Drittmitteltag der Philologisch-Kulturwissenschaftlichen Fakultät

Einführung

Heinz Miklas

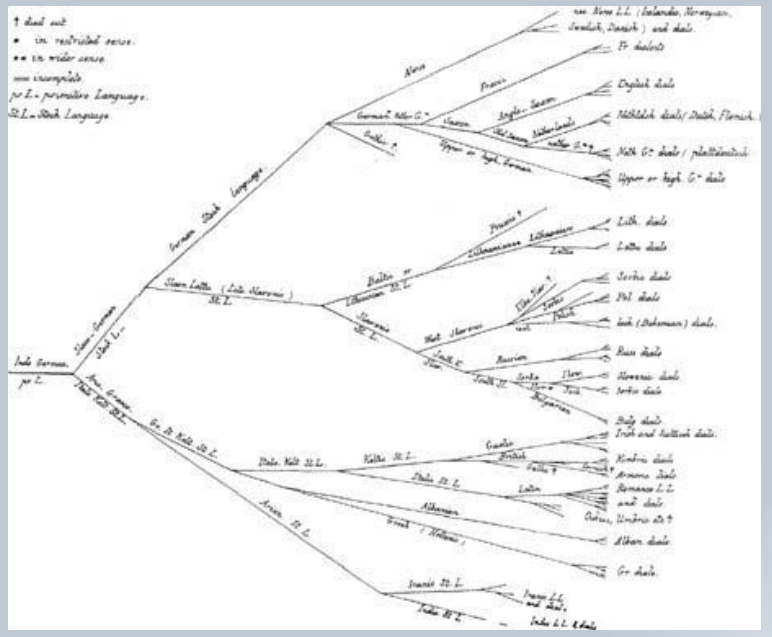
Wien, 12. April 2019

Naturwissenschaftliche Ansätze in der sprachwissenschaftlichen Theoriebildung

https://de.wikipedia.org/wiki/August_Schleicher

August Schleicher (1821-1869):

Stammbaum-Theorie



↓

"Junggrammatiker" A. Leskien, K. Brugman, H. Osthoff in Leipzig (1870s -):

Lautgesetze

(z.B.: *Ruki-Regel* im Balto-Slavischen, Albanischen, Armenischen, Indo-Iranischen: *s wird zu *š, wenn *r, *u, *k, *i vorangeht).

Hauptentwicklungsstränge von Heritage Studies

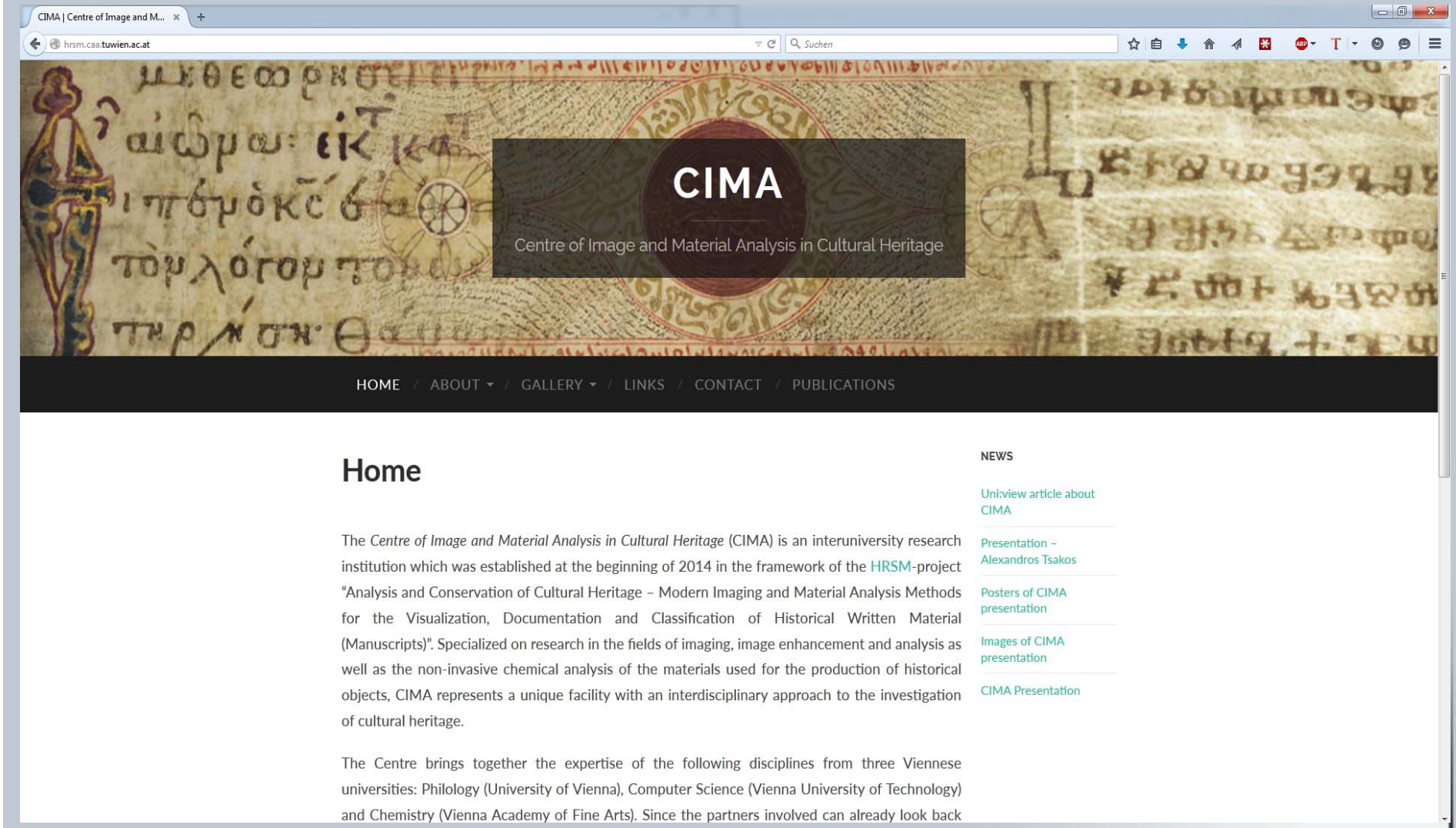
- Digital Humanities:

  Computer einziges Instrument

- Analytische Archäographie:

  Computer nur Teil der Instrumentation

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



CIMA – Ausgangsteam

Institut für Slawistik,
Spitalgasse 2, Hof 3, 1090 Wien

Heinz Miklas, Katsiaryna Ackermann

Institut für Byzantinistik und Neogräzistik,
Postgasse 7, 1010 Wien

Claudia Rapp, Giulia Rossetto

Computer Vision Lab, Favoritenstrasse 9-11, 1040 Wien

Robert Sablatnig, Simon Brenner

Institut für Naturwissenschaften und Technologie in der Kunst, Schillerplatz 3, 1010 Wien

Manfred Schreiner, Bernadette Frühmann, Federica Cappa, Wilfried Vetter

universität wien

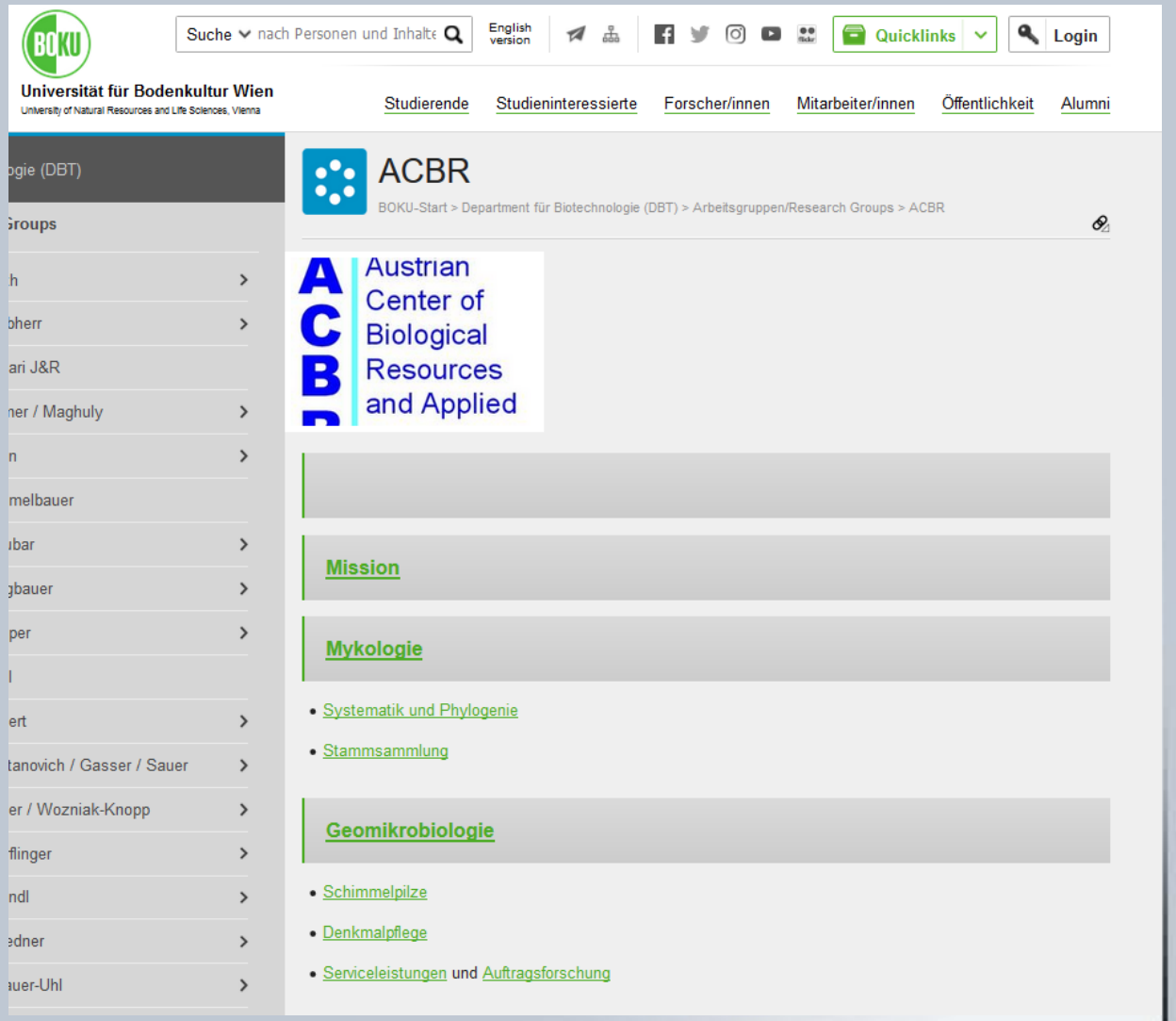
TU WIEN

]a[Akademie der bildenden Künste, Wien

DNA Analysen – BOKU Wien, Abteilung Biotechnologie

Katja Sterflinger
Guadalupe Piñar

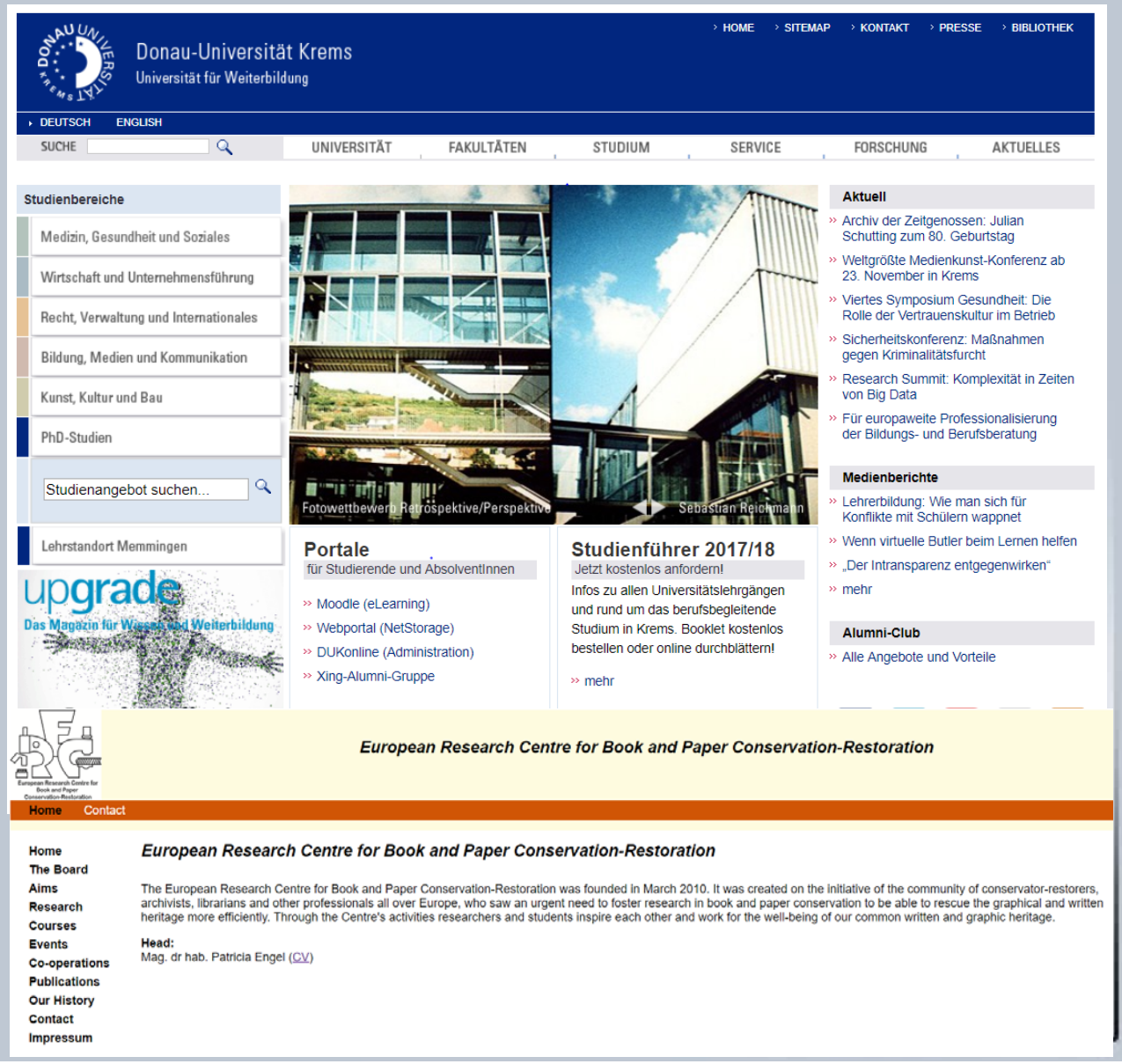
Muthgasse 18
A-1190 Vienna



Konservierung & Restaurierung – Donauuniversität Krems, Fakultät für Bildung, Kunst und Architektur

