Sammlungszentrum. SCHWEIZERISCHES NATIONALMUSEUM. MUSÉE NATIONAL SUISSE. MUSEO NAZIONALE SVIZZERO. MUSEUM NAZIUNAL SVIZZER.

STIFTUNG BASLER MÜNSTERBAUHÜTTE

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1. Einleitung

1.1 Grundgedanke des Forschungsprojektes PolyBasel

Wer heute das Basler Münster, die frühere Bischofskirche des Bistums Basel, betritt, vermag sich kaum den ursprünglichen und ehemals überaus farbigen Gesamteindruck des Bauwerks und seiner Ausstattung vorzustellen. Im Zuge der Reformation und des Bildersturms von 1529, aber auch durch die vermeintlich im Sinne des Mittelalters erfolgte „Purifizierung“ Mitte des 19. Jahrhunderts wurden die Räume des Kirchenbaus umgestaltet und steinsichtig gemacht. Weitere, zu Beginn der Neuzeit noch farbige Originalausstattung wie Altäre, Chorschranken, Lettner, Skulpturen und Wandbehänge wurden entfernt, ebenso die bunten Glasfenster, die zum Teil schon während des Erdbebens von 1356 zerstört und dann erneuert worden waren. Dasselbe gilt für den farbigen Eindruck an der Aussenhülle der Kathedrale. Ab dem 16. Jahrhundert entfernte man die mittelalterliche Polychromie an Figuren bzw. verzichtete teilweise auf die Pflege und Instandhaltung der Aussenfarbigkeit auf Wänden und Skulpturen. Auch hier war fortan „Steinsichtigkeit“ das erklärte Ziel.

Eine Gesamtbetrachtung der mittelalterlichen und neuzeitlichen Farbgebung und ihrer dem Zeitgeist unterworfenen Raumwirkung gab es für das Basler Münster bislang nicht. Was bisher vorlag, waren Farbuntersuchungen zu vielen Einzelobjekten. Hauptziele des Forschungsvorhabens „PolyBasel“ war einerseits die wissenschaftliche Aufarbeitung von Altbefunden mit modernen Methoden der Naturwissenschaft sowie die neue, zeitgemässe, minimalinvasive Untersuchung und Dokumentation vorhandener Fassungsspuren an ausgewählten Objekten und Architekturteilen. Andererseits eine daraus folgende Gesamtschau inklusive Einordnung der vorgefundenen Farbfassungen in die Abfolge der neuzeitlichen Aussen- und Innenrenovationen am Münster (16.-21. Jh.). Durch die systematisch vergleichende Analyse der historischen Substanz, die Interpretation der Fassungsreste mit naturwissenschaftlichen Technologien und Methoden sowie durch geisteswissenschaftliche Methoden wie Schrift-/Bildquellen- und Stil-Analyse ist bei diesem Projekt von einem deutlichen Erkenntnisgewinn auszugehen.

1.2 Das Münster

Das Basler Münster zählt mit dem Strassburger und Freiburger Münster zu den herausragenden mittelalterlichen Sakralbauten am Oberrhein. Charakteristisch für das Bauwerk ist, dass es vorwiegend aus rotem Buntsandstein errichtet wurde und wegen seiner langen Bauzeit (1019/Ende 12. Jh. bis 1503) spätromanische und gotische Bauformen aufweist. Die Synthese, die am Basler Münster daraus entstand, gilt als besonders gelungen. Der Gottesmutter Maria geweiht und bis zur Reformation Zentrum des mittelalterlichen Bistums Basel thront der bedeutendste Sakralbau der Stadt hoch über dem Rheinufer und prägt das Bild mit seinen beiden mittelalterlichen Türmen. Der Bau präsentiert sich heute als fünfschiffige Basilika mit Querhaus und Krypta, an deren Südseite ein Doppelkreuzgang mit drei Kapellen (Maria-Magdalena-, Niklaus- und Katharina-Kapelle) anschliesst (Abbildung 1.1). Grosser und Kleiner Kreuzgang werden durch eine weiträumige Halle miteinander verbunden und dienten im Mittelalter vor allem als Sakral-und Bestattungsbereich. Mit kunstvollen Gewölben, Wandbildern und zahlreichen Altären ausgestattet, wurden hier Prozessionen durchgeführt und Liturgien abgehalten. Nach der Reformation blieb der Kreuzgang bis 1861 Bestattungsort und ist seither mit zahlreichen Epitaphien ausgeschmückt (Schwinn Schürmann, 2013).

Abbildung 1.1: Münster Ansicht aussen (links) und innen (rechts) (Bildnachweis: Erik Schmidt)

1.3 Das Baumaterial

Als Baumaterial kamen ausschliesslich regionale Natursteine zum Einsatz, die über die Wasserwege von Rhein und Wiese in die Stadt transportiert wurden. Es handelt sich dabei hauptsächlich um Buntsandsteine aus der unteren Trias. Als Baustein für das aufgehende Mauerwerk wurde am Basler Münster seit dem 10. Jahrhundert der Mittlere Buntsandstein aus Brüchen bei Degerfelden (Bitterli-Brunner, 1988), westlich von Rheinfelden (Baden, Deutschland) bezogen, der im Folgenden immer als Degerfelder bezeichnet wird. Es handelt sich hierbei um einen mittel- bis grobkörnigen Sandstein mit zentimeterweisen, raschen Wechseln von hellroten, hellvioletten, hellbräunlichgelben und nahezu weissen Lagen, die oft diagonal geschichtet sind. Ein weiteres charakteristisches Kennzeichen ist die häufige Beimengung von Quarzfeinkies. Die Quarzgerölle sind überwiegend zwei bis zehn Millimeter gross, oft nur gering kantengerundet und sowohl milchig weiss als auch kräftig dunkelrot gefärbt. Die Quarzgerölle sind sowohl lagen- als auch nesterweise angereichert, aber auch regellos verteilt. Die feste Bindung ist rein kieselig und beruht vor allem auf gut verzahnten Körnern und Kornanwachssäumen aus

Quarz (Werner et al., 2013). Diese Eigenschaften, verbunden mit einem ausgewogenen Korn-Bindemittel-Verhältnis, verleihen ihm eine hohe Witterungsbeständigkeit (Abbildung 1.2).

Für Bauplastik, Reliefs und figürliche Bildwerke fand der Obere Buntsandstein aus Brüchen bei Schopfheim, Steinen und Hauingen im Wiesental (Deutschland) Verwendung. Im folgenden Text wird diese Varietät stets als Wiesentaler bezeichnet. Der dunkle bis rotbraune, zuweilen violettstichige, feinkörnige Sandstein gehört zur Plattensandstein-Formation und ist aufgrund seiner homogenen Struktur und Festigkeit für anspruchsvolle Bildhauerarbeiten gut geeignet (Werner et al., 2013). Lagenweise können bisweilen kleine dunkelrote Tonsteinklasten auftreten. Seine Färbung erhält der kieselig gebundene Wiesentaler durch Hämatit in den Quarzanwachssäumen auf den Oberflächen des ansonsten farblosen Zuschlags (Abbildung 1.2). Die seltenere grünlichgraue Variante des Wiesentaler Buntsandsteins entstand durch Entfärbeprozesse, bei dem mit Kohlendioxid angereicherte Sickerwässer die rötlichen Eisenverbindungen (Hämatit) herauslösten.

Für ein Objekt, die Baumeistertafel (PB6 um 1200), wurde ein heller, feinkörniger Molassesandstein verwendet (Abbildung 1.2). Der hellbeige bis lichtgrau-grünliche harte Kalksandstein ist ein Tertiärsandstein des Septarientons (Bitterli-Brunner, 1988). Er ist im Stadtgebiet von Basel am östlichen Rheinufer aufgeschlossen (de Quervain, 1969) und wurde im Mittelalter wahrscheinlich bei Niedrigwasser unterhalb des Münsterhügels ausgebeutet.

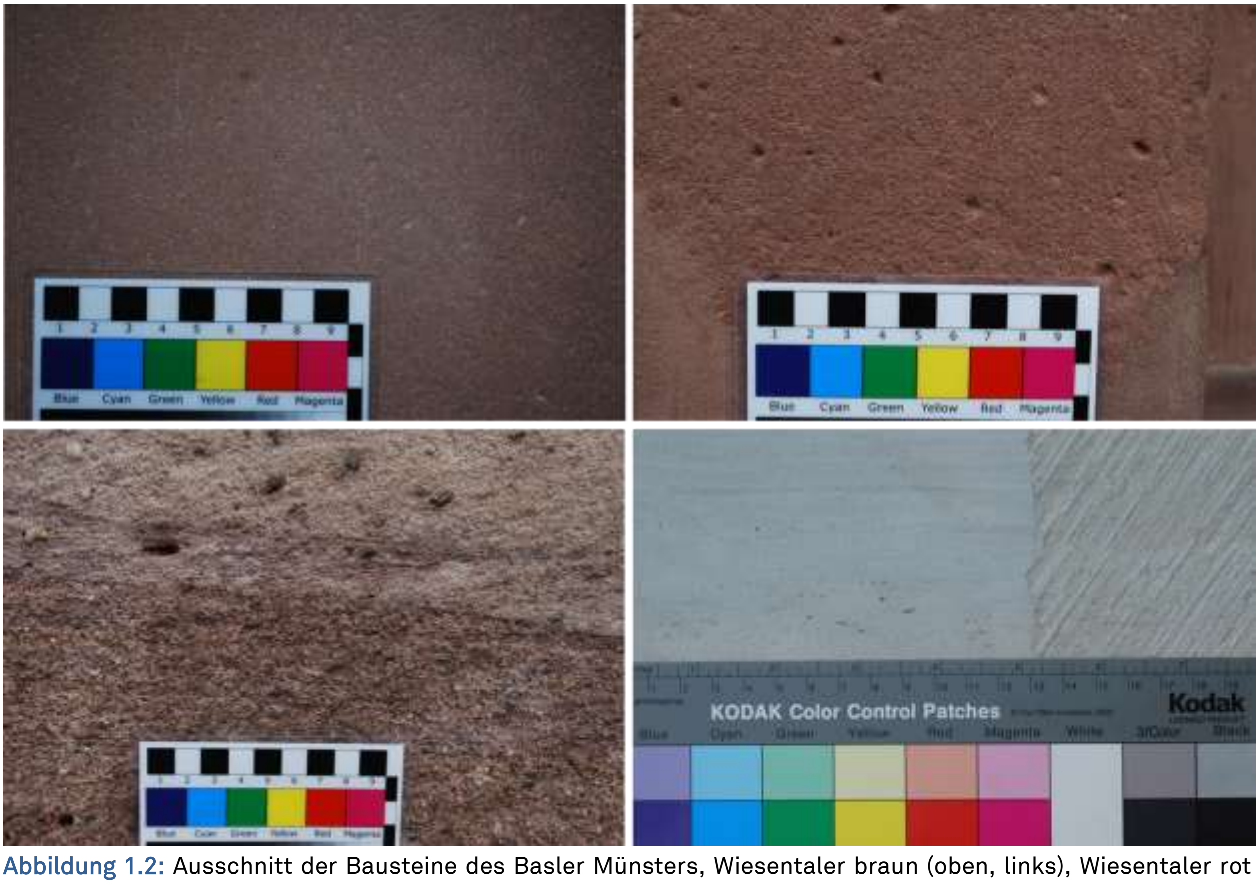


Abbildung 1.2: Ausschnitt der Bausteine des Basler Münsters, Wiesentaler braun (oben, links), Wiesentaler rot (oben, rechts), Degerfelder (unten, links) und Molasse (unten, rechts), Sandsteine.

1.4 Forschungsziele

Anhand der im folgenden Kapitel beschriebenen Auswahl von zu untersuchenden Objekten sollten folgende Ziele erreicht werden:

- Anhand noch nicht untersuchter Objekte (z.B. Grabungs-Fundstücken, ehemaligen Wandfassungen, verdeckten Wandbildern) sollten neue Erkenntnisse gewonnen werden, diese mit bekannten Ergebnissen kombiniert und so Lücken geschlossen werden, mit Schwerpunkt auf kunsttechnologischen Aspekten.
- Die Frage sollte beantwortet werden, ob das Material des Bildträgers oder der Anbringungsort Einfluss auf die verwendete Kunsttechnologie hatten. Hat man z.B. Verwitterungsaspekte bei der Bindemittelwahl hinzugezogen?
- Es sollte geklärt werden, ob es gestalterische Raumkonzepte gab für Innen- und Aussenraum bzw. Halbaussen (Kreuzgang).
- Es sollte die Frage beantwortet werden, wie sich die radikalen purifizierenden Massnahmen des 19. Jahrhunderts auswirkten, vor allem das Ablaugen und Entfernen von Farbschichten mittels Stockhammer.
- Ergebnisse von bereits Untersuchtem wie dem Hauptportal und der Galluspforte sollten vergleichend beigezogen und überprüft werden.
- In der Forschungsliteratur bereits bestehende Thesen (z.B. die Kanzel war polychrom gefasst; die Vincentiustafel stammt von 1100) sollten überprüft werden.
- Die Analyse von Farbfassungen auf Bildquellen und von Farbschichten an den Objekten sollten zu neuen Erkenntnissen der Objektgeschichte der einzelnen Bildwerke führen
- Es sollten neue Erkenntnisse zu den purifizierenden Massnahmen im Innenraum im Zuge der Reformation (Ende 16. Jh.) erzielt werden

Um diese Fragen beantworten und diese Ziele erreichen zu können, sollte folgende naturwissenschaftliche Strategie verfolgt werden:

- Es sollten allgemein die Farbpalette, der Malschichtaufbau und die Bindemittel charakterisiert werden, um die im Basler Münster angewandten Maltechniken rekonstruieren zu können. Hierzu sollten zerstörungsfreie In-situ-Untersuchungen im Basler Münster selbst sowie Untersuchungen an Proben im Labor durchgeführt werden.
- Verschiedentlich wurden zu früheren Zeiten von Restauratoren Proben von Farbfassungen entnommen und archiviert. Diese wurden zur Untersuchung herangezogen und sollten, wo nötig, durch neue Proben ergänzt werden. Durch die Interpretation erster In-situ-Untersuchungen sollte eine Probennahmestrategie festgelegt werden, nach der eventuell weitere aussagekräftige Proben entnommen werden sollten. Diese Proben sollten dann zu Querschliffen verarbeitet werden, um eine genaue Chronologie des Schichtaufbaus erstellen und die einzelnen Farbschichten auf ihre Zusammensetzung hin zu untersuchen.
- Die Messmethode für die Analyse von Spuren von Malschichten sollten mittels Testreihen an beschichteten Steinprobekörpern für die In-situ-Analysen optimiert werden.
- Ob und wie sich das radikale Purifizieren durch Ablaugen und Abstocken spektrometrisch erfassen lässt und welche Aussagen möglich sind, sollte zusätzlich

anhand von entsprechend bearbeiteten Steinprobekörpern eruiert werden. Die Interpretation sämtlicher Untersuchungsergebnisse sollte in die oben genannten Ziele einfliessen und so zur Bestimmung der Chronologie der verschiedenen Farbfassungen des Basler Münsters beitragen.

2. Dokumentation und Archivrecherche

Im Folgenden werden die Baugeschichte des Münsters, die wichtigsten neuzeitlichen Pflegeetappen mit Auswirkungen auf die Farbgebung und das verwendete Gesteinsmaterial vorgestellt. Geschildert werden zudem die für die Auswahl der Objekte massgeblichen Kriterien und die Ziele der Untersuchungen.

2.1 Bau- und Restaurierungsetappen am Münster (aussen und innen)

Im Laufe seiner bald 1000jährigen Geschichte kam es am Münster immer wieder zu einschneidenden Ereignissen gesellschaftlicher, politischer oder sogar geologischer Art, die bauliche Eingriffe am Bauwerk zur Folge hatten – meist auch mit Einfluss auf die farbige Ausstattung.

