Gorgan Wall

IRAN

Daland, Qaleh Gug, Qaleh Daland, Qareh Mohammed Tappeh

Geophysical Surveys using Magnetometery

14th June 2009

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

Carried out by

Chris Oatley, Milad Mirmoosavy, Majid Mahmoudi, Hamid Mahmoudi & Mehdi Ramezanifard

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

CONTENTS

Summary

Magnetometery surveys were carried out on these sites in April and May 2009.

Daland showed many possible ditch features but none which formed any kind of regular pattern. The present earthwork can be seen in the survey along with the current tacks which run at regular intervals across the site. A possible irrigation system is also shown, along with another unidentified geometrical negative anomaly.

Qaleh Gug suffered problems with interference from ferrous objects and the road. One possible circular feature was shown though.

The results from Qaleh Daland showed little but the modern irrigation channels which covered the site. These also made the survey of these areas difficult.

There appear to be some possible field systems at Qareh Mohammed Tappeh which have very irregular shapes. Further investigation of these would prove interesting.

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Introduction

The geophysical surveys were part of the work on this wall being carried out by the Gorgan Wall Research Project in 2009.

The 2009 season had geophysical surveys of Daland, Qaleh Gug, Qaleh Daland and Qareh Mohammed Tappeh.

Due to the time of year of the expedition in 2009, many of the sites around the Gorgan wall were under cultivation. This limited the sites which could be surveyed at the time; the ones selected being the most promising of those available. All of the sites featured earthworks which are still visible, either as boundary walls or tappehs; it was these features that led them to be established as archaeological sites.

Ground conditions at the sites varied a great deal and many were subject to ferrous contamination. Daland was cultivated but the crops were not showing at the time of survey, Qaleh Daland was much the same although this site had many modern irrigation channels running through it which made surveying it difficult and interfered with the results. Qaleh Gug was covered in thistles which were cut prior to surveying and Qareh Mohammed Tappeh was wild, though most of the plants were not high enough to cause any problems.

While the time of year caused problems with many of the sites being under crops, it was beneficial in terms of temperature. In previous seasons, the weather has been so hot as to expand the metal in the sensors causing them to drift greatly and affect the data. Due to the cooler temperatures this season, these problems were avoided.

The geology of the Gorgan wall sites is understood to be a thick bed of loess. This has been tested to ascertain its magnetic susceptibility which indicates whether it is able to be magnetically enhanced by human activities such as burning. Here mass susceptibilities of approx 32SI/per 10g were measured. These indicate that the soils here are likely to show magnetic enhancement if burnt. Thus sites without enhancement may have had little occupation or burning.

3

Survey Design and Equipment

Magnetometery was chosen for most of the work 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. Resistivity could have been used to give additional information but was not used as the sites were too large for a significant sample to be surveyed using that method. Saline conditions in the soil would have probably prevented ground penetrating radar from producing useful results.

A Bartington Grad 601/2 gradiometer was used with the probes 1 metre apart and with a 1 metre 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 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 and as some sites were large, a higher reading density could well have given major problems with data processing.

The grids were 30metres by 30 metres. 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. As it was anticipated that the anomalies would be weak the sensors were carried approx 10 cms from the ground surface.

The survey grids were laid out mostly by Eberhard Sauer and Hamid Omrani and the points were then recorded using a handheld GPS. Further grids were laid out by the geophysics team from these initial ones using tape measures.

Data processing
For magnetometery the following processes were principally used:-

1 Base Layer
2 Zero Mean Traverse – this seeks to correct imbalances between the 2 magnetometers.
3 Clip – this seeks to prevent the plot of the data being unduly influenced by a few very high or low readings.
4 Low Pass Filter – slightly smoothes the appearance of the data.

Survey locations

These are the GPS points which marked on the grid location plans for each site.

Daland

A = 325312 E, 4102301 N
B = 325422 E, 4102254 N
C = 325106 E, 4101834 N
D = 325161 E, 4101812 N

Qaleh Gug

A = 0337609 E, 4118679 N
B = 0337711 E, 4118615 N
C = 0337618 E, 4118457 N

Qaleh Daland Area A

A = 322673 E, 4107013 N
B = 322704 E, 4107021 N
C = 322726 E, 4106810 N
D = 322748 E, 4106849 N

Qaleh Daland Area B

A = 322933 E, 4106522 N
B = 322945 E, 4106464 N
C = 322844 E, 4106503 N
D = 322857 E, 4106445 N

Qareh Mohammed Tappeh

A = 340004 E, 413845 N
B = 339632 E, 413727 N
C = 339817 E, 413573 N

5

Survey Results

Each site is illustrated in various formats below. The features discussed here are marked on the interpretation plans for each site.

Daland

The earthwork bank can be seen in the northern section of the survey and can also be seen to the south where it has been spread out due to bulldozing. Various modern tracks also run along this site at fairly regular intervals.

There are many possible ditch features in his site. There is a vaguely circular feature to the north but it is so meandering it is hard to guess what purpose this served. There are also some in the west of the survey, two of which appear to be parallel linear features.

There is what is likely to be an irrigation system to the north east of the survey. It may be that some of the linear ditch features in this area are actually also part of this but have been infilled with different material, giving them different readings.

There is also a geometric negative anomaly in the northeastern section which is only visible properly in the trace plot. It is unclear what this is – the lines appear to be wider than those of the other features in the area. It is, however, on a similar alignment to the possible irrigation system so these may be connected.

Qaleh Gug

Several lines of metallic anomalies run through this site. These could possibly be caused by pipes made of plastic but with metal joints. There is also a modern drainage ditch in the eastern part of the survey.

The only possible archaeological feature is a circular anomaly in the southwestern section of the survey which could be a ditch.

There is a lot of interference on this site from the road and all of the metal that has been dumped here. This can make features hard to spot as they can be masked by the stronger readings.

Qaleh Daland

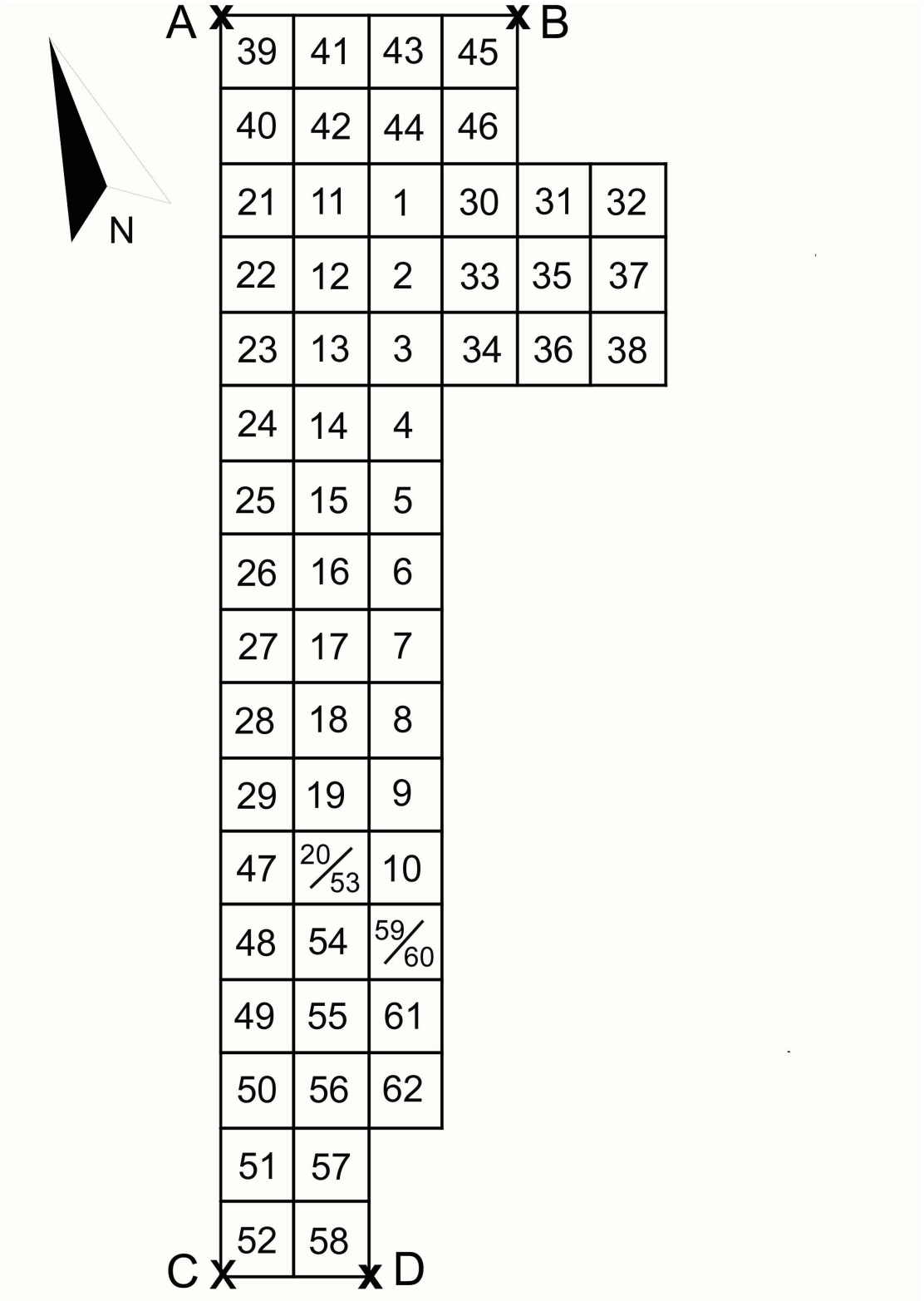
Both of the areas surveyed were covered in modern irrigation channels which can be seen in the results. Area A does appear to have two possible ditch features running across which are not part of the modern system however. Area B was extremely difficult to survey due to the narrow spacing of the irrigation channels (1/m). This caused some staggering in the results which cannot be rectified. Any archaeological features in this site have been masked by the modern irrigation channels in the survey.