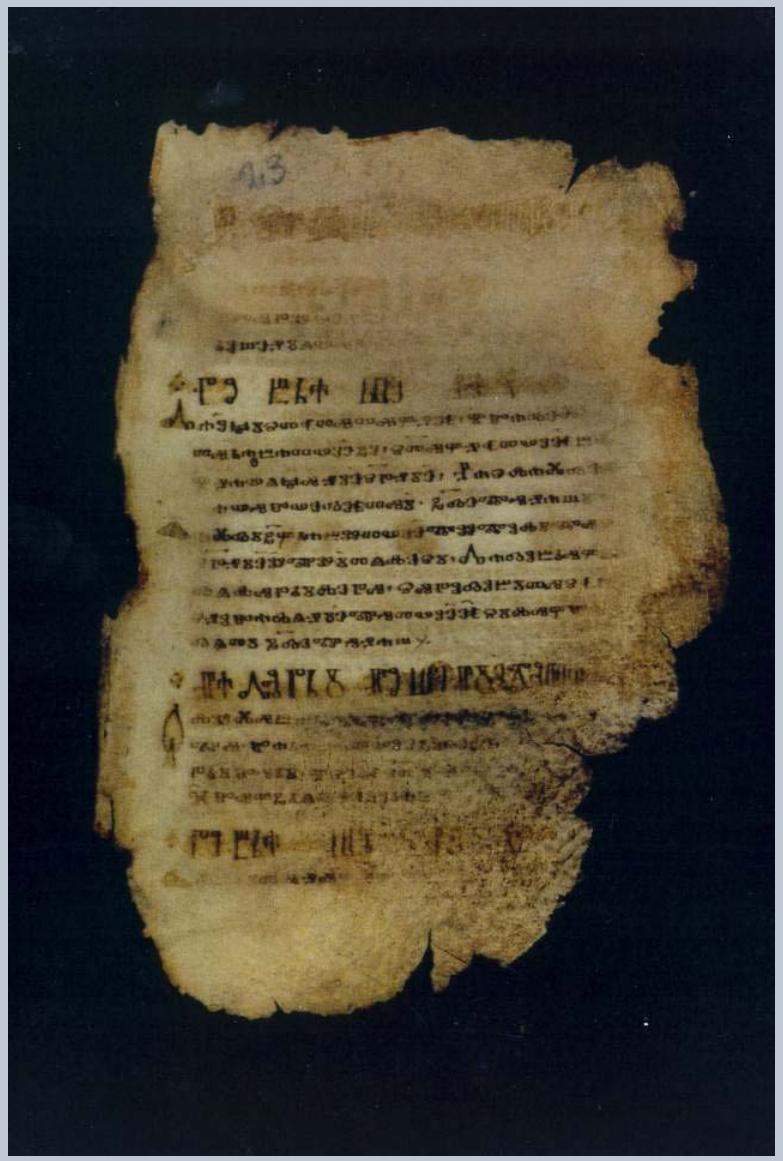
Patricia Engel

Abteilung für Bauen und Umwelt
Dr.-Karl-Dorrek-Strasse 30
A-3500 Krems

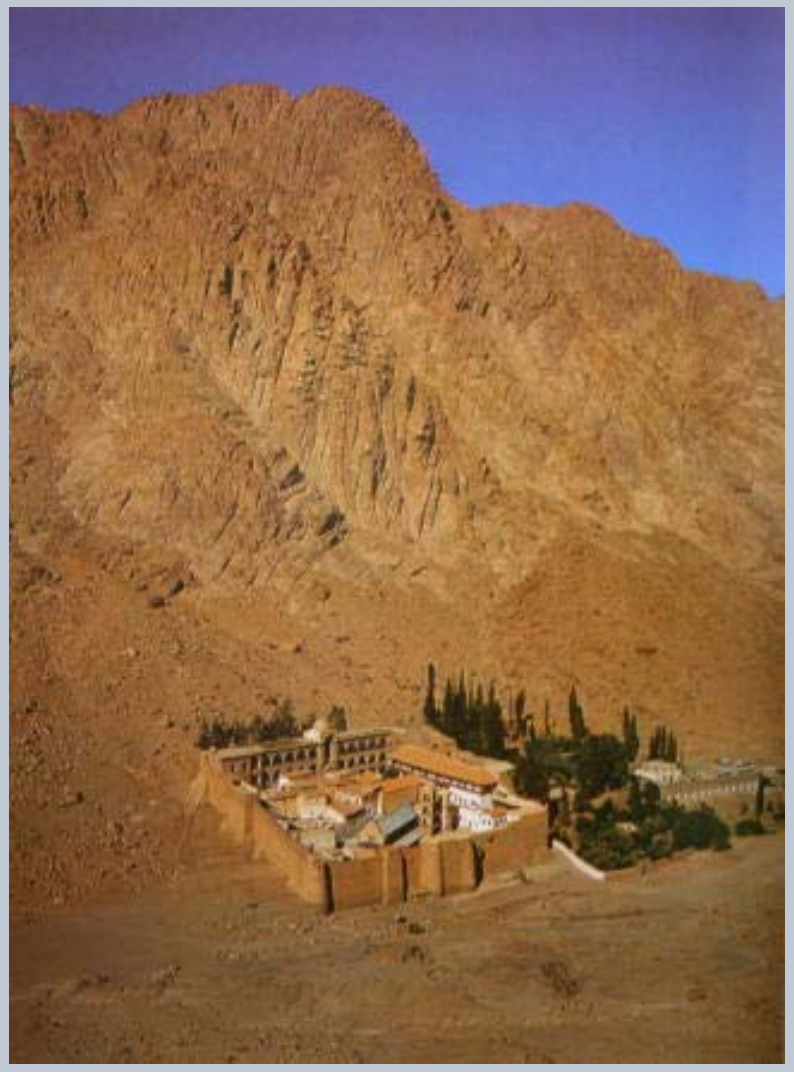


Glagolitica-Editionen im Portal *Manuskript*, Izhevsk
cf. http://manuscripts.ru/index_en.html

Missale Sinaiticum
Erste (Analog-) Bilder

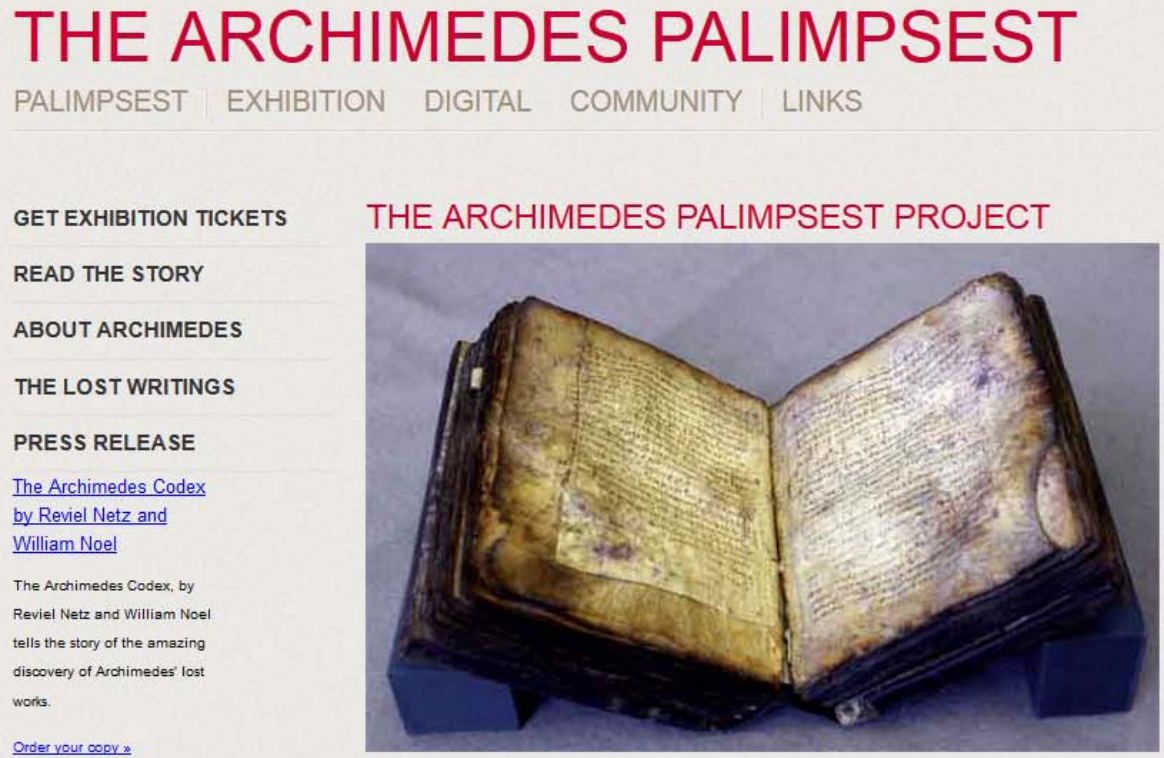


Katharinenkloster mit Mosesberg



Russ. Nationalbibliothek, St. Petersburg, Hss.-Abteilung mit Denis O. Cypkin

Archimedes-Projekt

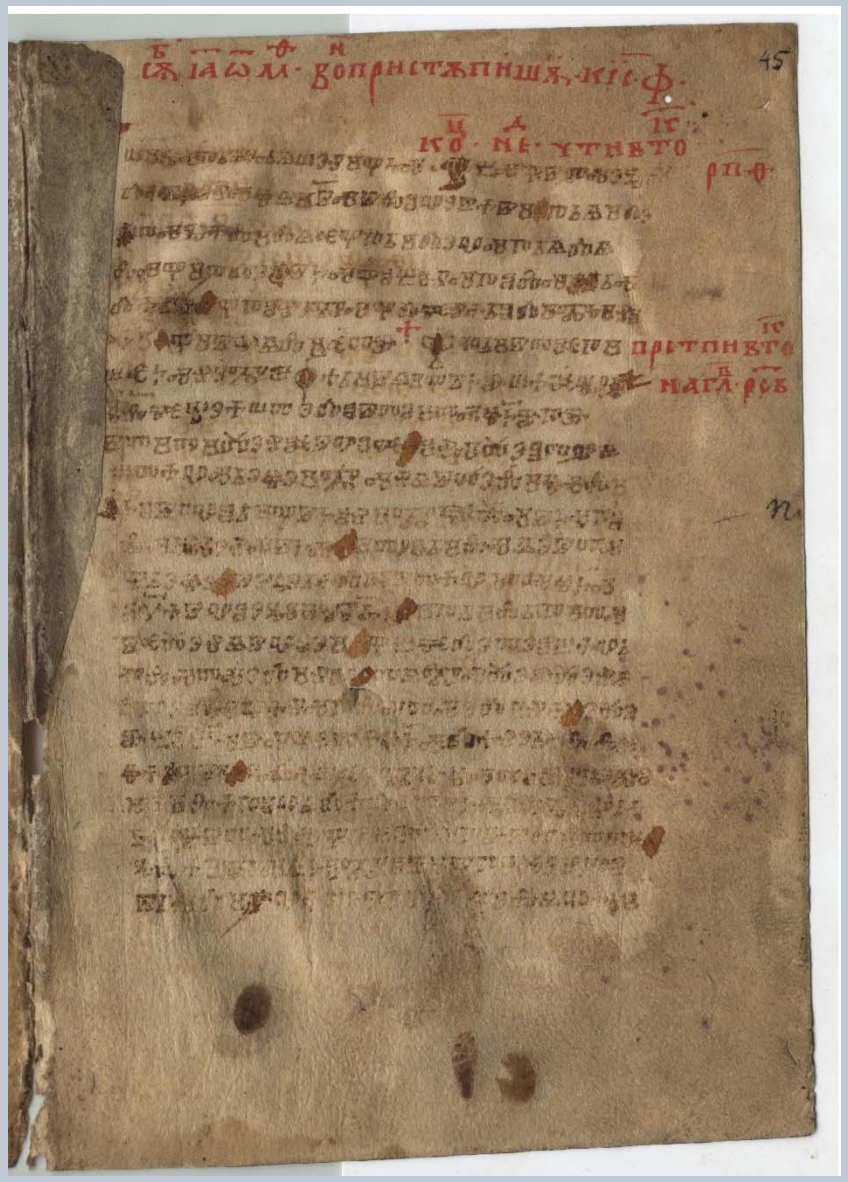


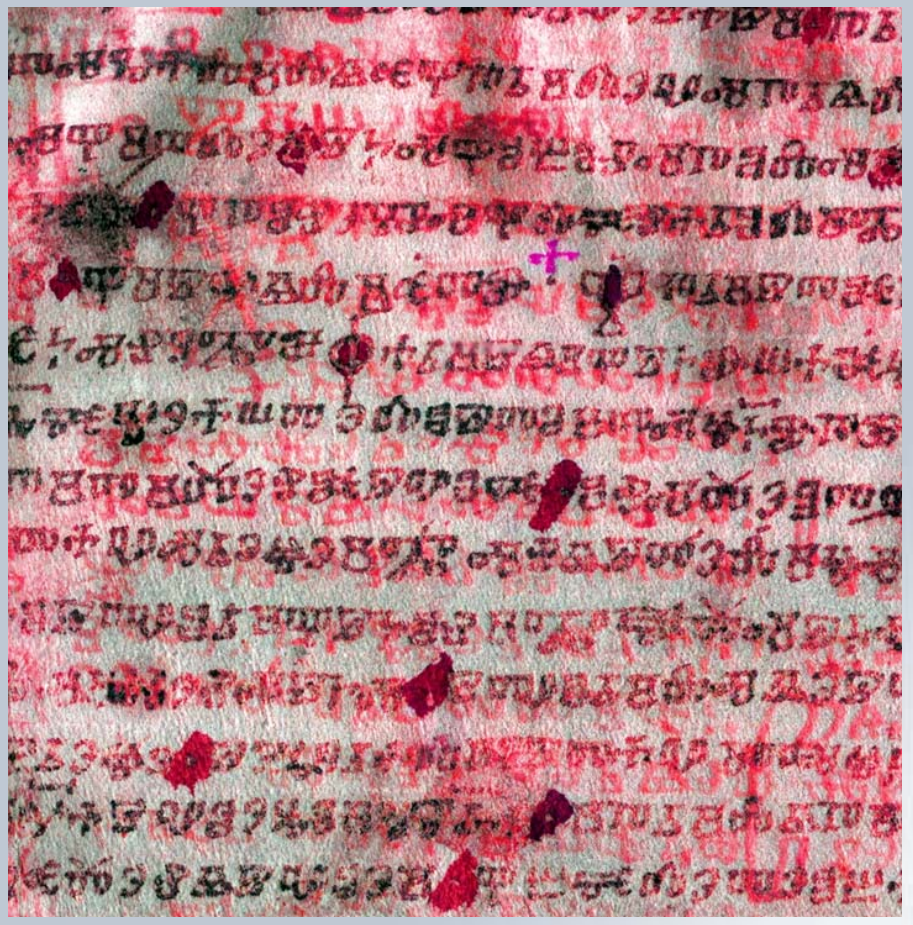
http://www.archimedespalimpsest.org/

Rinascimento virtuale

- http://palin.iccu.sbn.it/

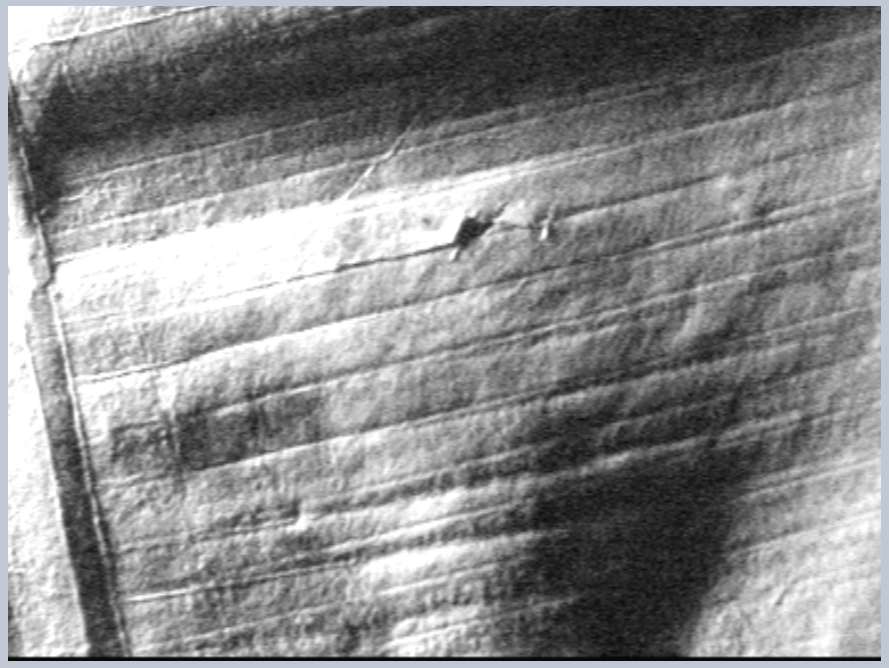
Cod. Zographensis, RGB und MSI-Bild der ergänzten Palimpsest-Lage

