Magnetic Survey at the Draper Site

Pickering Township, Ontario

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Magnetic surveying of archaeological sites has been utilized for about fifteen years as a tool for locating lateral magnetic contrasts which may result from human occupation. The technique has been applied mainly to study European sites of a wide range of ages and degrees of occupation, and has proven extremely successful in the detection and outlining of certain kinds of buried structures. The most common of these are pits which have been filled with organic rich debris and top soil. These materials generally have higher magnetic susceptibilities than the surrounding, undisturbed sub soil, the contrast being sufficient to produce peak anomalies of up to 50 gammas (1 gamma = 10^{-5} oersted, or about 1/50000 of the earth's main magnetic field).

It seemed possible that similar anomalies might be observed over sites occupied by North American Indians. Indian long-house floors were certainly marked by numerous hearths and pits. On the other hand occupation conditions were different from those at European sites, and the magnetic state of the top soil at Indian sites was unknown.

In the spring of 1973 additional excavations at the Draper Site, on concession 8, Pickering Twp. were begun under the direction of Mr. Brian Hayden of the University of Toronto (Department of Anthropology). Mr. Hayden invited the author to participate, and an exploratory program of magnetic surveying was planned. Earlier excavation of a longhouse at the Draper site had been carried out, and that work, and the nature of the site itself suggested that most of the area of possible habitation (about 7 acres) had not been disturbed by cultivation (i.e. ploughing) since aboriginal occupation.

Magnetic Survey

In order to delineate small magnetic anomalies of a few gammas magnitude on a fine grid, in a reasonable time, it was essential to use a magnetometer of the proton precession type with a sensitivity of at least ± one gamma. Through the courtesy of McPhar Geophysics Co. Ltd., a GP-70 proton magnetometer was obtained and over a period of three days, 750 total magnetic field readings at spacings of one metre were recorded in an area suggested by Mr. Hayden as a possible long-house site. Diurnal variations were monitored by reoccupying a base station at intervals of 4 to 5 minutes after making ten successive readings. Linear interpolation of the diurnal drift curve was used to correct the field station readings. This appeared to be a satisfactory procedure for two of the three days on which readings were taken. On June 2, changes in successive base station readings, in some cases, were as large as 10 gammas, and data taken on that day may have biases as a result of the linear interpolation corrections applied. Data for all stations were the average of three to five individual readings. The sensing head was at a height of about 60 cm above ground level.

The data was mapped and subsequently contoured, as shown in Figure 1. In areas in which no large anomalies were observed there were gradients of about one gamma per metre, which probably reflect the sensitivity limits of the instrument. Positive and negative anomalies were observed, having peak magnitude of about 15 to 20 gammas above and below the local background.

Discussion of anomalies

Several of the observed anomalies have maximum gradients of the order of 15 to 20 gammas per metre, but the breadth of the positive anomalies are generally of the order of three to six metres. The half width of anomaly A (Fig. 1) along profile AA' is about 1.5 metres, suggesting that the object causing the anomaly is centred about 3 metres below the sensing head, a depth which seemed too great to be attributed to the effects of the aboriginal occupation. These were known from previous excavations on the site to extend from depths of about 20 cm to perhaps 60 cm below the ground surface (i.e. 80 to 120 cm below the sensing head).

As a check, spot core samples of several of the positive anomalies were taken, but no indications of filled pits or hearths were observed. Subsequently, total excavation was commenced toward the eastern end of the block surveyed, where magnetic anomalies seemed more prevalent, and there, hearths, pits, traces of posts and artifacts were encountered. The hearths and pits were relatively small in diameter and depth (less than one metre) and were not directly related to any of the rather broad anomalies charted by the magnetic survey. At the sensing head height/ station spacing / instrument sensitivity used in this particular survey, undisturbed pits and hearths of this presumably typical Huron long-house are not detectable.

To define the survey parameters more accurately, a series of soil magnetic susceptibility measurements were made on cores from various points in the survey area, and from the hearths and pits revealed during excavation. The sample locations are indicated in Figure 1. The hand corer used provided a series of soil samples each about 25 cm in length to depths of 1.5 to 2 metres. Samples of each 25 cm length were dried, either by evacuation, or in air, before magnetic susceptibility measurements were made. The material from the individual cores was not homogenous, but duplicate measurements indicated that the results were reasonably representative for a given 25 cm core except where a sudden change in soil type (e.g. sand to clay) occurred part way through a core.

