

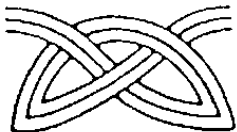
Methods of documenting iron production waste finds: the role of digital photogrammetry

Tena Karavidović
Dinko Tresić Pavičić
Tajana Sekelj Ivančan

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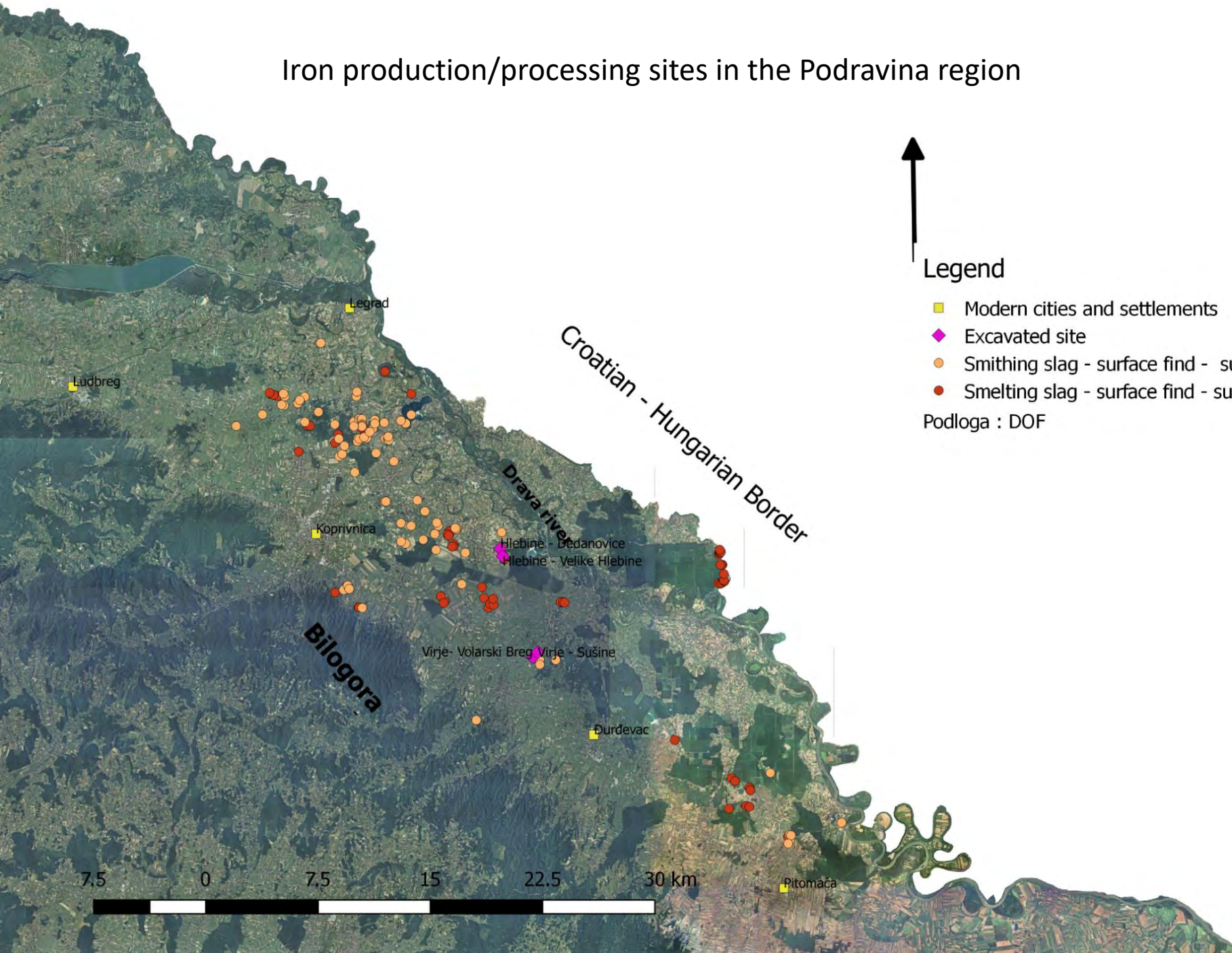
University of Zagreb, Faculty of Humanities and Social Sciences



TransFER



Iron production/processing sites in the Podravina region



Bloomery // Iron production workshop

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

Smithy ? // primary and/or secondary smithing furnaces

- **Hlebine – Dedanovice** ½ 7th century

Questions asked – methods of research

= optimisation of documentation strategy

- Ore - provenance, identifying characteristics of the ore (pre-treatment of ore, quality),
- types of procedures used - type of slag,
- thermodynamic conditions, use of flux, fuel, efficiency of the process and quality
- Smelting furnace - character/reconstruction
- Smithing instalations - character/reconstruction
- quantification of the workshop production

Archaeometric studies

Macroscopic analysis

Structured experiments

Objective macroscopic analysis/standardised method of observation

selection of samples and sampling methods

Destructive methods

variability in resource usage and inability to replicate procedures resulting in uncomparable results of experiments, scarce archaeological record

Archaeological record

Common site characteristics:

- large amounts of highly fragmented waste often concentrated as a uniform layer or several layers
- scarce or no remains of in situ structures such as furnaces preserved in elevation but rather as fragmented waste disposed together with other waste during the time of workshop functioning
- distinctive waste – several main categories
- Rare instances of wholesome objects – single smelting episode

Interpreted archaeological context

- structured spatial organisation leading to workspace cleaning and waste disposal area
- iron ore smelting or production of an iron bloom as well as several processes of primary smithing procedures
- multiple steps of the process of production carried out on the site.

