16. ROCK MAGNETIC PROPERTIES OF IGNEOUS ROCK SAMPLES—LEG 45[1]

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INTRODUCTION

One of the major efforts of rock magnetic studies is to identify those physical properties which play an important role in controlling the intensity and stability of magnetic remanence. It is knowledge of these factors that enables us to determine the origin of a particular magnetic remanence and then allows us to speculate on its geophysical significance. In addition to providing information on the reliability of paleomagnetic measurements, the study of the rock magnetic parameters can sometimes provide insight into the evolution and oxidation history of the oceanic crust as a whole. The magnetic properties reported here are intensity of magnetic remanence, coercivity (median demagnetizing field), Curie temperature, saturation magnetization, weak field susceptibility, and the $J_s(T)$ behavior during heating.

EXPERIMENTAL METHODS

Intensity and directions of magnetization of the Leg 45 drill core samples were measured both on shipboard, using a Schonstedt DSM-1 digital spinner magnetometer, and at the University of Colorado, using a Schonstedt SSM-1 spinner magnetometer. AF demagnetizing was carried out on board ship with a Schonstedt single-axis demagnetizing unit, and at the University of Colorado using a two-axis tumbling AF demagnetizer. Calibration samples were given an artificial remanence (ARM) and then measured and demagnetized in both units in order to provide inter-laboratory standardization. Sampling and orientation techniques for the 2 cm × 2.5 cm minicores used in this study have been described previously (Ade-Hall and Johnson, 1976). Susceptibility measurements were made using a commercial susceptibility bridge. Curie temperatures, saturation magnetization, and $J_s(T)$ behavior were determined using a Cahn electrobalance at the University of Colorado. Heating rates were of the order of 40°C/minute and heating was done in an atmosphere of 9 per cent hydrogen and 91 per cent nitrogen gas at atmospheric pressure to avoid oxidation. The compositions of the magnetic minerals (determinations of x in $Fe_{3-x}Ti_xO_4$) were determined by electron microprobe at the Smithsonian Institution, and are described in detail in Johnson and Melson (this volume).

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RESULTS

The rock magnetic data are presented on a sample-by-sample basis in the Appendix. Table 1 presents the average values of intensity of magnetization (J_{NRM}), saturation magnetization (J_s), Curie temperature (T_c), median demagnetizing field (H_c), weak field susceptibility (k), and composition (x) in $Fe_{3-x}Ti_xO_4$) for Sites 395 and 396. Table 1 shows the average value, the standard deviation, and the number of samples measured.

Intensity of Magnetization (J_{NRM})

Figure 1 shows a histogram of the values of intensity of magnetization for Site 395. Figure 2 shows the same type of diagram for Site 396. Both sites have average values of magnetization (3.41×10^{-3}emu/cm^3 for 395 and 1.50×10^{-3}emu/cm^3 for 396) that are considerably less than the average of 24×10^{-3}emu/cm^3 obtained from fresh pillow basalts from the FAMOUS area of the Mid-Atlantic Ridge at 36°N (Johnson and Atwater, 1977). As will be argued later, this lower intensity undoubtedly occurs because these drill core samples were subjected to low-temperature oxidation of the original titanomagnetite grains. Although there are too few samples from Site 396 to attribute anything to the shape of the distribution, the samples from Site 395 (Figure 1) appear to have a distribution skewed somewhat to the right.

Saturation Magnetization (J_s)

Figure 3 shows the histogram of saturation magnetization values for Site 395. The average value for the site is 0.337 emu/g (Table 1), and the distribution in Figure 3 is skewed to the right, in a manner similar to Figure 1. Figure 4 shows the histogram of J_s values for Site 396. It is interesting that the average J_s value for Site 396 (0.175 emu/g) is, similarly to the intensity of magnetization, also less than the average value for Site 395. Comparison of the ratios of the intensity of remanence for the two sites

$$\frac{J_{NRM}(395)}{J_{NRM}(396)} = 2.3$$

with the ratio of the saturation magnetization values

$$\frac{J_s(395)}{J_s(396)} = 1.9$$

TABLE 1
Average Values for Rock Magnetic Parameters for Holes 395, 395A, and 396

	Holes 395 and 395A			Hole 396		
	Average Value	1 Standard Deviation	n	Average Value	1 Standard Deviation	n
J_{NRM} (10^{-3} emu/cm^3)	3.41	2.36	135	1.50	0.792	28
J_S (emu/g)	0.337	0.199	131	0.175	0.061	27
T_C (°C)	234.	41.9	131	273	28.6	27
H_C (oe)	395	254	131	500.	147.	28
k ($\times 10^{-3}$ emu/cm^3/oe)	2.09	3.02	42	0.927	0.430	27
x ($Fe_{3-x}Ti_xO_4$)	0.603	0.039	10	–	–	–

Note: Values listed are for pillow basalt units only; glassy samples, samples from the breccia zones, and the dolerite intrusions, were excluded.

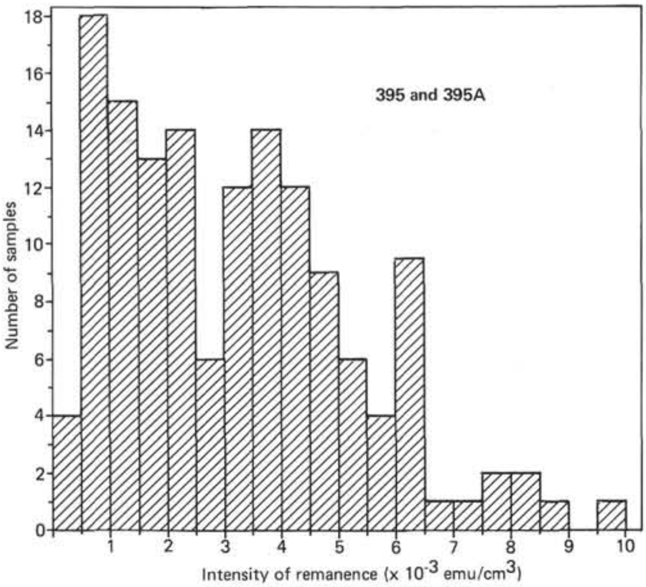

Figure 1. *Histogram showing the values for intensity of magnetic remanence (J_{NRM}) for Site 395. The average value of remanence intensity for this site is 3.41 × 10^{-3} emu/cm^3.*

seems to indicate that the reduced intensity of magnetization for site 396 with respect to Site 395 may be a result, in part, to a reduction of the saturation magnetization.

