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 6o 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

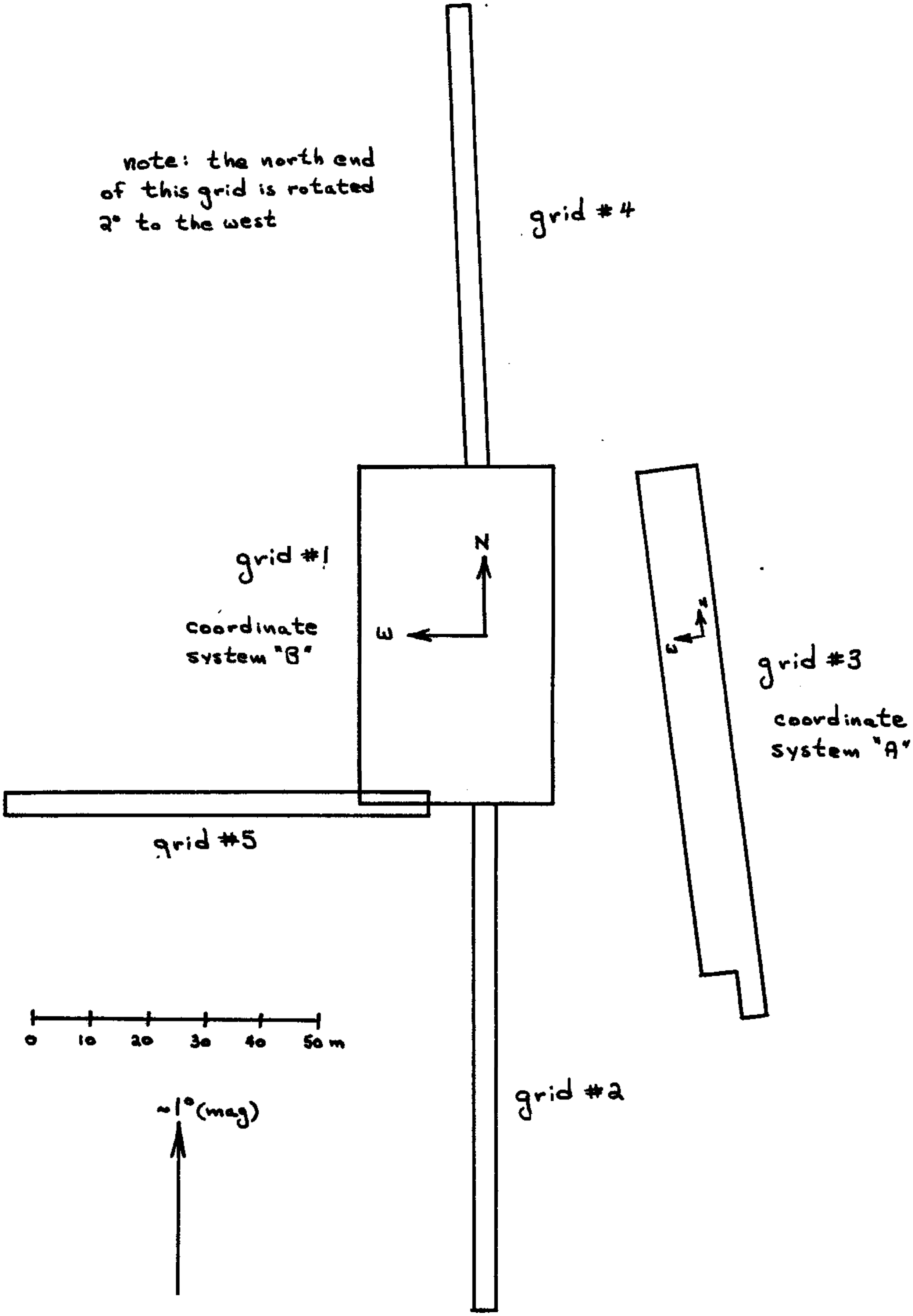


Figure 1: Survey areas

Measurements on a rock sample from the site

V = volume = 502 cm^3

$\frac{\text{max. dimension}}{\text{min. dimension}} = 1.6$

m = mass = 1.51 kg

ρ = density = $\frac{m}{V}$ = 3.01 g·cm^{-3}

D = distance from sample to sensor (center-center) ≈ 15 cm

H_{BG} = background reading (no sample) = 55,870 nT

rotating sample for extreme readings,

H_H = magnetic high = 55,911 nT

H_L = magnetic low = 55,877 nT

by the method of S. Breiner (Applications Manual for Portable Magnetometers, GeoMetrics, 1973),