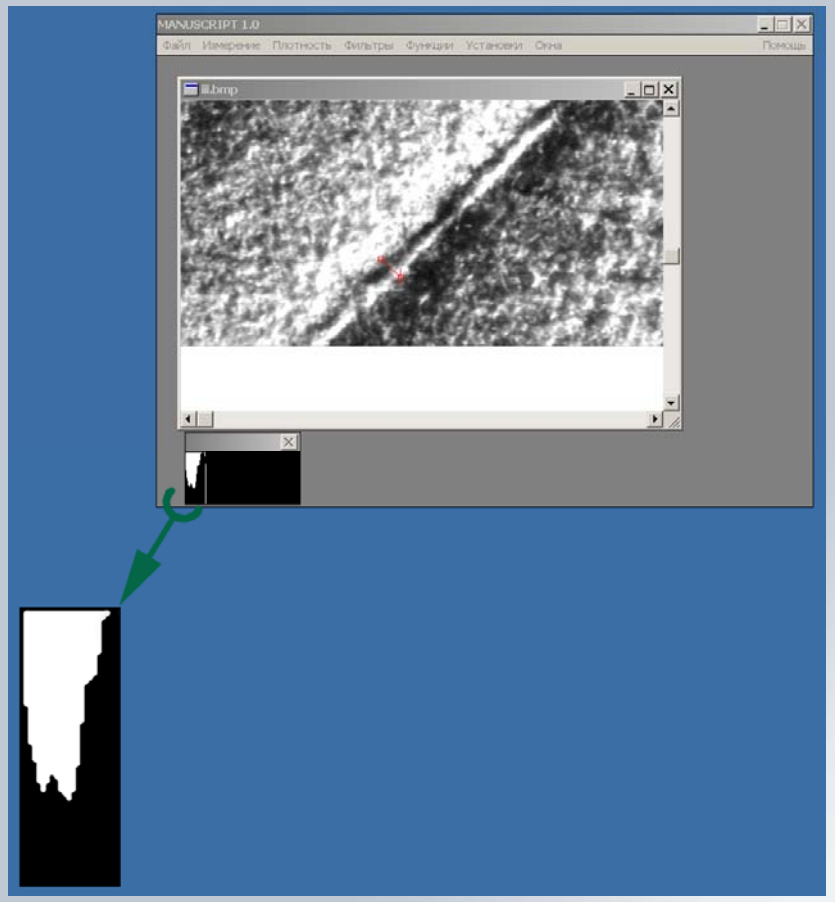




Aufnahmen und Bearbeitung
(mit Photoshop): D. O. Cypkin

MSI-Mikroskopaufnahme der doppelten (Palimpsest-) Liniierung (links), Rekonstruktion des Liniierungsinstruments (rechts)





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RNB St. Petersburg

Glagolitica-Projekte (FWF)

- “The Sinaitic Glagolitic Sacramentary (Euchology) Fragments” (2007-2011)
- “The Enigma of the Sinaitic Glagolitic Tradition” (2011-2014)
- “The Origin of the Glagolitic-Old Church Slavonic Manuscripts” (seit März 2017)

Vision (EVA-2004 Konferenz: http://conf.evarussia.ru/eva2004/eng/reports/report_211.htm)

Längerfristig wird die Untersuchung von schriftlichem Kulturgut

- fast ausschließlich anhand von Bildern erfolgen;
- ermöglicht und verbessert werden durch spezifische Aufnahmemethoden;
- erschöpfender, präziser, besser überprüfbar und zeitsparender sein durch automatisierte Bildanalysemethoden; und
- durchgeführt mit einer Anzahl leicht erhältlicher Geräte, die nach entsprechendem Training auch von Geisteswissenschaftern bedient werden können.

Arbeitsphilosophie

Analysen:

- unbedenklich (besonders nicht-invasiv)
- rasch & wirtschaftlich

Instrumente:

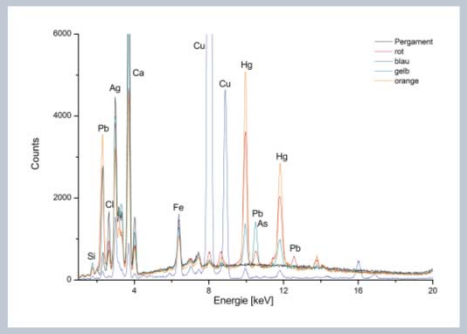
- mobil
- robust & zuverlässig

CIMA-Basiskomponenten

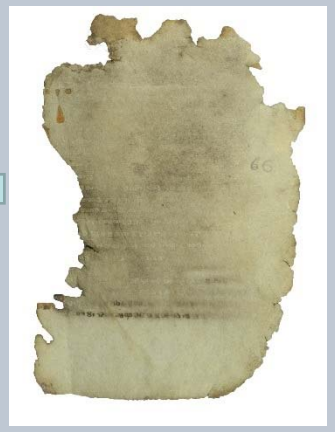
Reada-
ble
Docu-
ment

universität wien

Philology



Material
infor-
mation



CVL
Computer Vision Lab

Image Processing

Research &
Development

academy of fine arts vienna

Material Analysis

Research &
Development

Philologie

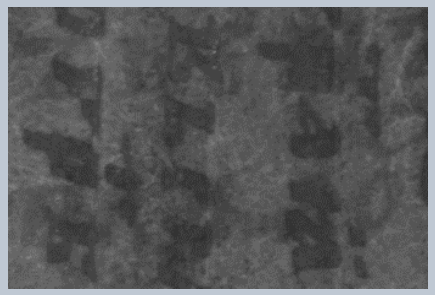
Die Philologen

- schlagen die Untersuchungsobjekte vor,
- leiten das weitere Vorgehen,
- diskutieren Lösungen für die technischen Aufgaben mit den Naturwissenschaftern
- und führen die philologischen Untersuchungen der Quellen durch.

Computer Vision

- Bildgebung & Bildbearbeitung:
  - Multispektrale Bildgebung (MSI)
  - Bildverarbeitung
- Automatisierte Dokumentenanalyse, z.B.:
  - Layout-Analyse
  - Schreiberidentifikation
  - Optical Character Recognition (OCR)

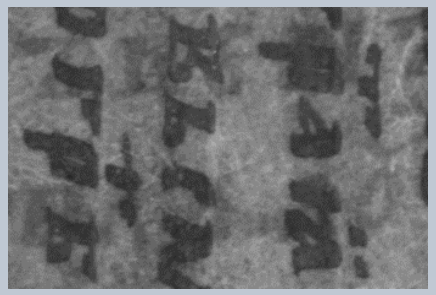
Multispektrale Bildgebung von UV bis NIR



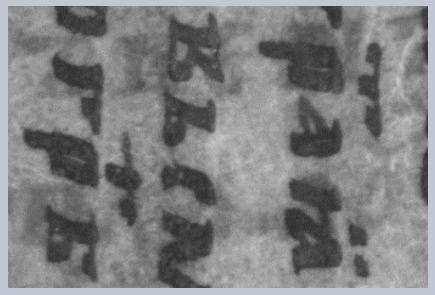
UV Reflektographie

UV Fluoreszenz

UV Fluoreszenz - Nikon



450 nm

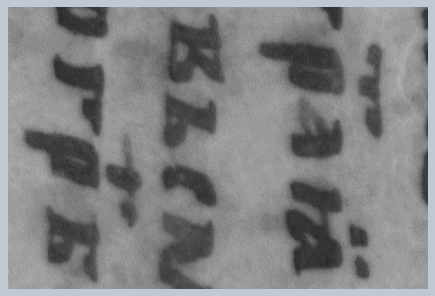


505 nm

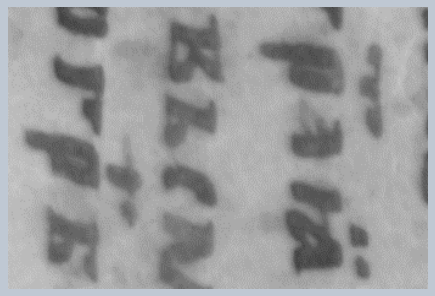
535 nm

570 nm

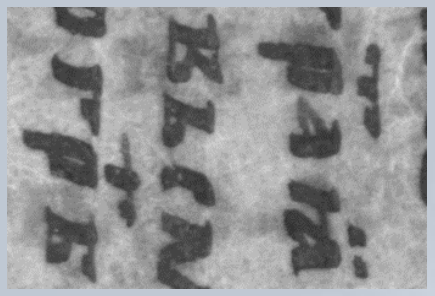
625 nm



700 nm



780 nm



Weisslicht

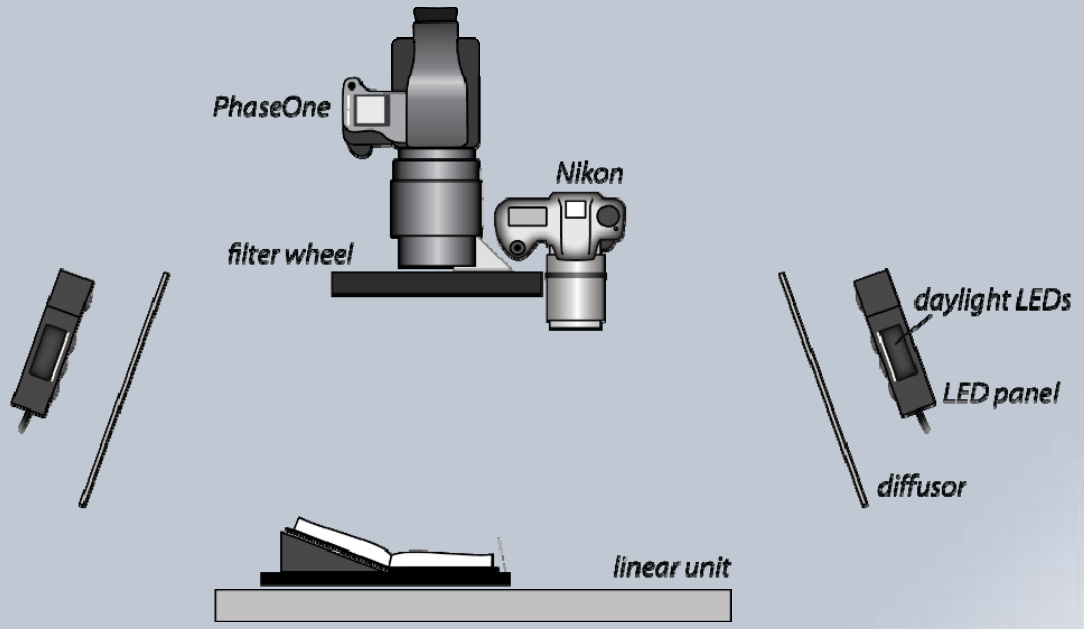
Weisslicht - Nikon

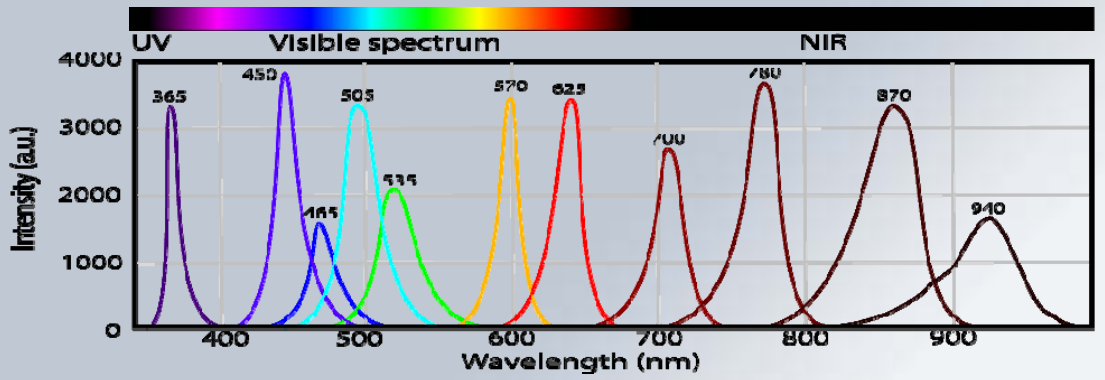
Mobiles Aufnahmesystem

Im Vatikan ohne (links) und in Plovdiv mit schwarzem Zelt (rechts)

Aufnahmesystem: Einheiten und Spektralbereich

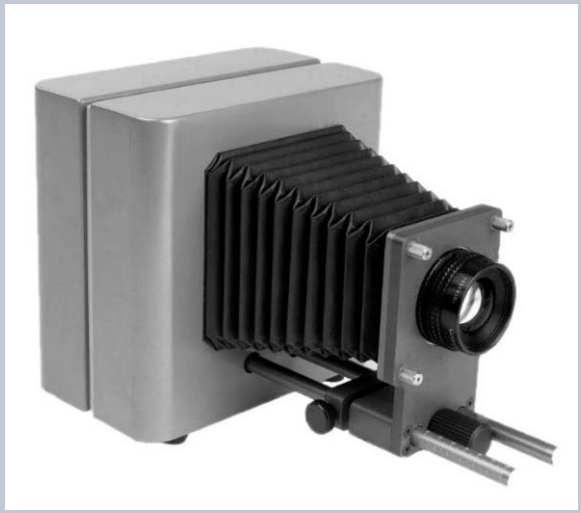
- LED Panels
  - 11 Spektralbänder
  - Tageslicht-LEDs
- Diffusoren
- Achromatische MSI-Kamera (PhaseOne)
- Filterrad
  - UV Fluoreszenz / Reflektographie-Aufn.
- RGB-Kamera (Nikon): Farb- u. Fluoreszenzaufnahmen
- Lineareinheit: automatische Positionierung des Objekts





Infrarot-Kamera ˈOsirisˈ (Opus Instruments/U.K.) mit Anwendungsbeispiel

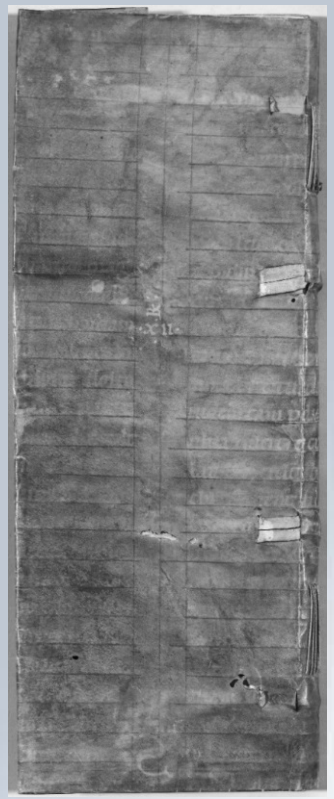
Auflösung: 4096 x 4096 *px*
Spektrale Antwort: 900 – 1700 *nm*



