Iron production management: a case study of bloomery iron production at Hlebine – Velike Hlebine and Dedanovic site

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Secrets of iron – from raw material to an iron object

The Podravina region – NW Croatia

**Bloomery // Iron production workshop**

- **Virje – Volarski breg & Sušine**
  2/2 8. – 9th century
  5th century
- **Hlebine – Velike Hlebine**
  ½ 7th century

**Smithy ? // primary and/or secondary smithing furnaces**

- **Hlebine – Dedanovice** ½ 7th century
• **edge of the flooding plain**

• **2nd Drava river terrace – elevation change**

• **Boggy - marshy areas in vicinity – ore exploitation area?**
Results of magnetometry (Geometrics G-858), background : aerial photography (DOF).

- Areas of extra high magnetic anomalies are concentrated on the place where a high concentration of surface slag was found.

- Cluster of low magnetic anomalies can be interpreted as pits without iron production debris. (Mušič, B., Medarič, I., Matijević, F., 2016 -2017.)
Ground plan, Hlebine - Velike
Hlebine site, excavation 2016 – 2017
(made by: K. Turkalj)
<table>
<thead>
<tr>
<th>Type</th>
<th>Mass/ kg</th>
<th>Total waste %</th>
<th>density kg/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slag/Fe/</td>
<td>382.98</td>
<td>81</td>
<td>0.61</td>
</tr>
<tr>
<td>Technical ceramics/furnace walls/tuyere</td>
<td>200.64</td>
<td>93</td>
<td>0.32</td>
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</table>

<table>
<thead>
<tr>
<th>Mass/ kg</th>
<th>Total waste %</th>
<th>density kg/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>90.90</td>
<td>19</td>
<td>0.44</td>
</tr>
<tr>
<td>15.08</td>
<td>7</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Spatial distribution of archaeological features and density of occurrence of indicative finds
Remains of the funaces with slag *in situ*
(SU 038/38-1
SU 037/ 37 -1 )

Free standing shaft, flat-hearth tapped furnace (Pleiner 2000: 258, fig.67)
Incorporated:
Hammercale Spheres of slag
Ground plan, Hlebine - Velike Hlebine site, excavation 2016 (made by: K. Turkalj)

Distribution area – operating space
- Smelting
- Bloom refining – compacting and/or primary smithing
- Storage area (temporary) – ore & charcoal

Post reduction slag – bloom refining/smithing?
Smelting slag
- Tap slag
- Furnace bottom slag
- Furnace slag
Roasted bog iron ore
Furnace walls/tuyeres
Western part: archaeological record

Ground plan, Hlebine - Velike Hlebine site, excavation 2017
(made by: K. Turkalj)

- 811 – 812 °C
(max range 701 – 891 °C)
- 2h

Bog iron ore (unroasted and roasted)

Smelting waste
- Technical ceramics
- Smelting slag

Distribution – structured workspace
- Prereduction: Roasting of iron ore
- Postreduction: Waste discarding area (382 kg)

Spatially divided concentrations of waste – seasonal/campaign use of workspace

Distribution of finds – western part

Bloom refining / primary smithing slag
Spatial organisation of the workshop

1. Pre-reduction – resource preparation
2. Reduction-smelting
3. Post reduction – bloom refining/primary smithing
4. Post reduction/Waste disposal

In situ slag = 1 smelt

Total smelting waste = 117 smelts/time span?
Results of magnetometry (Geometrics G-858), background: DOF, Mušič, B., Medarič, I., Matijević, F., 2016-2017

Hlebine – Dedanovice site

Settlement, 7th century?

Furnaces
Hlebine – Dedanovice, furnaces (phase 1)
Trench 1, 2018., (foto: T. Sekelj Ivancan)
Roasted bog iron ore

PCC – primary smithing slag

Furnace walls

<table>
<thead>
<tr>
<th>Type</th>
<th>Quantity/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furnace walls</td>
<td>18.747</td>
</tr>
<tr>
<td>Slag</td>
<td>15.339</td>
</tr>
<tr>
<td>Bog iron ore</td>
<td>0.993</td>
</tr>
<tr>
<td>Fe/object</td>
<td>0.053</td>
</tr>
</tbody>
</table>

Ground plan, Hlebine - Dedanovice 2018. (made by: K. Turkalj)
Primary/secondary smithing

Seasonal storage
?
– ore
Similar general trend of REE – similar origin of bog iron ores: similarity increases with spatial and temporal connection between sites.

Similar microenvironment for bog iron ore formation = same exploitation ground - workshop location selection?
RESOURCE PREPARATION – SMELTING – BLOOM REFINING

• Seasonal / Campaign activities – temporary location
  = Isolated ridge away from the settlement - close to the source of raw materials?

PRIMARY SMITHING/BLOOM REFINING SECONDARY SMITHING / STORAGE

• continuous labor, storage = edge of the settlement grounds
• structured organisation of labor and workspace on both sites

• Workspace location selection influenced by:

• type of activity (resource exploitation and preparation, smelting, primary smithing)

• dynamics of activities (seasonal or constant - continuous)

• natural landscape prerequisites (floods, wet-dry season, source of raw materials, bog iron ore deposits)

a high level of iron production management in the ½ 7th century

High level of demand for iron?
Levels of specialization?
- same organised group of people – interrelated specialists?
Thank you for attention!