Qareh Mohammed Tappeh

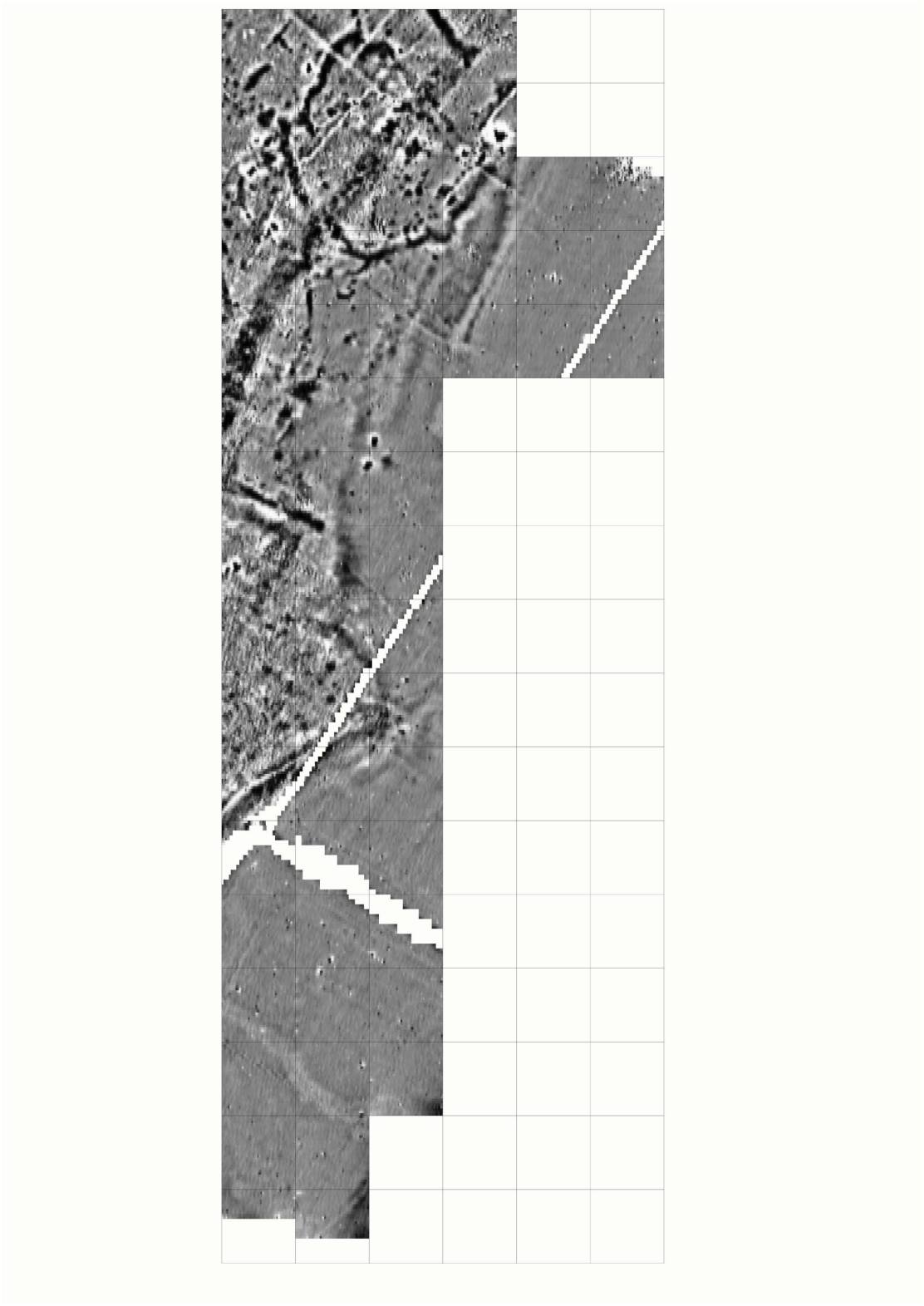
A large pile of what is probably rubble lies in the southern corner of the survey. This corresponds with the large man made hill which is in this area. There are several modern tracks running across the survey; it is also possible that the negative anomaly in the eastern section was once also a track.

The main features of interest here are all of the possible ditches. These appear to form several field systems as well as some boundaries. The irregular shapes are unusual and make it unclear what the exact purpose of these were. Further investigation to establish the extent of these features would be interesting.

