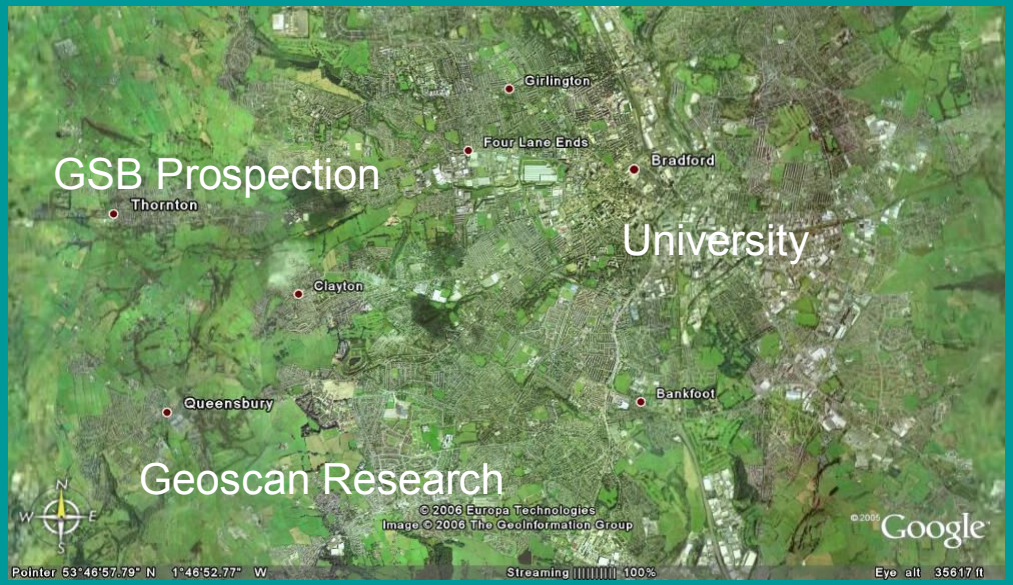
Geophysical Instrumentation in Bradford

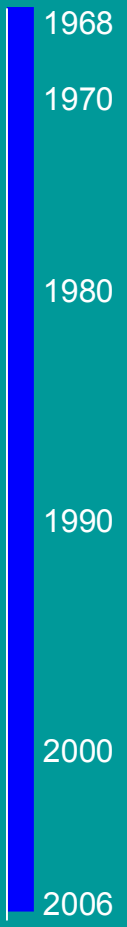
- Past and Present

by Roger Walker

Structure of Talk

- This talk is a whirlwind tour of the wide range of geophysical instrumentation used and developed "In Bradford", with a special emphasis towards those that Arnold has been involved with
- Includes the six PhDs in geophysical instrumentation admirably overseen by Arnold Aspinall
- References to papers that Arnold has been involved with are given at the bottom of some slides
- By "In Bradford" we mean :
  - The University Department
  - Geoscan Research
  - GSB Prospection
  - ……and areas of collaboration between them
- Essentially a good excuse to show as many interesting (and embarrassing ?) photos as possible !
- A time-line is shown of the right hand side as a guide to where we are in our time travelling





Early Days

- "Geophysical prospection methods in archaeology" starts in c1968
- Located in the Physics Department, Main Building then moved to Horton Building c 1975

1968
1970
1980
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2006

Induced Polarization and Resistance Methods 1968 - 1970

John Lynam, "Techniques of geophysical prospection as applied to near surface structure determination" 1970

- Four probe system – two current probes, two potential probes
- Examined Induced Polarisation in the time domain
- Non-polarizing probes made from Tufnol and conducting gel
- Measured IP and electrical resistance
- Slow measurement technique

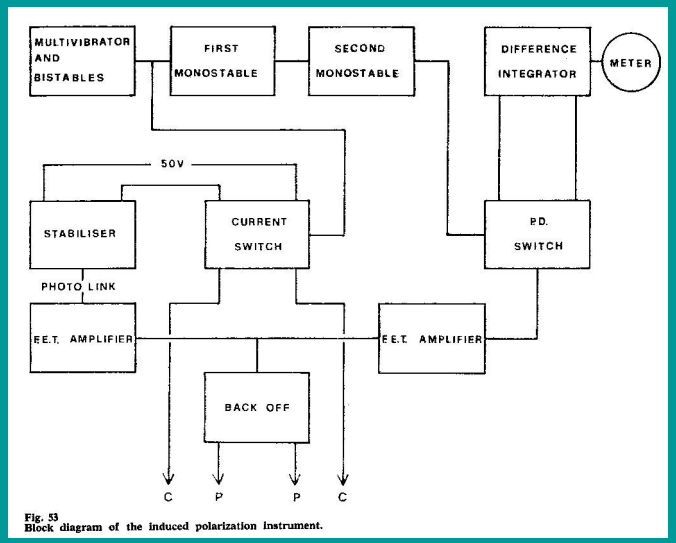

Fig. 53
Block diagram of the induced polarization instrument.

Block diagram

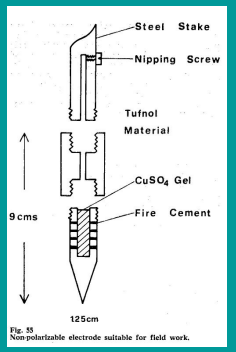

Fig. 55
Non-polarizable electrode suitable for field work.

Tufnol probe

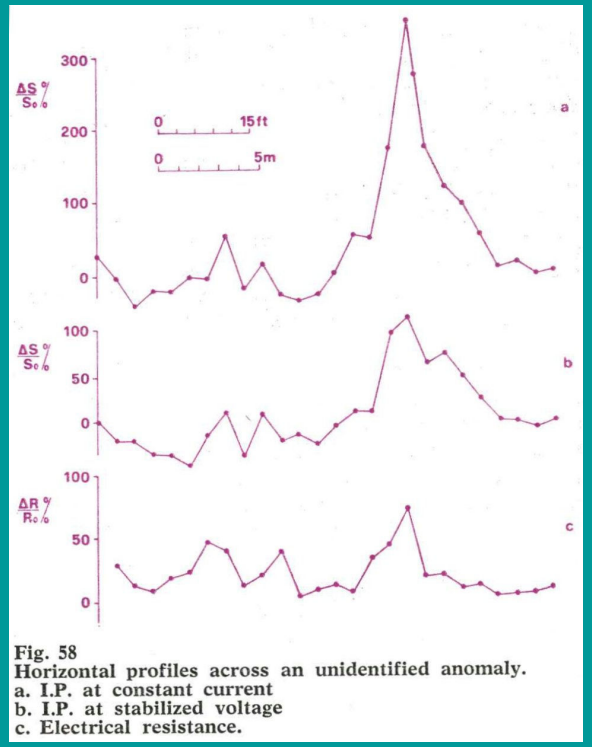

Fig. 58
Horizontal profiles across an unidentified anomaly.
a. I.P. at constant current
b. I.P. at stabilized voltage
c. Electrical resistance.

Typical results

1968
1970
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1990
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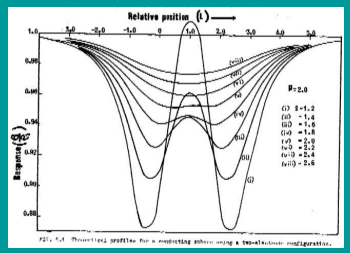
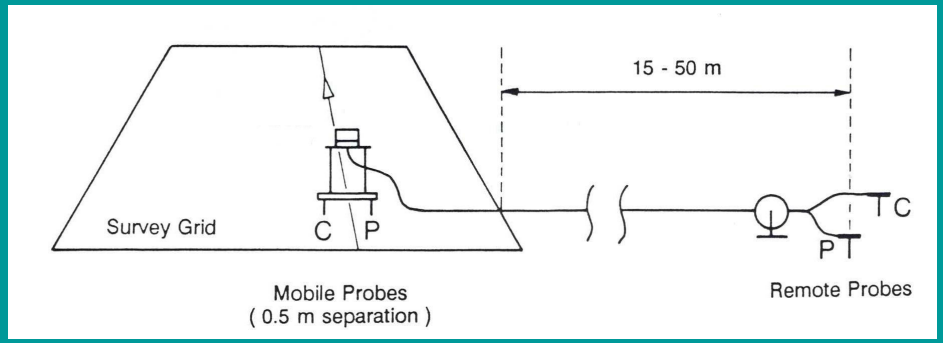
2006

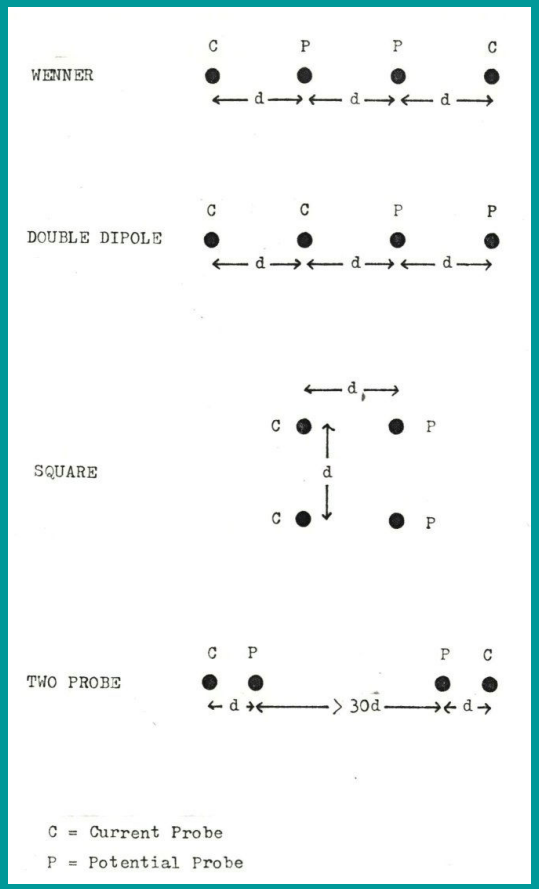
A.Aspinall, J.T.Lynam "Induced polarization as a technique for archaeological surveying " 1968

Resistance Methods and the Two Electrode Configuration

- Many different arrangements of four probes possible for electrical resistance measurements
- Prior to this time electrical resistance arrays typically used were : Wenner, Double Dipole and Square array
- John Lynam developed the idea, application and theory of the Twin Electrode Array in his thesis
- Four probes but only two probes move
- Independent of probe orientation
- Independent of probe insertion depth
- Single peaks only over typical targets







1968
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A.Aspinall, J,T.Lynam “An induced polarization instrument for the detection of near surface features“ 1970

“Bradphys” Resistance Meter 1970

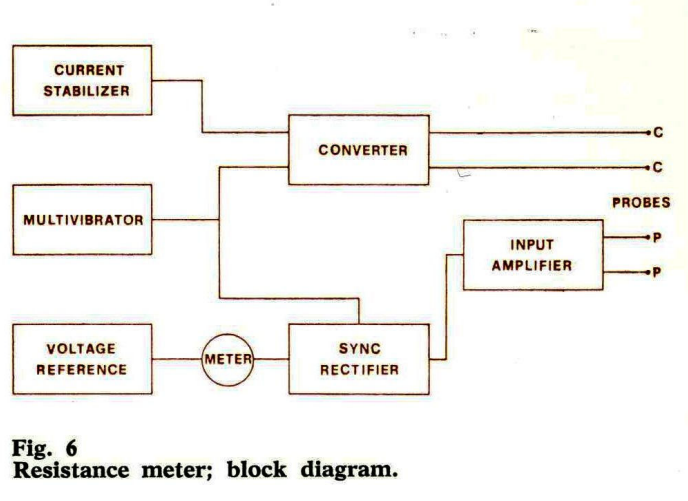
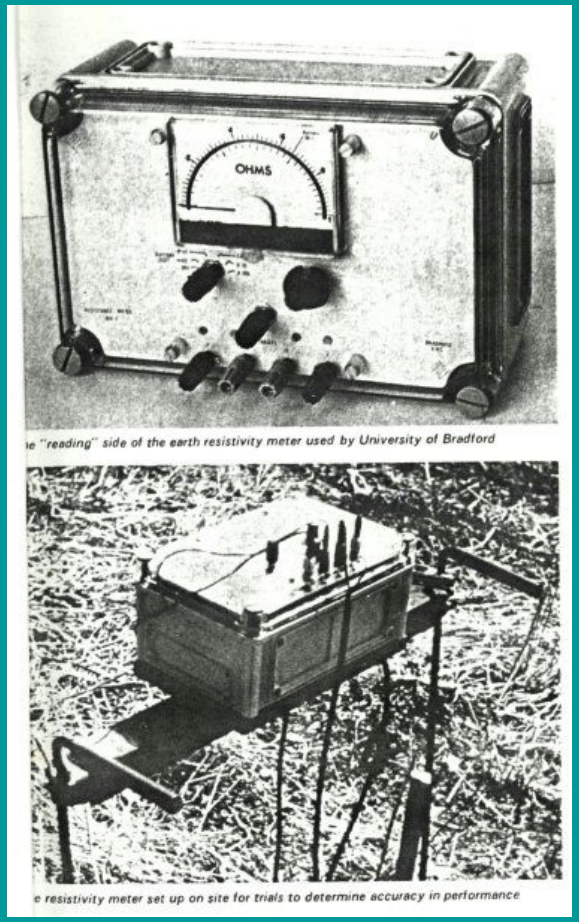


Fig. 6
Resistance meter; block diagram.

