A MAGNETIC SURVEY

AT PLUCKEMIN, NEW JERSEY

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A magnetic survey was made at Pluckemin, New Jersey on November 6, 1979. About 15 significant magnetic anomalies were located. While the locations of these anomalies are well-defined, they cannot yet be classified as either cultural or geological; however, test excavation of a sample would allow extrapolation to similar anomalies.

The site, in Somerset County of northern New Jersey, was evidentally a military camp during the Revolutionary War; it was a combination of a training site, forge, and artillary park. A large E-shaped structure is indicated to have been on the site. The magnetic survey gave no unambiguous clues to the location of any of the three arms of this building, although it is felt that the survey areas should have intersected it.

The area of the surveys is illustrated in Figure 1. While most of the time was spent with narrow exploratory grids, grid #1 covered a wider area and revealed an intense anomaly centered at S14E8. The average magnetic field in this grid was 56,000 nanoteslas, abbreviated nT. Over this anomaly, the magnetic field increased over 24, to 57,443 nT. From measurements on the granitic rock on the site, see Figure 2, it is suspected that buried stone rubble from building foundations would result in a magnetic anomaly much smaller, about 60 nT rather than 1400 nT. Therefore, it is suspected that this anomaly results from either buried iron-containing slag or a vein with magnetite in it. It is unfortunately not possible to distinguish these two, as Figure 3 indicates, although additional magnetic measurements might help.

A summary plot of the locations of the important anomalies is given in Figure 4. The intense magnetic anomaly, a, is seen to be associated with a magnetic gradient



Measurements on a rock sample from the site

V = volume = 502 cm³
max. dimension = 1.6
m = mass = 1.51 kg
p = density =
$$\frac{m}{V}$$
 = 3.01 g·cm⁻³
D = distance from sample to sensor (center-center) & 15 cm
H86 = background reading (no sample) = 55,870 nT
votating sample for extreme readings,
H₀ = magnetic high = 55,911 nT
HL = magnetic low = 55,877 nT
by the method of S. Breiner (Applications Manual for Portable
Magnetometers, GeoMetrics, 1973),
Hr = anomaly due to remanent magnetization = $\frac{H_{H}-H_{L}}{2}$ = 17 nT
H; = anomaly due to magnetic induction = $\frac{H_{H}+H_{L}}{2}$ - H86 = 24 nT
neglecting remanent components,
My = magnetic moment, on a volume basis = $\frac{H_{1}D^{3}}{V}$ = 161 nT
k = susceptibility = $\frac{M_{V}}{H_{00}}$ = 3.9 (10⁻³)
this value is typical of a rock containing ~ 1% magnetite

assume a buried pile of rock rubble having a volume of d m³ and
at a distance of d m from the sensor; its anomaly is
$$H = \frac{M_v V}{D^s} = 40 \text{ nT}$$

in general, it is reasonable that rubble from stone foundations could cause anomalies in the range 20 to 160 nT.

Figure 2: Estimation of anomaly amplitude



Narrow, deep, vod-like

probably archaeological (building rubble) or slag

Figure 3: Different structures can cause similar anomalies



which evidentally extends into grid #4. It is possible that anomaly a is related to anomaly b and possibly even anomalies \underline{j} and \underline{k} . All must be treated with suspicion since they could all have a geologic origin.

Paired nearby anomalies, one high and one low, can often be assumed to result from a single source. These dipole anomalies are probably the most interesting in this survey. Possible causes for some of them are listed in Figure 5. The orientation of these dipoles relative to the present or former magnetic north provides important clues to the buried source. My estimate of the 1780 declination can be improved, but it appears that the present and former values are too close to be reliably distinguished on the magnetic maps.

Since the purpose of this magnetic survey was a small test of the feasibility of this technique at this site, it is particularly important that a sample of the anomalies be tested before considering further work. Figure 6 lists a possible priority for tests. For the purpose of checking the anomalies, auger tests might be adequate; if this is inconclusive or inadvisable, test excavations extending 1 m from the listed test point should uncover the source of the anomaly.

Anomaly	Examples	Possible Causes
magnetic monopole	a,b,i,j,k	other pole outside survey
		area or undetectable
		see Figure 3
magnetic dipole aligned		compart inter this t
with present-day field	<i>s</i> ,J(.)	compace trovi beject
with present day held		compact cluster of large
		number of objects
		(brick or stone rubble)
magnetic dipole aligned	c,q,h(?)	iron-containing stone or
toward archaeological-		earth fired in place
period field		(kiln, hearth, oven)
magnetic dipole not aligned	d;e,f	red-like iron object
with magnetic north		fortuitous placement of
	•	small number of objects
		oblong cluster of large number
		of objects (brick or
		stone rubble)
		natural iron-containing rock
		or clay magnetized during
		geological formation

Figure 5: Different types of magnetic anomalies

Priority	Anomaly	Test Point	Notes
ا (top)	م	B:514E8	if no slag, this is geological
a	C	B: NII E7	if geological, all other anomalies are suspect
3	÷	B: 518 W16	could be stone rubble
4	h	B: NTEO	possibly fived structure
5	d	A: 540 EO	test for slag
6	Ь	B:NIGEO	if anomaly a is uninteresting neglect this

Figure 6: Priorities in testing

Appendix: Survey Procedures

The survey was made with a cesium magnetometer (Varian model 49-116). Since it was a magnetically quiet day and the brush was dense in areas, the difference setup was not used. While this double sensor configuration allows automatic correction of diurnal variation and micropulsations, the extra cable length makes it difficult to traverse. Instead, a single cesium sensor was used; repeated measurements were made at a reference point during the day. The readings, plotted in Figure 7, show that the diurnal shift was small compared to the magnitude of the magnetic anomalies. Traverses one or three columns wide were made to generate the matrices of magnetic measurements. Notes of the magnetic maps indicate the direction and timing of these traverses; with this information, the major part of the diurnal change can be corrected if ever desired.