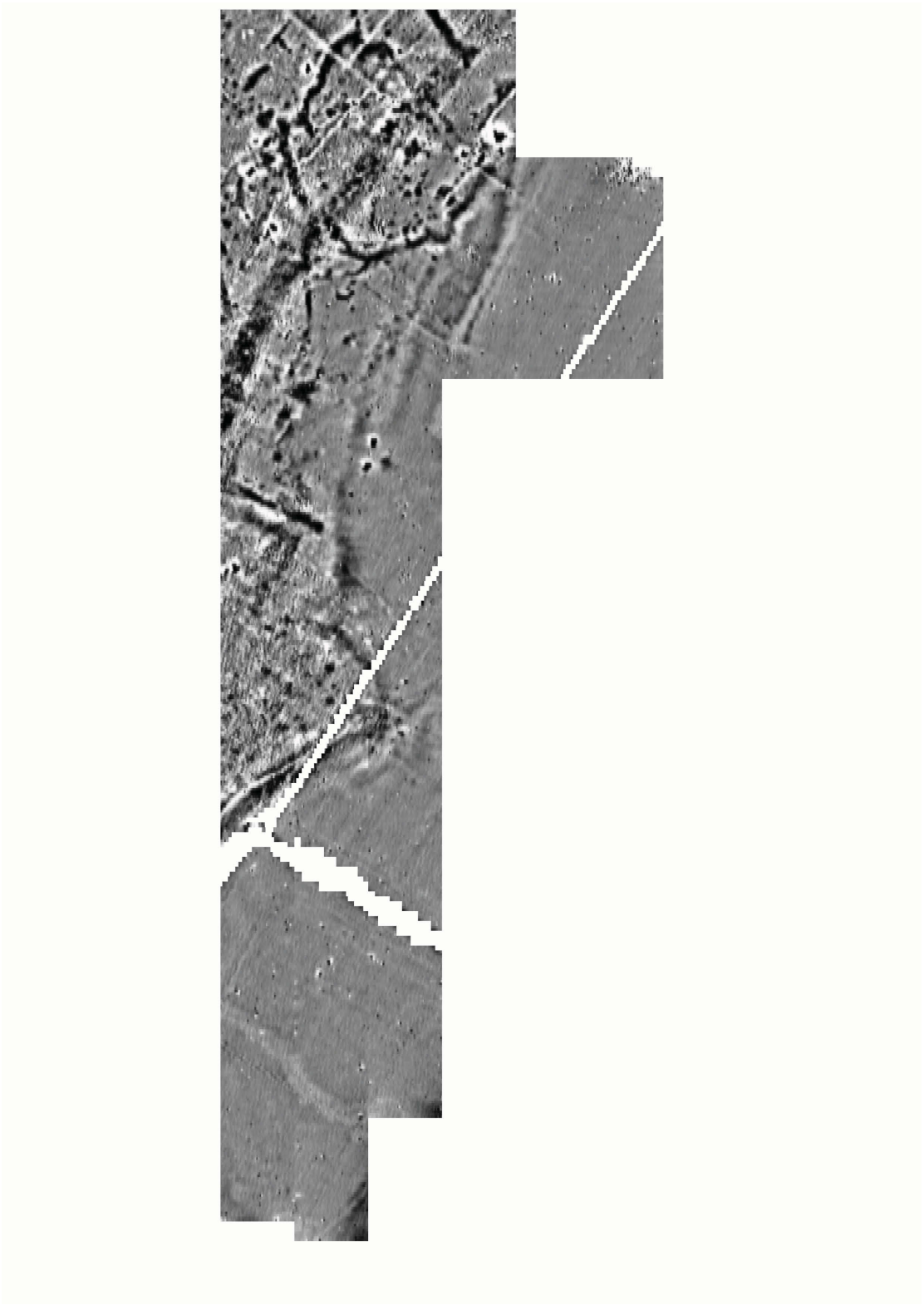
Daland Grid location



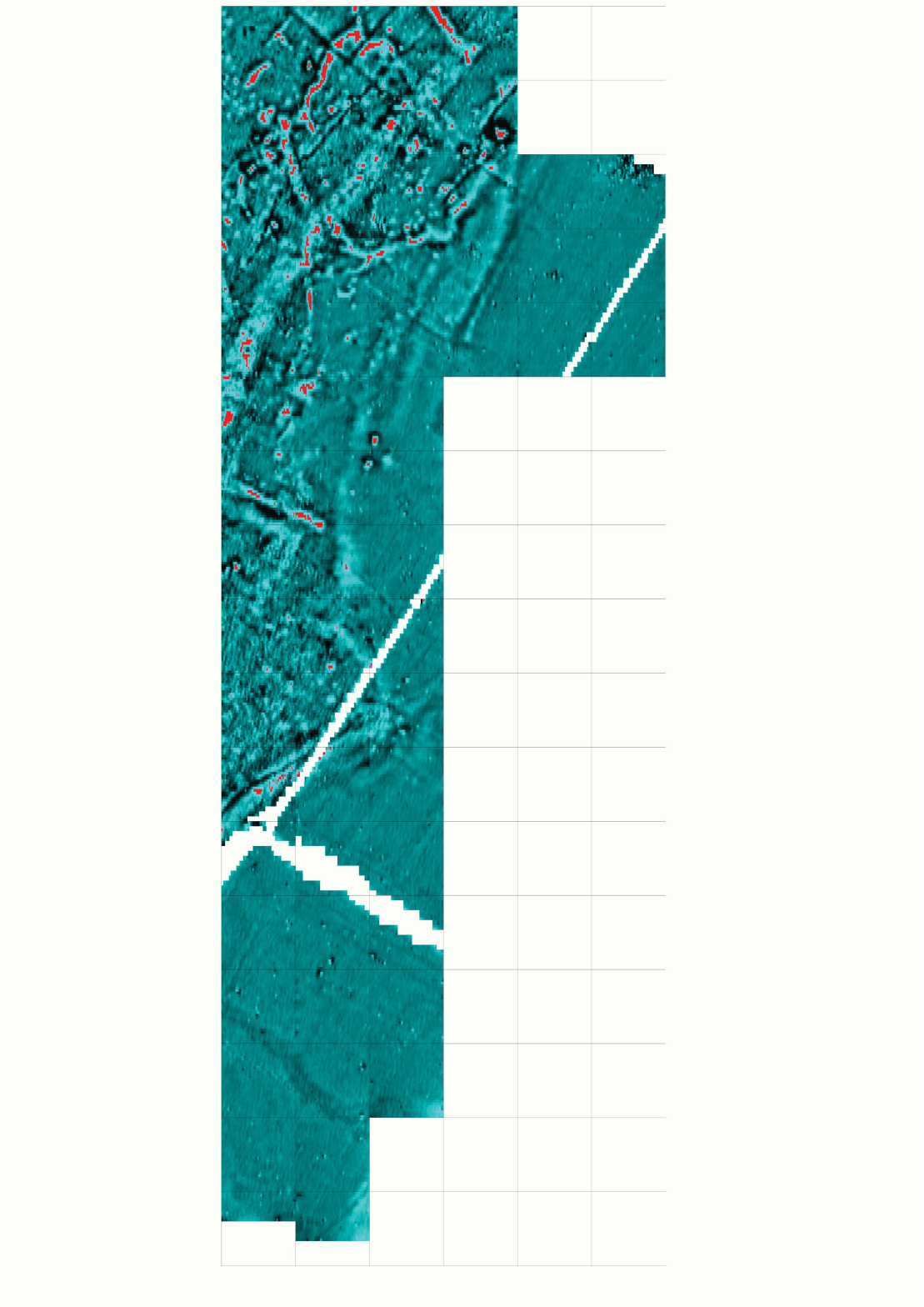
Daland greyscale with gridlines



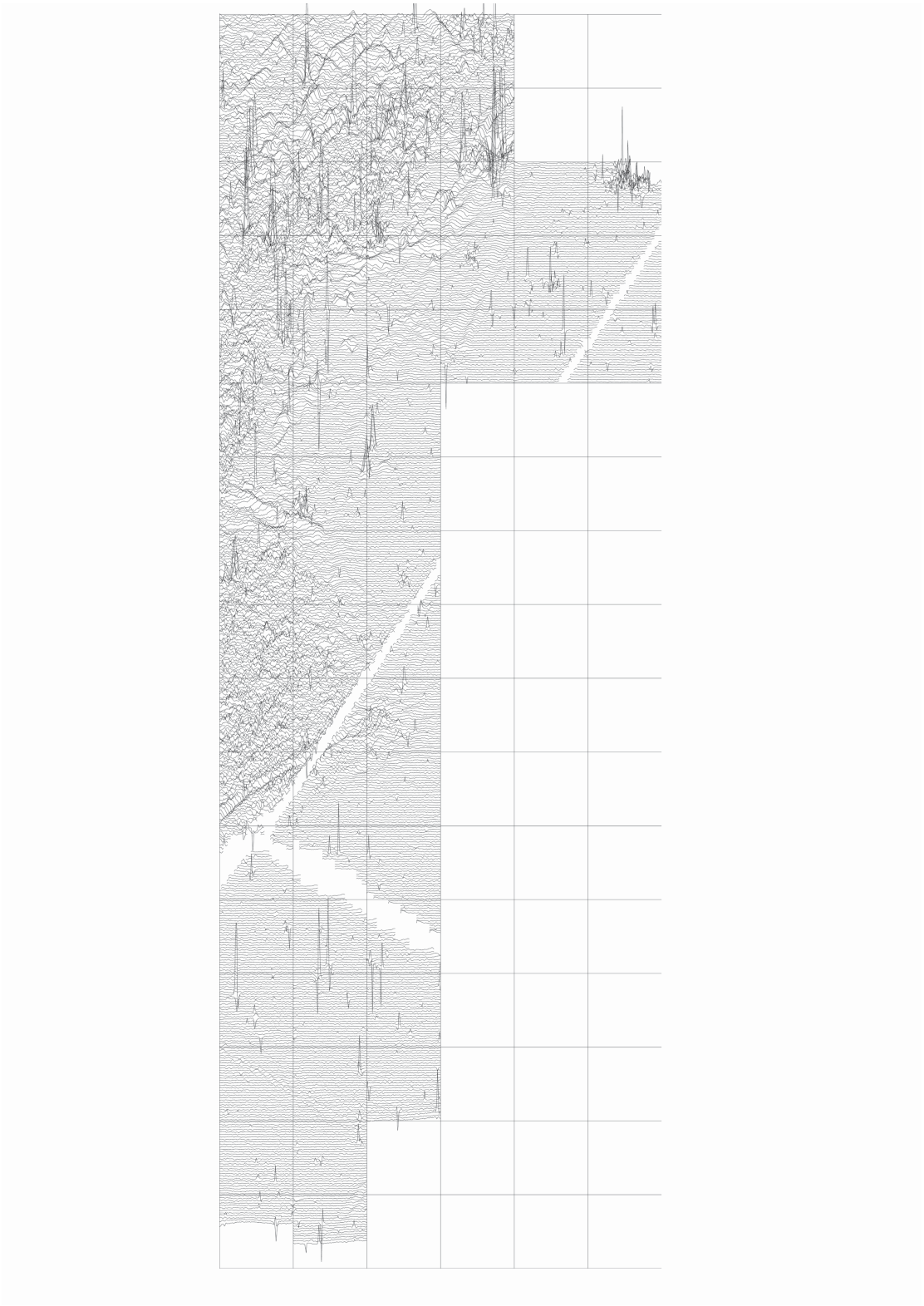
Daland greyscale



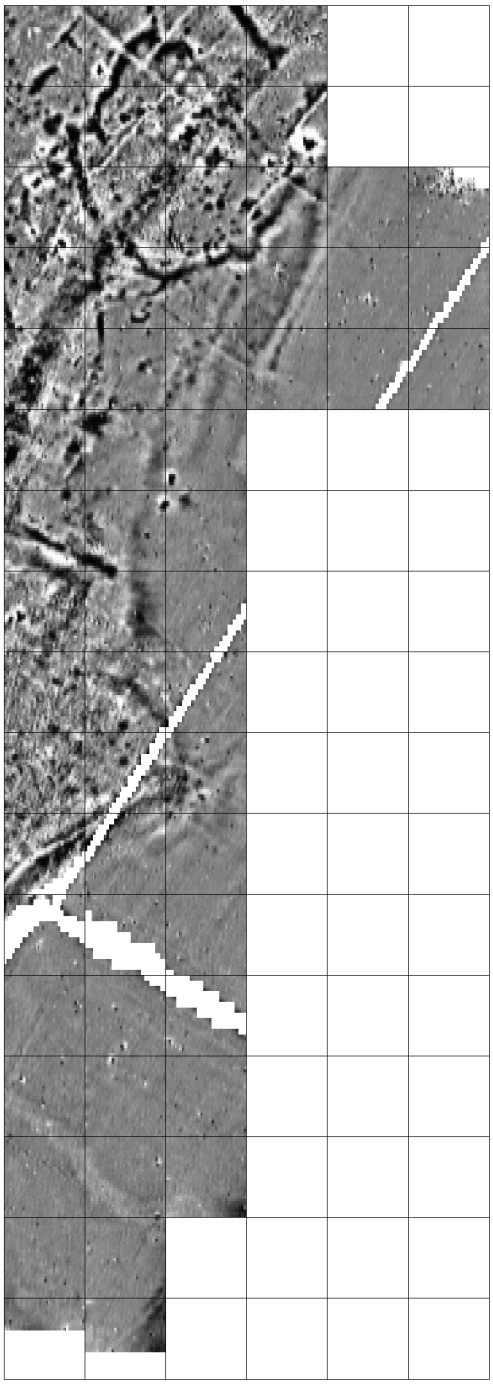
Daland colour

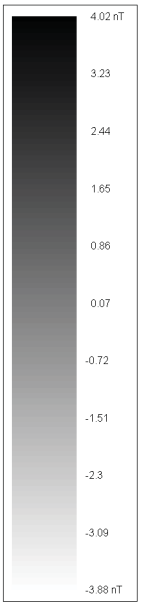


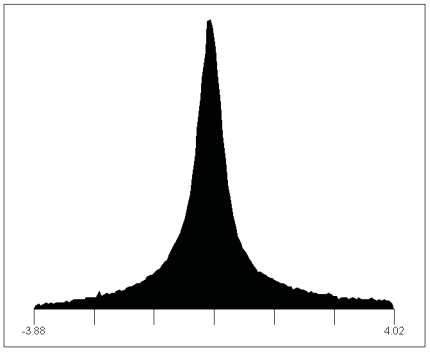
Daland trace plot