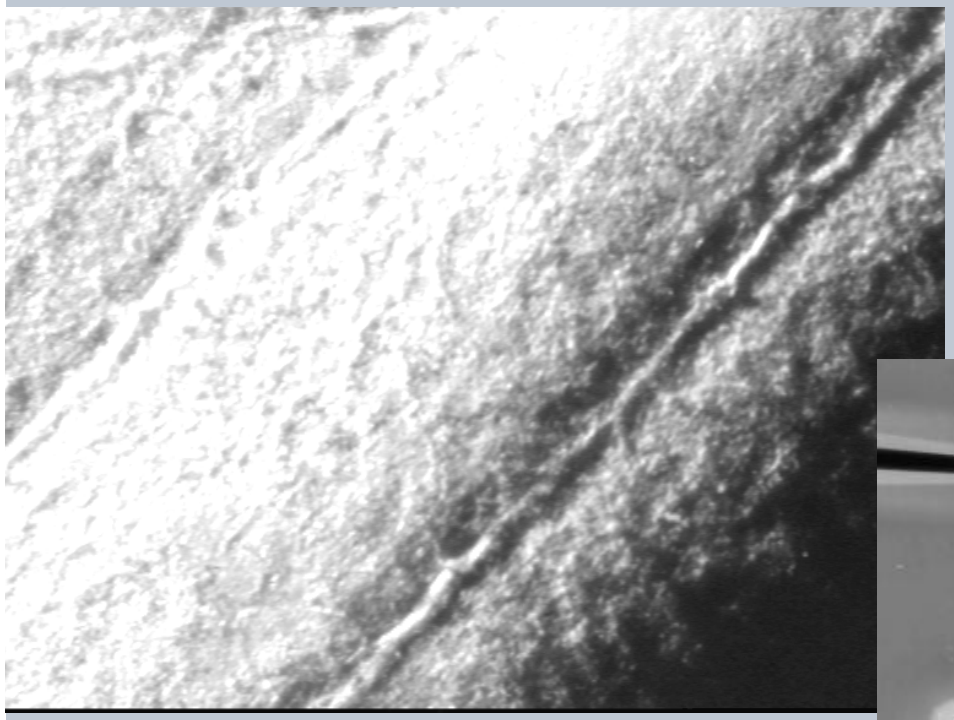
Objekt:

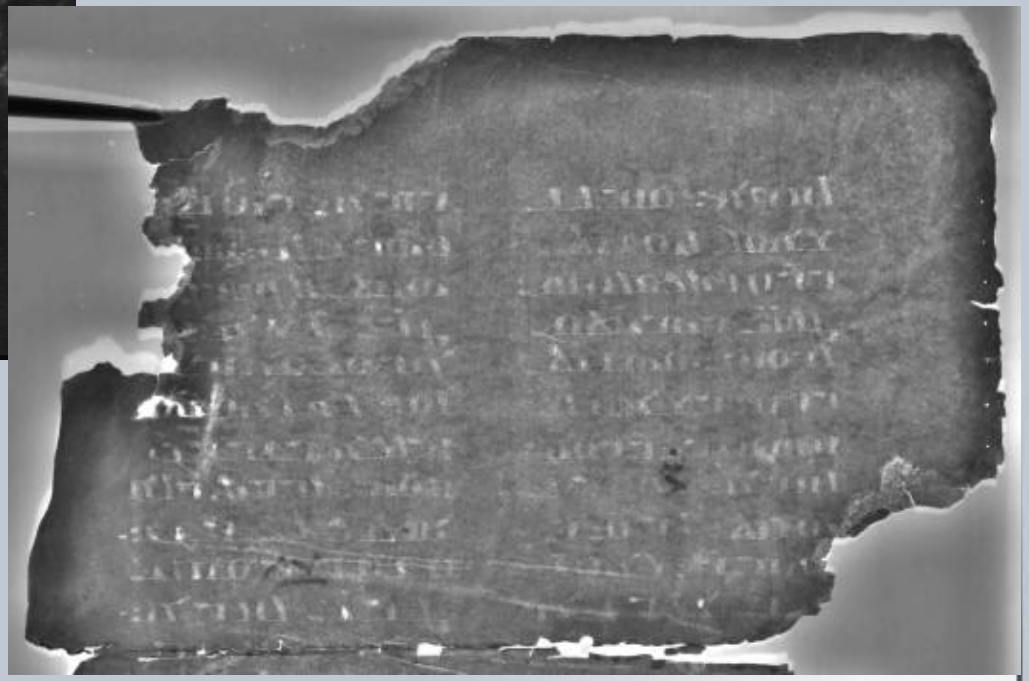
Abgegriffener Pergamentenband

Verarbeitetes Bild



Schräg- und Durchlicht-MSI Aufnahmen





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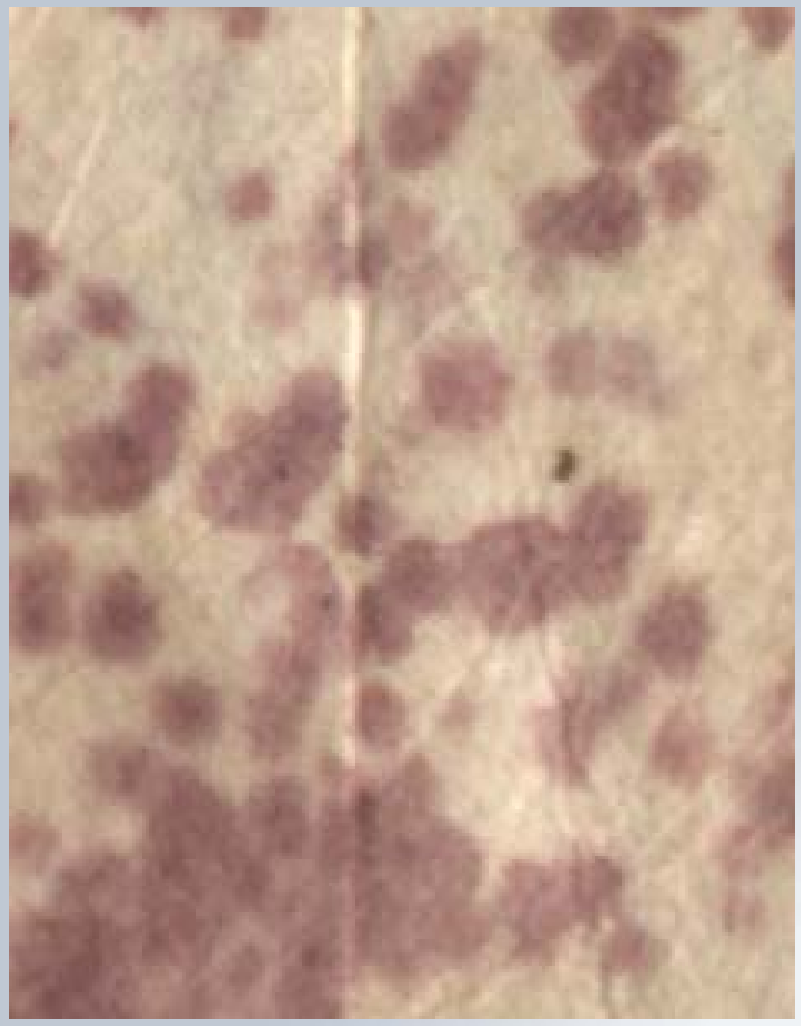
http://sinaipalimpsests.org/technologies

Normale and mikroskopische Farbaufnahme: *Aspergillus versicolor* im Cod. Zogr2



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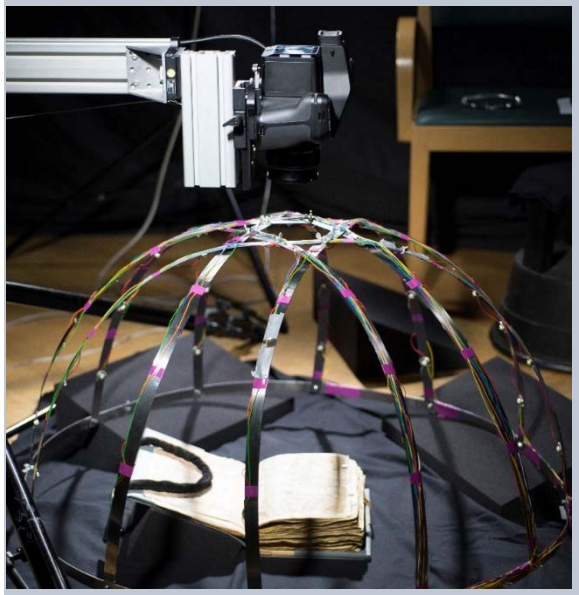
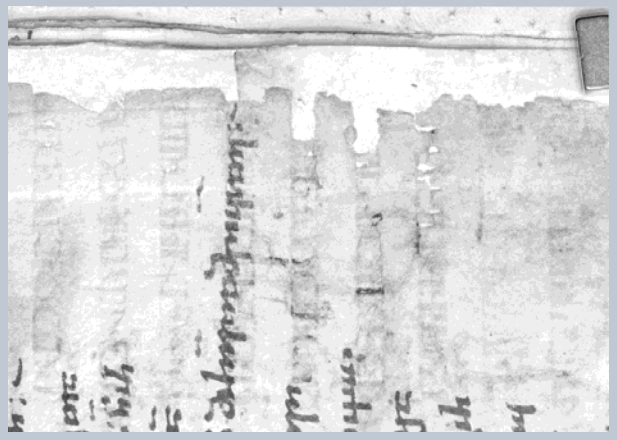
Lichtdom mit ersten Ergebnissen

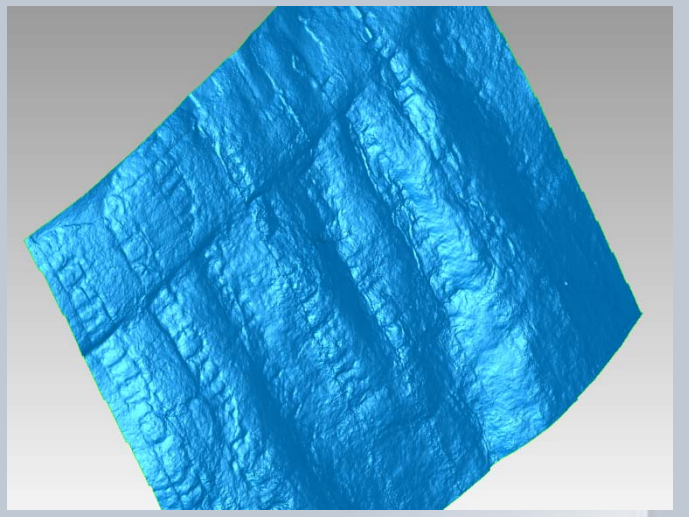


'Light Dome'
Prototyp

Normalaufnahme



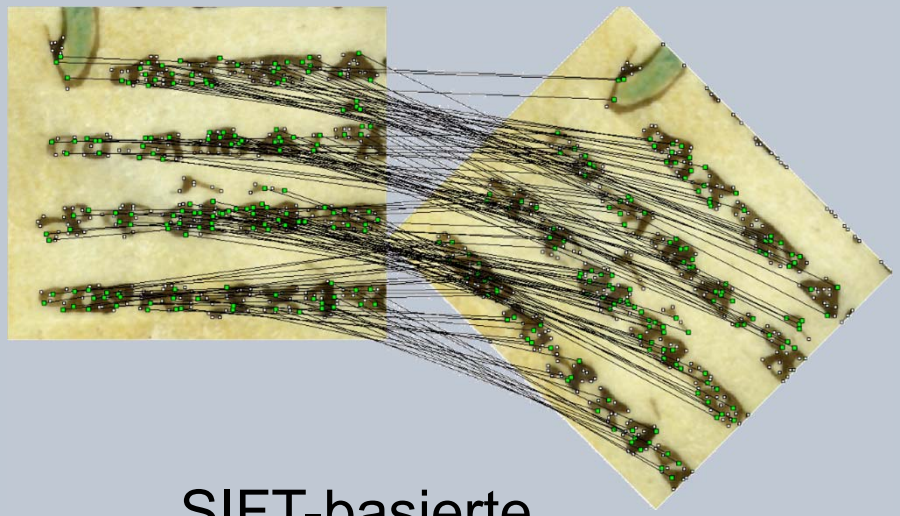
Reflektographische
Transformation



3D-Modell

Schritt 1: Registrierung

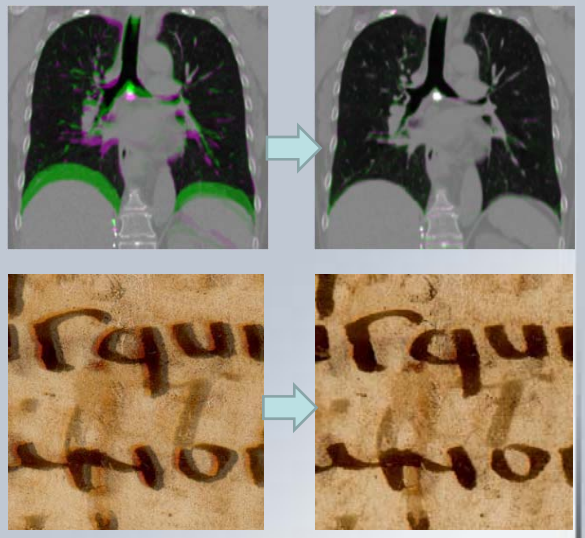
- Grobregistrierung
  - Merkmalsbasierte Methoden
  - Zufallsgesteuerte Startkonfigurationen
  - Ungefähre Ausrichtung



SIFT-basierte Methode

- Feinregistrierung
  - Bereichsbasierte Methoden
  - Startkonfiguration
  - Pixel-Genauigkeit

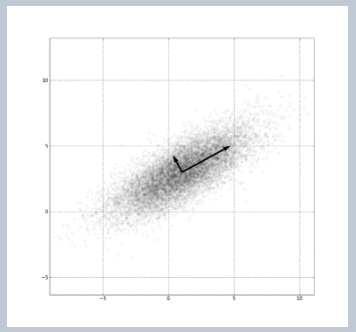
'MIND': Registrierungsmethode aus der medizinischen Forschung



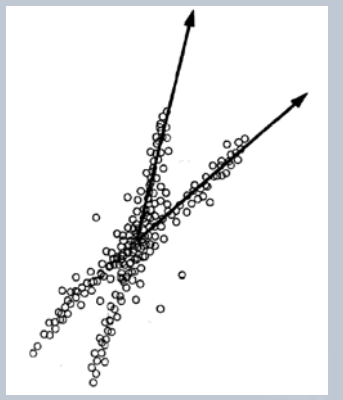
Schritt 2: Dimensionalitätsreduktion

- Unüberwachte Methoden
  - PCA: Zerlegung in **abhängige** Signale
  - ICA: Zerlegung in **unabhängige** Signale
- Überwachte Methoden
  - Klassisches automatisches Lernen: Bereitstellen eines Agorithmus mit Klassenbeispielen (Hintergrund, Text, Untertext,..)
  - Z.B. Lineare Diskriminanzanalyse (LDA)
  - Lösungsaufgaben:
    - Wie generiert man Trainingsbeispiele?
    - Individuelles Verhalten von Handschriften

