INSTITUTE OF ARCHAEOLOGY

BELGRADE, SERBIA

1ST INTERNATIONAL CONFERENCE WITH WORKSHOP

SCIENCE FOR CONSERVATION OF THE DANUBE LIMES

Mortar Design for Conservation – Danube Roman Frontier

2000 Years After

PROGRAMME AND ABSTRACTS

VIMINACIUM, SERBIA

JUNE 27TH - JULY 1ST, 2022

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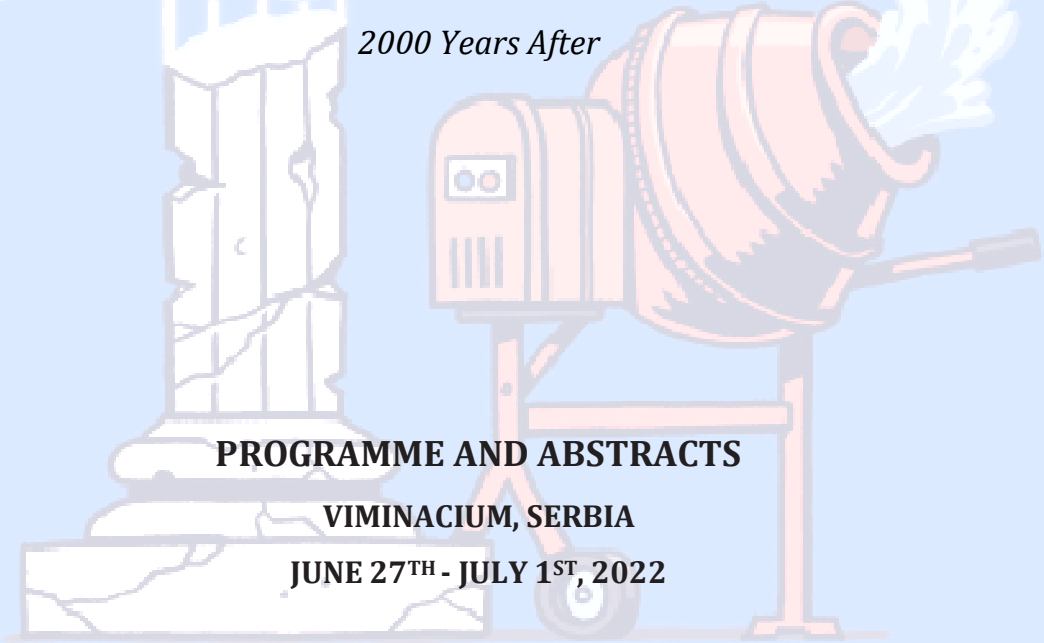

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Publisher:
Institute of Archaeology, Kneza Mihaila 35/IV, 11000 Belgrade, Serbia
institut@ai.ac.rs; https://ai.ac.rs; tel. +381 11 2637-191

ISBN 978-86-6439-072-9
This publication was created by the funding support of the Science Fund. The Institute of Archaeology is solely responsible for the content of this publication and it does not express the views of the Science Fund of the Republic of Serbia.

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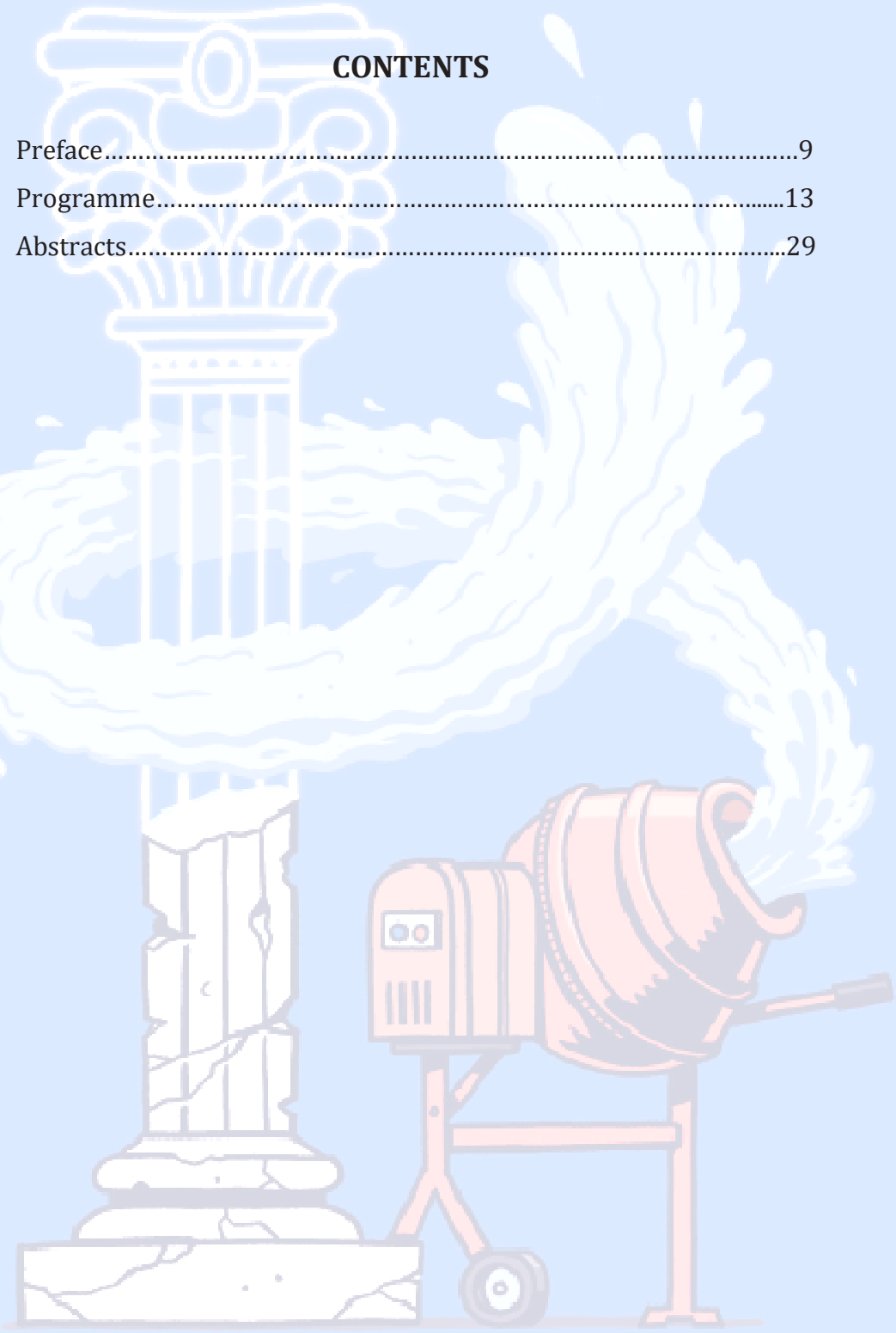