The magnetic susceptibilities were measured in a null balancing A.C. bridge, calibrating in e.m.u. with a set of synthetic standards. The results are given in Table I. The three cores east of the excavated area consisted of sand interbedded with thin 1 clay layers. The sand fractions have fairly uniform susceptibilities ranging from 120 to 190 x 10^{-6} e.m.u. The area in which the hearths, pits and abundant artifacts occur is overlain by a layer of sandy black soil, having a low susceptibility of 70 to 85 x 10^{-6} e.m.u. and a lower density than the top layers to the west. The thin layer of ash immediately above the burnt red sand of the hearths also had a low susceptibility, similar to that of the overlying top soil. The red sand of the hearths had much higher susceptibilities, roughly in the range of the susceptibilities of sands in the more westerly cores but in each of the two hearths sampled, the red sand susceptibility was about 25 x 10^{-6} e.m.u. less than the underlying sub soil. This difference may reflect a small ash component in the sand or perhaps a conversion of magnetite (Fe_3O_4) to hematite (Fe_2O_3) as a result of the local heating of the soil.

In any case there appears to be a small negative magnetic susceptibility contrast between the heated sand of the hearths and the soil below them. If the susceptibility of the soil surrounding the hearths is similar to that of the sand below them, then a small lateral magnetic susceptibility contrast might exist between hearths and adjoining soil. The anomaly resulting from this contrast, if it exists at all, is almost an order of magnitude below the detection level of the magnetometer. If the hearth is approximated by a horizontal circular plate (diameter 1 metre, thickness 6 cm, depth below detector 1 metre, susceptibility contrast -25 x 10^{-6} e.m.u.), the peak anomaly, assuming a vertical magnetizing field, is only about -0.1 gamma, i.e. below the sensitivity of even a differential proton magnetometer.

Table I (Mag susceptibilities in units of 10^{-6} e m.u.

Normal Cores

Depth (cm)	60N 13E	57N 12E	46N 24E	41N 42E
sand	150	130	120	(humic sand) 70
25				
sand	170	134	150	(sand clay) 100
50				
sand	180	170	144	(clay) 60
75				
sand	140	150	(clay) 50 / 140	
100				
sand	160	170	190	
125				
sand	150			
150				

Hearth I		Hearth II		Pit	
humic soil	84				
ash 5 cm layer	74			Top layer of exposed pit	140
red sand 8 cm layer	150	red sand 8 cm layer	107		
normal sand below	173	normal sand below	130		

