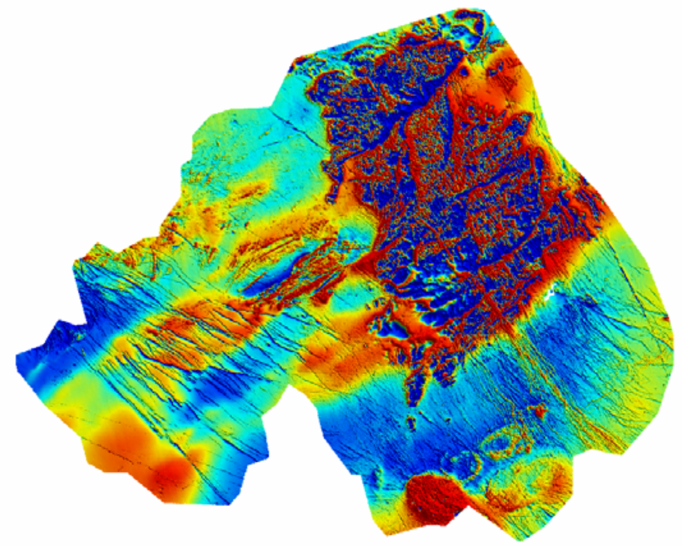
British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Deculturing of the Northern Ireland Tellus magnetic data

National Geoscience Framework Programme

Internal Report IR/07/47



BRITISH GEOLOGICAL SURVEY

NATIONAL GEOSCIENCE FRAMEWORK PROGRAMME

INTERNAL REPORT IR/07/47

Deculturing of the Northern Ireland Tellus magnetic data

M. Lahti, D. Beamish, R.J. Cuss & J. Williams

Keywords

Tellus, airborne survey, geophysics, magnetics, Northern Ireland.

Front cover

Decultured magnetic grid of Northern Ireland.

Bibliographical reference

LAHTI, M, BEAMISH, D, CUSS, R.J. &WILLIAMS, J, 2007. Deculturing of the Northern Ireland Tellus magnetic data. *British Geological Survey Internal Report*, IR/07/47. 47pp.

Keyworth, Nottingham British Geological Survey 2007

BRITISH GEOLOGICAL SURVEY

The full range of Survey publications is available from the BGS Sales Desks at Nottingham, Edinburgh and London; see contact details below or shop online at www.geologyshop.com

The London Information Office also maintains a reference collection of BGS publications including maps for consultation.

The Survey publishes an annual catalogue of its maps and other publications; this catalogue is available from any of the BGS Sales Desks.

The British Geological Survey carries out the geological survey of Great Britain and Northern Ireland (the latter as an agency service for the government of Northern Ireland), and of the surrounding continental shelf, as well as its basic research projects. It also undertakes programmes of British technical aid in geology in developing countries as arranged by the Department for International Development and other agencies.

The British Geological Survey is a component body of the Natural Environment Research Council.

British Geological Survey offices

Keyworth, Nottingham NG12 5GG
☎ 0115-936 3241 Fax 0115-936 3488
e-mail: sales@bgs.ac.uk
www.bgs.ac.uk
Shop online at: www.geologyshop.com

Murchison House, West Mains Road, Edinburgh EH9 3LA
☎ 0131-667 1000 Fax 0131-668 2683
e-mail: scotsales@bgs.ac.uk

London Information Office at the Natural History Museum (Earth Galleries), Exhibition Road, South Kensington, London SW7 2DE
☎ 020-7589 4090 Fax 020-7584 8270
☎ 020-7942 5344/45 email: bgslondon@bgs.ac.uk

Forde House, Park Five Business Centre, Harrier Way, Sowton, Exeter, Devon EX2 7HU
☎ 01392-445271 Fax 01392-445371

Geological Survey of Northern Ireland, Colby House, Stranmillis Court, Belfast BT9 5BF
☎ 028-9038 8462 Fax 028-9038 8461

Maclean Building, Crowmarsh Gifford, Wallingford, Oxfordshire OX10 8BB
☎ 01491-838800 Fax 01491-692345

Columbus House, Greenmeadow Springs, Tongwynlais, Cardiff, CF15 7NE
☎ 029–2052 1962 Fax 029–2052 1963

Parent Body

Natural Environment Research Council, Polaris House, North Star Avenue, Swindon, Wiltshire SN2 1EU
☎ 01793-411500 Fax 01793-411501
www.nerc.ac.uk

Deleted: IR/07/0

Deleted: Draft 0.1

Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

Foreword

This report describes the semi-automatic deculturing carried out on the magnetic data of the Tellus airborne geophysical survey data of Northern Ireland. Studies to find suitable deculturing techniques began after Phase 1 of the survey in 2005. The majority of the data cleaning was carried out during 2006 and continued into the first quarter of 2007. This report accompanies the decultured data delivered at the beginning of April 2007.

Deleted: the

Contents

Deleted: IR/07/0

Deleted: Draft 0.1

Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

FIGURES

Formatted: Font: 10 pt

TABLES

Deleted: IR/07/0

Deleted: Draft 0.1

Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

Deleted: Figure 1 – Three examples of low amplitude cultural noise. From the OS map the anomalies seem to be related to buildings adjacent to flight path. In the video images we see other possible sources of cultural noise such as a road, powerlines, cattle fences and gates. 8¶
Figure 2 – On the left Pointer locations for Block A. Towns Londonderry, Strabane and Omagh are seen as concentrations of Pointer data. On the right Pointer plotted on OS 50k map. The Pointer circles have a 250m diameter on the map. 9¶
Figure 3 – Magnetic map with Pointer locations (left) and OS 50k topographic map with Pointer circles (right). Pointer diameter of 250 m is suitable for removing most of the cultural noise. 10¶
Figure 4 – An example of how the Pointers intersect with flight lines. This is an ideal case of pointer filtering where the Pointers and cultural noise correlate well. The red part of the magnetic profile will be dummied and the green part will be saved. 10¶
Figure 5 – A detail from block D. On the left original magnetic total intensity data and on the right Pointer filtered data. 11¶
Figure 6 – A typical source of cultural noise passing Pointer filtering is a building without address point. Another expected type of passing cultural noise is moving objects, which can be farm tractors in the field, boats on lakes or vehicles on roads. 11¶
Figure 7 – Example of Pointer filtering results over the town of Armagh. Automatic Pointer filtering removes large amounts of data where Pointers are clustered. Original data show a linear bedrock structure (fault/dyke) under the town. Pointer-filtering disturbs this geological anomaly (outlined area). 12¶
Figure 8 – a) 50k Bedrock geology b) original magnetic data c) locations of the Pointers d) Pointer filtered data e) Pointer filtered data with blanking f) Pointer filtered with high gradient data restored. Comparison of original (b) and Pointer filtered (e) data shows that filtering has changed the geological and ... [1]

Deleted: Error! No table of figures entries found.

Deleted: ¶

Formatted: Font: 10 pt

Deleted: Error! No table of figures entries found.

Deleted: ¶

Summary

This report provides descriptions of the cultural/anthropogenic cleaning carried out on the Tellus HiRes airborne magnetic data acquired during 2005 and 2006. The deliverable is a deculturing channel that can be used for masking magnetic data to minimise cultural interference. This report also describes some background studies that were carried out to find the most suitable technique to clean the Tellus data. Previous descriptions of the Tellus survey data and their geophysical processing are given by Beamish *et al*. (2006 a,b,c).

The goal of the deculturing process is to produce high quality data suitable for map presentation as well as further interpretation and modelling. The aim is to keep the reduction of geological signal to an absolute minimum and to enhance subtle features that may be masked by cultural noise. Achieving maximum cultural suppression and minimum geological distortion requires manual control in the deculturing process. The manual approach is not ideal and can become subjective, even with detailed mapped information and aerial video footage it can still be difficult to decide whether certain features are geological or cultural when correlations of the two are known.

The technique developed during this work is semi-automatic. The cleaning is carried out in two steps. Step 1 is called Pointer[1]-filtering and is based on Pointer data that indicate locations of households/businesses receiving mail. Pointer locations are used for masking geophysical data. Pointer-filtering is an automated process and with some limitations it could be used by itself to produce enhanced maps. Step 2 of deculturing requires laborious manual work to improve the Pointer-filtered data. The data is checked line by line to clean remaining cultural noise and restore what was unnecessarily removed.

Deculturing is carried out on block data. Cultural influence and the amount of cleaning needed vary from block to block. Table 1 summarizes what level of processing the deculturing was conducted to. Four of the survey blocks are thoroughly manually cleaned whereas the other four are manually adjusted to a less reliable level.

The procedures, taking over 2 years to complete, have resulted in a final Tellus magnetic data set with a deculturing mask channel. The channel contains a simple set of noise classifications. The deculture mask channel can be applied, wholly or partly, to any or all of the data channels in the Tellus magnetic data set. The result is a Tellus magnetic data set decultured according to the procedures set out in this report.

Table 1 – Summary of deculturing level for Tellus survey blocks

Block	Deculturing status
A	Manually cleaned
B	Manually cleaned
C1	Pointer-filtered, some manual adjustments
D1	Manually cleaned
E1	Pointer-filtered, some manual adjustments
C2	No Pointer-filtering, only some manual cleaning
D2	Pointer filtered, some manual adjustments
E2	Manually cleaned

[1] Pointer® is the address/postcode database for Northern Ireland with the joint support of Ordnance Survey of Northern Ireland® (OSNI®), the Valuation & Lands Agency (VLA) and Royal Mail®, in conjunction with local councils.

Deleted: IR/07/0
Deleted: Draft 0.1
Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26
Deleted: de
Deleted: The
Formatted: Font: Italic
Deleted: will
Deleted: also
Deleted: the
Deleted: s
Deleted: then
Deleted: step
Deleted: s
Deleted: ,
Deleted: and
Deleted: ies
Field Code Changed
Deleted: Table 1
Deleted: cleaning
Deleted: brought into
Formatted: Font: 12 pt
Comment [r1]: Can you make an estimate of the total effort; i.e. do you mean the data took 2 person-years to complete?
Deleted: ¶ ¶
Formatted: Font: 11 pt, Italic
Formatted: Font: Italic
Formatted: Font: 11 pt, Not Bold, Italic
Deleted: *Table 1.*
Formatted: Font: Not Bold
Deleted: ¶
Formatted: Font: Italic
Formatted Table
Comment [r2]: Can you make an estimate of the total effort; i.e. do you mean the data took 2 person-years to complete?
Deleted: ¶ The procedures, taking ove ... [2]
Formatted: Font: 11 pt
Formatted: Superscript
Formatted: Superscript
Formatted: Superscript
Formatted: Superscript

1 Introduction

Northern Ireland is a densely populated, agricultured and industrialized country. Cultural noise is clearly affecting the Tellus dataset, in particular, the magnetic data. Magnetic maps are widely spotted by signals from different cultural origins. This is disturbing the geological image in areas where magnetic field is smooth and geological features are subtle. On the sites of high magnetic gradient the cultural influence is hardly discernible in the total field, but may be seen in derivative images.

Cultural noise. Cultural noise is signal from anthropogenic sources. In geological investigations cultural noise is a nuisance potentially masking subtle shallow geological features. The most common source of cultural noise in the Northern Ireland magnetic data is from individual or clustered housing and from farms; these give the magnetic map a spotted texture. Due to flight regulations villages and towns are flown over higher than survey altitude and therefore urban sites are not a major source of cultural noise. On the other hand larger distance to the source moves the anomaly amplitude and frequency closer to geological signal which can be misleading. Other common sources of cultural noise such as any infrastructure from roads to powerlines are densely covering the country. The cultural noise related to roads often can be explained by settlements following roads or by other infrastructure (powerlines, pipelines) or maybe even road construction materials.

There are also types of cultural noise that could be environmentally interesting; landfill sites and mine spoil heaps. Domestic landfills often produce a high amplitude short wavelength dipole anomaly.

Typically cultural noise is a short wavelength dipole anomaly with amplitude range from few nano-Teslas up to several hundreds of nano-Teslas. It is difficult to predict the characteristic amplitude of cultural noise. The amplitude depends strongly on the type of the source and exact location in relation to flight path. Preliminary statistics of the Northern Ireland data show that common amplitude for a signal from a large farm building directly under flight path is 50 nT. A residential house typically produces a smaller, yet still significant, anomaly of 10 nT. Figure 1 shows examples of low amplitude cultural noise. Larger buildings such as factories can create anomalies up to 300-500 nT.

Deculturing techniques. Several techniques to suppress cultural noise have been described in the literature. The manual approach is successful but time consuming, and hence expensive, compared to fast and effective automated techniques (Hassan *et al.*, 1998). Examples of successful automated techniques have been presented by Fedi *et al.* (2003), Gharibi & Pedersen (2000), Muszala *et al.* (2001), Wilson (1997) and many others. Cultural noise has both amplitude and wavelength overlap with geological signal. Numerical and automated deculturing techniques would be partially successful for Tellus data but would yield a compromised result of passing noise and geological distortion due to the wide spectrum of cultural signal. A manual approach to produce high quality decultured data in the highly developed North Midlands of the UK was presented by Cuss (2001, 2003). This work was established as a baseline against which the success of automatic and semi-automatic approaches could be judged. Several unpublished pilot studies have been conducted by BGS on automatic deculturing using Fourier based techniques and wavelet analysis. These were concluded to be unsuccessful and work has concentrated on using techniques that do not rely solely on mathematics, requiring other geographic information.

Deleted: IR/07/0
Deleted: Draft 0.1
Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26
Deleted: and
Deleted: ly
Comment [r3]: Feel free to remove this statement if you disagree
Deleted: houses
Deleted: or clusters of a few households that
Deleted: .
Deleted: These are for example
Deleted: shed
Deleted: n
Deleted: smaller that
Formatted: Font: 11 pt
Deleted: Figure 1
Deleted: M
Formatted: Font: Italic
Deleted: S
Formatted: Font: Italic
Formatted: English (U.S.)
Formatted: Font: Italic, English (U.S.)
Formatted: English (U.S.)
Deleted: cultural
Deleted: is
Deleted:) and Cuss (

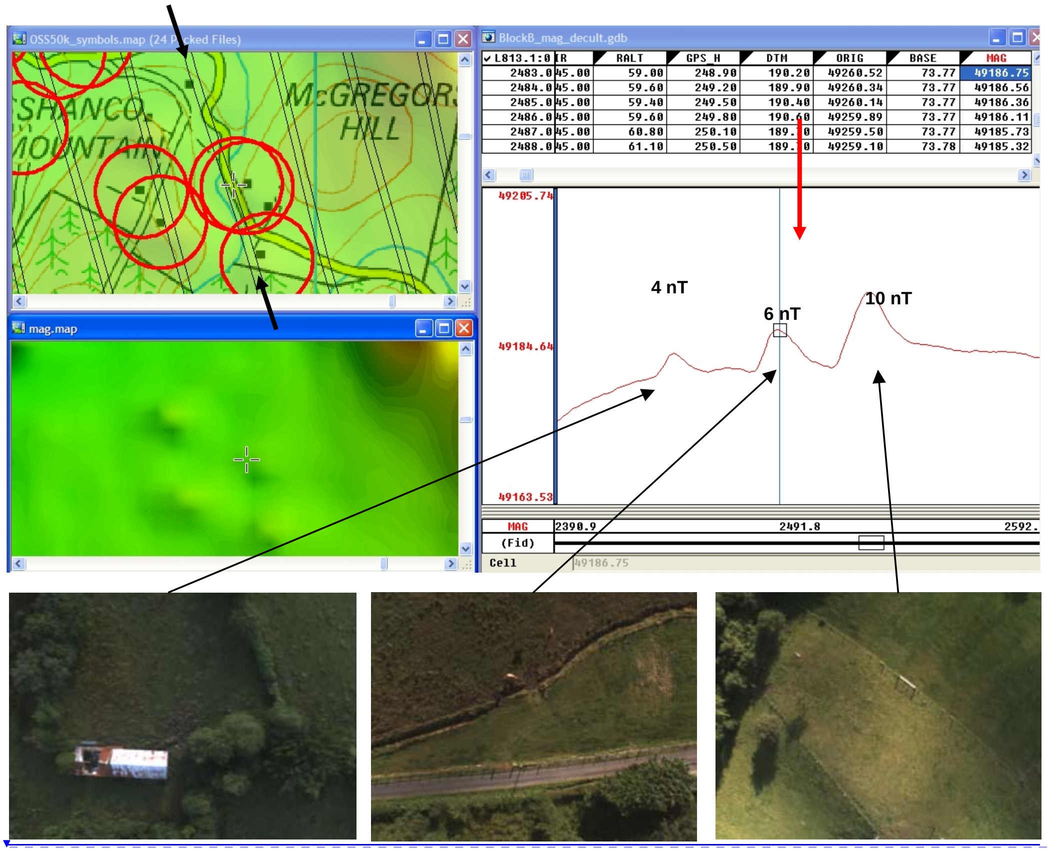


Figure 1 – Three examples of low amplitude cultural noise. From the OS map the anomalies seem to be related to buildings adjacent to flight path. In the video images we see other possible sources of cultural noise such as a road, powerlines, cattle fences and gates.

Deleted: IR/07/0

Deleted: Draft 0.1

Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

Deleted: <sp>

Deleted: T

Formatted: Font: 11 pt, Not Bold

Formatted: Font: Not Bold

Formatted: Caption

Deleted: Figure 1.

2 Step 1: Automatic Pointer filtering

It is obvious that the most common source of cultural noise is various buildings. A vast number of these buildings are residences and farmhouses which all have a common feature, a postal address. The address point database (Pointer) with reference to all buildings that have post delivered was utilized for informing the public of the low altitude surveying. The same database can be used for cleaning the data of cultural influence. The idea is to give each address point an area of influence and remove that area from the magnetic data.

This automatic Pointer filtering potentially improves the data by removing a large amount of cultural noise. The method has however two major limitations. Firstly, after pointer filtering the data still contain visible cultural noise. Secondly, pointer filtering is removing a large amount of data unnecessarily, which can result in geological distortion. The cultural noise not corrected by Pointer filtering originates from buildings that do not have a postal address, incorrect diameter of sphere of magnetic influence, other infrastructure sources such as power lines and pipelines, or even mobile sources like heavy machinery.

2.1 SETUP

The Pointer database was imported into Oasis montaj software together with geophysical databases and digital maps. The address point locations were then plotted onto topographic maps and geophysical maps to check the correlation with map symbols and cultural noise (Figure 2-Figure 3). The diameter of the mask is determined by checking what diameter would be enough to remove a typical cultural noise anomaly. A diameter of 250 m worked well for most sources of cultural noise, and corresponds to the average size of cultural noise reported in Cuss (2001). The Pointer data are then sampled into a channel in the geophysical database and this channel can be used as a mask channel. This means that geophysical data will be masked using the Pointer data by simple equations (*if pointer is larger than zero then dummy and if pointer is zero then copy mag channel*). The result (e.g. filtered magnetic data) will be a new channel in the database and the original magnetic channel will remain untouched. How successful the filtering is depends strongly on how the pointer locations intersect with flight paths (Figure 4).

