Gorgan Wall

IRAN

forts 4 and 5

Geophysical Survey using Magnetometery

8 October 2006

For
Great Gorgon Wall Research Project
No. 8 Modifan House
Emamzadeh Alley
7th Sar-khajeh Ave.
Gorgan
Iran

Carried out by

Roger Ainslie, Mohammed Eshardi and Julian Jansen van Rensburg
assisted by Armin ??? and Noradin Armashi

Abingdon Archaeological Geophysics
4 Sutton Close, Abingdon, Oxon OX14 1ER
tel. 01235 529720
website www.archaeologicalgeophysics.co.uk

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1 SUMMARY

Magnetometer surveys were carried out on these sites in September 2006.

The survey of fort 5 revealed little which was not already visible on the ground. It did however indicate that only the side of the fort which ran along the wall itself had fired bricks and he assumption is therefore that the other sides had walls of mud brick.. There is a possibility that there may have been tower type structures near the corners of the fort on its Gorgan wall side but further work will be necessary to clarify this. The interior had a large fairly recent burial enclosure which had some grave markers made from mis -fired bricks and several smaller burial enclosures. This disturbance could have obscured any other remains in that area.

Fort 4 was far larger and only approximately one third of its interior contained recent funerary enclosures and monuments. Here weak anomalies were detected which indicated that the interior had three rows of buildings, each subdivided into many apparently identical rooms. There was a space on the eastern side which was of the same size as one of the buildings but appeared to have few anomalies indicating its use. There appeared to be a ditch around this area which again differentiated it from the areas with buildings. The walls appear to have had a fired brick component on all four sides. Little was located of archaeological significance outside the fort which could indicate that either there was nothing there or that the remains have been heavily damaged by ploughing and cultivation.

2 INTRODUCTION

The geophysical surveys were part of the work on this wall being carried out by the Gorgan Wall Research Project in 2006. In the previous year brick kilns along the wall had been located and excavated to produce samples for scientific dating – See Iran 44, 2006.

The 2006 season had geophysical surveys of part of fort 5 and of fort 4. It also had further work on kilns elsewhere on the wall and the excavation of features indicated by the magnetometery in fort 4.

Both forts can be identified on the land as they have earth banks around them which are between approximately 2 and 4 metres high. Yhese appear to have been the upcast from the broad dithes around the forts,

Fort 4 had high dried weeds which were flattened before the survey took place to enable the sensors to be carried close to the ground to seek to enable weak magnetic signals to be detected. Fort 5 had been used for grazing sheep and had short grassy vegetation.

The weather was mainly hot and dry although there were some cloudy days and one very rainy day in which no work could take place.
The geology of both sites is understood to be a thick bed of loess

3 Survey Design and Equipment

Magnetometery was chosen as it is a fairly rapid and thus cost efficient method of locating shallow buried features. It largely depends on the soil having natural iron in it which can be enhanced by human or bacterial action. Unlike resistivity it does not require the ground to have a sufficient water content to enable anomalies to be detected and would therefore be preferred on dry sites.

A Bartington Grad 601/2 gradiometer was used with the probes 1 metre apart and with a 1metre spacing between the top and bottom sensors.

The survey was carried out with traverses 1 metre apart and 4 readings being taken per metre along each traverse. Our experience is that traverses at less than 1m separation seldom produce sufficient additional information to justify the extra effort which would be necessary if the traverses were half a metre apart. Whilst we could have taken readings at 8 readings per metre we felt that the more usual 4 readings per metre would be adequate bearing in mind the fact that the grids were at an angle to the main axis of the fort and as fort 4 was large, a higher reading density could well have given major problems with data processing.

The grids were 30metres by 30 metres and were at an angle to the main axis of the forts in order to maximise the chances of locating features and reduce the possibility of features being lost in the data processing. The person carrying the gradiometer walked along strings with markings every metre to seek to ensure that the data was collected at the correct intervals.

The survey areas were located by a hand held Global Positioning System and the grids were laid out using tape measures. It is estimated that the furthest parts of the grid in fort 4 from the base line may have been some 40 cms from their true positions.