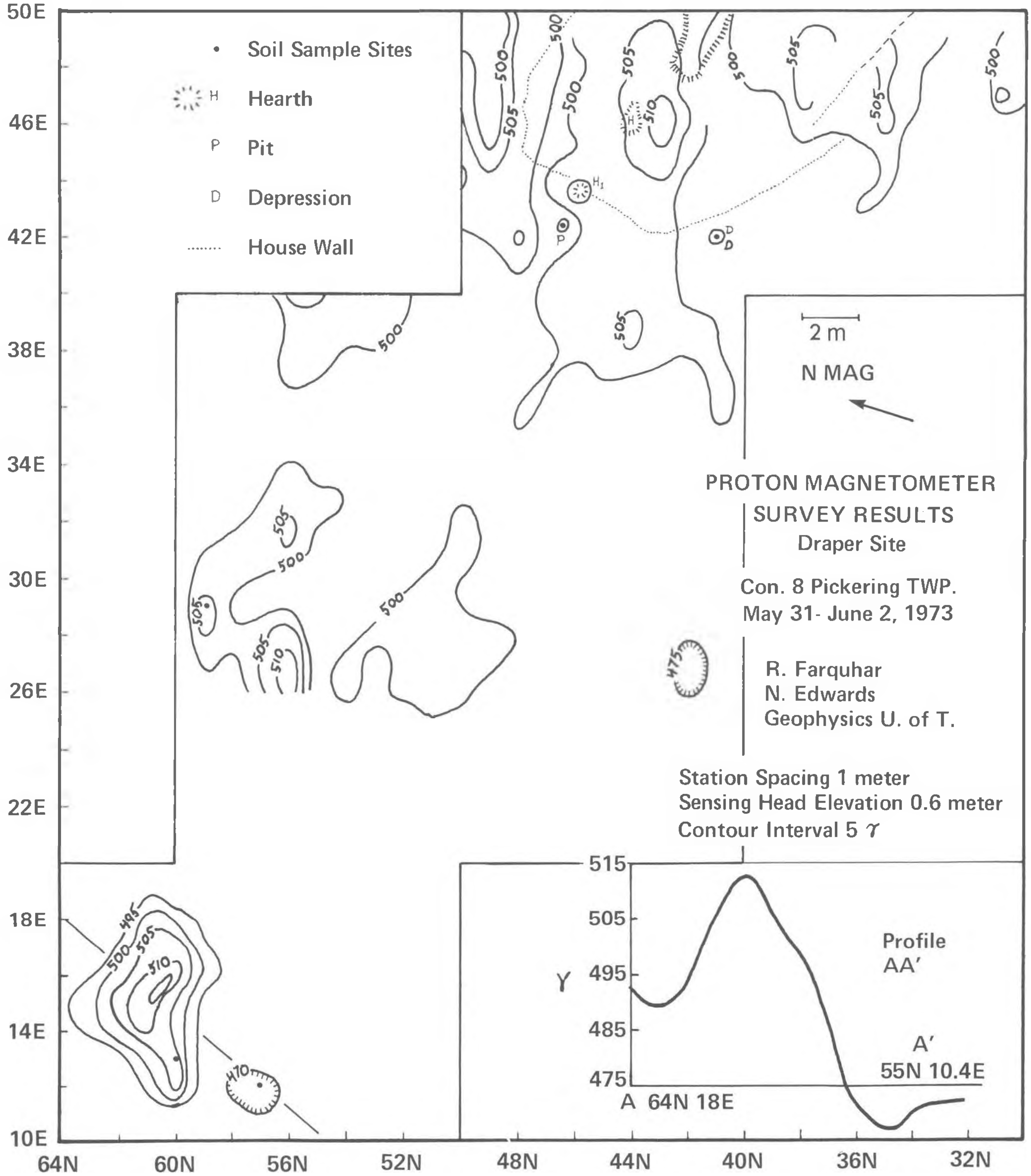
Soil Sample Sites
Hearth
Pit
Depression
House Wall
2 m
N MAG
PROTON MAGNETOMETER
SURVEY RESULTS
Draper Site
Con. 8 Pickering TWP.
May 31- June 2, 1973
R. Farquhar
N. Edwards
Geophysics U. of T.
Station Spacing 1 meter
Sensing Head Elevation 0.6 meter
Contour Interval 5 γ
Profile
AA'
A'
55N 10.4E
A 64N 18E
Y
515
505
495
485
475
50E
46E
42E
38E
34E
30E
26E
22E
18E
14E
10E
64N
60N
56N
52N
48N
44N
40N
36N
32N

Fig. 1.

Conclusions

The soil magnetic susceptibility data suggests that any lateral contrasts associated with hearths, and probably also pits, are too small to be detected using a ± one gamma sensitivity magnetometer. A 0.1 gamma differential proton magnetometer might indicate anomalies, if the detecting head height was reduced to less than 25 cm above ground level. However the susceptibility contrasts being sought are probably not much different from the normal fluctuations present in the soil resulting from changes in composition, and the scale of the latter is not known. If the sizes of the hearths are typically 1 metre or less in diameter, the station spacings on the search grid would have to be 0.5 metres or less, which would increase the time spent covering a given area by a factor of 4 or more.

If the occurrence of the low density, low magnetic susceptibility dark soil, is closely related to the position of the long-houses, and presents a sharp contrast to top soil in unoccupied areas, it might be possible to detect the presence of this boundary, using a ± 1 gamma magnetometer close to the ground. Once the edges of this boundary were located, the boundary could be followed using a relatively small number of measurements, unless the gradients were obscured by the superimposed anomalies due to deep seated objects. These exist in the area, and are easily detected. They are probably due to glacial boulders buried several metres below the surficial sands and clays.