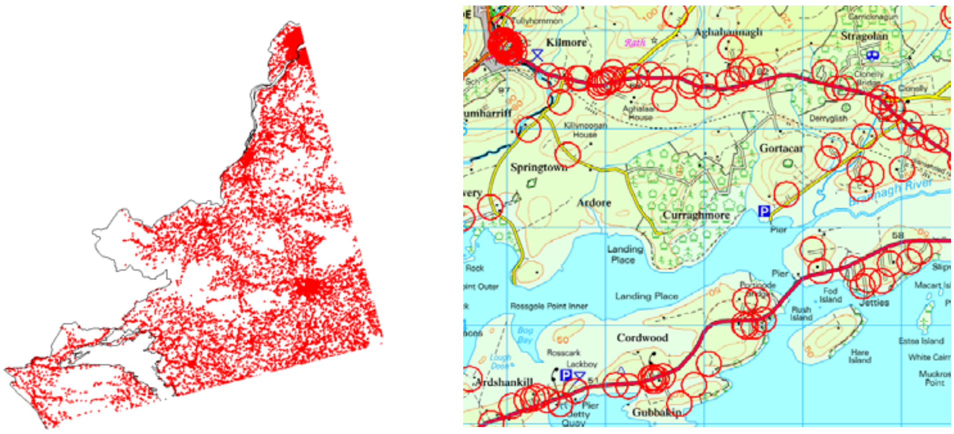


Figure 2 – On the left Pointer locations for Block A. Towns Londonderry, Strabane and Omagh are seen as concentrations of Pointer data. On the right Pointers plotted on OS 50k map. The Pointer circles have a 250m diameter on the map.

Deleted: IR/07/0
Deleted: Draft 0.1
Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26
Deleted: pointer
Deleted: amount
Deleted: for
Comment [r4]: I've made Pointer a capital P as it's a trade name.
Deleted: pointer
Deleted: causing
Deleted: passing
Deleted: p
Deleted: without
Deleted: point
Comment [r5]: Remove if this isn't the case
Deleted: address point
Deleted: can be
Deleted: M
Deleted: are
Deleted: i
Formatted: Font: 11 pt
Formatted: Font: 11 pt
Deleted: Figures 2 and 3
Deleted: seems to
Deleted: pointers
Deleted: pointer
Formatted: Font: 11 pt
Deleted: Figure 4
Formatted: Font: 11 pt, Not Bold
Formatted: Caption
Deleted: <sp>
Formatted: Font: 11 pt, Not Bold
Deleted: Figure 2.
Formatted: Font: Not Bold
Deleted: pointer
Formatted: Font: Not Bold
Deleted: pointer
Deleted: pointers
Formatted: Font: Not Bold
Deleted: p

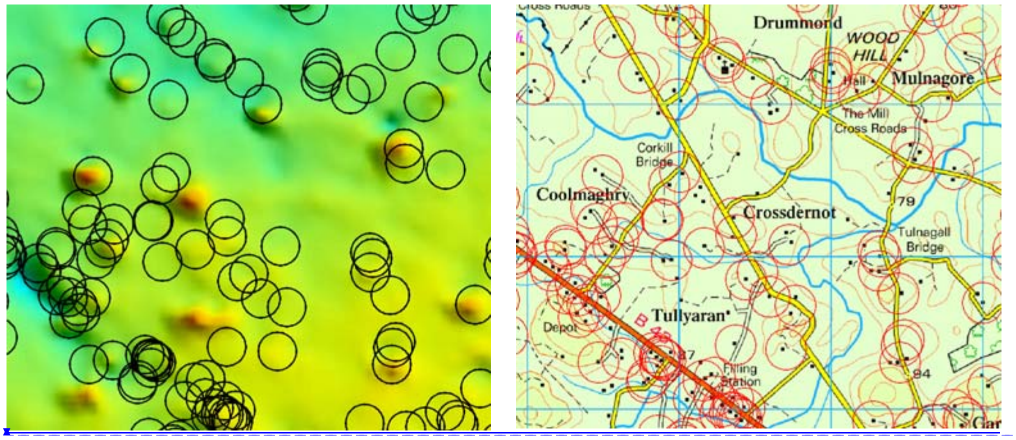


Figure 3 – Magnetic map with Pointer locations (left) and OS 50k topographic map with Pointer circles (right). Pointer diameter of 250 m is suitable for removing most of the cultural noise.

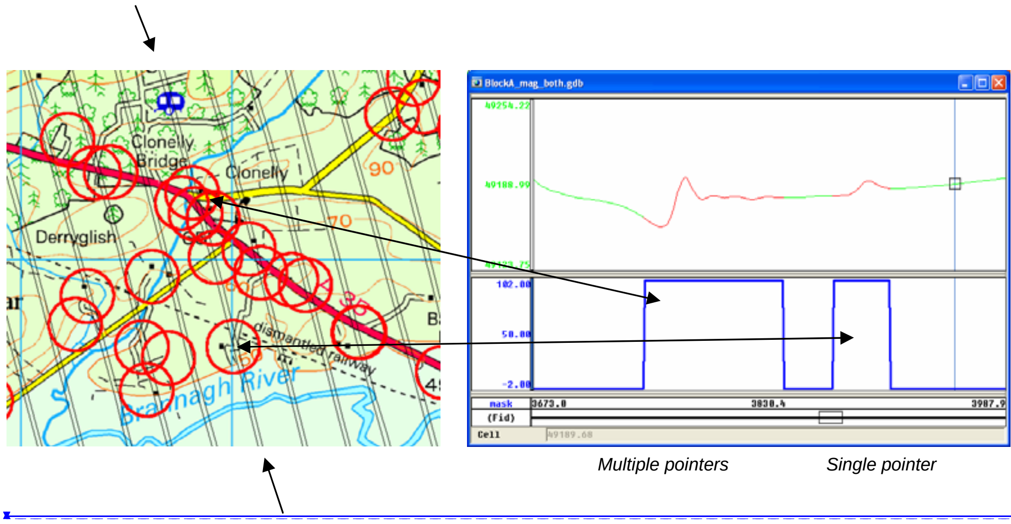


Figure 4 – An example of how the Pointers intersect with flight lines. This is an ideal case of pointer filtering where the Pointers and cultural noise correlate well. The red part of the magnetic profile will be dummied and the green part will be saved.

Deleted: IR/07/0
Deleted: Draft 0.1
Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26
Deleted: <sp>
Formatted: Font: 10 pt
Deleted: Figure 3.
Formatted: Font: Not Bold
Deleted: pointer
Deleted: pointers
Formatted: Font: 11 pt, Not Bold
Formatted: Caption
Deleted: <sp>
Formatted: Font: 10 pt
Deleted: Figure 4.
Formatted: Font: Not Bold
Deleted: pointers
Formatted: Font: 11 pt, Not Bold
Formatted: Caption
Deleted: pointers

2.2 LIMITATIONS

2.2.1 Cultural noise passing

Due to the nature of address point data it can be expected that some cultural noise will pass Pointer filtering, as shown in Figure 5 and Figure 6). A quick comparison between OS 50k maps and address point data shows that approximately 20 % of the buildings shown on OS 50k map do not have an address point. If these buildings are probable sources of cultural noise their influence on the magnetic data will be missed. A smaller amount of passed cultural noise will originate from new buildings that do not appear on maps as well as from moving objects. Video images are an excellent tool for checking the source of these cultural anomalies. Another expected type of passed cultural noise is moving objects, which can be farm tractors in the fields, boats on lakes or vehicles on roads.

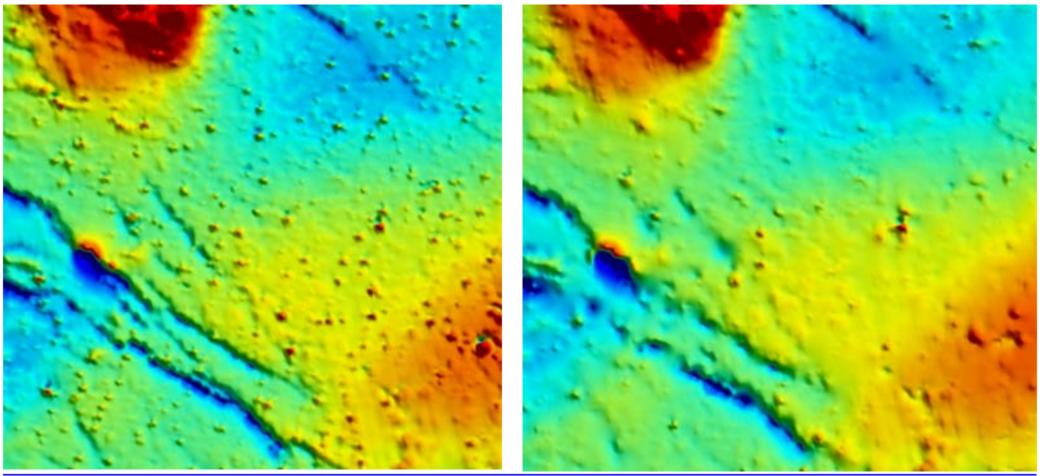


Figure 5 – A detail from block D. On the left original magnetic total intensity data and on the right Pointer filtered data.

Mag with pointers *OS50k with pointers* *Pointer filtered*

Figure 6 – A typical source of cultural noise passing Pointer filtering is a building without address point. Another expected type of passing cultural noise is moving objects, which can be farm tractors in the field, boats on lakes or vehicles on roads.

2.2.2 Geological distortion

Automatic Pointer filtering will remove significant amount of data points especially where the address points are clustered. Major towns may have thousands of address points, whereas smaller villages only have a few tens. Sometimes just an unfavourably situated cluster of a few address points can significantly distort a subtle geological feature.

Major towns are associated with high flight elevation that decreases the anomaly amplitude of cultural noise. Therefore the data over certain survey elevation (for example 120 m) could be restored in the pointer-filtered data. In many cases geological features can be followed through urban areas (Figure 7) so data should be retained. Figure 8 is another example of the difficulty of when geology and cultural noise separation can be very difficult.

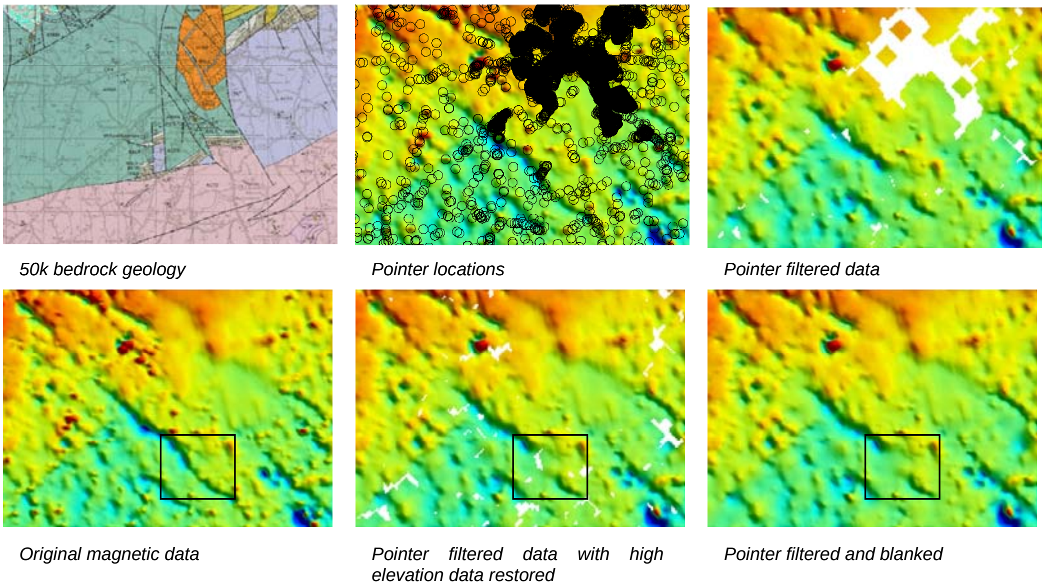


Figure 7 – Example of Pointer filtering results over the town of Armagh. Automatic Pointer filtering removes large amounts of data where Pointers are clustered. Original data show a linear bedrock structure (fault/dyke) under the town. Pointer-filtering disturbs this geological anomaly (outlined area).

Deleted: IR/07/0
Deleted: Draft 0.1
Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26
Deleted: pointer
Deleted: piling up
Deleted: Over m
Deleted: there are
Deleted: be
Deleted: on
Deleted: <sp>
Deleted: under
Formatted: Font: 11 pt
Deleted: Figure 7.
Deleted: that
Deleted: is often worth saving
Formatted: Font: 11 pt
Deleted: <sp><sp><sp><sp><sp>
Deleted: <sp>
Formatted: Caption
Formatted: Font: 11 pt, Not Bold
Deleted: Figure 7.
Formatted: Font: Not Bold
Deleted: pointer
Deleted: pointer
Deleted: will
Deleted: stacking
Deleted: s
Deleted: <sp>

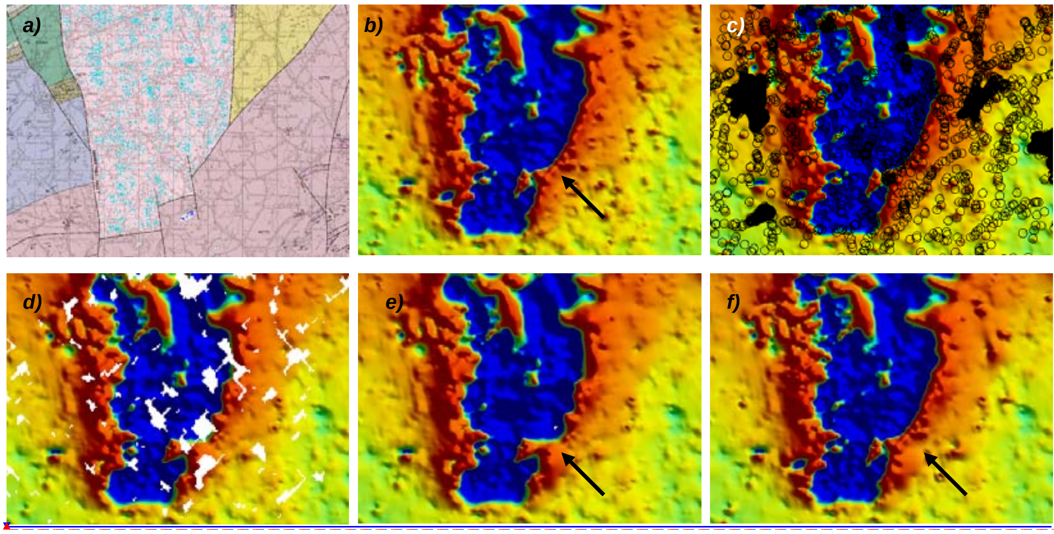


Figure 8 – a) 50k Bedrock geology b) original magnetic data c) locations of the Pointers d) Pointer filtered data e) Pointer filtered data with blanking f) Pointer filtered with high gradient data restored. Comparison of original (b) and Pointer filtered (e) data shows that filtering has changed the geological anomaly. In Pointer-filtered data where the high gradient data has been restored (f) the geology is better preserved but also more cultural noise passes due to the amplitude overlap.

2.2.3 Data outside NI border

The Pointer data only includes addresses in Northern Ireland. The flight lines were extended generally 2 km over the border and in some cases the coverage on the Republic of Ireland side is even wider. This is due to continuous flight lines instead of cutting the lines short where the border is curving, as shown in Figure **9**. As this data is part of the dataset they should also be cleaned. A rough estimation is that 6 % of all the data is outside Northern Ireland border and needs to be manually handled as a dataset similar to Pointer was not available for the Republic of Ireland.

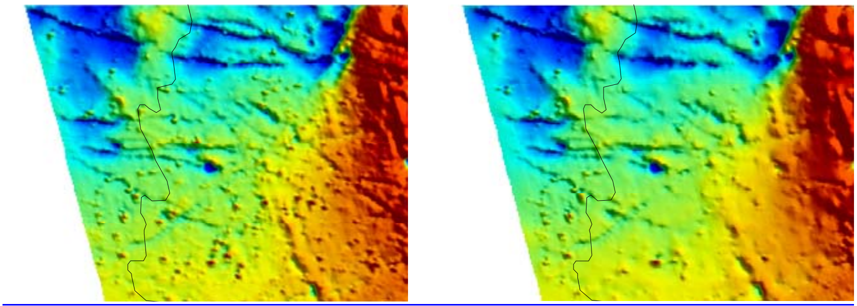


Figure 9 – Example from BlockE showing that flight lines continue over the Northern Ireland border (left side of the images is outside the border). The map on the left is the original magnetic data and the map on the right is Pointer filtered magnetic data. The data outside of the border will not be cleaned by Pointer-filtering.

Deleted: IR/07/0
Deleted: Draft 0.1
Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26
Deleted: <sp>
Formatted: Font: Not Bold
Formatted: Caption
Deleted: Figure 8.
Formatted: Font: Not Bold
Deleted: pointers
Deleted: pointer
Formatted: Font: 11 pt, Not Bold
Deleted: pointer
Deleted: pointer
Deleted: a
Deleted: pointer
Deleted: pointer
Deleted: <sp>
Deleted: address point
Deleted: United Kingdom
Formatted: Font: 11 pt
Deleted: as well
Formatted: Centered
Formatted: Font: 11 pt, Not Bold
Formatted: Caption
Deleted: Figure 9.
Formatted: Font: Not Bold
Deleted: p

2.3 STEPS TO REFINE POINTER FILTERING

Although automatic Pointer filtering has the limitations presented above it is a step forward in the deculturing process. By itself Pointer filtering is removing too much useful data for producing high quality results. Pointer filtering can be refined by the following simple steps:

1) Not all of the Pointer locations correlate with cultural noise. Filtering can be refined to remove data only where there is a probable cultural anomaly. The anomaly can be identified using for example the analytical signal channel.
2) Over urban sites the high fly elevation reduces cultural noise. High elevation data can be restored e.g. not filtered. This can be done by setting an elevation limit that cancels the Pointer filtering (120 m was found to be suitable).
3) Areas with high magnetic gradient, for example major magnetic anomalies associated with flood basalts, are generally not affected by cultural noise. The cultural noise signals are very weak compared to real anomalies and their interference is not visible in anomalous areas. On the other hand removing significant amount of data points with Pointer filtering is causing distortion to geological anomalies. Therefore high gradient data should be restored by cancelling the Pointer filter where the amplitude exceeds a certain limit. This can be performed by interrogating the analytical signal channel. However, due to the amplitude overlap of cultural and geological signals this will pass more cultural noise and finding the suitable limit is not straightforward.