- Based on instrumentation from John Lynam’s thesis
- Meter weight 4.8 Kg plus frame
- Range 1000 ohms to 0.01 ohms
- Constant current 0-10 mA RMS at 200V
- Frequency 128 Hz
- Maximum contact resistance 40 Kohm
- High Input impedance synchronous voltmeter
- Back-off facility to speed up readings
- Digital version followed known as the “DigiPhys”
- Electric shock common in wet weather !



e "reading" side of the earth resistivity meter used by University of Bradford

e resistivity meter set up on site for trials to determine accuracy in performance

1968
1970
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A.Aspinall, K.Pickard “A direct reading resistance meter”, 1971

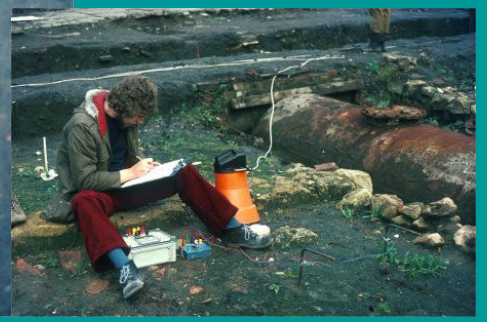
Survey Methods

- Area surveys typically used sampling intervals of 1m
- A mesh of 100 x 1m grids was laid out as a guide
- Mesh made from linked washing lines – tangling was a curse !
- No data loggers – all readings written down on gridded sheets of paper
- Other probe arrays were explored for special applications eg 3 probe

John Samuels at Barnetby Top

Jenny Pearson and Jim Pocok

Three probe array at York



Dave Brinklow with “Dalek” cable drum

1968
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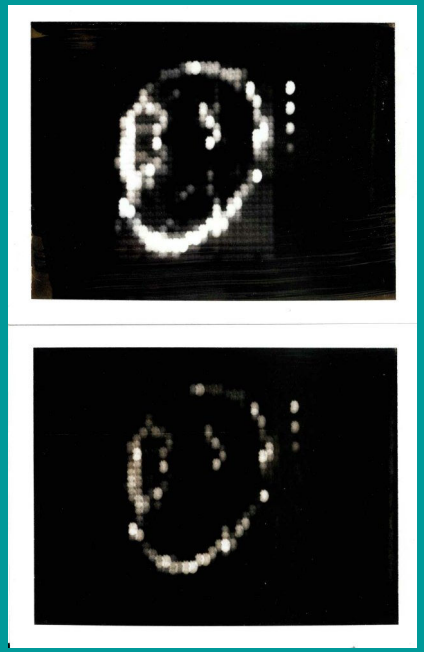
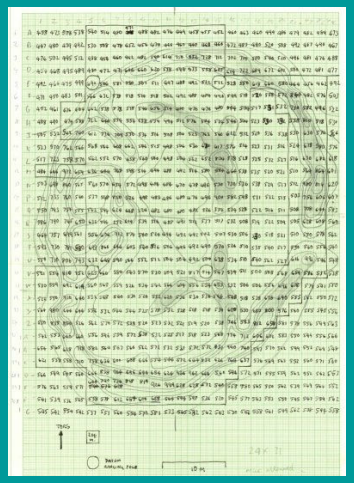
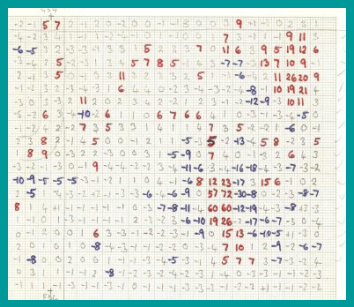
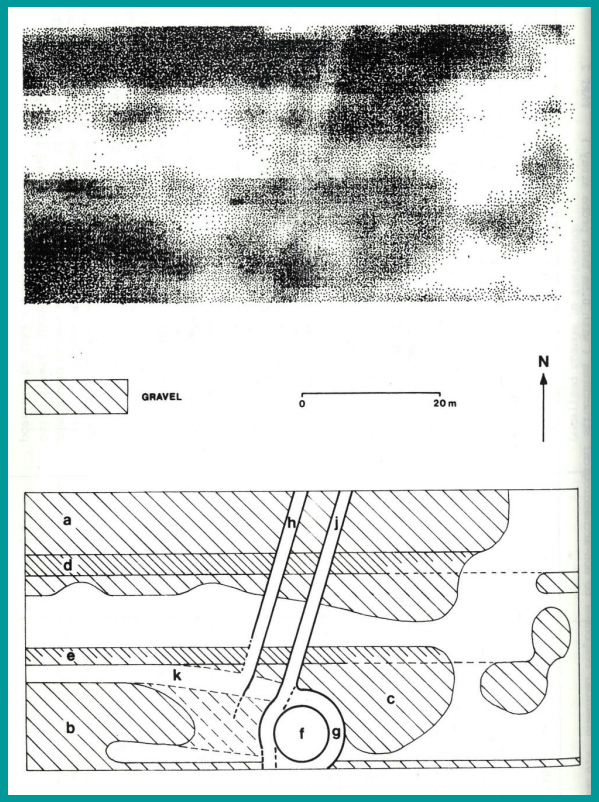
Early Data Presentation Methods

- Polaroid picture of light box with >100 individual bulbs adjustable for brightness to very plotting levels
- Hand contouring
- Numbers highlight above threshold with colour – good for gradiometers (red positive, blue negative)
- Hand dot-density plots – effective for gradiometer data but very time consuming for resistance data
- eg illustration on the right took two evenings to plot – must get plotting levels right first time !









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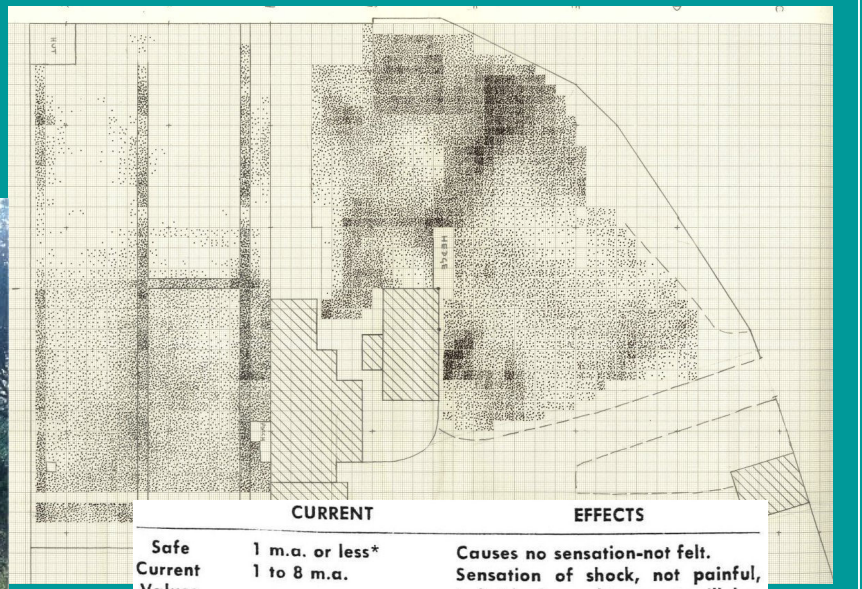
Cogges Manor Garden Survey

- An early example of garden archaeology and geophysics – one of Arnold's current pet persuits
- Garden paths show clearly plus some evidence of earlier building phases
- Overwhelming memory of Pavlov type electric shock therapy in the wet long grass !
- Not surprising when you look at what 10 mA RMS current can do……..



	CURRENT	EFFECTS
Safe Current Values	1 m.a. or less*	Causes no sensation-not felt.
	1 to 8 m.a.	Sensation of shock, not painful, individual can let go at will because muscular control is not lost.
	8 to 15 m.a.	Painful shock; individual can let go at will because muscular control is not lost.
	15 to 20 m.a.	Painful shock; muscular control of adjacent muscles lost, can not let go.

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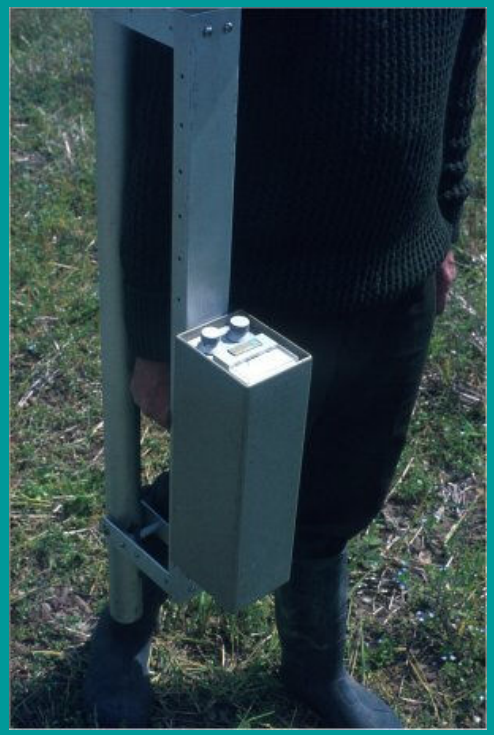
Plessey Gradiometer c 1971

- Fluxgate Gradiometer
- 1m sensor separation
- Analogue meter display
- No data logger
- Very heavy – 6 Kg



Arnold Aspinall

Gill Bussell and Dave

1968
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Philpot, F.V., 1973 “An improved fluxgate magnetometer for archaeological prospecting” Pros. Arch., 7-8, 99-106

Littlemoor Gradiometer c1972

- Fluxgate Gradiometer
- 1m sensor separation
- Bar graph meter display
- No data logger
- Heavy – 4.5 Kg

Jim Pocock and student

Arnold Aspinall

1968
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Philpot AM01, DM01, DM02 c1973-c1986

- Fluxgate Gradiometer
- 0.5m sensor separation
- Introduced with analogue display version as AM01
- Department acquired digital display version DM01 in about 1977
- Lightweight – 1.6 Kg
- No data logger
- Computerised plotting system producing traces

Note the obligatory well cut smart suit for field survey !

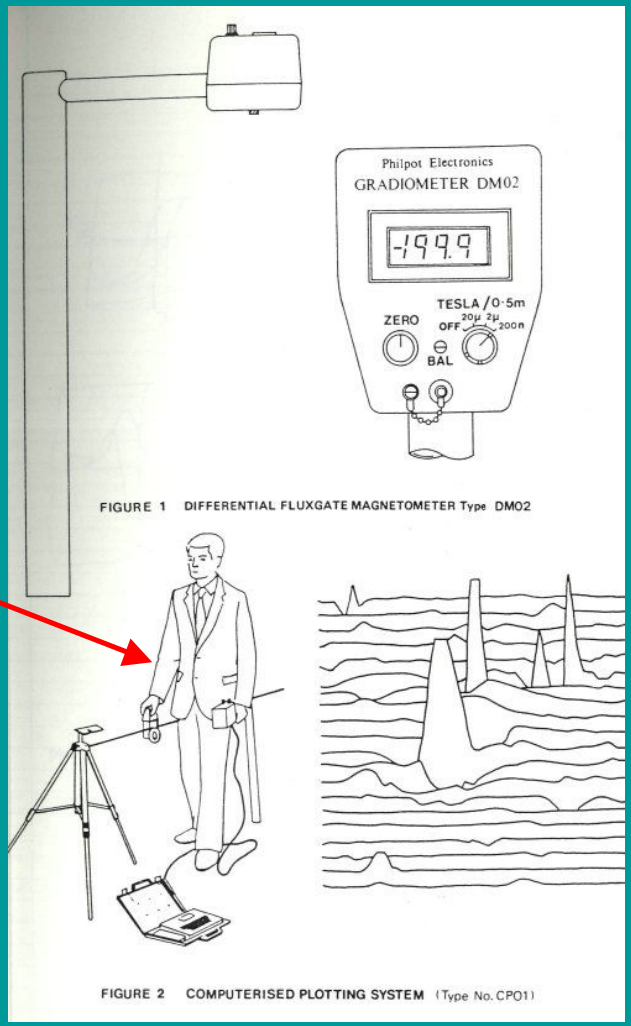

FIGURE 1 DIFFERENTIAL FLUXGATE MAGNETOMETER Type DM02

FIGURE 2 COMPUTERISED PLOTTING SYSTEM (Type No. CPO1)

1968
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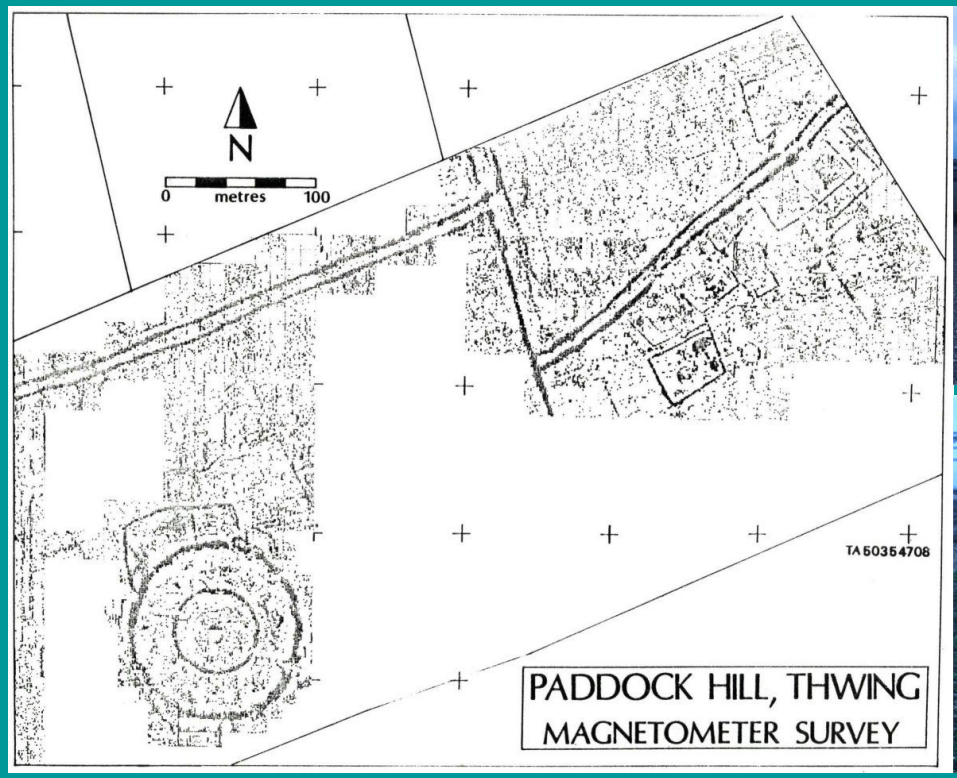
Heathcote, C, Aspinall, A. 1981 “Some aspects of the use of fluxgate magnetometers (gradiometers) in geophysical prospection in archaeology”, Revue D’Archeometrie, No.5, Volume II

Paddock Hill Survey 1972-1982 +



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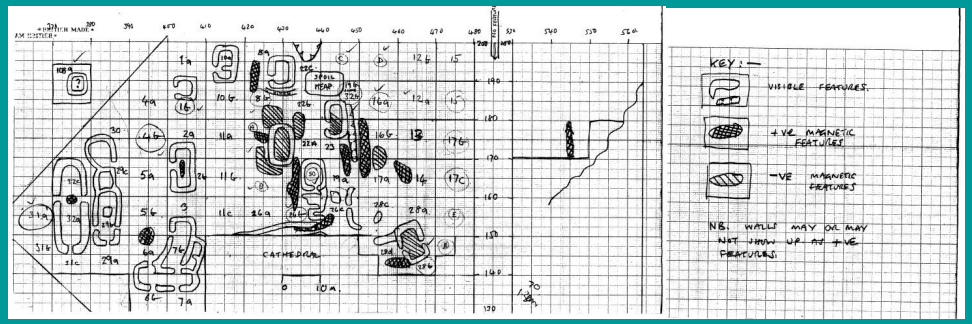
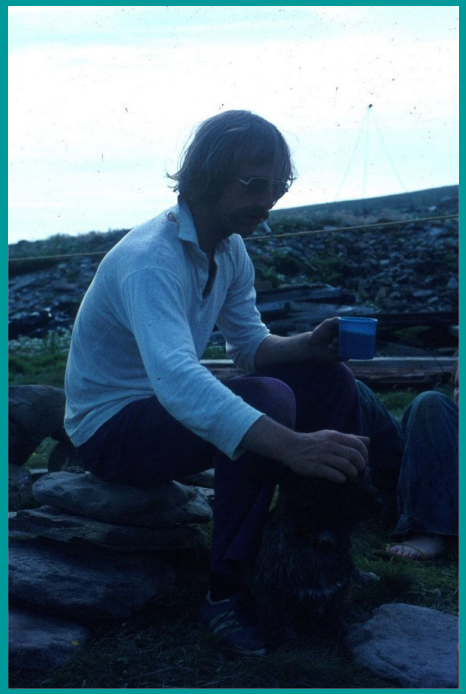
- Surveyed using a combination of Littlemoor and Philpot DM02 fluxgate gradiometers
- Start of large landscape surveys
- Data recorded on paper then hand dot-density plots produced
- Jim was so keen he was even known to have spent some holidays there !
- Arnold and Jim accompanied by Priscilla and Gaye as data recorders…….
- Competitions to see who recorded the most 20m grids in a day !