4 Survey results

Fort 5

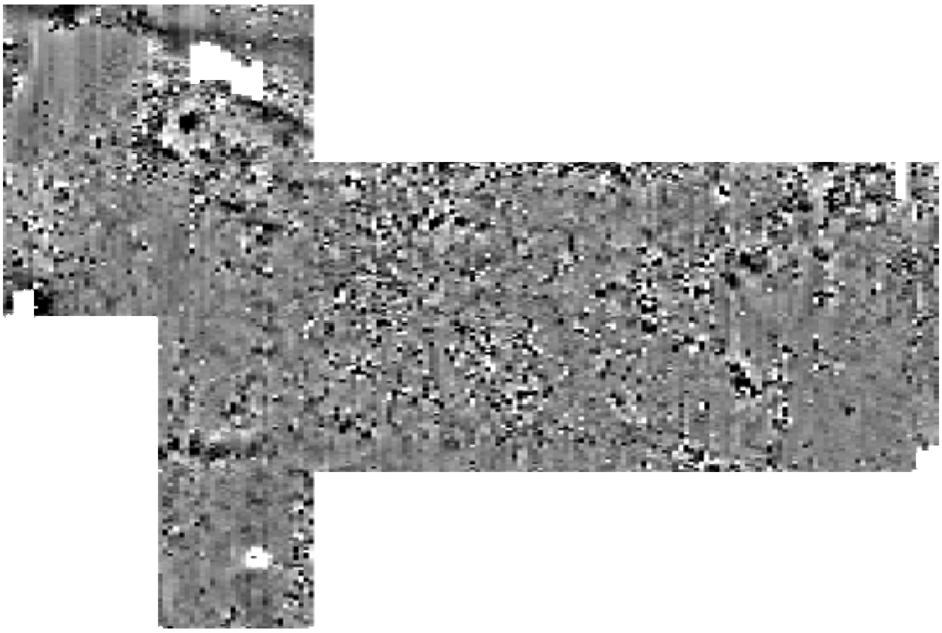
Grid order

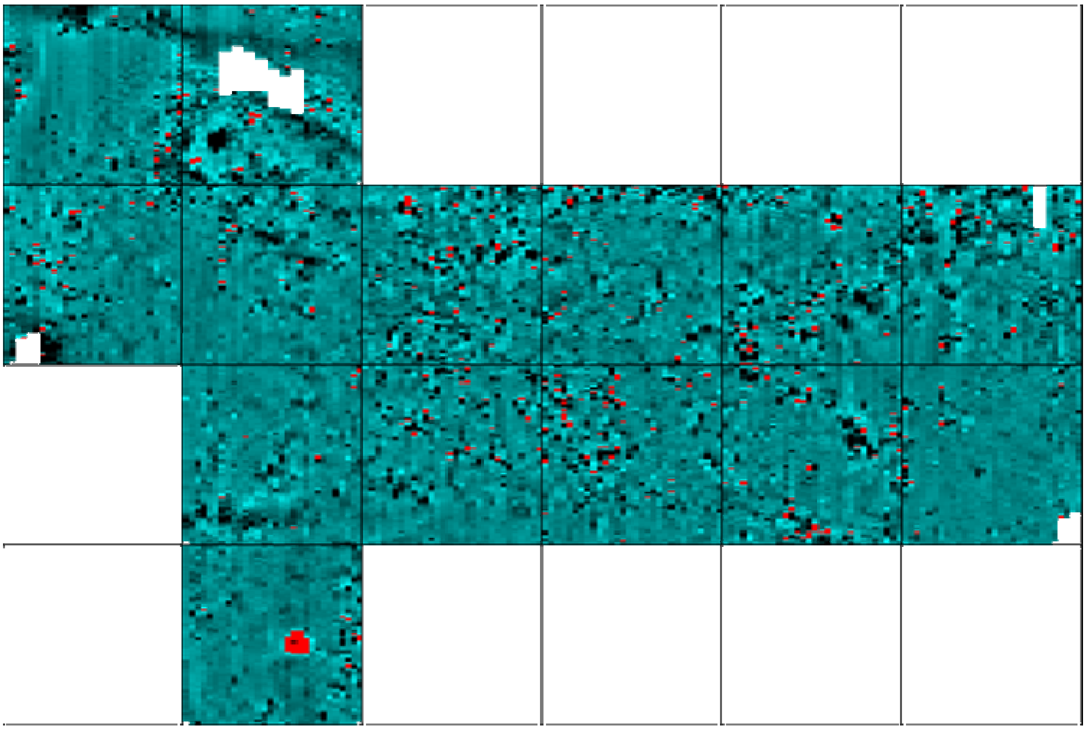
1	2				
4	3	8	7	6	5
	13	12	11	10	9
	14				