Examples of results using refined pointer filtering are presented in Figure 7 and Figure 8. Steps 1 and 2 are quite straightforward, although the limit set for step 1 may result in some very low amplitude cultural noise to pass the filtering. The feasibility of step 3 is ambiguous and a decision of limits is best for each survey block. For example Block B is characterized by relatively low amplitude dyke anomalies on a magnetically smooth background and the discrimination between geology and culture is difficult based on the analytical signal on a single line observation. This means that a suitable analytical signal limit to preserve relatively subtle geological anomalies will pass a large amount of high amplitude cultural noise. For Block D1 on the other hand the method works better because of the high amplitude basalts that make the amplitude range larger and discrimination based on analytical signal easier.

Deleted: IR/07/0
Deleted: Draft 0.1
Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26
Deleted: POINTER
Deleted: pointer
Deleted: its
Deleted: earlier
Deleted: pointer
Deleted: useful
Deleted: data
Deleted: pointer
Deleted: pointer
Deleted: seems to be suitable
Deleted: e.g.
Deleted: influenced
Deleted: pointer
Deleted: pointer
Deleted: done using
Deleted: earlier
Formatted: Font: 11 pt
Formatted: Font: 11 pt
Deleted: Figures 7 and 8
Deleted: to use
Deleted: probably
Deleted: to be done based on
Deleted: s
Deleted: basin

3 Step 2: Manual refining of Pointer filtered data

Manual refining of Pointer filtered data consists of cleaning the remaining cultural noise that was not removed by filtering and restoring data that were unnecessarily removed. This deculturing step requires a manual approach and handling data line by line. The remaining cultural noise needs to be identified using available digital maps and ground path images.

Cultural noise sources can be identified in most cases using Ordnance Survey topographic maps. The 1:50,000 scale digital maps are generally adequate. When the topographic map fails to give indication of the source the ground path images can be used as a backup. The 1:50 000 scale geological maps should also be included in the process for following geological structures and giving indications of subtle geology present.

3.1 SETUP

Oasis montaj allows simultaneous and linked viewing of profile data, gridded data and topographic or geologic maps (Figure 10). Video images can also be viewed in the Oasis montaj project. The OS 50k topographic maps give indication of the cultural noise source approximately in half of all cases. The suspected cultural signals without any indication of the source in the maps can be checked from the video images.

The video data is recorded as jpeg-images with a sampling frequency of about 2 per second. The ground path images are stored on flight based DVDs. The geophysical data point and the corresponding video image can be tracked based on time. The images have proved to be very useful for identifying cultural noise. At the nominal survey altitude the images cover approximately 40 × 50 m ground area. In many cases the cultural noise anomaly source itself can be seen in the image. When the source is further away from the flight path the noise amplitude is generally small.

Deleted: IR/07/0

Deleted: Draft 0.1

Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

Deleted: pointer

Deleted: pointer

Deleted: comprehends

Deleted: was

Deleted: The c

Deleted: Also t

Deleted: hints

Deleted: M

Deleted: provides possibility to

Deleted: simultaneously

Formatted: Font: 11 pt

Deleted: Figure 10

Deleted: Also v

Deleted: imported

Deleted: to

Deleted: M

Deleted: the

Deleted: on

Deleted: *

Deleted: IR/07/0

Deleted: Draft 0.1

Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

Deleted: <sp>

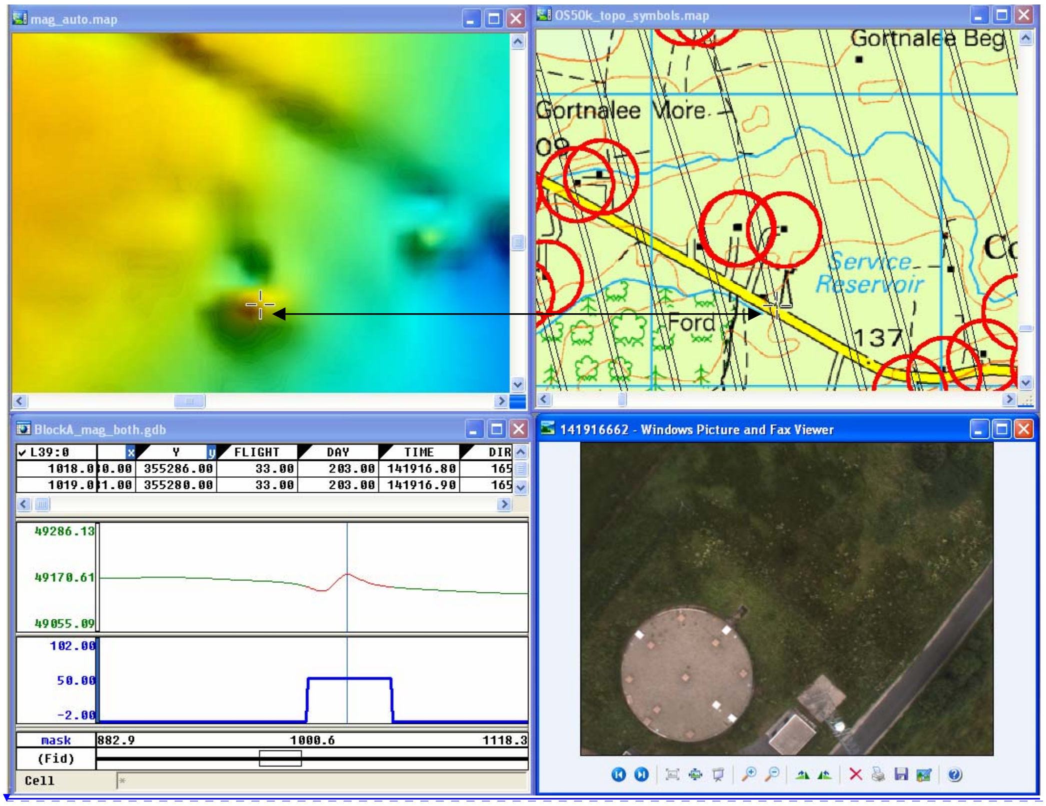


Figure 10 – Example of the setup for manual deculturing. The identified source of cultural noise in this example is a mast. The starting point for manual adjustment is the Pointer-filter channel. Survey lines will be manually checked line by line and remaining cultural noise removed by creating a refined mask channel. The source can be identified using OS 50k maps and video images.

Formatted: Font: 11 pt, Not Bold

Formatted: Caption

Deleted: Figure 10.

Formatted: Font: Not Bold

Deleted: pointer

Deculturing is based on creating a mask channel in the Oasis montaj database. The mask has a geographic and time reference that potentially allows use of the same mask for other data types (e.g. electromagnetic data). The mask can also be coded; for later use it might be useful to have a recording of what the cultural source has been and how it was identified. The coding should be simple though. The three methods of identifying objects are address point data (Pointer), OS50k digital topographic map and ground path recording. The actual sources are divided into six main classes: house, road, powerline, pylon or mast, railway, populated site and other (moving objects, scrap, etc.). The first part of the code comes from the identification method and the second part from the source class (e.g. a house identified from a topographic map is coded 11, road 12, and power line 13). If the object is checked and identified from the video images the coding is accordingly house 111, road 112, power line 113. The buildings identified by address point data have a code number 1. The codes used are listed in *Table* **2**, Figure **11** shows a profile with the mask channel highlighted.

Deleted: The d

Deleted: to

Deleted: M

Deleted: as well

Deleted: be

Deleted: .

Deleted: F

Deleted: pointer

Formatted: Font: 11 pt, Italic

Formatted: Font: 11 pt

Deleted: Table 2

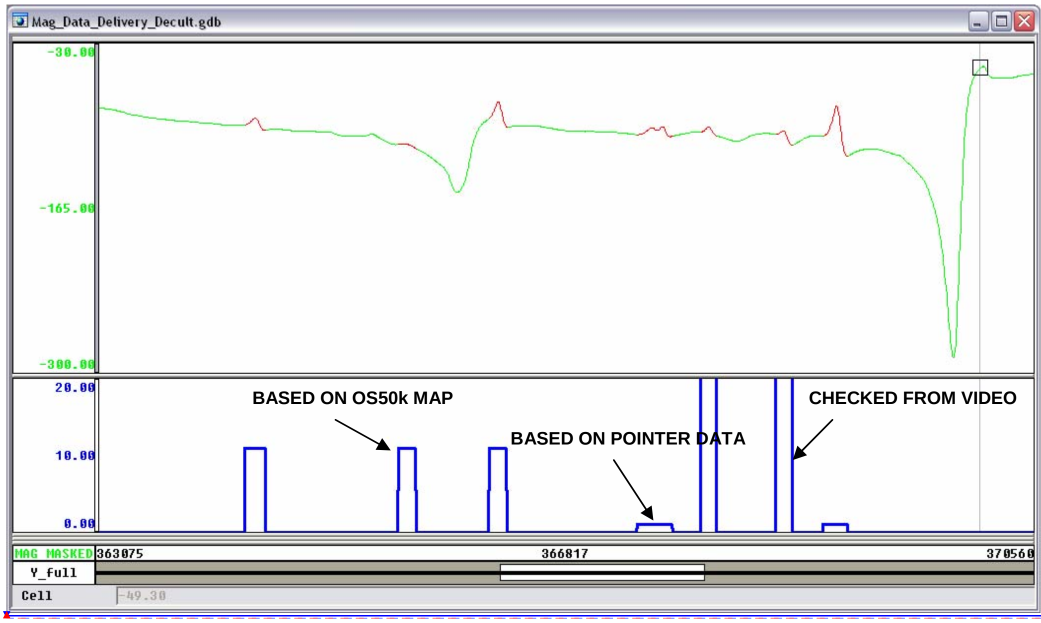


Figure 11 – The idea of the manual refining is to produce an adjusted mask channel that can be applied for the filtering. A simple coding will tell how the source was identified and what the actual source is.

Table 2 – Simple classification for the cultural noise sources.

	House	Road	Power line or mast	Railway	Populated area	Other	Landfill
Pointer	1						
OS50k	11	12	13	14	15	16	20
Video	111	112	113	114	115	116	120

The cultural noise classification is simplified; for example a house can mean anything from a residence or a farmhouse to a farm shed and even larger buildings. This is mainly because the main identification method for this type of source, the OS50k map, displays buildings with a single symbol. Other objects are typically scrap identified from the video images that can include anything from abandoned quarry constructions to a scrap yard of old cars. If anything of environmental interest is identified from the videos it can be labelled and documented during the process. For example landfills or spoil tips are coded using number 20 or 120.

Deleted: IR/07/0
Deleted: Draft 0.1
Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26
Deleted: <sp>
Formatted: Font: Not Bold
Formatted: Caption
Deleted: Figure 11.
Formatted: Font: 11 pt, Not Bold
Formatted: Font: Not Bold
Formatted: Font: 11 pt, Not Bold, Italic
Formatted: Caption
Deleted: *Table 2.*
Formatted: Font: 11 pt, Not Bold
Formatted: Font: Bold
Formatted: Centered
Formatted Table
Formatted: Font: Bold
Formatted: Font: Bold
Deleted: coarsely
Deleted: .
Deleted: F
Deleted: are included into the same class
Deleted: shows
Deleted: worth
Deleted: spotted
Deleted: tha

3.2 PRELIMINARY RESULTS

The manual approach to refine the automated deculturing was tested in order to get an estimate of how much time the work would take. The test comprised of lines 2-110 of Block A, a total of 1658 line-km (Figure 12). The area represents 14 % of the whole of Block A. The manual refining of the area took three working days, which equates to an estimated 21 working days for the whole of BlockA. In practise the time needed depends on the amount of cultural influence as well as the geological setting.

The deculturing test was carried out simultaneously for both left and right magnetometer data. First, the left magnetometer data of a single line was cleaned and then the mask channel for that line was copied for the right magnetometer. Generally cultural noise has some cross-plane gradient but the mask width determined for left wingtip data seems to work well enough for the right wingtip data as well. Later in final deculturing the cleaning was carried out using magnetic residual channel (midpoint of left and right data for 2005 data and nose for 2006 data). The results of the test are shown in Figure 12.

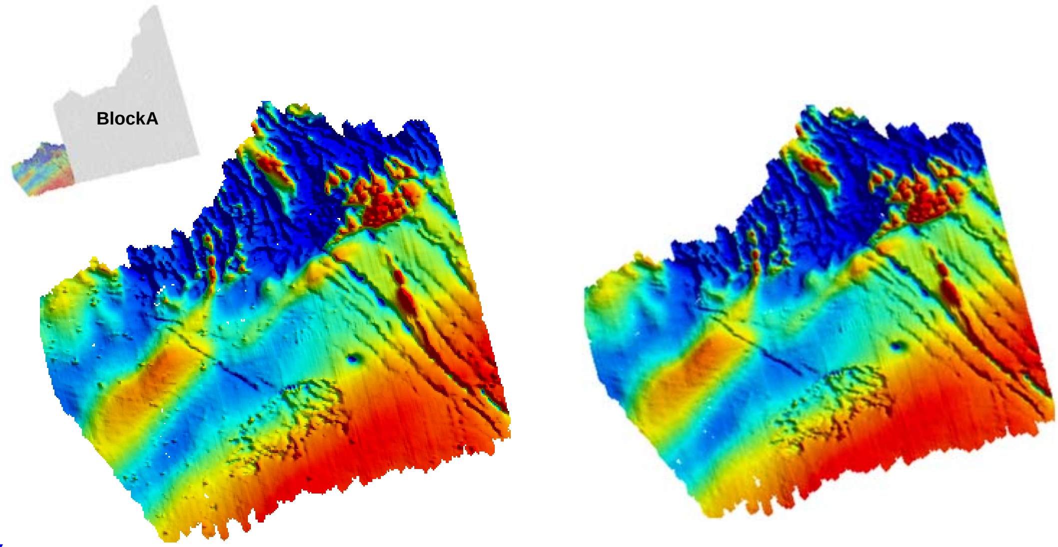


Figure 12 – Initial results of manual cleaning of Pointer filtered data from part of BlockA. On the left data after pointer filtering and on the right data after manual refining. No microlevelling has been applied for the magnetic data shown.

Deleted: IR/07/0
Deleted: Draft 0.1
Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26
Deleted: will
Deleted: comprehends
Deleted: ltogether
Deleted: Figure 12
Formatted: Font: 11 pt
Deleted: resulted
Deleted: in
Deleted: manual work of
Deleted: After some practise the speed also improves.
Deleted: D
Formatted: Font: 11 pt
Deleted: Figure 12
Deleted: <sp>
Formatted: Caption
Formatted: Font: 11 pt, Not Bold
Deleted: Figure 12.
Formatted: Font: Not Bold
Deleted: pointer
Formatted: Font: Not Bold

4 Results

Deculturing is carried out for block based data. The need for cleaning varies from block to block. Cultural noise is mainly affecting magnetically quiet areas and is hardly discernible where the magnetic gradient is high. Quiet magnetic areas are common especially in blocks A and B (Figure 13) so these were obvious targets to start manual cleaning. In addition to blocks A and B, D1 and E2 were also thoroughly manually cleaned. Blocks C1, E1 and D2 were Pointer-filtered and afterwards manually refined to some extent. Block C2 consists mainly of high gradient lavas where cultural influence is insignificant and therefore C2 was cleaned only of the most obvious cultural noise. *Table* 3 shows the level of cleaning conducted for each block.

The data cleaning was conducted by creating a mask channel in the magnetic database. The mask channel is based on Pointer locations, this channel is manually adjusted to fit better the cultural noise while preserving geological signal. The cleaning is based on the magnetic residual channel which is the mid point of the left and right magnetometers for the 2005 survey data (Blocks A, B, C1, D1 and E1). For the 2006 survey data (Blocks C2, D2 and E2) the residual channel is the nose magnetometer data.

It is necessary to provide a number of caveats to the use of the mask data. It is in the authors opinion that the mask channel should only be used as a warning channel for potential cultural noise instead of using a masked magnetic grid, especially in detailed studies. Masking is always the processor's opinion of what is noise and what is signal. Also in many cases it is difficult to decide what part of the sum of the geological signal and cultural noise should be removed without disturbing geological information.

Table 3 – Deculturing level of survey blocks.

Block	Deculturing level
A	Manually cleaned
B	Manually cleaned
C1	Pointer-filtered, some manual adjustments
D1	Manually cleaned
E1	Pointer-filtered, some manual adjustments
C2	No Pointer-filtering, only some manual cleaning
D2	Pointer filtered, some manual adjustments
E2	Manually cleaned

Deleted: IR/07/0

Deleted: Draft 0.1

Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

Deleted: o

Formatted: Font: 11 pt

Deleted: Figure 13

Deleted: those

Deleted: are

Deleted: pointer

Deleted: adjusted

Deleted: i

Formatted: Font: 11 pt, Italic

Deleted: Table 3

Deleted: is

Deleted: pointer

Deleted: that are

Deleted: to remove

Deleted: existing

Comment [r6]: It's not really a resuidual. In previous reports we have referred to it as the microlevelled result.

Deleted: data

Deleted: E

Deleted: it is safer to use the mask channel only as a warning channel for potential cultural noise instead of using the masked magnetic grid.

Formatted: Font: 11 pt, Not Bold, Italic

Deleted: *Table 3.*

Formatted: Font: 11 pt, Not Bold

Deleted: ¶

Formatted: Font: Italic

Deleted: IR/07/0

Deleted: Draft 0.1

Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

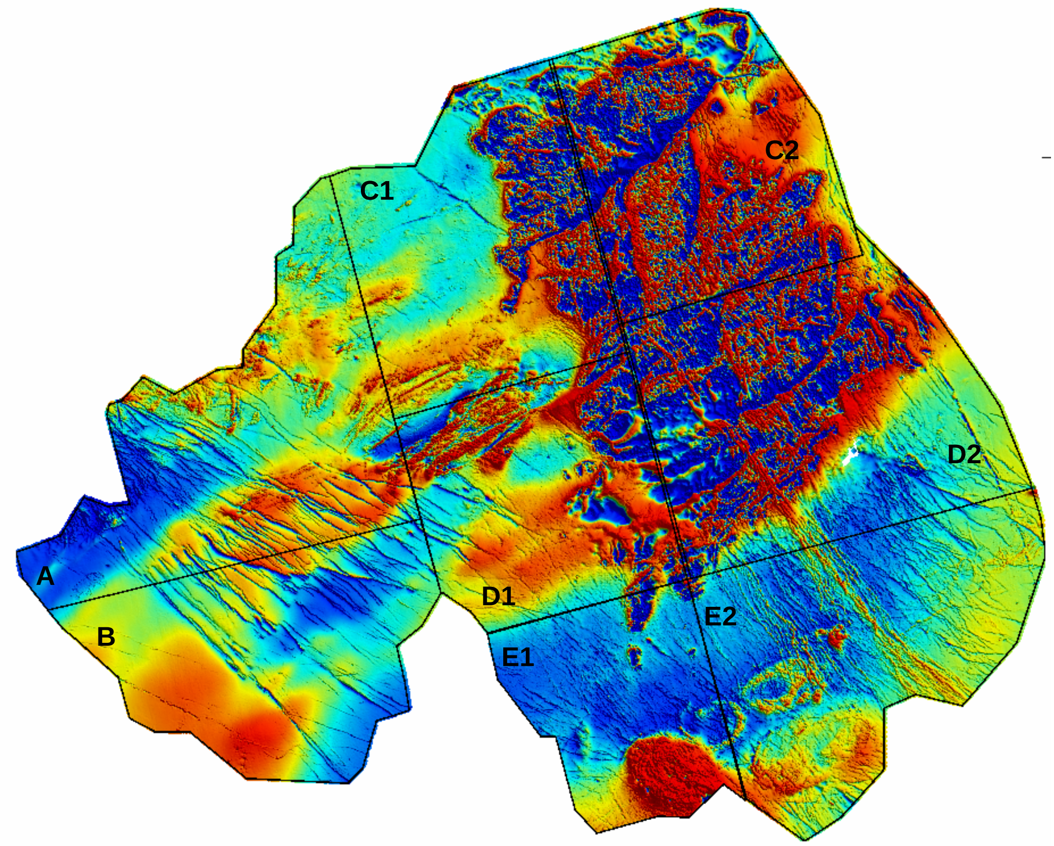


Figure 13 – Survey blocks for the Tellus survey.

