Archaeometric prospection using electrical survey predictive deconvolution (ESPD)

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Plan

- Introduction – The past revisited!
- What is a Grubenhaus?
- Where is the search area?
- How? – Experimental Methodology
- How? – Data Analysis – Predictive deconvolution
- Results
- Conclusions
- Who? – Acknowledgments
Grubenhäuser

- Small sized
- Excavated floors lined with planks or packed clay
- Multiple use – workshops rather than dwellings
  - Pottery
  - Weaving
  - Metal-working
  - Animal husbandry…etc.
- Usually found in association with timber-framed halls

Typical excavated Grubenhäuser from 3 UK sites (Glover, 1985)
Grubenhäuser

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Line drawing of the New Bewick Grubenhaus
Grubenhäuser

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Reconstruction of the New Bewick Grubenhaus
http://www.bedesworld.co.uk/site_2003-05-10/building/nbkdescr.htm
General Location

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200 m from River Breamish

Elevation 94 m

1.8 km from Old Bewick Iron Age Hillfort (rock art)

16 km from
- Milfield
- Yeavering
- Thirlings

Anglo-Saxon royal/Palace settlements
General Location

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Light grey area represents The survey area (in two parts)

Dark grey area represents the subsequently excavated area
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**Marks include**
- Tramlines
- Drainage
- Glacial Till
- Frost Cracking
- Old Hedge Boundaries

**Archaeological Remains**
Aerial Photography
Methodology

Plan

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- ABEM Mk II Terrameter & in-house meter
- 33 electrodes multiplexed into 4
- Survey area 10140 m²
- May and June, dry weather with short winter wheat
- Light, sandy topsoil
Raw data

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Raw data from the first part of the survey area

Profile A - B
Profile C - D
Profile E - F
Each structure has an electrical signature or source function

Predictive deconvolution – need to predict the source function

Source function can be calculated uniquely from a geometrical model of the subsurface feature

The model, however, is not unique

The method restores the target structure…

…but destroys structures of other geometries

Analysis carried out by matrix inversion
Data Analysis: The Source Function

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Convolution: Synthetic Data

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![Graphs and charts illustrating convolution process]
Deconvolution: Restoration of Location

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Graphs:
- Observed Profile
- Inverse Shape Function A
- Result compared with that from a perfect deconvolution

Graphs show T(x), R(x), and D(x) as functions of distance (m).

Graphs illustrate the deconvolution process and the results obtained from different shape functions.
Deconvolution: Restoration of location and extent

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**Graphs**
1. **Observed Profile**
   - $T(x)$
   - $-20 \ldots 20$

2. **Inverse Shape Function B**
   - $R(x)$
   - $0 \ldots 3$

3. **Result compared with that from a perfect deconvolution**
   - $D(x)$
   - $0 \ldots 3$

Distance (m)
**Plan**

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**Data Analysis – Test 1**

**Restoration of location**

![Graphs showing apparent resistivity profiles](image)

- **PROFILE A - B**
- **PROFILE C - D**
- **PROFILE E - F**

- Dashed line: Original apparent resistivity profiles
- Solid line: Apparent resistivity profiles deconvolved with inverse shape function A

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Data Analysis – Test 2
Restoration of location and extent

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Who? – Acknowledgments

<table>
<thead>
<tr>
<th>PROFILE</th>
<th>APPARENT RESISTIVITY (ohm.m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A - B</td>
<td></td>
</tr>
<tr>
<td>C - D</td>
<td></td>
</tr>
<tr>
<td>E - F</td>
<td></td>
</tr>
</tbody>
</table>

- Original apparent resistivity profiles
- Apparent resistivity profiles deconvolved with inverse shape function B
Results - Undeconvolved

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  - How? – Data Analysis
- Results
  - Undeconvolved
    - Deconvolved 3 m width
    - Deconvolved 4 m width
    - Deconvolved 5 m width
  - Combined Data
- Conclusions
- Who? – Acknowledgments

Diagram:
- Ditch II
- Packed earth
- Ditch I
- A, B, C, D, E, F

Colors:
- 400
- 600
- 800
- 1000
Results – Deconvolved

Source function 4 m wide

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- Deconvolved 5 m width
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Conclusions

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Results – Deconvolved

Source function 5 m wide

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Results

Undeconvolved

Deconvolved 3 m width

Deconvolved 4 m width

Deconvolved 5 m width

Combined Data

Acknowledgments
Results - Combined View

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Proof by Excavation
(Gates and O’Brien, 1988)

Deconvolved survey

<table>
<thead>
<tr>
<th>(in metres)</th>
<th>Survey</th>
<th>Excavated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>4</td>
<td>3.9</td>
</tr>
<tr>
<td>Length</td>
<td>5</td>
<td>4.7</td>
</tr>
<tr>
<td>Depth</td>
<td>0.6</td>
<td>0.5</td>
</tr>
<tr>
<td>Topsoil</td>
<td>(0.3)</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Who? – Acknowledgments

Gates and O’Brien, 1988
Conclusions

- Complex electrical survey data can be deconvolved to provide the location and extent of buried features IF their source signature can be predicted.
- Electrical survey at New Bewick predicts the presence of at least 6 grubenhäuser.
- One of the predicted grubenhäuser has been excavated and confirmed with the same dimensions as the survey predicted.
- The site shows other features, and may be the site of a significant settlement (timber-framed halls?)
Acknowledgments

- Mr. J Clark – New Bewick Farm
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- Prof. Norman McCord – Aerial photography