

## Heritage Science Days 2017

### The Centre of Image and Material Analysis in Cultural Heritage (CIMA)

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#### 1. Introduction

The *Centre of Image and Material Analysis in Cultural Heritage (CIMA)* is an interdisciplinary and interuniversity research institution with main focus on historical written heritage. It was established in 2014 in the framework of the project **(2)** “Analysis and Conservation of Cultural Heritage – Modern Imaging and Material Analysis Methods for the Visualization, Documentation and Classification of Historical Written Material (Manuscripts)” with a starting-grant from the Austrian Federal Ministry of Science and Research.

The Centre brings together the expertise of three disciplines from three universities **(3)**: Philology from the University of Vienna (here mainly the Departments of Slavonic and of Byzantine and Modern Greek Studies), Computer Science from the Computer Vision Lab of the TU Vienna and Material Chemistry from the Institute of Science and Technology in Art at the Vienna Academy of Fine Arts. Since the partners involved could already look back on several years of successful cooperation, the main idea behind its foundation was to prolong and intensify this cooperation by establishing a central laboratory which would offer its expertise to universities, libraries, museums, exhibitions, and the like.

Since the starting-grant finished, CIMA is now being kept up by the three universities with the aid of new project grants and (rare) fees from missionary work. In this context we are co-

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<sup>1</sup> H. Miklas (<https://slawistik.univie.ac.at/mitarbeiter/miklas-heinz/>) is a specialist in Slavic and Balkan linguistics, Church Slavonic literature, codicology and palaeography and engaged in the interdisciplinary investigation of historical written sources. After studying Slavonic and English philology as well as Philosophy in Graz and Sofia/Bulgaria, he began his academic career at the Universities of Würzburg (1975-1976) and Freiburg in Breisgau (1997-1994) where he habilitated in 1988. As a guest lecturer/professor he worked also at the universities of Trier, Basel and Zürich. Between 1994 and 2013 he was an ordinary professor of Vienna University, where he is still engaged in project work. Miklas is Dr. h.c. of Sofia University and Foreign member of the Bulgarian Academy of Sciences, the founder of the *Vienna Archaeographic Forum* (<https://waf.cvl.tuwien.ac.at/>) and one of the founders of CIMA (<https://hrsm.cvl.tuwien.ac.at/>).

operating with several other Austrian and foreign institutions. Thus, in our new project a conservation-restoration expert from the Danube University at Krems **(4)** and microbiologists from the Department Biotechnology at the University of Natural Resources and Life Sciences (BOKU) take part **(5)**, the latter with DNA-analyses.

While the philologists **(6)** are mainly engaged in the codicology, palaeography, textology and the editing of the sources, our technical research is in the fields of imaging, image processing and -analysis as well as in the non-invasive analysis of the materials used for the production of the sources. These are in the first place codices **(7)**, but also epigraphic, diplomatic and other types of written material. Special attention is given to those which pose particular problems to the scholarly investigation: on the one hand badly preserved manuscripts **(8)** or manuscripts containing overwritten text (palimpsests) which cannot be deciphered with the mere eye; and on the other, objects with a particular make-up which arouses the interest of the art historian and the chemist.

Beyond research, we have also begun conducting university courses, and 2018 we plan to organize an international summer school, too. With this specialization CIMA is rather unique **(9)**. Recently, however, the Centre for the Study of Manuscript Cultures at the University of Hamburg has also made efforts in the same direction; while the American EMEL-initiative, with whom we are also co-operating, is concentrating on the imaging and image-processing of manuscripts.

Before going into detail about our work, let us have a look back into history!

## 2. History:

Scholars of the humanities have always dreamed of getting closer to the natural scientists and advancing towards verifiable results by incorporating scientific methods. From the middle of the nineteenth century **(10)** – to name only August Schleicher with his *Stammbaum- (Family tree) Theory* and the positivistic circle of the Neo-Grammarians with their *Sound Laws* – such attempts had a considerable impact on the progress of linguistic research and moved more than any other school before them. What lagged behind was the development of technical support. Thus, at the beginning of my activity, the typewriter and the magnifying glass were about the only technical means which a philologist could rely on in his source work. Analogue photography had just developed the microfilm, and a few libraries disposed also of ultraviolet lamps for the deciphering of palimpsests.

Only in the 1970s things began to develop rapidly: first the triumphal march of the personal computer, then the invention of digital photography, and soon the Internet joined in as a revolutionary development.

Recently, we have again been observing important innovations that have already shaped the image of source research: a few years ago the introduction of chemical spectroscopy, and now the inclusion of microbiological and isotopic investigations into the study of written heritage. In this complex development, reasonable research is only possible with the constant exchange of ideas and mutual assistance, i. e., depending on the subject, either trans- or interdisciplinary.