PREFACE

The dust that a building is transformed into when it becomes a ruin holds precious traces of the past. The hands of an archaeologist will search through it patiently, and find a necklace bead of a woman that lived in it. The hands of an architect will virtually transform the dust into a mortar, brick, or stone. The first profession sees through the unbuilt. The second one builds from it. However, both perform their work by communicating with the sciences.

Throughout history, various components were chosen, measured, and mixed into one of the most complex building composites ever - mortar, whose re-creation is of invaluable importance for architectural conservation. Geologists and chemists will best tell us about its composition. However, sometimes, while excavating a ruined wall, an archaeologist finds a mortar trowel, accidentally left by the past builder. Is this a more valuable trace for revealing the creation of a wall than the binder/aggregate ratio of the mortar used? Can we pick it up and imagine the hands that combined colourful aggregate grains with the earth, gypsum, lime, or cement?

From the exploitation, transport, and use of raw materials, to the product called mortar, we pass by the people from the past, the quarries, roads, and rivers, we look at the craftsmen working with tools, and observe the investors negotiating with engineers, and the rulers supervising the construction. The four hands from the beginning of the story can combine the chemistry of the red, blue, green, yellow, black, and white mineral grains with the found trowel, and help us revive many

unknown hands from the past. Thus, the research of historic mortars for conservation purposes must not be a purely technical process. Only by understanding the multiple values of a historic building, we can adequately protect it.

The project Mortar Design for Conservation – Danube Roman Frontier 2,000 Years After (MoDeCo2000), funded by the Science Fund of the Republic of Serbia, was created with the sincere intent and great hope that it could help in the future discoveries and preservation of the rich heritage in Serbia from the period of the magnificent Roman Empire, whose Danubian monuments are part of the preliminary list for UNESCO World Heritage. Different researchers and professionals - architects, archaeologists, geologists, chemists, materials scientists, physicists, biologists, restorers, craftsmen, and managers have all made an effort to get closer to the fulfilment of the wish of the project creators.

After sampling and investigating numerous mortars originating from the structures dating to the period from the 1st to the 6th century, many conclusions were made, but challenges for future researchers and conservators also arose, telling us we need to continue our work in the future, in an attempt to gain more knowledge and, thus, preserve our heritage more adequately.

We welcome you to the Viminacium Archaeological Park and the 1st International Conference with Workshop, Science for Conservation of the Danube Limes. With the hope that many new fruitful collaborations between our guest researchers will be developed on this occasion, taking us one step further towards long-term technical

solutions for architectural conservation and civil engineering based on nature, but also to new cognitions about the life of the past people, always for the cause of the preservation of rich world material and immaterial cultural heritage and our planet, we invite you to peruse this publication. All the authors have shown their enormous affection and passionate devotion towards the discoveries of ancient knowledge, advocating its use in the further preservation of the most monumental physical witnesses of the past – buildings, for future generations.