- 1019 Errichtung des frühromanischen Neubaus auf Fundamenten der karolingischen Vorgängerkathedrale, Weihe durch das ottonische Kaiserpaar Heinrich II. und Kunigunde
- Um 1170/1200 spätromanischer Neubau, wahrscheinlich infolge eines Brandereignisses 1258, Zufügung von Querhaus, Chorumgang, Fassaden- und Chorflankentürmen, Vierungsturm zu einem fünftürmigen Bau, Maria–Magdalena-Kapelle und Grossem Kreuzgang
- 1270/85 Einbau eines neuen Portals in gotischem Stil in der Vorhalle zwischen den Fassadentürmen
- 1274/1300-1346 Anbau von Grabkapellen an den Seitenschiffen und Zusammenschliessung zu äusseren Seitenschiffen
- 1356 Erdbeben, rascher Wiederaufbau in gotischen Formen (Chorweihe 1363), Einwölbung des Kryptaumgangs, der Vierung, des Quer- und Langhauses bis 1420, Versetzen des Hauptportals von 1270/85 aus der Vorhalle in die Hauptfassadenflucht, Aufführung des Georgsturms (1414-1428/29), des Grossen und Kleinen Kreuzgangs (1429-1487) und des Martinsturms (1488-1503). 1503 Fertigstellung der mittelalterlichen Kathedrale.
- 1529 Reformation, ab 1580 Anpassungen an die neue Liturgie, unter anderem Abräumen von Skulpturfragmenten aus dem Bildersturm, Übertünchen von Wand- und Gewölbemalereien (Gewölbe und Wände Innenraum, Kapellen und Kreuzgänge, Umplatzierung Taufstein, Abendmahlstisch, Kirchenbänke)
- 1597 Aussen- und Innenrenovation des Münsters
- 1684 Reparaturen am Martinsturm
- 1733/34 Erste umfassende Renovation seit 1597 mit Ausbesserungen am Steinwerk, Neuanstrich der Wände, der Kanzel und beider Aussenportale
- 1751-53 Pflegemassnahmen an den Türmen
- 1761/1767-1771 Aussenrenovation, zweite umfassende Renovation seit 1597
- 1772 Teilweise Innenrenovation, Weisseln von Mauerwerk, Malerei an Grabmälern
- 1785-1787 Umfassende Innenrenovation
- 1811, 1818, 1822 Aussenmassnahmen, Anstrich der Türme

- 1852/57 Dritte umfassende Renovation, mit tiefgreifenden baulichen Veränderungen des Innenraums zur Schaffung eines „Einheitsraums“[1] , unter anderem Abbau des Lettners und Teilwiederaufbau als Orgelempore, Versetzung der Kanzel, Einebnen der Westkrypta und Beseitigung der farbigen Anstriche (Details siehe Abschnitt Auswirkungen Farbentfernungen 1852/57 weiter unten).
- 1870 Renovation der Kreuzgänge
- 1880-90 Aussenrenovation, vierte umfassende Renovation
- 1925-39 Aussenrenovation, fünfte umfassende Renovation
- 1966/1973-74 Archäologische Grabungen im Innenraum
- 1975 Innenrenovation
- 1992-2000 Etappenweise Innenrestaurierung, vor allem Reinigung und Konsolidierung
- 1975 Innenrenovation nach den Grabungstätigkeiten
- 1986.2013 Aussenrenovation (1. Zyklus)
- 1991-1999/2002 Innenrenovation
- 2014 bis ca. 2040 Aussenrenovation (2. Zyklus)

2.2 Auswirkungen der Farbentfernung von während der Innenrestaurierung 1852/57

Um im Innenraum des Münsters die Steinoberflächen des aufgehenden Mauerwerks und zahlreicher bildhauerischer Ausstattungsstücke in den Zustand einer vermeintlich ursprünglichen Steinsichtigkeit rückzuversetzen, mussten wahrscheinlich teils dicke Farb- und Putzschichten auf möglichst ökonomische Weise entfernt werden. Für die Bearbeitung der Flächen aus dem grob- bis mittelkörnigen, rot-hellgrau gebänderten Degerfelder Sandstein fiel die Wahl auf den sogenannten Stockhammer. Es handelt sich dabei um ein hammerähnliches Handwerkzeug mit einer eisernen Hammerplatte, deren Oberfläche ähnlich einem Fleischklopfer mit kleinen Spitzen besetzt ist. Der Schlag mit dem Stockhammer hinterlässt kleine kraterförmige Vertiefungen auf der Oberfläche und wird üblicherweise zum Einebnen grob vorgearbeiteter Hartgesteine wie Marmor und Kalkstein eingesetzt. Für Sandsteine kommt dieses Werkzeug normalerweise nicht zur Anwendung, da es die Steinoberfläche so beschädigen kann, dass es zu schalenförmigen Abplatzungen kommt, wenn Sandsteine im Freien verbaut werden. Die Spuren dieser dennoch konsequent eingesetzten Praktik sind im Münster allgegenwärtig. Man beseitigte so nicht nur die Farb- und Putzreste sondern grösstenteils auch die mittelalterliche Originalbearbeitung mitsamt Steinmetzzeichen. Die eisenbewährten Spitzen des Hammers zertrümmerten die Kristallstruktur der Sandkörnchen. Als kleine weisse Pünktchen zeichnen sich diese Mikrotrümmer heute als erkennbare Struktur auf den Quadern ab und bewirken zudem

[1] Dem Beschluss, den Innenraum steinsichtig zu gestalten, gingen eingehende Diskussionen voran. Die Entscheidungsträger waren von einer „romanischen“, d.h. steinsichtigen Architekturfassung überzeugt (u.a. 1853 Bericht des Baukollegiums an Bürgermeister und Kleinen Rat des Kantons Basel-Stadt, 22. September 1853 oder 1853 Verwaltungsbericht des Kleinen Rats vom Jahr 1853, p.113).

aufgrund der kleinen weissen Pünktchen eine leichte ins Hellgraue tendierende Gesamtaufhellung der Steinoberflächen (Abbildung 2.1).

Abbildung 2.1: Oberfläche eines Degerfelder-Quaders mit gestockter Textur.

Auf den Bildhauerarbeiten aus feinem roten Wiesentaler Sandstein kam diese „schlagkräftige" Methode nicht in Frage. Zahlreiche Beobachtungen während des Projektes sprechen dafür, dass man höchstwahrscheinlich auf eine chemische Entfernung mit sogenanntem Seifenstein (Natronlauge) zurückgriff, die 1880 nachweislich auch zur Farbentfernung am Georgsturm benutzt wurde. Farbreste mit vollständiger Schichtenabfolge konnten sich ausschliesslich in schwer zugänglichen Tiefen und Hinterschneidungen halten. Auf gewölbten oder stark bewegten Flächen blieben immerhin einzelne Farbschichtfetzen hängen, während glatte, ebene Bereiche, die mit harten Pinseln oder sogar Drahtbürsten kräftig abgerieben werden konnten, fast immer nur noch unter UV-Licht sichtbare einzelne Spuren enthalten. An einigen Objekten wie dem Taufstein und der Vincentiustafel ist überdies zusätzlich von einer Nachbearbeitung mit Bildhauerwerkzeugen auszugehen.

2.3 Aussenbau

Der Aussenbau wurde in der Neuzeit immer wieder mit dunkelroten Anstrichen versehen. Der Strategiewechsel erfolgte im 19. Jh. mit dem Ziel der Steinsichtigkeit: im Zuge der Innenrenovation von 1852/57 wurden nun auch während der Aussenrenovation

1880/1890 vor allem bei den Türmen, aber auch beim Westportal, die im Innenraum erprobte chemische Methode des Ablaugens mit Bürste eingesetzt (s. Jahresberichte Münsterbaukommission 1880/1890). So wurden die Türme steinsichtig. Und 1883 entfernte man die am Hauptportal noch sichtbaren bunten Farbreste (Meier/Schwinn Schürmann 2011, S. 38)

2.4 Objektauswahl

Grundlage für die technologischen Untersuchungen stellte eine erstmalige, umfassende, logische Auswahl von Einzelobjekten des Basler Münsters anhand verschiedenster Kriterien dar. Es wurden folgende Kriterien für eine Auswahl festgelegt und 37 Objekte, gegliedert in 28 Objektgruppen[2], ausgewählt:

- Jegliche vorhandene Malerei-Technologie sollte berücksichtigt werden (Malerei direkt auf Stein/Wand, Malerei mit Grundierung, Malerei auf Putz etc.).
- Alle bis ins 19. Jahrhundert am Münster verbauten Bau- und Bildhauergesteine (Degerfelder und Wiesentaler Buntsandstein, Molasse-Sandstein) sollten berücksichtigt werden.
- Möglichst grosse Datierungs-Spanne, in Schritten von je 50 Jahren (früheste Objekte spätromanisch um 1180/1200, spätestes Objekt Epitaph Maria Burckhardt um 1610).
- Die wichtigsten Bauteile des Münsters mussten repräsentiert sein: Aussenbau – Innenraum – Krypta - Kreuzgänge mit Kapellen.
- Möglichst breite Spanne an Objekt-Funktionen: liturgische Ausstattungsstücke (Bischofsthron, Taufstein, Kanzel), Altartafeln oder Chorschranken (Vincentius/Apostel), Grabmäler (Annagrab, Georg von Andlau), Wandmalerei, Deckenmalerei, Schriftenmalerei, Bauplastik (Schlusssteine).
- Sichtbares (heute noch erkennbare Farbreste) und Unsichtbares (nur durch UV-Beleuchtung sichtbares) sollte vertreten sein. Dafür wurde vorab ein Rundgang durchs Münster unter UV-Beleuchtung gemacht, bei dem einige bisher unsichtbare Motive entdeckt wurden.

Bei der Auswahl der zu untersuchenden Objekte lassen sich vier Kategorien von farbig gefassten Bildträgern unterscheiden:

1. Fassung auf Kalk-/Gipsputz (Wand- und Gewölbemalereien PB1a, 1b, 2, 3, 7a, 11, 12, 14, 15, 20, 21b, 25b, 26 und 28a)
2. Fassung auf feinem roten Buntsandstein (PB4, 5, 7a, 7b, 8, 9 Grabplatte und Tumba, 10, 13, 16, 17, 18, 21a, 22, 23, 25a und 27)
3. Fassung auf mittel-bis grobkörnigem Buntsandstein (PB9 Wandmalerei, 19, 24 und 28b)
4. Fassung auf hellbeigem Molassesandstein (PB6).

[2] Mit „PB“ plus laufende Nummer bezeichnet.

Alle ausgewählten Objekte sind, soweit möglich, auf dem Grundrissplan in Abbildung 2.2 eingezeichnet und in Tabelle 2.1 aufgelistet. Auf dem Plan sind diejenigen Objekte angegeben, die eindeutig verortet werden können. Nur in etwa gekennzeichnet sind PB1b Fundstücke, deren genauer Originalstandort bisher unbekannt ist. Objekt PB27 befindet sich im Museum Kleines Klingental, kann jedoch eindeutig dem Lettner zugeordnet werden, der sich vor der Vierung befand.

Die ausgewählten Objekte werden im Folgenden einzeln mit Fotos (Abbildungen 2.3 bis 2.36), ihren Charakteristika und den wichtigsten allgemeinen Fragestellungen zu ihrer Polychromie vorgestellt (Tabellen 2.2 bis 2.36)[3]. Die in den einzelnen Datenblättern verwendeten Quellen (historische Quellen, Untersuchungsberichte, Sekundärliteratur und Bildquellen) werden im Quellen- und Literaturverzeichnis aufgeführt. Die Benennung der Objekte und Bauteile folgt der von Dorothea Schwinn Schürmann 1990 für die Basler Denkmalpflege/Museum Kleines Klingental zusammengestellten "Nomenklatur Basler Münster“.

Im Rahmen des Projektes wurden alle Objekte eingehend bearbeitet und die gewonnen Ergebnisse in die Gesamtbetrachtung mit einbezogen. Die zeitliche Befristung erlaubte es jedoch nicht, für alle Objekte auch eine ausführliche Auswertung der naturwissenschaftlichen Analysen zu formulieren. Diese musste auf die Objekte des Innenraums beschränkt werden. Demzufolge werden in Kapitel 3 nur diese ausführlich ausgewerteten Objekte beschrieben (dies sind PB1, PB2, PB3, PB4, PB5, PB6, Pb7, PB8, PB9, PB10, PB11, PB12, PB13, PB16, PB17, PB22, PB23, PB28, siehe Tabelle 2.1).

[3] Die Objektbeschreibungen sowie der naturwissenschaftliche Teil (Kapitel 3, 4 und 5) sind in englischer Sprache abgefasst.

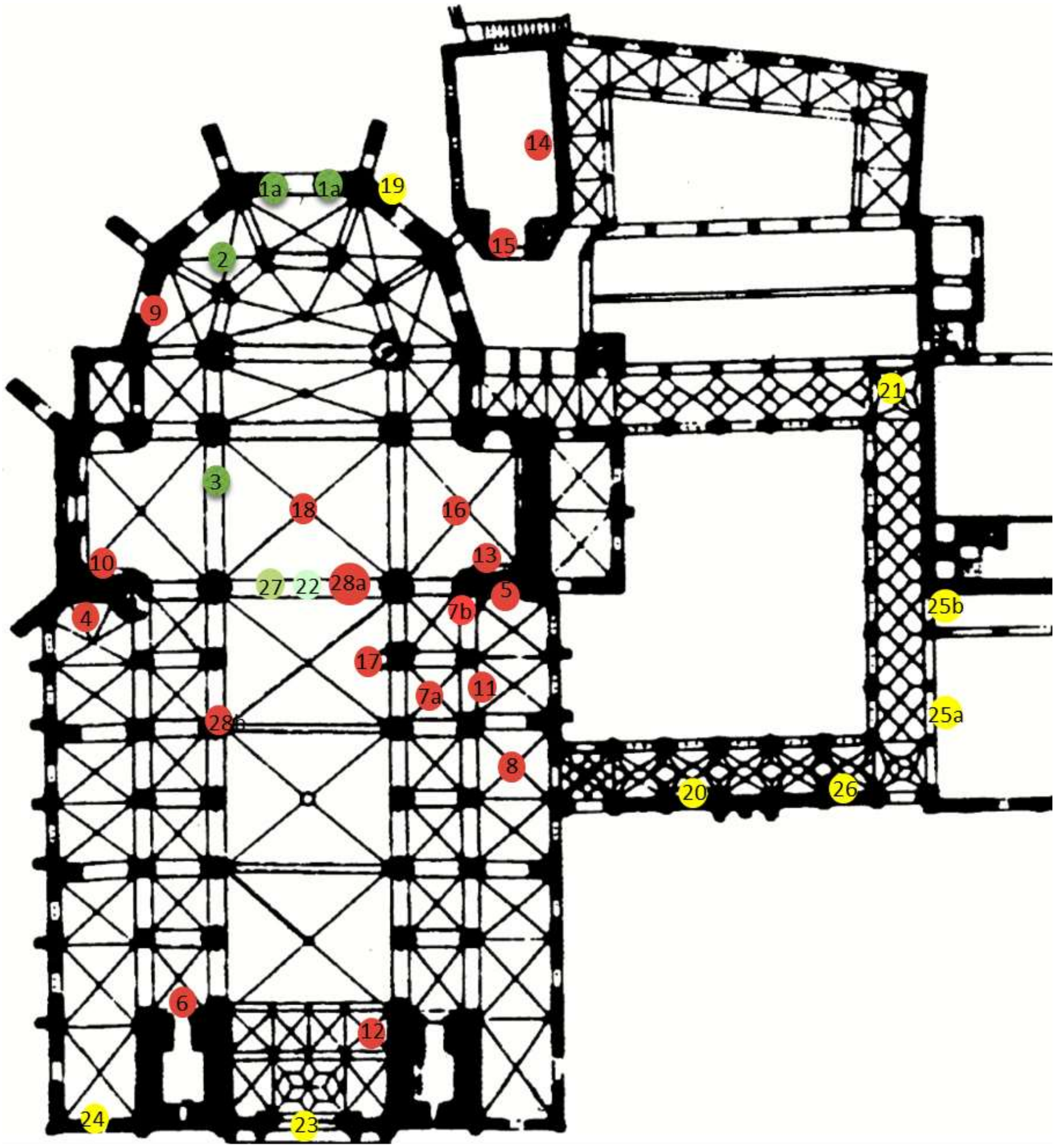


Abbildung 2.2: Grundrissplan

Münster Innenraum: *Untergeschoss (grün):* 1a Krypta, Wandbild Bischöfe Lüthold+Adalbero; 1b Krypta, Wandbild Fundstücke 1973/75; 2 Krypta, Margaretha, Nord-Gewölbejoch; 3 Vierungskrypta, Wandbild Christus vor der Kreuzanheftung;

Erdgeschoss (rot): 4 Vincentiustafel, 5 Aposteltafel, 6 Baumeistertafel, 7a Schlussstein Männerkopf, 7b Epitaph Rudolph von Hallwil, 8 Schlussstein Blattgesicht, 9 Grabmal Anna und Karl von Habsburg, 10 Grabmal Georg von Andlau, 11 Seitenschiff, Deckenbild Wirbelrosetten, 12 Wandbild Orgelempore, 13 Bischofsthron, 14 Niklauskapelle, Wandbild 2 heilige Frauen, 15 Niklauskapelle Orgelempore, Wandbild 7 Heilige, 16 Taufstein, 17 Kanzel, 18 Abendmahlstisch, 22 Blaue Hand, 28a Wandmalerei Triumphbogen Dachboden, 28b Langhauspfeiler Nr. 4 Nord.

Münster Aussenbereich/Kreuzgänge (gelb): 19 Fassade Chor und Niklauskapelle Nord-West, 20 Darbringung im Tempel, Gr. Kreuzgang West, 21 Südostjoch Grosser Kreuzgang, 23 Hauptportal, Fundstück sitzender Christus, 24 Georgsturm, Blattfries, 25a Maria Magdalena Kapelle, Epitaph KB 52 Maria Burckhardt, 25b Maria Magdalena Kapelle, Wandbild Darbringung Jesu, 26 Grabmal Utenheim.

Museum Klingental: 27 Engel-Lettnerkapitell

Table 2.1: List and date of the objects chosen for the project PolyBasel. In blue: objects which have been fully investigated during the project and whose results are reported in chapter 3; in black: objects partially investigated and whose results are partly evoked in chapter 6.