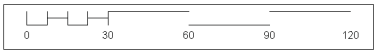


Daland greyscale with scales

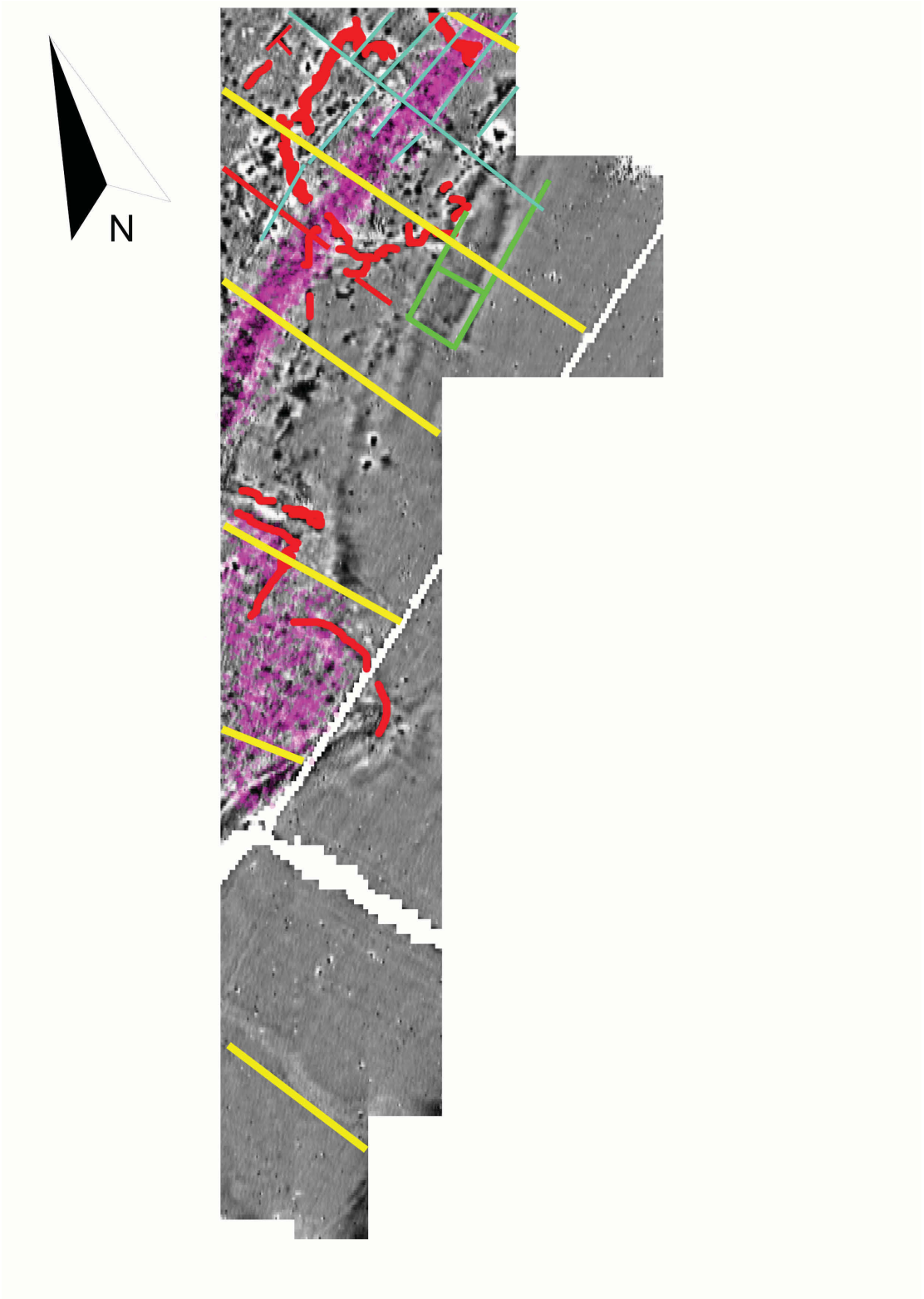




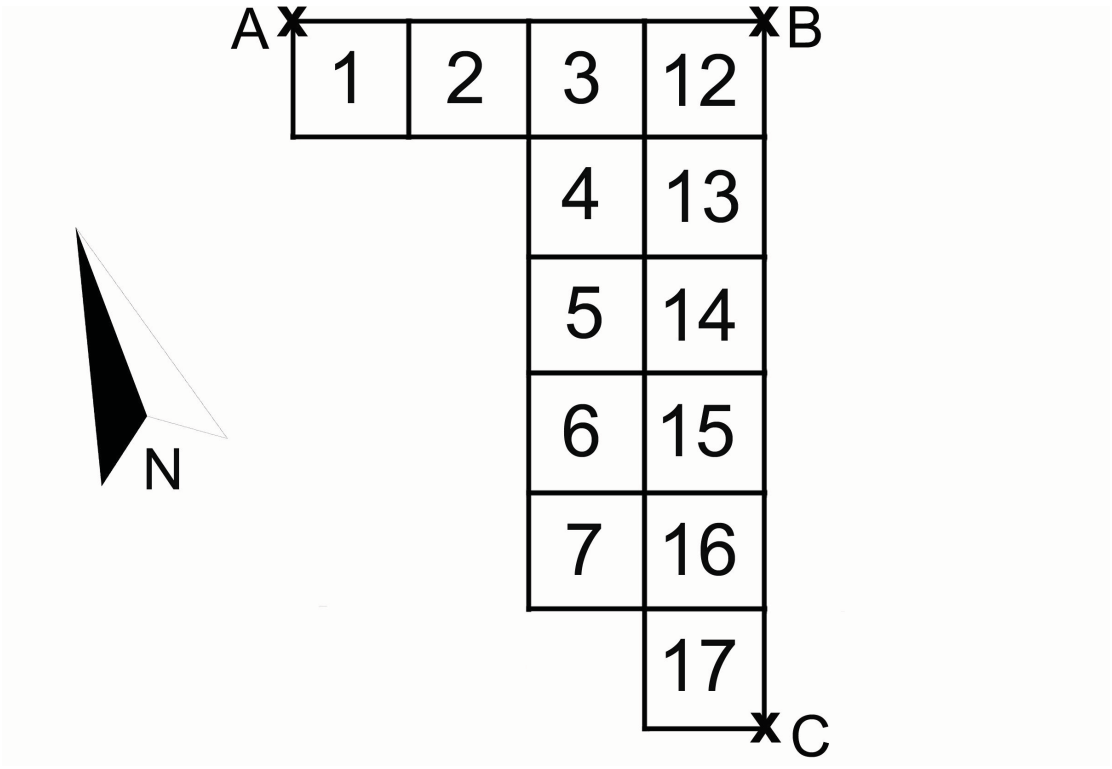




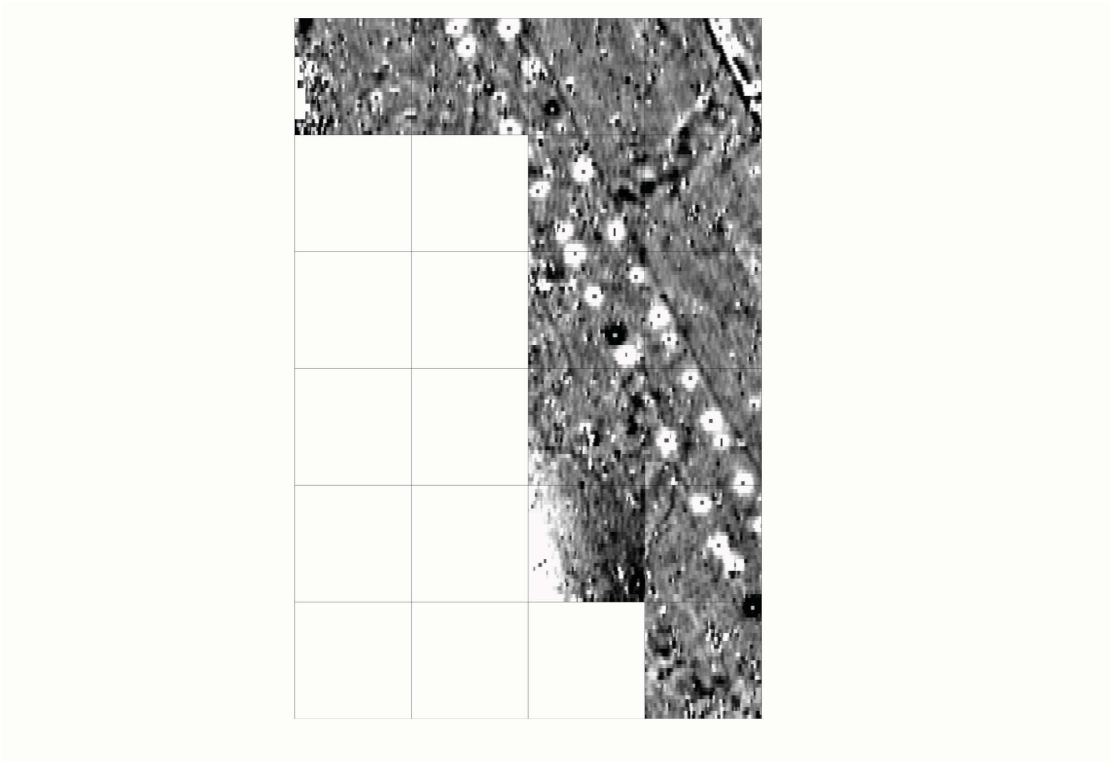
Daland interpretation



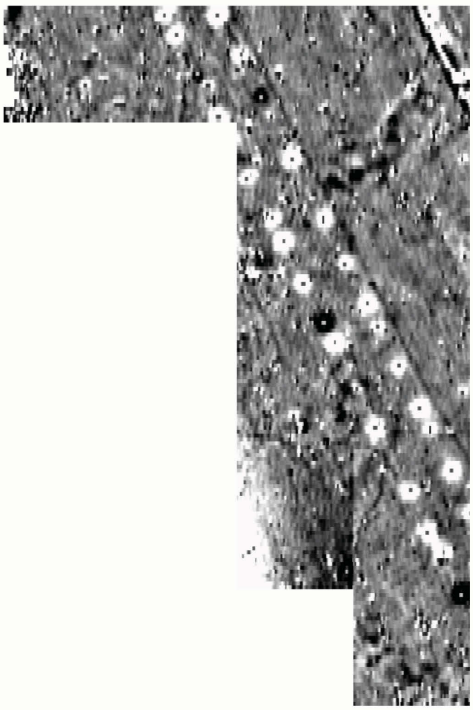
Qaleh Gug grid location



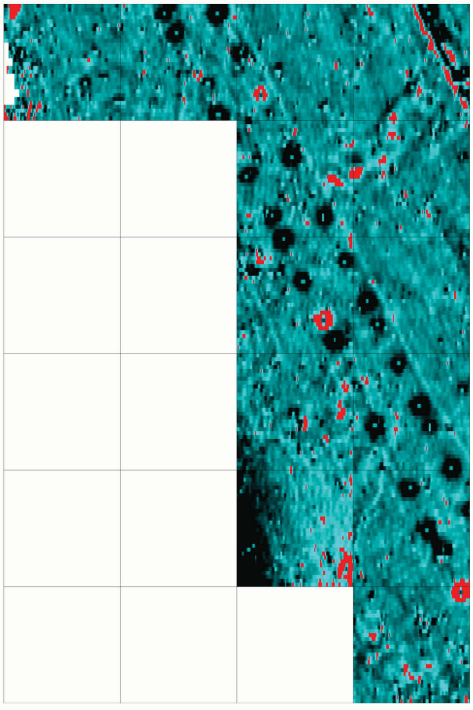