Curie Temperature (T_c)

Histograms of the Curie temperatures for Sites 395 and 396 are shown in Figures 5 and 6. Comparison of the average values of Curie temperatures for Site 395 (age 7.2 m.y.) and Site 396 (age approximately 10 m.y.) indicates that the older site is, on the average, more oxidized (Table 1). Only the Curie temperatures of pillow basalts were used for the average in the case of Site 395, and the values for the dolerite intrusions, the reheated aphyric inclusion, and the reheated breccia zones were excluded. This was done to compare the

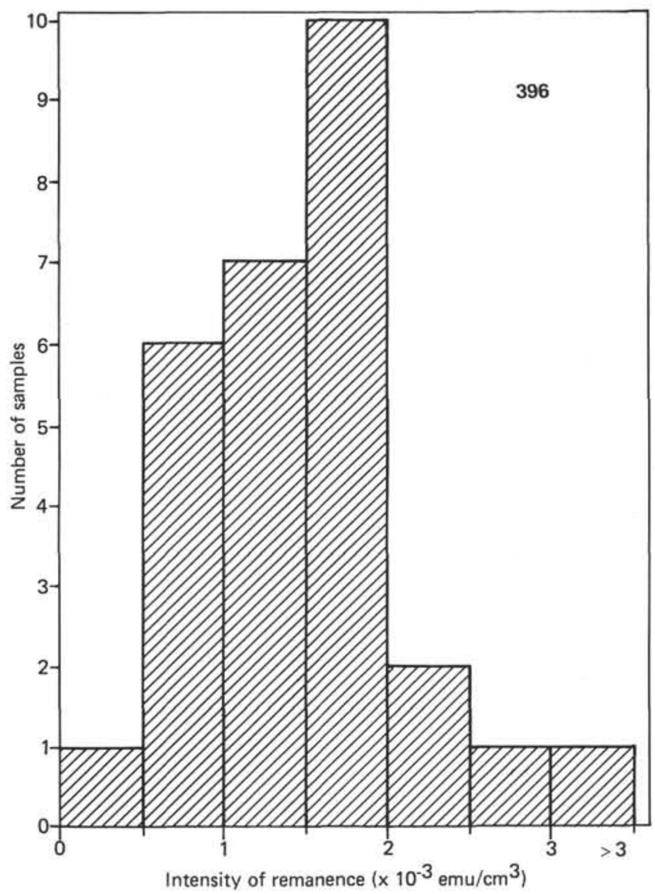

Figure 2. *Histogram showing the values for intensity of magnetic remanence (J_{NRM}) for Site 396. The average value for this site (1.50 × 10^{-3} emu/cm^3) is less than half that for Site 395.*

extent of weathering in the (presumed) permeable pillow basalt units of both sites. This increase in Curie temperature with increasing age is a consequence of progressive low-temperature oxidation of the initial titanomagnetite grains to titanomaghemite, and has been previously observed in submarine pillow basalts from the Mid-Atlantic Ridge (Irving, 1970; Schaeffer and Schwarz, 1970; Johnson and Atwater, 1977; Ryall et al., 1977).

Weak-field Susceptibility (k)

The average values of weak-field susceptibility for Sites 395 and 396 are shown in Table 1. The ratio of the two values

$$\frac{k_{395}}{k_{396}} = 2.3$$

is almost identical to the ratios for saturation magnetization and intensity of remanence for the two sites. Both sites have average values considerably less than the value of 3.8 × 10^{-3}emu/cm^3/Oe which was obtained for the fresh pillow basalts from the FAMOUS area (Johnson and Atwater, 1977).

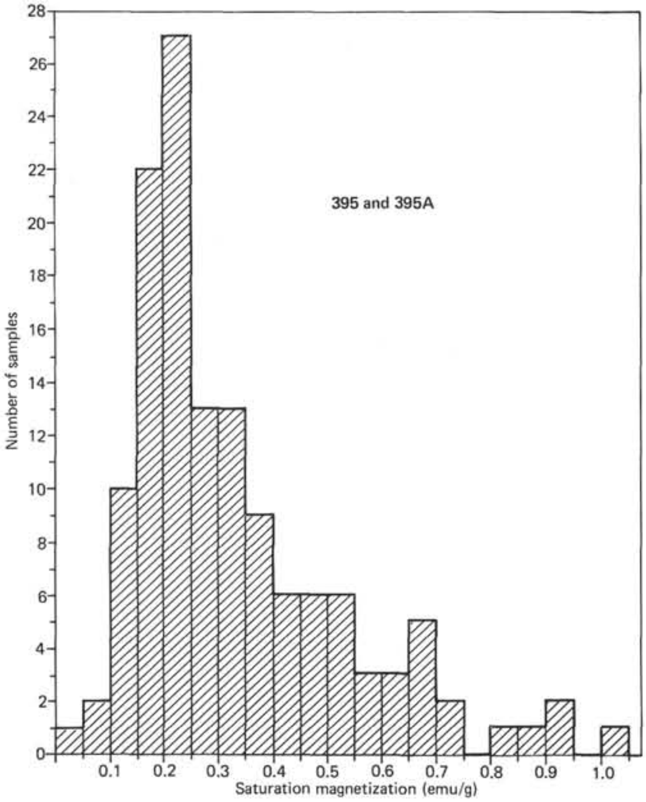

Figure 3. *Histogram of saturation magnetization* (J_S) *for Site 395. The distribution is skewed somewhat to the right, similarly to Figure 1.*