Nr.	Objektname		Datierung
PB1a	Bischofsbilder Lüthold und Adalbero, Ostkrypta		1202
PB1b	Fundstücke aus Gewölbeschutt 1973/74, Ostkrypta		um 1200
PB2	Margaretha/Martin, Gewölbemalerei, Ostkrypta		1380, 1400 oder 1420
PB3	Christus vor der Kreuzanheftung, Wandbild, Vierungskrypta		ab 1400, 15. Jh.
PB4	Vincentiustafel		um 1200
PB5	Aposteltafel		um 1200
PB6	Baumeistertafel		um 1200
PB7a	Schlussstein Männerkopf, Inneres Südseitenschiff, Gebwiler-Kapelle		um 1170
PB7b	Epitaph für Johann Rudolph von Hallwi		1527
PB8	Schlussstein Blattgesicht, Äusseres Südseitenschiff		um1320/40
PB9	Anna Grab, Hochchor	Grabplatte Tumba Wappenschilde Wandmalerei	1282 nach 1356 nach 1465/66 nach 1356 oder um 1460
PB10	Grabmal Georg von Andlau		1466
PB11	Gewölbemalereien Äusseres Südseitenschiff, Fröwlerkapelle		1326, 1340 oder 1370
PB12	Wandmalerei und Barockinschrift Orgelempore		um 1400/15. J.
PB13	Bischofsthron		um 1381
PB14	Zwei heilige Frauen, Wandbild über Nische, Niklauskapelle		1316 oder 1358
PB15	Sieben Heilige, Wandbild auf Orgelempore, Niklauskapelle		um 1400
PB16	Taufstein		1465
PB17	Kanzel		1486
PB18	Abendmahlstisch		1580
PB19	Südost-Chorwand		1170-1230
PB20	Darbringung im Tempel, Wandmalerei, Westflügel Gr. Kreuzgang		um 1458/60
PB21a	Zwei Schlusssteine und Rippen mit Krabben, Südostjoch Grosser Kreuzgang		1442
PB21b	Gewölbemalerei im Zwickel, Südostjoch Grosser Kreuzgang,		1442
PB22	Blaue Hand einer weiblichen Skulptur		1270/80
PB23	Thronender Christus, Skulpturenfragment vom Tympanon des Hauptportals		1270/85
PB24	Pflanzenfries, Georgsturm		um 1420
PB25a	Epitaph KB52 für Maria Burckhardt, Maria Madgalena Kapelle		1610
PB25b	Darbringung im Tempel, Wandbild, Maria Magd. Kapelle		um 1400
PB26	Utenheimgrabmal, Westflügel Gr. Kreuzgang		1501/1503
PB27	Engelskapitell Lettner / Museum Kleines Klingental Basel		um 1381
PB28a	Wandmalerei auf Triumphbogen, Dachboden,		1270/80, 1300, 1340 spätestens 1401
PB28b	Nördlicher Langhauspfeiler Nr. 4		1180

2.4.1 PB1a Bischofsbilder Lüthold und Adalbero, Ostkrypta

Figure 2.3: General view of the two Bishops wall painting: left: Lüthold; right: Adalbero.

Table 2.2: Description of main features of object PB1a “Bischofsbilder”.

Determination of age	1202	
Location	Wall painting of the Romanesque ring crypt	
Size in cm	150 x 100	
Height from ground in cm	238	
Accessibility	Sturdy scaffold-platform at 105 cm to bridge the bannister rail	
Material	Plaster on stonework	
Polychromy	Visible polychromy X	
Technique of painting	Secco	
Mode of examination	UV-screening, ARTAX and Handheld in situ, Raman of a cross-section	
Samples	2015	Bianca Burkhardt
Cross section	2015	Bianca Burkhardt
Available reports	1970 1993 1995 2007 2009	Ratschlag 6. Juli 1970 (Archiv ERKBS, J 1.011) Paul Denfeld Diana Graf Bianca Burkhardt Dorothea Schwinn Schürmann
History of object	Visible from 1200 until 1356, after the earthquake of 1356 cut in the middle by the construction of the ribs when the open ring crypt was vaulted.	
Restaurations	1975 re-opening of the vaults and restauration of the paintings (consolidation). Second consolidation in 1994/95.	
Central questions	Are there any parallels to be found to PB1b Fundstücke 1973/74? Are there any similarities to the other objects from 1200 (PB4 Vincentiustafel, PB5a+b Aposteltafel, PB6 Baumeistertafel)?	

2.4.2 PB1b Fundstücke aus Gewölbeshutt 1973/74, Ostkrypta

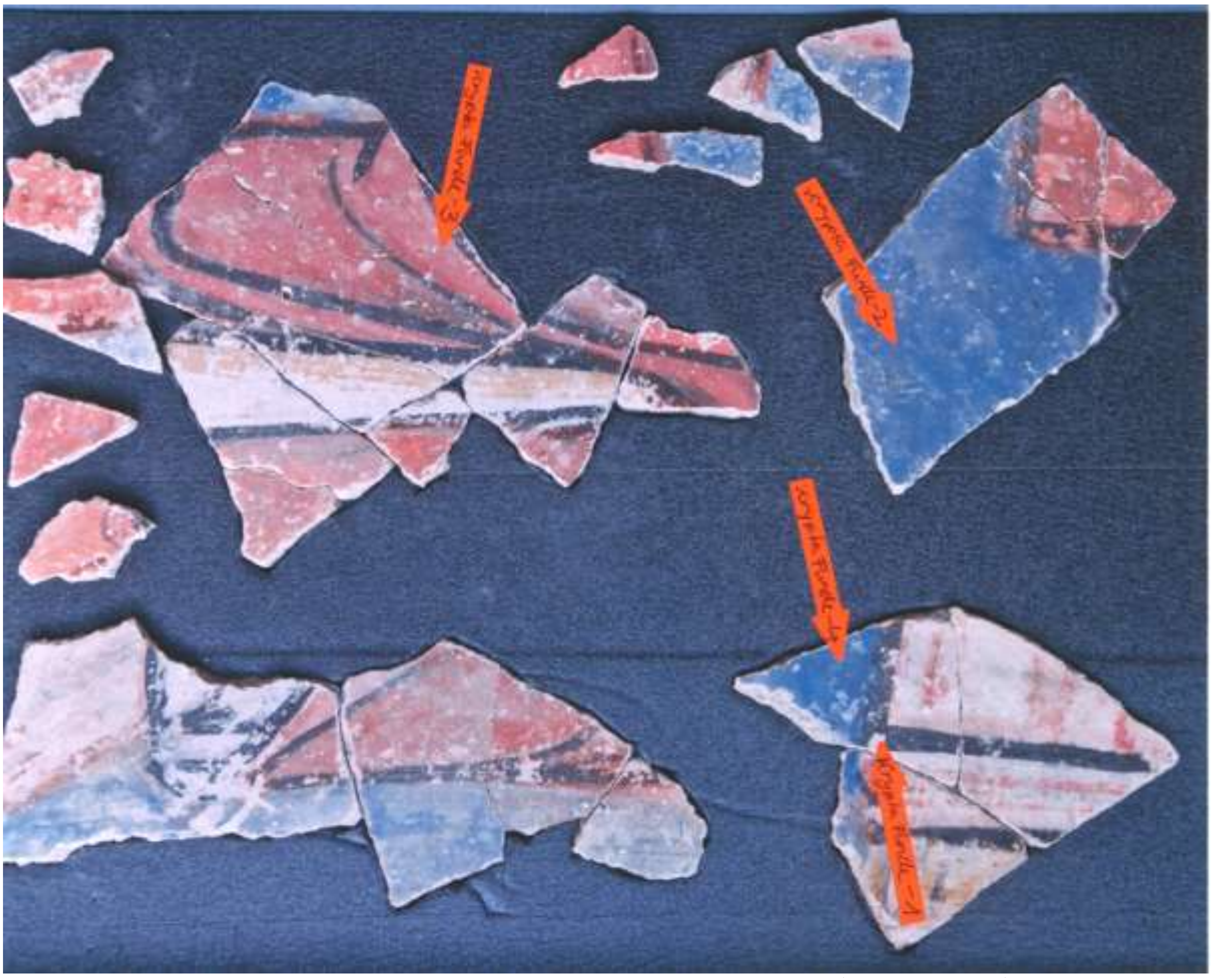


Figure 2.4: Photos of the Fundstücke with the indication of sampling points (orange arrows)

Table 2.3: Description of main features of object PB1b "Fundstücke".

Determination of age	Around 1200	
Location	Most likely part of a wall painting of the Romanesque ring crypt	
Size in cm	350 pieces from 1 x 1,5 to 9 x 7	
Height from ground in cm	-	
Accessibility	Archive of Stiftung Basler Münsterbauhütte	
Material	Plaster on stonework	
Polychromy	Visible polychromy	
Technique of painting	Secco	
Mode of examination	Raman of cross sections	
Samples	2015	Bianca Burkhardt
Cross-section	2015	Bianca Burkhardt
Available reports	2011	Bianca Burkhardt
History of object	Found 1973/74 at the archaeological excavation at the interior of the Basler Münster (inventory number B73.475.1974). During the campaign these pieces of wall paintings were found as a filling above the vaults of the eastern crypt. They might have been removed from the walls through or after the earthquake of 1356 when the open ring crypt was vaulted and closed.	
Restaurations	Pieces were transferred from the Historisches Museum Basel to Stiftung Basler Münsterbauhütte in 2010. Cleaning and consolidation.	
Central questions	Is there only one layer? What does it consist of? Is it close to the PB1a Bischofsbilder, PB2 Margaretha or PB3 Christus vor der Kreuzanheftung - or different? If so – how can the differences be described?	

2.4.5 PB4 Vincentiustafel

Figure 2.7: General view (left) and detail (right) of the object PB4

Table 2.6: Description of main features of object PB4

Determination of age	Around 1200	
Location	Schaler-Chapel (exterior northern side aisle, eastern wall)	
Size in cm	70 x 195	
Height from ground in cm	185	
Accessibility	Sturdy scaffold-platform at 100 cm	
Material	Fine grained red sandstone (Wiesentaler)	
Polychromy	Traces X	invisible traces (UV-detected) X
Technique of painting	Oil-based paint	
Mode of examination	UV-screening, ARTAX and Handheld in situ, Raman of cross sections	
Samples	2015	Bianca Burkhardt
Cross section	2015	Bianca Burkhardt
Available reports	Unknown	
History of object	Part of a choir screen or an altar retable. Original location in the choir (western wall of the crossing), since 1580 until 1852/57 divided in two tablets and attached to the walls leading to the crypt, in 1852/57 transferred to the present location in the Schaler-Chapel.	
Restaurations	1852/57 mouldings taken from the original, repositioning and gluing of fragments, some stone replacements made on the frame.	
Central questions	Can any parallels to the Aposteltafel be verified concerning the base coat and following polychromies? Can the two post-reformatory monochrome reds be detected? Art technology?	

2.4.5 PB5 Aposteltafel

Figure 2.8: General view (left) and detail (right) of the object PB5a

Table 2.7: Description of main features of object PB5a

Determination of age	Around 1200	
Location	Fröwler-Chapel (exterior southern side aisle, eastern wall)	
Size in cm	100 x 152	
Height from ground in cm	175	
Accessibility	Sturdy scaffold-platform at 100 cm	
Material	Fine grained red sandstone (Wiesentaler)	
Polychromy	Traces	
Technique of painting	Unknown	
Mode of examination	UV-screening, ARTAX and Handheld in situ, Raman of cross sections	
Samples	2013	Bianca Burkhardt
Cross section	2013	Bianca Burkhardt
Available reports	1997 1998	Konrad Zehnder, Institut für Denkmalpflege ETH Katrin Durheim, Andreas Walser
History of object	Original location in the crossing as part of an altar screen, a choir screen or an altar-retable, 1356 or 1580 dislocated to the southern wall that was dismounting to the crypt, 1852/57 transferred to the current location in the Fröwler-Chapel.	
Restaurations	1852/57 mouldings taken from the original, some fitting stone replacements, partly reworking of the original, in the mid-20th century use of a consolidant («Cephasite» from GB), during 2nd World War tablet concealed behind a faceplate, in 1997 investigation on damaging salts, in 1998 abrasive cleaning and restauration, in 2013 further technical investigations.	
Central questions	How many polychromies can be detected in total? Is an original polychromy to be found? Can any parallels to PB4 Vincentiustafel be verified concerning the base coat and following polychromies? Can the two post-reformatory monochrome reds be detected?	

2.4.6 PB6 Baumeistertafel

Figure 2.9: General view (left) and detail (right) of the object PB6

Table 2.8: Description of main features of object PB6

Determination of age	Around 1200	
Location	Georgs tower, ground floor, above the inner entrance of the eastern wall	
Size in cm	136 x 56 x 10	
Height from ground in cm	215	
Accessibility	Sturdy scaffold-platform above the treads at 150 cm	
Material	Upper part consists of medium grained Molasse sandstone, the lower of fine grained yellowish Early-Trias sandstone (maybe a variety of Wiesentaler)	
Polychromy	Traces	
Technique of painting	Oil-based paint	
Mode of examination	UV-screening, ARTAX in situ, Raman of cross sections	
Samples	2013 + 2015	Bianca Burkhardt
Cross section	2013 + 2015	Bianca Burkhardt
Available reports	2013	Bianca Burkhardt
History of object	Original location from 1200 until 1410/20 at the back of main portal. From 1410/20 (dislocation of the main portal and porch) until 1852/57 at the southern wall of the ground floor of the Georgs tower. Possibly divided after Reformation in 1529 in two parts and attached side by side instead on top of each other to the aforementioned wall. 1852/57 placed to the actual location one upon another. Both parts differ in workmanship: the upper part shows inferior quality than the lower part with the two figures.	
Restaurations	1853/54 mouldings taken from the original, 1852/57 upper part of the left tower patched with another beige stone material, possibly remains of colour removed.	
Central questions	How many polychromies can be detected in total? Both parts hold a white-greyish layer. Is it a medieval base coat or a layer? Can the reds be called post-reformatory and be connected to other objects like the other tablets? The pulpit or the baptismal font?	

2.4.7 PB7a Schlussstein Männerkopf, Inneres Südseitenschiff, Gebwiler-Kappelle

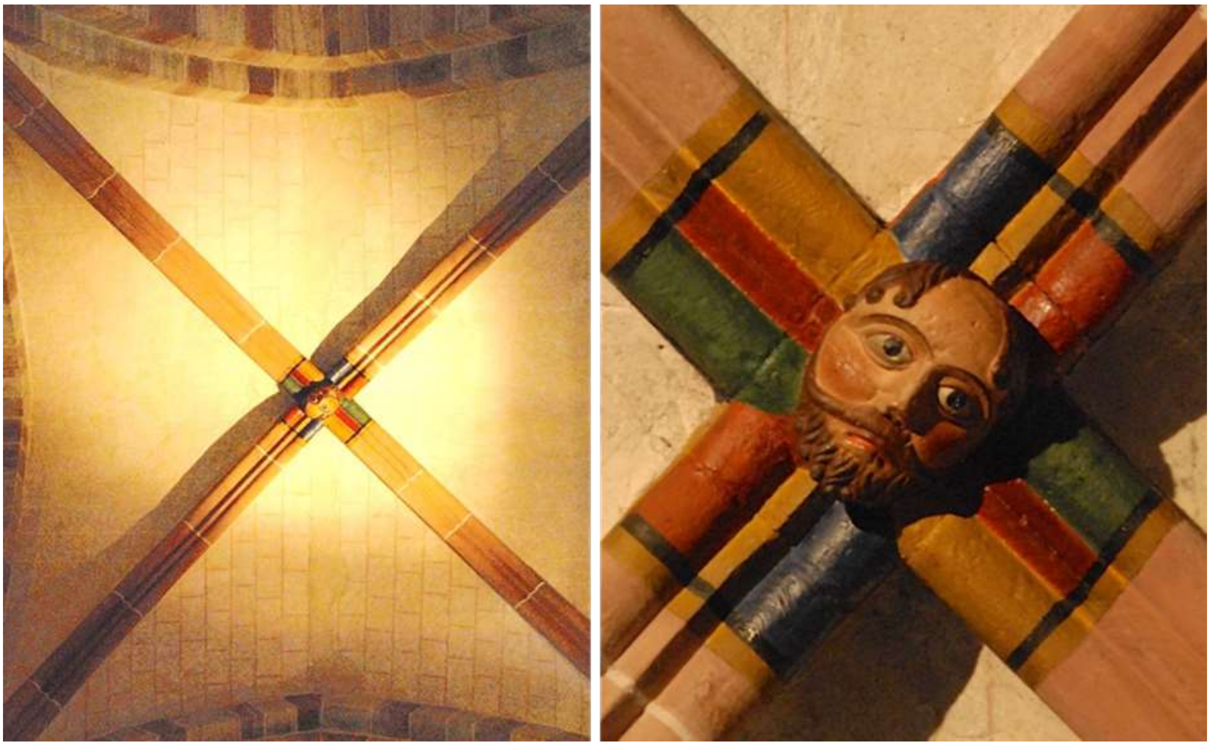


Figure 2.10: General view (left) and detail with the localisation of XRF analysis (right) of the object PB7a.

Table 2.9: Description of main features of object PB7a

Determination of age	Around 1170	
Location	Interior southern aisle	
Size in cm	50 x 50	
Height from ground in cm	790	
Accessibility	Man-carrying platform with crossbar extension joint	
Material	Fine grained red sandstone (Wiesentaler)	
Polychromy	Visible polychromy X traces X	
Technique of painting	Oil-based paint	
Mode of examination	Handheld in situ, Raman of cross sections	
Samples	2015	Bianca Burkhardt
Cross section	2015	Tiziana Lombardo
Available reports / references	1854 1998/99 1998 2006	StABS Protokolle H 4.5, p. 190 Paul Denfeld Andreas Arnold Andrea Vokner
History of object	Unknown	
Restaurations	Restauration and new polychromy in 1852/57, cleaning by Paul Denfeld and Urs Weber in 1998/99.	
Central questions	How many polychromies can be detected in total? Does the latest one really date from 1852/57? Is there another one beneath? Can any monochrome red paint-layers be proved and can they be dated (1580, 1772, 1785/87)? Is there a parallel or a difference to PB8 Schlussstein Blattgesicht? Are there similarities to the polychromy on the coat of arms at PB9 Grabmal Anna, PB10 Grabmal Andlau, PB7b Epitaph Hallwil or PB21 Schlussstein Grosser Kreuzgang?	

2.4.8 PB7b Epitaph für Johann Rudolph von Hallwil

Figure 2.11: General view (left) and detail (right) of the object PB7b

Table 2.10: Description of main features of object PB7b

Determination of age	1527	
Location	Exterior southern aisle (Fröwler-Chapel), buttress number 46, inventory number M16-1	
Size in cm	134 x 58 x 8	
Height from ground in cm	193	
Accessibility	From ground floor	
Material	Fine grained red sandstone (Wiesentaler)	
Polychromy	Visible polychromy	
Technique of painting	Oil-based paint and gilding	
Mode of examination	Raman of cross sections	
Samples	2015	Bianca Burkhardt
Cross section	2015	Tiziana Lombardo
Available reports	1940 2002 (provisional)	Buxtorf Anne Nagel
History of object	The epitaph was originally located at the eastern side of the southern nave-pillar number 17. Obviously it was moved in 1852/57 to the present location when the pulpit was placed at nave-pillar number 17.	
Restaurations	No actions are recorded but must be assumed for 1852/57 (new polychromy).	
Central questions	How many polychromies can be detected in total? Are they similar? Dates the latest polychromy from 1852/57? Are there any similarities to the blue on PB7a Männerkopf?	