EDITORS

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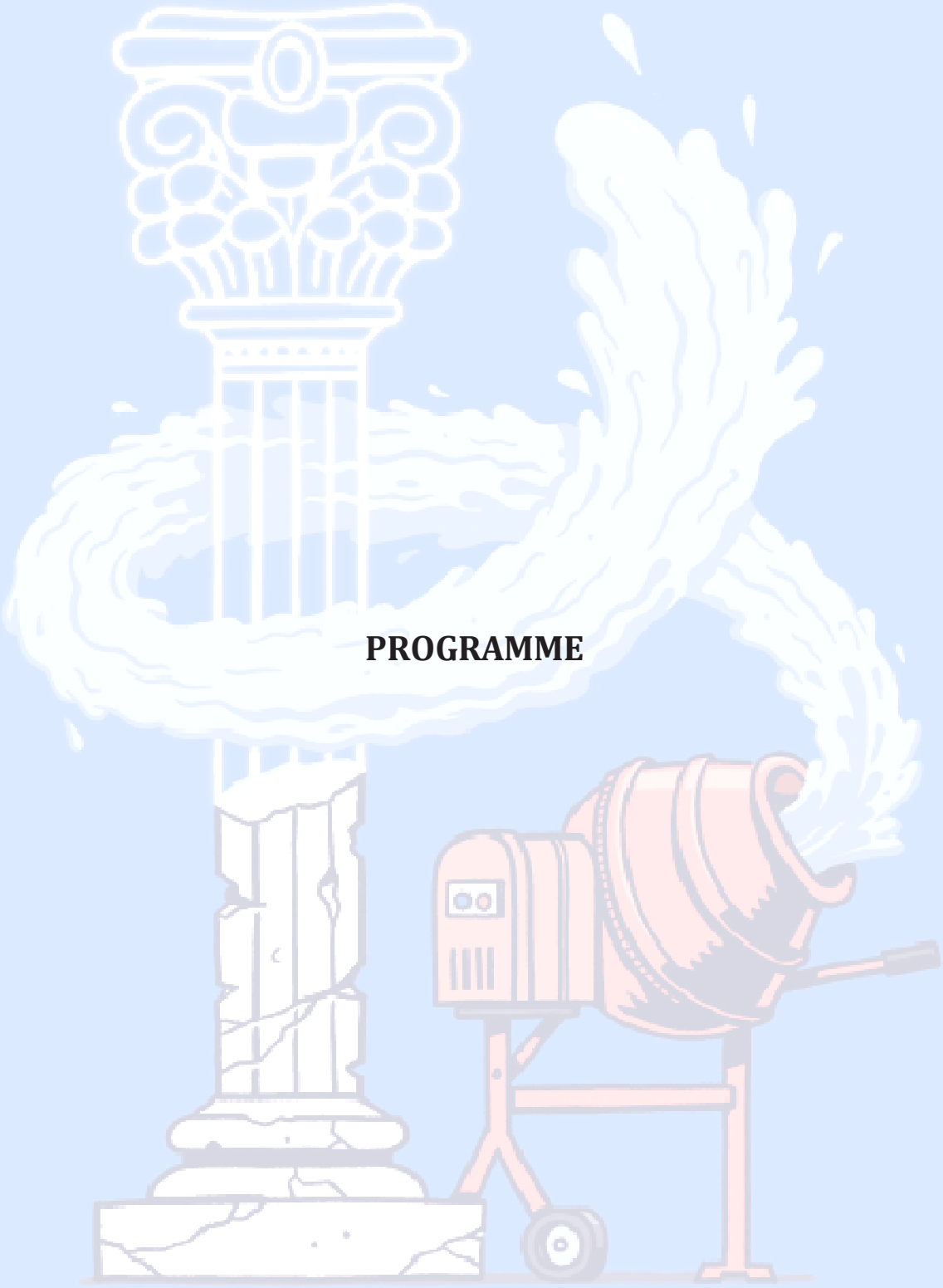


PROGRAMME

MONDAY, JUNE 27TH

08.30 – 10.00 *Breakfast / Coffee and registration*

WELCOME AND INTRODUCTORY SPEECHES

10.00 – 10.40
MIOMIR KORAĆ, Institute of Archaeology, Director
EMILIJA NIKOLIĆ, Institute of Archaeology, PI MoDeCo2000
DUBRAVKA ĐUKANOVIĆ, Institute for the Protection of Cultural Monuments of Serbia Belgrade, Director
JAROSLAV KATONA, Faculty of Technology Novi Sad, University of Novi Sad, Vice Dean for Finances

10.40 – 11.00 NEMANJA MRĐIĆ, IVANA KOSANOVIĆ, MILICA MARJANOVIĆ
Danube Limes in Serbia: On the Way to a UNESCO World Heritage Site – Problems, Challenges and Solutions

11.00 – 11.20 EMILIJA NIKOLIĆ, MLADEN JOVIČIĆ, IVANA DELIĆ-NIKOLIĆ, LJILJANA MILIČIĆ, SNEŽANA VUČETIĆ, JONJAUA RANOGAJEC
Our MoDeCo2000: Results Overview of the Scientific and Research Project

11.20– 11.40 *Coffee break with snack*

LECTURES

11.45 – 12.05 MLADEN JOVIČIĆ

Researching Roman Mortars from the Danube Region - Archaeological Perspective of the MoDeCo2000 Project

12.05 – 12.25 SNEŽANA VUČETIĆ, JONJAUA RANOGAJEC, IVANA DELIĆ-NIKOLIĆ, LJILJANA MILIČIĆ, EMILIJA NIKOLIĆ, MLADEN JOVIČIĆ

Design of Compatible Mortars for Conservation Interventions

12.25 – 12.45 EUGEN VAIDA, VERONICA VAIDA, ALEXANDRA TEODOR

The Ambulance for Monuments - Safeguarding Heritage through Community Engagement

12.45 – 13.30 NIGEL COPSEY

Rediscovering Traditional Mortars, part 1

13.30 – 14.30 *Lunch break*

LECTURES

14.35 – 15.20 NIGEL COPSEY

Rediscovering Traditional Mortars, part 2

15.20– 15.35 *Coffee break*

LECTURES

15.40 – 16.25 NIGEL COPSEY

Rediscovering Traditional Mortars, part 3

17.00 – 18.30 *Viminacium sightseeing*

18.30 – 19.30 *Dinner*

21.00 *Viminacium Fest / Theatre festival*

(Closing night in the Viminacium amphitheatre with a jazz concert)

TUESDAY, JUNE 28TH

07.30 – 09.00 *Breakfast / Coffee*

PRACTICAL WORKSHOP ON LIME MORTARS

09.00 – 13.00 NIGEL COPSEY DEMONSTRATION
Building Experimental Structures of Brick and Stone with Lime Mortar