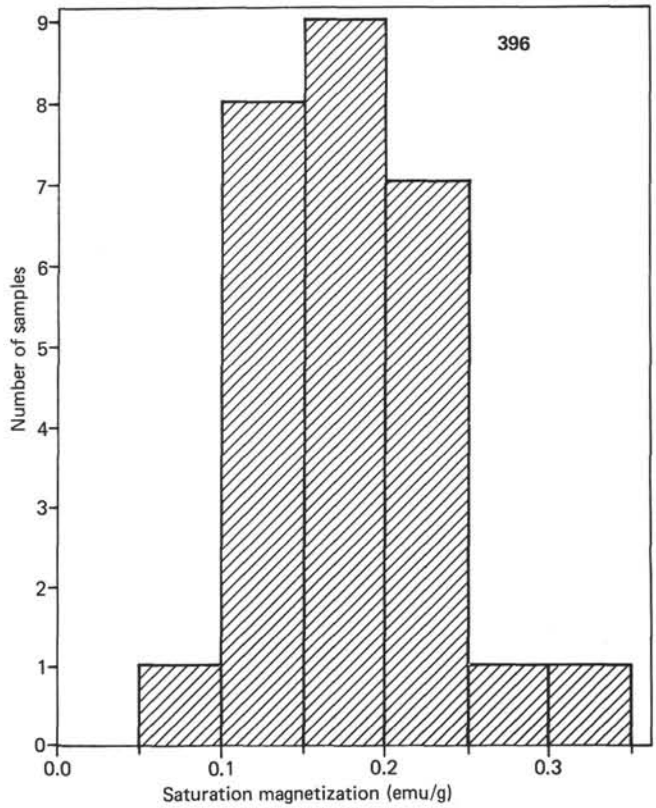

Figure 4. *Histogram of saturation magnetization* (J_s) *for Site 396. The average value for this site is about half that for Site 395.*

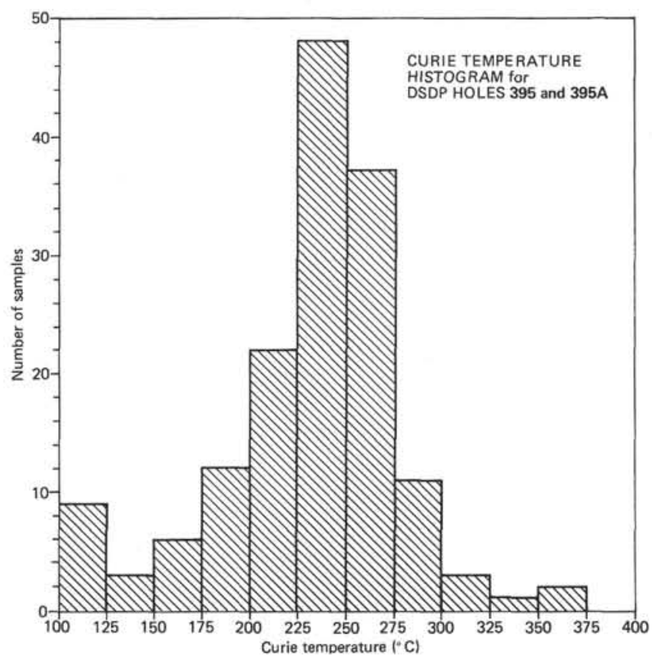

Figure 5. *Distribution of Curie temperatures for Site 395.*

Median Demagnetizing Field (H_c)

Table 1 shows the average values of median demagnetizing field for Sites 395 and 396. The older site (396) has a significantly higher MDF (H_c). Since previous work (Johnson and Merrill, 1973; Johnson and Ade-Hall, 1975; Johnson and Hall, in press) has shown that coercivity (MDF) increases with increasing degree of low-temperature oxidation, the trend (if two points can be considered a trend) with H_c in Table 1 is in agreement with the other rock magnetic parameters in indicating that the older site (396) is more oxidized.

Composition (x in $Fe_{3-x}Ti_xO_4$)

The composition of the titanomagnetite grains in 10 samples from the drill core of Site 395 was analyzed and reported in Johnson and Melson (this volume). The average value of x for these samples is shown in Table 1. This is in agreement with the average composition of titanomagnetite grains ($x = 0.62 \pm 0.05$) from submarine basalts from both the Atlantic and Pacific oceans, as compiled by Johnson and Hall (in press). It is slightly lower than, but not significantly different from, the value of $x = 0.64$ obtained by a compilation of analyses of continental tholeiitic basalts reported by Petersen (1976).

INTERPRETATION

The statistical parameters, covariance (S_{xy}) and correlation coefficient (R_{xy}), between the various rock magnetic variables, are presented in Table 2. It may be pointed out from elementary statistics that if there is a high probability that large values of x go with large values of y and small values of x go with small values of y, the covariance will be large and positive. If there

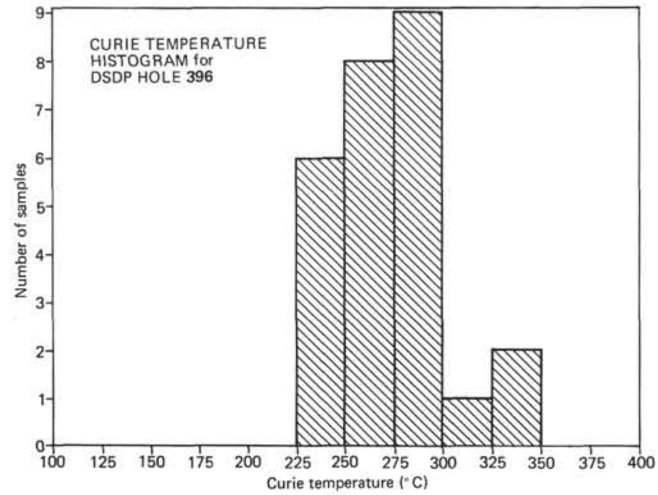

Figure 6. *Distribution of Curie temperatures for Site 396.*

is a high probability that large values of x go with small values of y and vice versa, the covariance will be large and negative. If x and y are independent, the covariance will be zero (Freund, 1962). Similarly, the correlation coefficient, R_{xy}, is a measure of the linear relationship between x and y, and $100 \times R_{xy}^2$ is the percentage of the variation in y that can be accounted for by a linear relationship with x. The 1 per cent and 5 per cent critical values of $|R_{xy}|$ shown in Table 2 are those levels of significance at which we reject the null hypothesis that the population of x's and y's has zero correlation (Crow et al., 1960). It is useful to restate at this point the two classical injunctions of statistical analyses: a strong correlation between two variables does not imply cause and effect, and the lack of correlation between two variables does not imply that they are independent.