Qaleh Gug greyscale with grid lines



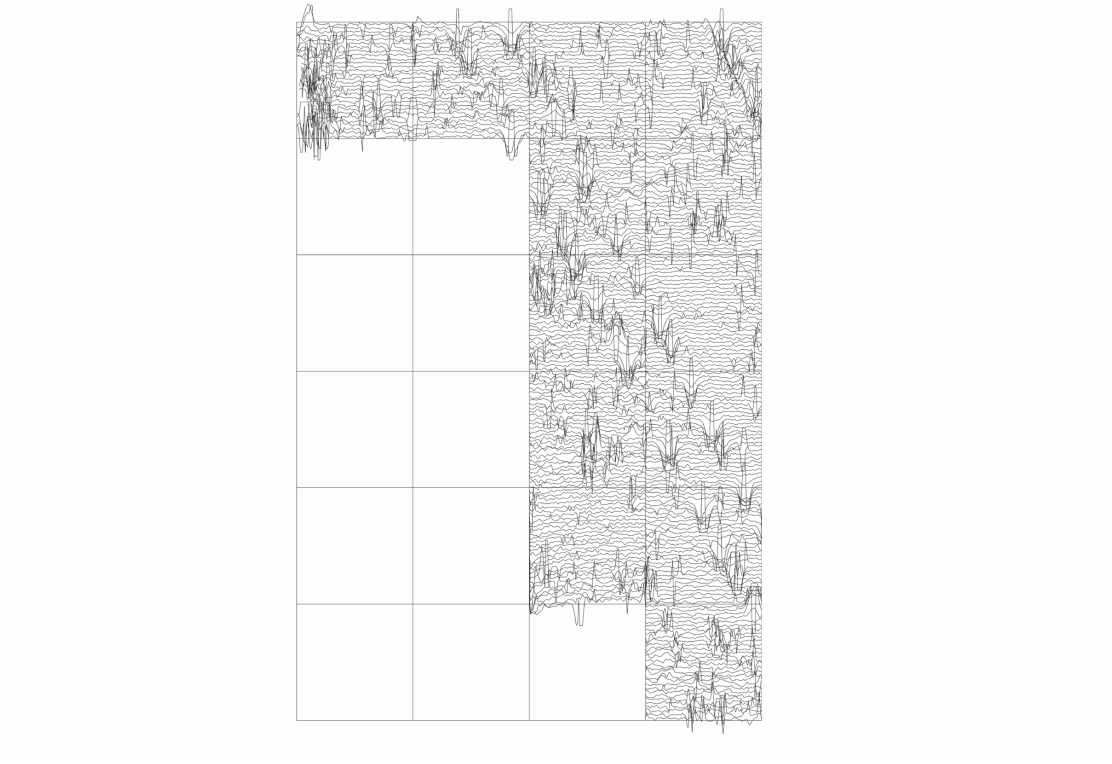
Qaleh Gug greyscale



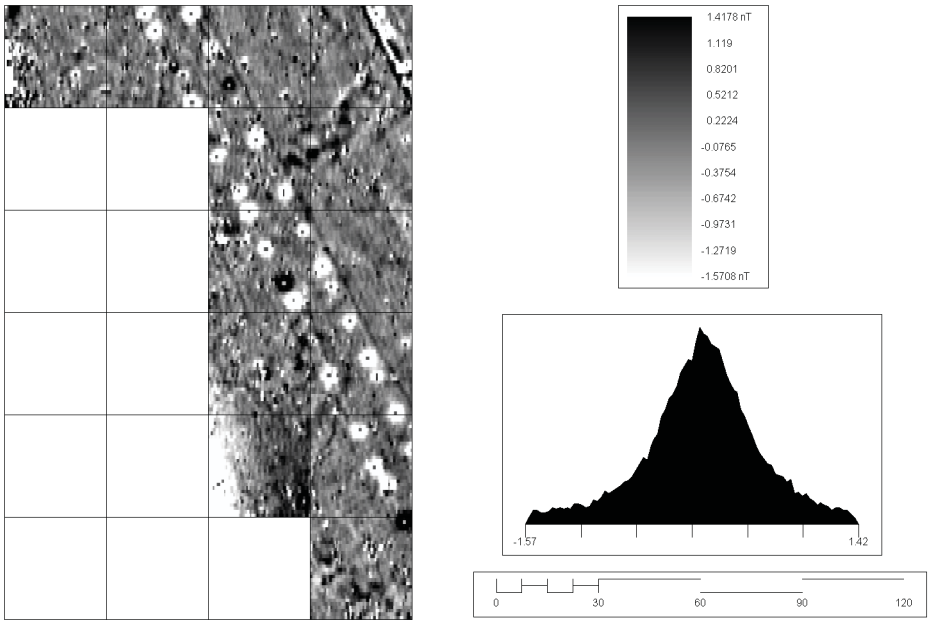
Qaleh Gug colour



Qaleh Gug trace plot



Qaleh Gug greyscale with scales



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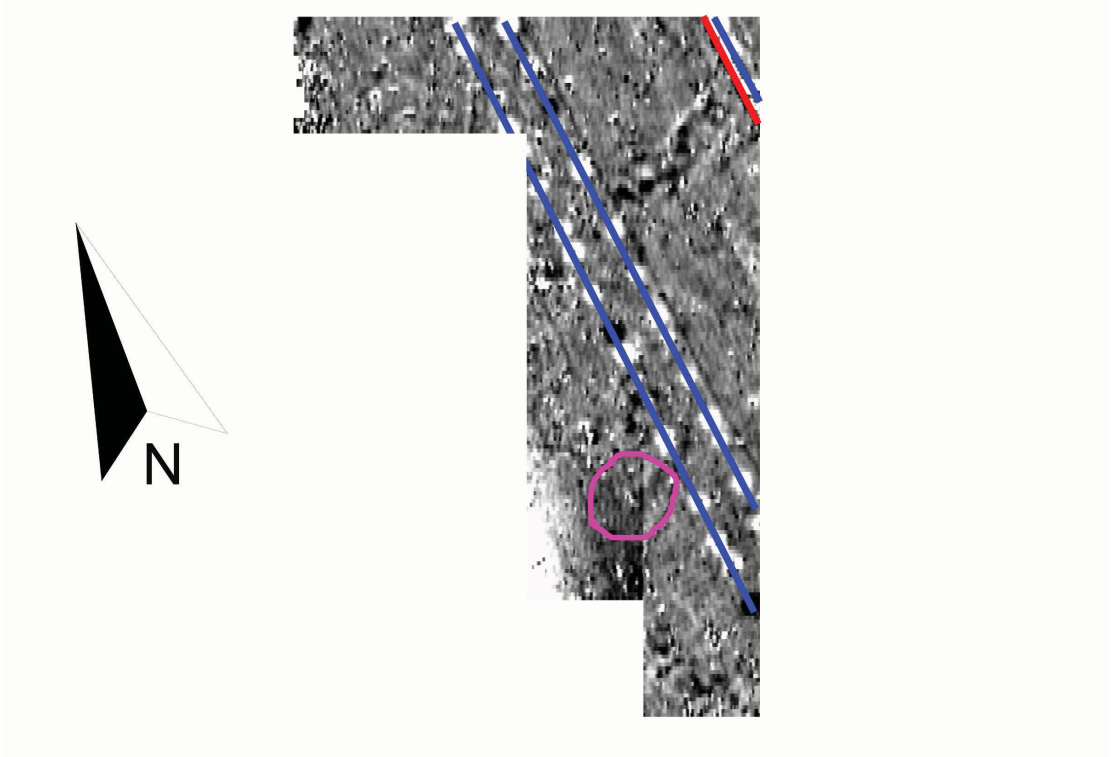
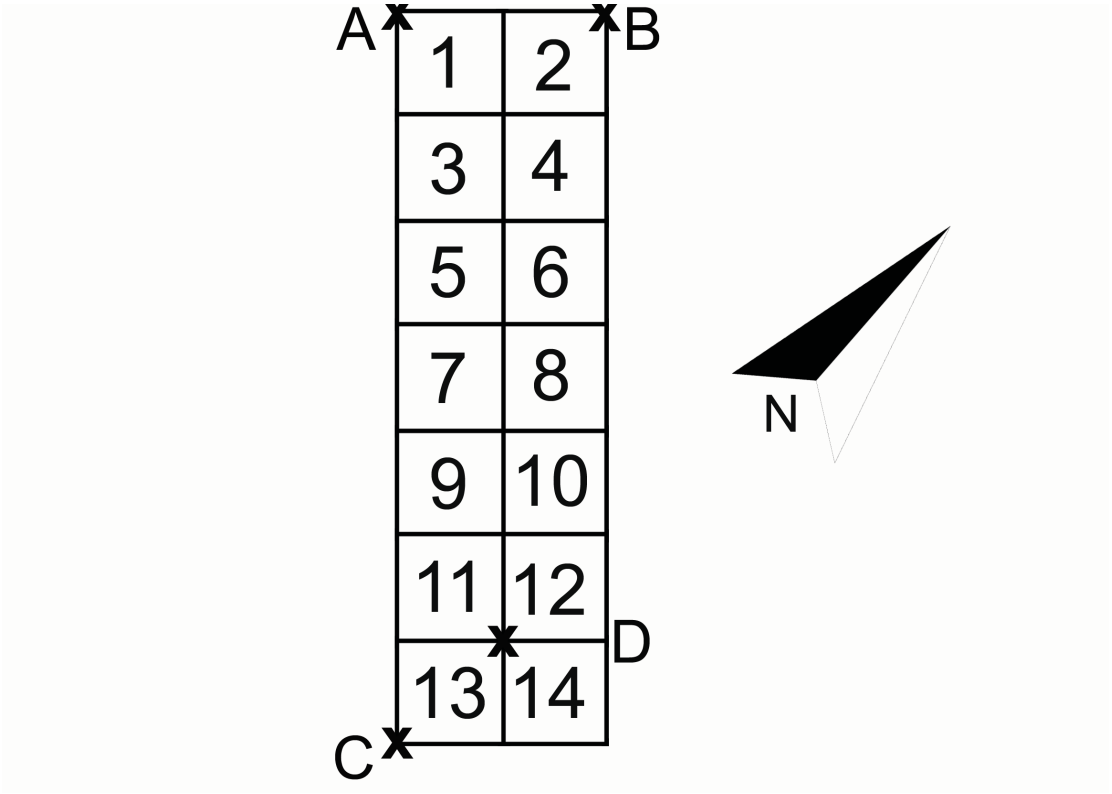


Pipelines?