PCA

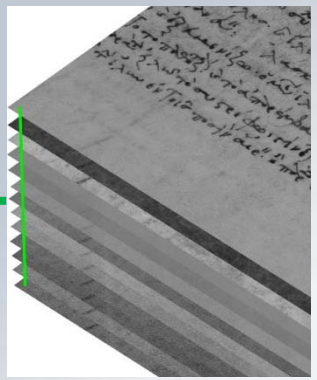


ICA

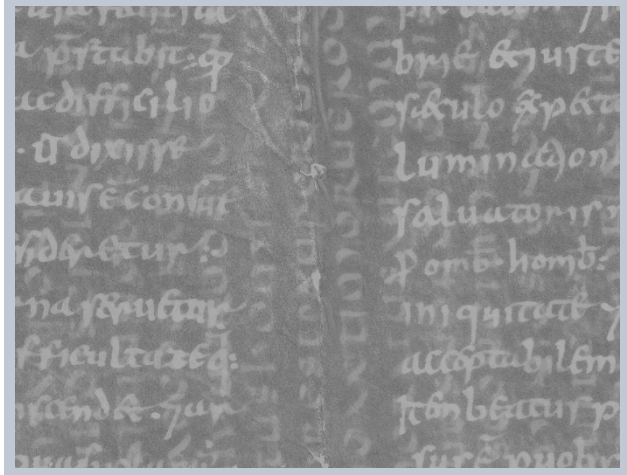


Beispiel für „Hintergrund“

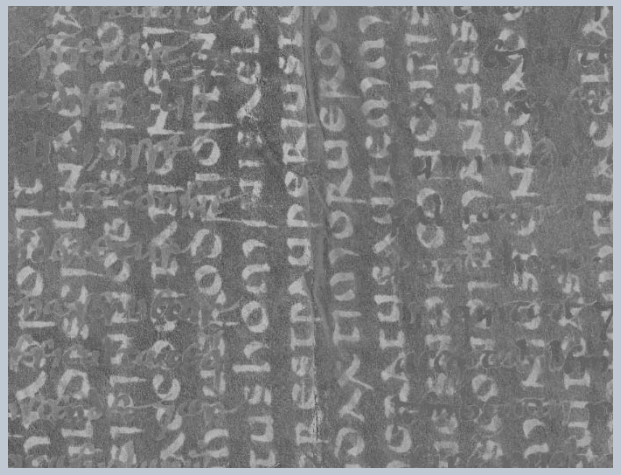
$$\begin{bmatrix} x_1 \\ x_2 \\ . \\ . \\ . \\ x_n \end{bmatrix}$$



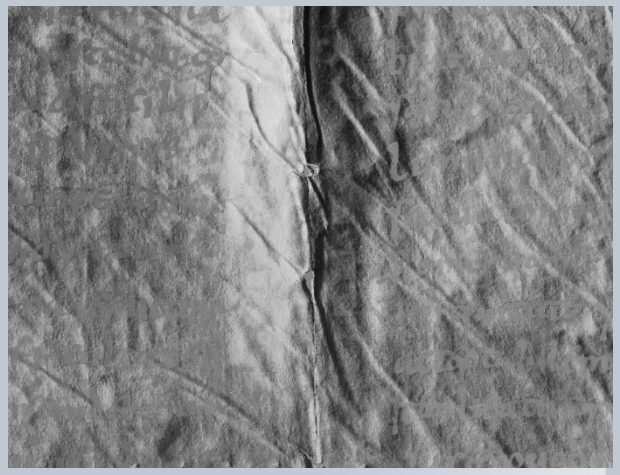
Schichtentrennung durch Unabhängige Komponentenanalyse (ICA)



Komponente 3:
Obertext

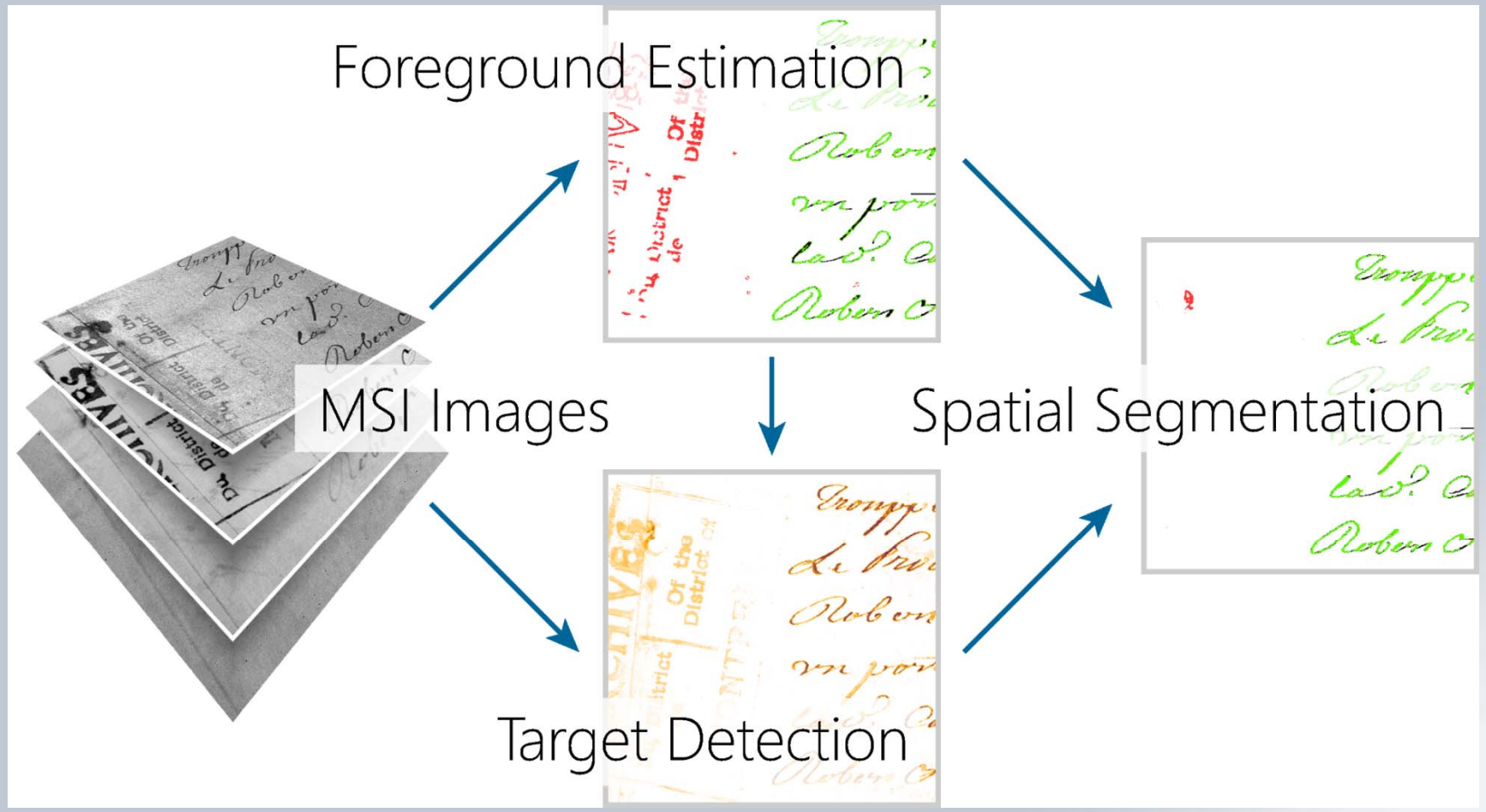


Komponente 5:
Untertext



Komponente 9:
Schreibgrundlage

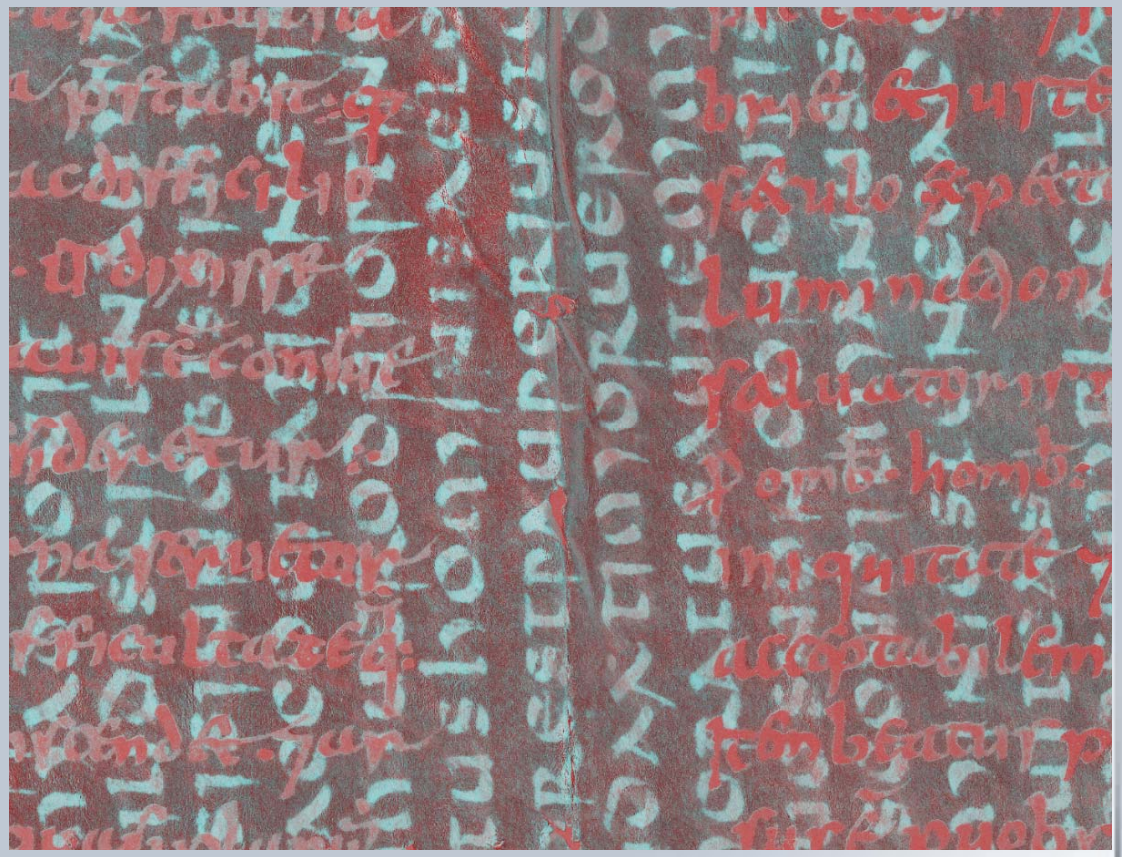
Räumliche Segmentierung



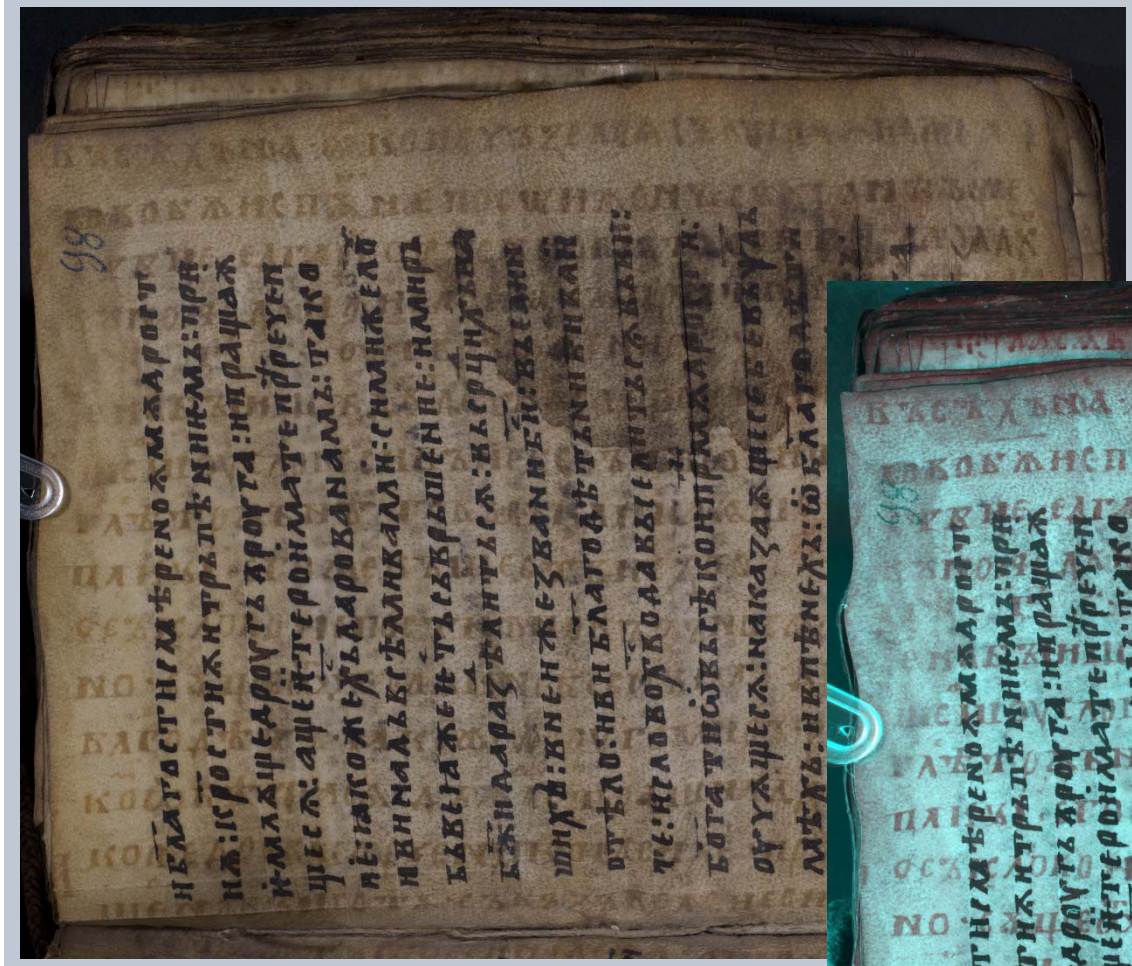
Schritt 3: Visuelle Verbesserungen

- Pseudofärbung
  - bringt verschiedene Komponenten zur Geltung
- Kontrastverstärkung / Histogramm-Dehnung
- …

→ Wissenschaft & Kunst



Kyrillisches Palimpsest im Dragotin-Apostolus (Cod. BNL 880), 12. Jh.

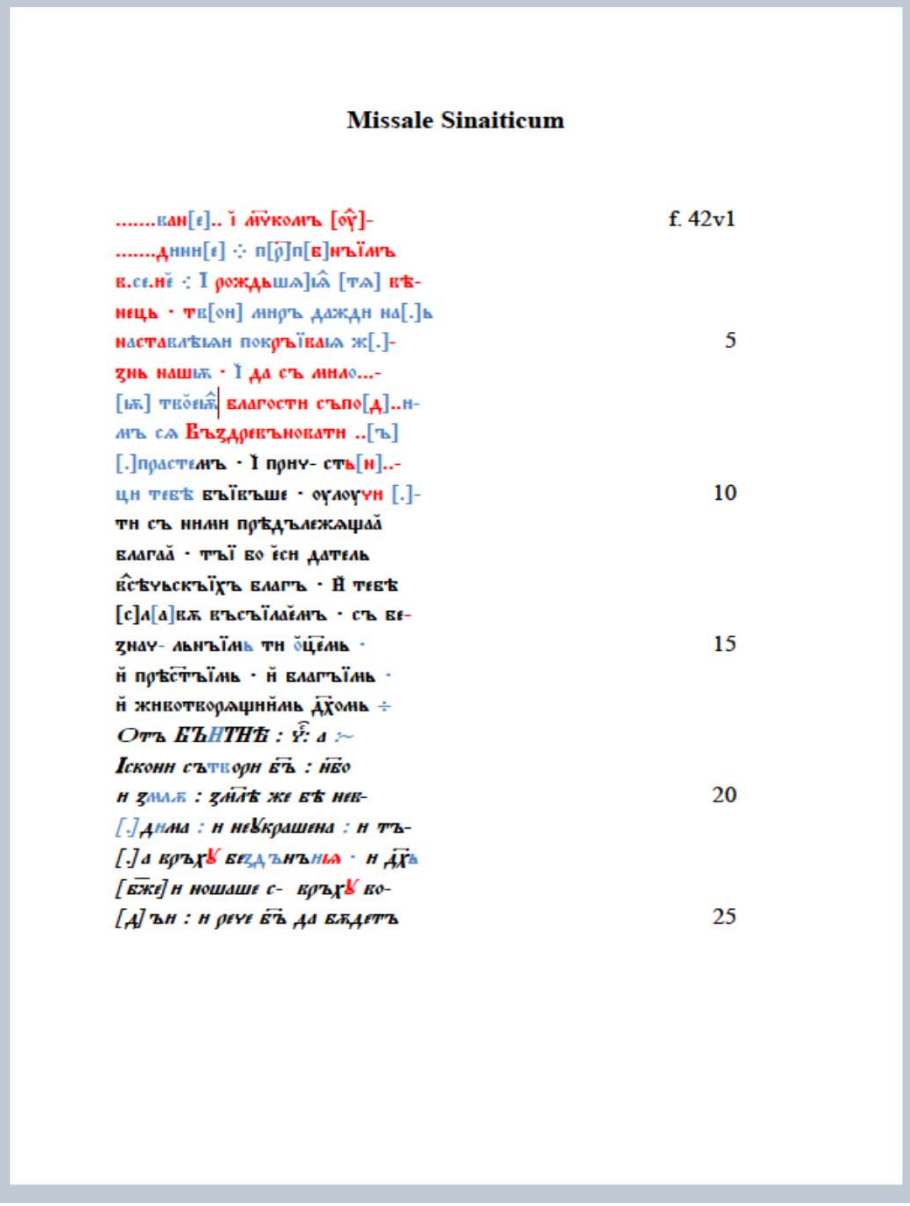


RGB-Bild

Pseudofarbbild

RGB- and pseudofarbiges LDA-Bild des Sinaitischen Missale (Sin. slav. 5N)