Postdepositional conditions

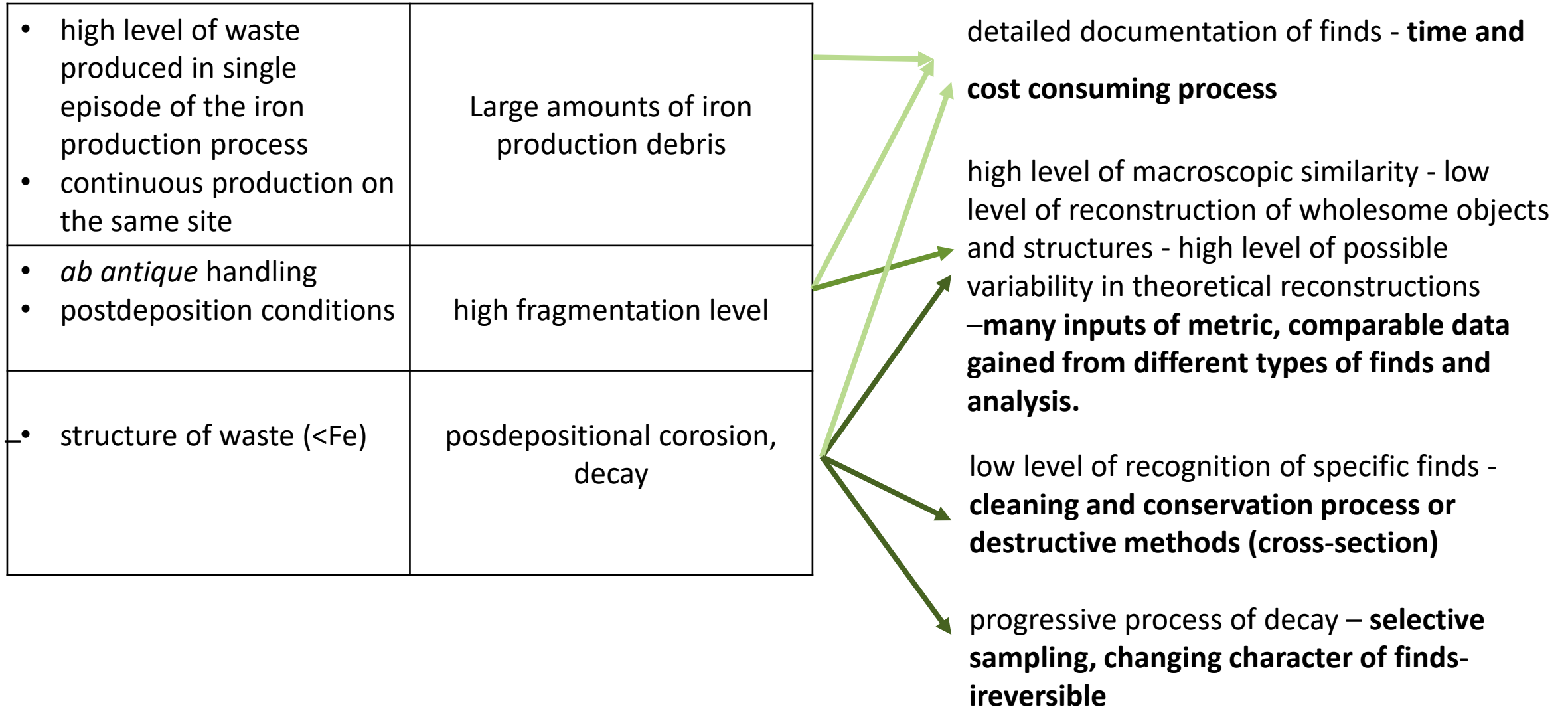
- postdepositional destruction (plowing), constant flooding (decay of finds)



Virje – Volarski breg 2012, SU 214,215,231 – layers of concentrated waste – waste disposal area

Archaeological context implications / limits of information gained

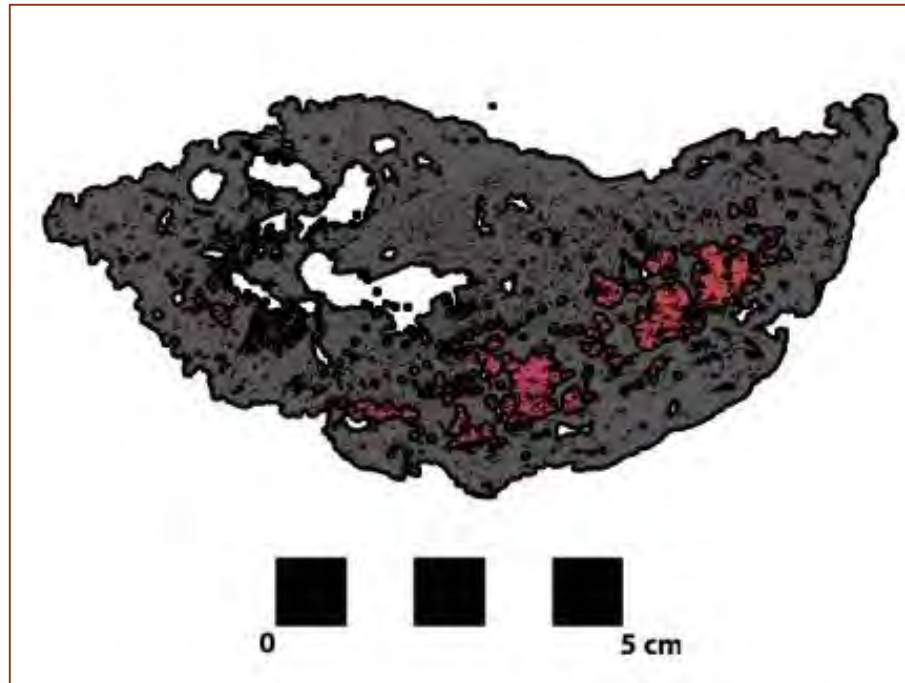
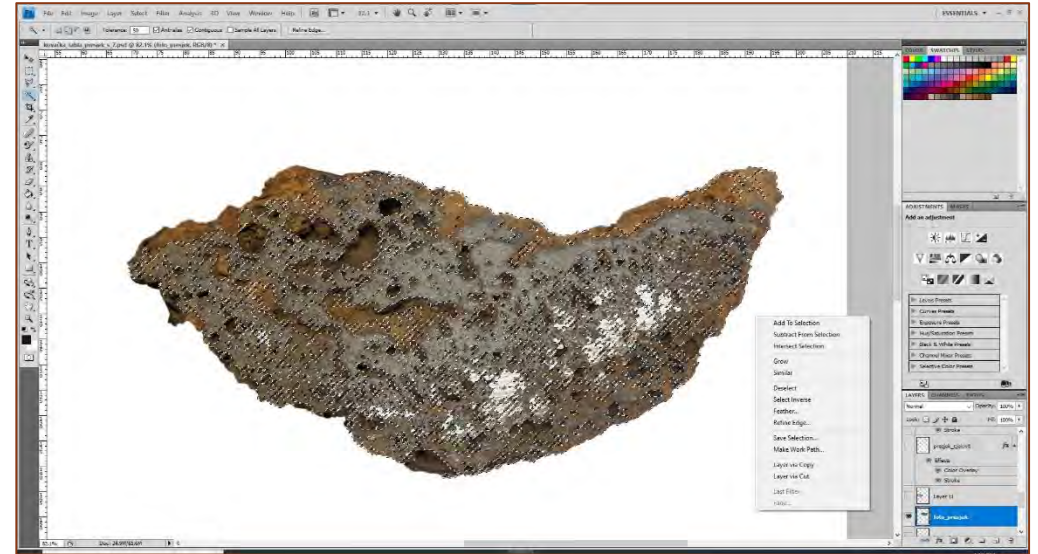
= optimisation of documentation strategy



Cross-section examination = macro slag structure definition

- gaining new/comparable information on macroscopic level
- sampling -
 - ✓ unified, verifiable, controlled positioning of sampling areas for archaeometric analysis, layered sampling
 - ✓ controlled postpositional influence on the results of the analysis (rust – surface and subsurface sampling positions)

- semi- automated isolation of similar structures and colors of material
- quantifiable
- objective
- large amount of specimens
 - minimum time consumption and -
 - detailed resource for further analysis and comparison of groups of finds.