Modern ditch

Possible ditch

Qaleh Daland Area A grid location

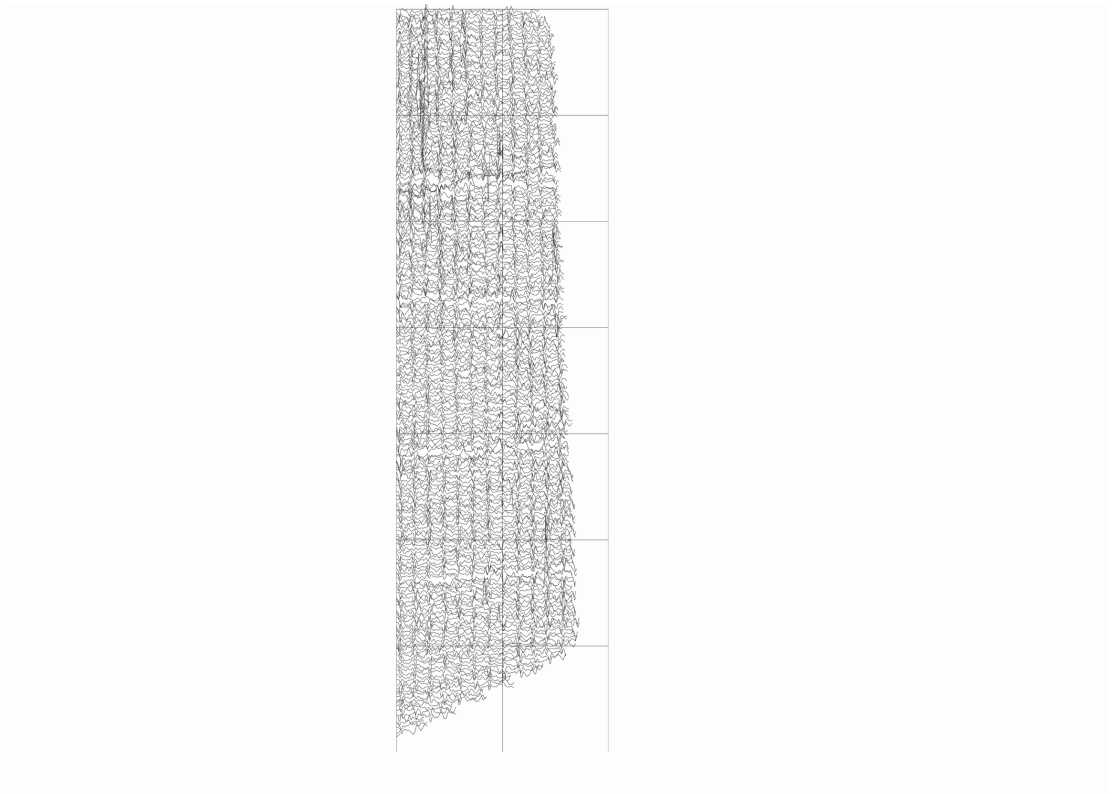


Qaleh Daland Area A greyscales with gridlines

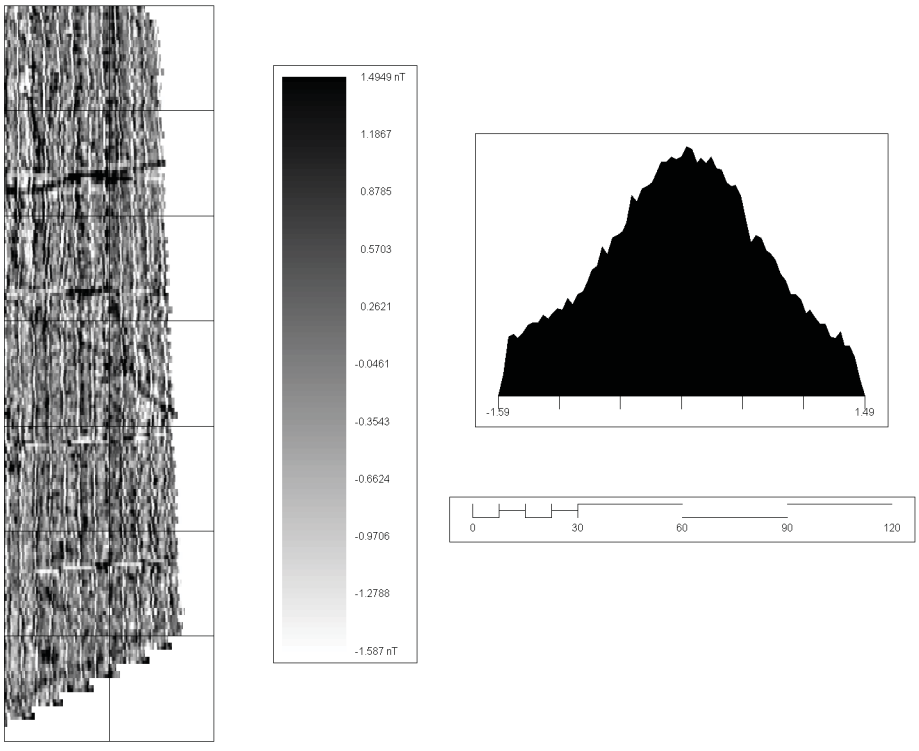
Qaleh Daland Area A greyscale

Qaleh Daland Area A colour

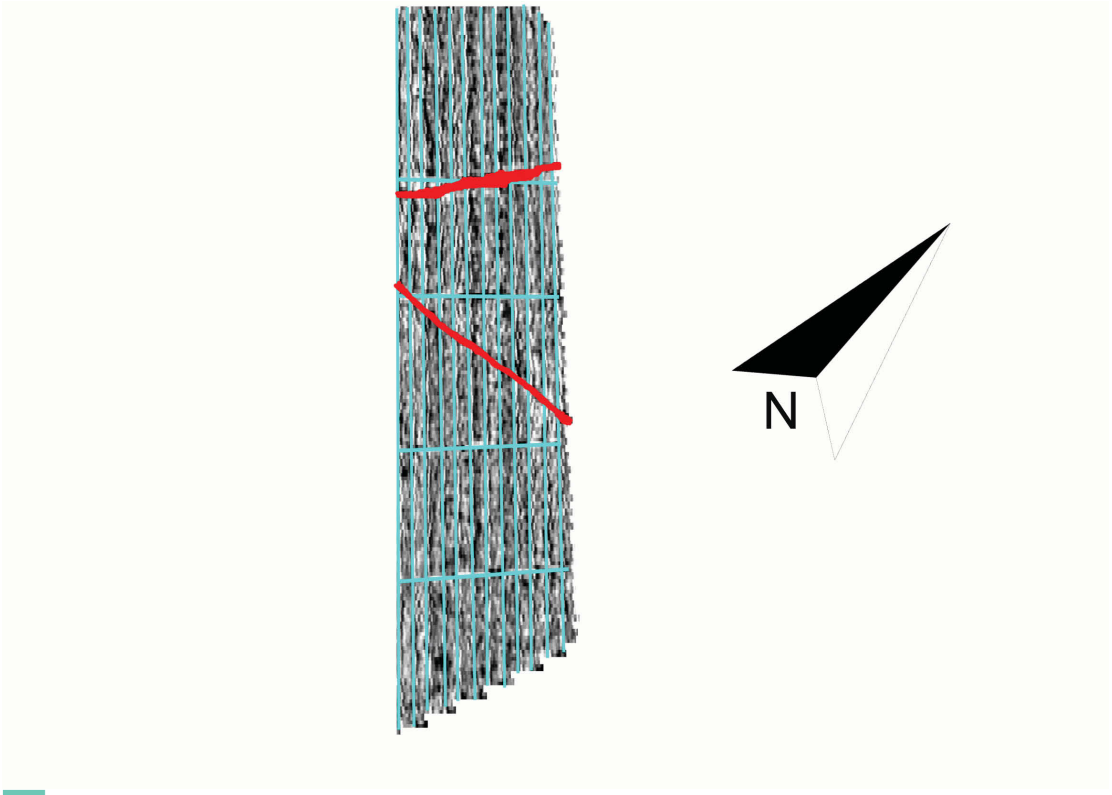
Qaleh Daland Area A trace plot



Qaleh Daland Area A greyscale with scales



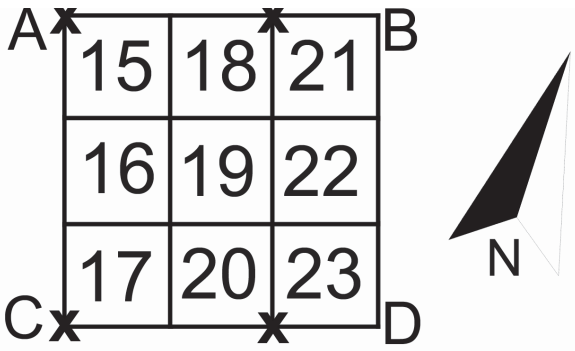
Qaleh Daland Area A interpretation



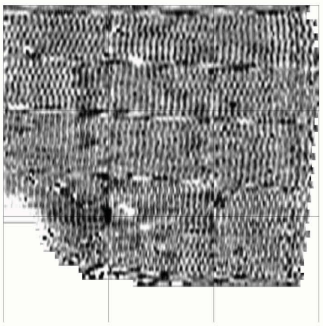
Modern irrigation channels

Possible ditches

Qaleh Daland Area B grid location



Qaleh Daland Area B greyscale with gridlines



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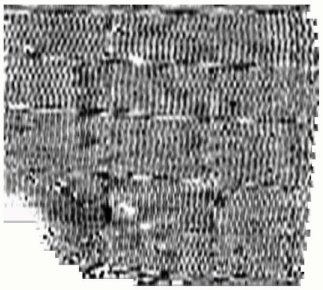
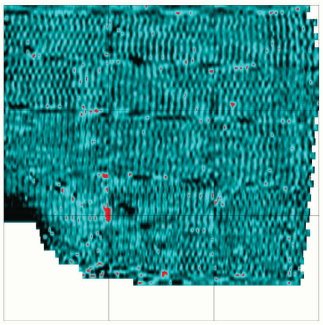
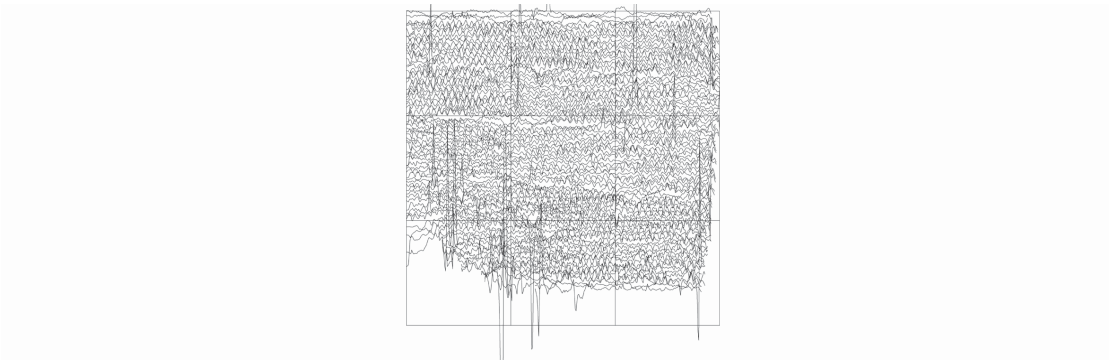


