

# newsletter

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EVENTS  
RESEARCH

 Czech Academy  
of Sciences

 ITAM ARCCHIP  
INSTITUTE OF THEORETICAL  
AND APPLIED MECHANICS

1 / 2020

## INTERNATIONAL PROJECTS STARTED IN 2020

In the first half of this year, several international projects funded by the Interreg and Horizon2020 programs began, in which the Institute of Theoretical and Applied Mechanics CAS participates as a partner.

The first of these is the STRENCH project (STRENGTHening resilience of Cultural Heritage at risk in a changing environment through proactive transnational cooperation, Interreg Central Europe), which builds on, among others, the ProteCHt2save and RUIINS projects. Logically, therefore, it also deals with the protection and resilience of cultural heritage to natural and man-made disasters which constitute a threat of increasing frequency. Such ever-changing challenges call for innovative approaches to conservation and protection. The STRENCH project aims to increase the capacity of the public and private sectors to mitigate the impacts of climate change and natural risks through the use of climate change models, risk indices, vulnerability assessments, services and products developed, tested and used in previous projects. Another Interreg project, this time an Austrian-Czech collaboration, is the project with the acronym ImageHeadstart (full name Breakthrough applications of computer vision in the microworld: Consortium of research organizations for industry 4.0). As the name suggests, the project aims to create a consortium of companies and regional research organizations in which companies can draw on the knowledge of research organizations and thus achieve competitiveness in specific areas and an edge in global competition, specifically in the field of computer imaging of the microworld. Ordinary users, including in the realm of business, rarely get information on how much a particular method of capturing and saving images preserves or fundamentally changes the basic structure of an image. To get a perfect picture, the perception of the human eye must be deceived. This is possible only by distorting the original signal of the camera sensor. However, this significantly limits the competitiveness of image data users because from distorted data they are not able to develop groundbreaking algorithmic solutions in related technologies such as automatic recognition, measurement and similar applications. At the same time, these are the input for artificial intelligence, and thus form the basis for the development of robotic devices in the entire range from production, through operation control and building security,

medical applications to automated machines, in short, the entire industry 4.0. Thanks to the project, companies in the region will receive the necessary information, which will increase their competitiveness in the field, and subsequently the competitiveness of the entire region.

The IPERION HS project (Integrated Platform for the European Research Infrastructure, Horizon2020) builds on, among others, the preparatory project E-RIHS, in which ITAM AV ČR also participated. The consortium project brings together national infrastructures for cultural heritage research. The aim is to create a unique research infrastructure in which state-of-the-art equipment and laboratories, methodologies, data and tools can be shared and used across Europe. Also, bringing together experts from different disciplines and countries should lead to greater knowledge sharing, further innovation and a higher level of knowledge in the field of monument science. The project brings together partners from more than 23 countries.

B. Přečová

## EDITORIAL

Dear friends of science,

The current newsletter of the Institute of Theoretical and Applied Mechanics, now in front of you, is largely devoted to the field of cultural heritage protection and materials research. This is a good thing; activities in these areas lead to understanding the technological processes of our ancestors, from which it is possible to gain even today. A world chess champion once said: "The start of the game does not have to be new, it just needs to be well forgotten." This comes to mind when I see the research on Baroque stucco techniques, or the process of unveiling the secrets of rolled-up lead sheets, concealing a more or less dark curse, by means of scattering photons on the shallow engraved font. The staff of the Laboratory of X-ray Tomography at our Centre Telč is able to do that with the help of equipment using biaxial X-rays and the large-area detectors of the TORATOM set.

In addition to these fascinating contributions, the new issue also provides information about research on the chemical degradation of concrete, which was published in a prestigious scientific journal, as well as information on the activities of the Department of Heritage Science at the SCOLA TELCZ workshop.

Activities in the field of monument protection are the result of ITAM's many years of successful involvement in the international context, especially in the Interreg and Horizon2020 programs. At home, ITAM had success with a project linking the approaches of technical, natural and social sciences within the AV21 Strategy. The next issue of the Newsletter will focus on those results. It's definitely something to look forward to.