H_r = anomaly due to remanent magnetization = $\frac{H_H - H_L}{2}$ = 17 nT

H_i = anomaly due to magnetic induction = $\frac{H_H + H_L}{2} - H_{BG}$ = 24 nT

neglecting remanent components,

M_V = magnetic moment, on a volume basis = $\frac{H_i D^3}{V}$ = 161 nT

k = susceptibility = $\frac{M_V}{H_{BG}}$ = 2.9 (10^{-3})

this value is typical of a rock containing ~1% magnetite

assume a buried pile of rock rubble having a volume of 2 m^3 and at a distance of 2 m from the sensor; its anomaly is

$H = \frac{M_V V}{D^3}$ = 40 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

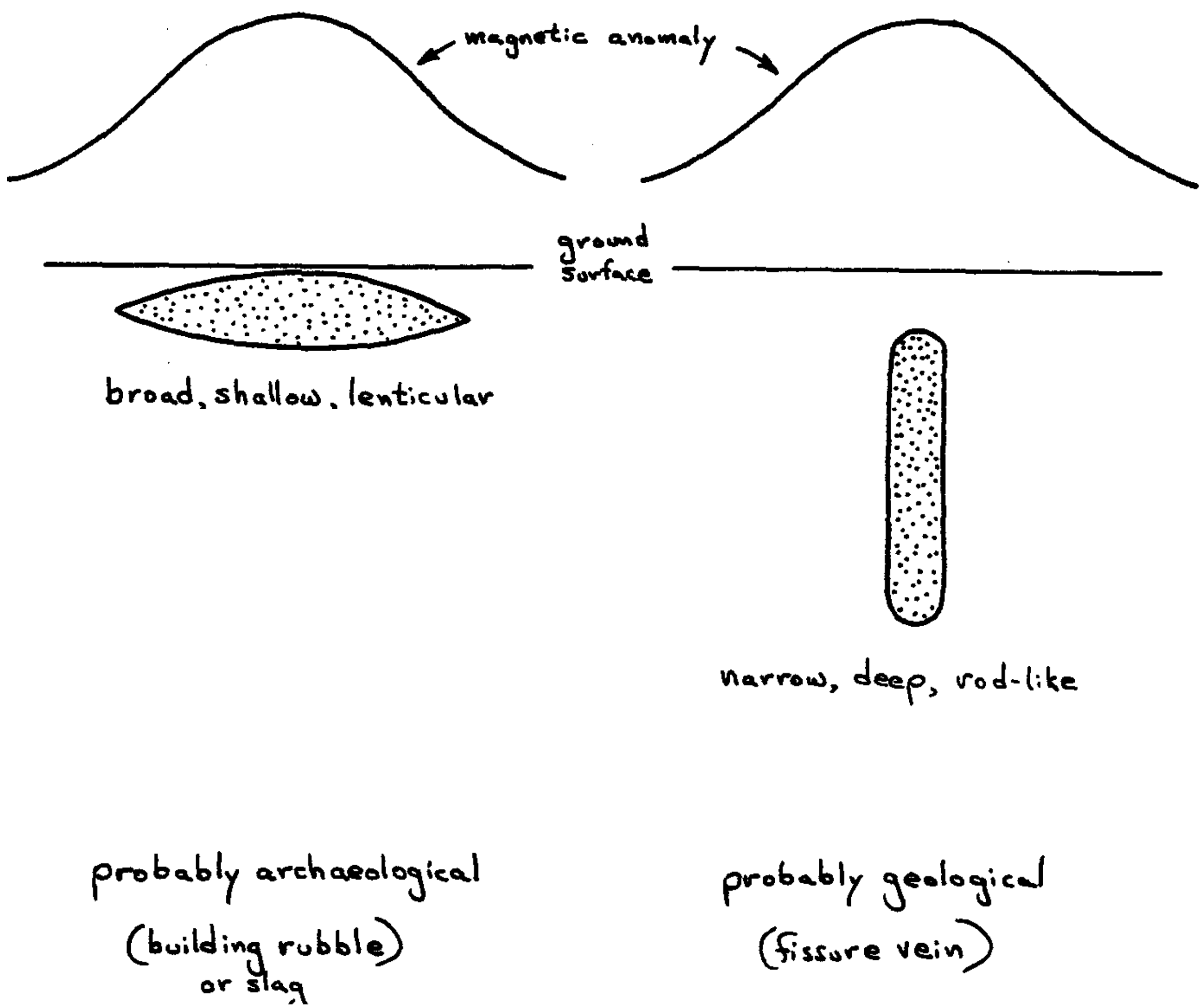


Figure 3: Different structures can cause similar anomalies

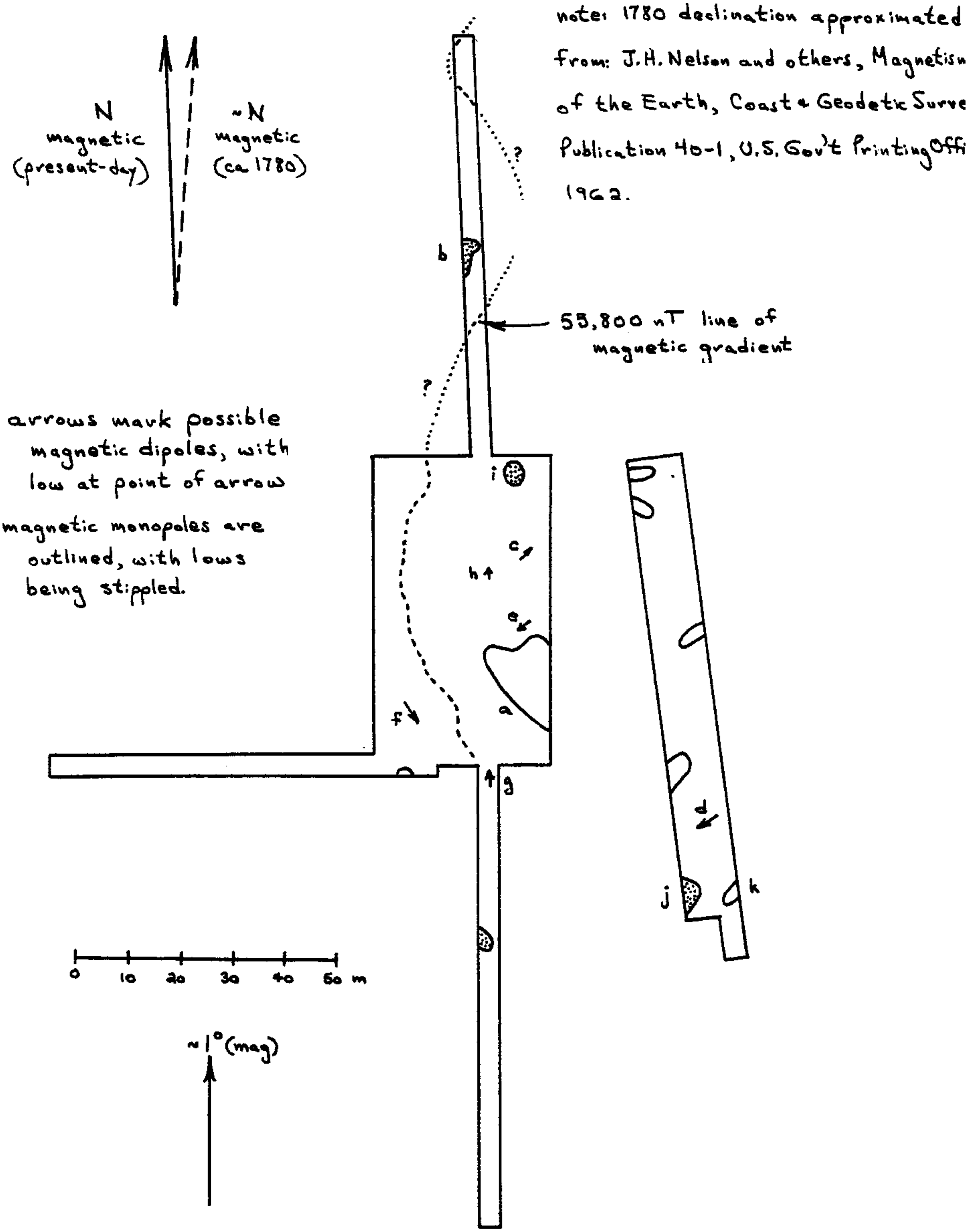


Figure 4: The major magnetic anomalies

which evidentally extends into grid #4. It is possible that anomaly a is related to anomaly b and possibly even anomalies j and 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 with present-day field	c,g(?)	compact iron object compact cluster of large number of objects (brick or stone rubble)
magnetic dipole aligned toward archaeological-period field	c,g,h(?)	iron-containing stone or earth fired in place (kiln, hearth, oven)
magnetic dipole not aligned with magnetic north	d;e,f	rod-like iron object 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
1 (top)	a	B: S14E8	if no slag, this is geological
2	c	B: N11 E7	if geological, all other anomalies are suspect
3	f	B: S18W16	could be stone rubble
4	h	B: N7E0	possibly fired structure
5	d	A: S40E0	test for slag
6	b	B: N16E0	if anomaly a is uninteresting neglect this