Formatted: Font: 11 pt, Not Bold

Formatted: Caption

Deleted: Figure 13.

Formatted: Font: Not Bold

Deleted: IR/07/0
Deleted: Draft 0.1
Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

4.1 MANUALLY CLEANED BLOCKS

4.1.1 Block A

The manually cleaned Block A magnetic data is presented in Figure **14** and Figure **15**. Figure **16** shows how the Pointer locations were adjusted during manual cleaning. Major differences occur over towns where Pointer filtering has been cancelled due to high survey altitude and lack of high frequency noise. Figure **17** shows the residual of original and manually cleaned magnetic data showing what has been removed in the deculturing process. For comparison a similar residual map is presented for a trial using numerical filtering. Non-linear filtering removes effectively the high frequency noise, but also high frequency geological signal is lost. Figure **18** shows an example of comparing manually cleaned and filtered profiles.

Formatted: Font: 11 pt
Formatted: Font: 11 pt
Deleted: Figures 14 and 15
Formatted: Font: 11 pt
Deleted: Figure 16
Deleted: pointer
Deleted: pointer
Formatted: Font: 11 pt
Deleted: Figure 17
Deleted: effectively
Deleted: will be
Deleted: Figure 18
Formatted: Font: 11 pt
Formatted: Centered
Deleted: <sp>

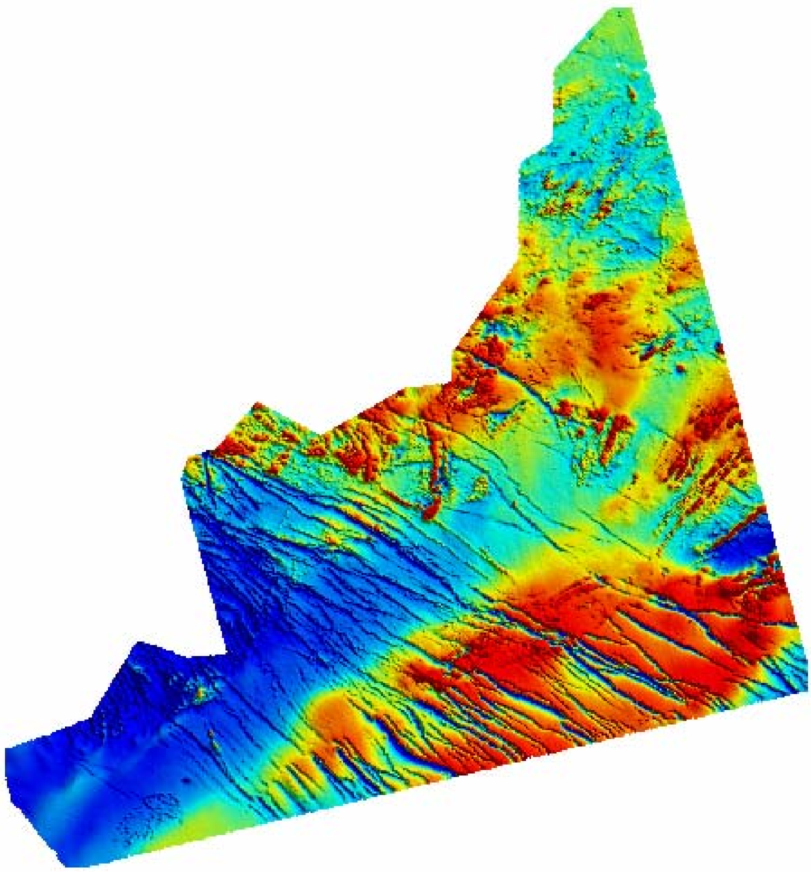


Figure 14 – Manually cleaned magnetic data of Block A.

Formatted: Font: 11 pt, Not Bold
Formatted: Caption
Deleted: Figure 14.
Formatted: Font: Not Bold

Deleted: IR/07/0

Deleted: Draft 0.1

Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

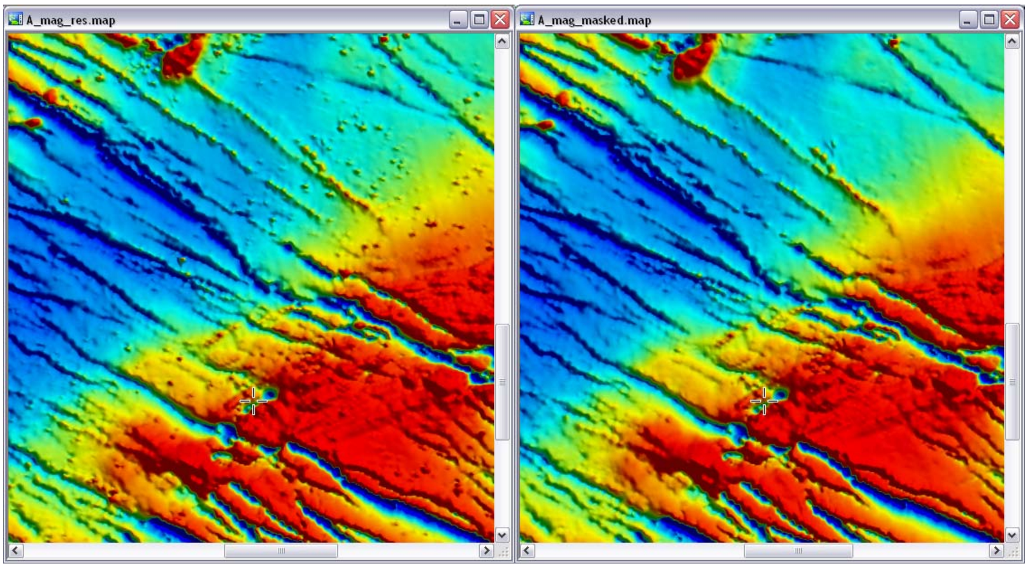


Figure 15 – Detailed example of original (left) and manually cleaned (right) magnetic data. The width of the map window is 20 km.

Formatted: Font: 11 pt, Not Bold

Formatted: Caption

Deleted: Figure 15.

Formatted: Font: Not Bold

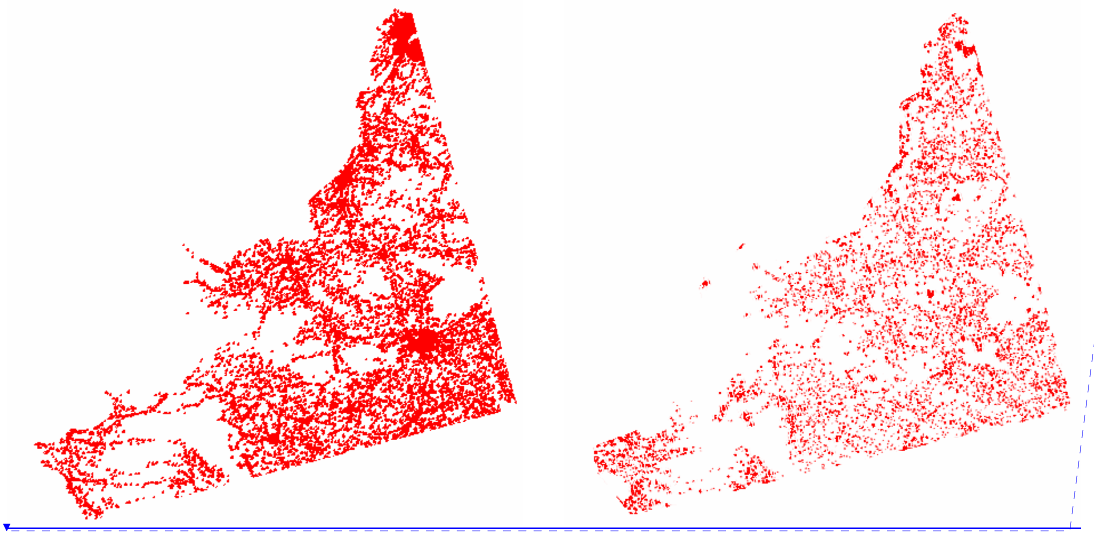


Figure 16 – Pointer locations for Block A (left) and manually refined mask locations (right). Major towns and roads come out in Pointer data as concentrations of Pointer locations. Manually adjusted mask locations are more evenly distributed.

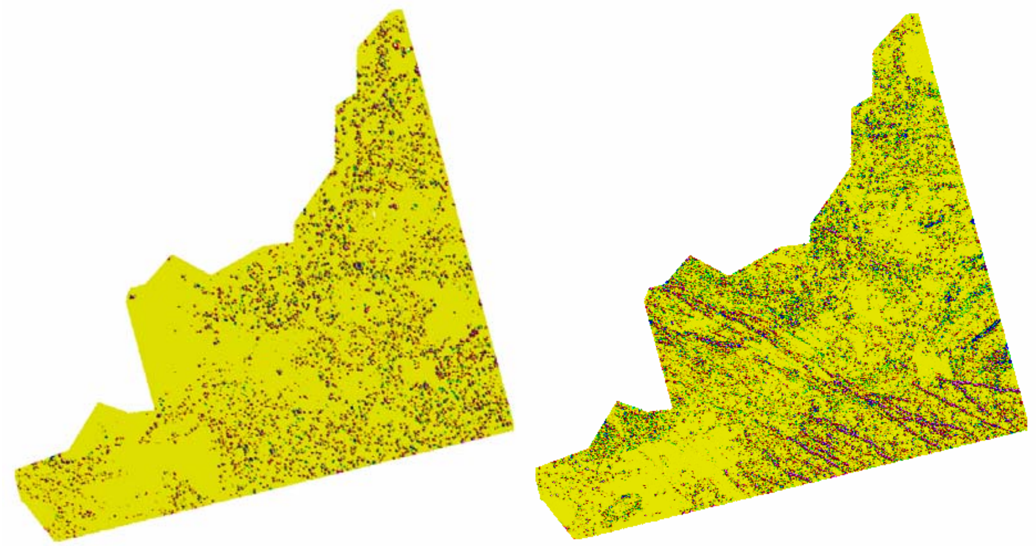


Figure 17 – On the left residual of original and manually decultured magnetic grids showing what has been removed. On the right residual of original and frequency filtered magnetic grids. Filtering removes effectively high frequency noise but also geological signal, the dykes within the area can be clearly identified. On the other hand filtering struggles with lower frequency and higher amplitude noise.

Deleted: IR/07/0

Deleted: Draft 0.1

Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

Deleted: <sp>

Formatted: Font: 11 pt, Not Bold

Formatted: Caption

Deleted: Figure 16.

Formatted: Font: Not Bold

Comment [r7]: Not sure what you mean

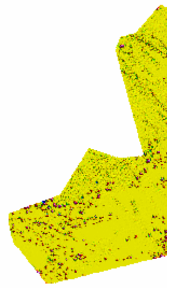
Formatted: Font: 11 pt, Not Bold

Formatted: Font: Not Bold

Deleted: pointer

Formatted: Font: Not Bold

Formatted: Centered



Deleted:

Formatted: Font: 11 pt, Not Bold

Formatted: Caption

Deleted: Figure 17.

Formatted: Font: Not Bold

Formatted: Font: Not Bold

Deleted: IR/07/0

Deleted: Draft 0.1

Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

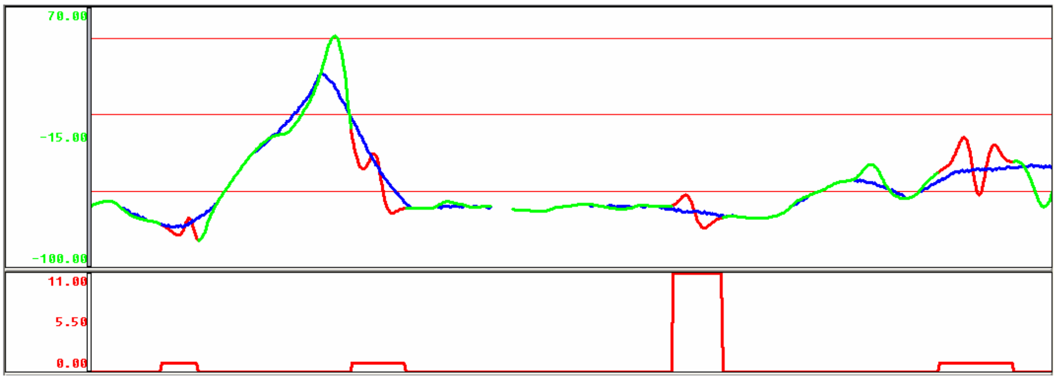


Figure 18 – Comparison of Pointer filtered manually adjusted data (green profile) and filtered data (blue profile). Original magnetic data is shown with the red profile. The lower panel shows the mask channel. Applied filtering is non-linear using filter width of 13 data points.

Deleted: pointer

Formatted: Font: 11 pt, Not Bold

Formatted: Caption

Deleted: Figure 18.

Formatted: Font: Not Bold

Deleted: IR/07/0
Deleted: Draft 0.1
Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

4.1.2 Block B

Block B is characterised by low amplitude magnetic anomalies and very quiet areas in the west. It is the block that potentially benefits most from deculturing. The manually cleaned magnetic grid of Block B is presented in full in Figure 19 and in detail in Figure 21. Figure 20 shows what has been removed in cleaning.

Deleted: of
Deleted: M
Deleted: Figure 19
Formatted: Font: 11 pt
Deleted: Figure 20
Formatted: Font: 11 pt
Formatted: Font: 11 pt

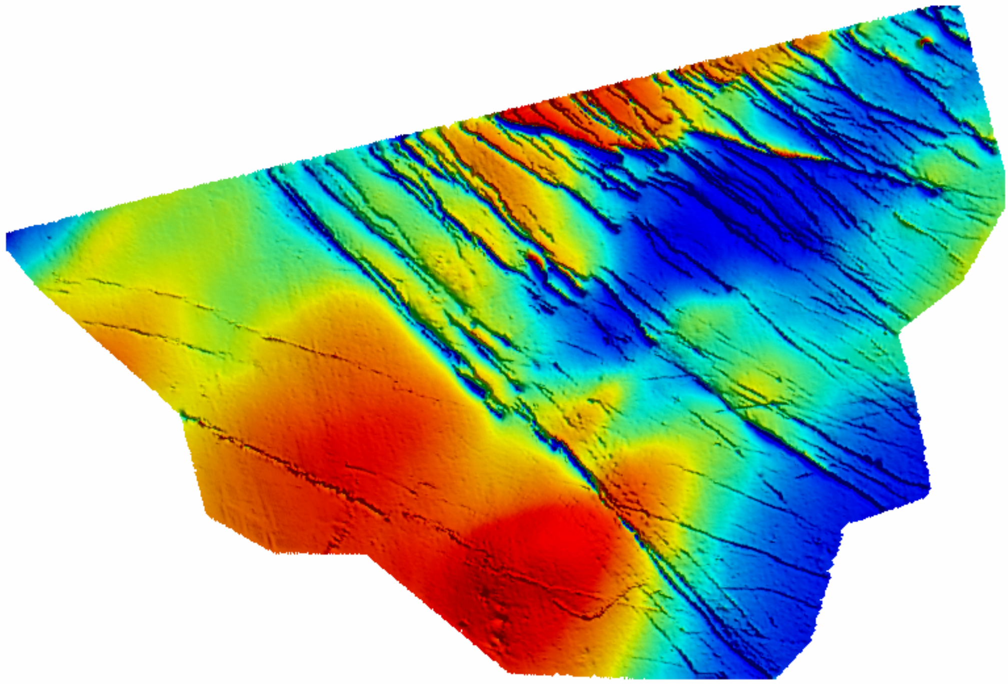


Figure 19 – Manually cleaned magnetic data of Block B.

Formatted: Font: 11 pt, Not Bold
Formatted: Caption
Deleted: Figure 19.
Formatted: Font: Not Bold

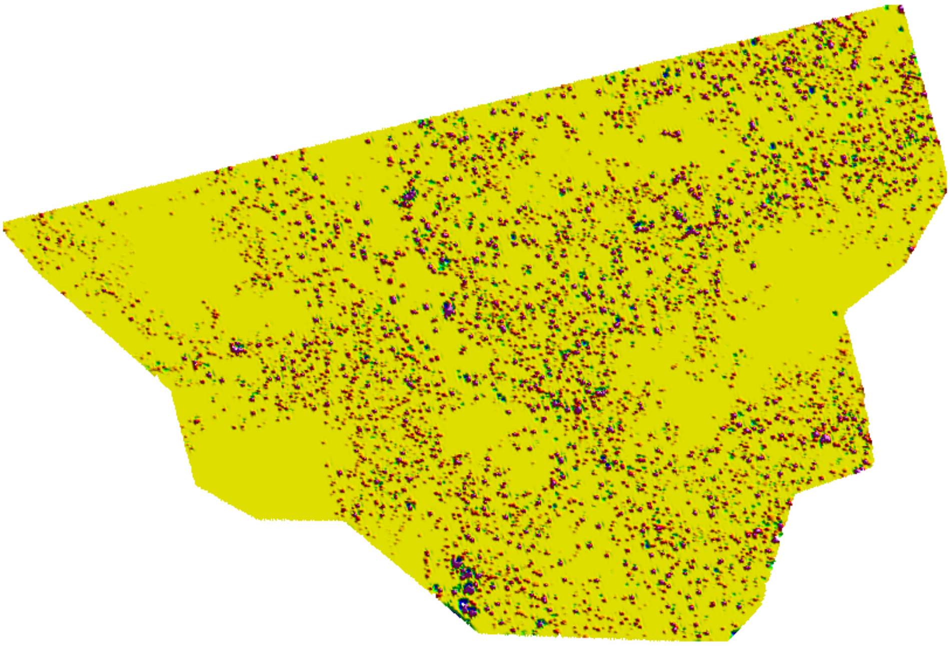


Figure 20 – Residual of original and manually cleaned magnetic grid showing what has been removed in deculturing.

