicates and non-magnetic oxides like ilmenite or hematite. Low oxidation levels favor divalent iron minerals like ferromagnesian silicates and ilmenite, whereas high oxidation levels favor hematite. Scarcity of magnesium and titanium reduces the competition for iron and thus obviously favors magnetite, and abundant aluminum (likely in pelitic metasediments) favors the formation of muscovite + magnetite as opposed to biotite.

MAGNETIC PROPERTIES OF COVER ROCK

Quartz, calcite, and dolomite are all weakly diamagnetic, with magnetic susceptibilities on the order of -2 x 10^{-6} cgs units but even miniscule amounts of magnetic minerals will produce positive susceptibilities.

Highly oxidizing conditions, including low-temperature alteration and weathering, destroy or prevent the formation of magnetite. Magnetic susceptibility in weathered specimens (75, 183) is dramatically lower than in unweathered equivalent rock. Because of the effects of oxidation and weathering, most interpretations of magnetic maps treat sedimentary cover rock as non-magnetic. The samples measured in this study support that assumption.

Keeweenawan sedimentary rock and quartzite of the Baraboo interval also shows low magnetic susceptibilities, rarely much over 100 x 10^{-6} cgs units. This low susceptibility is to be expected given the lack of Keeweenawan metamorphism and the purity of the Baraboo interval quartzite, although a few give high readings, apparently due to metamorphic magnetite. The post-Penokean Marshall Hill Conglomerate is remarkable for its high magnetic susceptibility.

MAGNETIC PROPERTIES OF BASEMENT CRYSTALLINE ROCK

Although basalt is commonly assumed to be magnetic, it can actually have quite low magnetic susceptibility. Part of the Keeweenawan rift system has weak magnetic signatures, even though strong gravity signatures indicate the presence of large amounts of mafic rock. The magnetic susceptibilities found for the few Keeweenawan basalts measured are extremely variable. On textural grounds, specimens 152 and 179, with low susceptibilities, solidified in an oxygen-rich environment and were perhaps subaerially weathered after eruption, whereas 235, with a very high susceptibility, is part of a sequence of very thick, massive flows where conditions might be more favorable for magnetite formation and preservation.

The metamorphic rock of central Wisconsin consists of Archean gneissic basement and Proterozoic mafic and silicic metavolcanic rock. Both rock suites have susceptibilities between 100 and 500 x 10^{-6} cgs units, with some indication of higher susceptibility in Archean rock. Cataclastic rock, abundant in Wisconsin, often has high susceptibility (7, 9, 13, 58, 77).

Several suites of granitic rock are represented: Penokean synorogenic rock about 1800 Ma, post-orogenic rhyolite and epizonal granite about 1700 Ma, and the 1500 Ma Wolf River Bathlith. The granitic rock is rather more magnetic than the metamorphic basement rock, with the rhyolite-epizonal granite suite showing very high susceptibilities of over 2000 x 10^{-6} cgs units.

This pattern of low susceptibility in coarse batholithic rock, increasing in fine-grained epizonal and volcanic rock, is similar to that reported by Allinghan (1964) for rhyolite and granite from the St. Francois Mountains of southeastern Missouri, the only large exposure of a widespread 1420-1500 Ma rhyolite-granite terrane that covers much of the southeastern Midcontinent. He reported susceptibilities of 0-1000 x 10^{-6} cgs units for coarse-grained granite, over 2000 x 10^{-6} cgs units for fine-grained granite near the roof of the batholith, and over 3000 x 10^{-6} cgs units for rhyolite. A rough inverse correlation between magnetic susceptibility and grain size or depth of emplacement thus appears to exist in both Wisconsin and Missouri, in rock suites of two different ages. The petrologic explanation for this pattern is not known, but it may be due to a lower degree of oxidation in the coarser (and presumably deeper) granite.

CONCLUSIONS

Most major geophysical studies of Midcontinent basement have assumed density and magnetic susceptibility values for Midcontinent rock that are in good accord with the values found in this study. Keeweenawan basalt, however, appears to be less dense than assumed in most studies. Rhyolite and epizonal granite are very magnetic and probably account for much of the magnetic fabric of the southeastern Midcontinent, as well as the high magnetic anomalies across southern Wisconsin.

It is obvious that many more values are needed, especially from basement drill holes. Density and magnetic susceptibility are neither difficult nor expensive to determine, and not even very time-consuming once a systematic procedure is established. Undoubtedly there are a large amount of data scattered throughout the literature and in theses that would be very useful if assembled.

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