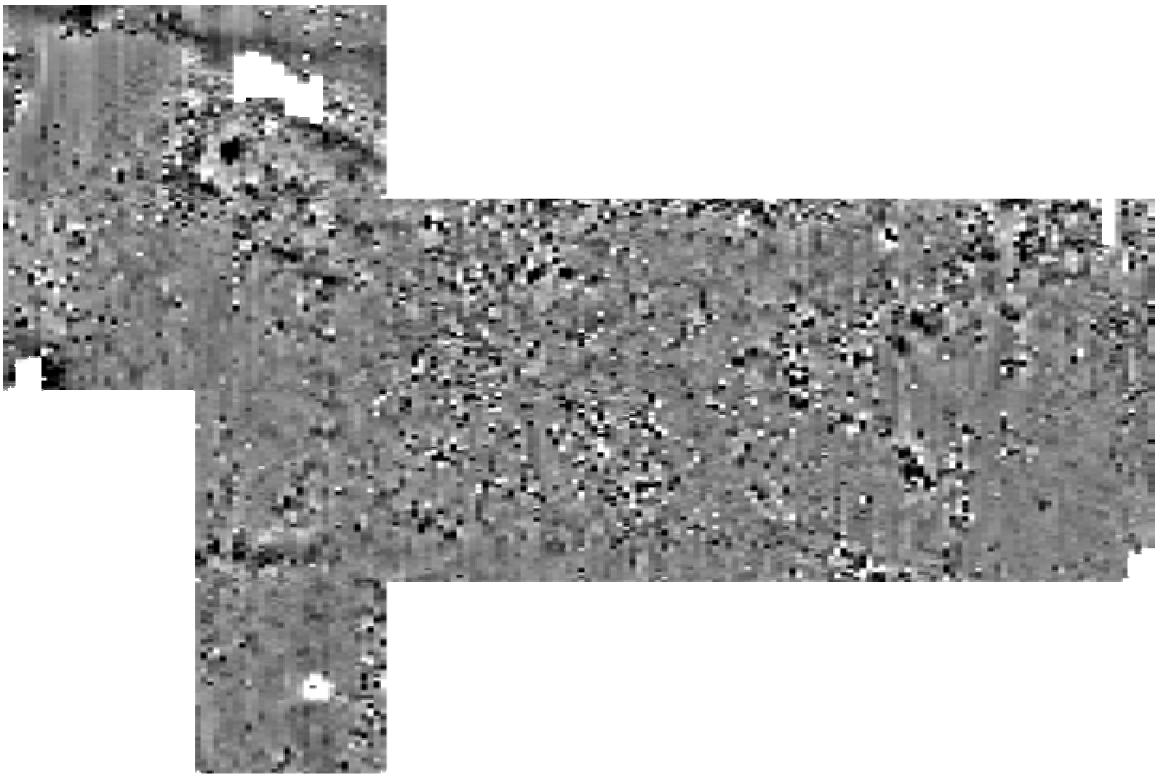
Grid location

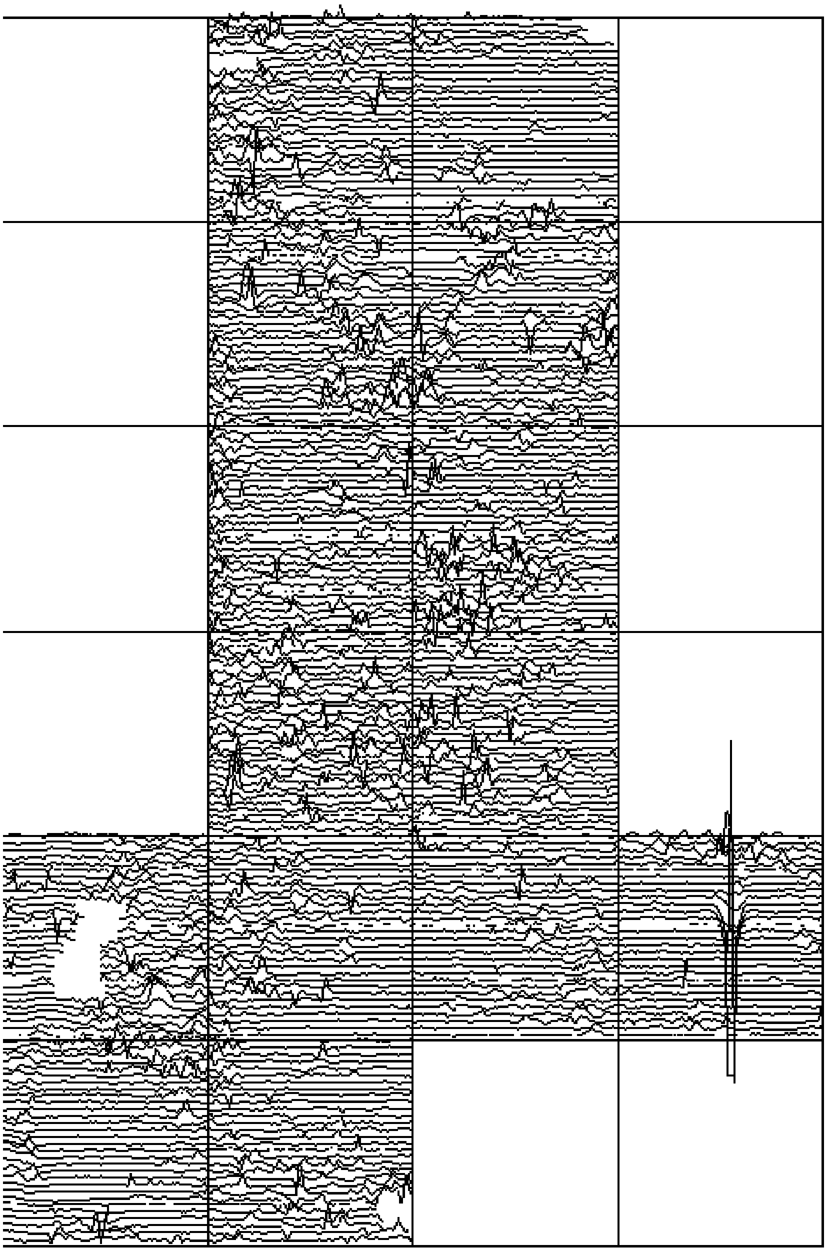
NW corner of grid 1
N 37deg 25.627 minutes
E 55 deg 22.266 minutes