The combined effect of the electronic stability of the magnetometer and micropulsations in the magnetic field was tested by making 22 consecutive readings in 1/2 minute with the sensor at a fixed point. The standard deviation of these readings was 0.45 nT. The repeatability of the survey was estimated from the overlap between grids 1 and 5. The 14 repeated measurements indicate that the error of a reading is approximately 75% of the difference between the given reading and an adjacent reading; stated another way, the accuracy of the contour lines is about 3/2 m. The isomagnetic maps have been drawn using very approximate linear interpolation, all that is needed for this survey.

A total of 1224 point measurements were made and the area surveyed at a 2 m measurement spacing was 3732 ${\rm m}^2$.



Diurnal change measured with cesium sensor resting ou stake "aocm above soil at point N30W10 of coordinate system "B."

Isomagnetic Map Pluckemin, New Jersey 6 November 1979

Varian cesium magnetometer model 49-116, average field = 56,000 nT measurement spacing = am, sensor height = = m, contour interval = 100 nT

* & (869 840 811 340 842 378 744 ۰٬۰۰**۰ - ۱**٬۵۰۰ 748 735769 781 793 5781 778 783 • 530 56.000 Grid #1 858 264 923 -076 **----**- 323 870 796 775 758 177 768 779 711 718 777 · Sar 835 9<u>4</u>7 119 892 90 6154 100 191 1911 880 791 768 789 781 -170 761 783 776 769 524 coordinate system"B" 932 057 82 883 811 905) **V**908 8/7 717 753 768 719 734(00) 743 775 5.0 • \$24 magnetic lows 754 728 746 (630: 643 919 917 25 911 869 505 797 741 ماير*؛* لا . 522 are stippled 948 5951 938 870 5112 750 (806) 780 (816) 863 1717 761 · Sao arrows mark 746 -294 5963 903 ent and 831 755 727 5157 518 traverse direction and time 371 Faq . 516 58:00 825 -788 804 773 748 721 716 only changing digits 826 200 486 764 5920 211 74! 761 \$14 630 are recorded 268 249 6082 6030 5911 315 730 729 . Sia ية شرك وا reference point for 741 751 179 760 751 . 510 538 testing diurnal ÷ . change at (An 6575 438 748 76 749 730 · 58 6349 681 620 10 6554 173 642 NJOUO 6317 907 743 730 738 700 . 54 1243 6409 10% 843 761 723 714 710 6328 6.351 6335 ٢ • \$4 520) (33) 2 (80) 6139 626A 953 28F 194940 351 7-59 708 707 740 6 720 6224 • sa 06154 6103 6108 6149 6185 ضتك 8 10 m 2 6075 6093 6389 6065 6100 6111 146 847 253 684 69. 7-CH 6169 6148 6099 0 357 54 6021 5981 6993 (1**9**0 6035 6029 6034 601 6030 923 835 404 **~1**96 ∓09 761 NA The 1967 1951 1953 200 6034 5927 973 5976 987 930 898 819 +69 696 701 + N4 972 4946 6403 ° 48 907) 343 463 645 685 ∈ ₹⊋I 157 6002 993 950 751 5955 980 918 NG ୧୫୦ ୧୫୦ 732 18 هر <u>595</u> 00° 6155 021 5966 5966 929 5953 952 972 904 + N8 6068 980 824 280 281 745 684 1509 5+43 2849 324 090 984 6000 997 5993 993 التو Nio (519 6030 6007) 392 (6007) 993 972 319 345 713 703 40 669 • NIa 6127 <u>13</u>7 974 374 6068 1983 768 971 996 326 751 608 665 653 • N14 138 135 6100 149 6012 989 953 971 964 147 381 1EQ 209 345 673 655 643 • NIG ~1°(mag) 20 928 20 -854 6088 019 6026 007 977 961 94Z 285 641 641 633 . NIS ter l 938 259 134 791 947 944 1004 403 1 2004 6099 6091 081 6028 010 781 677 627 -49 . Nao total intensity 914 8:38 791 736 070 766 048 6853 6067 057 6069 6031 980 991 947 669 654 653 . NAA not corrected for 748 703 200 241 647 . N24 $\leq \mathbf{\hat{b}}$ ୍ୟା ତ୍ୟା 014 060 6098 6009 977 9.31 9**29** 892 has 6016 diurnal change CHS 057 6002 607 029 6027 596 989 95D 914 874 274 715 707 740 651 + N26 370 646 004 054 6041 6018 فاتحر ج ليداعا. 143 Ciot Coulita 783 951 706, 841 € 10-+6+8 (·5% + Nat f 302 1631 + 44 + 1830 063 064 065 6049 74% 903 264 330 6046 6020 993 E4 EA EQ Wa 64 6 66 010 014 014 016 018 020 022 Elo Εß **E**4 0



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