But the impetus for the formation of our cooperation **(11)** came from the need to make poorly preserved manuscripts readable. Thus, in the early 1990ies difficulties in deciphering new Slavonic finds from the Sinai and palimpsests caused me get in touch with the codicological laboratory of the Russian National Library in St. Petersburg under Denis O. Cypkin, who had been the first to use Multispectral Imaging on Slavic material **(12)**. We soon tried to develop his methods even further **(13)**. Having started the relevant project in the framework of the Balkan Commission of the Austrian Academy of Sciences **(14)**, we worked out a concept for the establishment of a technical laboratory for the analysis of written records, which we proposed to the then Vice-President (later President) of the Academy Herbert Mang. He was enthusiastic about the idea and promised to support it; the Secretary-General, however, found himself unable to provide the million shillings we had foreseen. So he (the archaeologist Herwig Friesinger) advised me to found an association. Later, with the Austrian Centre for Digital Humanities **(15)**, a similar initiative was set up that today functions as a complementary partner to our inter-university center.

In this way, the *Vienna Archaeographic Forum* (WAF) was established in 2002 **(16)**. As we noted on its homepage, its primary goal was "to initiate and conduct interdisciplinary research, which will be followed by appropriate training courses". We have stuck to this dictum from the very beginning, although it should take a while to succeed. Because our first large-scale project, which was submitted to the Austrian Science Fund (FWF) in 2004, was perfectly planned, but nevertheless fell through the grate due to a review-problem (no rarity when it comes to interdisciplinary endeavours). Further applications followed, of which most went through, including two Sinai projects **(17)**. Here, in addition to computer vision, the non-invasive material analysis was probably involved for the first time in written heritage studies

(2007). So, the foundation of CIMA was the logical consequence of these projects, which in its turn forms the basis for new running projects **(18)**.

### 3. Key-word Vision and Work Philosophy

When you tackle such a venture, you have to have a vision and you must develop a certain work philosophy. Our vision was outlined on the 2004 EVA-conference **(19)** as a scenario in which the investigation of written heritage will, in the long run, be

- done almost exclusively based on images. This relieves the originals and makes their investigation independent of the place of preservation;
- enabled or improved by special recording-methods (like multispectral and radiographic imaging);
- more exhaustive, precise, better objectivizeable and less time-consuming via automated image-analysis; and
- executed with a set of easily obtainable tools which can be applied also by humanity-scholars with appropriate training.

Even if our tools – and consequently, our research possibilities – have already exceeded these starting limits, the philosophy of our work has not changed; thus, we are still following four principles **(20)**:

- (1) Harmlessness (esp. non-invasiveness): The analyses must not harm the objects, neither before nor in the process nor after the investigation. Minor exceptions pose microbiological and isotopic analyses, but even here gentle methods are being developed presently (such as the rubbing method for gaining DNA samples invented by our colleagues at York University).
- (2) Mobility: Since the sources are usually preserved in places from where they cannot or must not be removed (or the expenditure for their removal would be too high), all technical instruments we are using or developing must be easily transferable.
- (3) Rapidity and economy: Especially the application of our instruments must be as quick – and therefore also cheap – as possible, without lessening the quality of the analyses. Usually this requirement implies a maximum simplicity of the construction.
- (4) Robustness and reliability: This requirement I usually illustrate with the sentence: “What we need is an allround Jeep, which works under any condition, not a sophisticated Ferrari which can only be used under ideal conditions.”

### 4. Practice

Now let us turn to practice. In order to better understand where we stand in our practical work, I have tried to combine the relevant data and disciplines in the following slide **(21)**. The blue parts are covered by our own teams, the violet ones we are executing with the help of external partners. This concerns especially the internet-presentation (with linguistic retrieval possibilities) of Slavic texts which is mainly done by our colleagues at the State Technical University of Izhevsk in the Russian Federation **(22)**. (For texts in so-called Western languages there are, of course, strong partners in Vienna itself). And now we will shortly characterize the work done by the three groups:

*Philology* **(23)**. The philologists propose the objects of investigation, supervise the work and execute the philological examination of the sources. Here we must differ between the scholars who actually belong to the CIMA team and the colleagues from other institutions (they can be also historians, archaeologists and others) who propose interesting objects for examination and receive as results images and/or material data. (As long as the starting grant lasted, our help was cost-free; from now on we will mostly be forced to ask for an “obolus”. Our best “clients” have been the participants of the Greek Palimpsest-project of the Austrian Academy).