Stanislav Pospíšil, ITAM director

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RESEARCH IN BAROQUE STUCCO TECHNIQUES HELPED RESTORE THE GRANDEUR OF THE LARGE HALL AT ČERVENÁ LHOTA

Throughout their practice, restorers encounter a wide range of historical materials and original technologies which they are not always able to thoroughly understand. Their knowledge should be a cornerstone while designing corrective procedures, especially if concerning original work unchanged by any previous repairs. The project NAKI DG16P02H012 Lime Materials for Restoration and Conservation (2016-2020), which is focused on technological support for restorers, deals with this issue. The project aims to develop lime plasters which, in their composition, quality, and processing, correspond to the originals, as well as design appropriate application procedures. One of the case studies was the early Baroque stucco decoration of the Tencall Hall at the Červená Lhota chateau.

Restoration of the paintings, stucco, and plaster of this hall began in 2017 when the first samples were collected for a detailed material study. Due to the extent of the stucco decoration, research activities focused on the decorations of the vaulted ribs. In Fig. 1 we see that the ribs are covered with small shapes (leaves, cups, cherries) and larger elements, which are collectively referred to as fruits. Thanks to a detailed analytical approach, two basic mortar mixtures, used to create highly plastic decors, were characterized: a fine lime mixture and a gypsum-lime mixture. In addition to the two types of binders, plasterers also used sand of local origin, which they modified depending on the modelled element, Fig. 2. Traces of collagen were detected in the mortars, which showed the use of glue water as a gypsum setting modifier. An important part of this research phase was cooperation across the departments of ITAM.

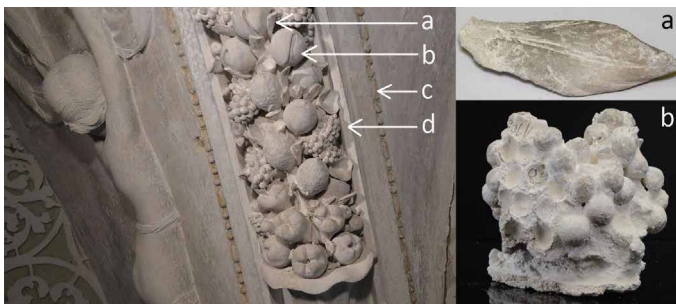


Figure 1: Detail of stucco decoration the Tencall Hall. a - small shapes (e.g. leaf), b - fruit (e.g. grapes), c - mother-of-pearl, d - rib.

Based on the identified characteristics, a survey of available materials was conducted. The Calcarius database (created in the previous NAKI project, <http://www.calcarius.cz/gis-calcarius/>) provided information on the selection of raw materials for lime production, which directed the prospecting to the Chýnov locality, 25 km north of the chateau. A deposit of a suitable pure raw material in the form of crystalline limestone was found there, and the obtained material was fired in an experimental kiln in Solvay quarry and further processed in a manner corresponding to the procedures of the time. According to the mineralogical composition, the filler used was the local river sand, which can be found, among other places, directly in the subsoil of the pond surrounding the chateau. The question of the provenance and processing of the gypsum proved to be a greater research challenge. The nearest gypsum deposits can be found in the Opava Basin (CZ and PL), in the Northern Limestone Alps (A) and in Zechstein (D). Samples from Czech Kobeřice and Austrian Preinsfeld were obtained and analysed. Based on the analysis