*Adobe Photoshop
CS4*

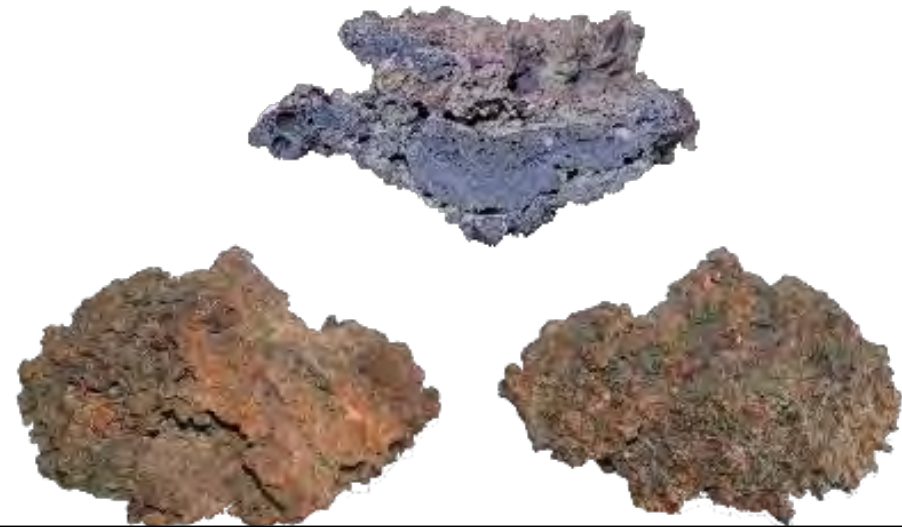
Workflow:

/sectioning tools
/tolerance
range, similarity
function for
automatic
recognition
/processing of
segments

Cross section of two types of primary smithing slag (structure analysis):

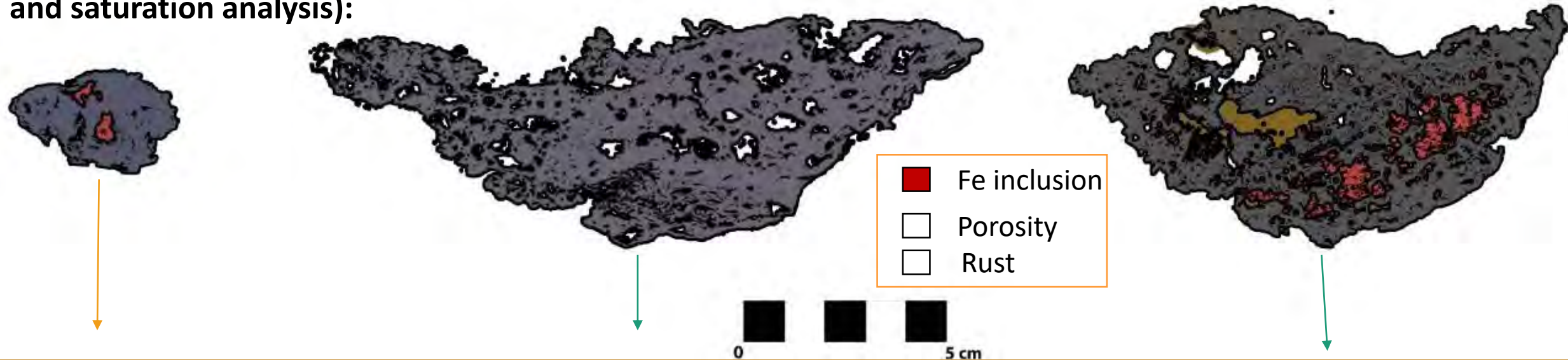
- **layered structure** – discontinuous rhythm of primary smithing (?)
- **uniform structure** – one-take primary smithing / prolonged period of settling in the hearth (?)

site: Hlebine – Dedanovice, ½ 7th century



10 cm

Cross section of three sub-types of slag (macro density and saturation analysis):



- High density, no porosity-compact layers of irregular form
- Inclusion - Iron particles – 10% explored surface

Compacting slag
1st stage of post-reduction processing of bloom

- Low density, regular distribution of porosity
- No inclusions

Primary smithing slag
2nd(?) stage of post-reduction processing of bloom

- Lower density, irregular distribution of porosity-layered
- Inclusions – iron particles
- Rust covered area < fe

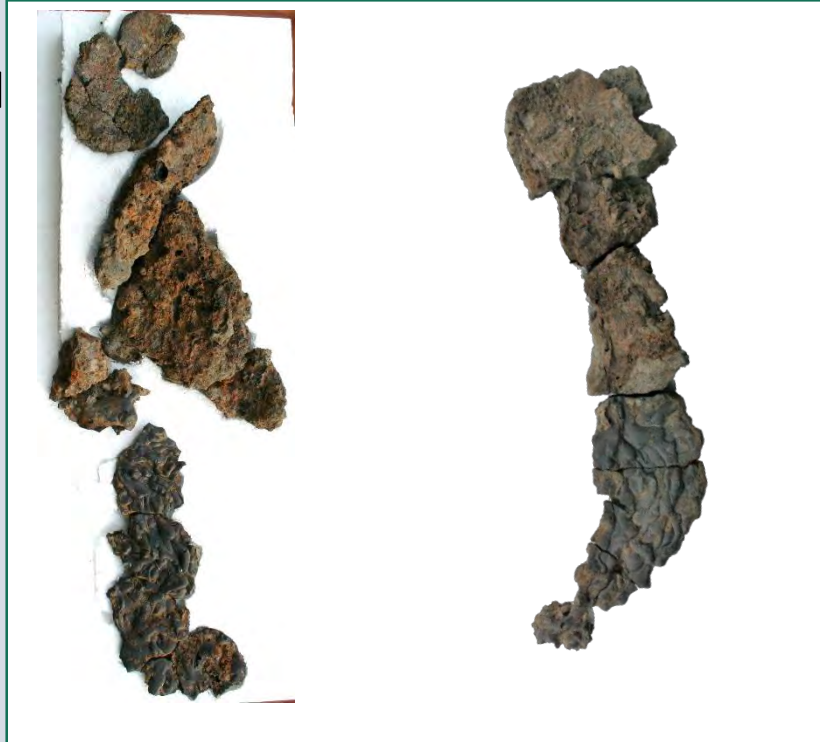
Primary smithing slag
2-3rd(?) stage of post-reduction processing of bloom, difference in processing steps