13.30 – 14.30 *Lunch break*

LECTURES

14.35 – 15.05 VLADICA CVETKOVIĆ, KRISTINA ŠARIĆ
Tuffs of Serbia – What We Need to Know when Characterising Them as Archaeological Raw Material

15.05 – 15.35 KRISTINA ŠARIĆ, SUZANA ERIĆ, VLADICA CVETKOVIĆ, JOSIP ŠARIĆ, DRAGANA ANTONOVIĆ, VESNA BIKIĆ
Geological Knowledge in Service to Archaeological Investigations: Rock and Ceramic Findings as Examples

15.35 – 15.55 YOTAM ASSCHER, MICHELE SECCO, GIULIA RICCI, SERGIO TAMBURINI, GILBERTO ARTIOLI *(virtual)*
Evaluation of Ancient Mortars Hydraulicity through the Characterisation of Long and Short-range Crystallinity

15.55 – 16.15 LJILJANA DAMJANOVIĆ VASILIĆ, VESNA BIKIĆ, SRNA STOJANOVIĆ, IVANA RADOSAVLJEVIĆ EVANS, DANICA BAJUK – BOGDANOVIĆ, IVANKA HOLCLAJTNER – ANTUNOVIĆ
Physicochemical Characterisation of the Medieval Pottery Excavated in Serbia

16.15 – 16.35 *Coffee break with snack*

LECTURES

16.40 – 17.00 MARIA STEFANIDOU
Technological Characteristics of Fired Bricks from Roman and Byzantine Period in Greece

17.00 – 17.20 SIMONE DILARIA, CATERINA PREVIATO, JACOPO BONETTO, MICHELE SECCO, ARTURO ZARA, DOMENICO MIRIELLO, RAFFAELLA DE LUCCA, GILBERTO ARTIOLI
Pyroclastic Rocks in the Structural Mortars of Roman Nora (Sardinia). A Green Material for the Production of Sustainable Concretes in Antiquity

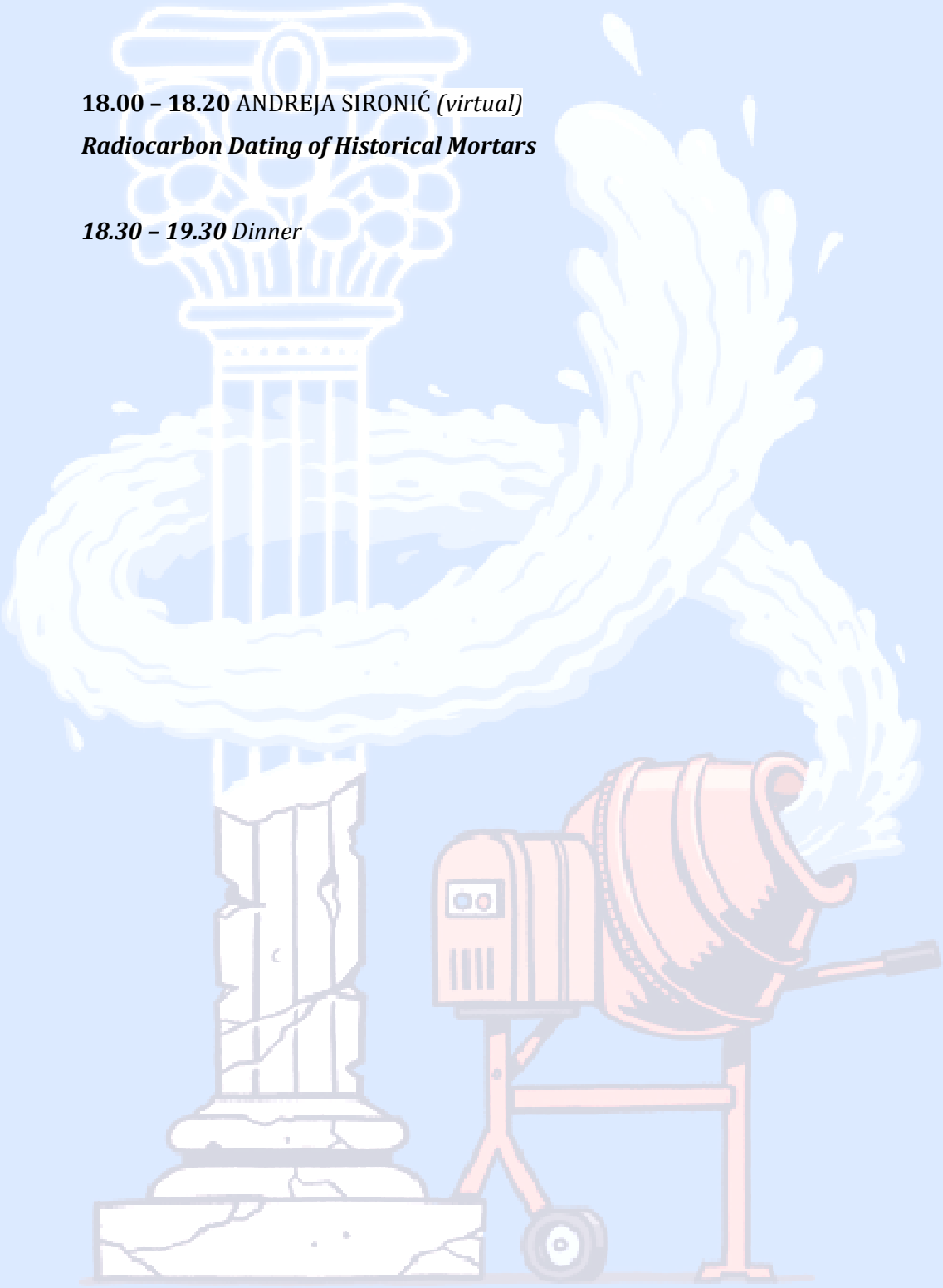
17.20 – 17.40 ANNA ARIZZI
Learning from Historic Mortars: Studies on Lime Manufacturing and Fresco Conservation