Brough of Birsay Survey, Orkney 1975

- Survey of Ancient Monuments ecclesiastical site with Plessey fluxgate gradiometer
- First met John Gater here – though the stampeding cows made it touch and go if we ever left Orkney alive !
- Igneous nature of Orkney posed problems though not as much as the causeway !
- We left the island via a flooding causeway each evening at the last possible moment, water up to our thighs, carrying a very expensive departmental gradiometer. I had nightmare visions of slipping and the wooden case the gradiometer was in floating off to sea !



The director of operations was a certain John Hunter……..



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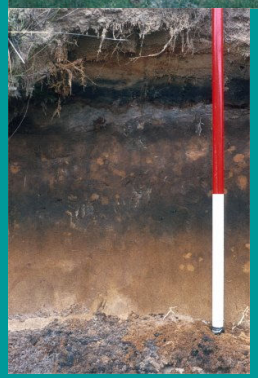
Bartington Magnetic Susceptibility Meter and Glenluce

- The department also had a Bartington magnetic susceptibility meter
- Seen here taking measurements at Glenluce sand dunes in the Scottish Borders
- An hospitable site : desert like, adders and unexploded ordnance on a military firing range !
- But very memorable as I am sure Arnold would agree. Desert sickness obviously got to some of us ……



Arnold, Rob Poulton, Dennis Mott

1968
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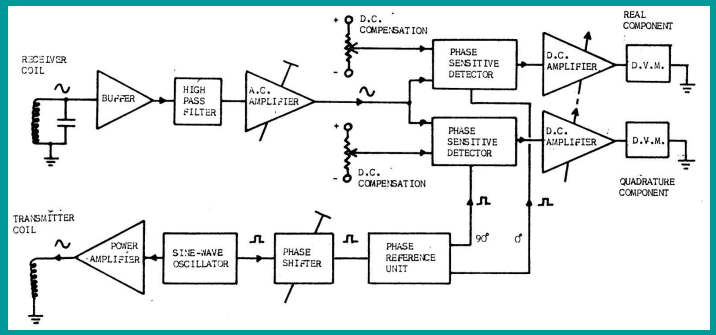
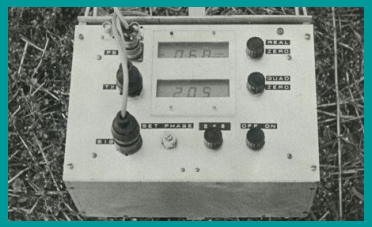
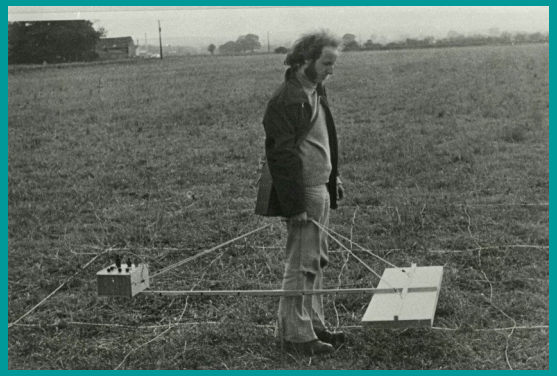
Electromagnetic Methods 1973-1976

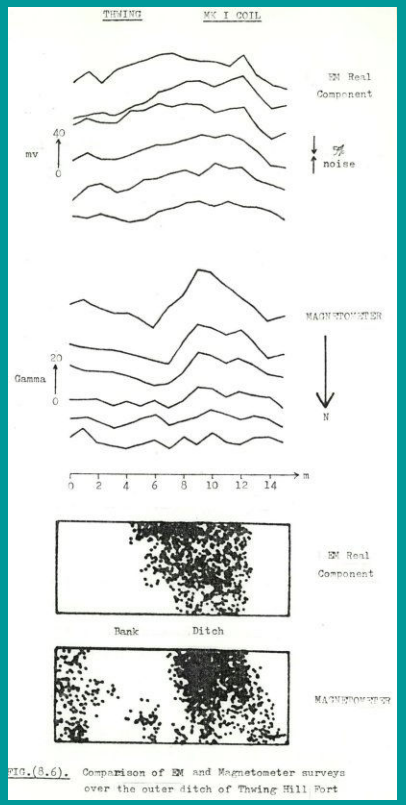
Roger Walker, "An investigation into the application of electromagnetic methods of geophysical surveying to shallow depths" 1980

- In-phase and quadrature measurements for magnetic and conductive responses at 12.5 KHz
- Horizontal co-planar coils, 3rd coil to null coupling

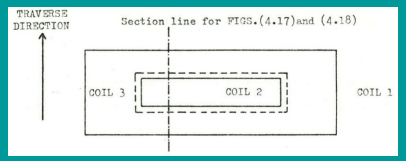








EM Real and Gradiometer, Thwing



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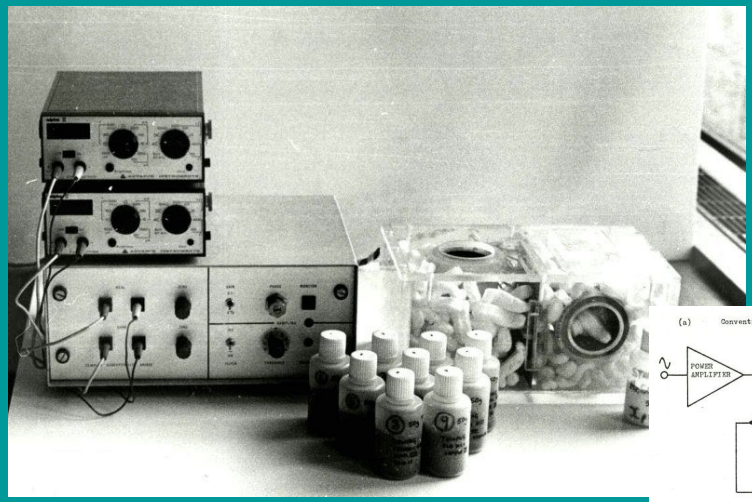
Magnetic Susceptibility Bridge 1973-1976

- Department had a bridge that measured just In-phase only
- New bridge design conceived as a pilot study towards an improved EM instrument
- In-phase and quadrature measurements for magnetic susceptibility and magnetic viscosity parameters of soil samples



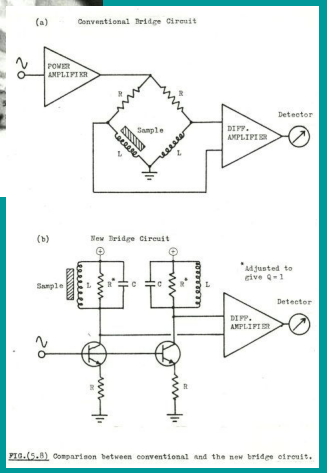


FIG.(5.8) Comparison between conventional and the new bridge circuit.

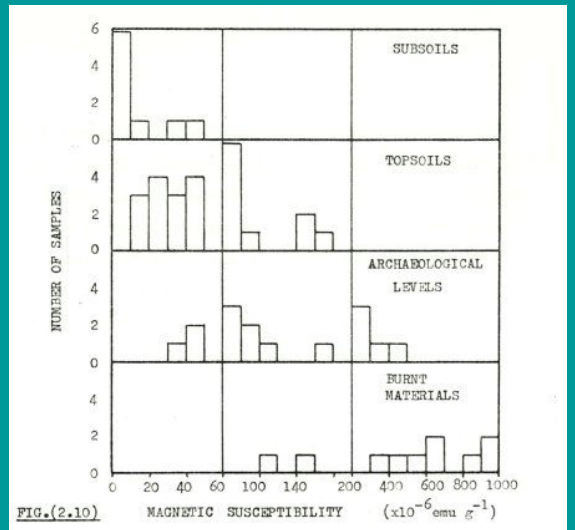


FIG.(2.10)

MATERIAL	MAGNETIC SUSCEPTIBILITY (Real component) $x10^{-6}$ emu g^{-1}	MAGNETIC VISCOSITY (Quadrature component as a % of Real)
HAEMATITE (solid)	24	0
HAEMATITE (powdered)	77	2.0%
MAGNETITE (diluted)	39000	0.2%
FERRITE	62000	0.1%
MANGANESE SULPHATE $MnSO_4 \cdot 4H_2O$	64.6	0
HIGH ALUMINA CEMENT	565	0.6%
IRON SLAG	1900	0.1%
SOFT IRON	248000	-

FIG.(2.11)

1968
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In-situ Measurement of Magnetic Susceptibility 1973-1976

- Profiles of soil section magnetic susceptibility
- Coil system moved down soil section at 2cm intervals
- Existing EM electronics used with new coil design
- Over-lapping coils for zero coupling, 12.5 KHz

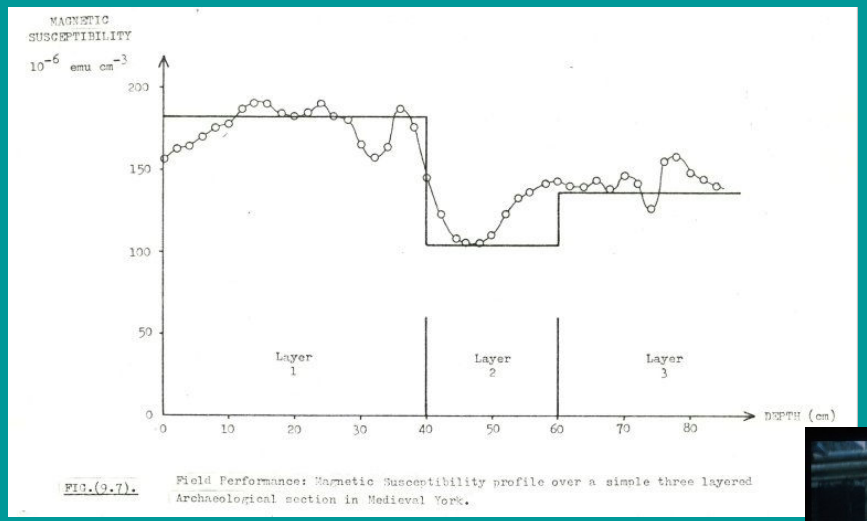

FIG.(3.7). Field Performance: Magnetic Susceptibility profile over a simple three layered Archaeological section in Medieval York.

Field tests at York Archaeological Trust site

1968
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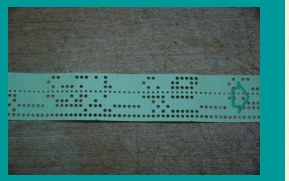
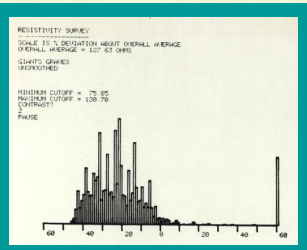
Program “Dotty” – forerunner to Geoplot 1975

- Computer processing well established (Linnington 1968)
- Only main frame computers generally available at this time
- Dot-density plots described by Scollar in 1966
- Program “Dotty” written on Hewlett Packard HP2116B :
- 16K memory, 16 bit processor, paper tape reader
- Tektronix thermal hard copy
- Data punched in on paper tapes at a teletype terminal
- Plotting parameters : Minimum, Maximum, Contrast
- Histogram output





1968
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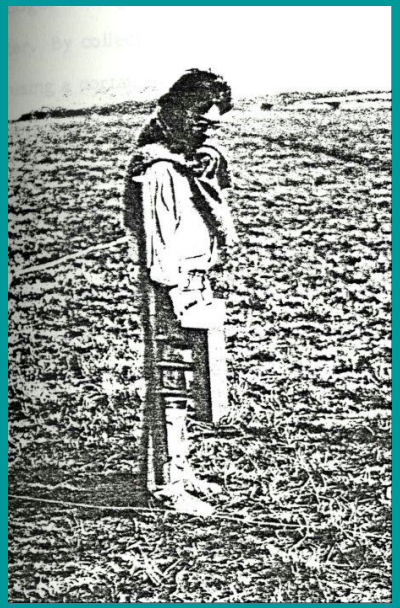
Pulse Induction and Magnetic Methods 1977-1980

Colin Heathcote, "Applications of magnetic and pulsed induction methods to geophysical prospection at shallow depths" 1983

- Pulse Induction methods provided a measure of the magnetic viscosity component of soils
- Fluxgate sensor design explored
- A comprehensive library of magnetometer response curves derived



Colin and Littlemoor Gradiometer

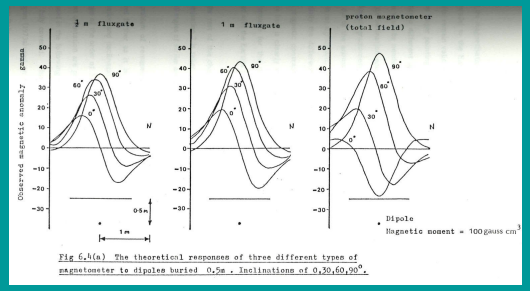


Fig 6.4(a) The theoretical responses of three different types of magnetometer to dipoles buried 0.5m . Inclinations of 0,30,60,90°.

Magnetic response curves

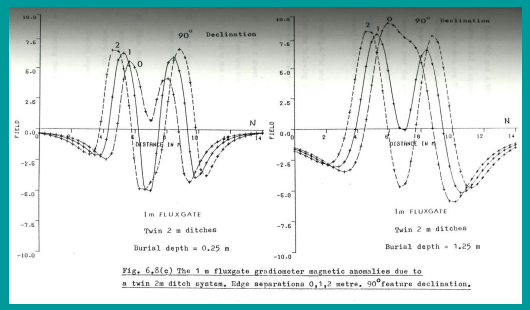


Fig. 6.8(c) The 1 m fluxgate gradiometer magnetic anomalies due to a twin 2m ditch system. Edge separations 0,1,2 metre. 90° feature declination.