Previous studies of submarine basalts have shown that certain trends are visible in the rock magnetic parameters with increasing age (see, for example, Johnson and Atwater, 1977, or Ryall et al., 1977). Specifically, as pillow basalts age, the increasing degree of low-temperature oxidation of the initial titanomagnetite to titanomaghemite should cause:

a) the intensity of magnetization to decrease;
b) the Curie temperature to increase;
c) the saturation magnetization to decrease;
d) susceptibility to decrease;
e) coercivity (MDF) to increase.

Table 2 shows that the drill core samples from Sites 395 and 396 also follow these same trends. With increasing Curie temperature, J_{NRM}, J_s, and k decrease and coercivity (MDF) increases. Figure 7 shows the plot of intensity of remanence as a function of Curie temperature for Site 395.

The relationship between J_{NRM} and J_s for Site 396 shown in Table 2 is an interesting example of a relatively high correlation coefficient and a covariance close to zero (the converse would imply that the variables are related, but not linearly). The reason for this is shown in Figure 8, where the relationship between J_{NRM} and J_s for Site 396 is characterized by increasing scatter in J_{NRM} with increasing J_s. While J_{NRM} would be constrained to be zero if J_s were zero, there is no obvious reason why there should be increasing scatter at higher values of both variables. Figure 8 does, however, show that the per cent variation of J_{NRM} with J_s is roughly constant, and the increasing scatter may be due to systematic experimental error. The distribution shown in Figure 8 may also be an artifact of the small number of data points for Site 396.

One of the strongest relationships shown in Table 2 is that between coercivity (or median demagnetizing field) and Curie temperature. This relationship has been pointed out previously in both natural samples (Johnson and Ade-Hall, 1975, and Johnson and Atwater, 1977) and laboratory oxidized samples (Johnson and Merrill, 1973). Figure 9 shows the relationship between coercivity and Curie temperature for the samples from both Site 395 and Site 396. This increase in stability is very probably related to the decreasing effective grain size that is a product of the formation of shrinkage cracks during low-temperature oxidation of the titanomagnetite grains (Johnson and Hall, in press). This cracking becomes very common in these samples when Curie temperatures rise much above 200°C (Johnson, opaque mineralogy of the igneous rock samples from Hole 395A, this volume).

One of the major problems of studying the magnetic properties of oceanic igneous basement has been the restriction of sampling, because of technical reasons, to the upper 600 meters. Since evidence is accumulating that the magnetic layer is thicker (perhaps considerably thicker) than this, extrapolation of data from the upper accessible part to the lower sections of the oceanic crust becomes a risky, but interesting, exercise. Table 2 shows the variation of J_{NRM} and T_c with core number for Sites 395 and 396. Core number is assumed to be proportional to penetrated depth in the igneous crust. The penetration of Holes 395 and 396 was less than 100 meters, and little significance can be attributed to these trends. Hole 395A penetrated just under 600 meters of basalt, and the decrease in intensity and the increase in Curie temperature with increasing depth make it tempting to speculate. If these trends are real, they are both in the right direction to imply that the upper part of the extrusive pillow basalts is less oxidized than the lower (and presumed older) sections of the crust. This is the same result obtained for the very young oceanic crust in the FAMOUS area of the Mid-Atlantic Ridge from comparison of surface rock samples with deep-towed and surface-towed magnetometer studies (Johnson and Atwater, 1977; Macdonald, 1977). Again, if these trends are real, they imply that this increase in oxidation state with depth, which begins during crustal formation in the median valley, is preserved even after the oceanic crust is laterally displaced 100 km over a period of 7 million years. Further confirmation of this effect would be needed to make this a convincing argument.

The magnetic mineralogy of these drill core samples is clearly typical of other samples taken from the oce-

TABLE 2
Correlations Between Magnetic Parameters and Variation with Depth for Holes 395, 395A, and 396

Variables x	Variables y	Holes	Covariance of x and y S_{xy}	Correlation Coefficient of x and y R_{xy}	Critical Values of R_{xy} 1%/5%	$y = mx + b$ m	b
J_{NRM}	T_C	395/395A	-33.5	-0.316	0.228/0.174	-6.16	253.
J_{NRM}	T_C	396	-7.2	-0.456	0.496/0.388	-24.4	306
J_{NRM}	J_S	395/395A	+0.133	+0.286	0.228/0.174	+0.0237	0.252
J_{NRM}	J_S	396	+0.0244	+0.497	0.487/0.381	+0.0374	0.119
J_{NRM}	H_C	395/395A	-206.	-0.342	0.208/0.159	-37.1	518.
J_{NRM}	H_C	396	-27.1	-0.233	0.478/0.374	-43.2	565.
J_S	T_C	395/395A	-6.6	-0.615	0.228/0.174	-167.	284.
J_S	T_C	396	-0.254	-0.146	0.487/0.381	-68.6	285
J_S	X	395A	+0.000313	+0.0660	0.765/0.632	–	–
k	T_C	395/395A	-74.4	-0.575	0.418/0.325	-6.83	263.
k	T_C	396	-2.30	-0.221	0.505/0.396	-18.4	291.
k	J_S	395/395A	+0.417	+0.853	0.418/0.325	+0.038	0.167
k	J_s	396	+0.0292	+0.175	0.487/0.381	-43.2	565
k	H_C	395/395A	-231.	-0.469	0.393/0.304	-25.3	612.
k	H_C	396	-30.5	-0.605	0.478/0.374	-260	743.
H_C.	T_C	395/395A	+6235.	+0.585	0.228/0.174	+0.0965	196.
H_C	T_C	396	+2247.	+0.527	0.487/0.381	+0.101	222.
J_{NRM}	Core Number	395	+1.06	+0.182	0.478/0.374	–	–
J_{NRM}	Core Number	395A	-13.2	-0.290	0.254/0.195	-2.54	44.6
J_{NRM}	Core Number	396	+0.984	+0.350	0.478/0.374	–	–
T_C	Core Number	395	+25.7	+0.176	0.478/0.374	–	–
T_C	Core Number	395A	+242	+0.282	0.254/0.195	+0.136	2.97
T_C	Core Number	396	+1.37	+0.0136	0.487/0.381	–	–