Archaeological record – *in situ* smelting slag

Remains of
the smelting
furnaces with
slag *in situ*



Reconstructed
slag position



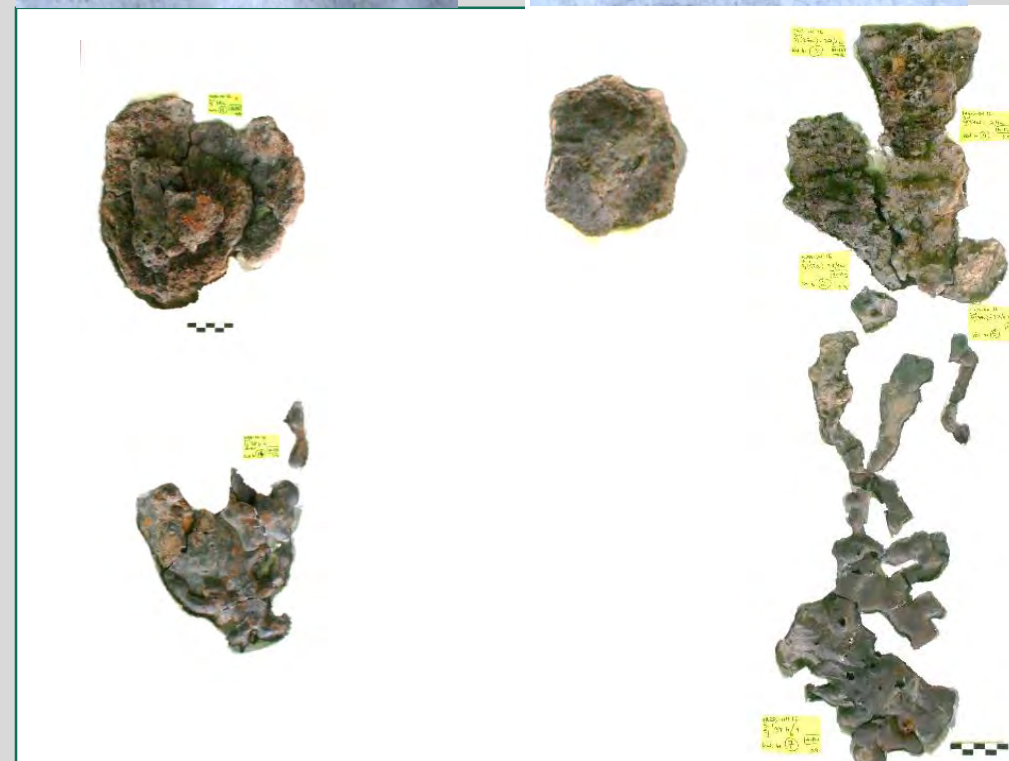
(Virje-Volarski
breg,
Trench 1)
SU 29/30

56



(Hlebine-Velike
Hlebine,
Trench 1)

(SU 038/38-1
SU 037/ 37 -1)

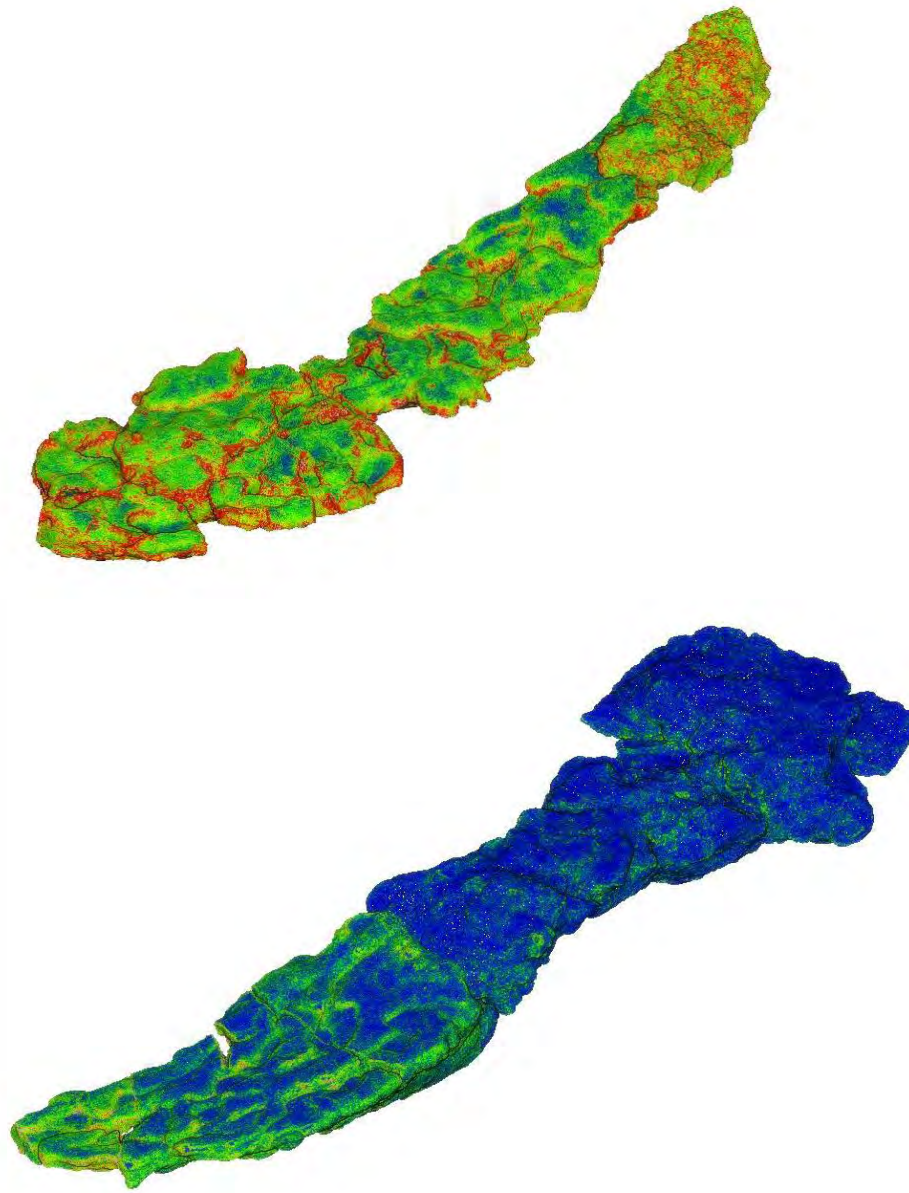
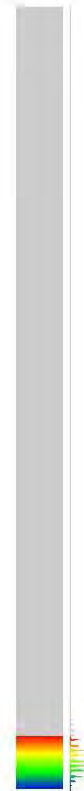
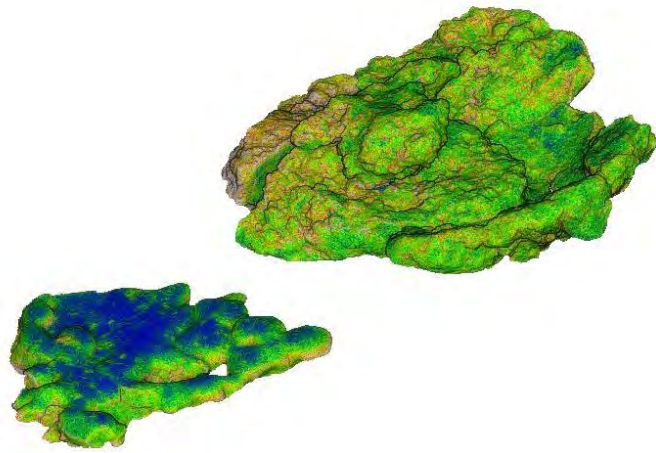