Fig. 7.4(a) The basic structure of a PIM system

PIM system MK II and Arnold Aspinall

1968
1970
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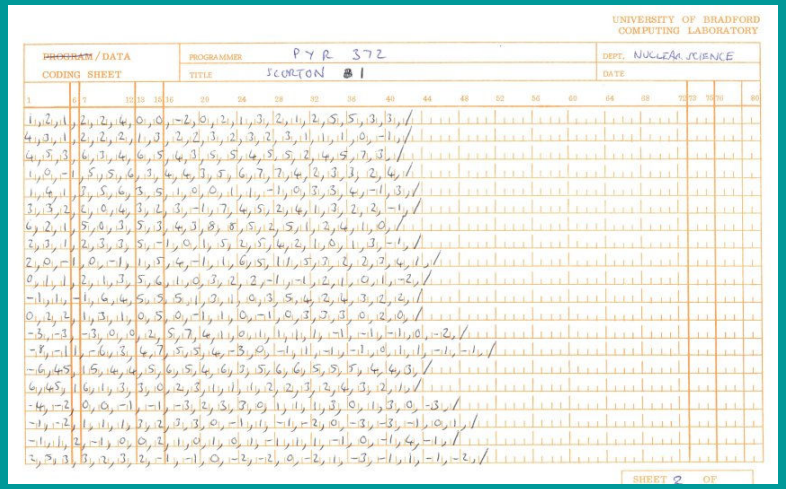
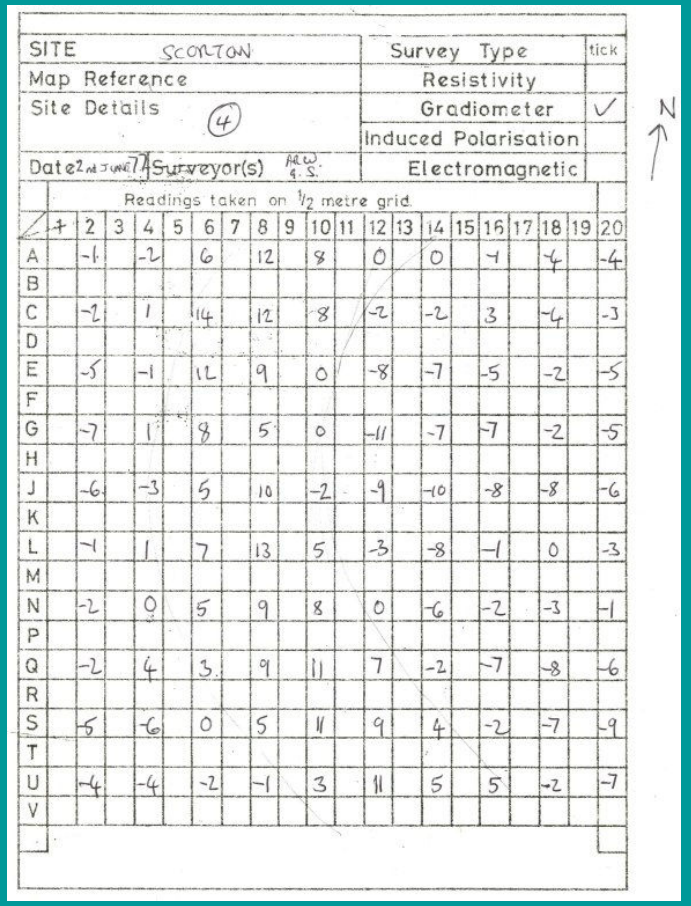
Proton Magnetometer 1977

- Two sensors in vertical gradiometer configuration
- Developed by Geoff Spinks
- Tests performed at Scorton, Catterick, May-June 1977
- Sample interval 1m



Data entry form for submitting data to the computing centre



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A		-1		-2		6		12		8		0		0		-1		-4		-4
B																				
C		-2		1		14		12		8		-2		-2		3		-4		-3
D																				
E		-5		-1		12		9		0		-8		-7		-5		-2		-5
F																				
G		-7		1		8		5		0		-11		-7		-7		-2		-5
H																				
J		-6		-3		5		10		-2		-9		-10		-8		-8		-6
K																				
L		-1		1		7		13		5		-3		-8		-1		0		-3
M																				
N		-2		0		5		9		8		0		-6		-2		-3		-1
P																				
Q		-2		4		3		9		11		7		-2		-7		-8		-6
R																				
S		-5		-6		0		5		11		9		4		-2		-7		-9
T																				
U		-4		-4		-2		-1		3		11		5		5		-2		-7
V																				

Date entry form for use in the field

1968
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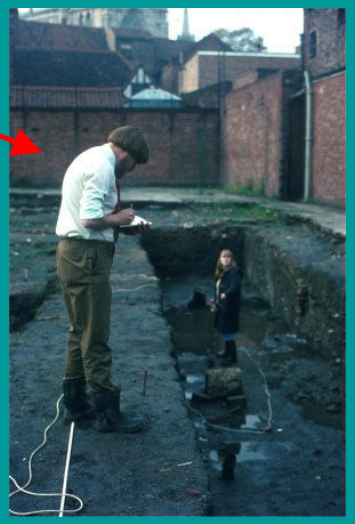
Technical Staff – Past and Present

Geophysics and instrumentation development at Bradford was only made possible with the support and enthusiasm of the Universities technical staff :

Keith Pickard
Dennis Mott
Dennis Ives
Jim Pocock
John Crummett
Geoff Spinks
Peter Dale
Stuart Fox



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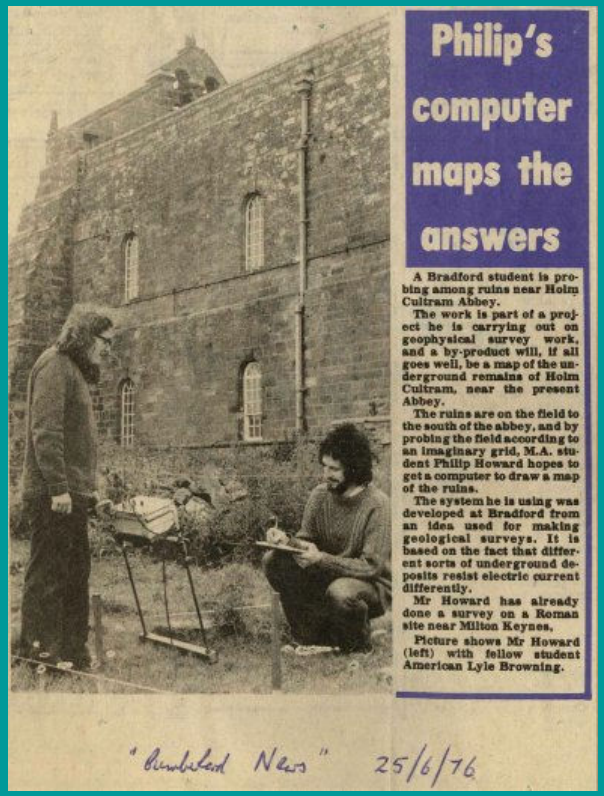
Some familiar faces from the past……



Philip's computer maps the answers

A Bradford student is probing among ruins near Holm Cultram Abbey.

The work is part of a project he is carrying out on geophysical survey work, and a by-product will, if all goes well, be a map of the underground remains of Holm Cultram, near the present Abbey.

The ruins are on the field to the south of the abbey, and by probing the field according to an imaginary grid, M.A. student Philip Howard hopes to get a computer to draw a map of the ruins.

The system he is using was developed at Bradford from an idea used for making geological surveys. It is based on the fact that different sorts of underground deposits resist electric current differently.

Mr Howard has already done a survey on a Roman site near Milton Keynes.

Picture shows Mr Howard (left) with fellow student American Lyle Browning.

"Cumberland News" 25/6/76

RM4 Resistance Meter and PA1 Probe Array 1984

CAN YOU RESIST THIS OFFER?

Have you ever thought about doing your own geophysical surveys but been put off by the technicalities? If so, then think again! The new range of instruments from Geoscan Research is designed specifically for the archaeologist with no knowledge of the techniques involved. The instruments also cater for the demands of the professional surveyor. First of a complete range of instruments is the RM 4 RESISTANCE METER:

The RM4 Resistance Meter-for all weathers!

RM4 Resistance Meter

Dot Density Display of a Geophysical Survey

What can the RM4 Resistance Meter do?

It can help you to locate rapidly and identify buried features such as walls, ditches, pit complexes, barrows etc. This ability to detect buried features could help you to decide **exactly** where to excavate saving time, labour and resources. It could help you to extend your excavations in the right directions – don't find out on the last day where you **should** have excavated! In the case of rescue excavations it could help to decide where to dig in the limited time available or indeed it may be the only way of recording the positions of buried structures before they are swept away. The RM4 could be used to supplement aerial photographs with much more detail or supply confirmation of sites spotted by field walking – the applications are limitless!

Geoscan Research can supply all the equipment you need for resistivity surveying. This includes a comprehensive manual which explains the basic principles, shows how easy it is to use the equipment, and, of prime importance, shows how to present and interpret the readings—all at surprisingly low cost.

- Very light and compact – 0.9 Kg, 160 x 85 x 85 mm
- Range 2000 ohms to 0.01 ohms
- Constant current 1mA peak-peak at 40V
- Maximum contact resistance 40Kohm
- Current chosen to avoid electric shocks
- PA1 0.5m Twin Electrode Array
- Corny first advert !

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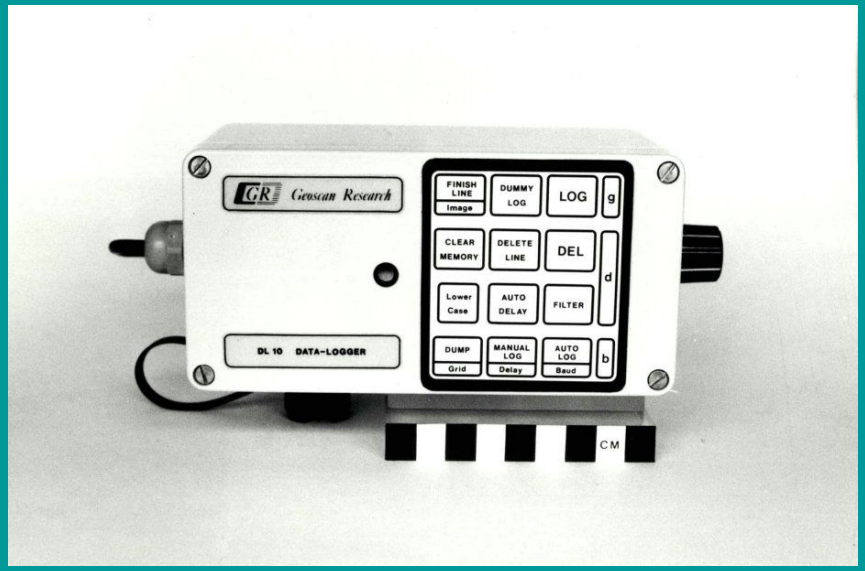
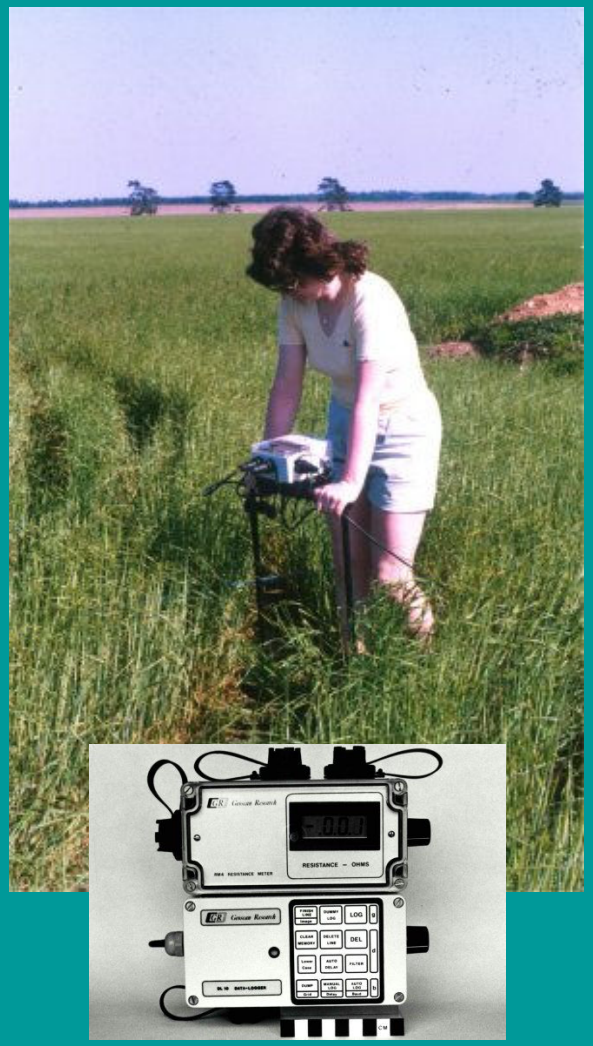
DL10 Data Logger for RM4 1985



- 1000 reading data logger
- Elimination of paper recording allowed one person surveys
- Auto-logging when Twin probes inserted into the ground
- Logging commands : Dummy, Finish Line, Image Line
- No LCD display – survey tracking with audible sounds :
  “beeps”, “chirps” and “warbles” !
- Analogue input for use with other instruments
- Needed a portable computer in the field, ie Epson HX20
- Download every two 20m square grids
- Weight 0.7 Kg



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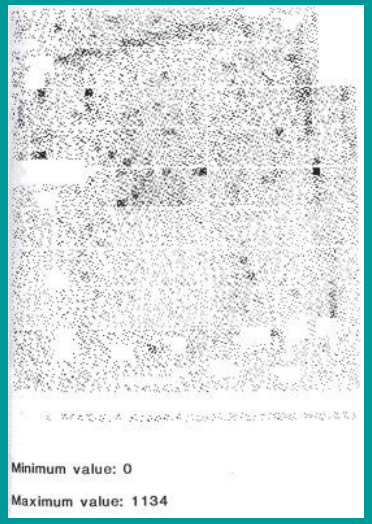
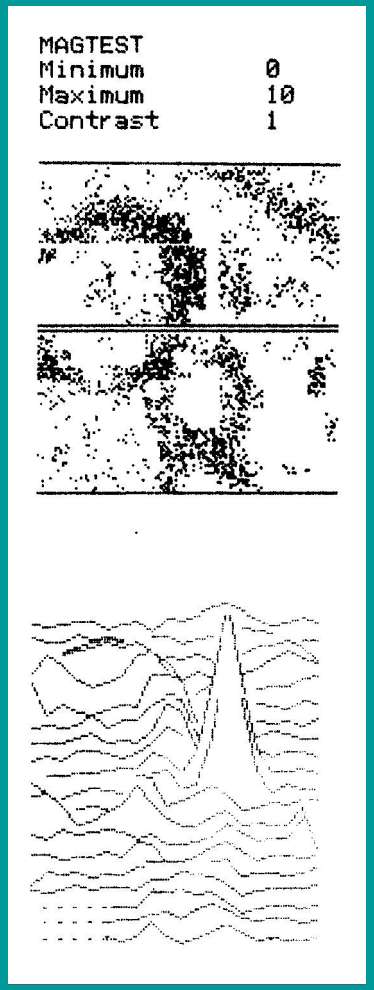
Geoplot for Epson HX20 portable 1985