Aufeinanderfolgende Lesungen des Sinaitischen Missale (Sin. slav. 5/N)



Missale Sinaiticum

.....ван[е].. ї м҃ѵкомъ [оу҃]- f. 42v1
.....дини[е] ⁘ п[р҃]п[в]нъїмъ
в.се.нѐ ⁘ І рождьшѧ]іѧ҃ [тѧ] вѣ-
нець · тв[он] миръ дажди на[.]ь
наставлѣіѧи покръїваіѧ ж[.]-
знь нашѭ · І да съ мило...-
[ѭ] твоеѭ҃ благости съпо[д]..и-
мъ сѧ Въздревъновати ..[ъ]
[.]прастемъ · І прич- сть[н]..-
ци тебѣ бъївъше · оулоучи [.]-
ти съ ними прѣдълежѧщаа҃
благаа҃ · тъї бо ѐси датель
в҃сѣчьскъїхъ благъ · И҃ тебѣ
[с]л[а]вѫ въсъїлаѐмъ · съ бе-
знач- льнъїмь ти ѻ҃цемь ·
и҃ прѣс҃тъїмь · и҃ благъїмь ·
и҃ животворѧщиимь д҃хомь ÷
Отъ БЪНТНѢ : ч҃: а :~
Іскони сътвори б҃ъ : н҃бо
и змлѫ : змл҃ѣ же бѣ нев-
[.]дима : и неѹкрашена : и тъ-
[.]а връхѹ бездънъніѧ · и д҃хь
[б҃же] и ношаше с- връхѹ во-
[д]ъи : и рече б҃ъ да бѫдетъ

Schwarz: 1996-98 (Basis: Analog-aufnahmen)

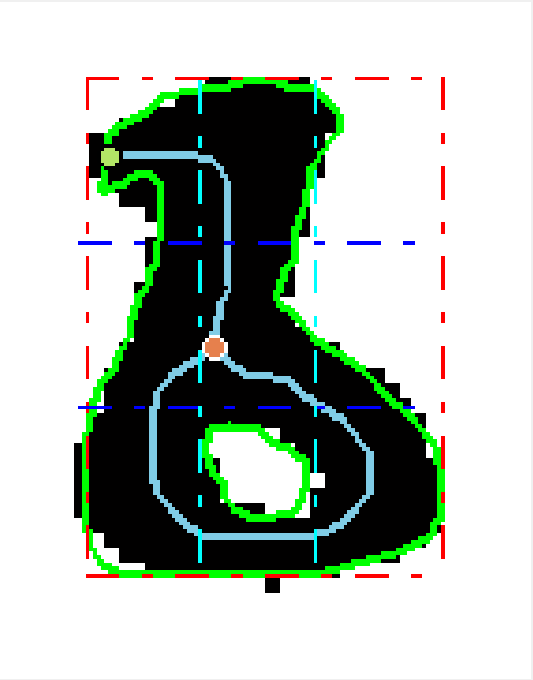
Rot: 2008 (Basis: VIS- + PCA-bearbeitetes MSI-Bild)

Blau: 2013-14 (Basis: VIS- + LDA-bearbeitetes MSI-Bild)

Graphetische Merkmalskalkulation

Selected Character

Color image Show attributes

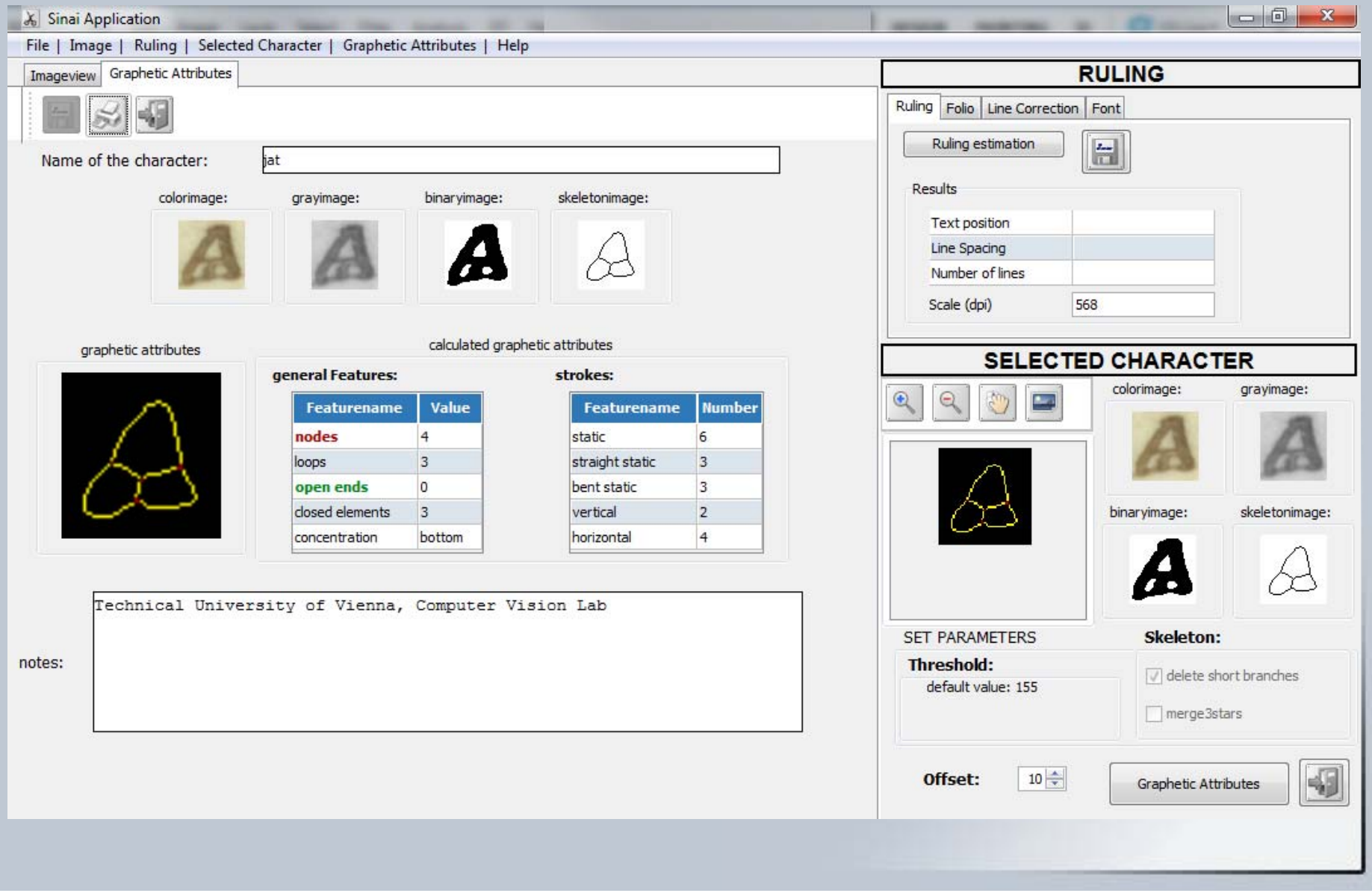


Graphetic Attributes Save Img

Results Save to Database

# Static Strokes	2
# Nodes	1
# Straight Static Strokes	0
# Bent Static Stroke	1
# Vertical Strokes	0
# Horizontal Strokes	1
# Sharp Angles	0
# Water Reservoirs	0
# Closed Elements	1
Horizontal Symmetry	0
Vertical Symmetry	0
Top/Bottom Concentration	bottom
Centered	0
Left/Right Concentration	-
# Loops	1
# Open Ends	1

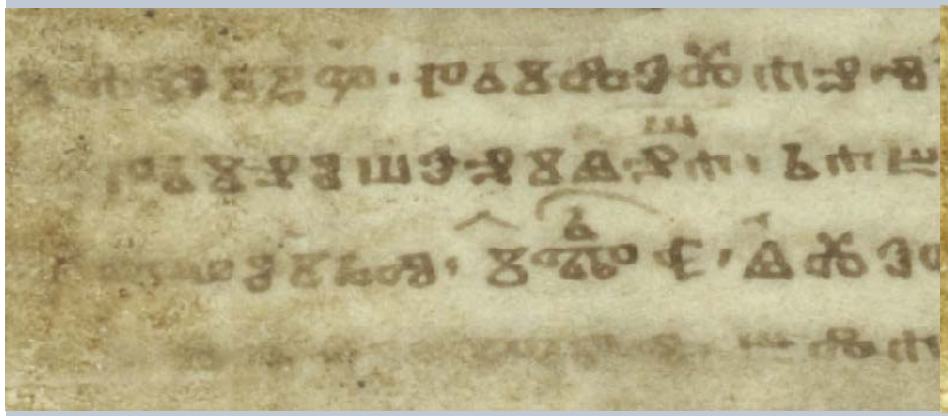
Toolbox for Manuscript-Research:
Buchstaben- und Liniierungsanalyse



OCR-Ergebnis eines beschädigten Texts

Grün: korrekt erkannte Zeichen

Rot: falsch erkannte Zeichen



Eingabebild

OCR-Output

Chemische Materialanalyse

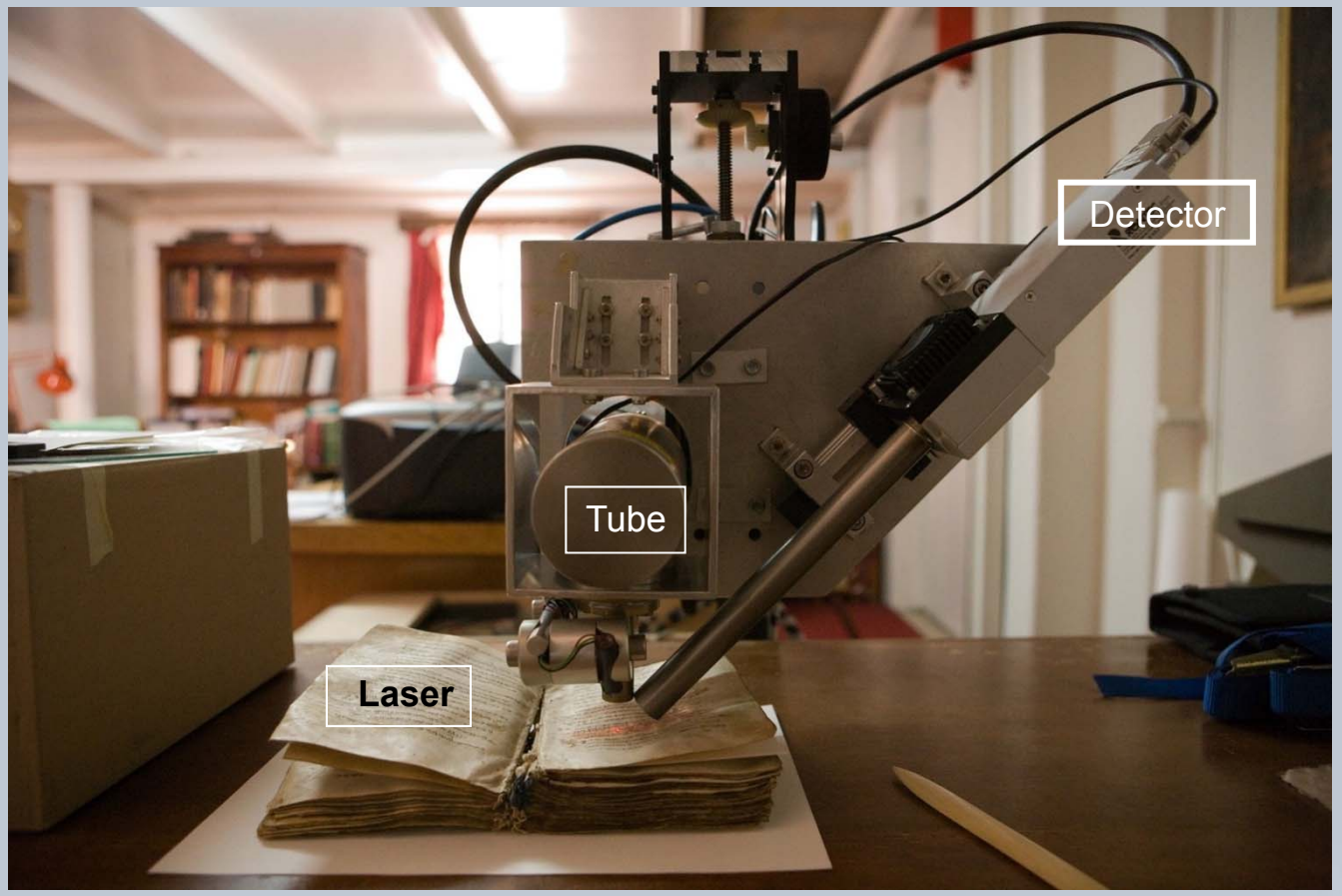
funktioniert mit Spektroskopie und betrifft

- Beschreibstoffe (Pergament, Leder etc.),
- Tinten, Pigmente, Farbstoffe und
- Bindemittel

für die Handschriftenherstellung sowie

- Umwelt- und andere Einflüsse, die mit diesen Methoden zu ermitteln sind.

Röntgenfluoreszenzanalyse mit Eigenkonstruktion (INTK)



Psalterium Sinaiticum (Hauptteil), 11. Jh.

V. Desnica, M. Schreiner:

A LabVIEW controlled portable x-ray fluorescence spectrometer for the analysis of art objects. *X-Ray Spectrometry* **35** (2006), 280-286.