Point cloud and 3d modeling: reconstruction and surface analysis

Tehnical setup	Processing	Objective
<p><i>Artificial studio light:</i> reflector 6x, Aputure Amaran HR672, light.temp. 5200 kelvin + diffuser white paus paper</p> <p><i>Camera:</i> NIKON D5300, obj. 18 – 55 mm ISO 125 EXPOSURE TIME 1/180 sec f/8</p>	<p>Each segment of slag was photographed and processed individually, then merged (point recognition 3x) manually to fit the reconstruction and scaled</p> <p>Modeling : fitting of individual objects – scaling - dense point cloud – mesh –texture -.obj file (Meshlab)</p>	<ul style="list-style-type: none">• Precise model – surface analysis• Volume calculation• multiple cross-sectioning – reconstruction• 3d visualisation and reconstruction (museum presentation)

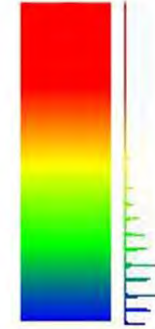
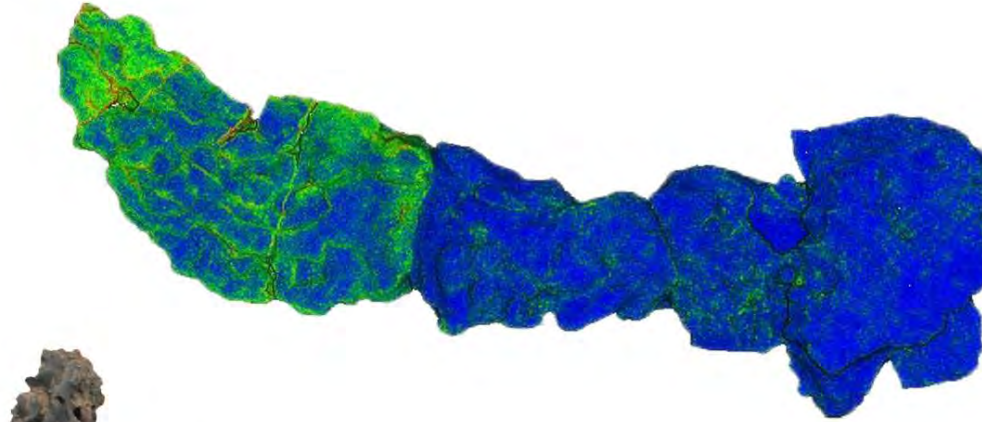