NE corner of grid 2
N 37deg 25.627 minutes
E 55deg 22.297 minutes

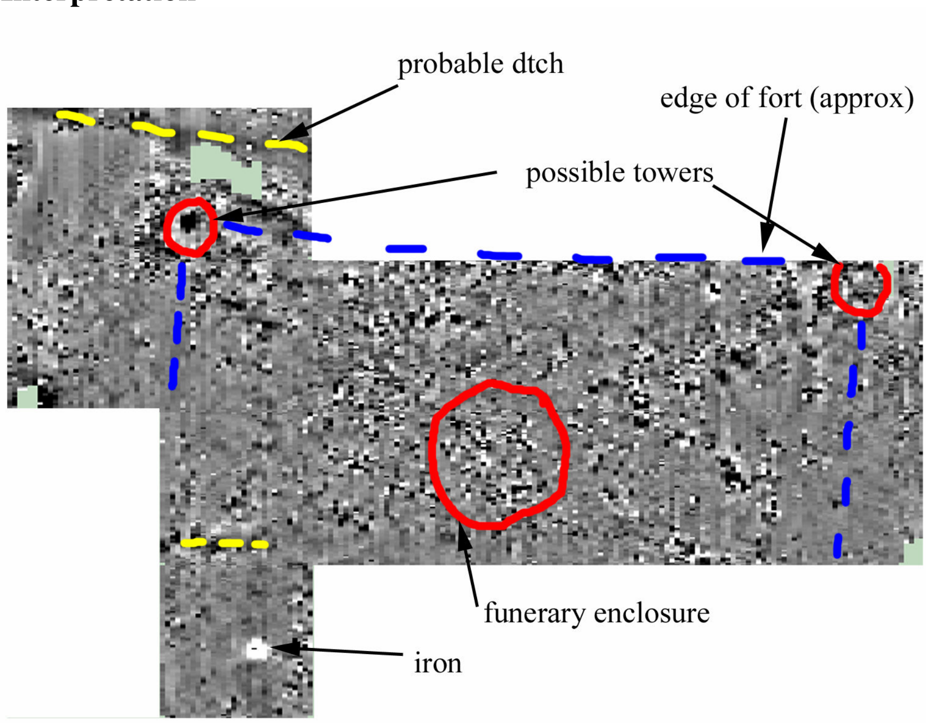








Interpretation



Fort 4

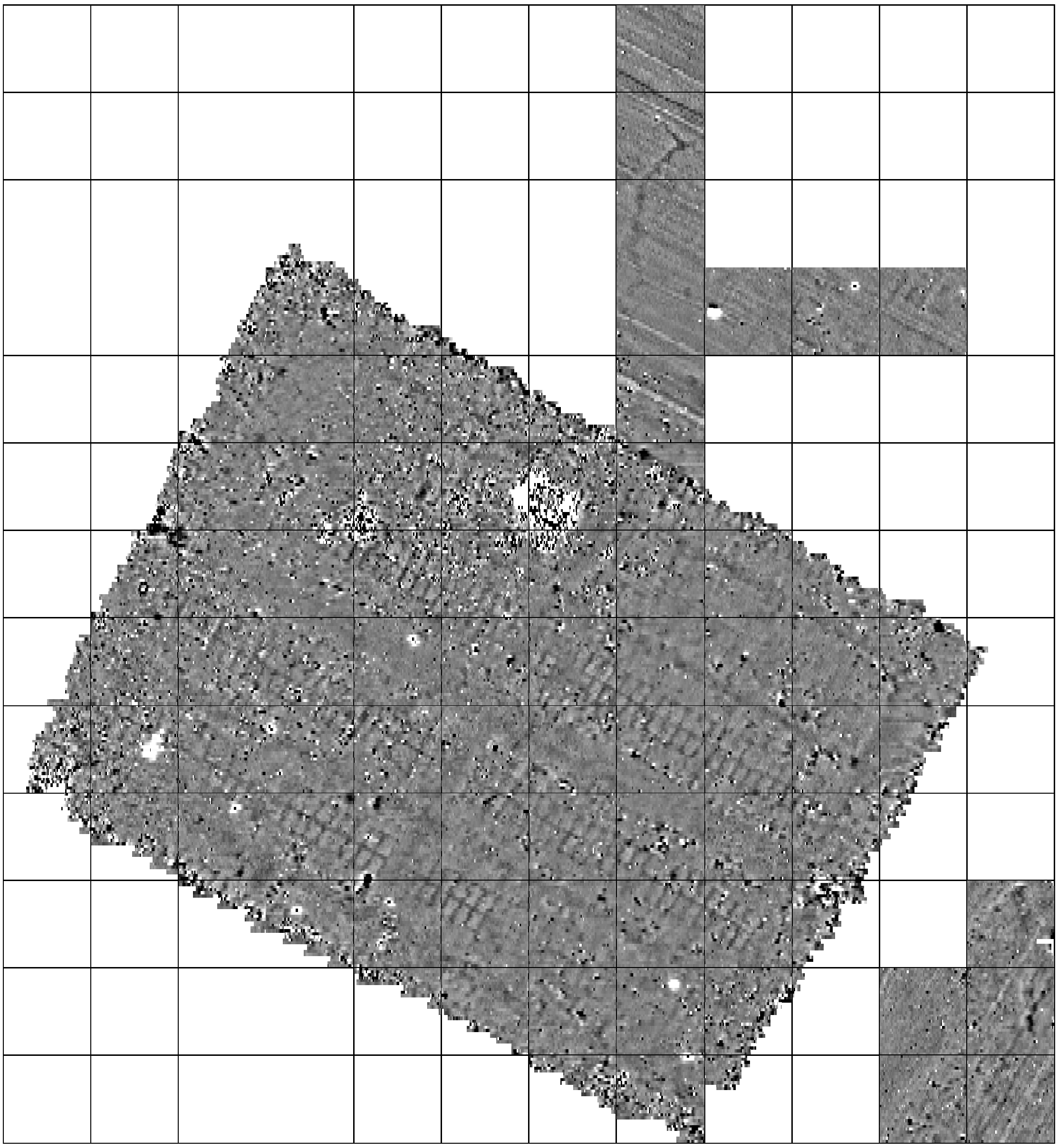
Grid order

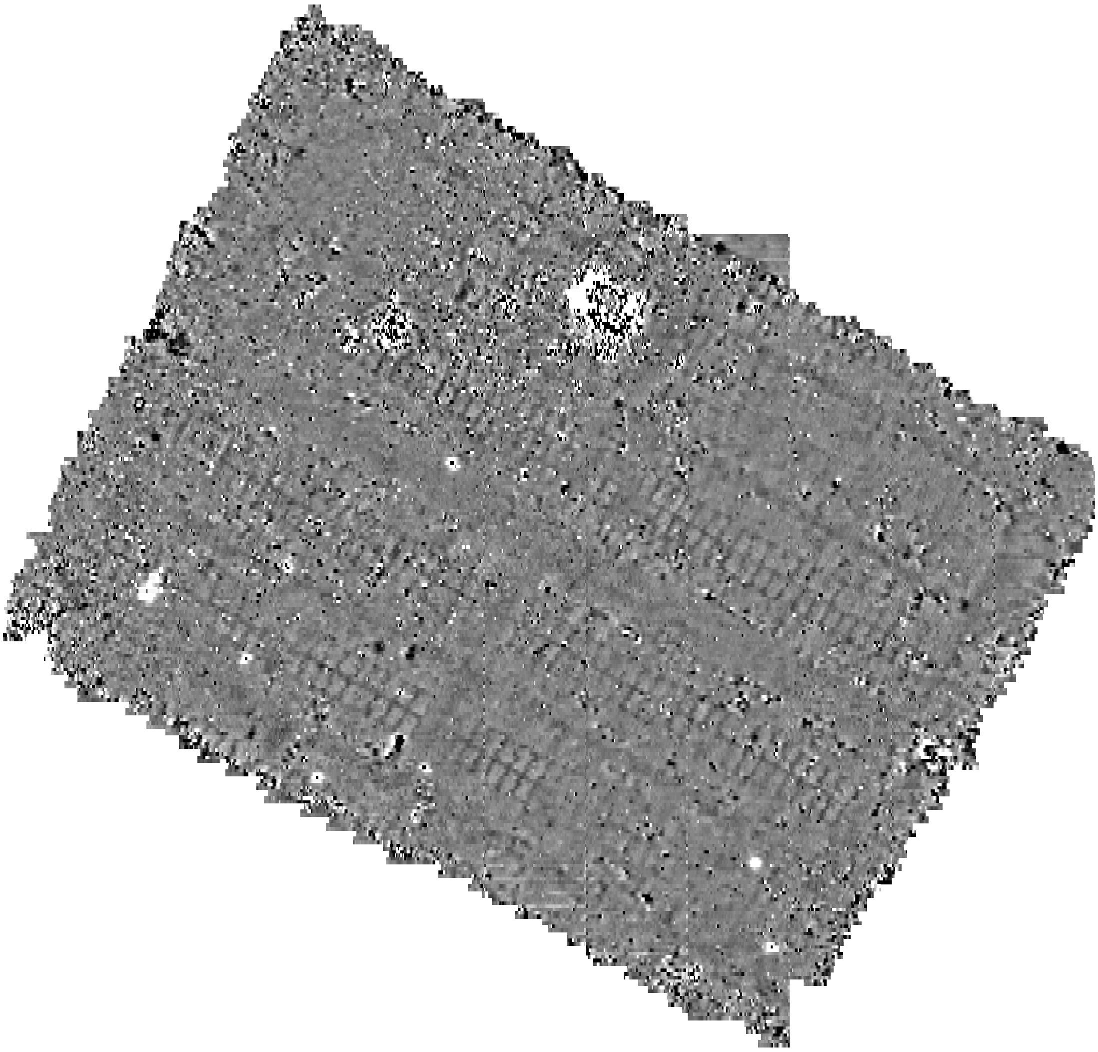
							90				
							89				
			63				88				
		64	62	55	48		87	91	92	93	
		65	61	54	49	47	01				
	75	66	60	53	50	46	02	79			
	74	67	59	52	51	45	03	13	21	27	
76	73	68	58	39	38	18	04	14	22	28	31
77	72	69	57	40	37	10	05	15	23	29	
78	71	44	40	41	36	11	06	16	24	30	
		70	56	42	35	12	07	17	25		82
				80	34	32	08	19	26	86	83
						33	09	20		85	84