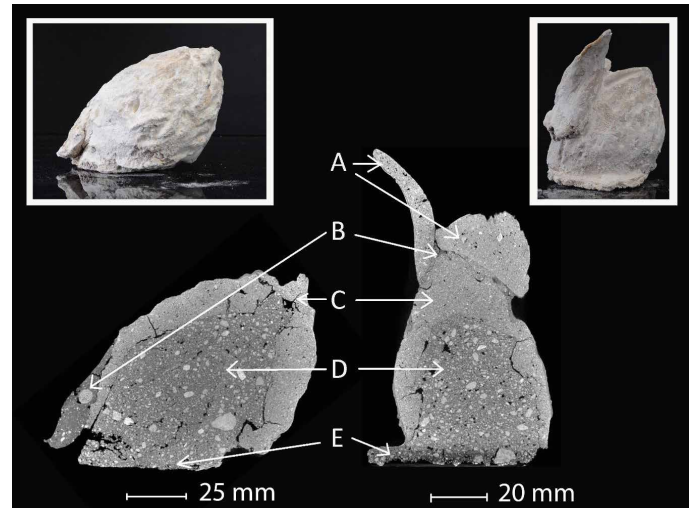


Figure 2: CT scans and photos of lemon (left) and almond (right). A - leaves (L, < 1 mm), B - fine adhesive mortar (GL, < 1 mm), C - outer stucco layer (L, < 1 mm), D - inner core mortar (GL, < 8 mm), E - coarse adhesive mortar (GL, < 8 mm). The different colours of the binder matrix may also indicate a different mortar density (difference between D and E). Cracks, pores, larger grains of filler or binder pieces are also visible. L - lime mortar, GL - gypsum-lime mortar.

of stable isotopes of sulfur and strontium, gypsum from Kobeřice was excluded. The obtained raw material was experimentally fired at both low and high temperatures according to procedures described in a treatise from the turn of the 17th century.

The preparation of the materials was followed by verification of their functionality through practical testing conducted together with



Figure 3: A view of the part section with glued transfers and accessories in daylight (A) and in UV light (B). Zinc whiteoxide, which was mixed in to the new supplements additions, fluoresces green.



restorers. Several workshops took place in the experimental centre in Solvay's quarry, during which a methodology for creating a copy of the studied stucco was gradually established. Thanks to detailed analyses and practical verification of the methods of working with authentic materials, it was possible to design mortar mixtures and technological procedures for the repair of the stucco decoration of the hall. The transferred fruit was successfully reattached using the proposed adhesive mortars, and the missing parts were replaced with material and technological copies of the originals, Fig. 3. The whole process of designing the material and technological copy is detailed in an accredited procedure, and the research was published in professional journals and presented at conferences. Here we would like to thank all of our colleagues who participated in this study. We believe that use of the obtained information in practice is a pleasant reward for all of us. We cooperated on the realisation of the accredited Procedure with the restorers Mgr. J. Waisser and MgA. Z. Wichterlová.

O. Skružná, J. Válek

**Related article:** Válek, J., Skružná, O., Kozlovce, P., Frankeová, D., Mácová, P., Viani, A., Kumpová, I. *Composition and technology of the 17th century stucco decorations at Červená Lhota Castle in Southern Bohemia. International Journal of Architectural Heritage. 2020. ISSN 1558-3058. Doi: 10.1080/15583058.2020.1731627.*