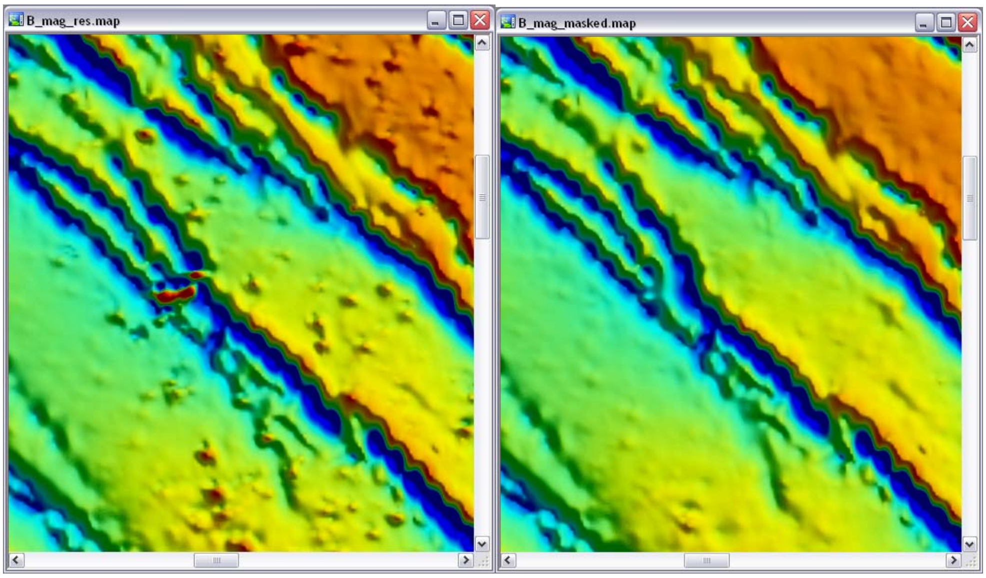


Figure 21 – Detailed example showing original (left) and manually cleaned (right) magnetic data from Block B. The cleaned map looks improved and geological image is potentially enhanced.

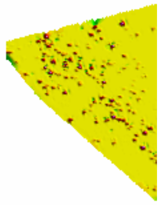
Deleted: IR/07/0

Deleted: Draft 0.1

Deleted: Last modified: 2007/04/11 17:162007/04/ ... [3]

Formatted: Caption

Deleted:



Formatted: Font: 11 pt, Not Bold

Deleted: Figure 20.

Formatted: Font: Not Bold

Formatted: Caption

Comment [r8]: There are quite a few dyke traces in there

Formatted: Font: 11 pt, Not Bold

Formatted: Font: Not Bold

Formatted: Centered

Deleted: Figure 21.

Formatted: Font: 11 pt, Not Bold

Formatted: Font: Not Bold

Formatted: Caption

Comment [r9]: What do you mean?

Deleted: but

Formatted: Font: Not Bold

Formatted: Font: 11 pt, Not Bold

Deleted: is only

Formatted: Font: Not Bold

Deleted: margina

Formatted: Font: Not Bold

4.1.3 Block D1

Block D1 is a combination of a quiet magnetic field in the west and some high gradient basalts starting to appear in the east. Lough Neagh covers the block partly in the east. Cleaned magnetic data are shown in Figure 22, the cultural noise is shown in Figure 23, and an example of the refinement of Pointer data is shown in Figure 244. Cleaned Block D1 data (Figure 22) contains some high frequency anomalies that could not be identified as noise either by OS_50k maps or video images. These features were left in the data and examples of them are shown in Figure 25.

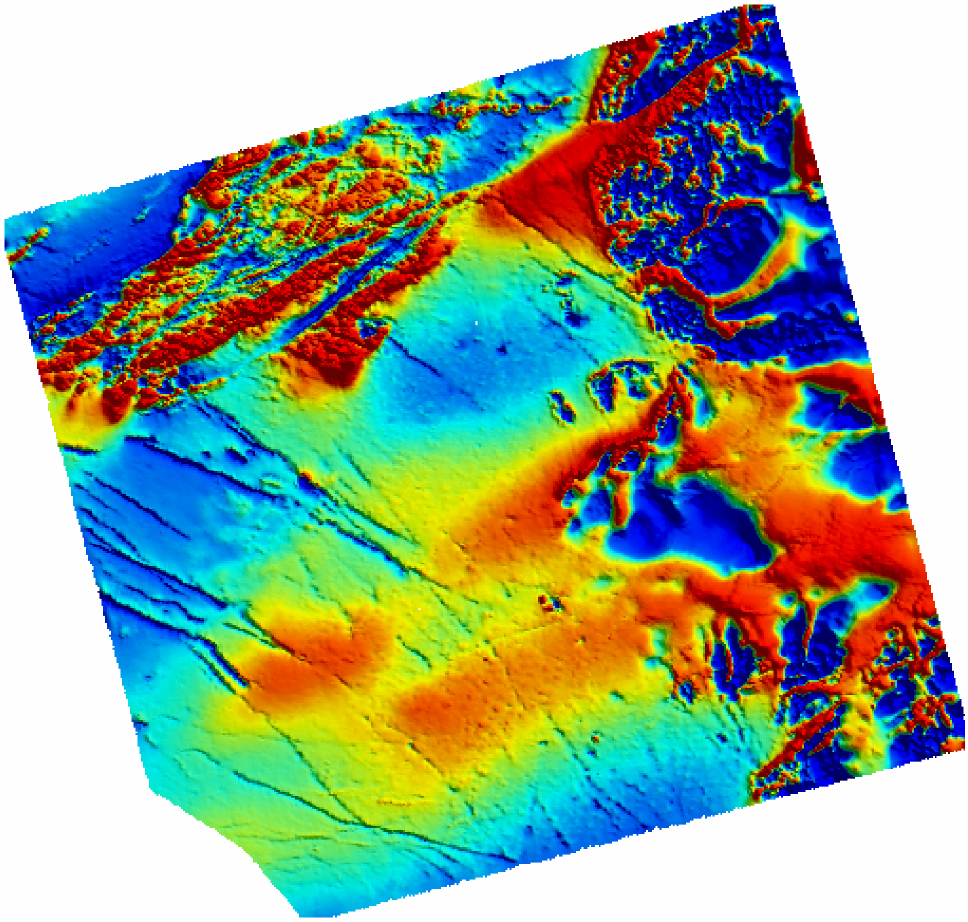


Figure 22 – Manually cleaned Block D1 magnetic data.

Deleted: IR/07/0

Deleted: Draft 0.1

Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

Deleted: <sp>

Deleted: come out

Formatted: Font: 11 pt

Formatted: Font: 11 pt

Formatted: Font: 11 pt

Deleted: blockD1

Formatted: Font: 11 pt

Deleted: Figure 22

Formatted: Font: 11 pt

Deleted: Figure 25

Formatted: Centered

Formatted: Caption

Deleted: Figure 22.

Formatted: Font: 11 pt, Not Bold

Formatted: Font: Not Bold

Formatted: Centered

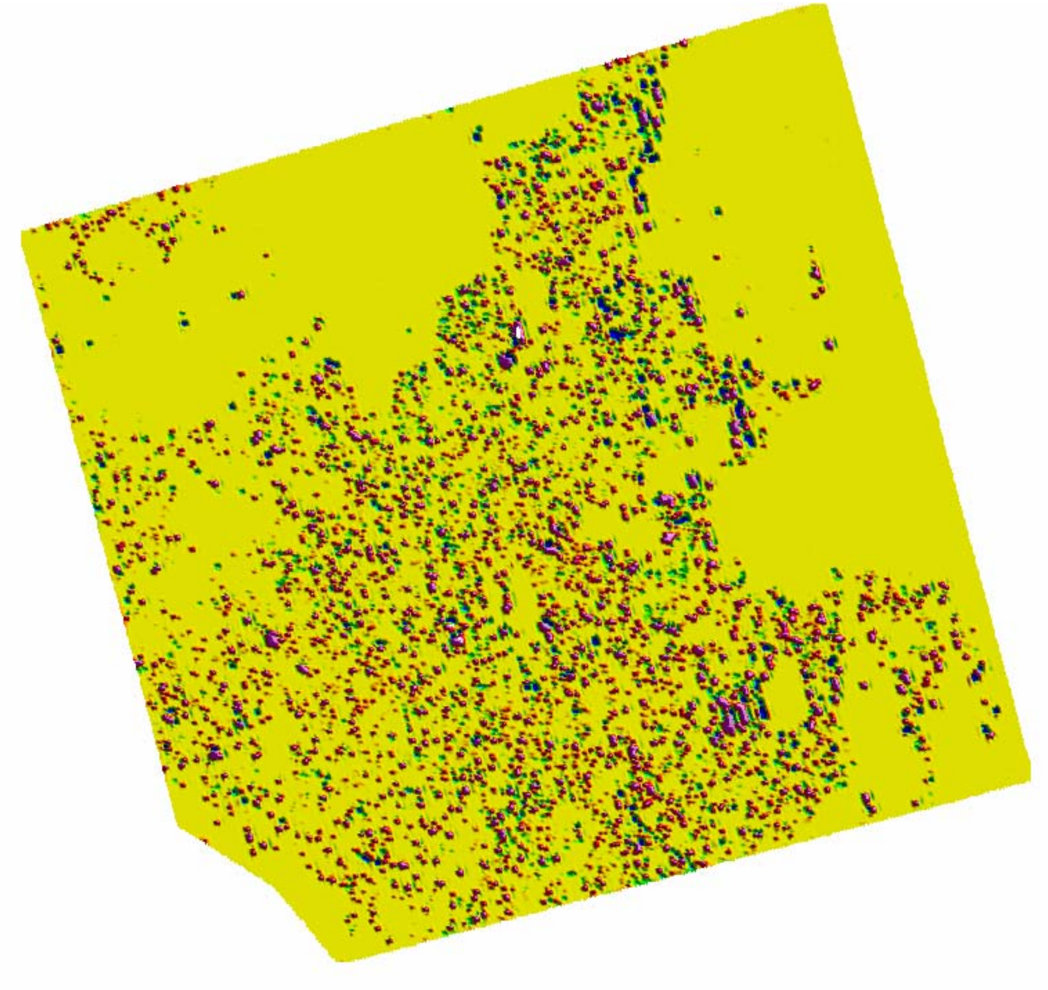


Figure 23 – Residual of original and manually cleaned magnetic grid of Block D1 showing what has been removed.

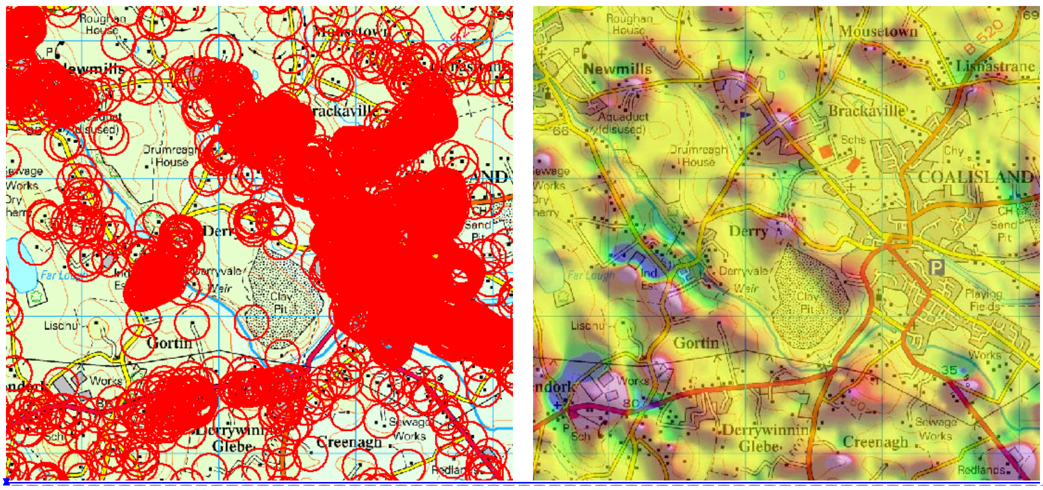
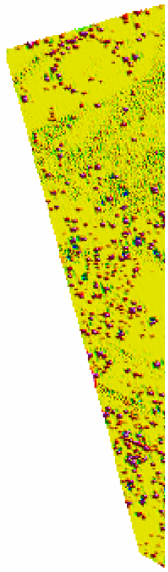


Figure 24 – Detailed example of Pointer locations (left) and residual of what has been removed in manual cleaning (right). Pointers have been cancelled especially over the town of Coalisland.

Deleted: IR/07/0… Draft 0.1 …Last modified: ... [4]



Deleted:

Formatted: Font: 11 pt, Not Bold

Formatted: Caption

Deleted: Figure 23.

Formatted: Font: Not Bold

Deleted: blockD1

Comment [r10]: Do you mean gridding algorithm

Comment [r11]: Are you trying to explain grid-base ... [5]

Deleted: The low amplitude noise in the background is ... [6]

Deleted:

Deleted: technique. This map is produced by subtracting th ... [7]

Formatted ... [8]

Formatted ... [9]

Deleted: <sp>

Formatted: Centered

Formatted: Font: 10 pt

Formatted: Font: 11 pt

Deleted: Figure 24.

Formatted

Deleted: pointer …….v ... [10]

Deleted: ¶
¶

Formatted: Centered

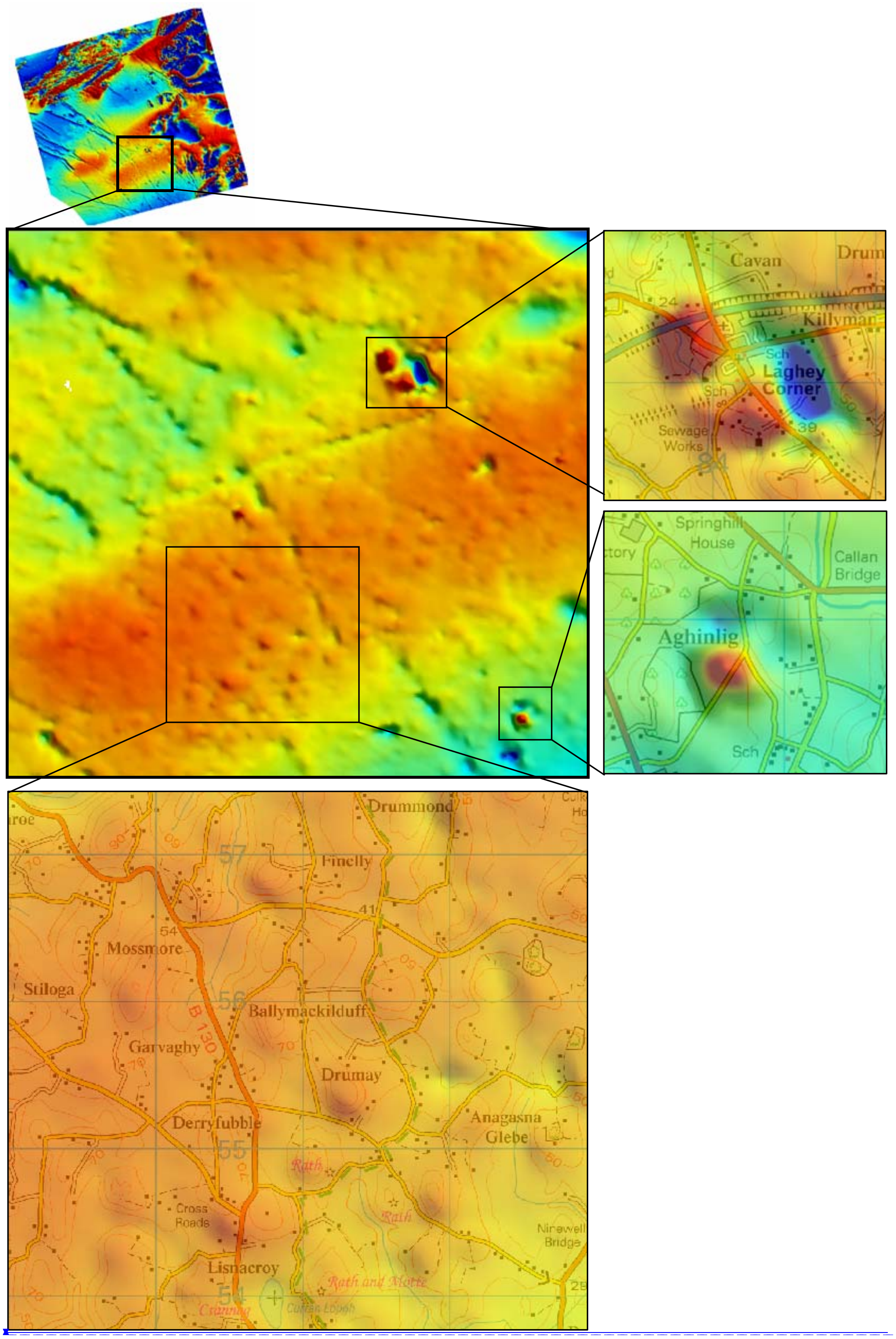


Figure 25 – Details from Block D1 showing examples of high frequency anomalies that could not be identified as noise either by map or video images and were therefore left in the data.

Deleted: IR/07/0

Deleted: Draft 0.1

Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

Deleted: <sp>

Formatted: Font: 10 pt

Deleted: Figure 25.

Formatted: Font: Not Bold

Deleted: block

Formatted: Font: 11 pt, Not Bold

Formatted: Caption

4.1.4 Block E2

Block E2 magnetic map is characterised by a moderate amplitude range and NW-SE trending structures. Geological signal is subtle compared to Blocks D2 and C2. Although Block E2 is manually cleaned some cultural noise still remains. Figure 26 shows the result of manual deculturing, with the noise displayed in Figure 27. Figure 28 shows some offshore underwater anomalies that were not identified either by maps or video images and were therefore left in the data.