Mike Kelly – 1st use of HX20



Geoplot Output



Epson HX20 Computer :
- 16K memory and battery operated
- Built-in micro-cassette audio tape drive for data storage
- Built-in dot-matrix “till-roll” printer for hardcopy output

Mike Kelly and John Haigh made first use of the HX20 in 1984

Geoplot for HX20 followed in 1985
- Data input manually or downloaded from the DL10 logger
- Dot-density plots, trace plots, editing of data (no processing)
- Auto-plots after input from the DL10

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Soutra Medieval Hospital – RM4/DL10 survey 1986

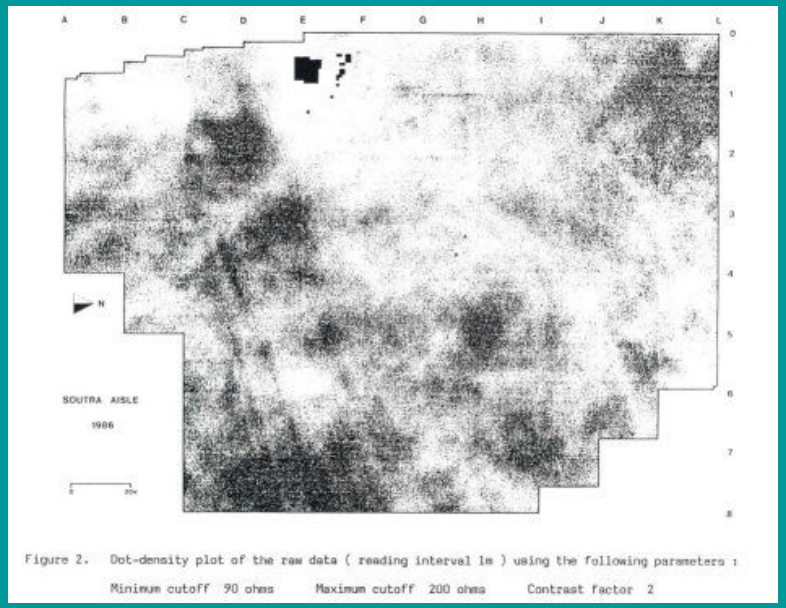

Figure 2. Dot-density plot of the raw data (reading interval 1m) using the following parameters :
Minimum cutoff 90 ohms Maximum cutoff 200 ohms Contrast factor 2

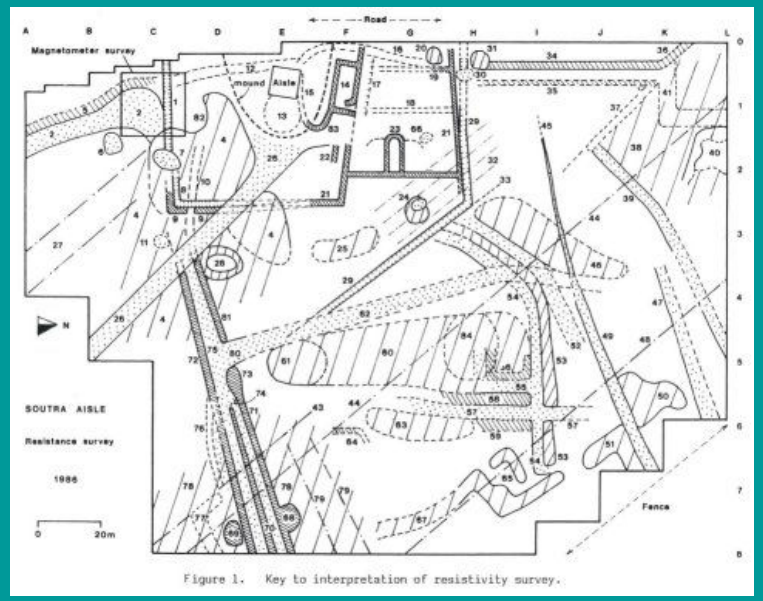

Figure 1. Key to interpretation of resistivity survey.

- 84 x 20m x 20m square grids surveyed
- 1m sample interval
- Duration 4.5 days
- Two people surveyed (one pregnant !)
- Blizzard conditions part way
- Geoplot HX20 for on site presentation
- Subsequent processing and presentation performed with a BBC B computer

1968
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Schlumberger Array 1986

Chris Gaffney, "The Schlumberger array in geophysical prospection for archaeology" 1990

- Investigation of directional properties of the Schlumberger array over linear features of width comparable with the potential probe separation
- Instrumentation, including current booster for the RM4 developed by Peter Dale

Chris and Steve Manifold at that Well known test site, Manor Vale (Arnold's back garden !)

Sue Gaffney with RM4, P1 and current booster on metal plate

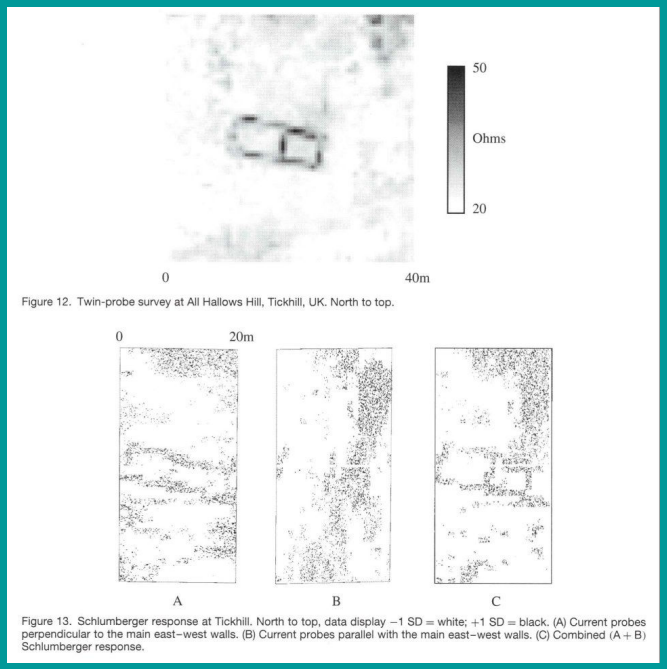

Figure 12. Twin-probe survey at All Hallows Hill, Tickhill, UK. North to top.

Figure 13. Schlumberger response at Tickhill. North to top, data display −1 SD = white; +1 SD = black. (A) Current probes perpendicular to the main east–west walls. (B) Current probes parallel with the main east–west walls. (C) Combined (A + B) Schlumberger response.

Schlumberger response at Tickhill

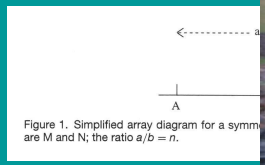

Figure 1. Simplified array diagram for a symm
are M and N; the ratio $a/b = n$.

Schlumberg

Chris from his Dyno-Rod days...

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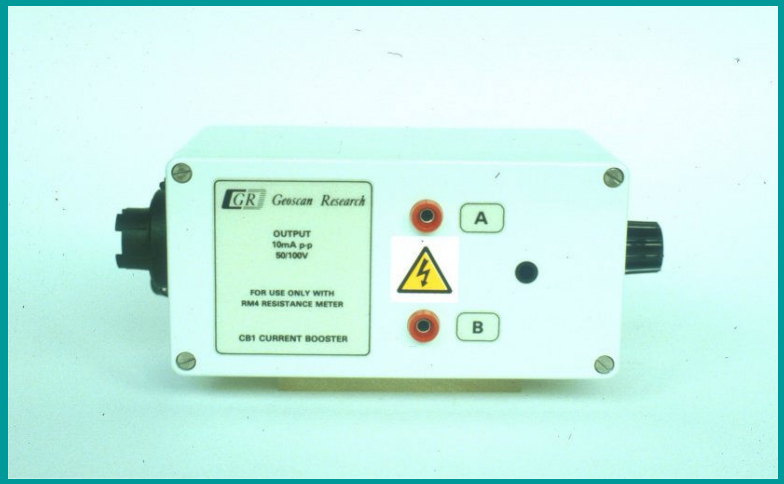
CB1 Current Booster for RM4 1989



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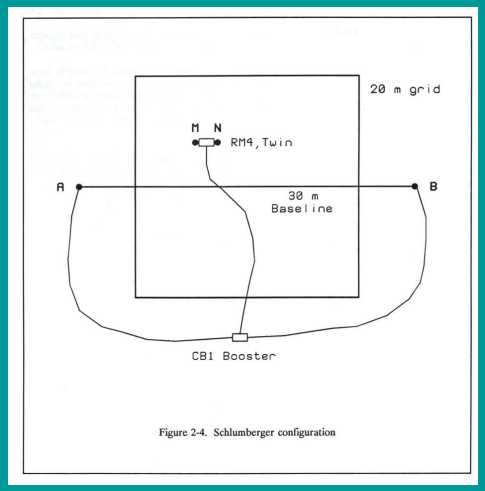
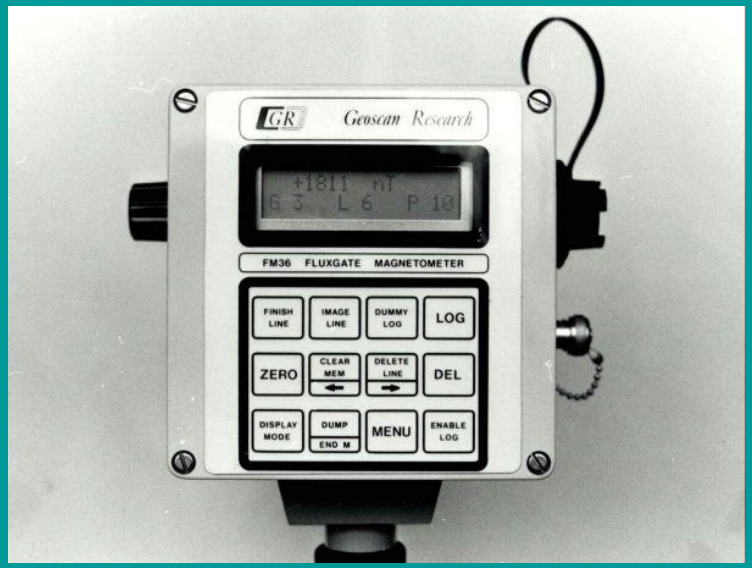
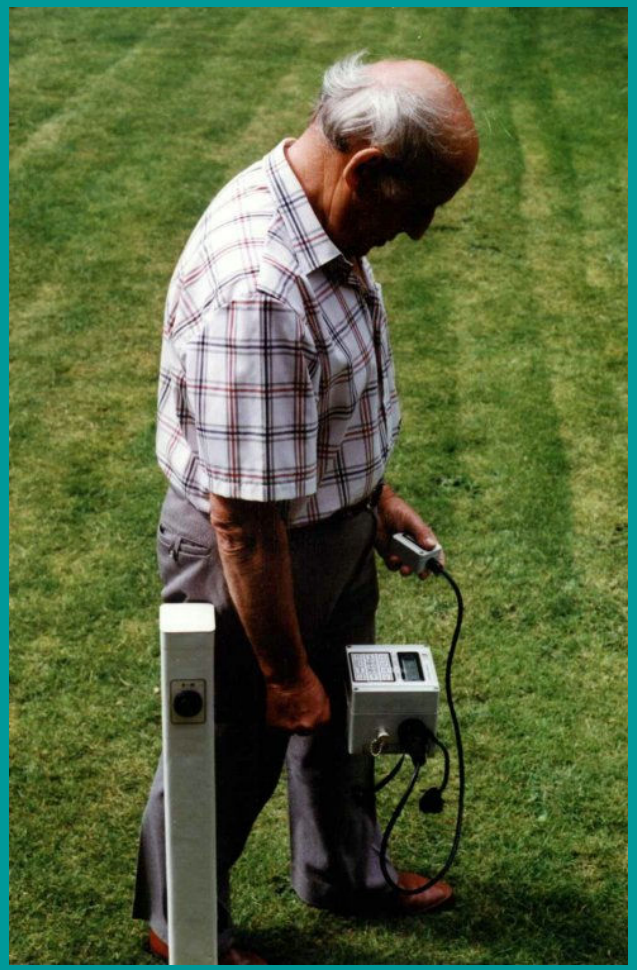
- Increased RM4 output to 10 mA peak to peak, 100 V
- Provided 10 times increase in sensitivity for RM4 when used with arrays such as the Schlumberger
- Developed as a result of Chris Gaffney's and Peter Dale work
- RM4+CB1 combination a pre-cursor to the RM15 resistance meter



FM9, FM18, FM36 Fluxgate Gradiometer Series 1987

- Fluxgate Gradiometer
- 0.5m sensor separation
- Digital display plus bar graph display
- FM9 : no data logger
- FM18 : built-in data logger 4000 readings
- FM36 : built-in data logger 16000 readings
- Hand-held trigger device for logging readings
- Survey tracking and commands like DL10 but displayed
- Lightweight – 2.35 Kg





Alan Walker demonstrating the FM36

1968
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ST1 Sample Trigger for FM series 1987

- Generates trigger pulses for FM18 and FM36
- Enabled rapid collection of detailed data sets at :
  1, 2, 4, 8 or 16 sample per metre
- Variable speed metronome to guide walking position
- Powered by FM18 or FM36