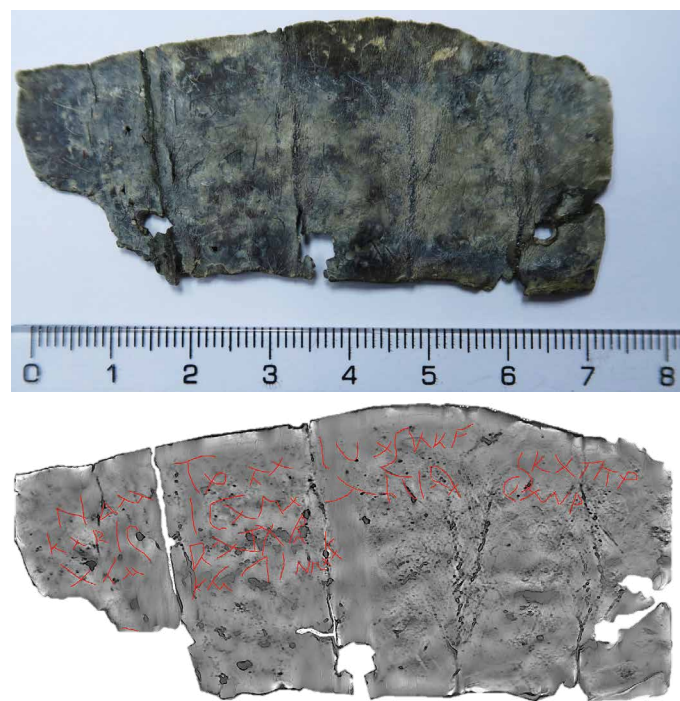
## TABELLAE DEFIXIONIS: X-RAY MICRO-TOMOGRAPHY OF THE TEXT HIDDEN IN LEAD

In recent years, the topic of curse tablets—referred to as *tabellae defixionis* in Latin—has attracted great interest among professionals from many countries. These tablets, in the form of thin lead sheets with an engraved message, tightly folded, rolled and sometimes pierced, were intended to affect the lives of humans or animals against their will by supernatural means. They were usually deposited in places where chthonic deities and daemons of death were expected to appear and fulfill the wishes of the writers, such as graves of prematurely dead or violently killed people, fountains or wells, sanctuaries, and amphitheatres. Curse tablets were being discovered for centuries, but many of them were found mechanically damaged (corroded, broken) or have been stored in depositories for long periods of time and are now illegible, their dark messages remaining a mystery. In Pannonia, there are only 10 such extraordinary and precious finds documented. Two of them found in the Savaria region (today Szombathely) were investigated in the Laboratory of X-Ray Tomography, CET in cooperation with the Research Institute for Linguistics of the Hungarian Academy of Sciences and the Masaryk University, Faculty of Arts, Department of Classical Studies.



**Figure 1:** Accommodation of the box with the tablet in the TORATOM scanner.

In the past, these tablets were mechanically unfolded in an effort to read the engraved text. However, this was only partly possible due to the presence of folds and corrosion products on the surface of the lead sheets. “Iseum” defixio (dimensions of 150 × 55 mm, approx. 1st century AD) was found near the wall of Iseum by the Amber road leading through Savaria. On this tablet, some names of soldiers and officers are legible, which is rarely documented in curse tablets. A substantial part of the tablet, however, is illegible. “Bartók Terem” defixio (dimensions of 75 × 35 mm, approx. 4th century AD) was found on the other side of the Amber road in a Roman cemetery. Only the first words—which read “my enemies”—are known, while the rest of the text is either not interpretable or illegible due to deterioration by corrosion. Therefore, the feasibility of X-ray micro-tomography providing image information sufficient for recognition of the engraved text was studied. Decrypting the text without the need of unfolding or the use of destructive methods can help preserve similar artifacts in their authentic form in the future.



**Figure 2:** Photo of the “Bartók Terem” defixio (top) and an example of readable letters after tomographically obtained data post-processing (bottom).

The patented TORATOM device was used for scanning the tablets. However, X-ray imaging and tomography of these objects is a challenging problem since the inscriptions are rather shallow and thin compared to the total thickness of the tablets, and lead is a very effective absorber of X-rays. Although the X-ray parameters, including filtering, were set in the best way allowed by the TORATOM device, the text was hardly recognizable after reconstruction. The main reason for this was a combination of the shallow engraving and photon scattering. Although mechanically unfolded, the tablets are not fully flat, and that the front and back sides cannot be easily separated virtually. Moreover, mechanical damage around the folds prevents visualization in those areas. Therefore, it was necessary to decrypt individual letters from the tomographic sections after further image processing based on focusing and local contrast enhancement.

This work was presented at the 10th Conference on Industrial Computed Tomography, Wels, Austria (iCT 2020), [www.ict-conference.com/2020](http://www.ict-conference.com/2020).

I. Kumpová

CONCRETE IN AGGRESSIVE ENVIRONMENTS

A group from the Department of Materials Research has recently published a study in the well-known journal *Cement and Concrete Research* regarding the microstructure of chemically degraded Portland-limestone concrete on a long-term time scale. Concrete structures such as building foundations, roadworks, masonries, etc. are exposed to varying environmental conditions during their service life. Cold groundwater contaminated with sulfate ions can be highly detrimental when in direct contact with concrete since the main phase of the hydrated cement matrix that binds the aggregates and steel reinforcement together, and provides concrete with most of its strength, can gradually degrade through a process known as thaumasite sulfate attack.

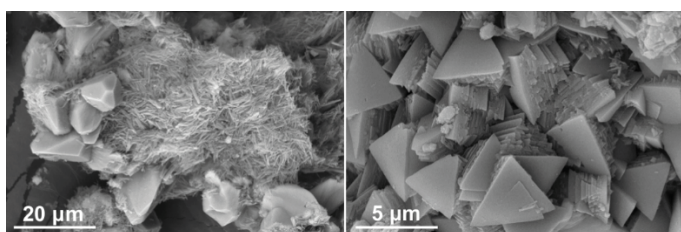


Figure 1: Scanning electron microscope images obtained from the deteriorated part of concrete specimens. Left: needle-like thaumasite crystals surrounding calcite crystals; right: brucite crystals.