Surface analysis – point density



**lower point density -
smooth surface,
flow texture**

**higher point density -
rough/coarse surface**



tap slag



- molten - fast air cooling

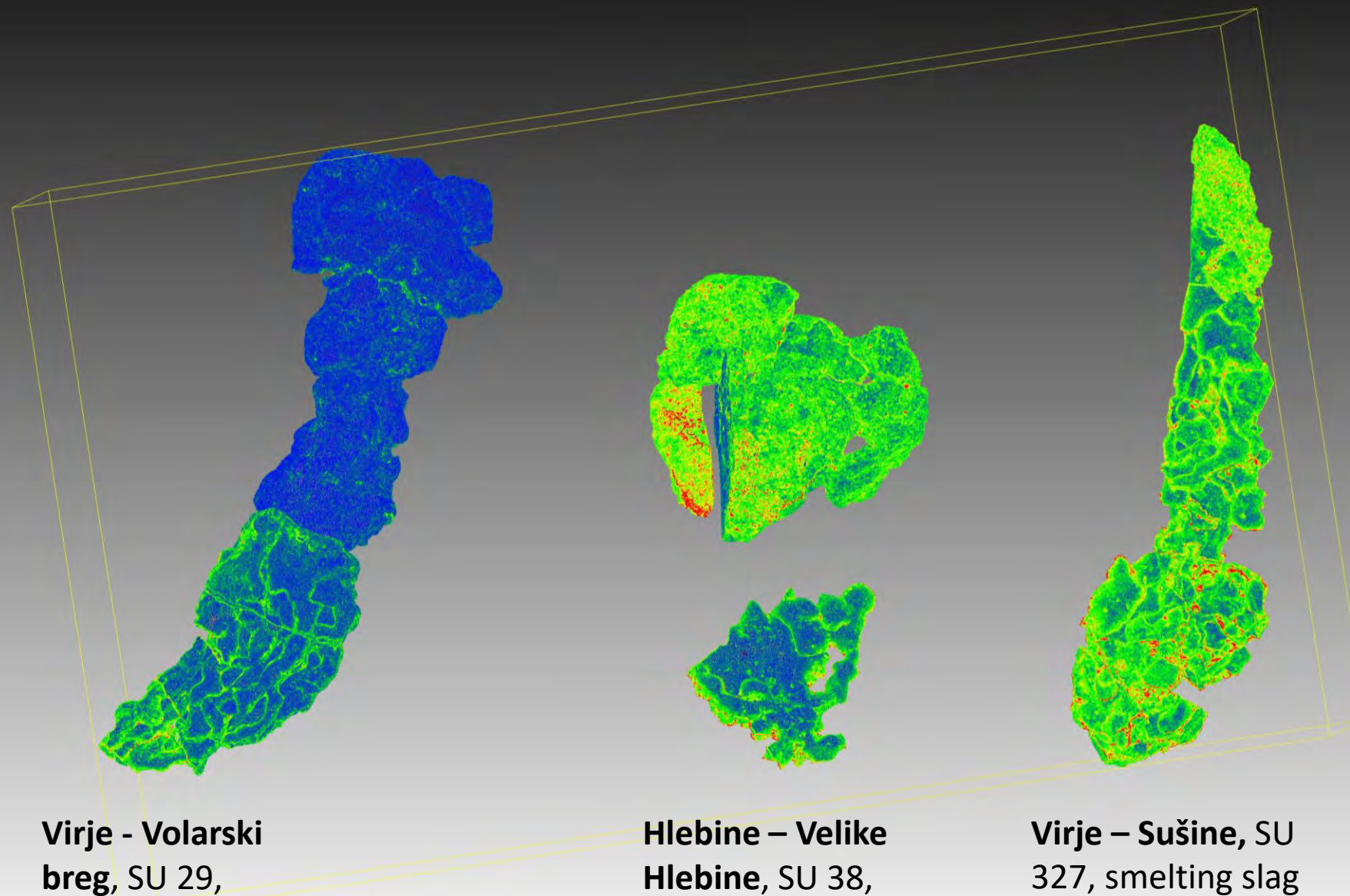
- slag pit in front of the furnace

furnace/furnace bottom slag

- subsidence, slow cooling process

- inside the furnace



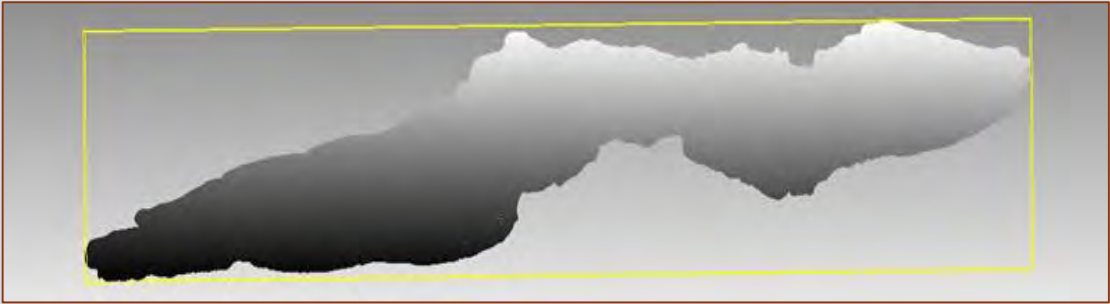
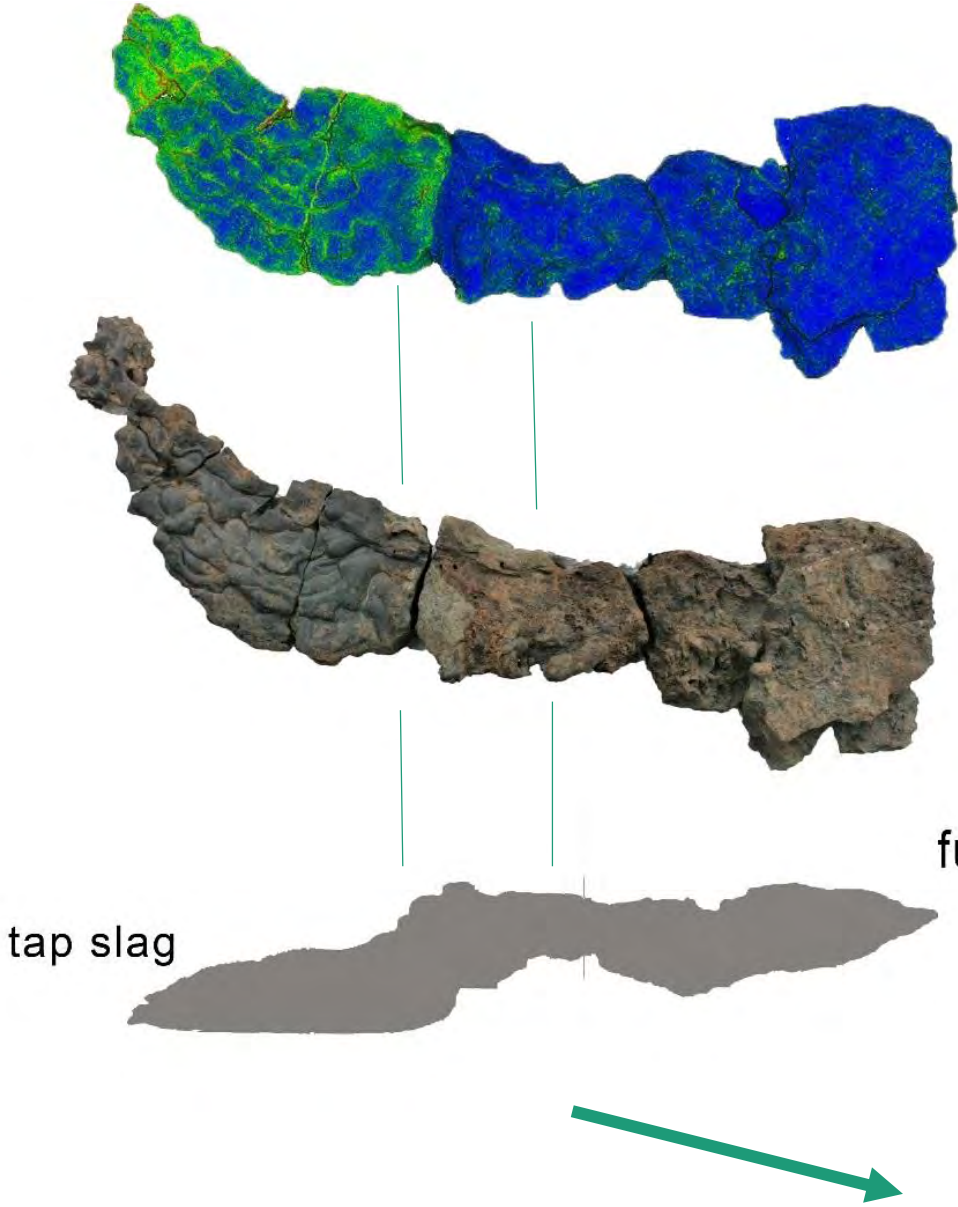


