Bloomery works – organisation of an early medieval iron production process

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The Podravina region (NW Croatia)
Location selection –

- edge of the flooding plain
- 2nd Drava river terrace – elevation change
- Boggy - marshy areas in vicinity – ore exploitation area?
- Hlebine – Velike Hlebine – isolated ridge, away from the settlement
- Hlebine – Dedanovice – outer perimeter of the settlement
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
Remains of the smelting furnaces (SJ 038/38-1 and SJ 037/37-1)

Flat – hearth tapped furnace (after: Pleiner 2000: 258, fig.67)
Post reduction slag – bloom refining / smelting?

Smelting slag (TS, FBS, FS)

Roasted ore

Distribution area – operating space
- Smelting
- Bloom refining / Primary smithing?
Raw and roasted ore

Smelting waste – tuyere, slag, furnace walls

Distribution area – operating space –
• Ore roasting
• Waste discarding (382 kg)
1. Pre-reduction

2. Reduction

3. Post-reduction/bloom refining?

4. Post-reduction/Slag discard area

In situ slag = 1 smelt

Total smelting waste = 117 smelts/time span?
Hlebine Dedanovice site excavation, furnaces 2018. (photo: T. Sekelj Ivančan)
Results of magnetometry (Geometrics G-858), background: aerial photography (DOF) Mušič, B., Medarič, I., Matijević, F., 2016-2017

Roasted bog iron ore

Bloom refining /smithing slag?

Ground plan of archaeological excavation 2018, Hlebine -Dedanovice site
<table>
<thead>
<tr>
<th>Arh. Sample</th>
<th>Site</th>
<th>Period</th>
<th>Type</th>
<th>Quartz</th>
<th>Goethit</th>
<th>Hematit</th>
<th>Magnetit</th>
<th>Rutile</th>
<th>Other min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>SJ 83 (N 242)</td>
<td>Hlebine - Velike Hlebine</td>
<td>Iron ore</td>
<td>++</td>
<td>+++</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td></td>
<td>Pl</td>
</tr>
<tr>
<td>SJ 27 (U 71)</td>
<td>Hlebine - Dedanovice</td>
<td>Roasted iron ore</td>
<td>+</td>
<td>-</td>
<td>+++</td>
<td>-</td>
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<td></td>
<td>/</td>
</tr>
<tr>
<td>SJ 10 (U 26)</td>
<td>Hlebine - Dedanovice</td>
<td>7th century</td>
<td>Roasted iron ore</td>
<td>+</td>
<td>-</td>
<td>+++</td>
<td>-</td>
<td></td>
<td>Mgh</td>
</tr>
<tr>
<td>SJ 16 (U 45)</td>
<td>Hlebine - Dedanovice</td>
<td>Roasted iron ore</td>
<td>+</td>
<td>-</td>
<td>+++</td>
<td>-</td>
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<td></td>
<td>/</td>
</tr>
<tr>
<td>SJ 8 (U 11)</td>
<td>Hlebine - Dedanovice</td>
<td>Roasted iron ore</td>
<td>+</td>
<td>-</td>
<td>+++</td>
<td>+</td>
<td>-</td>
<td></td>
<td>/</td>
</tr>
<tr>
<td>SJ 102/90 (N 223)</td>
<td>Hlebine - Velike Hlebine</td>
<td>Roasted iron ore?</td>
<td>+</td>
<td>++</td>
<td>+++</td>
<td>-</td>
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</tbody>
</table>

Mineralogical composition of the ore (XRD), Tomislav Brenko, Faculty of geology and mining, Zagreb, Croatia

REE correlation – roasted ore: Hlebine Velike Hlebine – Hlebine Dedanovice = very similar general trend, minor differences in elements

same micro - enviromental conditions of formation? – same exploitation ground
• Contemporary sites – interrelated metalurgical activities

• Smelting and bloom consolidation/refining workshop situated 700 m from contemporary settlement,

• distribution of finds shows spatial organisation in relation to steps of the process

• Bloom refining/consolidation and/or primary smithing? - within settlement grounds and workshop

• REE corellation – single exploatation ground – Hlebine Velike Hlebine and Dedanovice - organisation of ore collecting, preparation, storage ?

Further considerations:

• Mineralogical and geochemical analysis – correlation of ore, slag from both sites

• Comparison with contemporary sites