The study, supported by the grant 18-26056Y (Czech Science Foundation), was performed using locally available resources in combination with the advanced technique of solid-state nuclear magnetic resonance (ssNMR) spectroscopy. The ssNMR experiments were conducted at the Center for Magnetic Resonance of the Saint Petersburg State University (Russia) in collaboration with our local partners. Access to the ssNMR

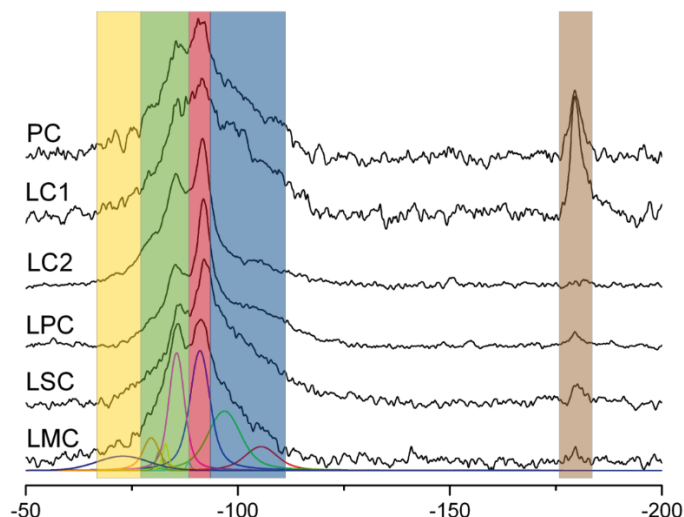


Figure 2: Si NMR spectra obtained for different deteriorated concrete compositions. Yellow: unreacted clinker; green: calcium silicate hydrates; red: cross-linked silicate structures with Al; blue: cross-linked silicates and silica gel; brown: thaumasite.

facility was provided through a Framework Agreement for Cooperation signed between the two institutions. The applied approach allowed for assessing the crystalline products of the deterioration process and for obtaining detailed information about the state of the amorphous binding phase. The results can be useful in understanding the degradation process in concrete structures and in optimizing concrete mix designs for specific applications.

**Related article:** K. Sotiriadis, P. Mácová, A.S. Mazur, A. Viani, P.M. Tolstoy, S. Tsvilis. Long-term thaumasite sulfate attack on Portland-limestone cement concrete: A multi-technique analytical approach for assessing phase assemblage. *Cement and Concrete*  
K. Sotiriadis

SCOLA TELCZ 2020 – STUDENTS RECOMMEND MAINTAINING A BUILDING THAT IN THE PAST SERVED AS SOCIAL HOUSING

**The SCOLA TELCZ winter workshop in Telč is already one of the traditional February events in which our Institute participates. This year it took place from 9 to 15 February.**

The main theme of this year's event was house No. 15 on 9. května street, which is currently owned by the city of Telč. Two groups of students tasked with the future of the building first performed an initial analysis of its historical and monumental value as well as the urban and social significance for its surroundings. In their proposals, the students agreed on the need to find ways to preserve the building.

"The building in question is exceptional in the context of the surrounding suburban development, it is one of the first multi-storey apartment buildings in Telč. The field surveys included archival research from conservationists from the Telč branch of the NHI, as well as dendrochronological dating of the truss structure from the Centre Telč specialists. This confirmed that the house was built in 1827 or 1828, most likely in connection with the economic recovery brought about by the activities of

Jakub Lang's drapery factory, which stood on today's Hradecká Street," says Jiří Bláha, one of the lecturers at this year's SCOLA TELCZ workshop, who is otherwise a researcher at ITAM's Centre Telč. "Both areas of design met in the fact that for a building located on a busy street, and at the same time having a garden with less economic facilities, it would be appropriate to combine the housing function with one or more small establishments focused on small crafts or repairs," he adds. The city of Telč is also considering the future fate of the building.

J. Novotný