1968
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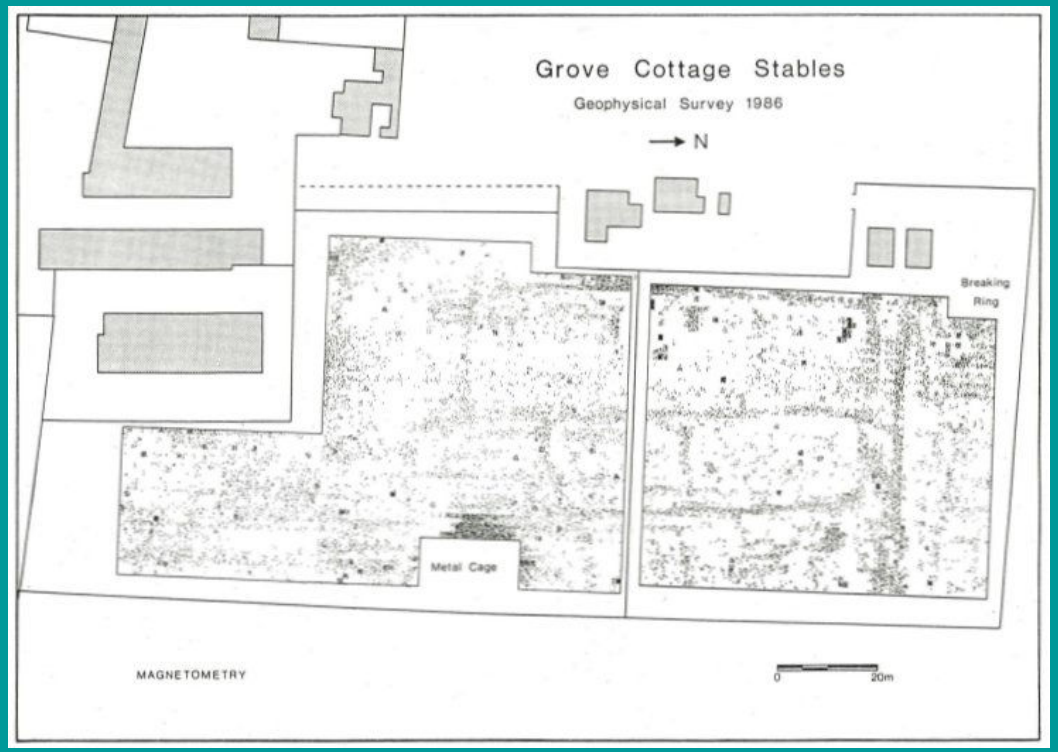
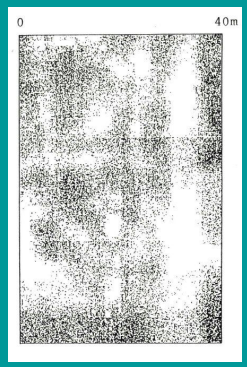
2006

Grove Cottage Survey (with John Gater of GSB) 1986

- First survey with an FM series gradiometer
- Right hand half surveyed with an FM9 and DL10 data logger
- Left hand half surveyed with a Philpot AM01 and DL10 data logger
- RM4 / DL10 complimentary resistance survey done at the same time



Gradiometer data



Resistance data

1968
1970
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Examples of FM18/36 in use

Shetland ?

Case customisation by Tomek Herbich !

Adel 1994

Geoplot 1.0 for IBM Compatible DOS computers 1989

Amstrad PPC portable computer

Portable IBM Compatible DOS computers introduced :
- 640K memory and battery operated
- Built-in floppy disks for data storage
- More pixels on the screen – but only 4 shades of grey
- Large size dot-density and trace plot printouts possible

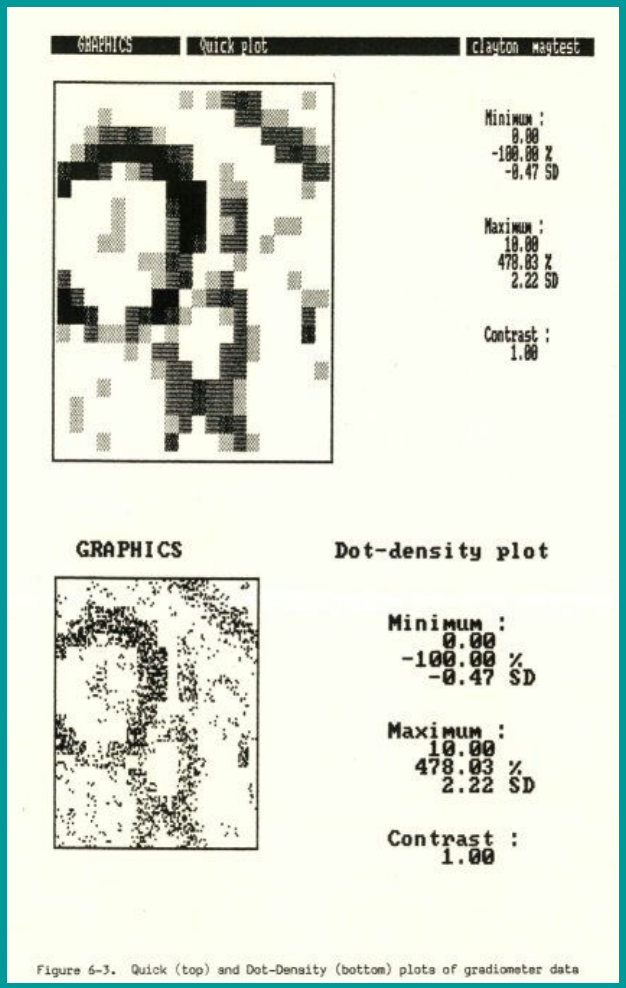

Figure 6-3. Quick (top) and Dot-Density (bottom) plots of gradiometer data

1968
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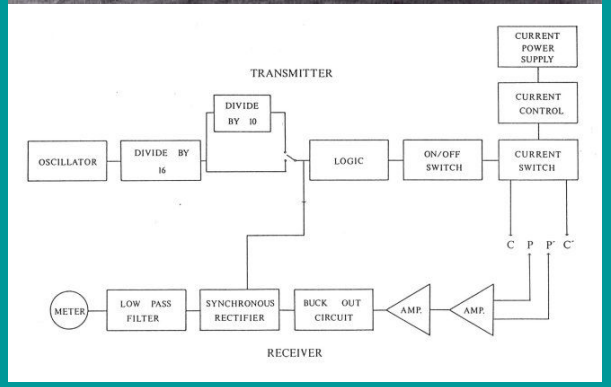
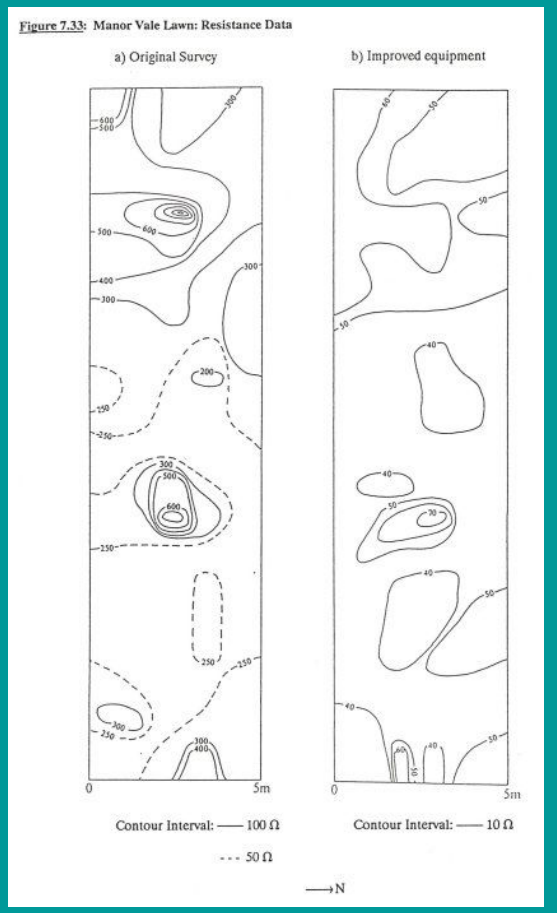
Induced Polarization Methods Revisited c1986 - 1989

Sue Ovenden, "Frequency mode induced polarization studies for geophysical exploration in archaeology" 1990

- Examined Induced Polarisation in the frequency domain
- Probe polarization problems avoided in the frequency domain
- Instrumentation developed by Peter Dale



Model studies



Manor Vale test results

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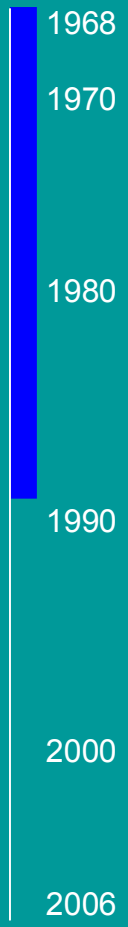
Pulse Induction Methods Revisited c 1986 - 1989

John Skinner. Sadly I could not gather information on John's PhD work so I'll use this as a good excuse to sneak in yet another of Arnold (and John Skinner with Sue Gaffney) !



RM15 Resistance Meter 1991

- Built-in data logger : 3600, 15000 or 30000 readings
- Expansion facilities via external multiplexer
- Very light and compact – 1.5 Kg
- Range 20000 ohms to 0.005 ohms
- Constant current 0.1mA, 1mA or 10 mA peak-peak
- Output Voltage 40V or 100V
- Maximum contact resistance 1 Mohm
- Currents chosen to avoid electric shocks

RM15 in use at Adel 1994

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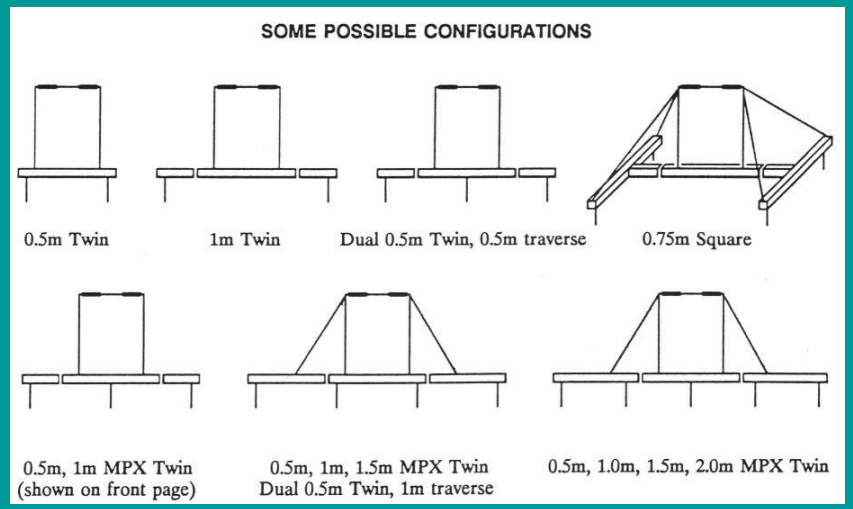
PA5 Multi-Probe Array and MPX4 Multiplexer 1991

PA5 Multi-Probe Array
- A “universal” probe array system for the RM4 and RM15
- Standard 0.5m Twin with additional wings and probes
- Twin: 0.25m, 0.5m, 0.75m, 1m, 1.25m, 1.5m, 2m
- Pole-pole
- Gradient
- Wenner
- Double-Dipole
- Square 0.75m

MPX4 Multiplexer
- Switch for manual multiplexing of up to 4 Twin spacings
- Configure Twin, Wenner, Double-Dipole, Square arrays



MPX4 Multiplexer

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Things don’t always go right……

Arnold and Jim hang their heads in despair as John vainly looks for a reading……

TRM Measurements in the Field, Shetland c1992

Device built by Peter Dale, used by John Crummet and Arnold for TRM measurements
Part of Steve Dockrill's excavations at Trowie Loch, Shetland
Aim was to determine if stones in burnt mounds were "fired" in situ or heated individually
Device clamped to the end of a Littlemoor gradiometer and stone rotated in 2 directions
Results inconclusive since most rocks in Shetland were igneous !

However I'm told Arnold will remember the trip not for the physics but for Mrs Blanches **MEGA** meals.

John Crummett surveying old croft dwellings, South Nesting, Shetland

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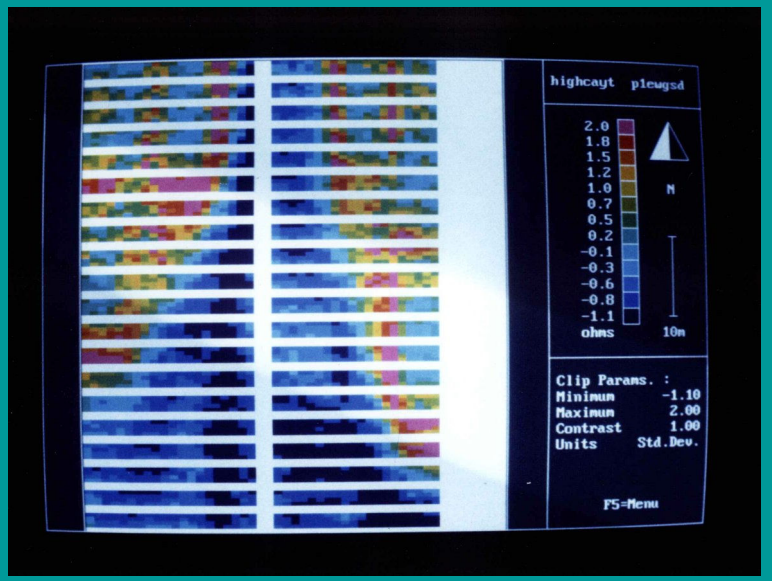
Geoplot 2.0 for DOS 1992

- Colour and full range grey scale plots introduced
- Large range of processing and analysis functions
- Improved print out quality



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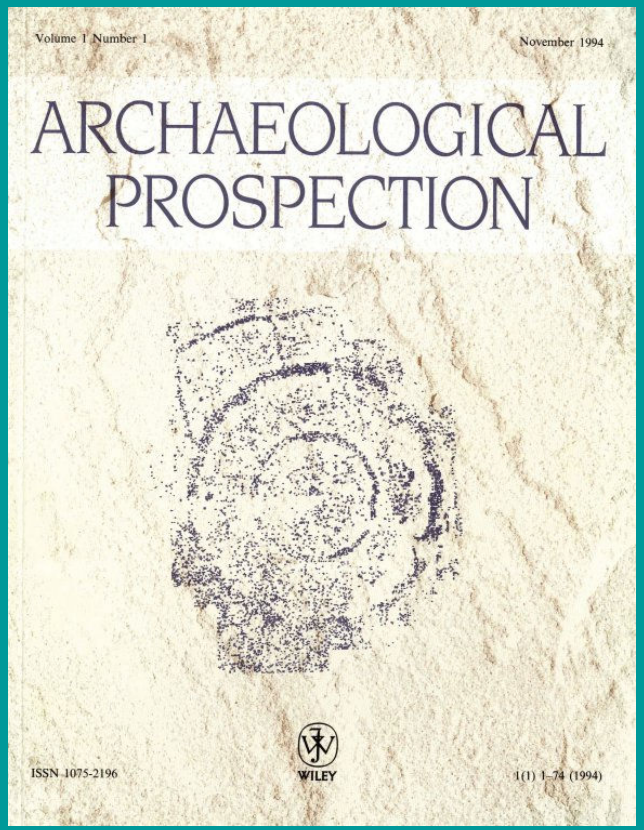
Birth of Archaeological Prospection Journal 1994