2.4.9 PB8 Schlussstein Blattgesicht, Äusseres Südseitenschiff

Figure 2.12: General view (left) and detail (right) of the object PB8

Table 2.11: Description of main features of object PB8

Determination of age	around 1320/40	
Location	Exterior southern aisle, Gebwiler-Chapel	
Size in cm	50 x 50	
Height from ground in cm	760	
Accessibillity	Man-carrying platform with crossbar extension joint	
Material	Fine grained red sandstone (Wiesentaler)	
Polychromy	Visible polychromy X traces X	
Technique of painting	Oil-based paint and gilding	
Mode of examination	Handheld in situ, Raman of cross sections	
Samples	2015	Bianca Burkhardt
Cross section	2015	Tiziana Lombardo
Available reports / references	1854 1998/99 2006	StABS Protokolle H 4.5, p. 190 Paul Denfeld Andrea Vokner
History of object	Unknown	
Restaurations	Restauration and new polychromy in 1852/57. Cleaning by Paul Denfeld and Urs Weber in 1998/99.	
Central questions	How many polychromies can be detected in total? Does the latest one really date from 1852/57? Is there another one beneath? Can monochrome red paint layers be proved and can they be dated (1580, 1772, 1785/87)? Is there a parallel or a difference to PB7a? Are there similarities to the polychromy on the coat of arms at PB9 Grabmal Anna, PB10 Grabmal Andlau, to the Epitaph PB7b Hallwil or PB21 Schlussstein Grosser Kreuzgang?	

2.4.10 PB9 Annagrab, Hochchor

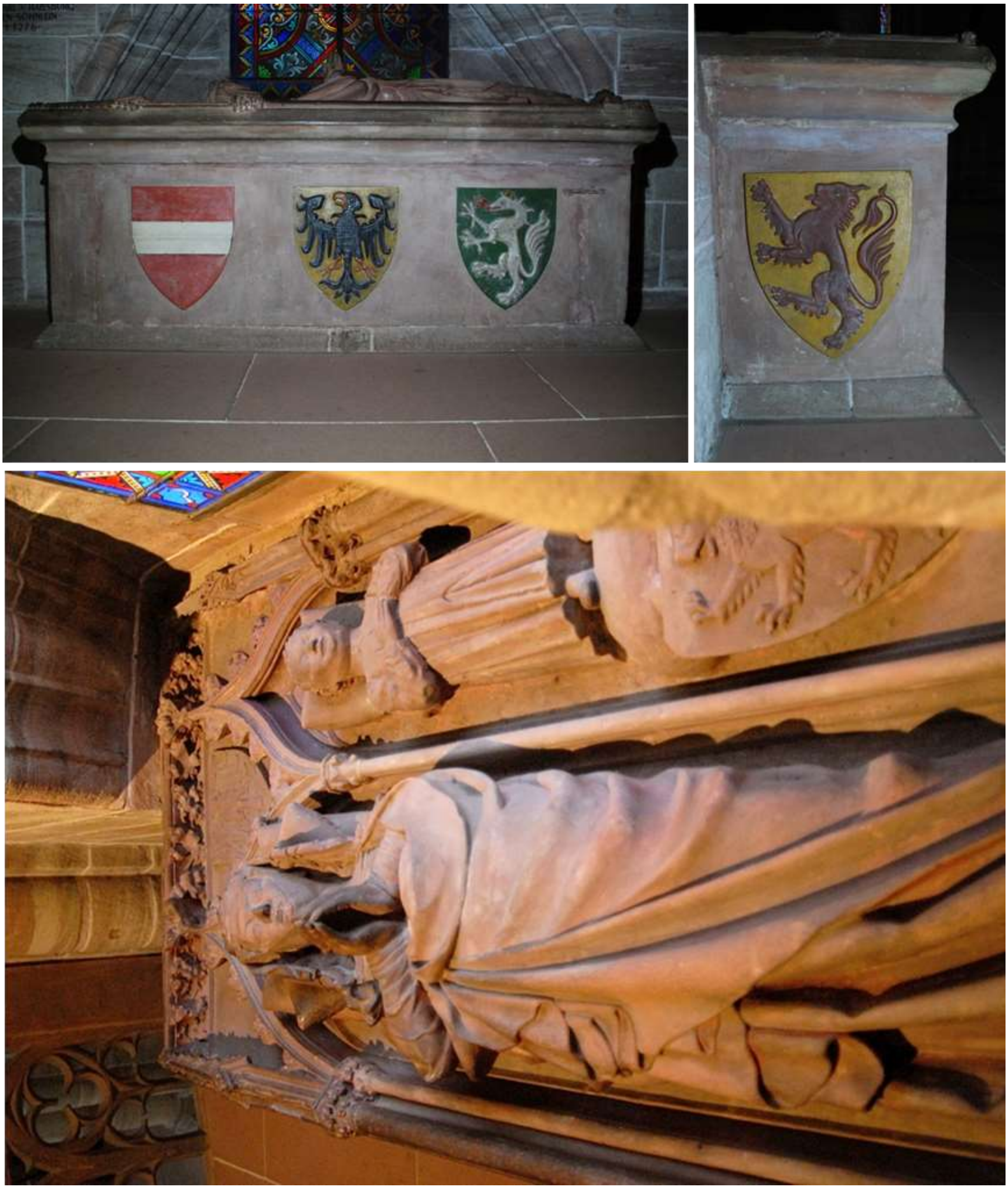


Figure 2.13: frontal and side views of the tomb (“Tumba”, top) and of the slab (“Grabplatte”, bottom) of object PB9

Table 2.12: Description of main features of object PB9 “Grabplatte”

Determination of age	1281	
Location	High choir, northern wall, placed in a window-niche	
Size in cm	94 x 240 x 118	
Height from ground in cm	94	
Accessibility	From ground floor	
Material	Fine grained red sandstone (Wiesentaler)	
Polychromy	Visible polychromy X	Traces X
Technique of painting	Oil-based paint and gilding	
Mode of examination	UV-screening, ARTAX and Handheld in situ, Raman of cross-sections	
Samples	2012 + 2015	Bianca Burkhardt
Cross section	2012 2015	Bianca Burkhardt Tiziana Lombardo
Existing reports	1869 1881 2012	A. Wielemanns Johann Jakob Neustück (reconstruction of polychromy) Sammlungszentrum Affoltern
History of object	The monument originally was placed in the high choir under the northern arcade, after the earthquake 1356 was moved to the present position. The tomb has been opened four times (1501, 1762, 1770, 1895).	
Restaurations	1852/57 mouldings taken from the original, 1852/57 some stone replacements (eg .hands and tip of Anna’s nose) and some reworking of the original surface, hidden behind a faceplate during 2nd World War (AR MBK 1939, p. 41). 1996 restauration of the wooden blazons by Christian Heydrich and cautious dry cleaning of the tomb by Paul Denfeld.	
Central questions	How many layers can be detected in total? Is it possible to detect an original polychromy (from 1281)? Is there another medieval polychromy that corresponds with the one on the Tumba (after 1365) or the five wooden blazons above? Are there any Post-Reformation monochrome reds to be found? If so, are they similar to other objects in the cathedral (PB10 Andlau, PB16 Taufstein, PB17 Kanzel)?	

Table 2.13: Description of main features of object PB9 “Tumba”

Determination of age	After 1356	
Location	High choir, northern wall, placed in a window-niche	
Size in cm	226 x 87 x 54	
Height from ground in cm	-	
Accessibility	From ground floor	
Material	Fine to medium grained red sandstone (Wiesentaler)	
Polychromy	Visible polychromy	
Technique of painting	Oil-based paint	
Mode of examination	UV-screening, ARTAX and Handheld in situ, Raman of cross-sections	
Samples	2015	Bianca Burkhardt
Cross section	2015	Bianca Burkhardt
Existing reports/references	No existing reports. References in literature : 2nd half of 15th 1771 1788 1842 1896	 Gräberbuch Emanuel Büchel Hieronymus Falkeisen Jakob Burckhardt Ernst August Stückelberg
History of object	Original location, built for this place after the earthquake from 1356. If there was an original polychromy (1466) it would coincide with PB16 Taufstein (1465).	
Restaurations	1852/57 new polychromy of coat of arms, mouldings taken from the original, probably also separate mouldings of the blazons (eventually those of the collection of Bibliothek für Gestaltung, Basel). Monument concealed during 2nd World War (AR MBK 1939, p. 41). 1996 cautious dry cleaning of the tomb by Paul Denfeld.	
Central questions	Is it possible to find the same polychromy after 1356 on the tomb and on the slab? Is it possible to find a second polychromy on the tomb that corresponds with the wooden blazons from 1466? Was it a full or partial polychromy? How many layers can be detected in total? Are there the two Post-Reformation reds?	

Figure 2.14: General view, under UV-light, of the wall overhanging the tomb of Queen Anna von Habsburg (Object PB9 “Wandmalerei”) (photo credits: Peter Fornaro)

Table 2.14: Description of main features of object PB9 “Wandmalerei”

Determination of age	After 1356 or around 1460
Location	High choir, northern wall, left and right besides window-niche, above the tomb
Seize in cm	140 x 100
Height from ground in cm	166
Accessibility	Sturdy scaffold-platform at 70 cm to bridge the tomb slab
Material	Coarse-grained red and greyish sandstone (Degerfelder)
Polychromy	Invisible traces (UV-detected) X
Techniques of painting	Oil-based paint
Mode of examination	UV-screening, ARTAX and Handheld in situ
Samples	-
Cross-section	-
Existing reports	-
History of object	The invisible traces were first detected in 2012 and until then completely unknown. In 1597 an inscription in Latin and German was placed on both walls on the left and right of the window above the monument and covered the paintings. Apparently by that time no wall painting was to be seen anymore.
Restaurations	During the renovation in 1852/57 all walls and pillars were texturized with bush hammers to remove all sorts of coating and to gain a « natural looking » surface.
Central questions	Is it possible to detect a polychromy at all? What kind of pigments can be assumed?

2.4.11 PB10 Grabmal Georg von Andlau

Figure 2.15: General view of the object PB10

Table 2.15: Description of main features of object PB10

Determination of age	1466	
Location	Northern transept, western wall	
Size in cm	238 x 83 x 39 (tomb slab) 182 x 63 x 4 (epitaph)	
Height from ground in cm	64 (slab), 82 (epitaph)	
Accessibility	From ground floor	
Material	Fine grained red sandstone (Wiesentaler)	
Polychromy	Visible polychromy	
Technique of painting	Oil-based paint	
Mode of examination	UV-screening, ARTAX and handheld in situ, Raman of cross sections	
Samples	2015	Bianca Burkhardt
Cross section	2015	Bianca Burkhardt
Existing reports/references	No reports existing. References in literature : 2nd half of 15th 1771 1788 1842 1896	 Gräberbuch Emanuel Büchel Hieronymus Falkeisen Jakob Burckhardt Ernst August Stückelberg
History of object	Original location, inventory number MM25-1 und -2.	
Restaurations	No actions are recorded but must be assumed 1852/57 (new polychromy of coat of arms).	
Central questions	Had the tomb slab and epitaph been painted originally in 1466? Was it a full or partial polychromy? If there was an original polychromy (1466), does it coincide with PB16 Taufstein (1465)? How many layers can be detected in total? Are there the two post-reformatory reds?	

2.4.12 PB11 Gewölbemalereien, Äusseres Südseitenschiff, Fröwlerkapelle

Figure 2.16: General view of the object PB11

Table 2.16: Description of main features of object PB11

Determination of age	1326, 1340 oder 1370
Location	Exterior southern aisle, Fröwler-Chapel
Size in cm	380 x 225
Height from ground in cm	830
Accessibility	Mobile scaffold, man-carrying platform with crossbar extension joint
Material	Plaster on brickwork
Polychromy	Visible polychromy X traces X
Technique of painting	Lime paint
Mode of examination	UV-screening, handheld in situ
Samples	-
Cross-section	-
Existing reports	1997 Jahresbericht Münsterbauhütte 1998 Andreas Arnold 1998/99 Paul Denfeld
History of object	Wall painting was covered with a whitewash after Reformation in 1529, again painted with lime-work in 1852/57 and rediscovered and uncovered in 1997.
Restaurations	Uncovering and consolidation in 1997
Central questions	How many polychromies can be detected in total? Was it painted over in medieval times? Are there similarities to the UV-detected wall paintings on bundle pillar EG16?

2.4.13 PB12 Wandmalereien und Barockinscrift Orgelempore

Figure 2.17: Location (left) and general view (right) of the object PB12

Table 2.17: Description of main features of object PB12

Determination of age	Around 1400/15th	
Location	Northern inner wall of Martins tower	
Size in cm	100 x 110	
Height from ground in cm	500	
Accessibility	At present no access is possible, photos and samples were taken during conservation works in 2001	
Material	Plaster on stonework	
Polychromy	Visible polychromy	
Technique of painting	Secco	
Mode of examination	Microscopy of samples, Raman of cross sections	
Samples	2002	Samples
Cross section	2015	Cross section
Available reports	1956 2002 2002	Available reports
History of object	1852/57 the former jube has been taken down and partly rebuilt as organ loft, where its vaults hit the walls of Martins and Georgs tower and thus covered the remains of ancient plasterwork. Rediscovered in 1955 when a new organ was constructed	
Restaurations	Cleaning, consolidation and setting up of faceplates to preserve the remains by Urs Weber and the Münsterbauhütte in 2001.	
Central questions	How many polychromies can be detected in total? Can the features be related to the earthquake in 1356? Is there any of the post-reformatory reds to be found?	

2.4.14 PB13 Bischofsthron

Figure 2.18: General view of the object PB13

Table 2.18: Description of main features of object PB13

Determination of age	Around 1381
Location	Southern transept, western wall
Size in cm	100 x 152
Height from ground in cm	175
Accessibility	Mobile scaffold, man-carrying platform with crossbar extension joint
Material	Fine grained red sandstone (Wiesentaler)
Polychromy	Visible polychromy X traces X
Technique of painting	Tempera and oil-based paint and gilding
Mode of examination	UV-screening, ARTAX and handheld in situ
Samples	2015 Bianca Burkhardt
Cross section	2015 Bianca Burkhardt
Available reports	2006 Andreas Küng, Expert-Center Zürich 2006 Bianca Burkhardt 2010 Bianca Burkhardt, Dorothea Schwinn Schürmann
History of object	Original location since at least 1381 until 1852/57 at the back of the jube, centred amidst the L-shaped choir stalls, since that time until 1973/74 in the Schaler-Chapel (exterior northern side aisle).
Restaurations	No actions are recorded but must be assumed for both relocations in 1852/57 and 1973/74. Cautious cleaning by the Münsterbauhütte in 2005.
Central questions	How many polychromies can be detected in total? Two from middle ages (about 1381 and 1500), two post-reformatory? Is there any connection between the blue that can be found on PB16 Baptismal font and the PB27 Angel`s capital? Are they the same?

2.4.15 PB14 zwei heilige Frauen, Wandbild über Nische, Niklauskapelle,

Figure 2.19: General view (left) and detail (right) of the object PB14

Table 2.19: Description of main features of object PB14

Determination of age	1316 or 1358	
Location	Niklaus-Chapel, ground floor, southern wall, above the small niche	
Size in cm	53 x 24	
Height from ground in cm	143	
Accessibility	From ground floor	
Material	Medium grained red sandstone (Wiesentaler)	
Polychromy	Visible polychromy X	traces X
Technique of painting	Tempera	
Mode of examination	UV-screening, Raman of cross sections	
Samples	2015	Bianca Burkhardt
Cross section	2015	Bianca Burkhardt
Existing reports	1949	Rudolf Riggenbach
History of object	After Reformation the chapel was used for secular purpose such as armoury or gym. Niches were filled with debris of the cathedral and plastered.	
Restaurations	Plaster and debris removed in 1947, probably consolidation (documented for PB15 Wandbild 7 Heilige in Niklaus-Chapel in 1947).	
Central questions	How many polychromies can be detected in total? Are there any technical similarities to PB15 Wandbild 7 Heilige or PB20 Darbringung im Tempel Westflügel, PB25b Darbringung Jesu Maria Madgalena-Chapel?	

2.4.16 PB15 Sieben Heilige, Wandbild auf Orgelempore, Niklauskapelle

Figure 2.20: General view (left) and detail (right) of the object PB15

Table 2.20: Description of main features of object PB15

Determination of age	Around 1400	
Location	Niklaus-Chapel, organ loft, western and southern wall	
Size in cm	296 x 150 southern wall 296 x 200 western wall	
Height of loft in cm	280	
Material	Plaster on stonework	
Accessibility	From the floor of the organ loft	
Polychromy	Visible polychromy	
Technique of painting	Secco	
Mode of examination	UV-screening, ARTAX and handheld in situ, microscopy of cross sections	
Samples	2009	Bianca Burkhardt
Cross section	2009	Bianca Burkhardt
Existing reports/references	1947 1947 1949 2009 (Jan+May) 2009	E. Fischer Ansprache zur Einweihung nach Renovation Basler Nachrichten Rudolf Riggenbach Bianca Burkhardt UV-photography by Erik Schmidt
History of object	Since 1534 the chapel was used for secular purpose such as armoury or gym. 1775 Emanuel Büchel copied some of the wall paintings, eg. the seven saints. At some unknown point of time the walls were hacked and plastered. The at present again visible saints are Evangelist Matthew and St. Maurice (southern wall), John the Baptist, Antonius Hermit, Dorothea, Katharina and Christophorus (western wall).	
Restaurations	1947 restoration of the whole chapel, plaster removed, wall painting consolidated and retouched, 2009 technological examination, cleaning and some small conservation by Stiftung Basler Münsterbauhütte.	
Central questions	How many polychromies can be detected in total? Are there any technical similarities to PB2 Margaretha/Martin, PB15 Wandbild 2 heilige Frauen or PB20 Darbringung im Tempel Westflügel, PB25b Darbringung Jesu Maria Madgalena-Chapel?	