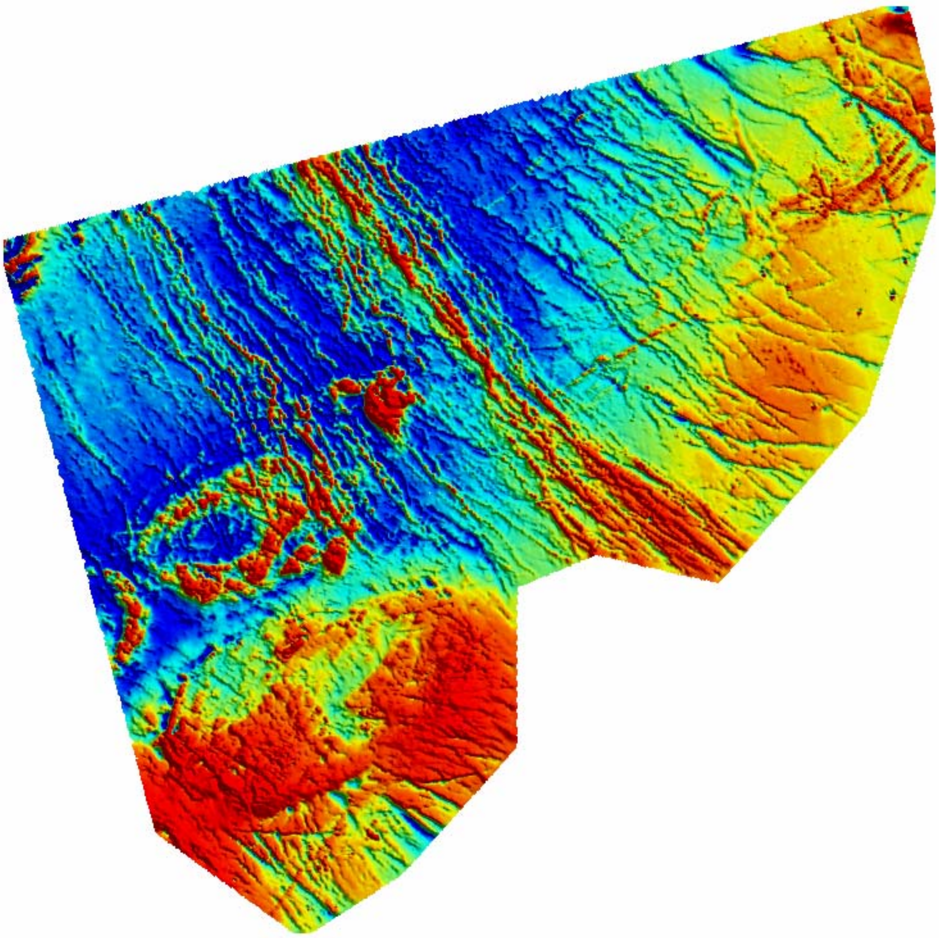


Figure 26 – Manually cleaned Block E2 magnetic data.

Deleted: IR/07/0

Deleted: Draft 0.1

Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

Deleted: block

Formatted: Font: 11 pt

Deleted: Figure 28

Formatted: Font: 11 pt

Formatted: Font: 11 pt

Formatted: Centered

Formatted: Font: 11 pt, Not Bold

Formatted: Caption

Deleted: Figure 26.

Formatted: Font: Not Bold

Deleted: IR/07/0

Deleted: Draft 0.1

Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

Formatted: Centered

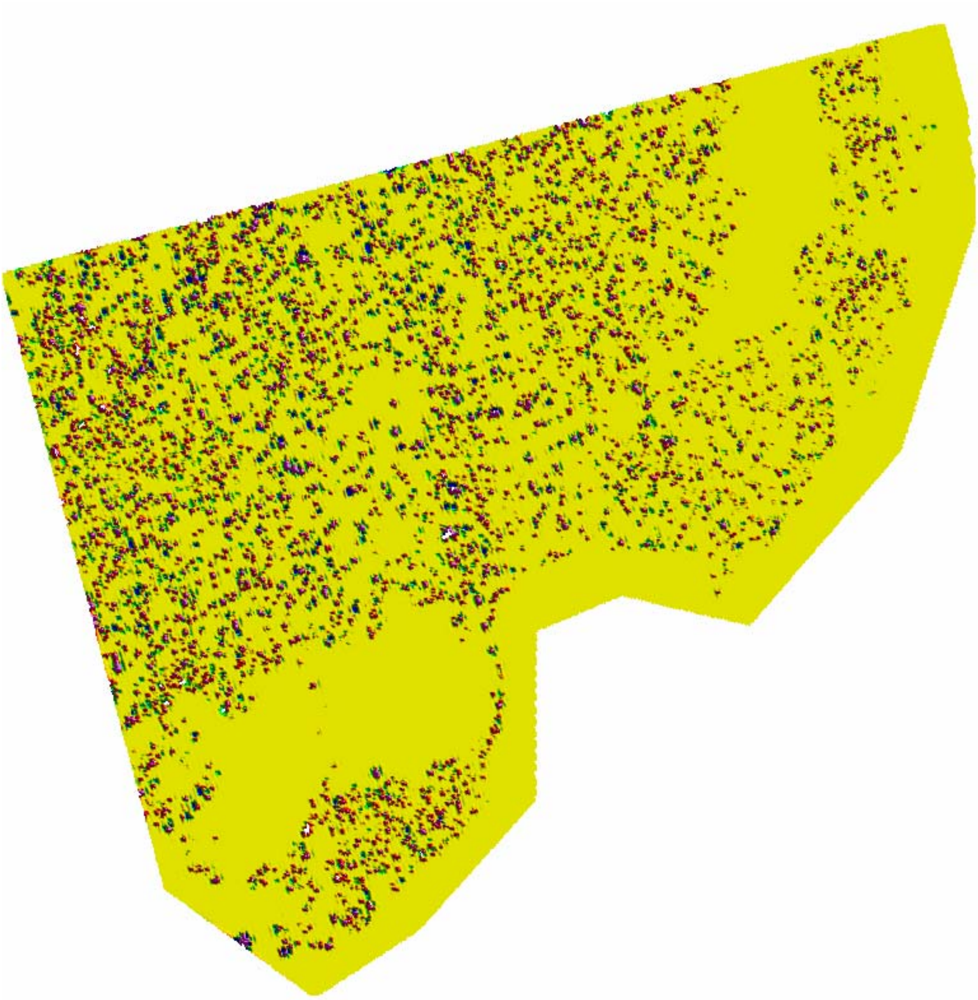


Figure 27 – Residual of original and manually cleaned magnetic grid of Block E2 showing what has been removed.

Deleted: blockE2

Formatted: Font: 11 pt, Not Bold

Formatted: Font: Not Bold

Formatted: Caption

Deleted: Figure 27.

Deleted: IR/07/0

Deleted: Draft 0.1

Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

Deleted: <sp>

Formatted: Centered

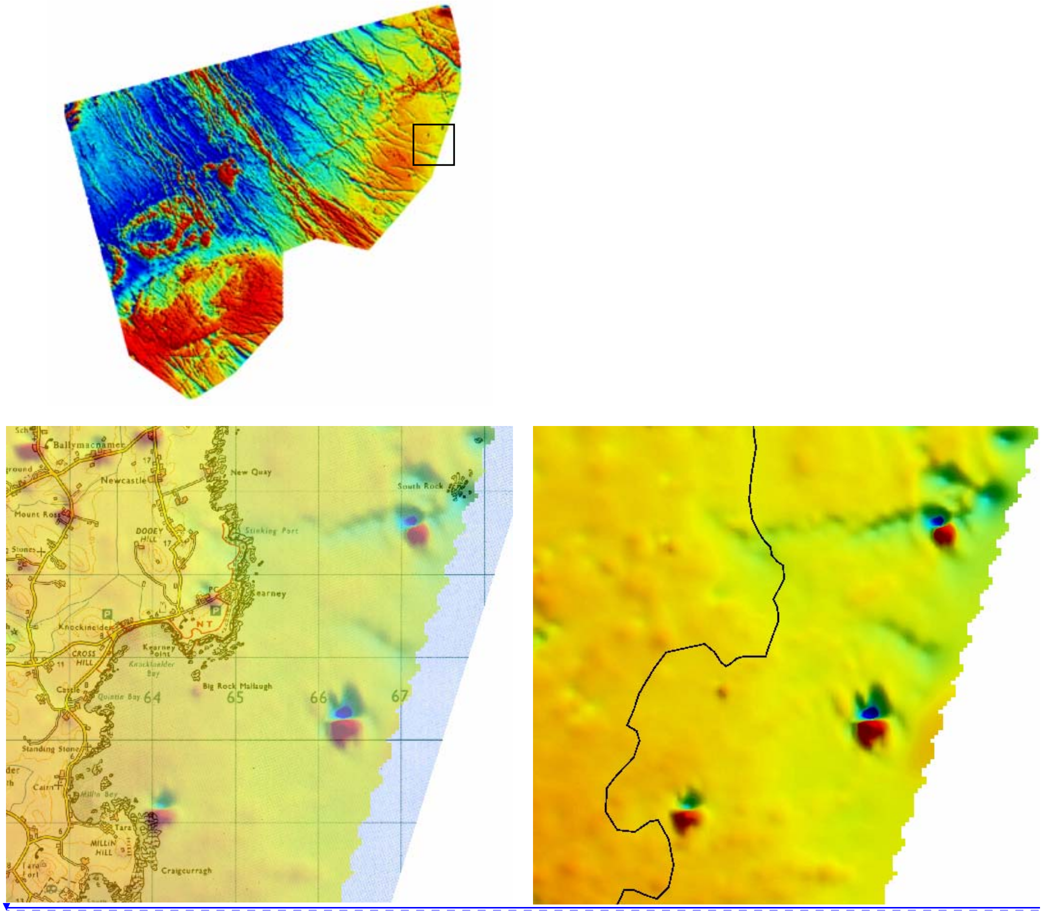


Figure 28 – Examples of offshore anomalies that are likely to be cultural in origin (wrecks) but were not identified either by maps or video images.

Deleted: Figure 28.

Formatted: Font: 11 pt, Not Bold

Formatted: Font: Not Bold

Formatted: Caption

Deleted: IR/07/0
Deleted: Draft 0.1
Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

4.2 POINTER FILTERED BLOCKS WITH SOME MANUAL ADJUSTMENTS

4.2.1 Block C1

Block C1 has moderately quiet magnetic field in the west and high gradient basalts in the east. Manual adjustments concentrate on the northwest corner of the block east from Londonderry. Figure **29** shows the result of manual deculturing, Figure **30** shows the residual of original and cleaned grids. Large areas are left untouched, these include the sea in the north, basalts in the west and the Sperrin Mountains in the south, Figure **31** shows a detailed example of the manual adjustments east of Londonderry.

Formatted: Font: 11 pt
Formatted: Font: 11 pt
Deleted: Figure 30
Deleted: central
Deleted: part
Deleted: Figure 31
Formatted: Font: 11 pt
Deleted: from
Formatted: Centered

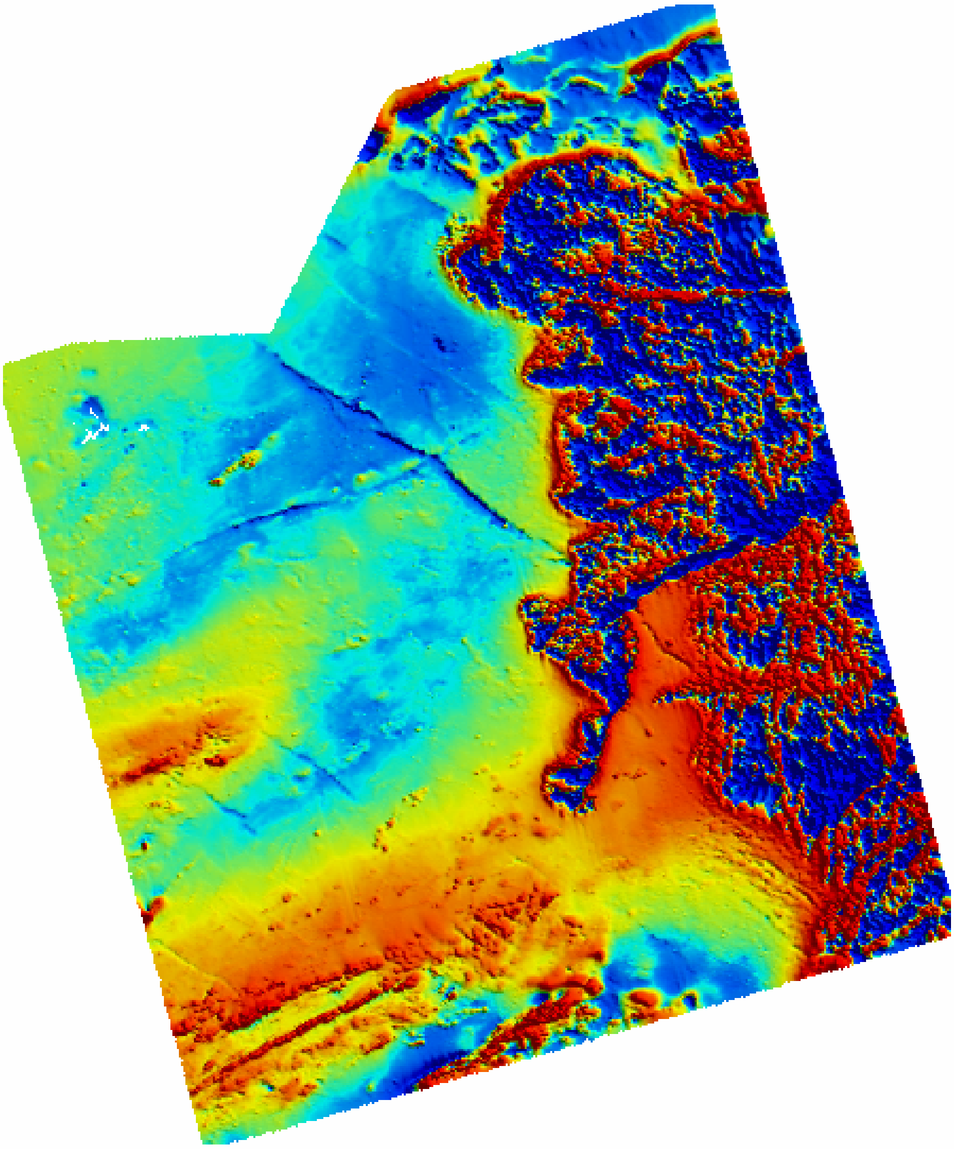


Figure 29 – Pointer filtered Block C1 magnetic data with some manual adjustment

Deleted: ¶
<sp>Figure 29. Pointer filtered BlockC1 with some manual adjustments.¶
Formatted: Font: Not Bold
Formatted: Font: 11 pt, Not Bold
Deleted: s
Formatted: Font: 11 pt, Not Bold
Formatted: Caption

Deleted: IR/07/0

Deleted: Draft 0.1

Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

Figure 30 – Residual of the original and cleaned magnetic grids of Block C1. Untouched areas include the sea (north), basalts (west) and Sperrin Mountains (southern central part).

Deleted: Page Break <sp>Figure 30.

Formatted: Font: Not Bold

Deleted: blockC1

Deleted: <sp><sp>

Formatted: Font: 11 pt

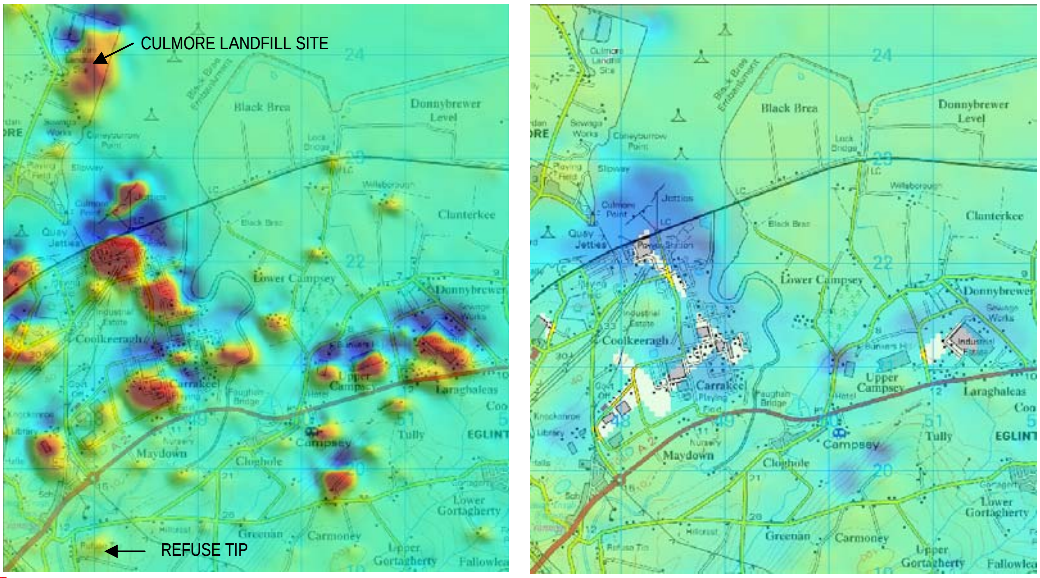


Figure 31 – Detailed example east of Londonderry. On the left original magnetic data are shown and on the right manually adjusted Pointer filtered data. The magnetic lows are mainly residual from dipole anomalies and removing these completely would have required more drastic deleting of data. Note that there are two landfill sites on the map area.

Formatted: Caption

Formatted: Font: 11 pt, Not Bold

Deleted: Figure 31.

Formatted: Font: Not Bold

Deleted: from

Deleted: pointer

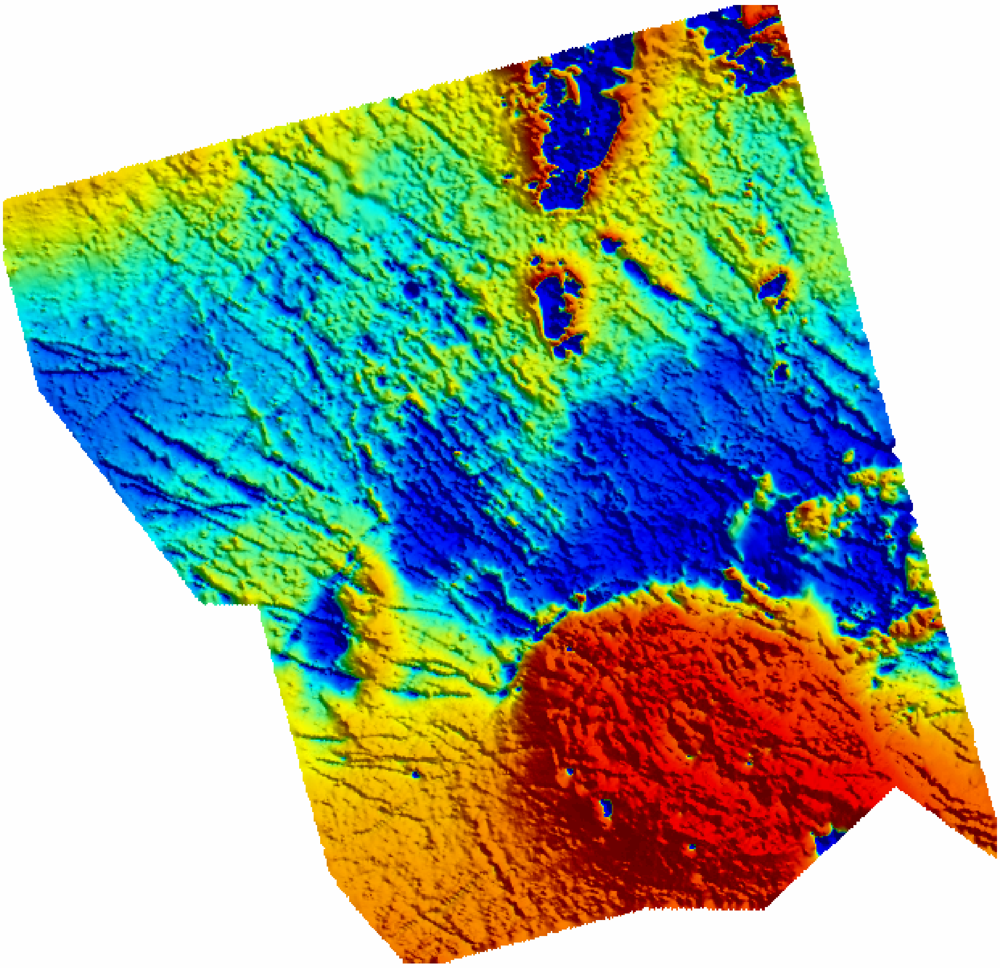
Deleted: those

Deleted: IR/07/0
Deleted: Draft 0.1
Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

4.2.2 Block E1

Block E1 has a complex magnetic texture that is challenging for deculturing. Large amounts of the geological anomalies have overlapping amplitude and frequency range with the cultural noise. After Pointer filtering some manual adjustments were carried out to remove visible high amplitude noise. Pointer filtering removes some geological signal and more manual work would be needed to improve the geological image. Figure **32** shows the result of manual deculturing, Figure **33** shows the cultural noise removed during deculturing and Figure **34** shows a profile of unadjusted Pointer filter data; this highlights the difficulty in spectral overlap for Block E1.