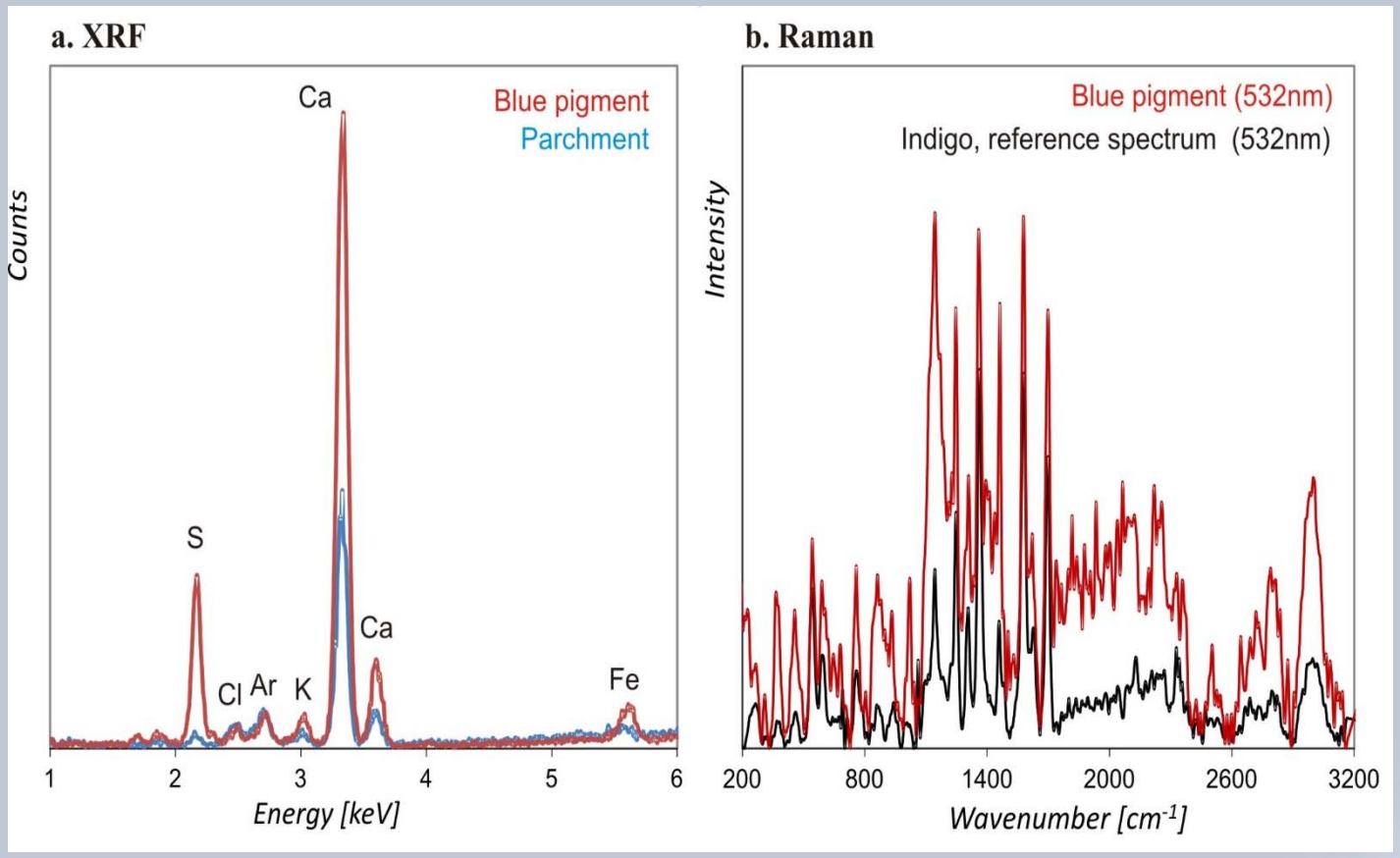
Wichtigste Instrumente zur komplementären Spektroskopie

Tragbares XRF-Gerät
(ELIO, XGLab, I)

rFTIR-Spektrometer
(ALPHA, Bruker, D)

Raman-Spektrometer
(Enwave, USA)

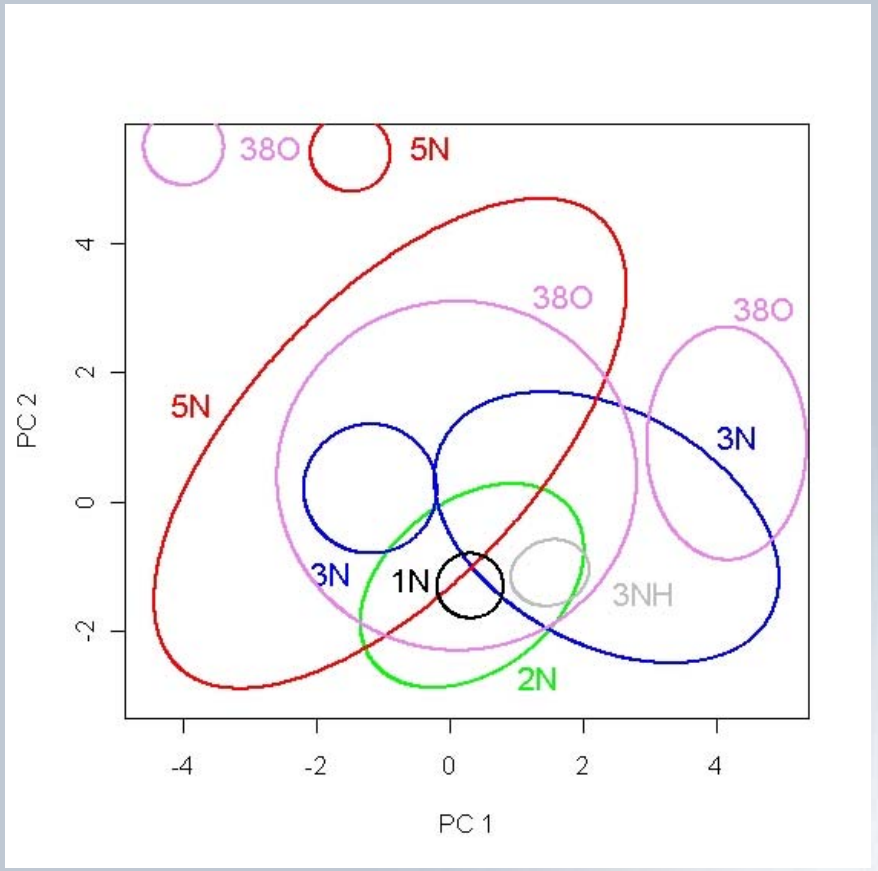
Materialidentifikation: XRF + Raman



Identifikation von Indigo durch 532 nm Laser

Vergleichsdaten & -Statistiken

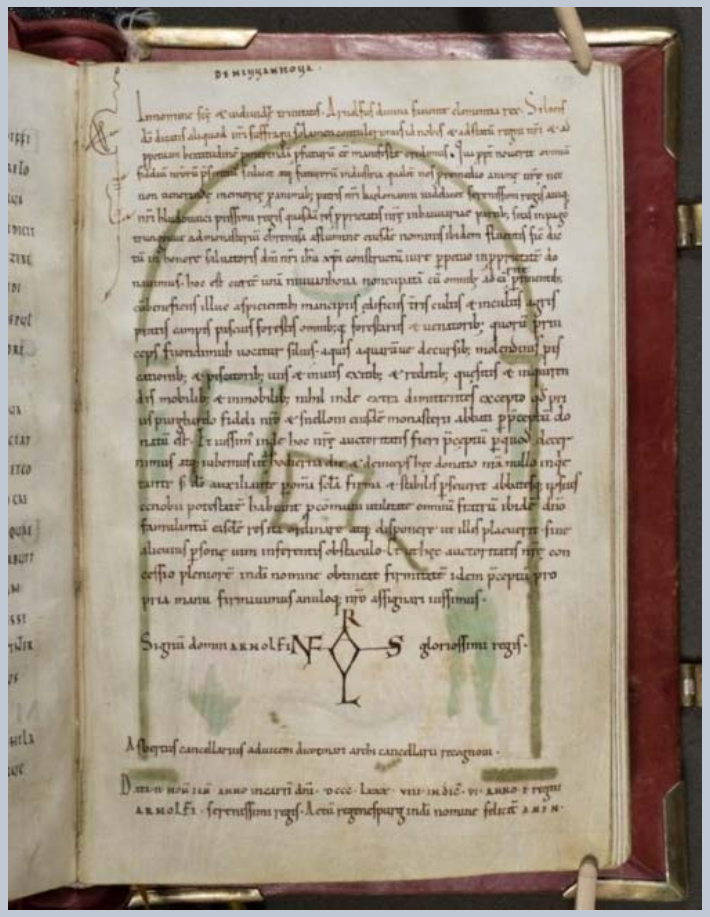
	Material	Methoden		
		XRF	rFTIR	Raman
	Vermilion	✓	-	✓
	Red led	✓	-	✓
	Red iron	✓	✓	✓
	Umber	✓	-	-
	Orpiment	✓	-	✓
	Atacamite	✓	✓	-
	Indigo	-	✓	-
	Azurite	✓	✓	✓
	Lapislazuli	✓	✓	-
	Carbon black	-	-	✓
	Lead white	✓	✓	-
	Kaolinite	-	✓	-

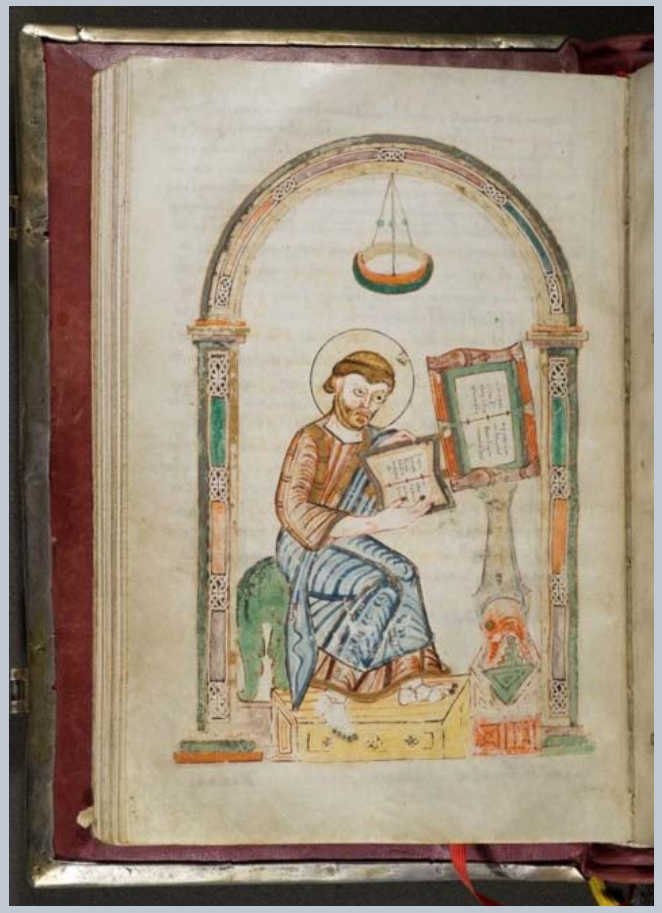


In glagolitischen, kyrillischen, griechischen, lateinischen, MHD und georgischen Hss. identifizierte Farbpigmente

Tinten in den glag. Sinai-Hss.

Pergamentdegradierung

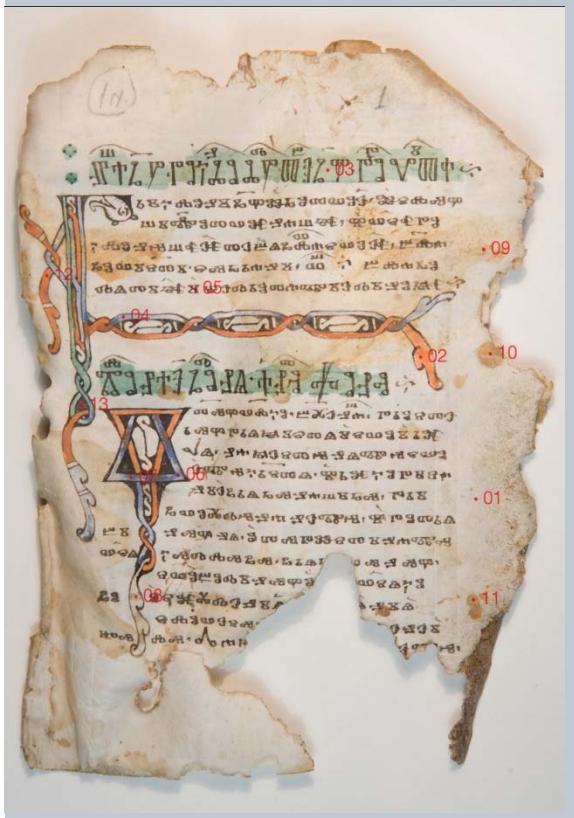




Durchdringen des Grünpigments und teilweise auch der Tinte

Cod. Millenarius Maior, 8./9. Jh., Abtei Kremsmünster

Kodikologische Beispiele

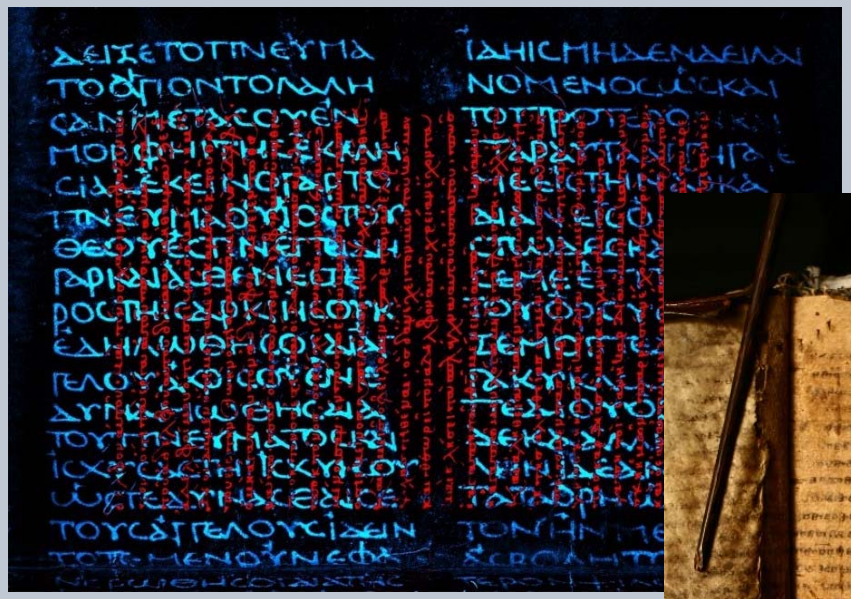


Euchologium Sin., 11. Jh.
Identifizierte Pigmente:

Rot – *Pb* (Minium),

Grün – *Cu* (Malachit),

Blau – *Si, S, K, Ca, Fe* (Lapis Lazuli)



Cod. Vind. Suppl. Gr. 119
Simonides-Palimpsest (Fälschung), 19. Jh.