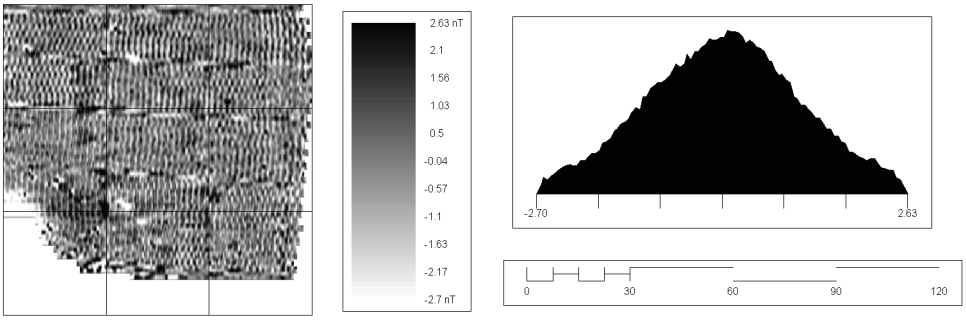
Qaleh Daland Area B colour



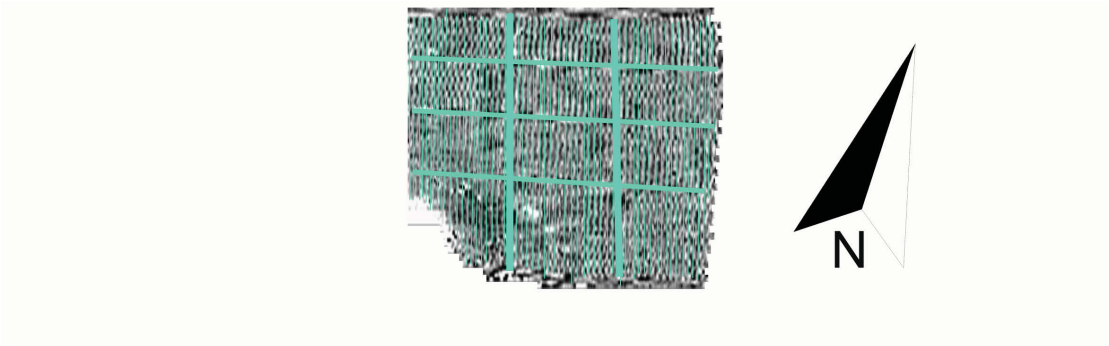
Qaleh Daland Area B trace plot



Qaleh Daland Area B greyscale with scales

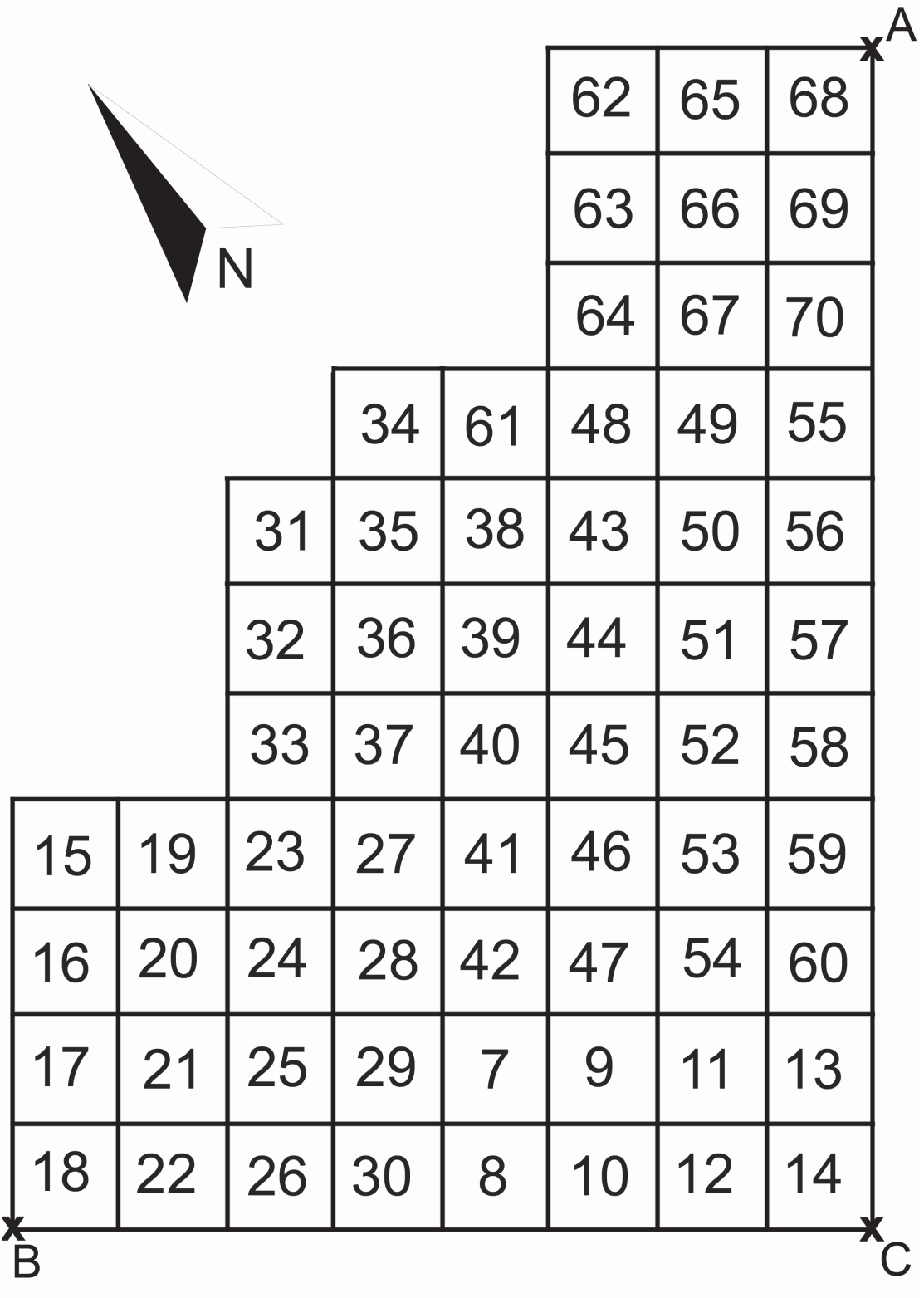


Qaleh Daland Area B interpretation

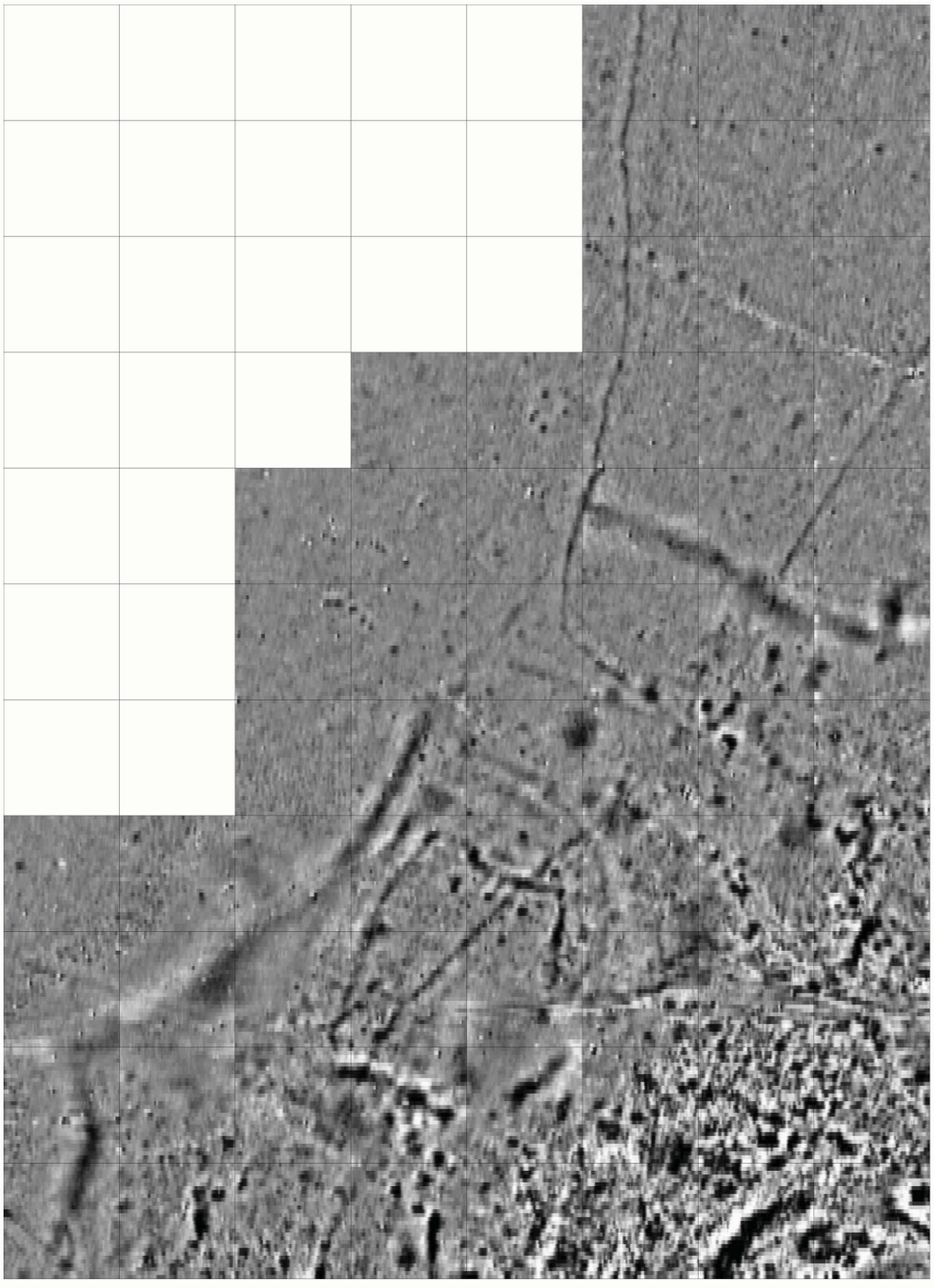


Modern irrigation channels

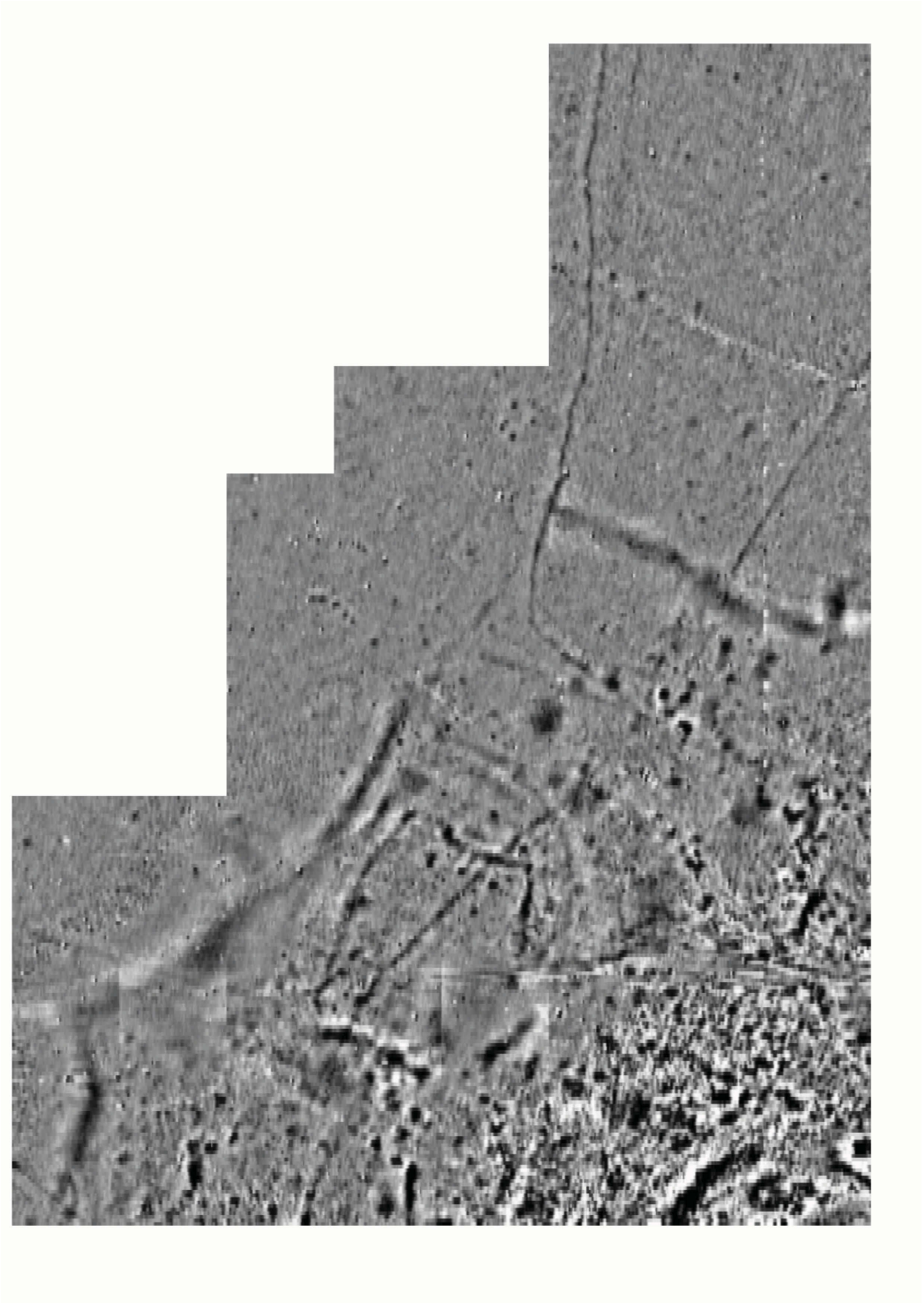
Qareh Mohammed Tappeh grid location



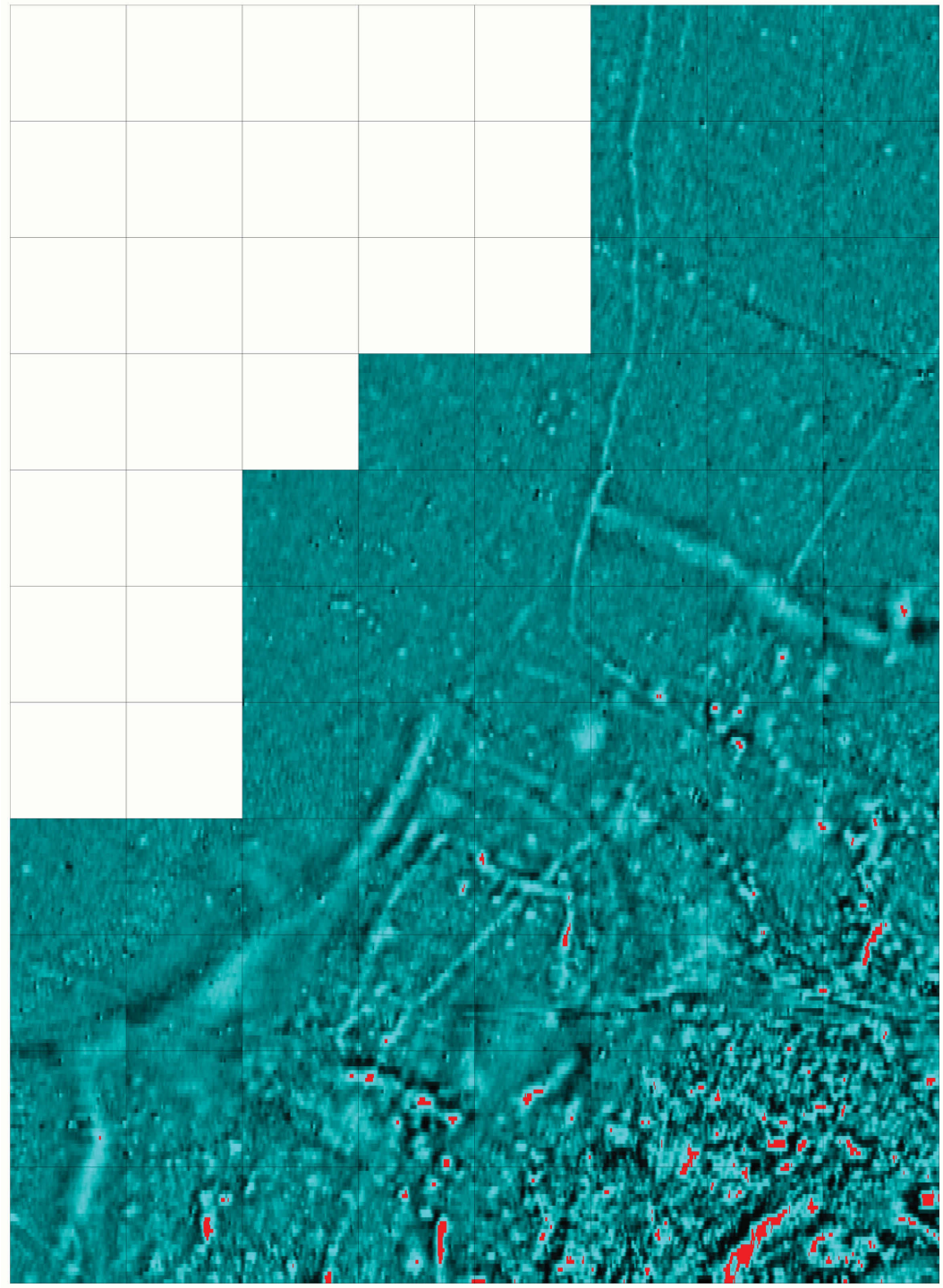
Qareh Mohammed Tappeh greyscale with grid lines