Deleted: comprises of
Deleted: pointer
Formatted: Font: 11 pt
Formatted: Font: 11 pt
Formatted: Font: 11 pt



Formatted: Centered

Figure 32 – Pointer filtered magnetic data of Block E1.

Formatted: Font: 11 pt, Not Bold
Formatted: Caption
Deleted: Figure 32.
Formatted: Font: Not Bold
Formatted: Centered

Deleted: IR/07/0

Deleted: Draft 0.1

Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

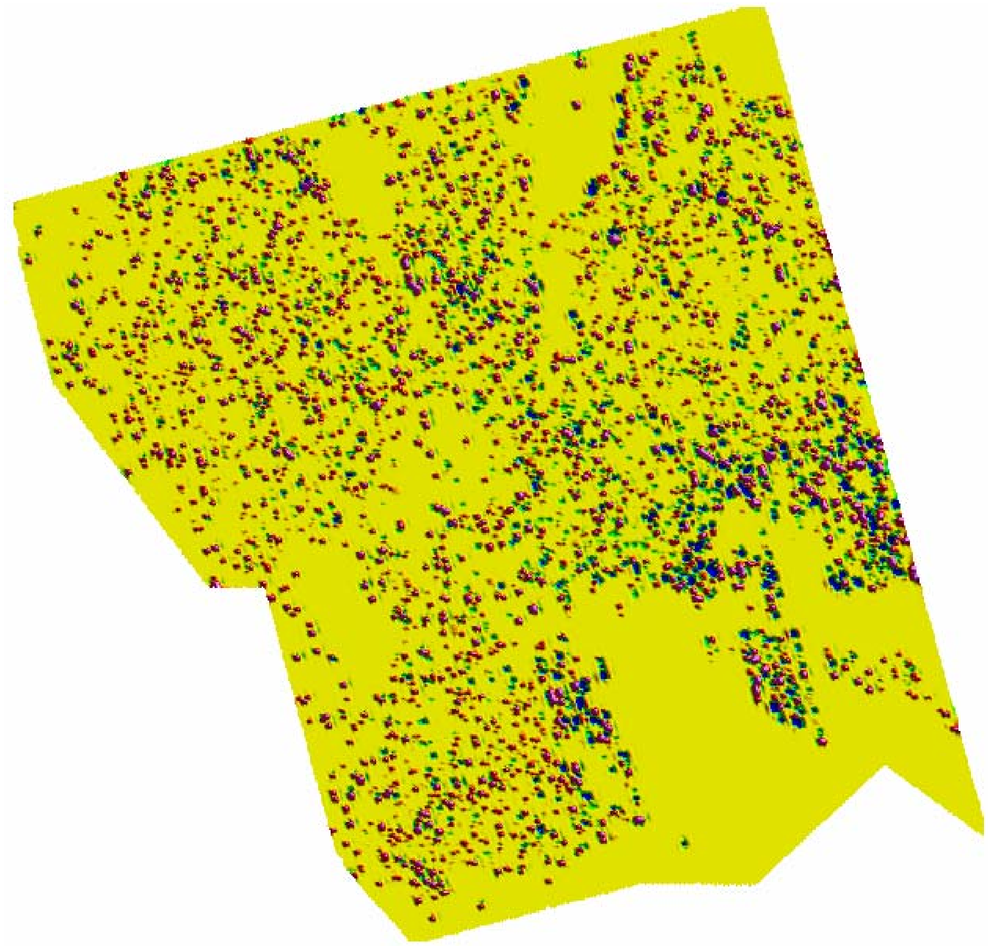


Figure 33 – Residual of original and masked magnetic grid of Block E1 showing what has been removed in deculturing. Untouched areas include major towns that are flown high, high magnetic gradient geology and unpopulated terrains.

Formatted: Font: 11 pt, Not Bold

Formatted: Caption

Deleted: Figure 33.

Deleted: is

Formatted: Font: Not Bold

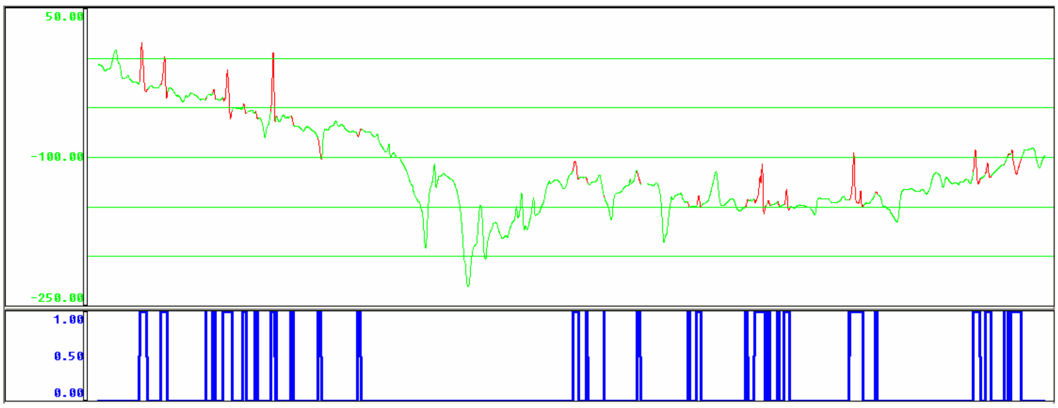


Figure 34 – Example of unadjusted Pointer filtering from Block E1 showing whole line L3082.

Formatted: Font: 11 pt, Not Bold

Formatted: Caption

Deleted: Figure 34.

Formatted: Font: Not Bold

Deleted: pointer

Deleted: Page Break

Deleted: IR/07/0

Deleted: Draft 0.1

Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

4.2.3 Block D2

Block_D2 covers the densely populated Belfast area. While the high gradient data over the basalts were left untouched a large amount of data were removed over the city. This is visible as gaps in data in Figure **35**. The cultural noise is displayed in Figure **36**.

Formatted: Font: 11 pt

Deleted: Figure 35

Formatted: Font: 11 pt

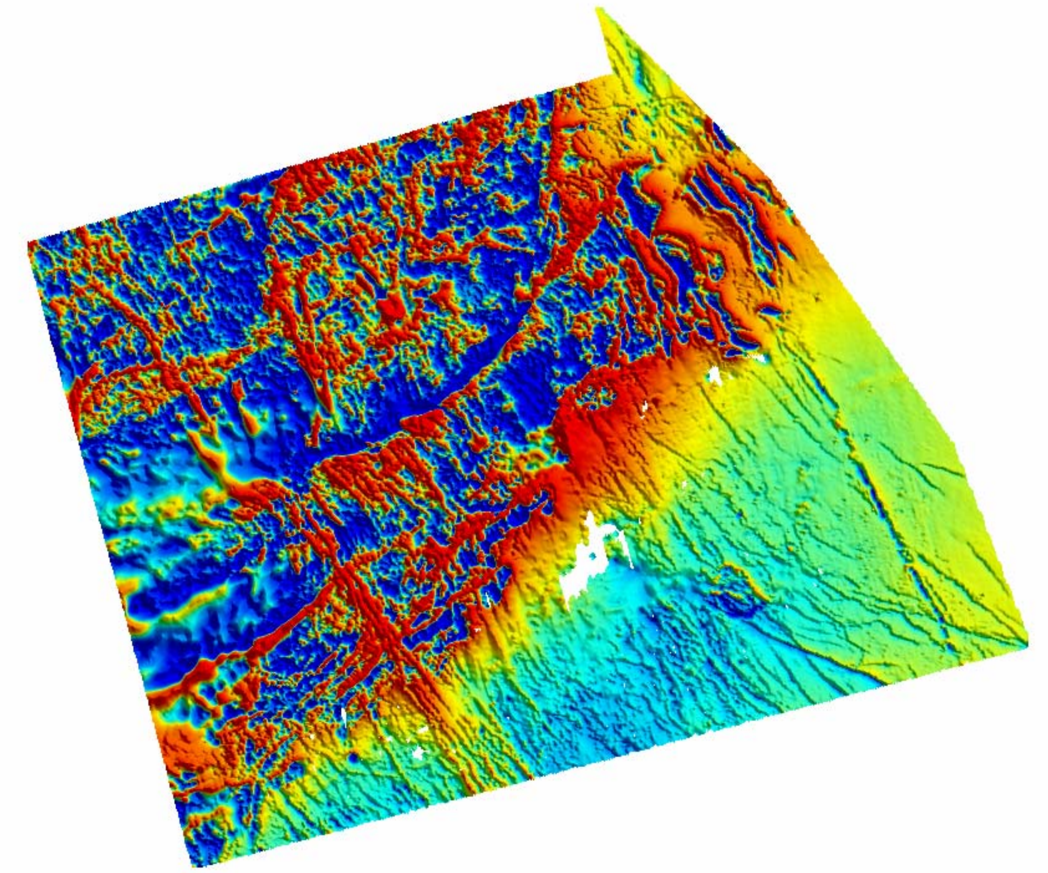


Figure 35 – Pointer filtered magnetic data of Block D2. To produce the map some blanking were used in gridding but large gaps are still visible over Belfast area.

Formatted: Caption

Deleted: Figure 35.

Formatted: Font: 11 pt, Not Bold

Formatted: Font: Not Bold

Deleted: IR/07/0

Deleted: Draft 0.1

Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

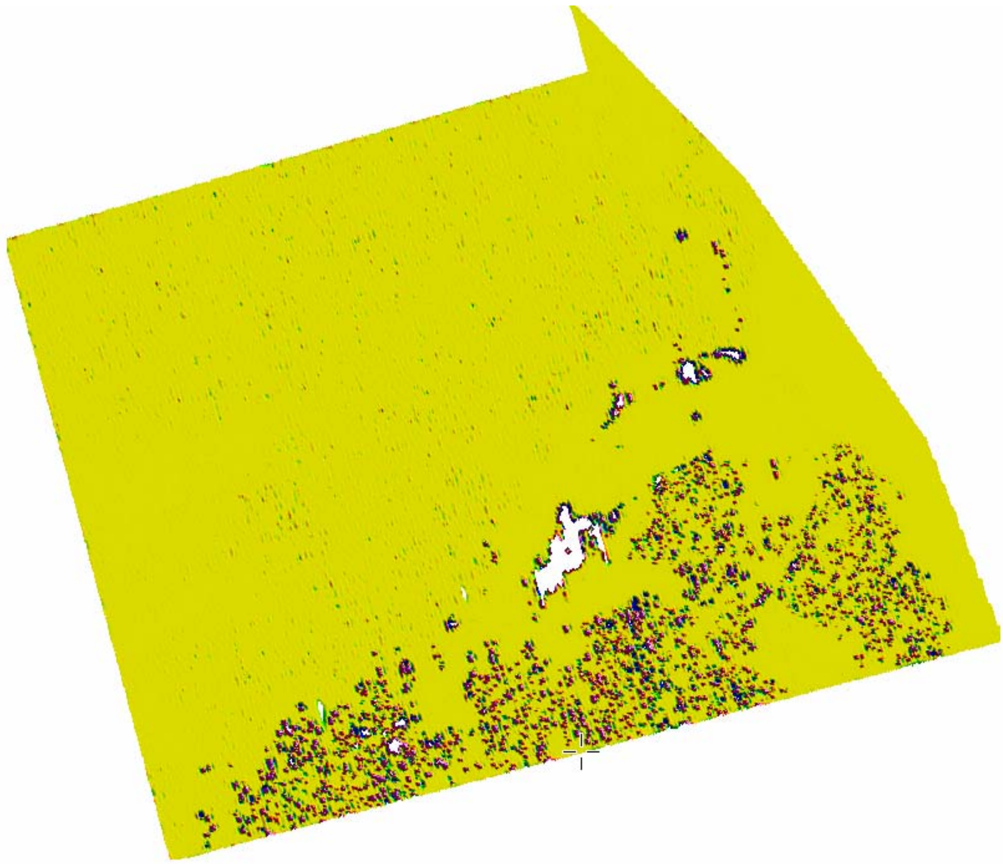


Figure 36 – Residual of original and masked magnetic grid of Block D2 showing what has been removed by deculturing. Untouched areas consist of high magnetic gradient geology over the basalts and unpopulated terrains (sea).

Formatted: Font: 11 pt, Not Bold

Formatted: Caption

Deleted: Figure 36.

Deleted: is

Formatted: Font: Not Bold

Deleted: in

Deleted: s

Deleted: IR/07/0
Deleted: Draft 0.1
Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

4.3 ONLY SOME MANUAL DECULTURING

4.3.1 Block C2

Block C2 geology consists mainly of basalts and the influence of cultural noise is minimal. Pointer filtering would have removed too much geological signal. Instead of pointer filtering only some manual cleaning has been applied for Block_C2 to remove visible and easily identifiable noise. Result of the cleaning is presented in Figure **37** and the removed noise in Figure **38**.

Formatted: Font: 11 pt
Deleted: Figure 37
Deleted: Figure 38
Formatted: Font: 11 pt

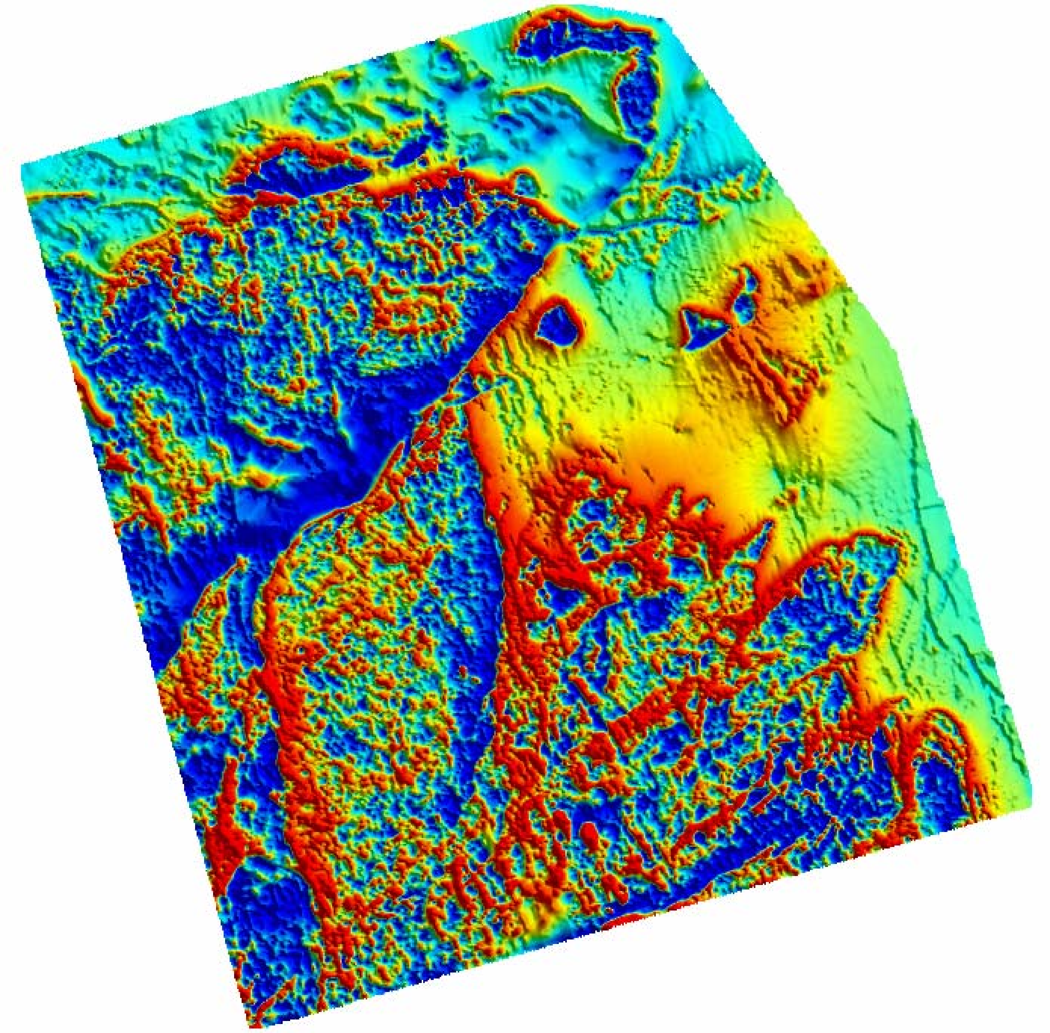


Figure 37 – Magnetic data of partly manually cleaned Block C2.