8/9th century

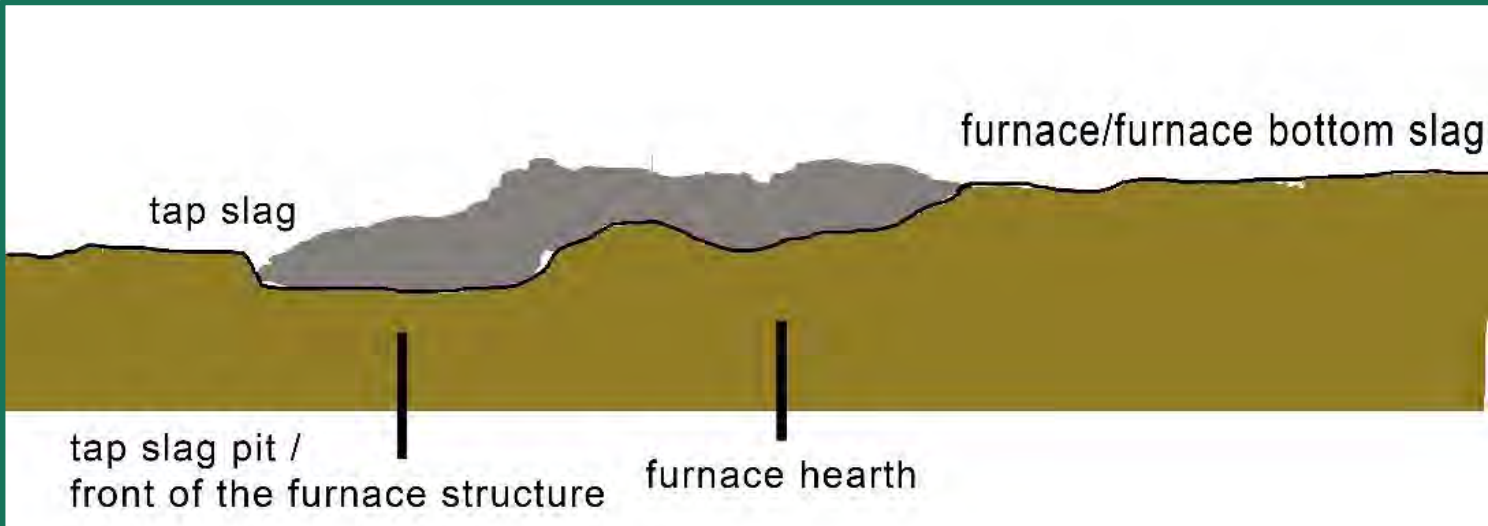
½ 7th century

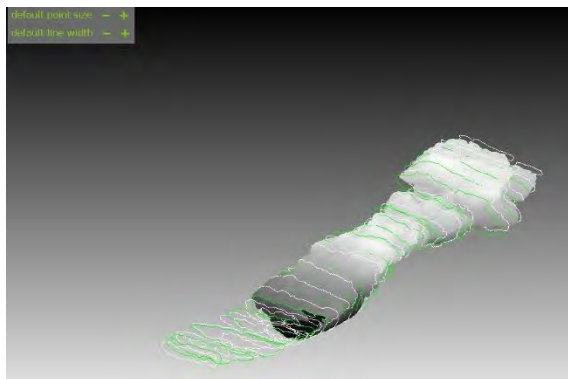
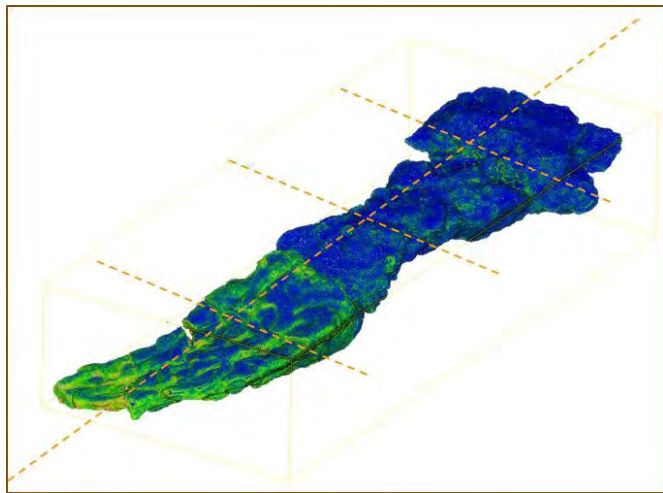
4/5.century