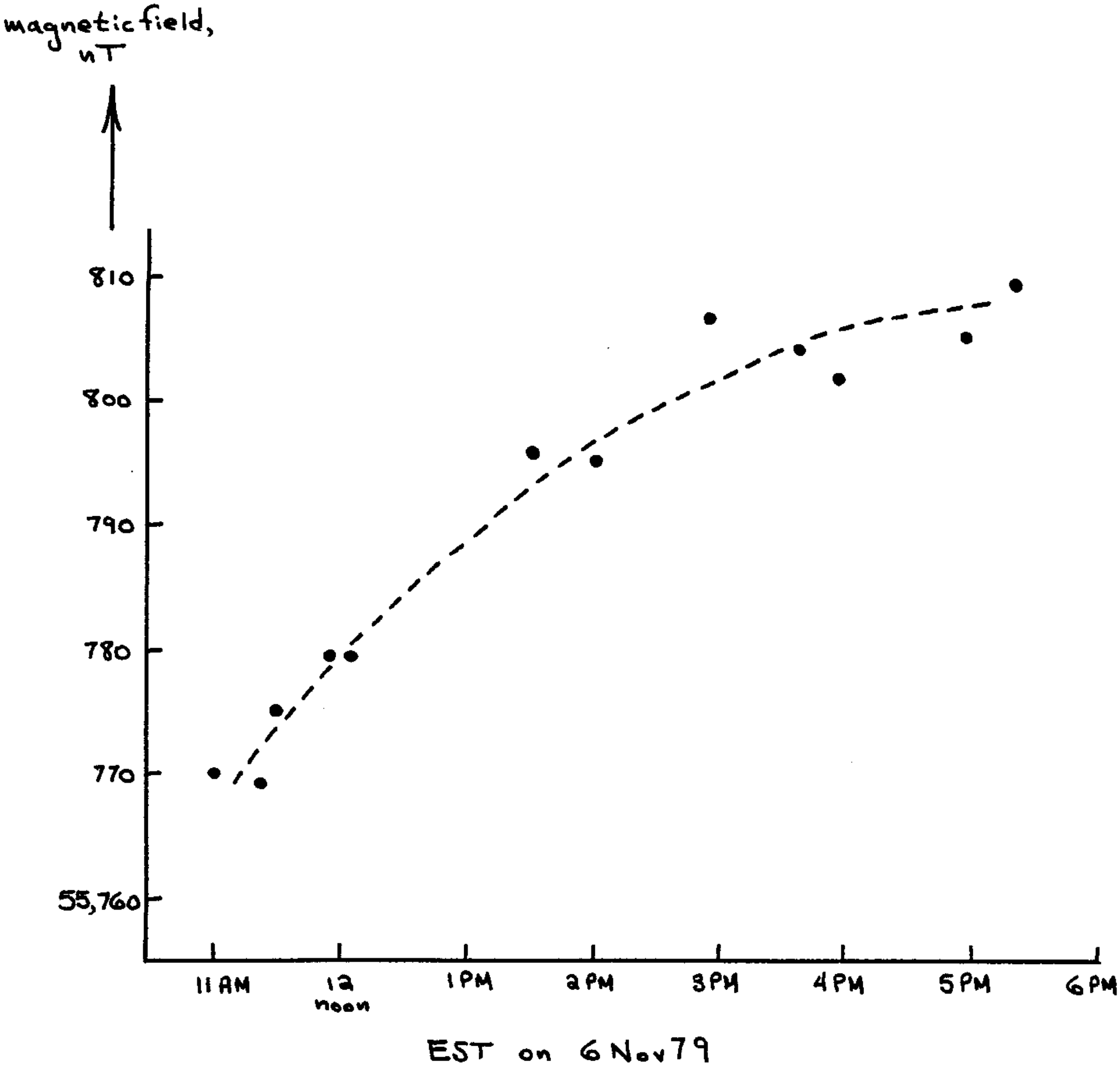
Figure 6: Priorities in testing

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 m^2.