Formatted: Font: 11 pt, Not Bold
Formatted: Caption
Deleted: Figure 37.
Formatted: Font: Not Bold
Deleted: blockC2
Deleted: ¶
¶

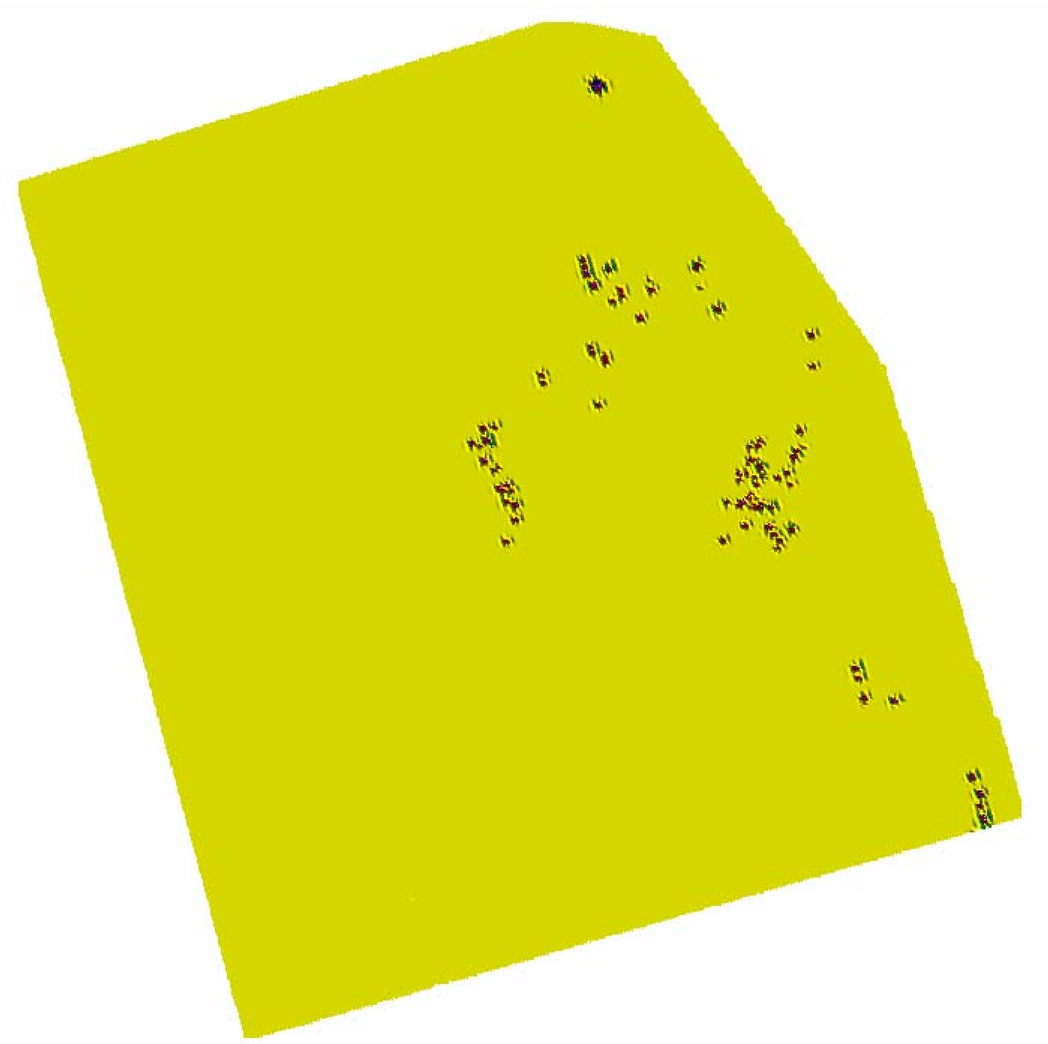


Figure 38 – Locations of manually removed cultural noise in Block C2.

Deleted: IR/07/0

Deleted: Draft 0.1

Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

Formatted: Font: 11 pt, Not Bold

Formatted: Caption

Deleted: Figure 38.

Formatted: Font: Not Bold

4.4 DECULTURED MAGNETIC GRID OF NORTHERN IRELAND

Figure 39 shows the survey blocks combined. This grid is produced by using 50 m grid cell size and 500 m blanking distance to fill the gaps. Belfast is still seen as a gap due to the large amount of data removed over the city. Figure 40 shows the locations of removed cultural noise.

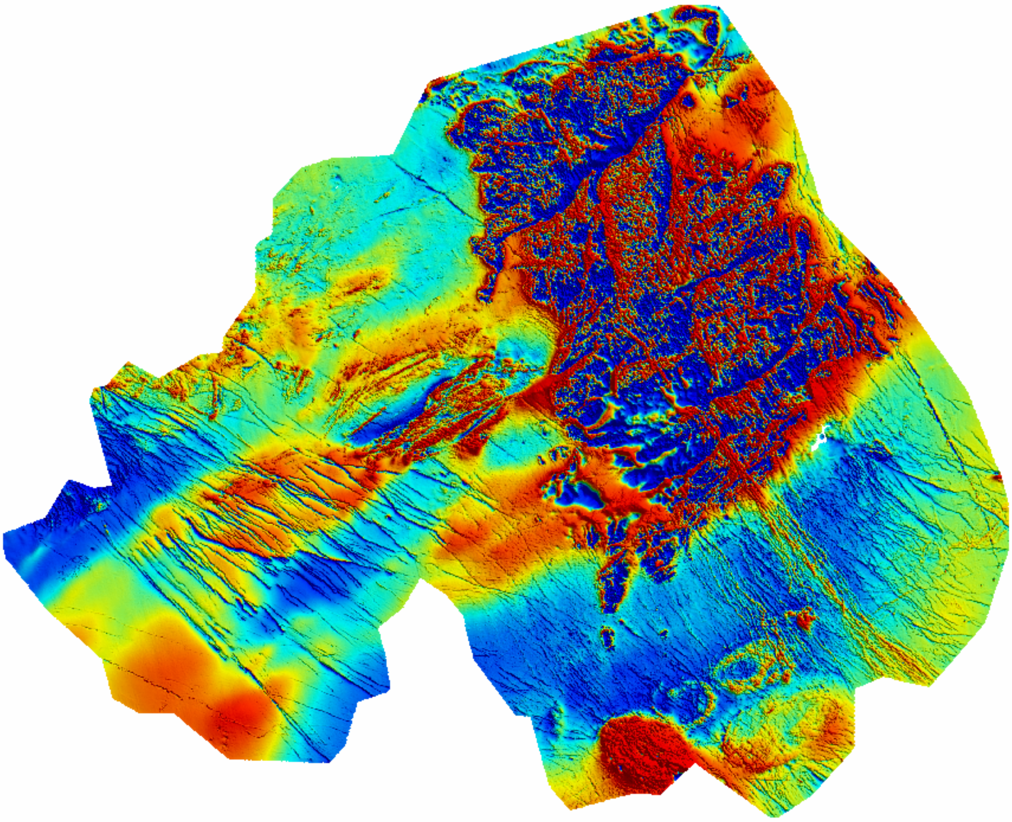


Figure 39 – Decultured grid of Northern Ireland.

Deleted: IR/07/0
Deleted: Draft 0.1
Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26
Formatted: Font: 11 pt
Deleted: ¶
Deleted: Figure 39
Deleted: Figure 40
Formatted: Font: 11 pt
Formatted: Font: 11 pt, Not Bold
Formatted: Caption
Deleted: Figure 39.
Formatted: Font: Not Bold

Deleted: IR/07/0

Deleted: Draft 0.1

Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

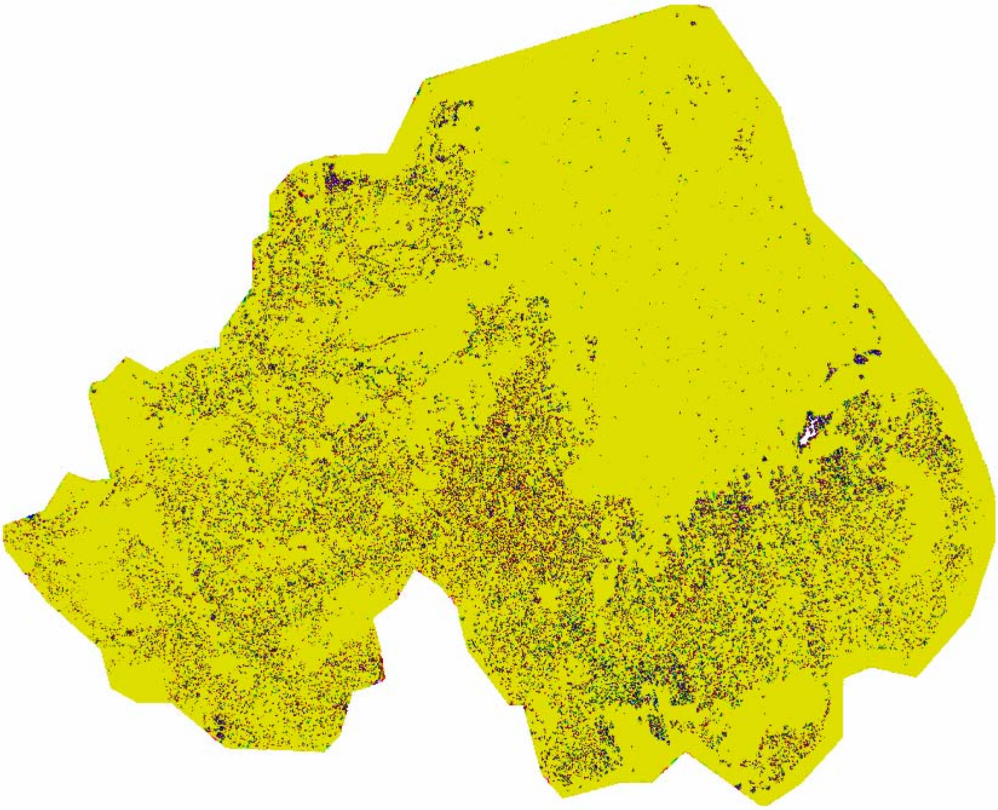


Figure 40 – Locations of cultural noise removed by deculturing. This map is produced by subtracting decultured magnetic grid from the original grid.

Deleted: in

Formatted: Font: 11 pt, Not Bold

Formatted: Caption

Deleted: Figure 40.

Formatted: Font: Not Bold

Deleted: IR/07/0

Deleted: Draft 0.1

Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

5 Summary of delivered data

The decultured Tellus magnetic data were delivered as two files:

Mag_Decult_Season1.xyz and Mag_Decult_Season2.xyz both with a date stamp of 04/04/2007. The Season 1 file contains data for the 2005 blocks A, B, C1, D1 and E1. The Season 2 file contains data for the 2006 blocks C2, D2 and E2. The separation into 2 files is purely for convenience (file size).

Formatted: Justified

The data channels are a repeat of the delivered Tellus Version 2 magnetic data (Mag_Version_2_260906.xyz, 26/09/2006) as described by Beamish *et al.* (2006c). This delivery effectively forms a Version 3 Tellus magnetic data set. A single additional deculturing channel (MAG_DECULT), with codes as described in this report, forms a final data channel. The data are accompanied by a Mag_Version_3_Readme.txt file:

Formatted: Font: Italic

```
Definition of channels in delivered .xyz file:

        X:              Grid Easting
        Y:              Grid northing masked to perfect
        LAT:            WGS84 latitude in decimal degrees
        LONG:           WGS84 longitude in decimal degrees
        FID:            numerical sum of Julian day and seconds past previous midnight
        Area:           Tellus survey area
        Flight:         Flight number
        DATE:           Date (YYYYMMDD)
        Day:            Day number (Julian)
        Time:           Time (HHMMSS.SS)
        DIR:            Flight direction (degrees clockwise)
        RALT:           Radar altitude (m)
        GPS_H:          GPS altitude (m) above geoid (WGS84)
        DTM:            Digital Terrain Model (m)
        MAG_MID:        Total magnetic Intensity for aircraft mid-point (nT)
        BASE:           Magnetic basestation correction (nT)
        GRAD_PERP:      Gradient perpendicular to aircraft (nT/m)
        MAG_ML:         Equivilent to MAG_MID microlevelled (nT)
        MAG_IGRF:       IGRF field (nT)
        MAG_RES:        Magnetic anomaly (IGRF corrected MAG_ML) (nT)
        MAG_DECULT:     Deculturing code

        Deculturing codes:

        1 Pointer

        Identified from OS50k map:

        11 House, building
        12 Road
        13 Powerline
        14 Railway
        15 Populated
        16 Moving objects and other
        20 Landfill, refuse tip

        Identified using video images:

        111 House
        112 Road
        113 Powerline
        114 Railway
        115 Populated
        116 Moving objects and other
        120 Landfill, refuse tip
```

Formatted: Heading 1

6 Statistics of delivered data

Table 4 summarises the degree of deculturing performed on Tellus data. The bottom line figure of 9.2 % cultural noise corresponds with that reported for the English Midlands (Cuss, 2001; Cuss, 2003). However, cultural noise levels block by block show a high degree of variability. Surprisingly, the most densely populated survey block (D2) shows a low level of cultural noise. This can be easily explained by the considerable coverage of this block by basalt; as described above, these magnetic terrains were not decultured as severely as the other blocks due to the very high amplitude of the geological signal, this is also shown in the very low noise figure for block C2.

The summary table (Table 4) should always be borne in mind when data are being interpreted. As already highlighted above, in areas where cultural noise is greatest there can be considerable changes to underlying geological signal. The careful deculturing steps aim to reduce this problem, but do not totally remove it. It is also vital to consider the lengths of the cut sections. For area D2 the longest cut is over 5km long. The use of line interpolation over such a long section is highly questionable. As shown in Cuss (2001) and Cuss (2003), the best approach to "in-fill" cleaned sections is to use grid-based interpolation in order to retain the regional field more realistically. However, the interpreter still needs to have detailed information on where data exists (clean data) and where data has been excised (culturally removed).

Table 4 – Summary statistics of the amount of deculturing for the Tellus survey.

	Total distance (line.km)	Total data points	Decultured data points	Unaffected data points	Noise (%)	Cuts	Average cut (m)	Longest cut (m)	Line
A	11,540	1,959,512	204,404	1,755,108	10.4	5,106	160	1,566	354
B	9,596	1,662,064	245,421	1,416,643	14.8	5,558	174	1,935	663
C1	10,428	1,744,975	112,338	1,632,637	6.4	3,701	365	3,602	1020
C2	9,999	1,691,371	2,990	1,688,381	0.2	91	109	478	1375
D1	8,655	1,487,460	215,883	1,271,577	14.5	4,991	183	1,914	2081
D2	13,369	2,290,149	111,981	2,178,168	4.9	2,601	507	5,061	2385
E1	6,316	1,045,104	168,141	876,963	16.1	5,486	171	631	3089
E2	10,854	1,844,701	203,745	1,640,956	11.0	4,355	187	2,200	3277
Total	**80,757**	**13,725,336**	**1,264,903**	**12,460,433**	**9.2**	**31,889**	**232**	**5,061**	**2385**

Deleted: IR/07/0

Deleted: Draft 0.1

Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

Deleted: ¶

Formatted: Body Text, Don't adjust space between Latin and Asian text

Formatted: Font: 11 pt

Deleted: o

Deleted: e

Deleted: E1

Formatted: Font: 11 pt, Not Bold

Formatted: Caption

Deleted: ¶

Comment [r12]: The final statistic that I think needs including is how long the deculturing took. Can you make an estimate of how long just Pointer takes, then how long the different refinements take. We can then use these numbers to make estimates of deculturing in the future.

Deleted: ¶
¶

References

Beamish, D., Cuss, R.J. and Lahti, M., 2006a. The Tellus Airborne Geophysical Survey of Northern Ireland: Phase 1 logistics report. British Geological Survey Internal Report, IR/06/032.

Beamish, D., Cuss, R.J. and Lahti, M., 2006b. The Tellus Airborne Geophysical Survey of Northern Ireland: Phase 2 logistics report. British Geological Survey Internal Report, IR/06/104.

Beamish, D., Cuss, R.J. and Lahti, M., Scheib, C, Tartaras, E., 2006c. The Tellus Airborne Geophysical Survey of Northern Ireland: Final Processing Report. British Geological Survey Internal Report, IR/06/136.

Cuss, R.J., 2001. Manual approaches to the removal of cultural noise from HiRES-1 aeromagnetic data. British Geological Survey Internal Report, IR/01/136. 25pp.

Cuss, R. J., 2003. Manual approaches to the removal of cultural noise from high-resolution aeromagnetic data acquired over highly developed areas. *First Break*, 21, 43-49.

Hassan, H. H., Peirce, J. W., Pearson, W.C. and Pearson, M.J. 1998. Cultural editing of HRAM data: Comparison of techniques. *Canadian Journal of Exploration Geophysics*, Vol. 34, Nos. 1&2, 16-22.

Fedi, M., Florio, G., Paoletti, V., Rapolla, a. And Supper, R. 2003. Analysis and interpretation of aeromagnetic data affected by intense cultural noise. 65th EAGE Conference, Stavanger, Norway, *Extended Abstracts*, E-33, 4pp.

Gharibi, M. and Pedersen, L. P., 2000. Removal of DC power line magnetic field effects from airborne total magnetic field measurements. *Geophysical Prospecting*, 48, 617-628.

Muszala, S., Stoffa, P. L.and Lawver, L. A. 2001. An application for removing cultural noise from aeromagnetic data. *Geophysics*, 66, 213-219.

Wilson, C.R. 1997. A high precision aeromagnetic survey near the Glen Hummel Field in Texas; Identification of cultural and sedimentary anomaly sources. *The Leading Edge*, 16, 37-42.

Deleted: IR/07/0

Deleted: Draft 0.1

Deleted: Last modified: 2007/04/11 17:162007/04/10 10:26

Deleted: ¶

Formatted: Font: Not Italic

Formatted: Reference Para, Adjust space between Latin and Asian text, Adjust space between Asian text and numbers

Deleted: CUSS, R.J. 2001.

Formatted: Font: 9 pt

Formatted: English (U.S.)

Formatted: Superscript

Formatted: Font: Italic

Formatted: English (U.S.)

Deleted: ¶

Page iv: [2] Deleted mlahti 31/05/2007 12:38:00

The procedures, taking over 2 years[r1] to complete, have resulted in a final Tellus magnetic data set with a deculturing mask channel. The channel contains a simple set of noise classifications. The deculture mask channel can be applied, wholly or partly, to any or all of the data channels in the Tellus magnetic data set. The result is a Tellus magnetic data set decultured according to the procedures set out in this report.

Page i: [3] Deleted mlahti 01/06/2007 12:30:00

Last modified: 2007/04/11 17:162007/04/10 10:26

Page i: [4] Deleted mlahti 01/06/2007 12:30:00

IR/07/0

Page i: [4] Deleted mlahti 01/06/2007 12:30:00

Draft 0.1

Page i: [4] Deleted mlahti 01/06/2007 12:30:00

Last modified: 2007/04/11 17:162007/04/10 10:26

Page 26: [5] Comment [r11] rjcu 11/04/2007 16:58:00

Are you trying to explain grid-based noise or cultural noise; too many noises!!

Page 26: [6] Deleted mlahti 31/05/2007 12:09:00

The low amplitude noise in the background is artificial and due to the

Page 26: [7] Deleted mlahti 31/05/2007 12:09:00

technique[r2]. This map is produced by subtracting the cleaned grid from the original grid and small grid differences come out as noise

Page 26: [8] Formatted mlahti 31/05/2007 12:07:00

Font: 11 pt, Not Bold

Page 26: [8] Formatted mlahti 31/05/2007 12:07:00

Font: Not Bold

Page 26: [9] Formatted mlahti 31/05/2007 12:07:00

Font: 11 pt, Not Bold

Page 26: [9] Formatted mlahti 31/05/2007 12:07:00

Font: Not Bold

Page 26: [10] Deleted rjcu 11/04/2007 16:59:00

pointer

Page 26: [10] Deleted rjcu 11/04/2007 16:59:00

.

Page 26: [10] Deleted rjcu 11/04/2007 16:59:00

village