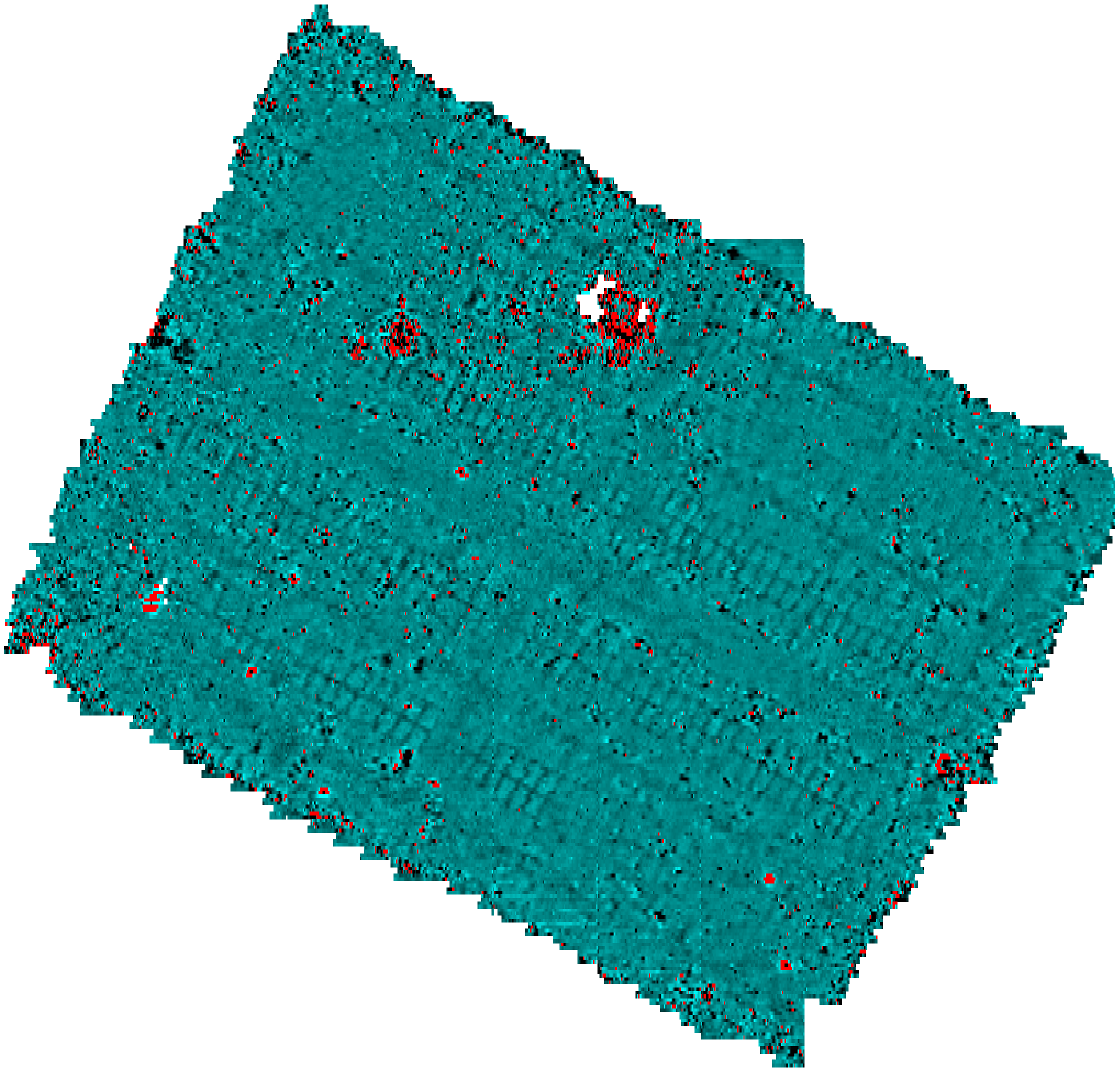
Grid location

NE corner of grid 1
N 37deg 27.172 minutes
E 55 deg 25.264 minutes

NW corner of grid 8
N 37deg 27.053 minutes
E 55 deg 25.204 minutes