Note: Symbols: J_{NRM} – intensity of remanence; T_C – Curie temperature; J_S – saturation magnetization; H_C – coercivity (expressed as median demagnetizing field during AF demagnetization); X – composition in the magnetite-ulvospinel solid solution series $Fe_{3-x}Ti_xO_4$; k – weak field susceptibility: core number – refers to drill core section with the core number assumed proportional to depth penetrated by the drill.

anic crust—a high-titanium titanomagnetite partially oxidized to titanomaghemite. One of the characteristics of titanomagnetite oxidized at low temperature is that the Curie temperature increases and the $J_s(T)$ curve becomes irreversible. This irreversibility is a result of the breakdown of titanomaghemite into a low-titanium magnetite and an ilmenite phase plus one of the polymorphs of rutile (Ozima and Larson, 1970; Readman and O'Reilly, 1970; Marshall and Cox, 1972; Ozima et al., 1974; Grommé and Mankinen, 1976; Hall and Ryall, 1977). Several studies have been made to determine the degree of oxidation necessary for the $J_s(T)$ curves of submarine basalts to become irreversible. Grommé and Mankinen (1976) suggest that transition between reversible and irreversible curves occurs when Curie temperatures are somewhere between 200° and 300°C (Z = 0.4 to 0.6). Hall and Ryall (1977) introduce a third state (slightly irreversible) and indicate that slightly irreversible $J_s(T)$ curves occur in the Curie temperature range of 165° to 235°C, reversible curves below 195°C, and irreversible curves above 195°C. Using the same definitions as Hall and Ryall (1977, Figure 1), the reversibility-irreversibility of the $J_s(T)$ curves for Sites 395 and 396 are shown in Figure 10. The range of reversible, slightly irreversible, and irreversible $J_s(T)$ curves is in very good agreement with both Grommé and Mankinen (1976) and with Hall and Ryall (1977). One consequence of the results of Figure 10 is that any sort of process that heats oxidized submarine basalt samples with Curie temperatures of 175°C or higher (or 150°C for 40% of the samples), even in a controlled reducing atmosphere, can cause dramatic changes in the magnetic mineralogy. This applies to sample preparation (i.e., thin- or polished-section preparation), thermal demagnetization, and paleointensity determinations, as well as natural reheating (hydrothermal zones, contacts with intrusions, low-grade metamorphism). Heating times for the samples in Figure 10 were of the order of a few minutes, and it seems likely that heating over geologically relevant time periods would cause similar phase changes even at temperatures lower than the 150°C

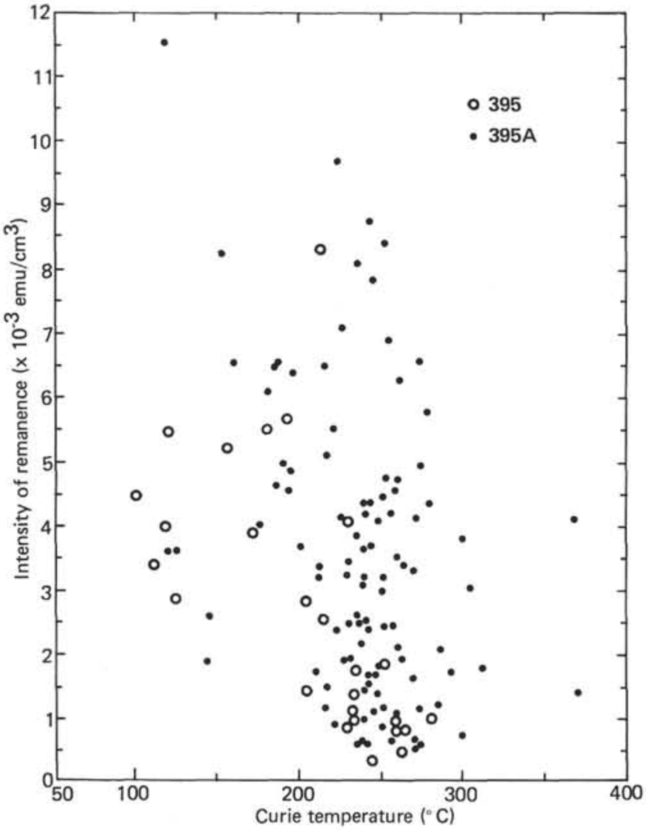

Figure 7. *Intensity of magnetization (J_{NRM}) as a function of Curie temperature for Site 395.*