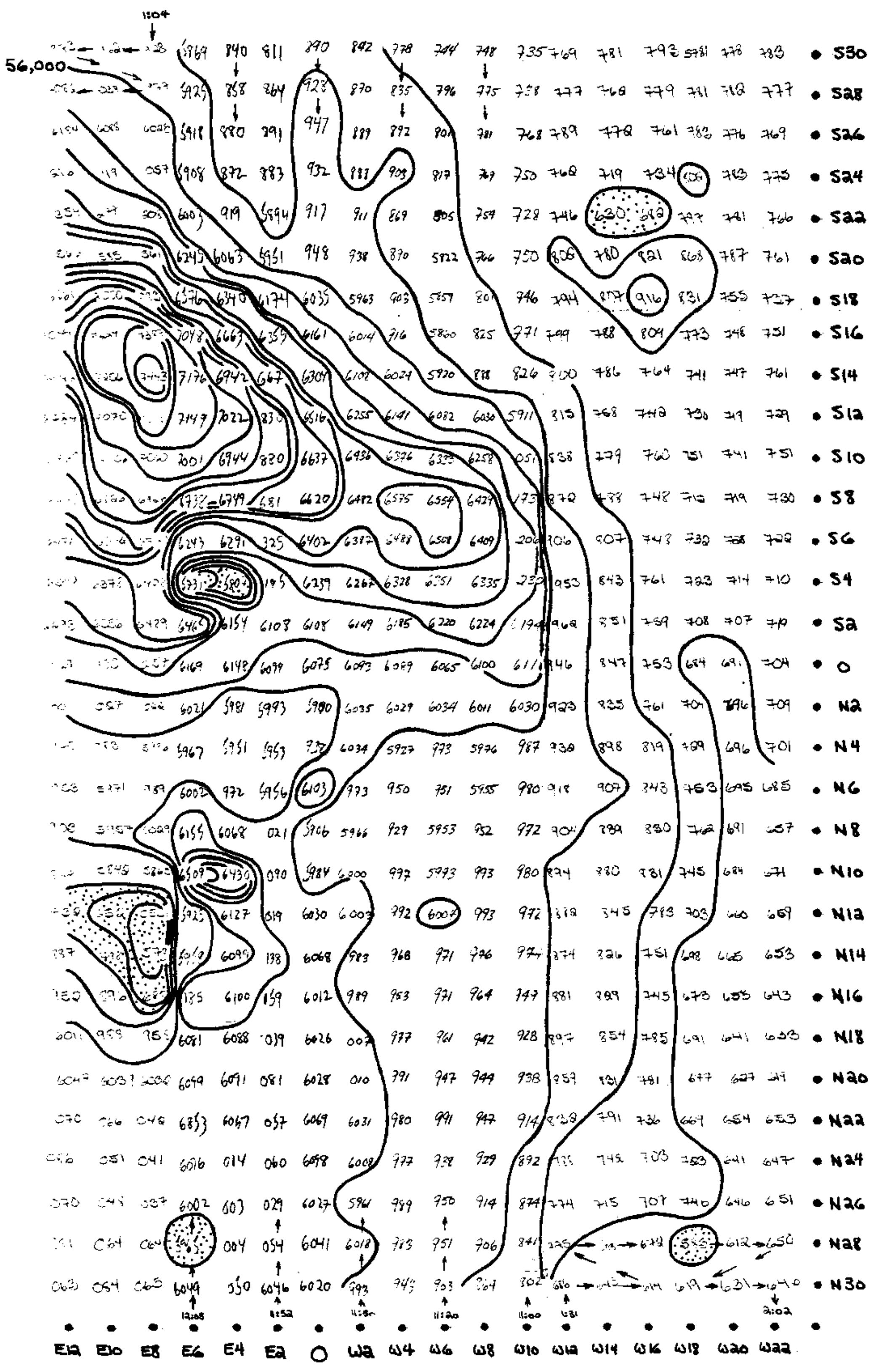
Diurnal change measured with cesium sensor resting on stake ~20cm above soil at point N30W10 of coordinate system "B."