Multiple cross- sectioning and reconstruction

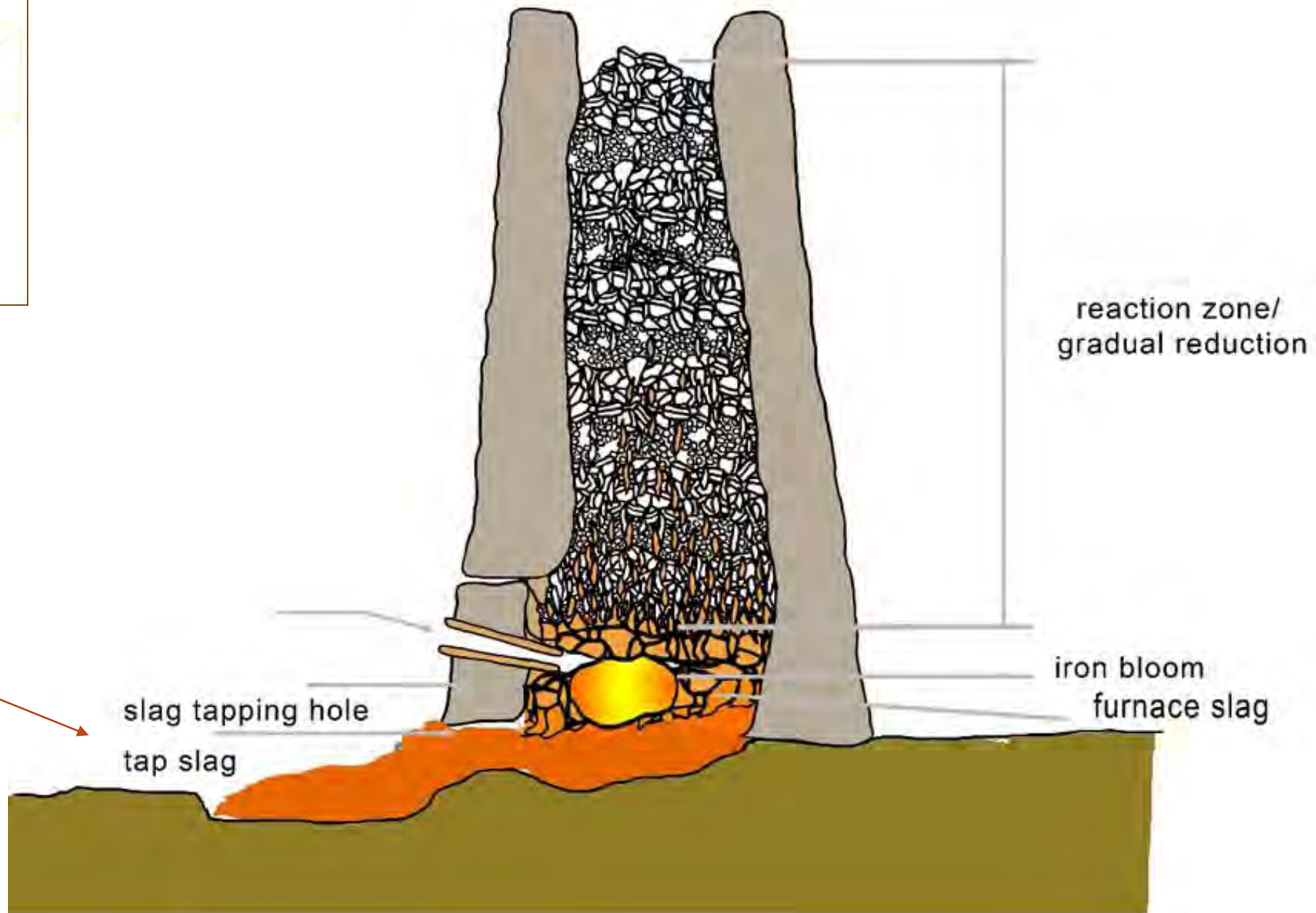


Visualised height ramp

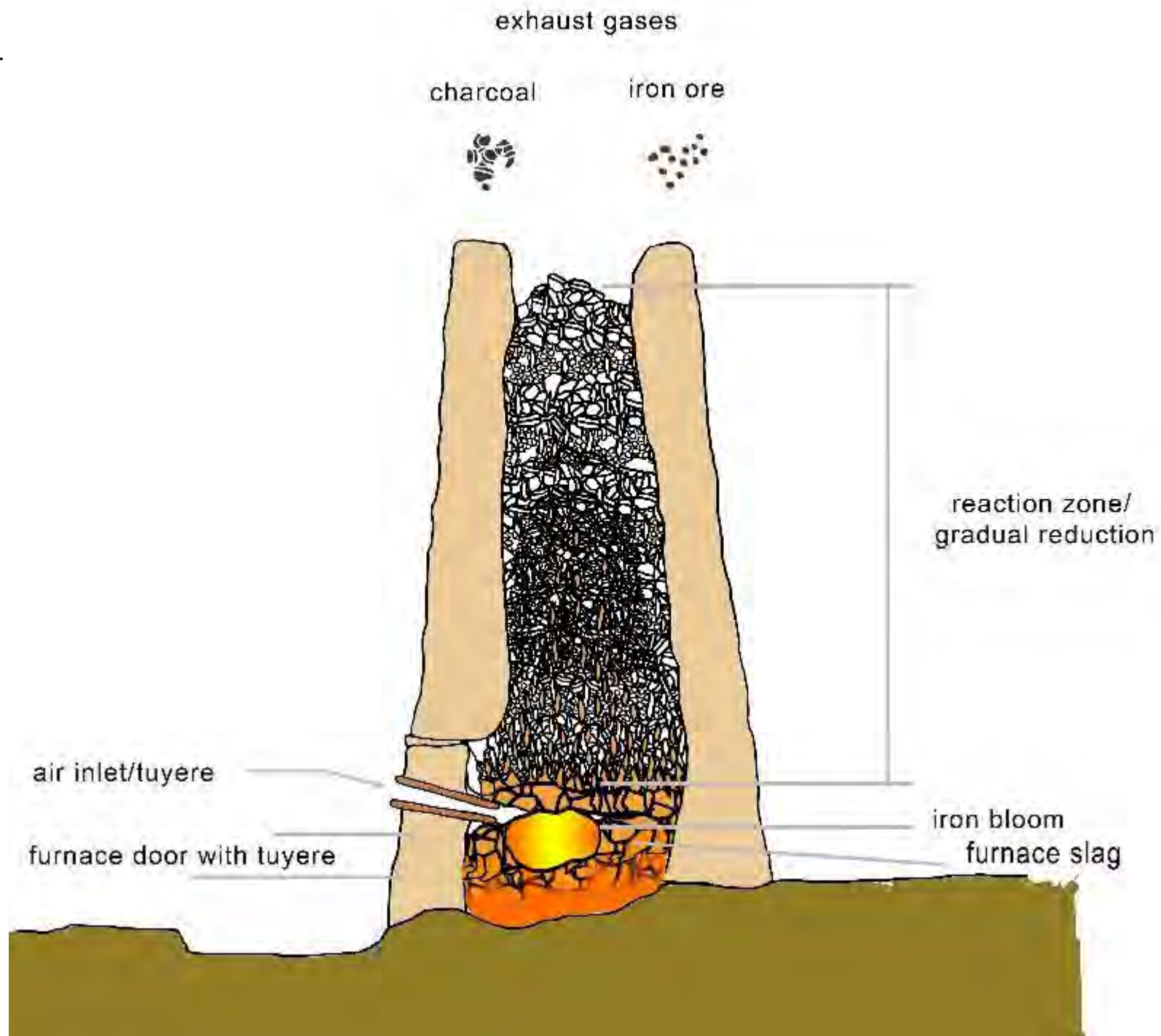


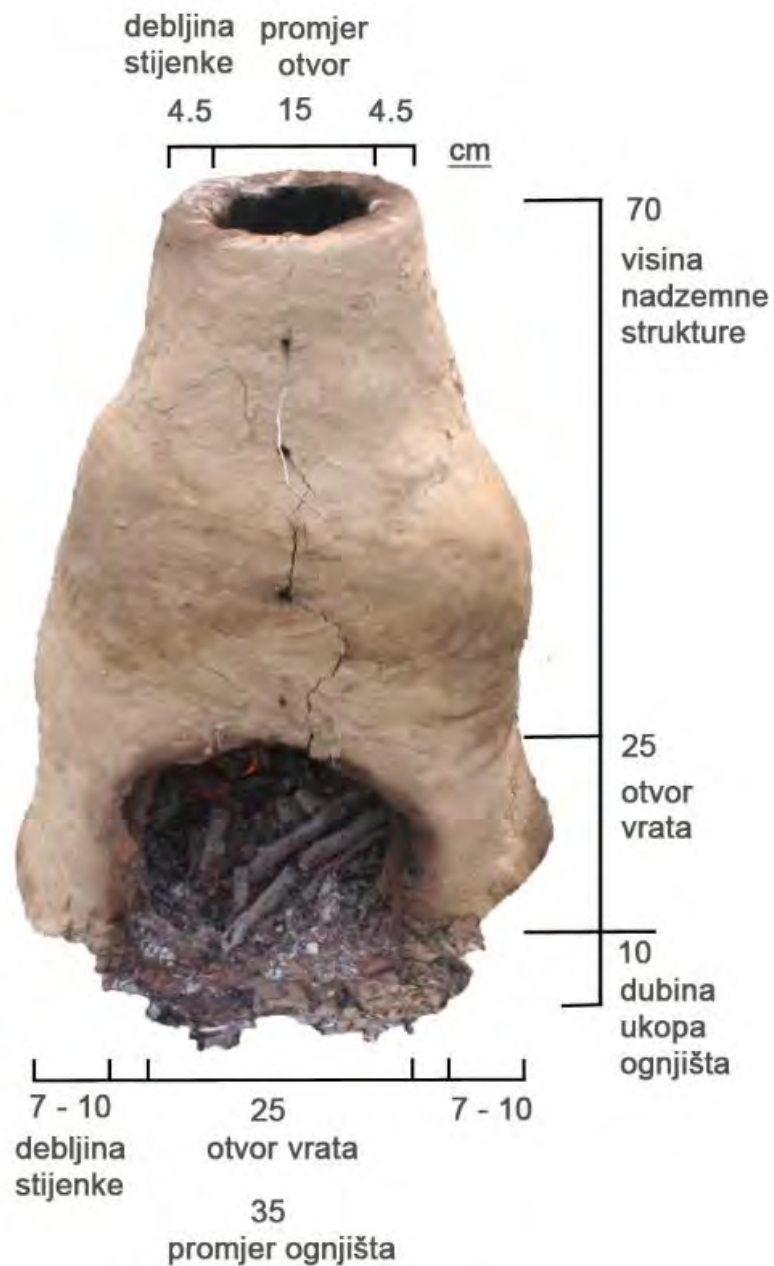


Multiple
sectioning of the
profile ; exact
dimensions and
reconstruction of
specific parts



Reconstruction -





Experimetal smelt, Furnace 1, Koprivnica 2019.

Furnace hearth and slag tapping pit,
Experimental furnace 1. after simulated
excavation

Potential / good sides

- potential to develop as a method for objective classification of objects by means of surface analysis, cross section, saturation of inclusions, porosity – non descriptive, measurable and comparable
- These informations could elevate the range of interpretative elements of macroscopic analysis of slag as well as the interpretation of the results of archaeometric analysis (specific problems – primary smithing slag – phases of development)
- monitoring the progressive corrosion process
- easy, semi automated visualisation
- longterm documentation - remote and continuous work (without revisiting the object)
- multipurpose – scientific and promotional – educational (further reconstruction, 2d and 3d - museums)

Problems /risks

- specific know-how and preconditions on several levels – photography (photo studio conditions), processing (several programs – primary (Agisoft, Meshlab, Cloud-Compare), secondary (3ds Max, Photoshop, AutoCad) - risk of inaccuracy – inconsistent conditions and low – level of know-how
- experimental - need for extensive sampling and comparison
 - experimental measurable results
 - useful comparison with archaeometric results
- time – cost // information gained ?



Thank you for the
attention !