2.4.17 PB16 Taufstein

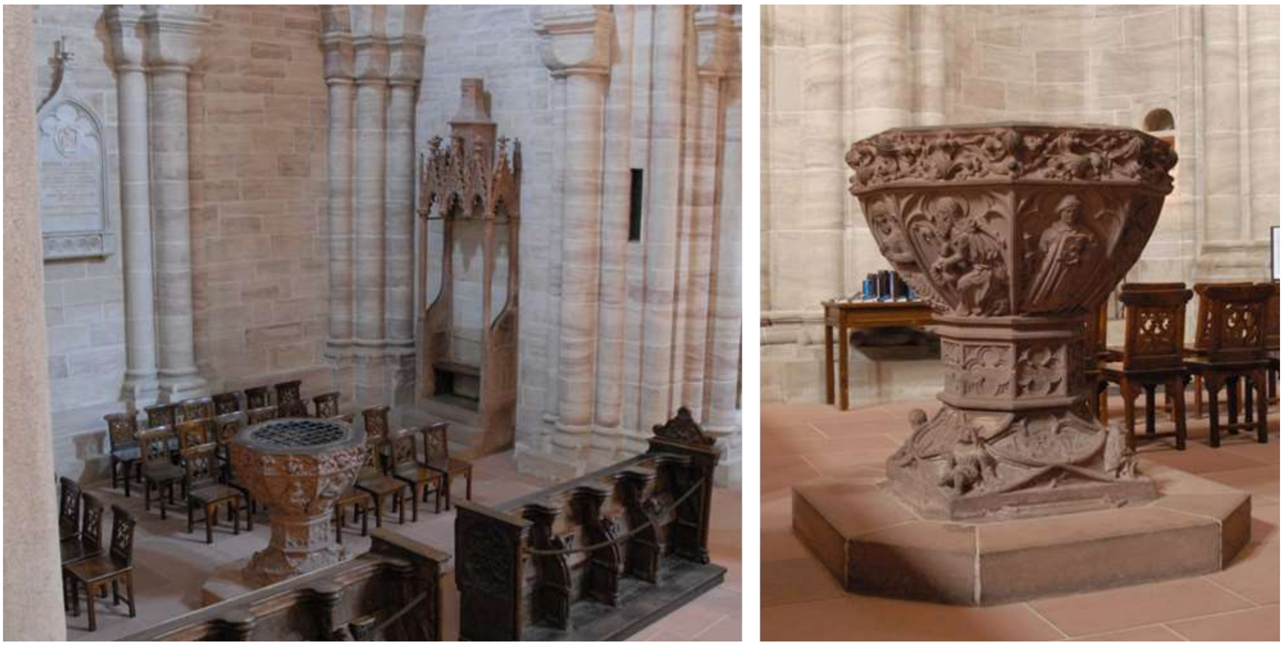


Figure 2.21: General view (left) and detail (right) of the object PB16

Table 2.21: Description of main features of object PB16

Determination of age	1465	
Location	Centre of southern transept	
Size in cm	150 x 100	
Height from ground in cm	15	
Accessibility	From ground floor	
Material	Fine grained dark red sandstone (Wiesentaler)	
Polychromy	Traces	
Technique of painting	Oil-based paint	
Mode of examination	UV-screening, ARTAX (upper part) in situ, Raman of cross sections	
Samples	2012 + 2015	Bianca Burkhardt
Cross section	2012 + 2015	Bianca Burkhardt
Existing reports	2012	Marie Wörle, Sammlungszentrum SNM
History of object	Original location most probably in the northern exterior aisle (Schaler-Chapel). Font has been moved three times: 1570 to the high choir, there again under the arcades, 1852/57 back to the to the exterior northern side aisle (Schaler-Chapel), 1973/74 to the centre of the southern transept.	
Restaurations	1918 by Meile, before 1921 mouldings taken from the original, reworking of the original surface in 1852/57 or 1918	
Central questions	How many polychromies can be detected in total? Is there a similarity to the blue found on PB13 Bischofsthron or PB27 Engelskapitell? Or any parallels to PB20 Darbringung im Tempel Westflügel Kreuzgang? Can the two post-reformatory monochrome reds be proved as well?	

2.4.18 PB17 Kanzel

Figure 2.22: General views of western and eastern sides of object PB17 (photo credits: Erik Schmidt)

Table 2.22: Description of main features of object PB17

Determination of age	1486	
Location	Nave, southern pillar number 17	
Size in cm	384 x 152 (goblet), 380 x 200 (spiral staircase)	
Height from ground in cm	53	
Accessibility	Sturdy scaffold-platform at 150 cm	
Material	Fine grained red sandstone (Wiesentaler)	
Polychromy	Traces	
Technique of painting	Oil-based paint	
Mode of examination	UV-screening, ARTAX and handheld in situ, Raman of cross sections	
Samples	2015	Bianca Burkhardt
Cross section	2015	Bianca Burkhardt
Existing reports	1998	Christian Heydrich
History of object	Original location since 1486 at the central southern nave-pillar number 18, 1852/57 removed eastwards to the actual location at the southern nave-pillar number 17, 1996 photogrammetry, 1998/99 mouldings taken from the original by H. Baumgartner.	
Restaurations	No actions are recorded but must be assumed for the relocation in 1852/57. Cautious cleaning by the Stiftung Basler Münsterbauhütte in 1999.	
Central questions	Was the pulpit originally painted at all? How? Can the two post-reformatory monochrome reds be detected? When were the pupils and the engravings of the banners painted black?	

2.4.19 PB18 Abendmahlstisch

Figure 2.23: General views of object PB18

Table 2.23: Description of main features of object PB18

Determination of age	1580	
Location	Crossing	
Size in cm	2010 x 105 x 110	
Height from ground in cm	0	
Accessibility	From ground floor	
Material	Fine and medium grained red sandstone (Wiesentaler, Maintaler for repairs)	
Polychromy	Traces X	
Technique of painting	Oil-based paint	
Mode of examination	UV-screening, ARTAX in situ, Raman of cross sections	
Samples	2014 + 2015	Bianca Burkhardt
Cross section	2014 2015	Bianca Burkhardt Tiziana Lombardo
Existing reports/references	1650 1826 1855 2013	Sixt Ringle, painting (Historisches Museum Basel) Neustück Neustück Bianca Burkhardt
History of object	The former jube (now organ loft) was originally placed in the crossing and the altar was placed in 1580 directly in front of this jube. 1852/52 moved to St. Peters Church/Basel, 1975 returned to the cathedral and re-established in the crossing.	
Restaurations	No actions are recorded but must be assumed in 1852/57, 1975 leaching of all remains of polychromy.	
Central questions	How many polychromies can be detected in total? Do they correspond to the ancient pictures?	

2.4.20 PB19 Südost-Chorwand

Figure 2.24: General views of object PB19

Table 2.24: Description of main features of object PB19

Determination of age	1170-1230	
Location	Southeastern exterior wall of the choir and counterfort, wall above the passage between Pfalz and cloister, tracery windows of St. Niklaus-Chapel	
Size in cm	Single patches maximum 150 x 200	
Height from ground in cm	550	
Accessibility	Mobile scaffold	
Material	Coarse-grained red and greyish sandstone (Degerfelder)	
Polychromy	Visible polychromy X	traces X
Technique of painting	Oil-based paint	
Mode of examination	UV-screening, handheld in situ, Raman of cross sections	
Samples	2015	Bianca Burkhardt
Cross section	2015	Bianca Burkhardt
Existing reports	1998 2006	Christian Heydrich Matthias Merki
History of object	Red monochrome coat of paint with white joints assumed for 1597	
Restaurations	1880/90 and 1925/39	
Central questions	How many red monochrome coats of paint can be detected in total? Can for one red layer the composition of pigments be linked to the recipe found in a bill from 1751 for the Martins tower? Can the determination of age for one red be reassured for 1597? Is there any similarity to the reds detected on PB24 Georgs tower or the two post-reformatory reds at the interior of the cathedral?	

2.4.21 PB20 Darbringung im Tempel, Wandmalerei, Westflügel Gr. Kreuzgang


Figure 2.25: General views of object PB20

Table 2.25: Description of main features of object PB20

Determination of age	1458/60
Location	Western wing of the big cloister, western wall
Seize in cm	275 x 200
Height from ground in cm	309
Accessibility	Mobile scaffold and man-carrying platform with crossbar extension joint
Material	Plaster on mixed brick-stonework
Polychromy	Visible polychromy
Technique of painting	Secco
Mode of examination	ARTAX and handheld in situ
Samples	-
Cross section	-
Existing reports	1915 Regierungsratsbeschluss 1951 Bericht der Münsterbaukommission
History of object	After Reformation in 1529 the walls of the cloister were hacked and plastered. The painting was probably rediscovered during the renovation 1869-1873.
Restaurations	1915 conservation by Gerhardt, 1950 consolidation and retouch by Heinrich Müller
Central questions	Is there only one polychromy? Are there any similarities to PB15 Wandbild 2 heilige Frauen or PB25b Darbringung Jesu Maria Madgalena-Chapel?

2.4.22 PB21a Zwei Schlusssteine und Rippen mit Krabben, Südostjoch grosser Kreuzgang

Figure 2.26: General view of object PB21a

Table 2.26: Description of main features of object PB21a

Determination of age	1442	
Location	Big cloister, vaults of south-eastern bay No. 10/11, keystones and ribs with gothic crockets	
Size in cm	33 x 35 x 12 (keystones) 5 x 3 x 3,5 (gothic crockets)	
Height from ground in cm	520	
Accessibility	Mobile scaffold, man-carrying platform with crossbar extension joint	
Material	Fine grained red sandstone (Wiesentaler)	
Polychromy	Visible polychromy	
Technique of painting	Oil-based paint and gilding	
Mode of examination	Handheld in situ, Raman of cross sections (crockets only)	
Samples	2014	Bianca Burkhardt
Cross section	2014	Bianca Burkhardt
Existing reports	1442/43 1899 1899	Fabrikbüchlein of Basler Münster concerning the painting and gilding of the cloister Viktor Flück, Kantonsbaumeister, Kostenvoranschlag für Überfassung u.a. von 12 Schlusssteinen Regierungsratsbeschluss
History of object	From the original account book of 1442/43 it is proved that the keystones had been gilded and the vaults been whitewashed. 1775 Emanuel Büchel copied some of the keystones (hammer with two crowns, cock). 1993 mouldings taken from the keystones by H. Baumgartner.	
Restaurations	1899 re-painting and –gilding of keystones, gothic crockets.	
Central questions	How many polychromies can be detected in total? Are the results coherent with the written records? Are there any modern pigments and parallels to the results on PB7a+b, PB8, PB9 Annagrab or PB10 Andlau?	

2.4.23 PB21b Südostjoch grosser Kreuzgang, Gewölbemalerei im Zwickel


Figure 2.27: General view (left) and detail (right) of object PB21b

Table 2.27: Description of main features of object PB21b

Determination of age	1442	
Location	Big cloister, south-eastern bay No. 10/11, wall painting in the spandrel	
Size in cm	80 x 120	
Height from ground in cm	410	
Accessibillity	Man-carrying platform with crossbar extension joint	
Material	Plaster on brickwork	
Polychromy	Visible polychromy X	traces X
Technique of painting	Limewash	
Mode of examination	UV-screening and handheld in situ, Raman of cross sections	
Samples	2014	Bianca Burkhardt
Cross section	2015	Bianca Burkhardt
Existing reports	1442/43	Fabrikbüchlein of Basler Münster concerning the painting and gilding of the cloister
	1899	Viktor Flück, Kantonsbaumeister, Kostenvoranschlag für Überfassung u.a. von 12 Schlusssteinen
History of object	From the original account book of the cathedral from 1442/43 it is proved that the keystones had been gilded and the vaults at least been whitewashed (if not even painted).	
Restaurations	1870 extensive renovation of the cloisters, possibly then these remains of an ancient plaster work in the spandrel were re-discovered and consolidated.	
Central questions	Is there a polychromy (green and beige) to be detected or only remains of a plaster work with whitewash?	

2.4.24 PB22 Blaue Hand einer weiblichen Skulptur

Figure 2.28: Frontal (left) and lateral (right) view of object PB22

Table 2.28: Description of main features of object PB22

Determination of age	Around 1270/80	
Location	Archeological artefact out of the vaults beneath the high choir under the floor in front of the former jube	
Size in cm	19 x 6,6 x 9	
Height from ground in cm	-	
Accessibility	Archive of Archäologische Bodenforschung Basel Stadt, signature BS ABBS 1974/29	
Material	Fine grained red sandstone (Wiesentaler)	
Polychromy	Visible polychromy X	
Technique of painting	Oil-based paint and gilding	
Mode of examination	ARTAX and Raman of cross sections	
Samples	2016	Bianca Burkhardt
Cross section	2016	Bianca Burkhardt
Existing reports	-	
History of object	The hand could most probably have belonged to a group of statues that were placed in the high choir and have been damaged in the earthquake of 1356. Among numerous other broken bits it was used as filling when the open ring crypt was vaulted. The hand was found in 1974 during the archaeological excavation at the cathedral. It has been returned to Archäologische Bodenforschung Basel Stadt in 2015.	
Restaurations	none	
Central questions	The polychromy is in a very good state of preservation and seems to be the original. Can that be proved? Can any parallels be detected to the statues of the main portal and in particular to PB23 Thronender or PB9 Annagrab?	

2.4.25 PB23 Thronender Christus, Skulpturenfragment vom Tympanon des Hauptportals

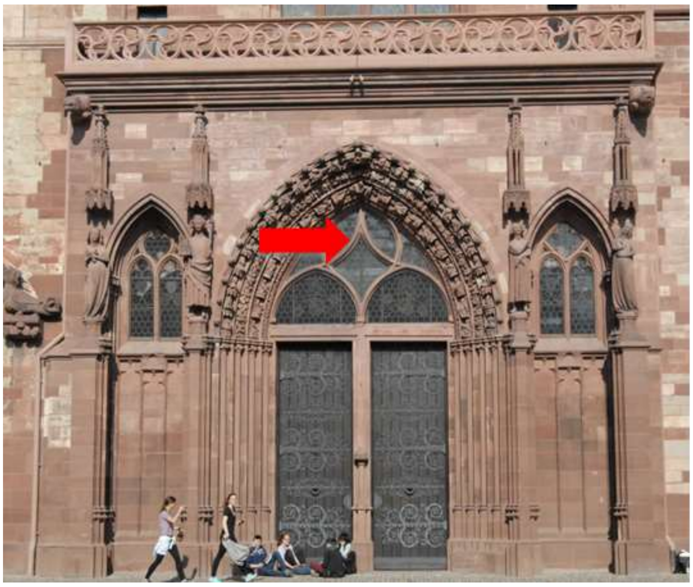



Figure 2.29: Location on the main portal (left) and view (right) of object PB23

Table 2.29: Description of main features of object PB23

Determination of age	1270/85	
Location	Western facade, main portal, tympanum	
Size in cm	35 x 30 x 27	
Height from ground in cm	-	
Accessibility	Archive of Stiftung Basler Münsterbauhütte	
Material	Fine grained red sandstone (Wiesentaler)	
Polychromy	Visible polychromy X	traces X
Technique of painting	Oil-based paint	
Mode of examination	UV-screening, ARTAX in situ, Raman of cross sections	
Samples	2014	Bianca Burkhardt
Cross section	2014	Andreas Küng, SUPSI Lugano
Existing reports	2014 2014 2015	Andreas Küng, SUPSI Lugano Bianca Burkhardt Bianca Burkhardt
History of object	Presumably after Reformation in 1529 the fragment came to a private house. When this building was demolished in the 1960ies the artefact ended up on a dump site in Therwil/BL where it was found by Andres Furger who handed it over to Francois Maurer in the 1970ies. The latter handed it over to the Stiftung Basler Münsterbauhütte in 2011 where it was examined.	
Restaurations	none	
Central questions	Can the paint techniques be described close to the ones of the western main portal or to PB22 Blaue Hand? How many polychromies can be detected? Any of the post-reformatory monochrome reds?	

2.4.26 PB24 Pflanzenfries, Georgsturm

Figure 2.30: Frontal (left) and lateral (right) view of object PB24

Table 2.30: Description of main features of object PB24

Determination of age	Around 1420	
Location	2nd gallery on Georgs tower, frieze beneath the balustrades	
Size in cm	65 x 55 x 26 (single work piece)	
Height from ground in m	37	
Accessibility	-	
Material	Coarse-grained red sandstone (Degerfelder)	
Polychromy	Traces X	
Technique of painting	Oil-based paint	
Mode of examination	Raman of cross sections	
Samples	2011	Bianca Burkhardt
Cross section	2014	Bianca Burkhardt
Existing reports	1988 1989	Christian Heydrich Andreas Arnold Institut für Denkmalpflege ETHZ
History of object	1822 red paint coat from top downwards to the first gallery (like the Martins tower few years before)	
Restaurations	1988 treated with consolidants by Stiftung Basler Münsterbauhütte	
Central questions	Is there any indication of a medieval polychromy (as on the floral frieze in Strasbourg eg.)? How many layers can be detected? Can remains of post-reformatory reds be found? Any indications of the leaching in the 19th century?	