17.40 – 18.00 MICHELE SECCO SIMONE DILARIA, GIULIA RICCI, ENRICO GARBIN, SERGIO TAMBURINI, YOTAM ASSCHER, GILBERTO ARTIOLI, CATERINA PREVIATO, JACOPO BONETTO
Novel Scientific Perspectives on Ancient Pozzolanicity

18.00 – 18.20 ANDREJA SIRONIĆ *(virtual)*

Radiocarbon Dating of Historical Mortars

18.30 – 19.30 *Dinner*



WEDNESDAY, JUNE 29TH

International Danube Day

07.30 – 09.00 *Breakfast / Coffee*

LECTURES

09.00 – 09.20 IVAN BOGDANOVIĆ

Roman Construction Techniques Used on the Viminacium Amphitheatre

09.20 - 09.40 FLORIAN MATEI-POPESCU

New Archaeological Excavations at the Drobeta Military Amphitheatre

09.40 – 10.00 JASMINA POPOVIĆ RUSIMOVIĆ

Restoration of Ram Fortress

EXCURSION

10.15 – 11.20 Viminacium – Golubac Fortress

11.30 – 12.30 Golubac Fortress Tour

12.40 – 13.45 Golubac Fortress - Golubinje

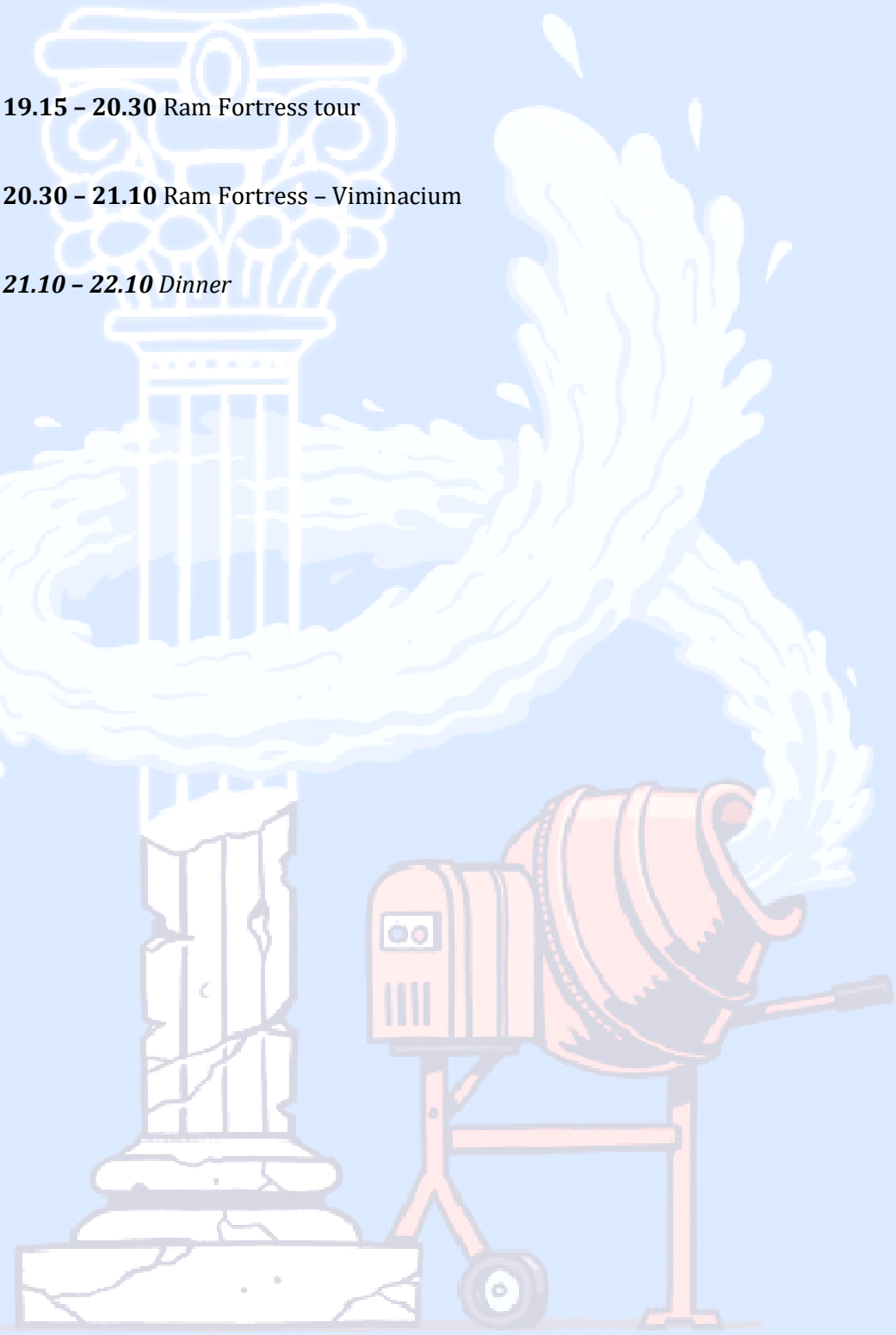
14.00 – 17.00 Hiking to viewpoint Ploče and back (lunch package at the top)