- 1994 sees the landmark launch of “Archaeological Prospection”
- With Arnold Aspinall and Mark Pollard as joint editors



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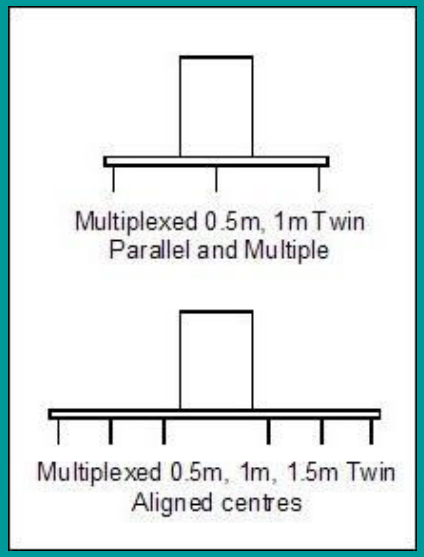
MPX15 Multiplexer for RM15 1995

- Automated multiplexing with the PA5 probe array
- Offers a wide range of configurations eg:
  - Parallel Twin for greater speed or more detail
  - Multiple Twin for depth investigations eg pseudosections
  - Simultaneous configurations eg Wenner alpha and beta
- User programmable
- Up to 8 user defined programs
- Up to 8 sequences per program
- Auto-Logs up to 4 readings per second



1968
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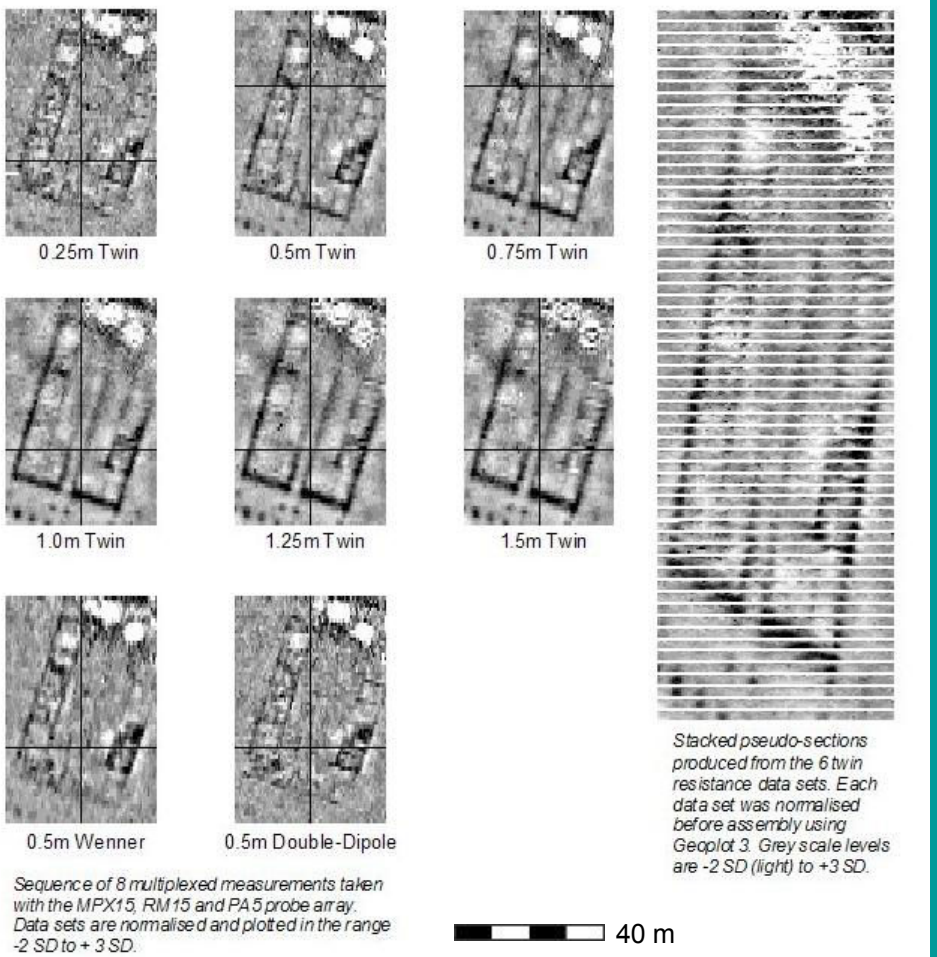
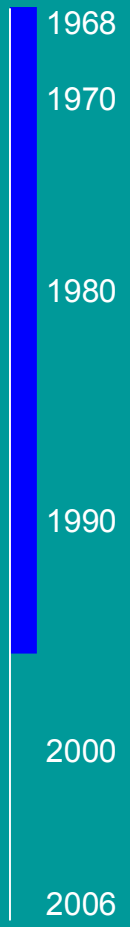
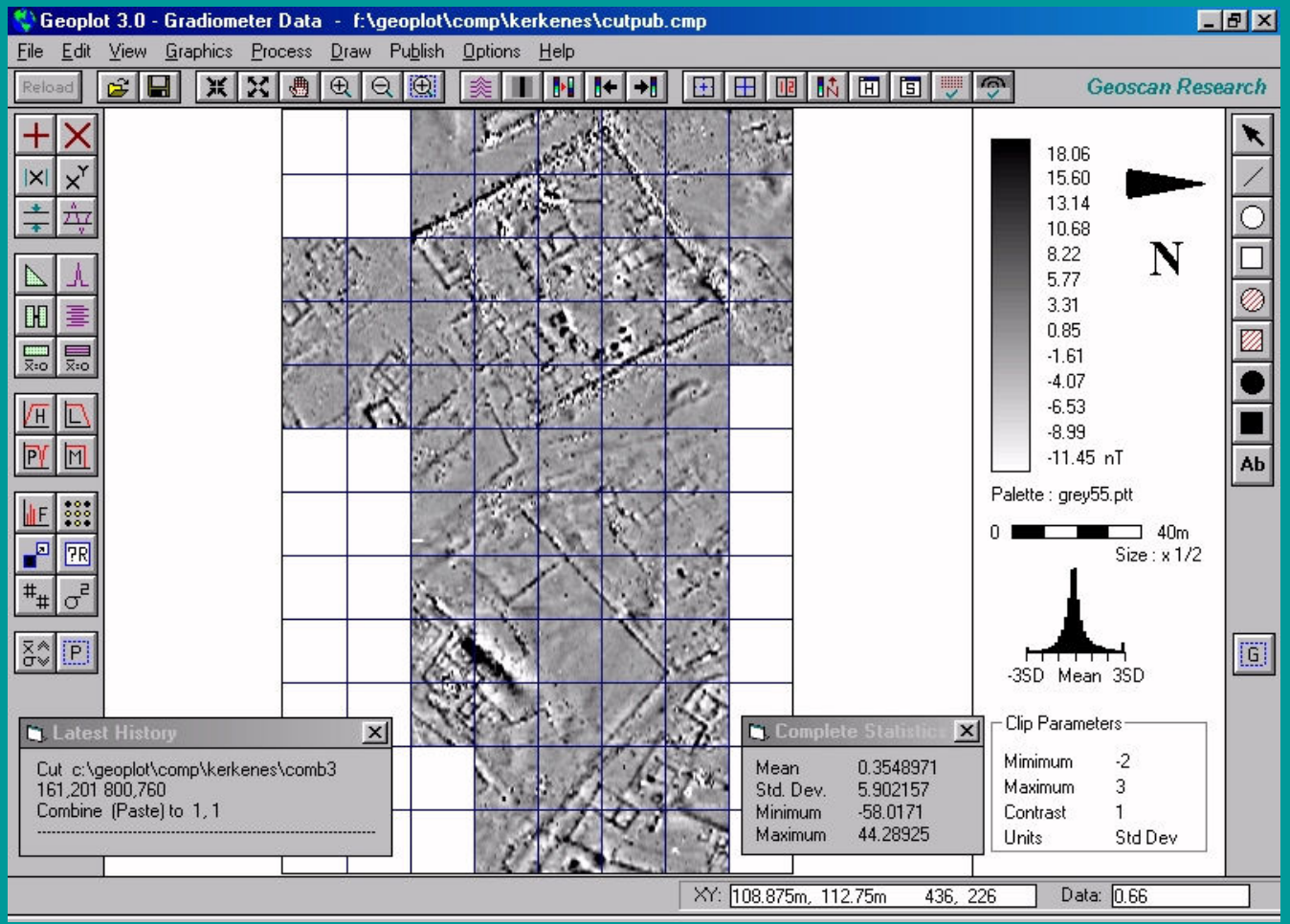
Wroxeter Survey June 1996

- Multiplexed Twin 0.25m to 1.5m
- Also Wenner and Double-Dipole
- Stacked pseudo-sections generated
- Enables broader understanding
- Narrower Twin spacing: near surface cellular structures, internal partitions
- Wider Twin spacing : substantial underlying features and colonade





Geoplot 3.0 for Windows 2000



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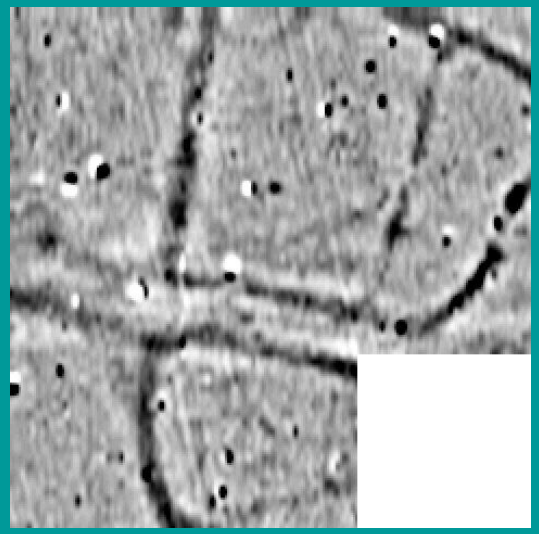
FM256 Fluxgate Gradiometer System 2002

FM256 Single Instrument
- Integral data logger, 256000 readings, 15 min. full download
- Integral sample trigger
- Independent sample and traverse intervals : 1 to 16 samples/m
- LCD backlight and contrast adjustment for poor light conditions
- NiMH battery, 21 hour operation, 4hr fast charge (LED status)

Dual Gradiometer System
- Use two instruments for double speed / increased density surveys
- Master/slave system accepts FM18/36 or FM256 slave
- Interleaving gives 0.5m or 0.25m traverse intervals
- Open frame gives rapid operator turn-around for zig-zag surveys
- Integral master start/stop controls on frame

Survey over Romano-British site, Towton



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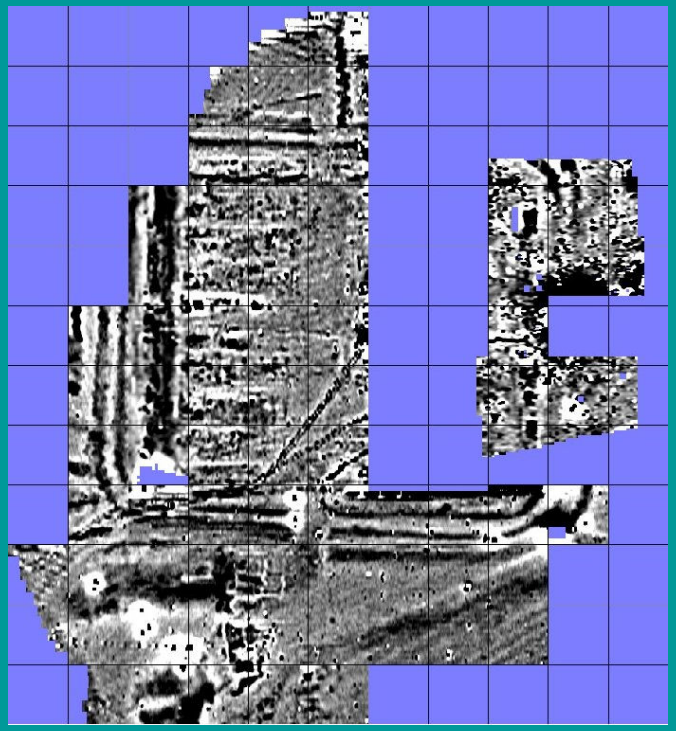
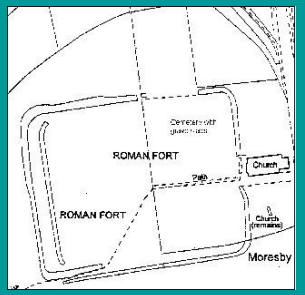
Moresby Roman Fort 2002 / 2004

- Dual FM256 fluxgate gradiometer survey, 4 samples / m
- Area 3.1 h, consisting of 78 20mx20m grids
- East side is heavily disturbed by a Victorian cemetery and churchyard
- A considerable wealth of features survive including rampart, outer ditches, internal buildings or barracks, entrance or gatehouse to the south, possible bath-house outside the fort also to the south





N

-5 nT +5 nT

40 m

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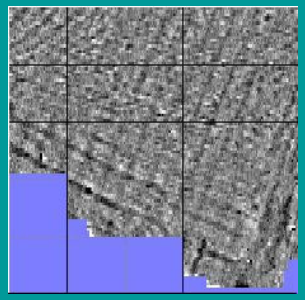
North Acres in Saxton, Towton Battlefield 2002

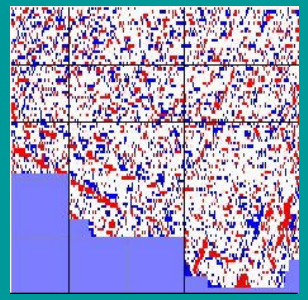
Comparison of FM256 fluxgate gradiometer survey with previous metal detector survey over arrow head spread. The absence of targets with +/- 2.5 nT thresholds compares well with the greatest concentration of metal detector finds but indicates a few remaining possible arrows on the perimeter.