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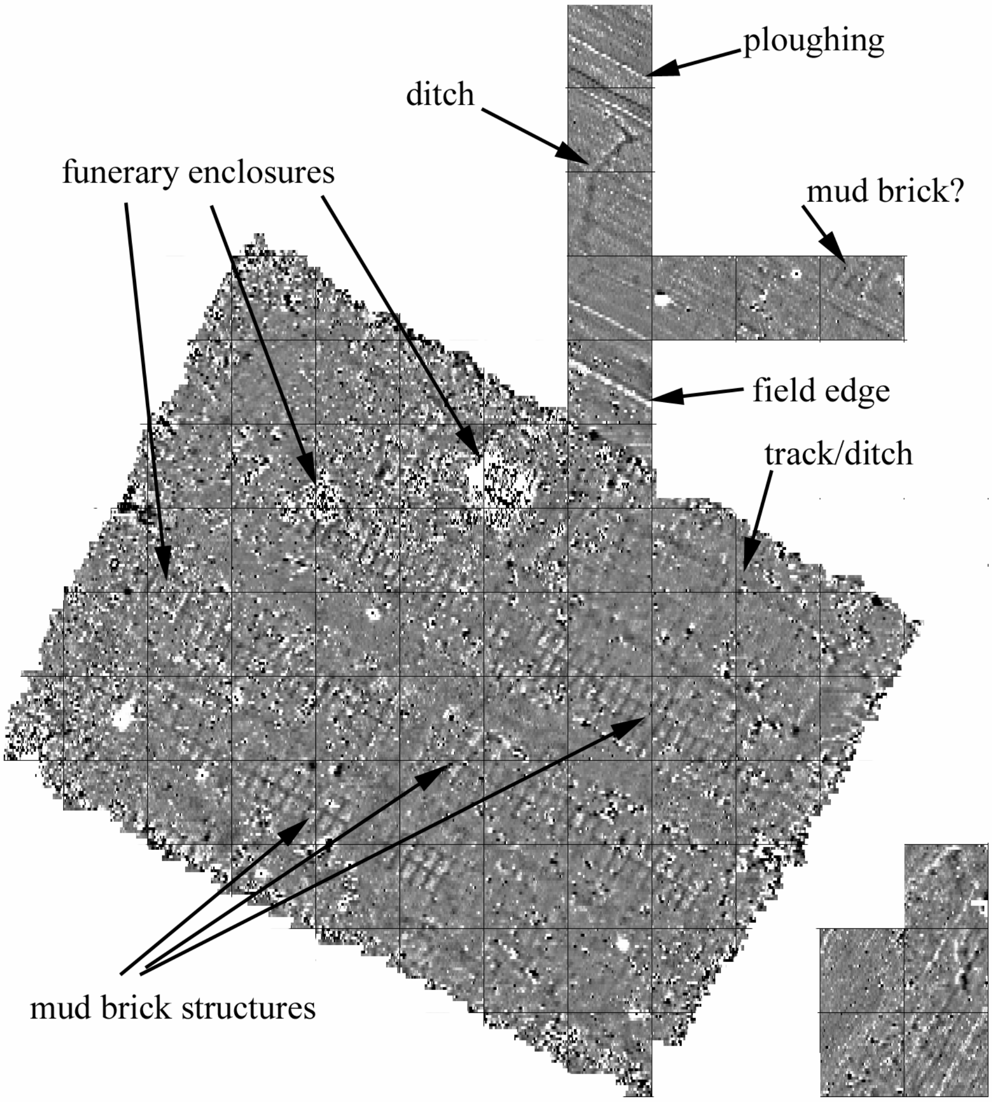
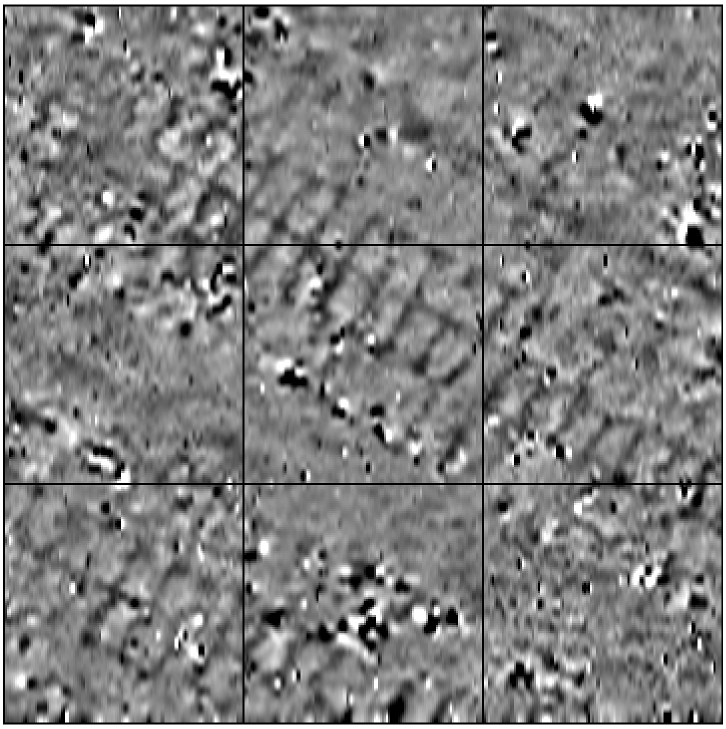
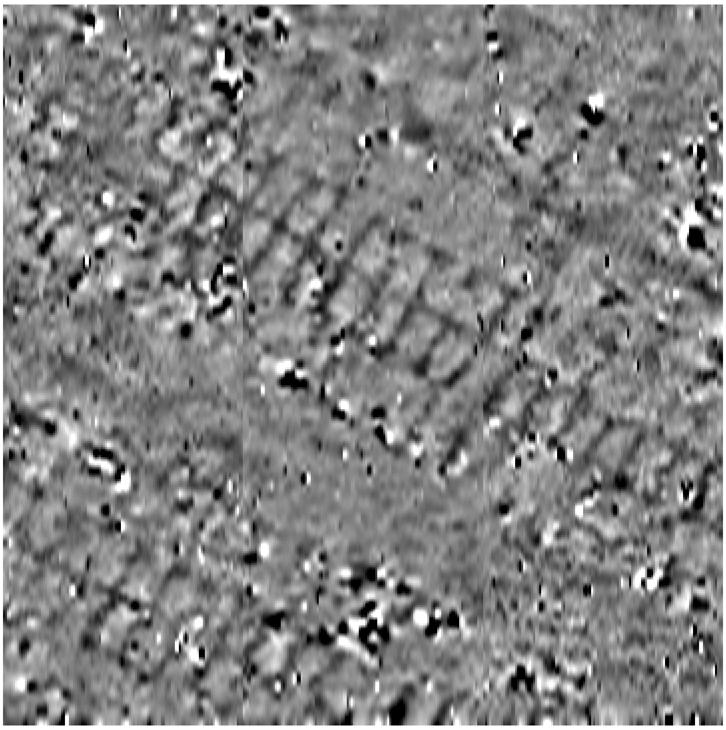
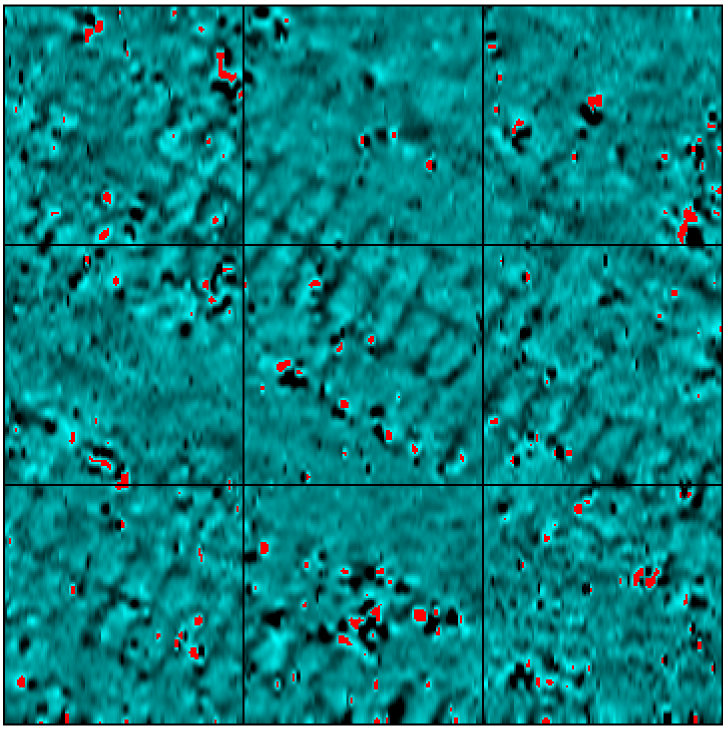