17.15 – 19.05 Golubinje – Ram Fortress

19.15 – 20.30 Ram Fortress tour

20.30 – 21.10 Ram Fortress – Viminacium

21.10 – 22.10 *Dinner*



THURSDAY, JUNE 30TH

07.30 – 09.00 *Breakfast / Coffee*

PRACTICAL WORKSHOP ON LIME MORTARS

09.00 – 13.00 NIGEL COPSEY DEMONSTRATION

Testing Conservation Mortar Mixtures on a Part of an Authentic Structure

13.30 – 14.30 Lunch break

LECTURES

14.35 – 15.05 IOANNA PAPAYIANNI

Analysis of Ancient Mortars from Roman Monuments in Northern Greece. Design and Application of Compatible Repair Mortars

15.05 – 15.25 SLAVICA VUJOVIĆ, RASTKO VLAJKOVIĆ

Holism as a Framework for Understanding and Preserving Heritage – the Example of the Cultural Landscape of Bač

15.25 – 15.45 BURCU TAŞCI ÖZDEMIR, HASAN BÖKE *(virtual)*

Raw Material Characterisation of Roman Mortars in Western Anatolia (Turkey)

15.45 – 16.05 ALEKSA JELIKIĆ

Lime Kiln. The Divine Crucible

16.05 – 16.25 LJUBOMIR JEVTOVIĆ

Ceramic Building Materials of Viminacium

16.25 – 16.45 *Coffee break with snack*

LECTURES

16.50 – 17.10 ANA RADIVOJEVIĆ

The Role of Brick in the Late Antique Architecture of the Central Balkan Roman Provinces

17.10 – 17.30 IGOR BJELIĆ

Construction Methods Applied to the Structures of the Trajan's Bridge over the Danube

17.30 – 17.50 BOJAN POPOVIĆ

Reconsidering the Archaeological Site of Glamija – Rtkovo, Serbia

17.50 – 18.10 TINO LELEKOVIĆ

How to Present the Ancient City of Aelia Mursa

18.10 – 18.30 HELENA HIRŠENBERGER, SNEŽANA VUČETIĆ, JONJAUA RANOGAJEC

Cross-disciplinary Collaboration in Conservation Projects – Managing Key Challenges

18.30 – 19.30 *Dinner*

FRIDAY, JULY 01ST

07.30 – 09.00 *Breakfast / Coffee*

LECTURES

09.00 – 10.30 BRANKO ORBANIĆ

Traditional Lime Production and its Application on the Monuments of Culture – Experience from the Work on Ancient Monuments

10.30 – 10.50 *Coffee break with snack*

LECTURES

10.55 – 11.15 MAJA FRANKOVIĆ, VESNA MATOVIĆ, NEVENKA NOVAKOVIĆ

Intrinsic Properties of the Limestone Used in the Belgrade Fortress and their Influence on Degradation Processes

11.15 – 11.35 DRAGANA GAVRILOVIĆ

Analyses of the Pigments and Plasters on the Examples of Roman Wall Paintings from Sirmium and Viminacium

11.35 – 11.55 MARIA ARGIROVA, GERGANA KABAKCHIEVA, DENITSA YANCHEVA, BISTRA STAMBOLIYSKA, NIKIFOR HARALAMPIEV, DIETER FISCHER, ALBENA LEDERER

Pigment Identification in the Mural Decoration from the Roman City of Ulpia Oescus by Vibrational Spectroscopy and SEM-EDS Analysis

11.55 -12.15 NIKOLA UNKOVIĆ, ŽELJKO SAVKOVIĆ, MILOŠ STUPAR, ALEKSANDAR KNEŽEVIĆ, IVICA DIMKIĆ, MILICA LJALJEVIĆ GRBIĆ
Fungal Proliferation on Fresco Painting: Deterioration of Mortar and Painted Layer

12.15 – 12.35 IVAN VANJA MARTINOVIĆ
Benefits and Limits of DRMS Technology in the Purpose of Designing Repair Mortars by Drilling Resistance Criterion

12.35 – 12.50 *Coffee break with snack*

LECTURES

12.55 – 13.15 MARKO NIKOLIĆ, ENA TAKAČ, JELENA ŠĆEKIĆ
Contemporary Approaches to the Revitalisation, Presentation and Promotion of Cultural and Natural Heritage of the Part of the Roman Limes - Case Study of the Late Antique Tomb in Brestovik

13.15 – 13.35 SILVANA BLAŽEVSKA, ANGELA PENCHEVA *(virtual)*
Master Conservation Plan for the Archaeological Site of Stobi: Goals and Outcomes

13.35 – 13.55 BOJAN MILJEVIĆ, ALENKA MAUKO PRANJIĆ, SERGEY E. KICHANOV, SNEŽANA VUČETIĆ
Computed Tomography as a Tool for Non-destructive Investigation of Cultural Heritage Materials' Inner Structure

13.55 – 14.15 ROMAN BALVANOVIĆ, PERICA ŠPEHAR, DRAGANA SPASIĆ-ĐURIĆ, OLIVERA MILOVIĆ, MIHAILO MILINKOVIĆ

Roman, Late Antique and Byzantine Window Glass from 3rd – 6th Century in Serbia: Chemical Characteristics, Compositional Groups and Provenance

14.15 – 14.30 *Closing of the event*

14.30 – 15.30 *Lunch*

SPECIAL GUEST OF THE WORKSHOP

NIGEL COPSEY, Stonemason and Building Conservator

Starting out as a dry-stone waller in Cornwall, Nigel trained after 1989 as a stonemason and carver at Weymouth College, working largely thereafter in the conservation industry across the south and south-west of England, as well as travelling widely in the USA, working and advising upon building conservation projects in Vermont, New York City and Nebraska as well as in Granada, Andalusia, and, more recently, in British Columbia and Alberta, Canada.