Glag. Rila-Folia, 10. Jh.
Bulgarien
(Textabdruck auf Einbandholz)

Epigraphische Beispiele

Nubische Lederhandschrift aus Notgrabung auf der Nilinsel Sur

Altägyptische Stele, Kunsthistorisches Museum Wien

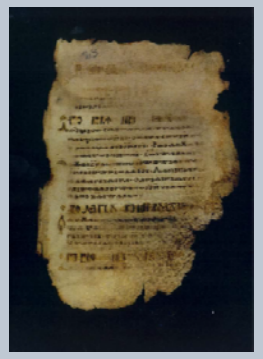
1. aramäische literarische Grabinschrift (ca. 6. vorchr. Jh.) in El Sheikh Fadl, Mittelägypten

DNA analyses applied to the study of ancient parchment manuscripts

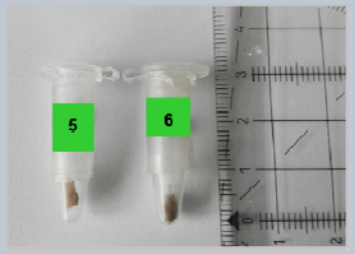
Guadalupe Piñar[1], Hakim Tafer[1], Heinz Miklas[2], Manfred Schreiner[3] and Katja Sterflinger[1]

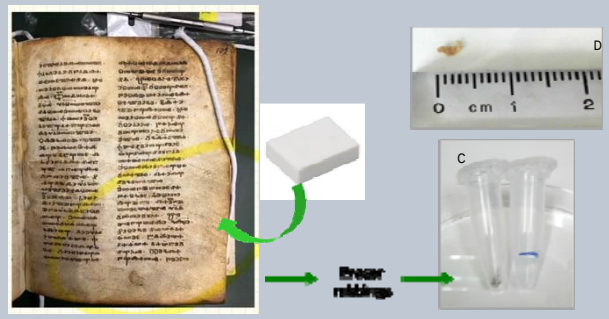
1 University of Natural Resources and Life Sciences Vienna, VIBT-Extremophile Center, Muthgasse 11, A- 1190 Vienna
2 Department of Slavonic Studies, University of Vienna, Spitalgasse 2-4, Hof 3, A-1090 Vienna
3 Institute of Science and Technology in Art, Academy of Fine Arts, Schillerplatz 3, A-1010 Vienna

Aus: El'Manuscript 2018, Universitäten Wien & Krems, 14.-18. Sept. 2018

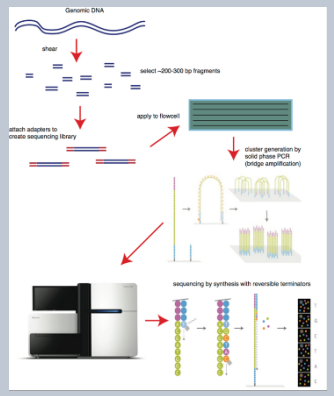


Samples:





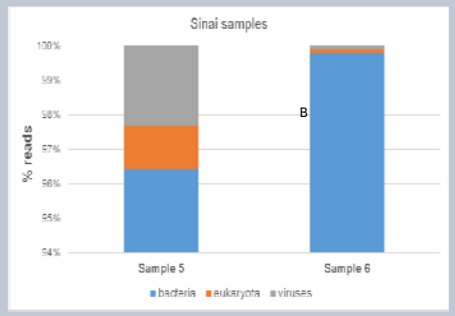
Analyses:

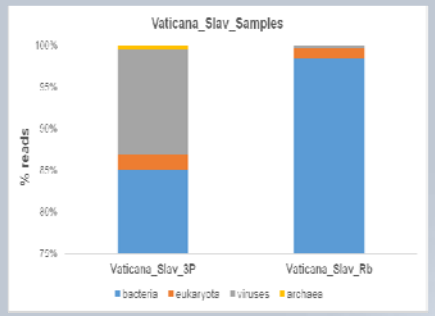


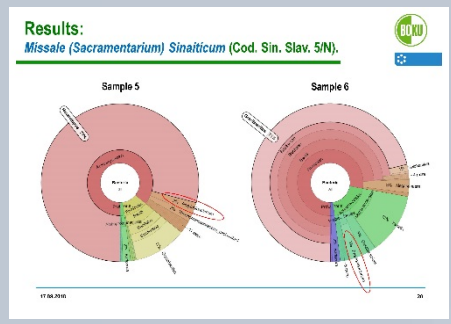
1. Library construction
2. Cluster generation (add to flow cell and amplification)
3. Sequencing ("read" of single base at a time)
4. Data analyses (images transformed in basecalls and reads)
5. Bioinformatic analyses (comparative analyses with DNA databases)

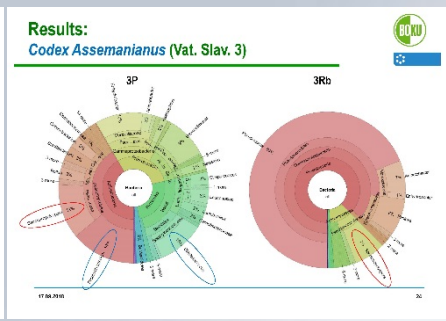
Comparative Results:

Species	Reads sample 5	Reads sample 6	Reads sample 3P	Reads sample 3Rb
Homo sapiens	208416	64370	7852951	143268
Ovis aries (sheep)	49223	-	55146	24465
Bos Taurus (cow)	-	4630	-	-









References

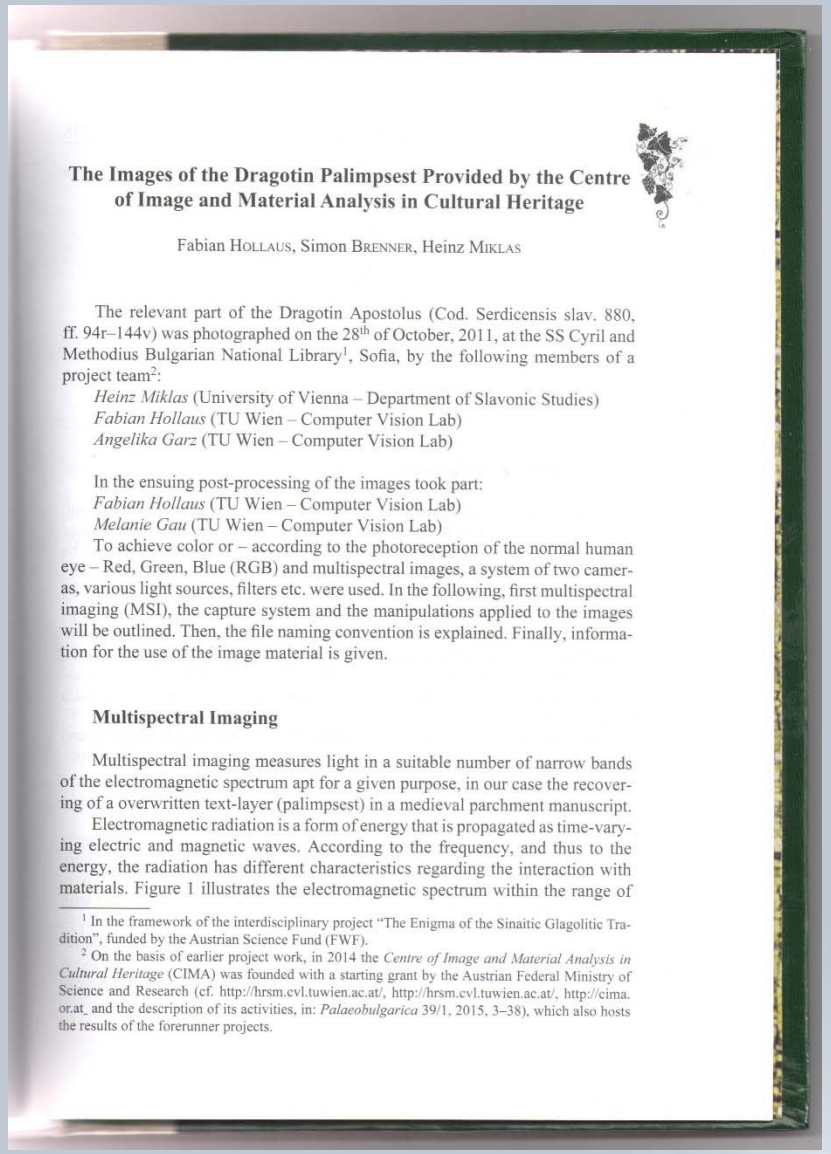
Piñar et al., 2015. *Environmental Microbiology* 17(2), 427–443
Bicchieri, 2014. *arXiv*:1404.6414 [physics.chem-ph]

Acknowledgements

This study is financed by the Austrian Science Fund (FWF) P 29892-G29

Memory-Stick zur Beigabe von Farb- und MSI-Bildserien in Quellenpublikationen

Beschreibung der Aufnahmen und ihrer Herstellung



The Images of the Dragotin Palimpsest Provided by the Centre of Image and Material Analysis in Cultural Heritage

Fabian HOLLAUS, Simon BRENNER, Heinz MIKLAS

The relevant part of the Dragotin Apostolus (Cod. Serdicensis slav. 880, ff. 94r–144v) was photographed on the 28th of October, 2011, at the SS Cyril and Methodius Bulgarian National Library[1], Sofia, by the following members of a project team[2]:

Heinz Miklas (University of Vienna – Department of Slavonic Studies)
Fabian Hollaus (TU Wien – Computer Vision Lab)
Angelika Garz (TU Wien – Computer Vision Lab)

In the ensuing post-processing of the images took part:
Fabian Hollaus (TU Wien – Computer Vision Lab)
Melanie Gau (TU Wien – Computer Vision Lab)

To achieve color or – according to the photoreception of the normal human eye – Red, Green, Blue (RGB) and multispectral images, a system of two cameras, various light sources, filters etc. were used. In the following, first multispectral imaging (MSI), the capture system and the manipulations applied to the images will be outlined. Then, the file naming convention is explained. Finally, information for the use of the image material is given.

Multispectral Imaging

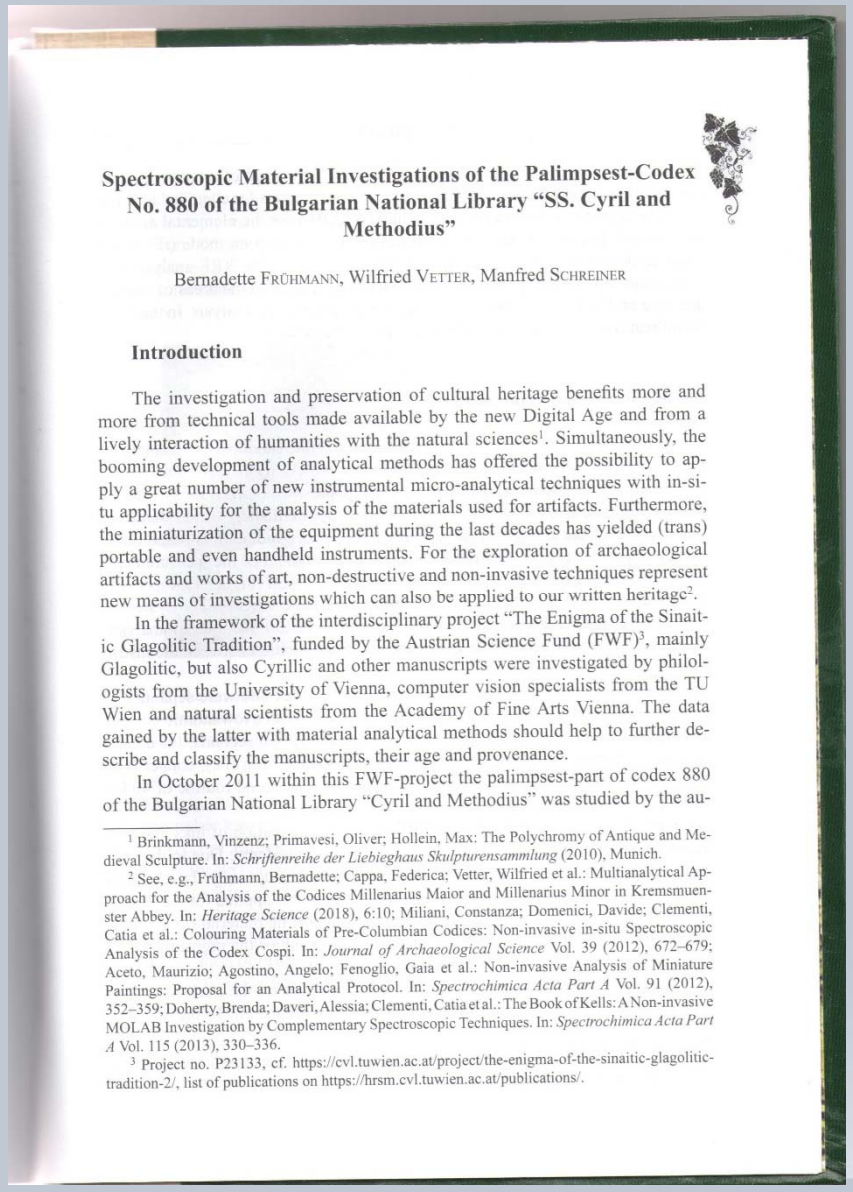
Multispectral imaging measures light in a suitable number of narrow bands of the electromagnetic spectrum apt for a given purpose, in our case the recovering of a overwritten text-layer (palimpsest) in a medieval parchment manuscript.

Electromagnetic radiation is a form of energy that is propagated as time-varying electric and magnetic waves. According to the frequency, and thus to the energy, the radiation has different characteristics regarding the interaction with materials. Figure 1 illustrates the electromagnetic spectrum within the range of

[1] In the framework of the interdisciplinary project "The Enigma of the Sinaitic Glagolitic Tradition", funded by the Austrian Science Fund (FWF).

[2] On the basis of earlier project work, in 2014 the *Centre of Image and Material Analysis in Cultural Heritage* (CIMA) was founded with a starting grant by the Austrian Federal Ministry of Science and Research (cf. http://hrsm.cvl.tuwien.ac.at/, http://hrsm.cvl.tuwien.ac.at/, http://cima.or.at_ and the description of its activities, in: *Palaeobulgarica* 39/1, 2015, 3–38), which also hosts the results of the forerunner projects.

Chemische Beschreibung des Denkmals



Spectroscopic Material Investigations of the Palimpsest-Codex No. 880 of the Bulgarian National Library "SS. Cyril and Methodius"

Bernadette Frühmann, Wilfried Vetter, Manfred Schreiner

Introduction

The investigation and preservation of cultural heritage benefits more and more from technical tools made available by the new Digital Age and from a lively interaction of humanities with the natural sciences[1]. Simultaneously, the booming development of analytical methods has offered the possibility to apply a great number of new instrumental micro-analytical techniques with in-situ applicability for the analysis of the materials used for artifacts. Furthermore, the miniaturization of the equipment during the last decades has yielded (trans) portable and even handheld instruments. For the exploration of archaeological artifacts and works of art, non-destructive and non-invasive techniques represent new means of investigations which can also be applied to our written heritage[2].

In the framework of the interdisciplinary project "The Enigma of the Sinaitic Glagolitic Tradition", funded by the Austrian Science Fund (FWF)[3], mainly Glagolitic, but also Cyrillic and other manuscripts were investigated by philologists from the University of Vienna, computer vision specialists from the TU Wien and natural scientists from the Academy of Fine Arts Vienna. The data gained by the latter with material analytical methods should help to further describe and classify the manuscripts, their age and provenance.

In October 2011 within this FWF-project the palimpsest-part of codex 880 of the Bulgarian National Library "Cyril and Methodius" was studied by the au-

[1] Brinkmann, Vinzenz; Primavesi, Oliver; Hollein, Max: The Polychromy of Antique and Medieval Sculpture. In: *Schriftenreihe der Liebieghaus Skulpturensammlung* (2010), Munich.

[2] See, e.g., Frühmann, Bernadette; Cappa, Federica; Vetter, Wilfried et al.: Multianalytical Approach for the Analysis of the Codices Millenarius Maior and Millenarius Minor in Kremsmuenster Abbey. In: *Heritage Science* (2018), 6:10; Miliani, Constanza; Domenici, Davide; Clementi, Catia et al.: Colouring Materials of Pre-Columbian Codices: Non-invasive in-situ Spectroscopic Analysis of the Codex Cospi. In: *Journal of Archaeological Science* Vol. 39 (2012), 672–679; Aceto, Maurizio; Agostino, Angelo; Fenoglio, Gaia et al.: Non-invasive Analysis of Miniature Paintings: Proposal for an Analytical Protocol. In: *Spectrochimica Acta Part A* Vol. 91 (2012), 352–359; Doherty, Brenda; Daveri, Alessia; Clementi, Catia et al.: The Book of Kells: A Non-invasive MOLAB Investigation by Complementary Spectroscopic Techniques. In: *Spectrochimica Acta Part A* Vol. 115 (2013), 330–336.

[3] Project no. P23133, cf. https://cvl.tuwien.ac.at/project/the-enigma-of-the-sinaitic-glagolitic-tradition-2/, list of publications on https://hrsm.cvl.tuwien.ac.at/publications/.

Kritische Erstedition des Dragotin-Palimpsests, 12. Jh. (Universitätsverlag Sofia, 2018)

Herzlichen Dank für Ihre Aufmerksamkeit!

Heinz.Miklas@univie.ac.at

TU WIEN

universität wien

[a]