*Computer Vision* **(24)**. Here CIMA’s efforts are focused on two major areas – Imaging and Image Processing and Automated Document Analysis. We will concentrate on the first part, the digital restoration and readability enhancement of degraded sources via Multispectral Imaging and post-processing. As the name indicates **(25a-c)**, MSI means taking images in different spectral bands which can be combined in various constellations and further developed. For this purpose a mobile system **(26)** has been established, which is usually surrounded by a black tent. In the next slide you see the six imaging units **(27)** and the range we are using presently: 11 narrow bands reaching from Ultra Violet to Near Infrared (or, in numbers, from 365 to 940 nanometers). For specific objects, for instance written with carbon ink or darkened by various influences, we use a special Infrared-camera with the beautiful name “Osiris” **(28)**. Contrary to our American colleagues who are working with a higher amount of bands, but only one camera, we produce also R(ed)G(reen)B(lue) or true colour pictures. This is important for three reasons, one of them being that the scholars engaged with them get a “natural” impression of the object (at least from the human point of view).

The processing-part can best be outlined in illustrations: First, the images have to be aligned **(29)** to each other or “registrated”, then dimensionality reduction-techniques **(30)** divide

different layers **(31)** or segment parts of interest **(32)**. Finally, mere visual methods can be added such as pseudo-colouring **(33)**, in order to further enhance the contrast or the like.

In one case the improvement of techniques led to three stages of readability (here the first and the last stage: **34a-b**). So we had to decipher the text three times, until we got the following result **(35)**!

*Chemical Material Analysis* **(36)**. The material analysis concerns the support (i.e. parchment, leather etc.), the inks, pigments, dyes and the binding material used for the production of written heritage. After starting with a self-built XRF-apparatus in the first project **(37)**, CIMA now applies several complementary spectroscopic methods in order to analyze elements and compounds, such as **(38)** the X-ray fluorescence analysis (XRF), Fourier Transform InfraRed analysis in the reflection mode (rFTIR) and Raman spectroscopy.

These analyses serve three coherent aims: first and foremost they lead (paradigmatically) to the detection of the elements **(39)** and compositions; secondly, by comparison the data help (syntagmatically) **(40)** to determine relationships between objects and contribute to their dating and localization; and thirdly, they can explain certain phenomena we observe on the objects; thus, for instance, the enigma of the “white” ink in the Sinaitic Missal **(41)**. In certain cases Raman can also serve to analyze living processes such as fungus **(42)**.

In the outlined way over 60 important objects from various traditions (especially Old Slavonic, Greek and Latin, but also Old High German, Armenian, Georgian, Nubian, Hebrew and Ottoman) have already been examined and partly also edited both by CIMA members and colleagues from other Austrian and foreign institutions. Often they were situated outside of Vienna, be it on the Sinai **(43)** or only in one of the monasteries in our vicinity **(44)**; so that over the years a handsome map has come together **(45)**.

As has been shown, the topics covered in our projects are considerable. Nevertheless, not all our initial ideas and goals have been realized yet. And, naturally, in the course of time new questions or solutions have been raised. So there is still room for important developments.

Looking back we can say that we have achieved two major aims: For once, we have become pioneers in some areas and play – as Robert Sablatnig puts it beautifully – in the first league of others. This applies, for example, to the mobile, non-invasive spectroscopic capture of manuscript-data by Manfred Schreiner and his team, to the handwriting recognition, where Fabian Hollaus and Markus Diem took the first two places in an international competition, or to the enhancement of multispectral images, where F. Hollaus developed the new LDA-

method I have just shown. And, we have been able to inspire a considerable number of young colleagues for our concerns and given them the opportunity to gain a foothold in science or to remain there (our first project teams: **46**). Hereby, the cooperation between scholars and scientist has proven to be very effective.

## 5. Outlook

How to go on in the future? Well, CIMA – and this applies also to the WAF –, will continue keeping up to date with the recruitment of new themes, areas, tasks, and, of course, young members! Young scholars and scientists who are open to a complex, interdisciplinary education and work; for they will be the future investigators of written heritage. Concerning new objects, besides manuscripts we will continue to analyze epigraphic testimonies, as in the Nubian H.U.N.E.-project (**47**) led by Claudia Näser of Berlin; or in the necropolis of El-Sheikh Fadl in Egypt, where we are trying to rescue the oldest Aramaic literary inscription (**48**) under the direction of Christine Köhler from Vienna university. We also plan to preserve and study the wall paintings and inscriptions of the Tibetan Tabo Monastery in the Indian Himalaya (**49**), if we can find an indological guide, who can fill in the gap caused by the retirement of the first one.

New topics represent the DNA-analyses by Katja Sterflinger and Guadalupe Piñar from the BOKU with which we hope to obtain additional data on the origin and migration of manuscripts, their manufacturers and users. The same applies to isotopic investigations which we are presently trying to establish. Concerning multispectral imaging, more codicological aspects and aspects of the artistic decorus of the sources will be taken into account, as can be seen on the last slide (**50**).

And finally, two important training courses are already near at hand: one university (ULG) course at the Danube University, led by Patricia Engel, and a special course for doctoral students at the University of Vienna, headed by Claudia Rapp! (**51**)