Nigel was consultant stonemason for the Irish Hunger Memorial project in Battery Park City, New York, 2001. Since 2001, Nigel has worked extensively as a consultant and practitioner in the field of building conservation and repair in North Yorkshire on a wide range of vernacular and high status buildings, as a building conservation consultant for the Fitzwilliam Estate in Malton, 2003-2010, designing, specifying and executing major repair projects on a wide range of historic buildings within the town, as well as researching, designing and specifying a number of building repair and conservation projects on behalf of Natural England, most recently at Scampston Hall.

A committed SPAB-member, Nigel is also a professionally accredited conservator-restorer and determined advocate for the thoroughgoing use of traditional materials in the care and repair of old buildings, and a leading advocate for the routine use of traditional

earth-lime and hot mixed lime mortars for most applications, working with Historic England, Historic Environment Scotland and CADW and international partners in the delivery of practical training and education regarding the informed use of traditional quicklime mortars for the like for like and compatible repair of historic buildings. In recent years, Nigel has worked closely with the North York Moors National Park, educating and upskilling builders and professionals regionally in the use of like-for-like traditional mortars.

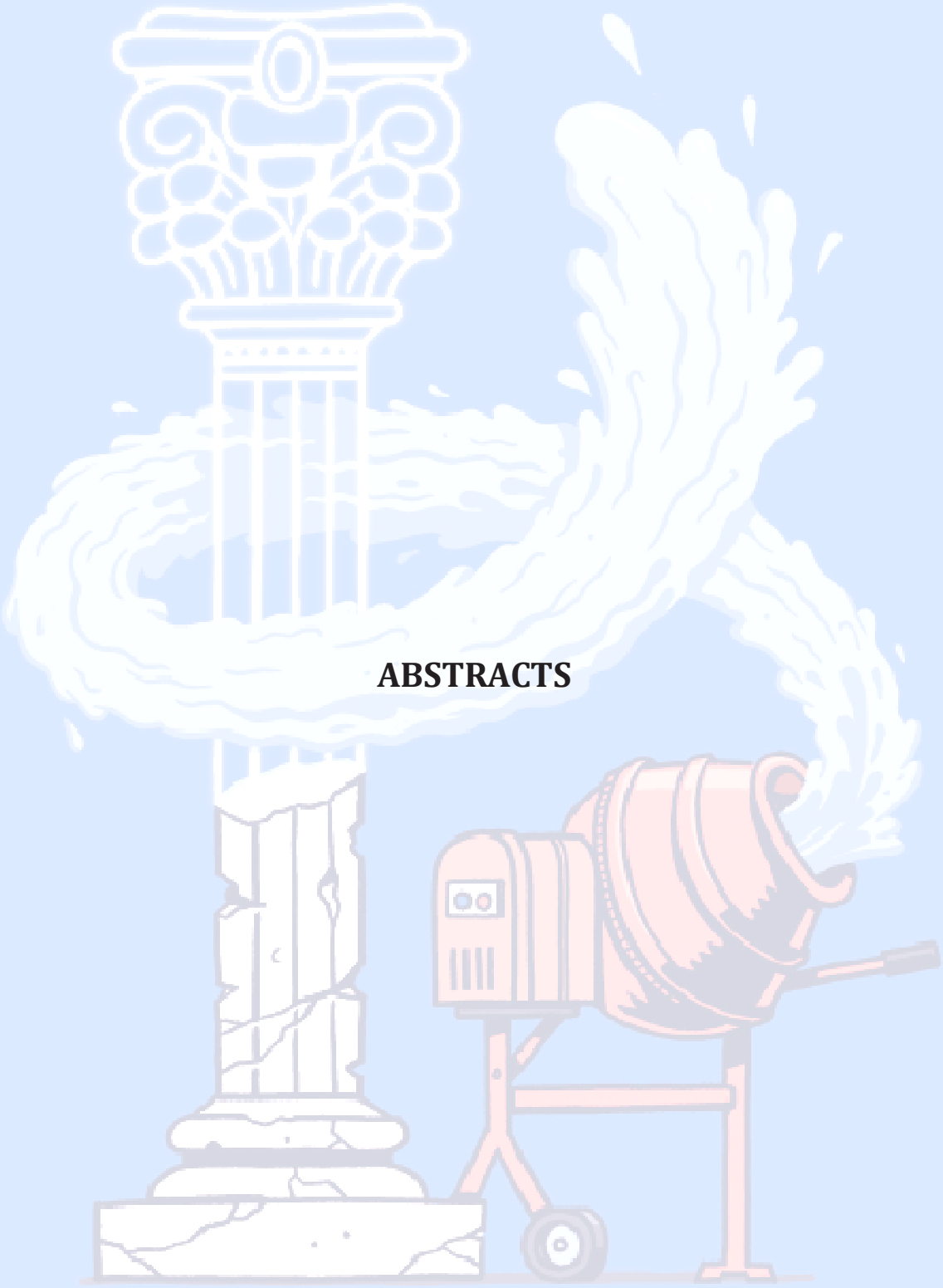
A Research Associate of the Department of Archaeology, University of York, Nigel regularly delivers hot mixed earth and lime mortars and traditional skills training and led the Practical Skills module for the MA Conservation Studies 2012-2018. Nigel has a BA (Hons) in Political Science from the University of York, a PGDip in Building Conservation from Bournemouth University, and an MA (by research) awarded by the University of York in 2019, for his critical review of historic texts, thinking and craft practice in the preparation and use of lime (and earth-lime) mortars.