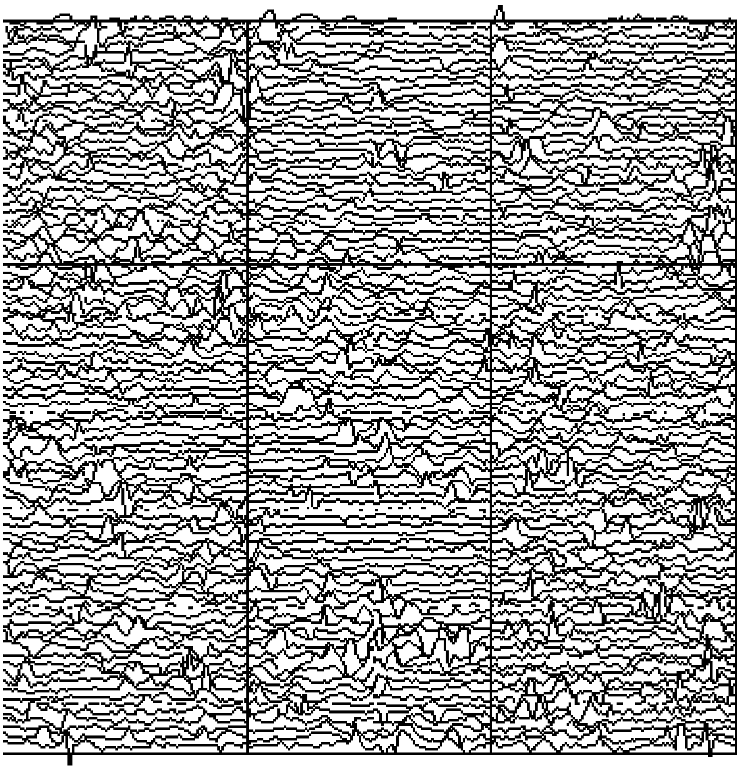
Part of interior

Grids	18	4	14
	10	5	15
	11	6	16









Processes

1 Base Layer
2 Clip at 3 SD
3 Clip at 3 SD

4 Zero Mean Traverse: Grids: 16.asg Threshold: 2.5 SDs (Area: Top 0, Left 0, Bottom 0, Right 0)
5 De Stagger: Grids: 18.asg 10.asg 11.asg 04.asg 05.asg 06.asg 14.asg 15.asg 16.asg Mode: Both Inc: -3
6 Interpolate: Match X & Y
7 Clip at 4 SD

Note on Processes

Clipping – This is used to prevent very high ir low readings from distorting the illustration. This is because the greyscale for example is allocated evenly over the range of readings with dark beinh high and light being the low readings. By reducing the level of the highest readings the shades are allocated over a smaller range of readings and therefore can be more sensitive to readings which are closer to zero which is often where the archaeological remains can be found.
Zero mean traverse – this removes striping from the data. This is caused by the instrument having been balanced over an area which was not magnetically quiet, the instrument being carried at an angle off vertical and temperature variations during the day altering the alignment of the sensors.
De Stagger – this adjusts for the lines walked not always starting and ending at the same line. This is probably caused by the Bartington logger system having an inherent defect as almost everyone finds a half metre stagger with this equipment.