Figure 7: Magnetic shift with time

Isomagnetic Map   Pluckemin, New Jersey   6 November 1979

Varian cesium magnetometer model 49-116, average field = 56,000 nT

measurement spacing = 2m, sensor height ≈ $\frac{3}{4}$ m, contour interval = 100 nT



Grid #1

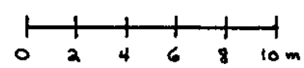
coordinate system "B"

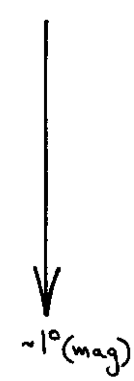
magnetic lows are stippled

arrows mark traverse direction and time

only changing digits are recorded

reference point for testing diurnal change at N30 W10

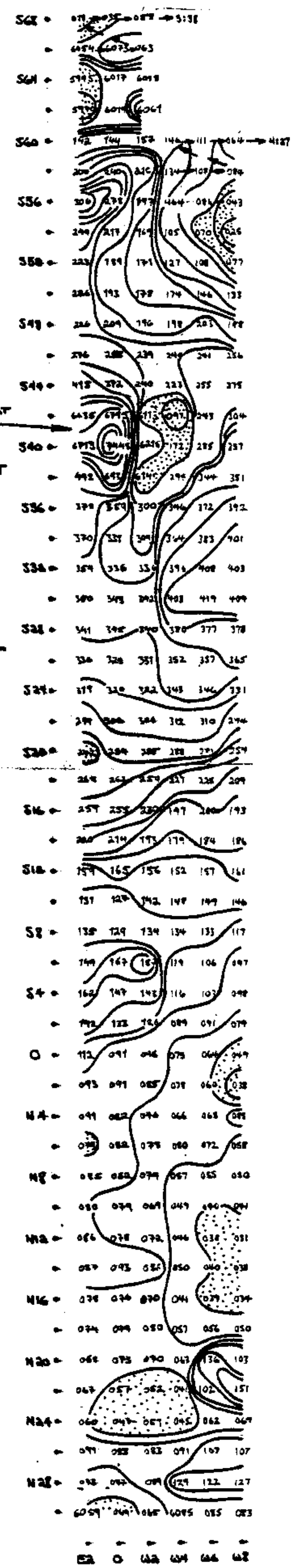




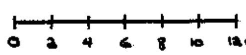
total intensity not corrected for diurnal change