Nigel has contributed to several volumes of the recently published Historic England Practical Conservation series. He has published a book on the subject of Traditional Mortars (2019) as well as a review of Historic Literature on Lime and Lime Mortars (HES Technical Paper 30 (2019).

www.nigelcopsey.com

www.maltonbuildingsgroup.com

www.hotmixedmortars.com



ABSTRACTS

GEOLOGY OF RAW MATERIALS IN ROMAN MORTARS OF THE DANUBE LIMES IN SERBIA

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Geological building materials have always played a very important role in the construction of all types of buildings. They were among the first mineral raw materials exploited, processed, and used by man (Prikril et al., 2016). In most cases, these are raw materials of a local character, cheap, and easily available. Accordingly, geological building materials used to make Roman mortars, known for their enviable mechanical properties and durability, played a very

important role in the area of the Danube Limes in Serbia. Geologically, this area is built of petrologically different rocks of different geological ages. The rocks formed from the Palaeozoic to the Quaternary contain all the basic geological building materials: sand and gravel, stone, clay, etc.

Probably the most important and most exploited and used mineral raw material in the Roman mortars of this area is sand and, less frequently, gravel, from the alluvial deposits of the Danube and other local watercourses, created by the mechanical accumulation of clastic material made in the process of decay of parent rocks. These alluvial sediments of the Quaternary age have a heterogeneous mineralogical-petrographic composition, conditioned by the hydrogeological regime and geological structure, i.e., the character of the rocks exposed to decay within the catchment zones and geomorphological conditions. They consist of unevenly rounded grains of quartz, chert, quartzite, metamorphic rocks, sandstones, volcanic rocks, etc. As the grain size of these unbound rocks decreases, the percentage of minerals increases.

In addition to sand and gravel, in the area of the Danube Limes, local stone fragments were occasionally used as an aggregate for making mortar. Thus, in the area around the village of Ram, schist grains were used as an aggregate, the origin of which is most likely the surroundings of the village itself, i.e., the Ram-Zatonje area. These schists represent the oldest geological formations in the wider area. They have a low degree of metamorphism, caused by the intensive

transformation of volcanogenic-sedimentary rocks, i.e., gabbroid rocks and fine-grained sandstones, siltstones and clays. According to the mineral composition, these schists are determined as: epidote-chlorite-actinolytic, chlorite-epidote-mica-actinolytic, epidote-amphibolytic, sericite-muscovite, muscovite, chlorite and chlorite-sericite-quartz.

Limestones are of special importance among geological building materials, as raw materials for lime production. Limestones are not very common in the area of the Danube Limes, they can be found in the area of Belgrade, in the vicinity of Golubac, and Veliko Gradište, along the Danube gorge. They are mostly Mesozoic, Cretaceous and Jurassic, but in the area of Belgrade, the Danube Key and in the vicinity of Donji Milanovac there are lithotamnian limestones with numerous remains of marine fauna. They are Tortonian, i.e., middle Miocene age.

In the area of Viminacium, crushed or ground bricks were often used as an aggregate, but also as an additive to mortars. In this area, brick raw materials had a significant distribution, so in accordance with that, Viminacium was a provincial centre for brick production. These raw materials are genetically related to Quaternary sediments, more precisely the occurrence of loess and clay, in the area of Požarevac ridge and villages around Kostolac: Kličevac, Majilovac, Kurjače, etc. In addition to brick and stone, “naturally baked bricks” were used to build ancient Viminacium. These were known locally as "crvenka", and were formed as a product of combustion of clay

sediments after self-ignition of coal deposits, which was found to have certain pozzolanic properties and is, therefore, assumed to have been added to lime mortars after crushing or grinding to improve their properties.

Natural materials with pozzolanic properties certainly played an important role in the production of historical mortars of the Danube Limes, and research into their use is still in its early stages. Since they did not necessarily have to be local raw materials, the process of their identification, role, importance, origin, etc. is a challenging task for researchers of various disciplines, and it can bring extremely important knowledge to the field of exploitation and use of raw materials and their transport, such as the economic flows between different territories in a given historical period.

Keywords - Roman mortars, raw materials, local resources, geological landscape, Danube Limes

Acknowledgments: *This research was supported by the Science Fund of the Republic of Serbia, PROMIS, #GRANT No. 6067004, MoDeCo2000*

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CIP - Каталогизација у публикацији
Народна библиотека Србије, Београд

904"652"(37)(048)

INTERNATIONAL Conference with Workshop Science for Conservation of the Danube Limes (1 ; 2022 ; Viminacium)
Mortar design for conservation – Danube Roman frontier 2000 years after [Elektronski izvor] : programme and abstracts / 1st International Conference with Workshop Science for Conservation of the Danube Limes, Viminacium, June 27th - July 1st, 2022 ; [editors Emilija Nikolić, Mladen Jovičić] ; [book illustration Nikola Korać]. - Belgrade : Institute of Archaeology, 2022 (Belgrade : Institute of Archaeology). - 1 elektronski optički disk (CD-ROM) ; 12 cm

Sistemski zahtevi: Nisu navedeni. - Nasl. sa naslovne strane dokumenta. - Tiraž 10.

ISBN 978-86-6439-072-9

а) Археолошка налазишта, римска -- Србија -- Апстракти

COBISS.SR-ID 70334473