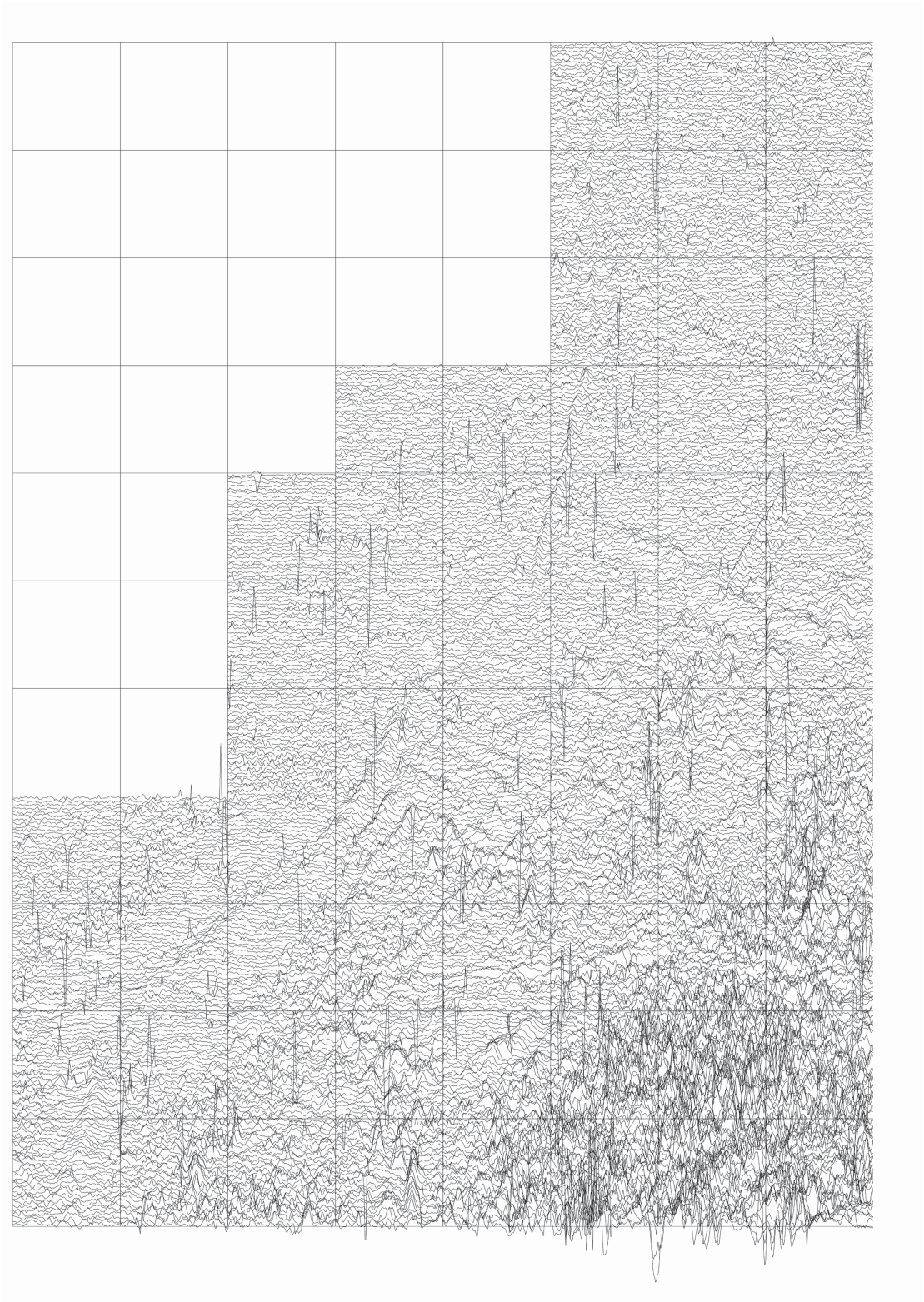
Qareh Mohammed Tappeh greyscale



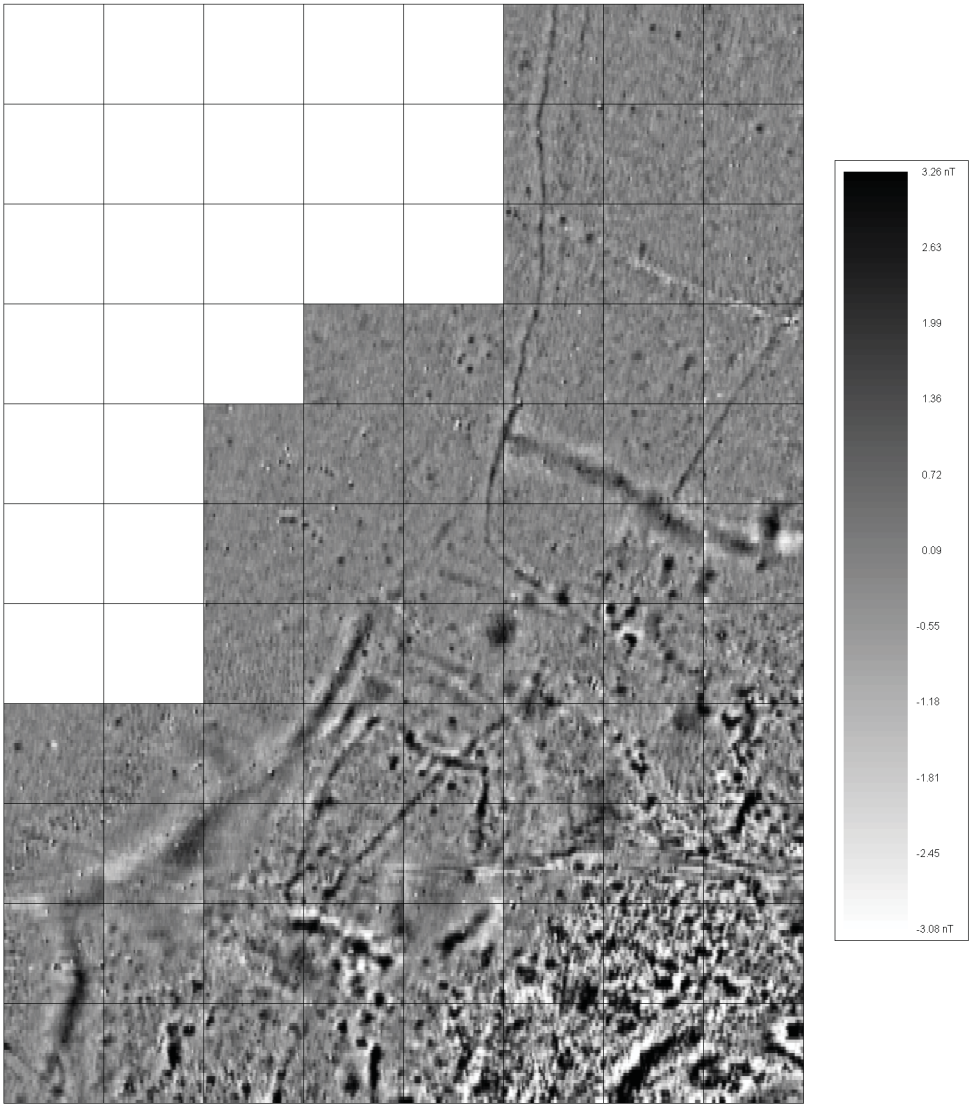
Qareh Mohammed Tappeh colour

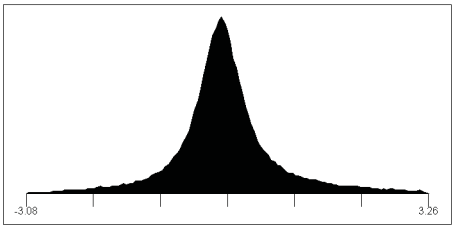


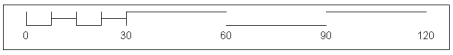
Qareh Mohammed Tappeh trace plot



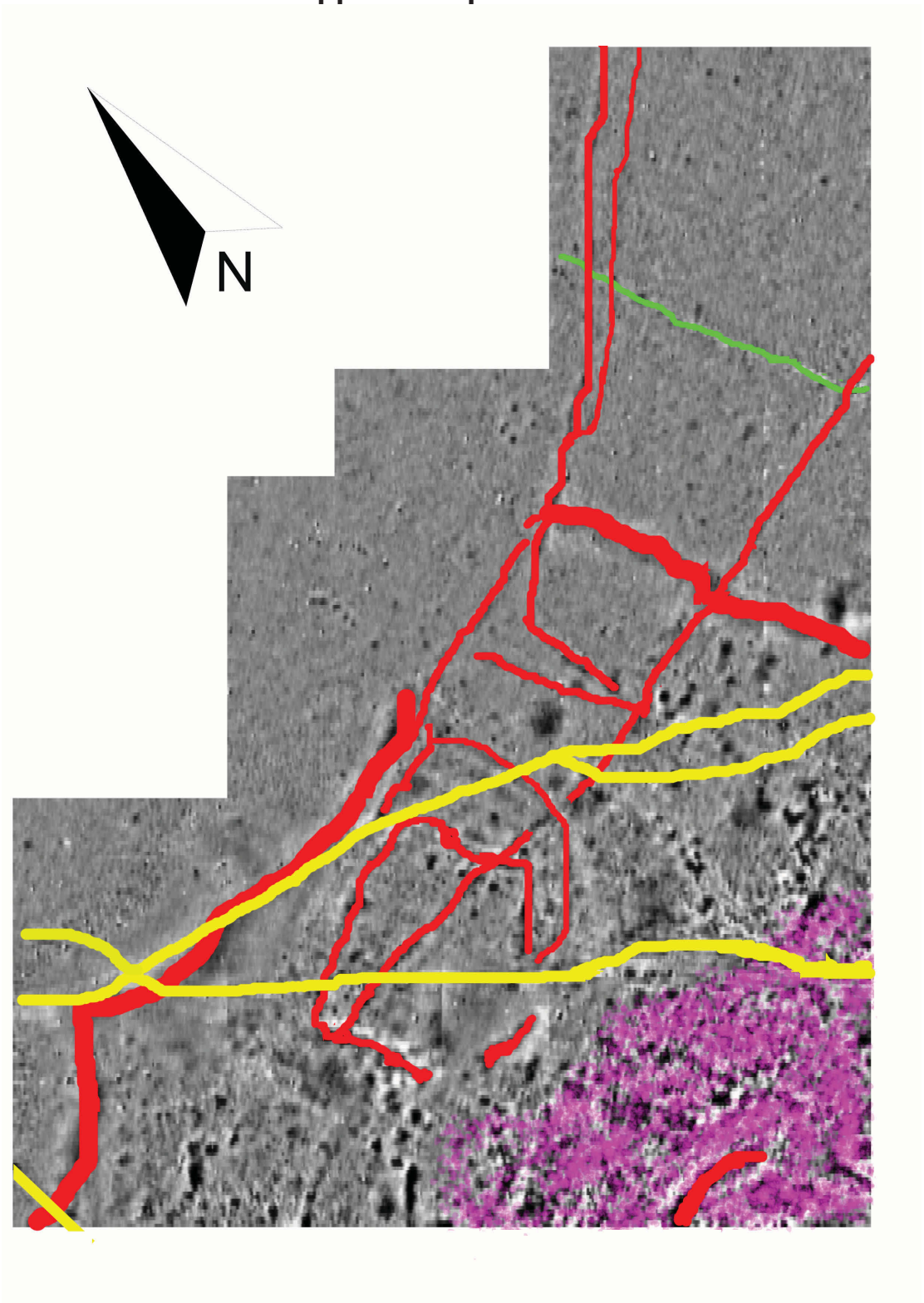
Qareh Mohammed Tappeh greyscale with scales







Qareh Mohammed Tappeh interpretation



Conclusions

The results from Daland identified many features but it is unclear how many of these are archaeological.

There is one possible circular features from Qaleh Gug but the site was subjected to much interference from ferrous objects.

The surveys at Qaleh Daland identified little other than the modern irrigation channels which cover the site.

Qareh Mohammed Tappeh produced the most interesting results, showing what appear to be various field systems.

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 our website.

7

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 caesium type equipment is expensive.

8 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.

9 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. Lawrence Conyers *Ground Penetrating Radar for Archaeology* 2004 gives a good account of that method.
Andrew David's guide *Geophysical survey in archaeological field evaluation* English Heritage Society 2008 gives a good overview of techniques and what to expect in reports.

10 Acknowledgements

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11 Compact Disc

This contains this report and the various pictures and data. The data is mainly in xcp. fomat which is used by the ArcheoSurveyor programme and the pictures in png format.
In the site folders you will see sub folders of comps, Export, Graphics, Grids, Comments and Site. The report and illustrations used to prepare it are in the Report folder.

Chris Oatley
4 Sutton Close
Abingdon
Oxon OX14 1ER

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