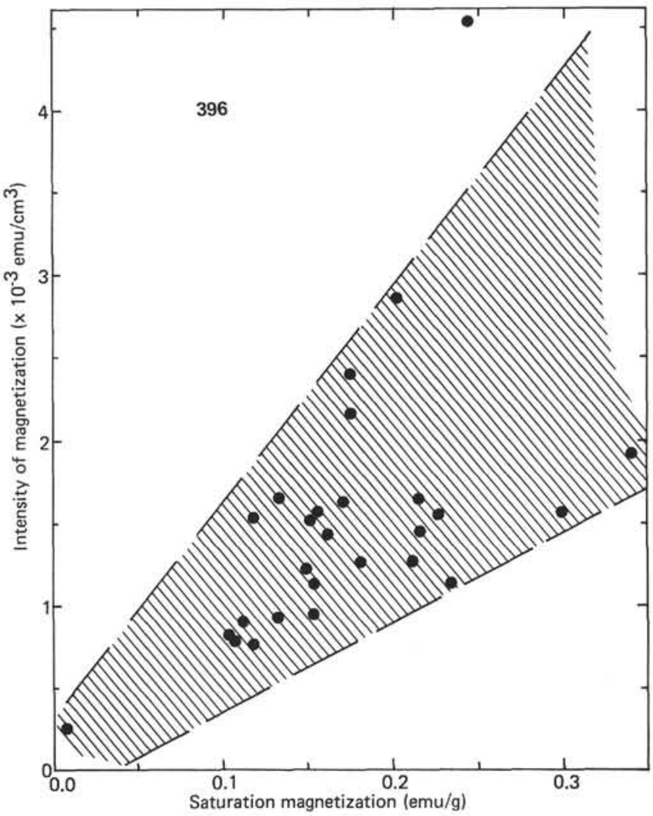

Figure 8. *Intensity of magnetization as a function of saturation magnetization for Site 396.*

that has been established for laboratory oxidation temperatures (Johnson and Merrill, 1973; Ryall and Hall, 1975a,b).

CHEMICAL REMANENT MAGNETIZATION

The ability of some types of rocks, including the coarse-grained massive flows from the Nazca plate, to acquire a directional change or chemical remanent magnetization during low-temperature oxidation, gives rise to the possibility that chemical remanence may play a role in the magnetization of the ocean crust (Johnson and Hall, 1976; Hall, 1976). The trend toward shallower inclinations with depth in Hole 395—not observed in the same rock unit in Hole 395A—makes the samples from Hole 395 likely candidates for addition of secondary magnetization components (Johnson, Paleomagnetism of igneous rock samples—Leg 45, this volume). If these shallower inclinations in the bottom of Hole 395 resulted from chemical remagnetization, then there should be a positive correlation between Curie temperature and ΔI, the difference between stable inclination and the axial, centered dipole inclination. Table 3 shows that both the covariance and the correlation coefficient are negative for Hole 395. Although the correlation coefficient is not large enough to be significant, the covariance is clearly negative. This would suggest that the trend in shallower inclinations with depth is *not* a result of the addition of a post-formation chemical remanence. Tectonic tilting subsequent to formation is the most likely explanation for the trend in inclinations in Hole 395.

For Hole 395A, the average value of ΔI is less than that for Holes 395 and 396, and the covariance is somewhat smaller but positive. Some of the lower units of Hole 395A contain some rather coarse grained samples, and it has been shown earlier that coarse-grained, multi-domain grains are more likely to undergo a direction change (addition of a CRM component) during oxidation than pillow basalts (Johnson and Hall, 1977). It is unlikely, however, that any real significance should be attributed to the positive covariance for Hole 395A in Table 3.

SUMMARY AND CONCLUSIONS

The intensity of magnetization (J_{NRM}), the saturation magnetization (J_s), and the weak field susceptibility for rock samples should all depend on (among other things) both the concentration and the intrinsic saturation magnetization of the magnetic mineral. Although other properties, like grain size, domain state and external field intensity, also play a role, for a first-order approximation and if we neglect these parameters, the above three variables should all be roughly proportional to the concentration and saturation magnetization of the magnetic mineral. The near equality

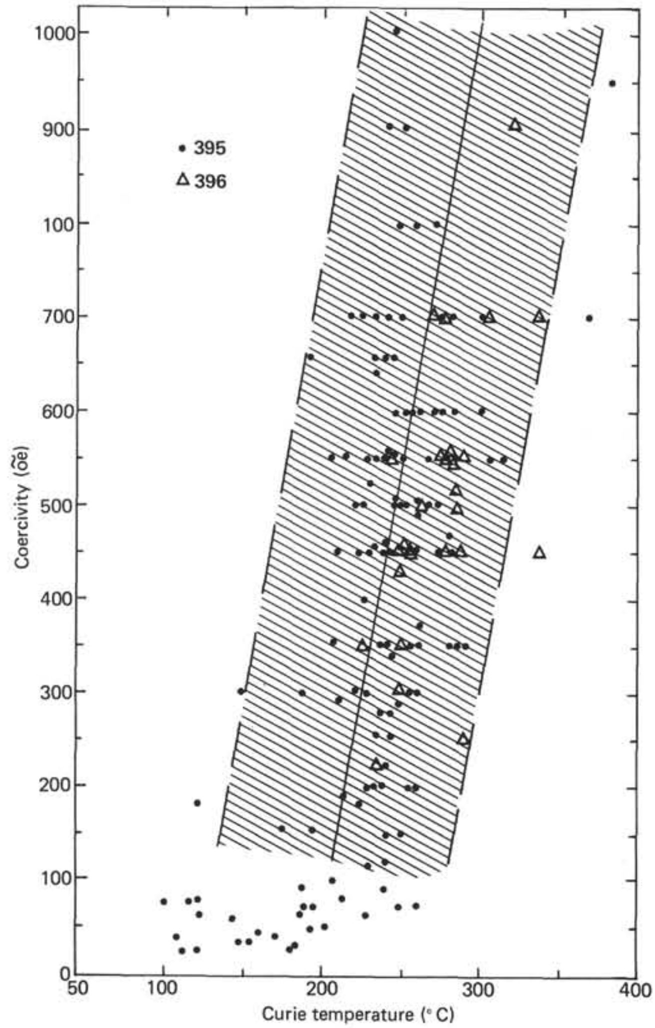

Figure 9. *Coercivity (expressed as median demagnetizing field) as a function of Curie temperature for Sites 395 and 396. Some of the higher coercivities have been rounded to the nearest 50 Oe.*