2.4.27 PB25a Epitaph KB52 für Maria Burckhardt, Maria Magdalena Kapelle

Figure 2.31: The Epitaph PB 25a as seen today in its location in the Maria Magdalene-Chapel (left) and watercolour drawing by Neustück in depicting the epitaph in 1819 (right, photo credits: Erick Schmidt)

Table 2.31: Description of main features of object PB25a

Determination of age	1610	
Location	Maria Magdalene-Chapel, northern wall between two arcades	
Size in cm	285 x 152	
Height from ground in cm	400	
Material	Fine grained red sandstone (Wiesentaler)	
Accessibility	-	
Polychromy	Visible polychromy X	traces X
Technique of painting	Oil-based paint and gilding	
Mode of examination	Raman of cross-sections	
Samples	2000	Bianca Burkhardt
Cross section	2000	Bianca Burkhardt
Existing reports	1996/99 2000	Anne Nagel Bianca Burkhardt
History of object	Original location since 1620. Painted over twice: original polychromy dark red with gildings, then pink, then grey. 1819 watercolour of Johann Jakob Neustück.	
Restaurations	2000 removal of the two paint coats and consolidation of the original polychromy by Stiftung Basler Münsterbauhütte.	
Central questions	How many polychromies can be detected in total? Does one correspond to the picture of Neustück 1819? Are there any similarities between the pink layers that have been detected on the two portals (main portal and Galluspforte) or in several objects inside the cathedral?	

2.4.28 PB25b Darbringung im Tempel, Wandbild, Maria Magdalena Kapelle

Figure 2.32: Frontal (left) and lateral (right) view of object PB25b

Table 2.32: Description of main features of object PB25b

Determination of age	Around 1400	
Location	Maria Magdalene-Chapel, annex, eastern wall, hidden behind epitaph KC13 for Caspar Mangoldt, died in 1671	
Size in cm	135 x 130	
Height from ground in cm	210	
Accessibility	-	
Material	Plaster, material of wall unknown	
Polychromy	Visible polychromy X	
Technique of painting	Secco and tempera (gilding)	
Mode of examination	Raman of cross sections	
Samples	2000	Bianca Burkhardt
Cross section	2000	Bianca Burkhardt
Existing reports	1996/99 2000 2004	Anne Nagel Christian Heydrich Bianca Burkhardt
History of object	After Reformation in 1529 the walls of the Maria Magdalene-Chapel were plastered. 1671 the epitaph was fixed to the wall. Maybe during the renovation of the cloisters 1869-73 the plaster around the epitaph has been destroyed and renewed. The painting was re-discovered during the restauration of the epitaph in 1999.	
Restaurations	2000 uncovering and consolidation by Christian Heydrich.	
Central questions	Is it the original wall painting without retouches? Are there any similarities to the other wall paintings like PB12 Orgelempore, PB15 Niklauskapelle 7 Heilige, PB20 Darbringung Gr. Kreuzgang?	

2.4.29 PB26 Utenheimgrabmal, Westflügel Gr. Kreuzgang

Figure 2.33: Localisation (left) and frontal view (right) view of object PB26

Table 2.33: Description of main features of object PB26

Determination of age	1501/03
Location	Western wing of the big cloister, western wall
Size in cm	315 x 150
Height from ground in cm	190
Accessibility	Man-carrying platform with crossbar extension joint
Material	Fine grained dark red sandstone (Wiesentaler)
Polychromy	Visible polychromy X traces X
Technique of painting	Oil-based paint
Mode of examination	ARTAX and handheld in situ
Samples	-
Cross section	-
Existing reports	1994 Andreas Walser, Katrin Durheim 2008 Matthias Merki, Bauforschung Basler Denkmalpflege 2009 Matthias Merki, Bauforschung Basler Denkmalpflege
History of object	1501/3 erected, after Reformation 1529 (at the latest 1597) some pieces were cut off in order to flatten the relief which then was covered by a plaster.
Restaurations	1870 rediscovered and cleaned, 1915 restored by Gerhardt, 1992/92 several cut-off elements were rediscovered as a filling in the walls of the western wing of the big cloister. Archive of Denkmalpflege Basel Stadt (inventory number 12401.1-30).
Central questions	How many polychromies can be detected in total? Was it painted monochrome red before it was covered by the plaster? Techniques and quality?

2.4.30 PB27 Engelskapitell Lettner, Museum Kleines Klingental Basel

Figure 2.34: Frontal view of object PB27 (photo credits: Erik Schmidt)

Table 2.34: Description of main features of object PB27

Determination of age	Around 1381	
Location	Exhibition of Museum Kleines Klingental, Basel, inventory number 12128	
Size in cm	55 x 63 x 69	
Height from ground in cm	170	
Accessibility	From ground floor	
Material	Fine grained red to brownish sandstone (Wiesentaler)	
Polychromy	Visible polychromy X	
Techniques of painting	Oil-based paint and tempera	
Mode of examination	Raman of cross sections	
Samples	2008	Bianca Burkhardt
Cross-section	2015	Bianca Burkhardt
Existing reports	2006 2008	Dorothea Schwinn Schürmann Andreas Küng, SUPSI Lugano
History of object	Capital from the arcades that were part of the ancient jube in front of the crossing, 1852/57 removed to the collection of Historisches Museum Basel, then to the exhibition of Museum Kleines Klingental. Since 1852/57 only parts of the jube are still used as organ loft.	
Restaurations	No actions are recorded but it must be assumed that some intervention was done before both relocations in 1852/57 and 1973/74. Cautious cleaning by the Münsterbauhütte in 2005.	
Central questions	How many polychromies can be detected in total? Two from middle ages (about 1381 and around 1500), two post-reformatory monochrome reds? Is the blue identical to the one on PB13 Bischofsthron?	

2.4.31 PB28a Dachboden, Wandmalerei auf Triumphbogen

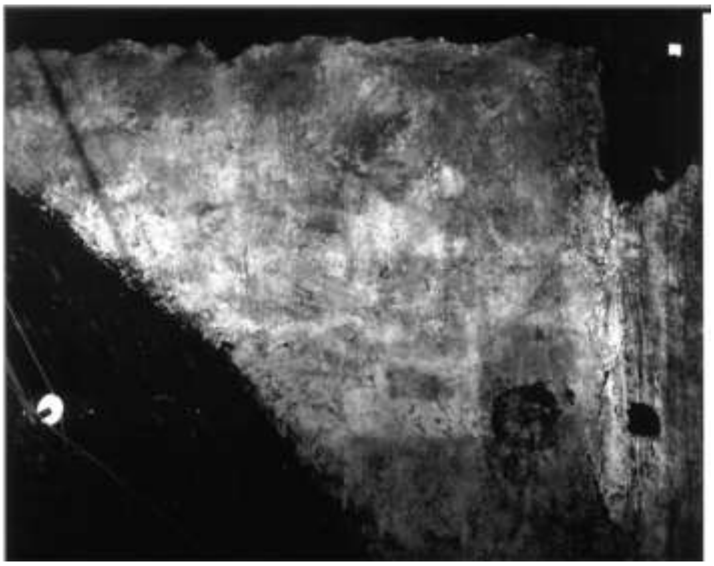



Figure 2.35: Location (left) and general view (right, photo credits: Erik Schmidt)) of object PB28a.

Table 2.35: Description of main features of object PB28a

Determination of age	1270/80, 1300, 1340 or at latest 1401	
Location	Attic of the cathedral, eastern wall of the triumphal arch, above the vaults	
Size in cm	Approximately 300 x 180	
Height from ground in m	16	
Accessibility	-	
Material	Plaster on stonework	
Polychromy	Visible polychromy X traces X invisible traces (UV-detected) X	
Technique of painting	Secco	
Mode of examination	Raman of cross sections	
Samples	1998/99	Urs Weber
Cross section	2015	Bianca Burkhardt
Existing reports/references	1895 1998 1999 1999	Stehlin/Wackernagel, S. 58 Paul Denfeld Erik Schmidt UV-Photography Urs Weber and Paul Denfeld
History of object	The wall painting has to be dated between late 13th and early 14th century. After the earthquake in 1356 the construction of vaults of the transepts was finished. Since that time the wall paintings were no longer visible, except from the attic.	
Restaurations	1999 consolidation by Urs Weber and Paul Denfeld	
Central questions	How many polychromies can be detected in total? Quality and techniques? Any similarities to other objects?	

2.4.32 PB28b Nördlicher Langhauspfeiler Nr. 4

Figure 2.36: View of object PB28b under normal (left) and UV-light (right, photo credits: Peter Fornaro)

Table 2.36: Description of main features of object PB28b

Determination of age	Around 1180
Location	Nave, northern pillar no. 4
Seize in cm	600 x 85
Height from ground in cm	56
Accessibillity	Sturdy scaffold-platform at 100 cm
Material	Coarse-grained red and greyish sandstone (Degerfelder)
Polychromy	Invisible traces (UV-detected) X
Technique of painting	Oil-based paint
Mode of examination	UV-screening, ARTAX and Handheld in situ
Samples	-
Cross-section	-
Existing reports	1479/80 Fabrikbüchlein 1480/81 Fabrikbüchlein 1853 Baukollegium to town-mayor
History of object	Until the UV-screening in 2015 the traces of a wall painting had been completely unknown.
Restaurations	During the renovation 1852/57 all walls and pillars were texturized with bush hammers to remove all sorts of coating to gain a « natural looking » surface.
Central questions	Is it possible to detect remains of a polychromy at all? What kind of pigments can be assumed? Under UV a whole « carpet » with a floral decor can be seen. Can the wall painting be connected to the cycle of statues of Apostles that was mentioned in 2014 by the original account book (Fabrikbüchlein) of 1479/80 and 1480/81?

3. Characterisation of visible polychromies on bas-reliefs, baptistery, graves, and wall paintings.

3.1 Strategy

The analytical investigations during this project, and in particular in WP2, were carried out using mainly non-destructive techniques, such us X-ray fluorescence spectroscopy (XRF) which allows determination of the elemental composition of materials. XRF was thus used to perform an extensive characterisation of most of the polychromies visible on the majority of the 28 selected objects. Nevertheless, for 8 objects (namely PB1b, PB12, PB14, PB24, PB25, PB26 and PB28A) it was not possible to perform in situ XRF, principally due to the inaccessibility of the object. In these cases only analysis of samples and/or cross sections were carried out.

For XRF investigations, three different apparatus were used: a mobile spectrometer (ARTAX 800) and two handheld (Niton XLt and XL3t). The choice among the spectrometers was performed according to their advantages/limitations. For instance, the ARTAX 800 permits analysis of very small areas (analysis spot: 80 μm) in a non-contact mode (focal distance: 0.8 mm), thus this instrument was to be preferred for highly sculpted objects (e.g. PB4 Vincentiustafel, PB16 Taufstein, PB17 Kanzel) as it was thus possible in most of the cases to attaint small remains of polychromy present in hollow areas (because preserved there during the removal of the colours). Also, with its integrated camera, the ARTAX allows a precise localisation of the analysis spot. On the contrary, although the ARTAX 800 has a flexible arm, it is not possible to perform analysis below 80 cm and higher than 160 cm from its base. Furthermore, to position the instrument it is necessary to have a flat, solid and sturdy base of 150 x 150 cm as a working surface. As regards to the two handheld Niton instruments, although they have no limitation of working height and their extreme mobility, analysis must be run in contact with the surface (contact surface 11x3 cm and 4x8 cm respectively for XL3t and XLt) so they are more adapted to flat surfaces (e.g wall, ceilings). Nevertheless, because of the relatively big spot measurement (≈8 cm in diameter for the XL3t and 2-3 times bigger for the XLt) and because of their “imprecise” positioning (they have no integrated camera) they cannot be used for the analysis of small details.

The systematic investigation by XRF allowed selecting specific positions where to take micro-samples to realise cross sections. These latter, were important for the establishment of an exact stratigraphy. Cross sections, after first observation under the microscope (UV and visible light), were systematically investigated by Raman spectroscopy, and some of them by Fourier transform infrared spectrometry (FT-IR) and/or XRF. This latter was performed with a laboratory apparatus, which permits the analysis of single layers whose thickness is $\geq$50 μm.

3.2 Analytical Methods

3.2.1 In situ measurement

In situ investigation of the polychromy present in the selected objects have been carried out using three different X-Ray Fluorescence spectrometers, namely a mobile one (ARTAX 800) and two handheld (Niton XL3t and Niton XLt). For these two latter, the XLt was preferred to the XL3t for practical reason most of the time. In most of the cases, for a specific object the analyses were carried out only with one type of spectrometer (mobile or handheld), while for some objects both mobile and handheld were used.

The analytical procedure was conditioned by the state of the object:

- if colours were visible, as in wall paintings (e.g. PB1, PB2, PB3, PB15) or polychromic sculptures (e.g. PB7, PB8), the analyses were carried out colour by colour in order to cover the full palette;
- if only tiny remains of polychromy were present as in most of the sculpted tablets (e.g. PB4, PB5, PB6) or other sculpted architectural ensembles (e.g. PB13, PB16, PB17), if geometrically possible, analysis were conducted on each single remain. In these cases, the analyses were oriented using a small portable UV lamp (allowing the detection of the typical fluorescence of organic binders) and/or our "iconographic knowledge" (choice of zone with possible decorations such as: robes, hair, jewellery, architectural features...).

3.2.1.1 Mobile XRF spectrometer: ARTAX 800

ARTAX 800 is a mobile spectrometer by Bruker allowing the simultaneous multi-elemental analysis in the element range from Si(14) to U(92) and attains a spatial resolution of down to 80 µm. The measurement is non-destructive and non-contact. ARTAX is fully PC driven and has an integrated CDD camera allowing a very precise positioning.

ARTAX is transported, dismounted into pieces, and can be set up and operational within 30 minutes. 4 big and heavy cases are required for its transport. Due to the precision of the measurement, the spectrometer is fixed to a solid vertical structure mounted on three crossed feet, the whole weighing circa 80 kg (Figure 3.1). Due to this geometry, the minimum required working surface is 150 x 150 cm.

ARTAX has a precise X-Y-Z motor stage thus it can work into three modes: spot measurement, line scans and area mappings. The required working distance is 0.8 mm (focus) (Figure 3.1). The motor stage is equipped with a 4.5 x 4.5 cm movement range. As the focus must be respected as precisely as possible at each measurement point a flat measurement surface is to be preferred.

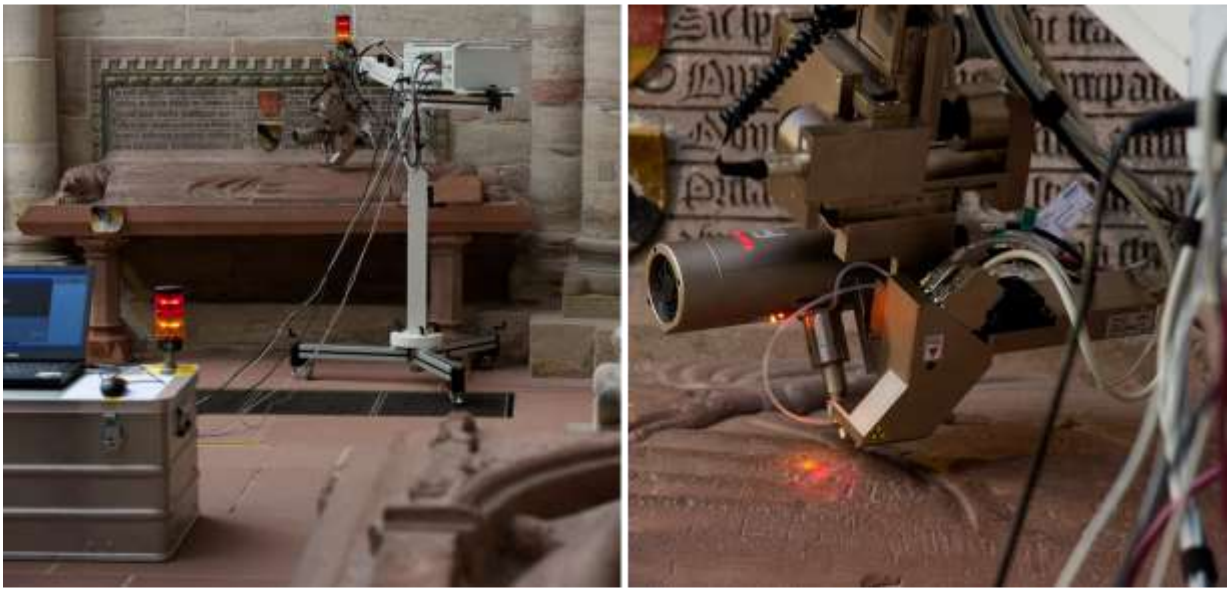


Figure 3.1: ARTAX 800 spectrometer: general view (left) and detail of the analytical head (right).

ARTAX is equipped with a poly-capillary lens for beam focusing and an extremely high fluorescence intensity, and a Peltier cooled XFlash® silicon drift detector (SDD) letting high count rates resulting in short measurement times. No liquid nitrogen as cooling agent is required.

During this project, measurements of polychromy (WP2) were performed at 50 kV and 600 μA; 2 points line scans were acquired, duration 300 sec/point.

Because of the high penetration depth of X-rays, and as polychromies are very thin, all acquired spectra present also the signals coming from the stone. Thus to correctly evaluate the elemental composition of the investigated polychromies, reference spectra for the substratum (stone or plaster) were necessary. In the case of polychromy on plaster the reference spectra were acquired directly in situ, whereas in the case of stone spectra were acquired in the laboratory. Because of the small size of the measurement spot, several spectra were acquired in order to take into account the possible heterogeneity of the stone.

Spectra were acquired on the Wiesentaler sandstone, as it is the unique stone substratum encountered on all the objects investigated with ARTAX in WP2. A total of 8 spectra were acquired (Figure 3.2). In agreement with the expected chemical composition of the stone, all spectra present Si, K, Ca, Ti, Fe, Zr, Rb and Sr and trace amounts of Mn and Zn; nevertheless a high dispersion of the elemental composition was observed (Table 3.1). This was problematic especially for elements such Fe and Ca which are highly susceptible to be present in pigments (e.g. ochre's, Prussian blue, green earths, chalk). Therefore it was decided to take spectrum 5 as a reference because it had the highest Ca amount which will prevent an overestimation of Ca content in the polychromies.