N

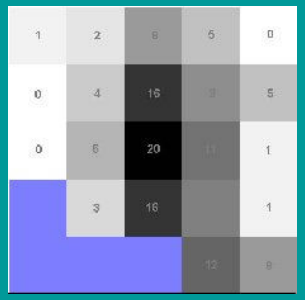
Grey scale –2.5 nT to + 2.5 nT



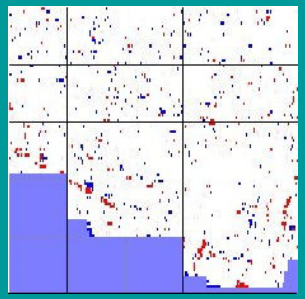
Significant +ve @ -ve targets



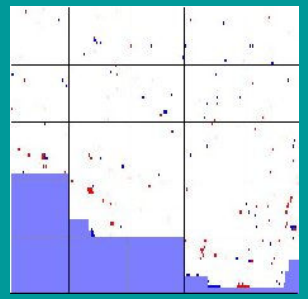
Metal detector finds and location



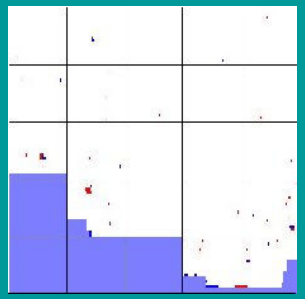
Threshold +/- 1.5 nT



Threshold +/- 2.0 nT



Threshold +/- 2.5 nT



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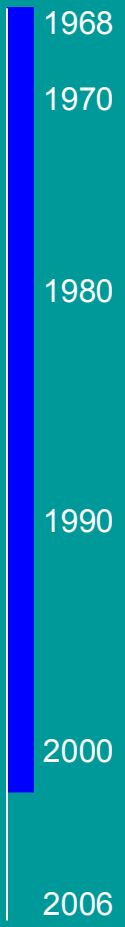
Taking a well earned rest !

Taking a well earned rest, Towton Battlefield 2002



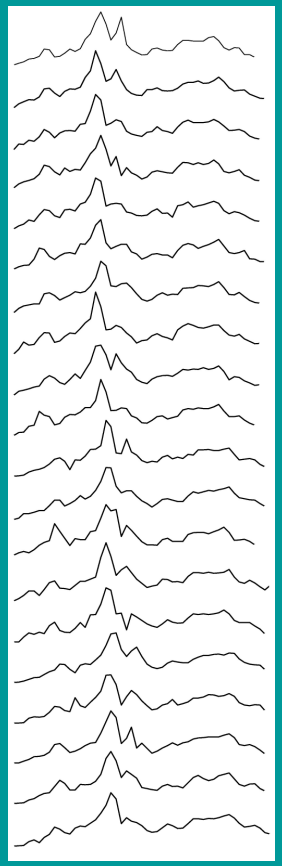
4 sandwiches

Start of development of Wheeled Square Array 2003

- 0.75m Square array
- Four spiked wheels
- 12 connected spikes per wheel
- Alpha configuration only
- Time based sample triggering
- Speed 1 –2 seconds / m
- Sample interval 0.25m

Alpha: A B → M N

Early results over a repeated 10m line



Wheeled Square Array in use over a very stubbly field at Towton Battlefield

Tim Sutherland wishing he had never suggested the idea !

Leonardo Da Vinci !

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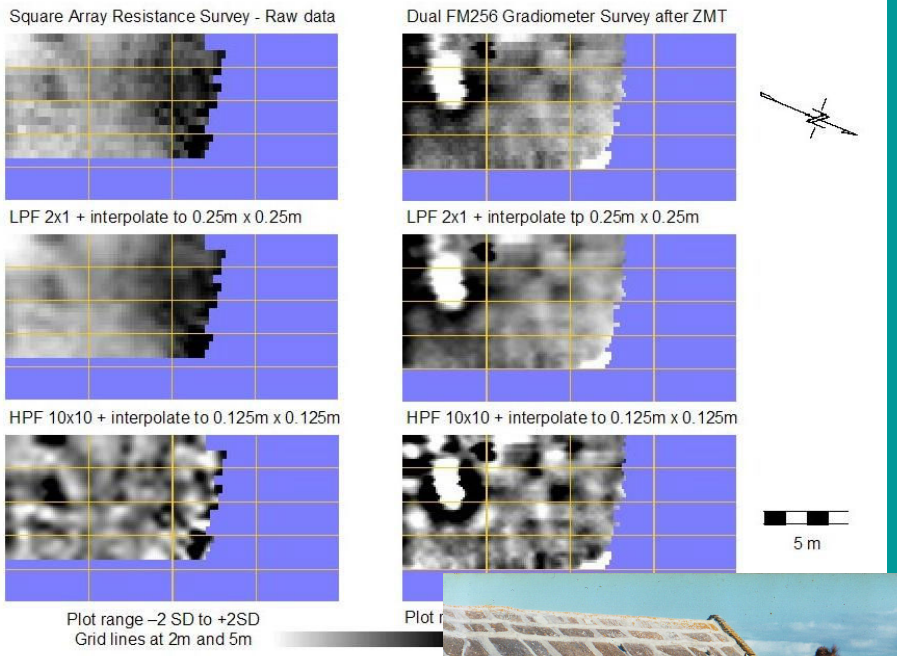
High Resolution Surveys, Jarlshof, Shetland 2003

- Comparative high resolution wheeled resistance and gradiometer surveys
- Prehistoric, norse and medieval settlement at Jarlshof, Shetland.
- Dual FM256 fluxgate gradiometer with sample interval = 0.125m and traverse interval = 0.25m
- Prototype Square array in Alpha mode with sample interval = 0.25m and traverse interval = 0.5m
- The survey area was only 13m x 8m but reveals considerable detail



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All went well for Kath and myself though
Steve Dockrill had trouble with the natives……

Square array investigations at the University c2002 - 2004

Whilst Geoscan worked on the Square array, MA students at the University were also doing their own investigations…..

Mary Saunders using the Square array on a Time Team programme

Tom Sparrow using the Square array at Adel

1968
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A.Aspinall, M.K.Saunders “Experiments with the Square Array”, 2005. AP 12, 115-129

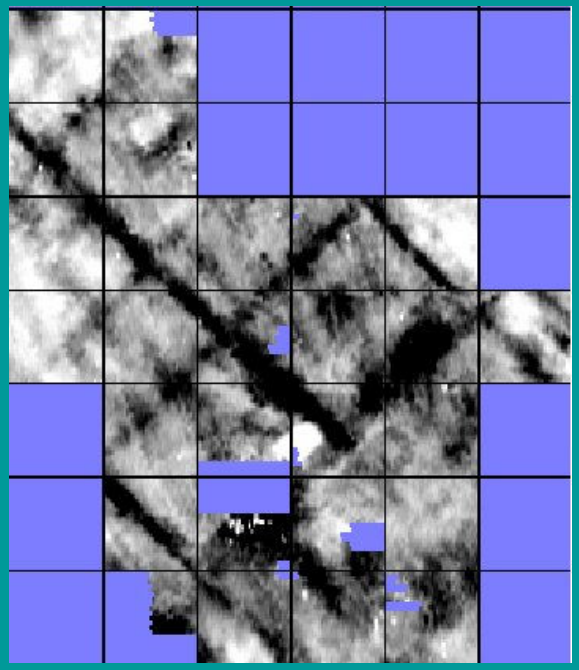
Drumlanrig Castle (with GSB and Time Team) 2004

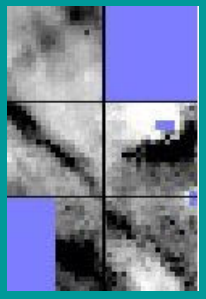
A suspected Roman fort in the grounds of Drumlanrig Castle was surveyed with a production prototype 0.75m wheeled square array system and comparative 0.5m Twin array. Alpha data was collected at 4 samples/m whilst Twin was collected at 1 sample / m. Alpha survey speed was approximately 7.5 minutes per grid.

Internal roadways of the fort are clearly visible, along with other fine detail which is not visible in the Twin data.

Alpha: A B → M N

Square Array Alpha data





0.5m Twin Array Data

N

40 m

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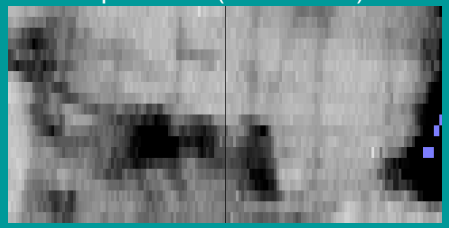
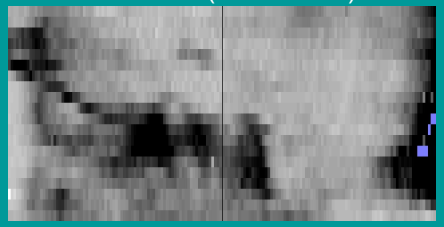
Littlemoor Castle Multiplexed Alpha/Beta Survey 2004

- New enclosed wheel design with distance encoder for triggering
- Multiplexed Alpha and Beta measurements
- 4 samples / m at a speed of 1 second / m
- Survey over filled in ornamental Victorian pond below Castle
- Complimentary FM256 gradiometer survey
- Alpha and Beta data is directional and complimentary (eg field drains)

Alpha Data (20m x 40m)

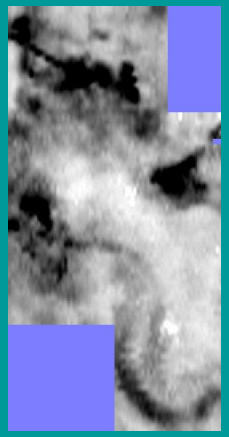


Beta Data (20m x 40m)

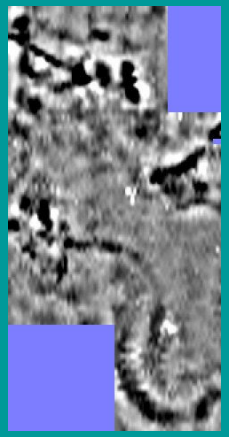


N

Alpha+Beta Data



HPF Alpha+Beta Data



Gradiometer Data

Alpha: A B → M N

Beta: B N → A M

20 m

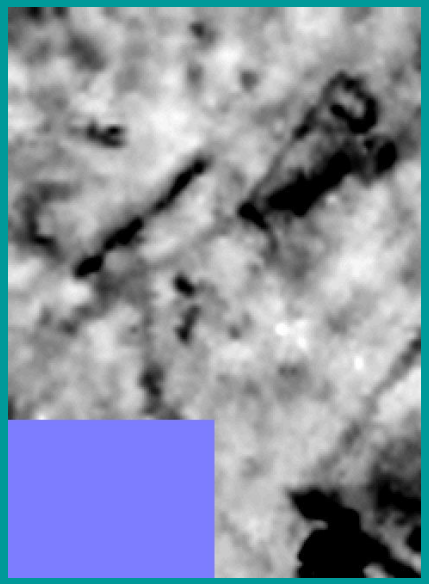
1968 1970 1980 1990 2000 2006

- A big thank you to Lew Somers seen here in action at Littlemoor !

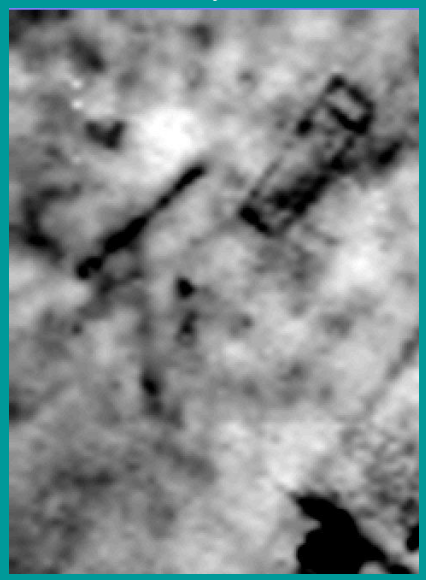
Dunkirt Barn Survey (with English Heritage) 2004

- Late Iron Age site with associated Roman villa in Hampshire
- Chalk, recent ploughing, straw stubble, very large flints
- 0.75m Square array, 2 samples / m, multiplexed alpha and beta
- 0.5m Twin array, 1 sample / m
- Very wet conditions built up “wattle + daub” on the wheels !
- Despite this foundations of part of villa complex were revealed
- Excellent correspondence between Square and Twin data sets

Square Array Data



Twin Array Data



30 m

A slight problem with mud !

(since resolved)

1968
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PA20 Probe Array 2004

- The PA5 gets a makeover in 2004
- Quick release system for rapid interchange of glass fibre beams
- Lighter in weight than the PA5

1968
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Duncombe Park Garden Survey 2005

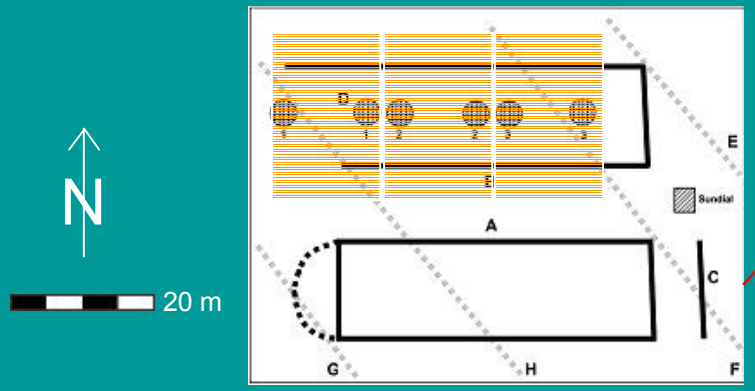
- Fluxgate gradiometer is added to wheeled square array
- Simultaneous resistance and magnetic surveys possible
- System becomes the MSP40 – becomes Mobile Sensor Platform
- Survey below reveals probable formal borders of 18 Century gardens
- Strong iron features probably posts for tennis court nets !

Resistance (alpha and beta)

-15 Ohm +15 Ohm

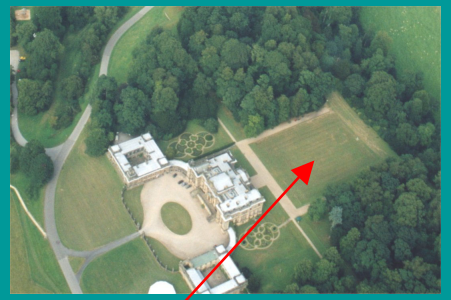
Gradiometer

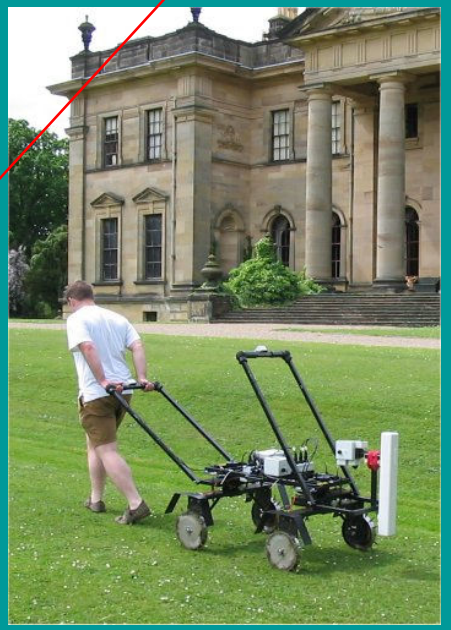
-2 nT +2 nT



N

20 m





1968
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2006

A finally a really big thanks to Arnold Aspinall……..

……..and not forgetting his Manor Vale test site !

John Crummett, Tim Sutherland and Arnold Aspinall at Towton