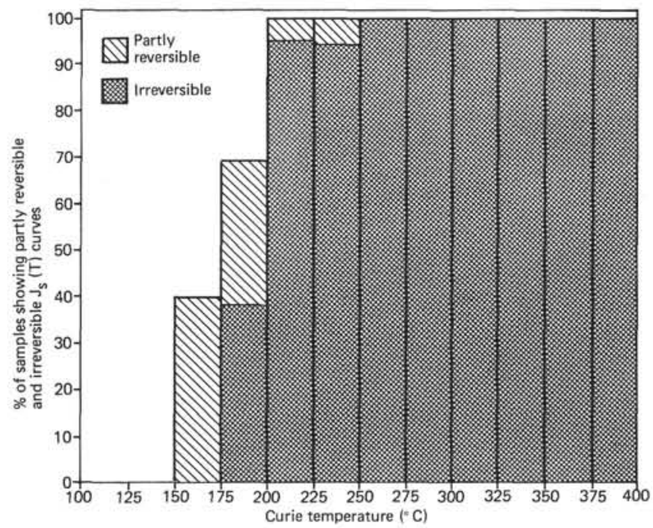

Figure 10. *Dependence of the reversibility of the saturation magnetization curves* J_s(T) *on Curie temperature for the Site 395 and 396 samples. The terms reversible, slightly irreversible, and irreversible are defined in text.*

TABLE 3
Correlations of the Difference Between the Stable Inclination and Axial Dipole Inclination (ΔI) and Curie Temperature for Holes 395, 395A, and 396

Hole	Average ΔI (°)	Number of Samples (n)	Covariance of ΔI and Tc S_{xy}	Correlation Coefficient of ΔI and Tc R_{xy}	Critical Values of R_{xy} 1%/5%
395	18.7	25	–110.	–0.208	0.505/0.396
395A	8.93	93	+41.8	+0.121	0.267/0.205
396	14.7	27	–46.0	–0.124	0.487/0.381

of the ratios of these three variable for Sites 395 and 396, as discussed earlier, should shed some light on the cause of the reduced magnetic intensity for Site 396, compared with Site 395. Since Site 396 is significantly older than Site 395, the first alternative that presents itself is that site 396 has undergone more low-temperature oxidation than Site 395. Indeed, Table 1 indicates that the average value of Curie temperatures for Site 396 (T_c = 273°C) is somewhat higher than that for Site 396 (T_c = 234°C), and that Site 396 has, on the average, undergone more low-temperature oxidation. However, the increase in Curie temperature from 234°C (oxidation parameter Z = 0.40) to 274°C (Z = 0.55) for the relevant composition of these titanomaghemites should cause a reduction of saturation magnetization of only 16 per cent (Readman and O'Reilly, 1972). The curvilinear cracks and partial replacement of the titanomaghemite grains that begin to occur in this oxidation range (Johnson and Hall, in press) could be responsible for the further reduction in intensity of magnetization, but are unlikely to reduce the saturation magnetization of the rock by a factor of 2. We are therefore left with the conclusion that although Site 396 is older and more oxidized than Site 395, at least part of the reason that Site 396 has J_{NRM}, J_s, and k values half those of Site 395 is that there was an initial difference in the average concentration of the magnetic mineral. Another possibility may be that the saturation magnetization of the magnetic mineral in the basalts of Site 396 is different than that of Site 395; but in light of the relatively uniform initial compositions of titanomagnetites from both the Atlantic and Pacific (Johnson and Hall, in press), this is unlikely.

The trends of the rock magnetic parameters of drill core samples from Sites 395 and 396 vary with increasing degree of low-temperature oxidation in the same way as those reported from other studies of submarine basalts. With increasing degree of low-temperature oxidation, the intensity of magnetization, the saturation magnetization, and the weak-field susceptibility decrease; the Curie temperature and median demagnetizing field increase. Although the data are not conclusive, there does appear to be a trend in oxidation state with depth in the long core from Hole 395A. The top of this core has a higher intensity of magnetization and lower

Curie temperature, on the average, than the bottom of the core—indicating that the top part of this section of the extrusive igneous oceanic crust may be less oxidized than the lower (at least to 600 m) section. This is the same trend that was found for the very young crust in the axial valley in the FAMOUS area (Johnson and Atwater, 1977), but more evidence is needed to establish it as a general phenomenon.

Finally, since there is no positive correlation between ΔI and Curie temperature for the samples from Hole 395, it would appear that the shallowing of inclinations with depth in that core have a tectonic rather than a chemical origin.

ACKNOWLEDGMENTS

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APPENDIX

The rock magnetic parameters of the samples from Holes 395, 395A, and 396. Rock types refer to the units defined in the text: A-aphyric basalt; P-phyric basalt; serp. perid.-serpentinized peridotite. Subscripts refer to individual units identified within the core, and are based on lithology, geochemistry, or magnetic boundaries.