Table 3.1: Elemental composition (as elemental ratios) detected on the reference Wiesentaler sandstone.

Ratio	P1	P2	P3	P4	P5	P6	P7	P8
Fe/Ca	100.0	36.2	723.2	25.3	2.8	116.3	80.4	5.1
Fe/Ti	5.2	39.0	423.0	40.5	7.8	32.4	25.6	11.4
Fe/K	7.5	18.9	124.6	14.5	20.0	14.1	11.2	21.6
Fe/Rb	10.5	9.4	26.7	4.6	6.0	14.1	11.4	4.8
Ca/K	0.1	0.5	0.2	0.6	7.1	0.1	0.1	4.2
Fe/Si	51.1	78.9	512.2	33.1	97.1	95.4	486.3	32.4
Ca/Rb	0.1	0.3	0.0	0.2	2.1	0.1	0.1	0.9

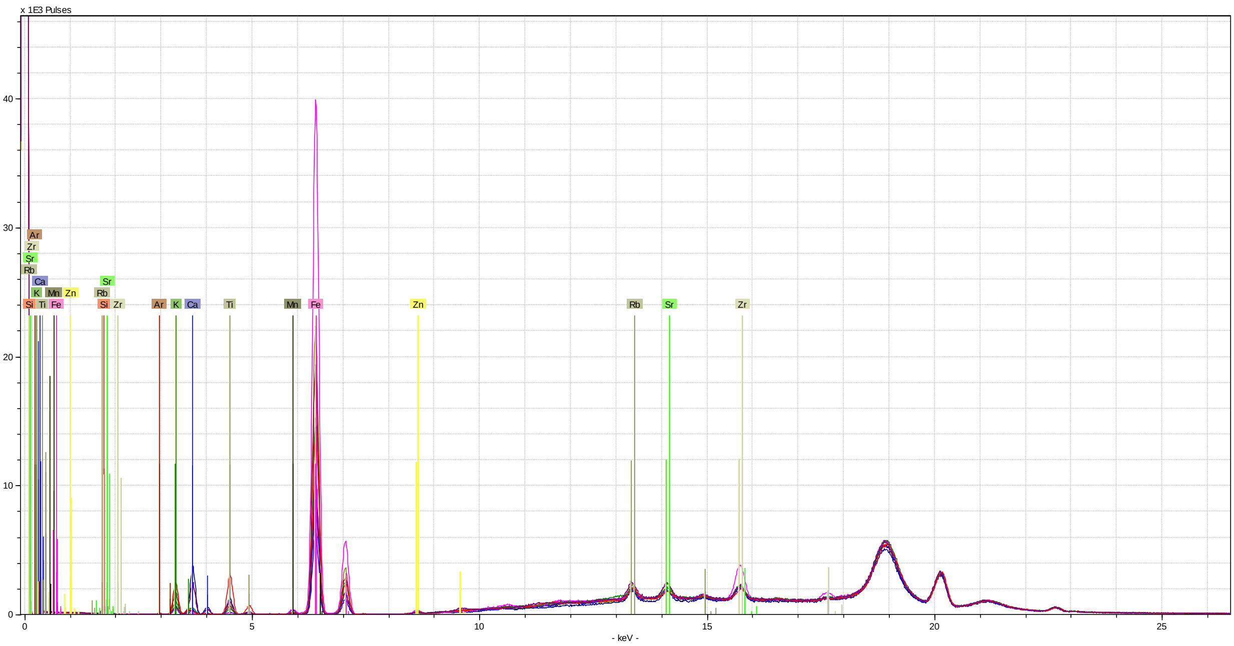


Figure 3.2: XRF (ARTAX) spectra acquired on Wiesentaler reference sandstone.

3.2.1.2 Handheld XRF spectrometers: Niton XLt and XL3t

Two handheld XRF spectrometers from Thermo Fisher were used during the project: Niton XLt and Niton XL3t. The first was usually preferred and thus only few spectra were acquired with the XL3t. Their technical specifications are summarised in Table 3.2.

With both handhelds, analyses are non-destructive, in contact mode and do not require a PC to be operated.

As for the ARTAX reference spectra of the substratum made of plaster were performed in situ, whereas in the case of stone they were acquired in the laboratory. According to the analysis performed in situ, references were taken for the Degerfelder with XLt only, and for the Wiesentaler with both XLt and XL3t. All the spectra present the same composition as described in paragraph 3.2. The following discussion is going to relate only to Fe and Ca.

Table 3.2: Technical specification of the two handheld XRF spectrometers

	Niton XL3t	Niton XLt
Tube	Ag	
Spot size	8 mm diameter 80.4	2-3 times bigger than XL3t
Collimator	W, circular beam	non circular beam
Detector	Pin diode encapsulated in Ni	
Filters (Excitation Energy)	Main: AlFeTi (50 kV) Low: Cu (20 kV) High: Mo (50 kV) Light: none (8 kV)	Main: AlTiFe (35 kV) Light: none (10 kV)
Operation mode	soil	mining

In the case of Degerfelder sandstone, analyses were carried out on the stone matrix far from the big mineral inclusions; this is why only 5 spectra were taken (Figure 3.3). The obtained spectra show a quite homogeneous content in Fe and Ca, with average intensity of 2.8±0.2 and 17.1±1.9 counts/sec respectively. For practical reasons, only the spectrum sp5, presenting the highest Fe and Ca intensities, was chosen as reference.

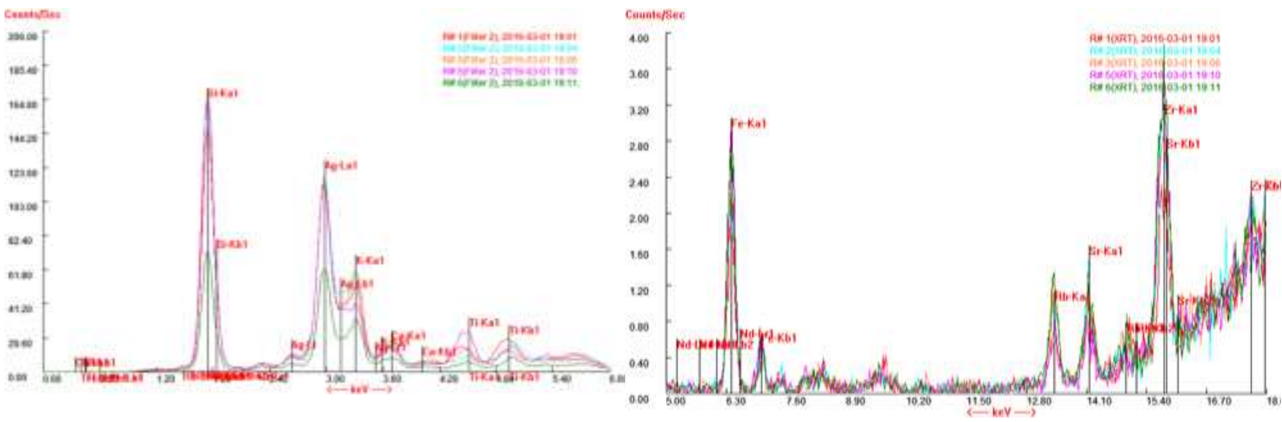


Figure 3.3: XRF spectra acquired with Niton XLt on Degerfelder reference sandstone: low (left) and main (left) range. Ag signal comes from X-Ray tube.

In the case of Wiesentaler sandstone, because of its quite homogeneous texture more spectra were taken, namely 14 with the XLt and 12 with the XL3t. XLt spectra were very similar, with an average intensity of 9.5±1.1 counts/sec for Fe and 57.5±5.4 counts/sec for Ca. Adopting the same criteria as before, spectrum 18 was chosen as reference. In the case of analyses performed with XL3t, a slight higher dispersion of the values was observed on the 12 acquired spectra; the average intensities were 1097.4±189.8 counts/sec for Fe and 187.3±42.2 counts/sec for Ca. In this case the reference was spectrum 19.

3.2.2 Laboratory measurement

3.2.2.1 Preparation and documentation of cross-sections

Samples taken on-site were first observed under optical microscope with reflected light in order to have a first evaluation of the sequence, number and colour of layers. Then the sample was embedded in resin (Technovit 200LC, a mixture of mono- and methacrylate), then located, for 12 minutes, in a device delivering a blue light at 400-520 nm which facilitate the polymerisation (Technotray CU, Kulzer). Afterwards the cross section was polished.

The obtained cross section was then analysed under the polarisation microscope (Axioplan, Zeiss) and observed under visible and UV light. Thus the precise number of layers, their thickness, as well as their optical appearance (colour, transparency, opacity) was described.

3.2.2.2 Raman

The cross sections, and some rare massive samples, were analysed by RAMAN spectroscopy in order obtain a precise mineralogical identification of the used pigments. Because the used RAMAN is equipped with a microscope and has a very small spot measurement (1-2 μm) it is possible to perform a precise determination of each single layer.

The spectrometer used for this project is ARAMIS, by Jobin-Yvon, equipped with a microscope (Olympus BX 41) allowing visualisation of the analysed spot. Three lasers are available, 785 nm (diode laser), 532 nm and 633 nm. All spectra were acquired using a 600 g/mm grating (theoretical resolution of the spectra is ± 5 cm^{-1}), at different laser power and with acquisition time spanning from 1 to 500s. Frequently the signal was hidden by a very high fluorescence, in this case quenching of the sample was performed for several minutes.

Some publications were considered for this project as “reference”, by given valuable information and overview about materials and techniques used in wall painting or about specific groups of pigments (Aliatis et al. 2010; Bell et al., 1997; Bersani and Lottici, 2016; Burgio et Clark, 2001; Clark et al. 2010; Correia et al. 2007; Froment et al. 2008; Gutman et al. 2014).

3.2.2.3 FTIR

Analysis of selected cross sections (PB 6, 10, 16, 17, 25, 27) and massive samples (Pb9, PB 12, PB19) were also investigated by Fourier transform infrared spectroscopy (FTIR), in order to determine the nature of the binders.

Analyses were performed using a spectrometer of the Excalibur series coupled with a UMA-500 microscope (Biorad), allowing selecting precise analysis areas. Analysis of single paint layers is possible as the investigated area can be adjusted according to the thickness from 250 x 250 μm (for thick layer) to 60 x 60 μm (for thinner ones). The detector is a mercury-cadmium-telluride (MCT).

All cross sections were analysed in reflectance mode, while the loose grains could be analysed in transmission mode with a diamond press cell.

FTIR allows the acquisition of spectra that give information mainly about the organic components constituting the objects, by comparison to spectra libraries or by identifying the peaks via literature.

3.2.2.4 Laboratory XRF fluorescence Eagle and ARTAX

For some selected cross sections, and for massive samples, complimentary analyses were carried out by X-ray fluorescence.

The cross sections were analysed using the Eagle III XXL spectrometer, equipped with a Rh tube and a Si(Li) semiconductor detector. Analyses were carried at 40 kV, 150 μA, under vacuum, with a point measurement of 300 sec each. The spot diameter was about 50 μm allowing the analysis of specific paint layers in most of the cases.

In the case of massive samples, that is to say small grains on polychromy collected in situ as well as PB22 Hand, the analyses were carried out in the lab by the ARTAX 800, under the same technical specifications as described before.

In both cases, no sample preparation was needed.

3.3 Results

3.3.1 PB1a Bischofsbilder Lüthold und Adalbero, Ostkrypta

These are wall paintings of two bishops, Lüthold and Adalbero, located in the eastern part of the eastern crypt (Figure 3.4 and 3.5). Visual observations highlighted the use of coarse stucco with reddish sand as additive of high quality.

For both these two wall paintings most of the analyses were carried out with the Niton Precisely, 9 spectra were acquired on the upper part of Bishop Lüthold, and 8 on the bottom part. As for Bishop Adalbero, were realised 8 spectra on the upper part and 8 on the lower one. In addition, some ARTAX measurements were performed on the bottom part (below the arch). Only one sample was taken from the blue background at the right side[4] of Bishop Lüthold's face, to realise a cross section.

[4] For all descriptions „right“ and „left“ sides are defined relative to the observer.

3.3.1.1 Results of the non-destructive analysis

Analysis of Lüthold

The elemental composition of each spectrum was evaluated using as reference a spectrum taken on the plaster (sp4) on the bottom part of Lüthold.

The palette of colour includes white (ground layer), yellow, red, flesh tones, blue, grey and black (Figure 3.4). The white background is composed of Ca, Fe and lesser quantity of S. The yellow at the picture frame and on the Tiara of the bishop presents an excess Fe and Ca and traces of Pb and/or As and S. The red of the picture frame is composed of Hg, Ca, S and traces of Fe. The flesh tones are composed of Ca, Fe and Hg. The blue surface shows Ca and a slight excess of Fe compared to the white ground layer, but no copper was detected. As for grey and black paint only Ca and Fe were detected.

To be noticed that all the spectra whichever the colour, acquired on the upper part presented traces of Hg. After investigation it was found out that in 1975, when the paint was rediscovered it was covered by a black soot layer. This layer was very luckily originated by a heating system (burning coal) which was formerly located to the left of the painting in the crypt. Indeed it is known that the combustion of coal produce trace amount of Hg (Rodríguez Martín and Nanos, 2016; Kelepertzis and Argyraki, 2015; Wang et al., 2010; Yang and Wang, 2008). All the spectra taken at the bottom part showed traces of S and Cl, presumably from salt contamination.

Figure 3.4: Localisation of the XRF analysis on upper (left) and bottom (right) part of Bishop Lüthold wall painting. Sp: spectra taken with Niton (in blue), P: spectra with ARTAX (in red).

Analysis of Adalbero

The elemental composition of each spectrum was evaluated taken as reference a spectrum taken on the stucco (sp4) on the bottom part of Lüthold.

The palette of colour includes white (ground layer), yellow, red, flesh tones, blue and black (Figure 3.5). The white ground layer is composed of Ca, Fe and a lesser quantity of S. The yellow of the picture frame presents an excess of Ca, Fe and traces of Pb, whereas on the aureole and on the Tiara of the Bishop the yellow presents an excess of Ca, Fe and Pb. The red of the picture frame is composed of Ca, Fe and traces of Pb. The red of the chasuble is composed of Ca, Fe and Hg with traces of Pb. The flesh tones are composed of Ca and Fe. The blue remains show Ca and a slight excess of Fe compared to the white ground layer, but no copper was detected. On the black painted parts only Ca and Fe were detected.

Figure 3.5: Localisation of the XRF analysis on upper (left) and bottom (right) part of Bishop Adalbero wall painting. Sp: spectra taken with Niton, P: spectra with ARTAX.

3.3.1.2 Results on complimentary study on cross sections

In order to better understand the nature of the pigment present in the blue layer, a sample was taken to be prepared as a cross section. The sample was taken at the right side of the Bishop Lüthold face at check level, on a quite thick and bright blue layer "Mü Luth 01"; Figure 3.4).

The cross section shows a blue and a turquoise layer (Figure 3.6). According to XRF analysis, both contains Cu. Raman indicated the presence of Azurite in the blue layer, while for the turquoise layer no precise mineralogical determination was possible. The spectra presents only Raman band characteristic of Cu-O vibration (Mattei et al., 2008).

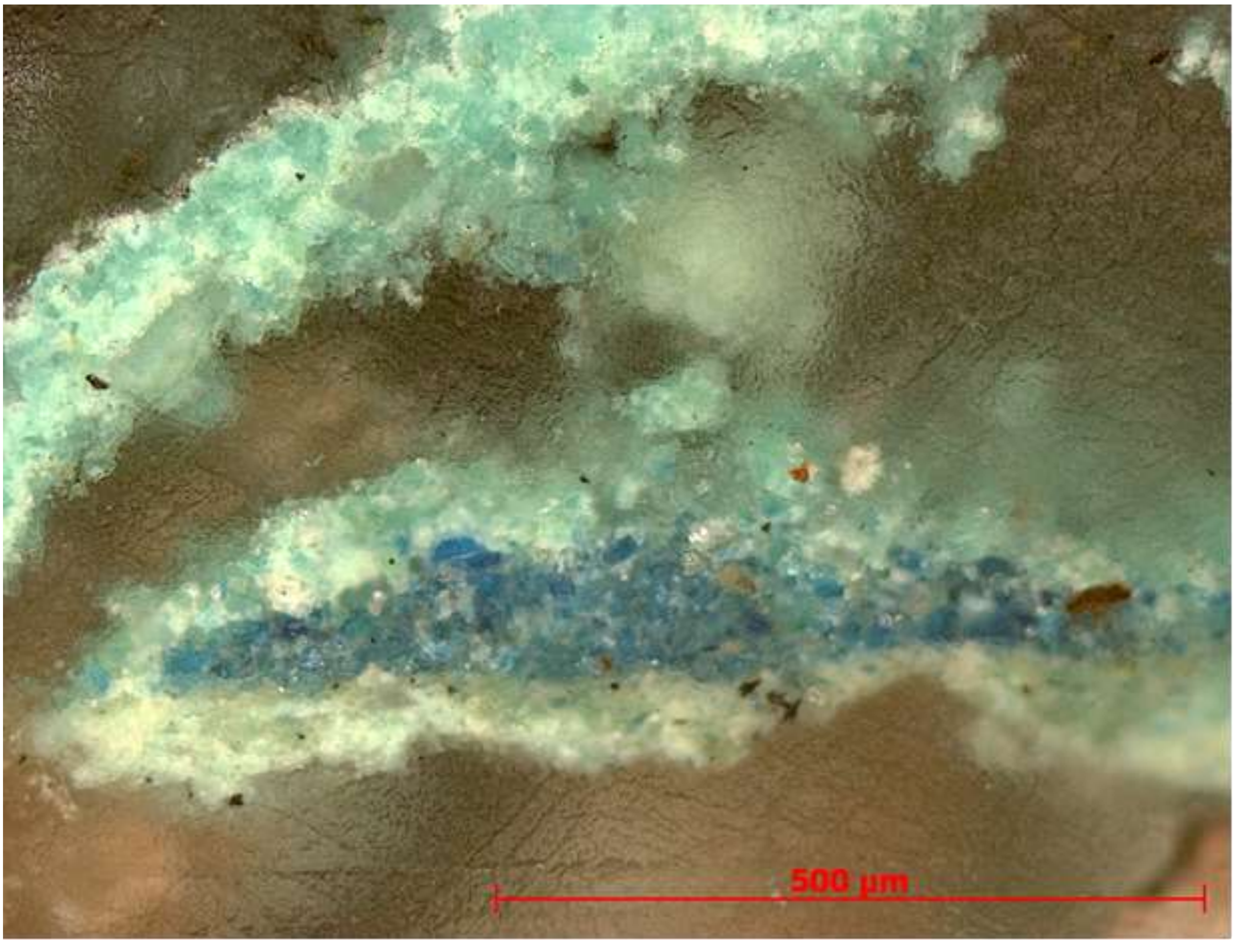


Figure 3.6: Partial view of cross section MüLüth_01.