5 Conclusions

Fort5

Despite having better conditions for magnetometery, (assuming that both sites have similar soil iron content), than fort 4 less was found there. This could be because more of the interior was disturbed by funerary monuments. Alternatively the remains inside this fort could have been less protected by collapsed material and have been destroyed by agriculture – or there may have been less there to leave remains detectable by magnetometery. The wall side had indications of two possible tower – like structures.

Fort4

The long blocks of building-like anomalies were only of approximately 2.5 nT above the background level. This indicates that if the magnetometers were held higher from the ground their signal would not have been detected

The narrow ditch-like feature at the bottom of the bank around the fort, indicated by a low magnetic response, was a cutting caused by ploughing eroding into the bank. This, if it was a ditch, would be expected to have a positive response rather than the negative one located here. What has happened is that the person walking with the magnetometer has stepped up over the cutting and in so doing the probes were higher above the surface when over the cutting and thus received less magnetic signal than elsewhere in that vicinity. This shows the type of problem which can occur if obstructions within the survey area lead to the probes being lifted to get over them.

Disclaimer

Any magnetometery survey will not be able to detect small features and those, such as graves, which have fills which are magnetically undetectable.

In general if geophysics hasn't found anything it does not mean that there is nothing there.

For more detail on this please refer to the English Heritage guidelines by Andrew David.

Dissemination

Please let me know if you wish this to be kept confidential for longer than 6 months from the date of this report as, unless you wish otherwise, I would wish to be able to put it on my website as an example of what can be achieved if the vegetation is cut first and the probes held low

6 Geophysical techniques-General notes

Magnetometery

A magnetometer is designed to detect variations in the Earths magnetic field. These variations occur where the field has been changed by factors such as iron pipes and features of archaeological interest. To be detected these features have to have certain properties. They have to contain iron which can be magnetically enhanced by human settlement. The larger the difference the better it can be detected. This enhancement can be by being burnt or it can be caused by microbes which by some process tend to concentrate magnetic material. The two factors necessary are therefore to have iron in the soil and for this to have been changed where human activity (or bacteria) has altered it.

It is therefore very unlikely that features will be detected which are made exclusively of oolitic limestone or chalk as these deposits contain very little iron. Even if there has been a lot of human activity there has just not been the iron there for that activity to enhance. Fortunately the topsoils on chalk soils often have quite strong magnetic characteristics so they can reveal ditches and other features which are cut into the underlying chalk. It is this difference in one area having magnetically enhanced soil and others not having it which is detected. A road surfaced with limestone over an iron rich topsoil would similarly show as that area would have less magnetic enhancement than the surrounding soils.

The theory is all very well but the practicalities are a bit more difficult. The main problem is that the earth has a magnetic field of approximately 47,000 nanoTesla whilst the features which we are seeking to detect have a difference above the background level of 0.5 to 10 nanoTesla. Things are complicated further by the magnetic field then changing during the day by some 30% and by magnetic fields caused by railway trains, electricity pylons and other factors changing as well. In order to seek to overcome these problems the sensors which are used are put in gradiometer mode which means that they are mounted as pairs with one above the other. My equipment has the sensors separated by 1 metre but other manufacturers make equipment where the separation is 0.5 metres. What happens then is that the earths magnetic field is detected by both sensors but only the bottom one also detects most of the reading caused by archaeological features. The readings from the top sensor are automatically deducted from those of the bottom sensor and this gives the reading which should approximate to the reading of the archaeological features.

A magnetometer will detect ditch - like features better than it can detect shallow spreads even of the same volume. The orientation of the survey traverses can be of importance as the processing used to remove striping caused by minor balancing errors in the sensors can also remove some of the data from the archaeological features. It is therefore best to have a grid at an angle to the expected remains rather than being on the same alignment.

Magnetic anomalies are difficult to detect at the best of times and the amount which can be detected declines with the cube of the distance between the anomaly and the sensor. Therefore an anomaly which had a strength of 8 nanoTesla is only read as 2 nanoTesla by a sensor 1 metre away from it. I tend to carry mine with the bottom sensor approx 15cms from the ground surface. The equipment can therefore detect small shallow anomalies or deep ones provided that they are large. Alluvium covering weak archaeological anomalies can therefore make them undetectable. It is possible to obtain equipment which can detect anomalies down to 0.1 nanoTesla but this equipment is expensive.

7 General

The relatively recent availability of automatic data logging, reasonably priced computer memory and processing software has made it possible to survey far larger areas than were previously practicable.

8 Further Reading

The best reference book on this is *Seeing Beneath the Soil* by A. J. Clark, 1990. Other books by I Scollar *Archaeological Prospecting and Remote Sensing* Cambridge University Press 1990 and by Gaffney and Gater *Revealing the Buried Past* Tempus, 2003 are also available. Andrew David's guide *Geophysical survey in archaeological field evaluation* English Heritage Society 1995 gives a good, if now somewhat dated, overview of techniques and what to expect in reports.

9 Acknowledgements

We would like to thank the British Institute of Persian Studies for providing accommodation in Tehran etc

10 Compact Disc

This contains this report and the various pictures and data. The data is mainly in Asg. fomat which is used by the ArcheoSurveyor programme. Data has also been saved as XYZ comma separated files in the Export folders as other programmes can use this format. This unprocessed data has been saved both as grids and as composites (i.e. grids joined in the right order) if there is more than one grid.
In the folders you will see sub folders of comps, Export, Graphics, Grids, Comments and Site

Roger Ainslie
4 Sutton Close
Abingdon
Oxon OX14 1ER

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