APPENDIX 1

Sample (Interval in cm)	J_{NRM} Intensity ($\times 10^{-3}$ emu/cm^3)	H_C Median Demagnetizing Field (oe)	J_S Saturation Magnetization (emu/g)	T_C Curie Temperature (°C)	k Suscepti-bility ($\times 10^{-3}$ emu/cm^3/Oe)	Rock Type
Hole 395						
11-1, 49-51	0.304	350	0.145	243	–	A_2
11-1, 105-107	0.476	550	0.102	Paramagnetic	–	A_2
11-2, 3-5	0.455	350	0.245	261	–	A_2
11-2, 62-64	3.94	75	1.20	117	–	A_2
11-2, 120-122	3.37	40	0.635	110	–	A_2
12-2, 109-111	2.79	75	0.531	122	–	A_2
12-2, 123-125	0.948	200	0.218	232	–	A_2
12-2, 145-147	2.83	50	0.450	202	–	A_2
13, CC, 2-4	2.50	75	0.345	214	–	A_2
14-1, 95-97	0.853	200	0.281	229	–	A_2
14-1, 130-132	0.877	200	0.212	260	–	A_2
15-1, 71-73	1.79	75	0.441	252	–	A_2
15-1, 93-95	4.01	60	0.517	230	–	A_2
15-1, 112-114	3.82	40	0.604	172	–	A_2
15-1, 147-149	5.11	30	0.696	156	–	A_2
15-2, 7-9	5.60	75	0.911	192	–	A_2
15-2, 130-132	5.43	30	0.477	120	–	A_2
16-2, 15-17	0.970	350	0.137	280	–	A_2
16-2, 55-57	0.579	500	0.140	265	–	A_2
16-2, 131-133	5.48	30	0.462	180	–	A_2
16-3, 19-21	1.39	250	0.457	232	–	A_2
17-1, 8-10	0.675	500	0.131	260	–	A_2
17-1, 66-68	0.0181	500	0.0513	Weight loss	0.237	Recrystal-ized GABBRO
18-1, 33-35	8.23	100	0.357	212	–	P_1
18-1, 78-80	No stable remanence		0.0386	Weight loss	–	Serp. Perid.
18-1, 123-125	No stable remanence		0.202	555	–	Serp. Perid.
18-2, 90-92	No stable remanence		0.178	575	–	Serp. Perid.
19-1, 18-20	10.8	500	0.213	239	–	A_2 (contact)
19-1, 36-38	1.32	350	0.888	205	–	P_2
19-1, 77-78	1.03	630	0.347	239	–	P_2
19-1, 144-146	4.39	75	0.689	102	–	P_2
20-1, 28-30	1.72	450	0.223	235	–	P_2
Hole 395A						
3-1, 89-91	1.02	125	5.25	570	–	Serp. Perid.
4-1, 91-93	2.47	800	1.59	540	–	GABBRO
4-2, 56-58	2.42	75	6.08	568	–	Serp. Perid.
5-1, 56-58	3.52	60	0.609	122	–	A_2
5-1, 138-140	2.42	80	0.298	241	–	A_2
5-2, 6-8	2.52	60	0.393	145	–	A_2
7-1, 94-96	1.06	275	0.360	246	–	A_2
7-1, 113-116	1.03	200	0.308	260	–	A_2
8-1, 20-22	1.43	225	0.314	219	–	A_2
8-1, 114-116	0.655	375	0.206	260	–	A_2
8-1, 124-126	0.639	600	0.214	256	–	A_2
9-1, 70-72	2.46	125	0.376	239	–	A_2
9-2, 18-20	1.10	200	0.183	252	–	A_2

APPENDIX I – *Continued*

Sample (Interval in cm)	J_{NRM} Intensity ($\times 10^{-3}$ emu/cm^3)	H_C Median Demagnetizing Field (oe)	J_S Saturation Magnetization (emu/g)	T_C Curie Temperature (°C)	k Suscepti-bility ($\times 10^{-3}$ emu/cm^3/oe)	Rock Type
10-1, 132-134	0.551	600	0.143	271	–	A_2
11-1, 129-131	11.5	20	0.529	115	–	A_2
13-1, 97-99	0.855	500	0.197	251	–	P_2
13-1, 140-142	2.54	275	0.306	236	–	P_2
14-1, 139-141	4.42	150	0.737	250	–	P_2
14-2, 116-118	1.87	110	0.596	231	–	P_2
14-3, 138-140	4.59	90	0.597	187	–	P_2
15-1, 142-144	3.96	150	0.501	170	–	P_2
15-2, 39-41	4.30	150	0.373	242	–	P_2
15-2, 55-57	4.81	75	0.636	195	–	P_2
15-2, 76-78	6.27	50	0.596	197	–	P_2
15-2, 128-130	6.42	20	0.735	185	–	P_2
15-3, 83-85	6.48	40	0.688	160	–	P_2
15-4, 113-115	8.18	40	0.469	153	–	P_2
15-5, 24-26	4.78	75	0.821	192	–	P_2
16-1, 63-65	4.72	75	0.469	259	–	P_2
16-1, 89-91	3.75	600	0.171	300	–	P_2
17-1, 98-100	4.01	700	0.106	368	–	P_3
17-1, 114-116	6.21	300	0.289	261	–	P_3
18-1, 142-144	8.34	350	0.253	251	–	P_3
20-1, 125-127	7.73	275	0.219	246	–	P_3
21-1, 125-127	8.69	250	0.340	242	–	P_3
22-1, 100-102	9.62	175	0.330	224	–	P_3
22-2, 34-36	4.52	150	0.421	195	–	P_3
22-2, 106-108	7.02	300	0.296	227	–	P_3
22-2, 132-134	6.87	300	0.338	253	1.84	P_3
23-1, 72-74	6.48	800	0.159	274	–	P_4
23-1, 99-101	3.38	500	0.243	265	1.50	P_4
23-1, 120-122	3.94	700	–	–	0.903	P_4
23-1, 145-147	4.70	600	0.210	260	–	P_4
24-1, 143-145	2.92	500	0.229	251	–	P_4
24-2, 5-7	4.13	600	0.213	256	–	P_4
24-2, 69-71	2.33	400	0.232	223	–	P_4
25-1, 85-87	3.15	450	0.257	230	–	P_4
26-1, 52-54	3.36	290	0.357	212	–	P_4
26-2, 21-23	6.01	300	0.476	182	–	P_4
27-1, 121-123	3.78	200	0.416	236	–	P_4
27-2, 23-25	6.47	180	0.405	216	–	P_4
27-2, 145-147	3.16	550	0.342	211	–	P_4
28-1, 58-60	1.65	450	0.188	242	–	P_5
28-1, 117-119	2.07	500	0.260	260	–	P_5
29-1, 110-112	3.59	550	0.223	240	–	P_5
30-1, 82-84	1.76	300	0.532	146	–	P_5
30-1, 144-146	1.72	550	0.274	250	–	P_5
31-1, 90-92	1.67	550	0.160	211	–	P_5
32-1, 54-56	1.82	75	0.344	535	–	Breccia clast
32-2, 56-58	3.35	225	0.370	228	–	Breccia clast
32-2, 133-135	2.31	225	0.233	245	–	Breccia clast
33-1, 34-36	1.34	950	0.0873	370	0.658	P_5
33-2, 130-132	6.43	650	0.260	187	1.38	A_3
35-1, 85-87	3.25	700	0.174	270	1.43	A_3
36-1, 82-84	3.64	340	0.307	244	3.10	A_3
37-1, 37-39	3.36	450	–	–	2.18	A_3