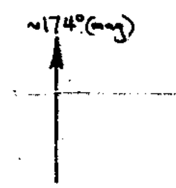
Grid # 3

Isomagnetic Map
Pluckemin, NJ
6 November 1979

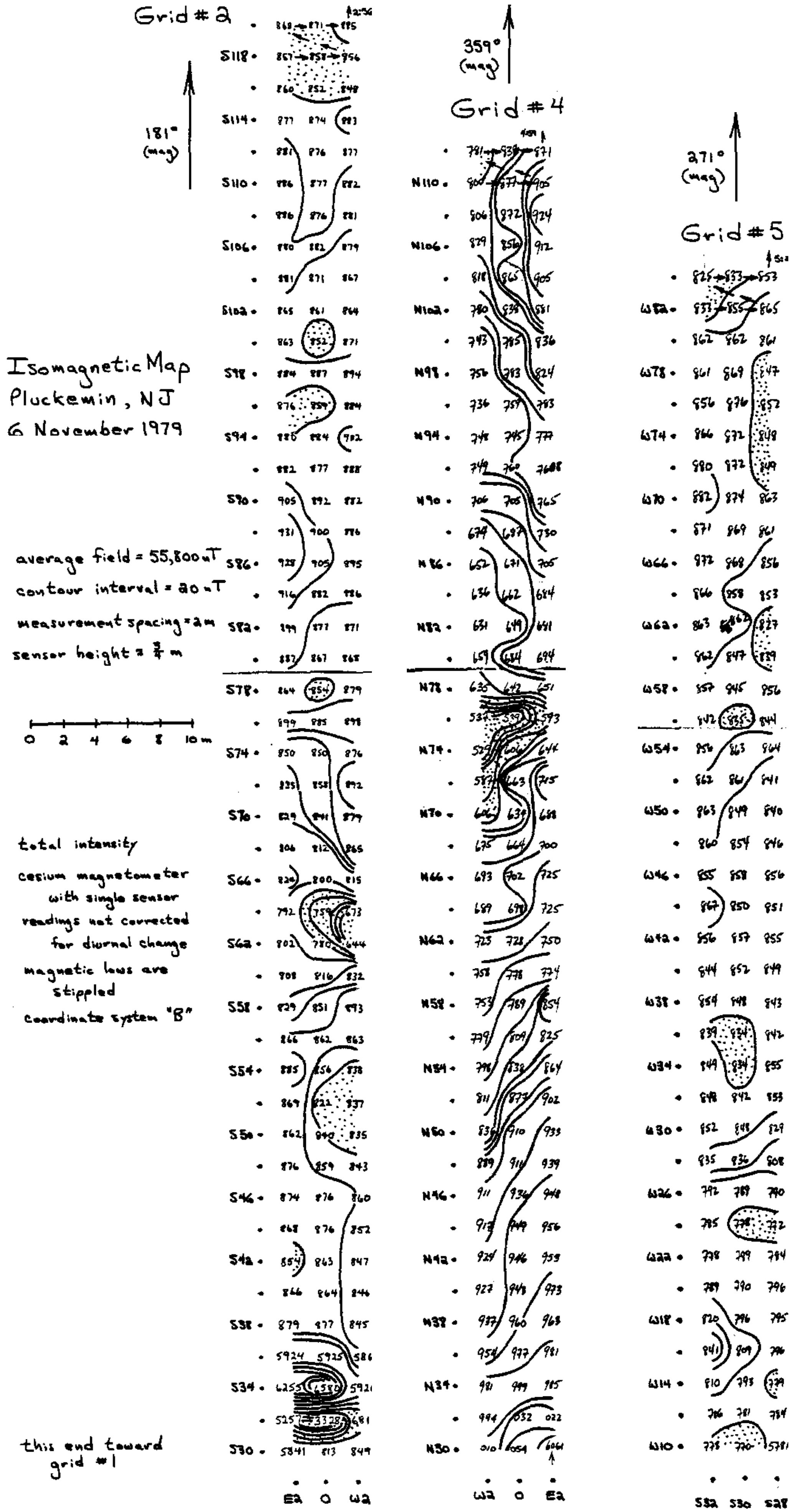


average field = 56,100 nT
contour interval = 20 nT
measurement spacing = 2m
sensor height = $\frac{3}{4}$ m





total intensity
cesium magnetometer with single sensor
readings not corrected for diurnal change
magnetic lows are stippled
coordinate system "A"


Grid #2
181° (mag)
Grid #4
359° (mag)
Grid #5
271° (mag)
Isomagnetic Map
Pluckemin, NJ
6 November 1979
average field = 55,800 nT
contour interval = 20 nT
measurement spacing = 2 m
sensor height = ¾ m
0 2 4 6 8 10 m
total intensity
cesium magnetometer with single sensor
readings not corrected for diurnal change
magnetic lows are stippled
coordinate system "B"
this end toward grid #1
E2 0 W2
W2 0 E2
S32 S30 S28