3.3.1.3 Conclusion/discussion

According to these results, the following hypothesis on the stratigraphy of both wall paintings can be formulated.

The ground layer for both wall paintings consists of a mixture of gypsum and iron oxide. The presence of Ca, S and Fe in all the overlying paint layers confirms this hypothesis.

The yellow paint layer on the frame of each Bishop was applied on the ground layer and was made of iron oxide and traces of Pb (perhaps lead white or lead oxide). Due to the absence of As in the yellow layer of Bishop Adalbero and, based on temporal and stylistic similarities of both Bishop's paintings, we exclude the presence of traces of As in the yellow layer of Lüthold.

The yellow paint layer applied on the aureole and Tiara of the Bishop Adalbero could be a mixture of lead oxide (massicot) and iron oxide. Due to the intensity of this yellow the use of lead white can be excluded.

The less intense yellow layer on the Tiara of the Bishop Lüthold is mainly composed of iron oxide with traces of lead.

There are two different red layers, one at the border of the pictures, mainly composed on iron oxide, whereas on the chasuble of the Bishop Adalbero, the red layer is a mixture of iron oxide and cinnabar.

The flesh tones are, for both Bishops, a mixture of calcite and iron oxide.

The composition of the blue layer is not characterised. XRF analysis performed in situ and the study of the cross section give two different results. Thus, it cannot be excluded that the sample for the cross section was taken in an area which have been retouched. The study of the “PB1b Fundstücke aus Gewölbeschutt Ostkrypta” could bring some complementary and conclusive results.

The black layer should be mainly composed of carbon black.

3.3.2 PB1b Fundstücke aus Gewölbeschutt Ostkrypta 1973/74

These are archaeological artefacts out of the scree of the eastern crypt (Figure 3.7), found in 1973/74. They are remains of a wall painting.

Visual observations of the pieces show the presence of coarse stucco (thickness ca. 5 to 8 mm used as a compensation for the coarse brickwork it was coated on), followed by 50 micron fine stucco, on top of which 1 to 2 thin painting layers are present.

These archaeological artefacts might have been removed from the walls through or after the earthquake of 1356. A comparison of the painting techniques between them and PB1a Bischofsbilder Lüthold and Adalbero wall paintings could be interesting, due to their contemporaneity.

For these fragments analyses were carried out in the laboratory by Raman spectroscopy, on four cross sections.

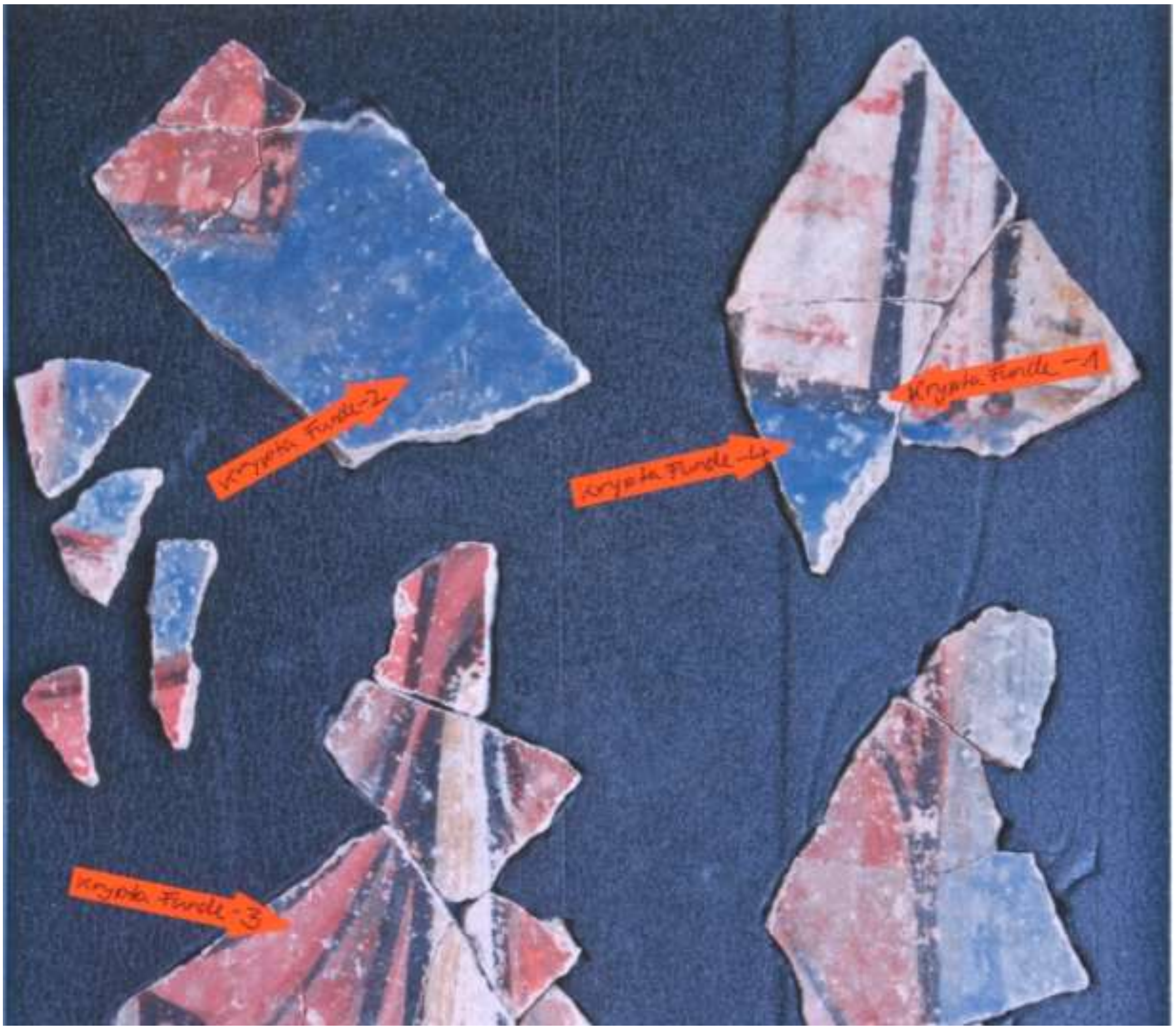


Figure 3.7: Localisation of the sampling for cross section P1 to P4

3.3.2.1 Results on samples

All four cross sections show more or less the same structure with, first a ground layer inhomogeneous as plaster (layer 1), followed by a thin beige homogeneous layer of gypsum (layer 2) and finally a colour layer on the top (layer 3). To be notice that no layer 3 was detected on P1 (Figure 3.8). On the second cross section P2, the turquoise paint layer is applied on a thin gypsum layer (Figure 3.9). On the third cross section P3, a thin layer of cinnabar and red lead is applied on a gypsum layer (Figure 3.10). On the fourth cross section P4, a thin layer of azurite is applied on the thin gypsum layer (Figure 3.11).

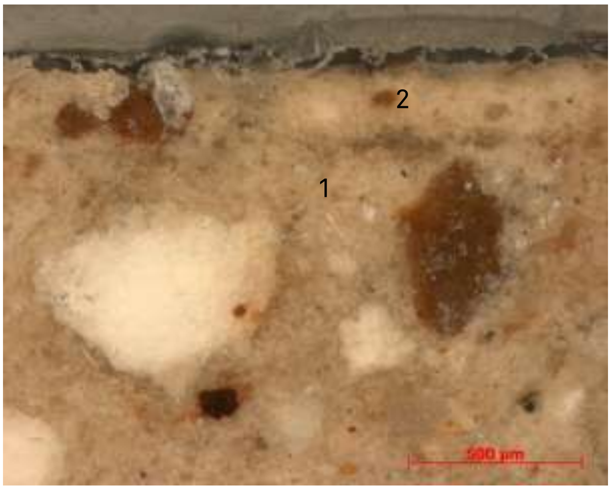


Figure 3.8: Cross section "P1", under visible light

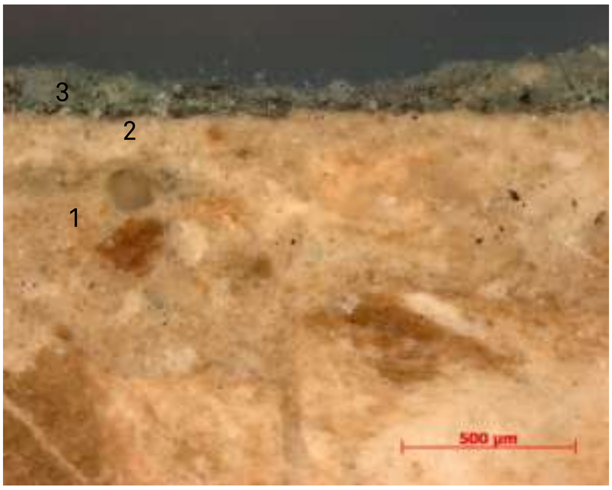


Figure 3.9: Cross section "P2", under visible light

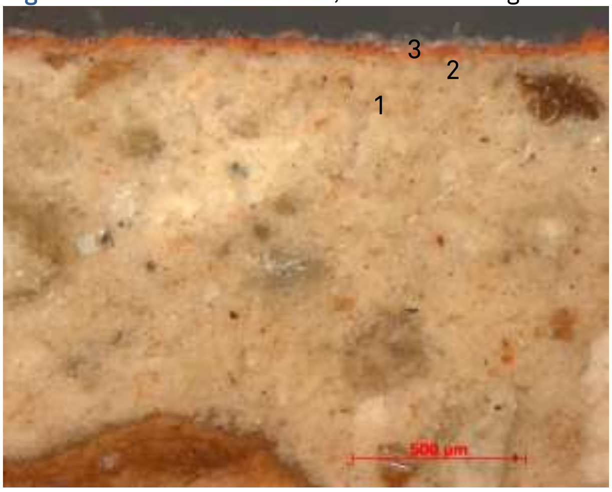


Figure 3.10: Cross section "P3", under visible light

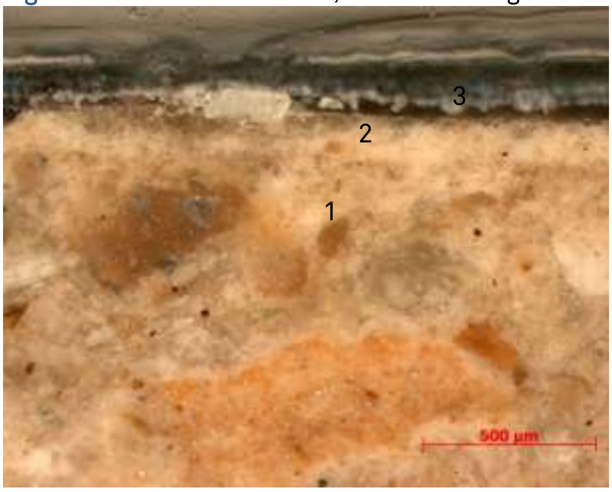


Figure 3.11: Cross section "P4", under visible light

3.3.2.1 Conclusion-discussion

All cross sections show a coarse stucco layer, followed by a thin layer of gypsum (ground layer?) on top of which colour was directly applied. The pigments used are cinnabar and red led (for red tones) and azurite (for blue). No precise attribution was possible for the turquoise colour.

Comparing these results with those obtained on PB1a some similarities/discrepancies can be highlighted. About the red colour, in PB1b this is a mixture of cinnabar and red lead while in the case of PB1a two different red were observed, one made of iron oxides and the other composed of a mixture of iron oxides and cinnabar. The turquoise cannot be precisely attributed on both PB1a and PB1b. The presence of azurite is confirmed on both PB1a and b.

3.3.3. PB2 Margaretha/Martin Gewölbemalerei Ostkypta

This is a wall painting located on the northern vault of the eastern crypt. This is a wall painting made on plaster layered on brickwork. The wall painting is composed of three sections: S. Margareta, Christ with the angels, and S. Martin with the horse. The different sections of the wall painting were analyses using the handheld XRF (Niton XLt). In total 35 spectra, representing the whole chromatic palette, were taken. No sampling was performed on this object.

3.3.3.1 Results on in situ analysis

Results are reported section by section.

The S. Margaretha section includes colour such as white, yellow, brown, grey and black (Figure 3.12).

Analysis carried out slightly outside of the painted scene (sp. 146) indicates enrichment in Ca and S compared to the naked stone and confirms the presence of gypsum stucco as substratum. This spectrum is therefore used as reference for the other spectra.

The white part, within the painted scene, presents in addition to S and Ca traces of Pb. As for the yellow, pale shades do not contain any additional element, while more "saturated" layers contain additional Pb. Brown areas contains excess Fe and sometimes Pb. Grey layer present Pb while black zones contain Pb and have more Ca than the stucco it-self.

The presence of Pb in all spectra (except sp. 148), which ever the colour, suggests that all colours were applied on a white layer (ground layer) containing lead white.

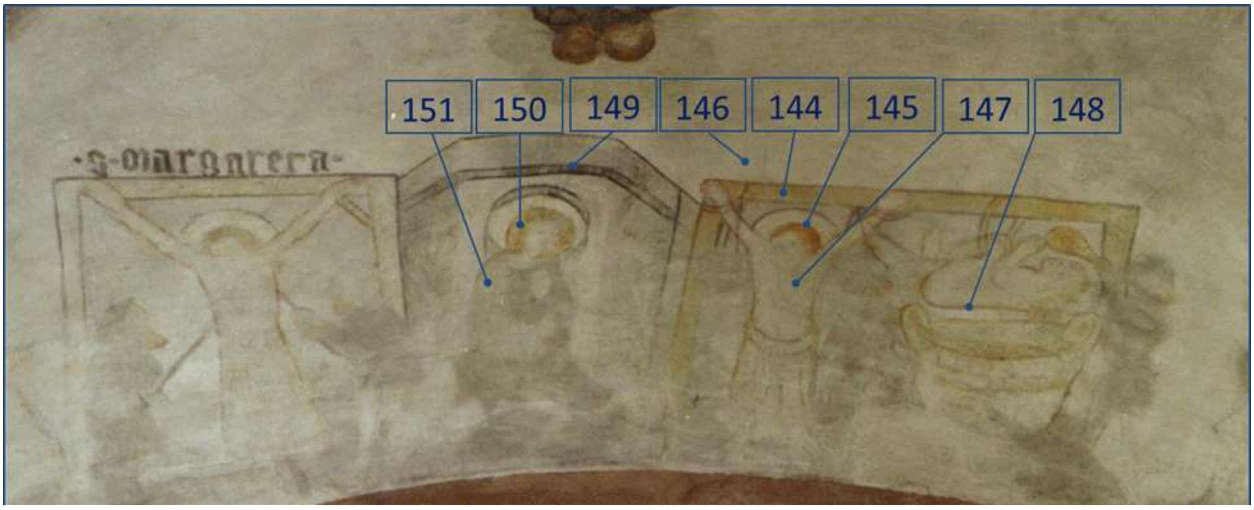


Figure 3.12: Localisation of XRF analyses on PB2 wall painting, section of S. Margareta

The Christ and the Angels section presents a palette of white, yellow, dark and light blue, flesh tones and black (Figure 3.13).

No measurement was performed on white area, and spectrum 146 (taken on S. Margaretha) was used as reference.

The yellow are made of Fe and variable amount of Pb. The flesh tones contain mainly Pb associated with Fe. As for blue, the dark tones contain Cu and Pb, while the light shade on the central angel chest is composed of Cu, Pb, Zn and Ti (indicating a possible restoration, see Denfeld 1993). Finally the black presents Pb, traces of As and an excess of Ca.

Figure 3.13: Localisation of XRF analysis on PB2 wall painting, section of Christ with the angels wall painting

The section of Martin on a horse shows colours such as white, yellow, yellow-orange, orange, red, brown, green, blue, carnation, grey and black (Figure 3.14).

In this case a new spectrum of the background (sp. 176) was taken and used as a reference. This reference contains Ca and S with a different ratio than sp. 146 and traces of Zn.

The white, measured on one of the dogs, is very similar to the reference. Yellow and orange tones contain Pb, and sometimes Fe. In one case Zn and Ti were also found (retouch). Red is mainly composed of Fe and less Pb. The brown contains Pb and Fe in different proportions than the black. Green shades are mainly composed of Cu with less amount of Pb, while on the contrary more Pb and less Cu is found on blue tones. Flesh tones are made of Pb and Fe with traces of Zn. Black only present traces of Pb. As for the other two sections the ubiquitous presence of Pb in all spectra suggests the use of lead white as ground layer.

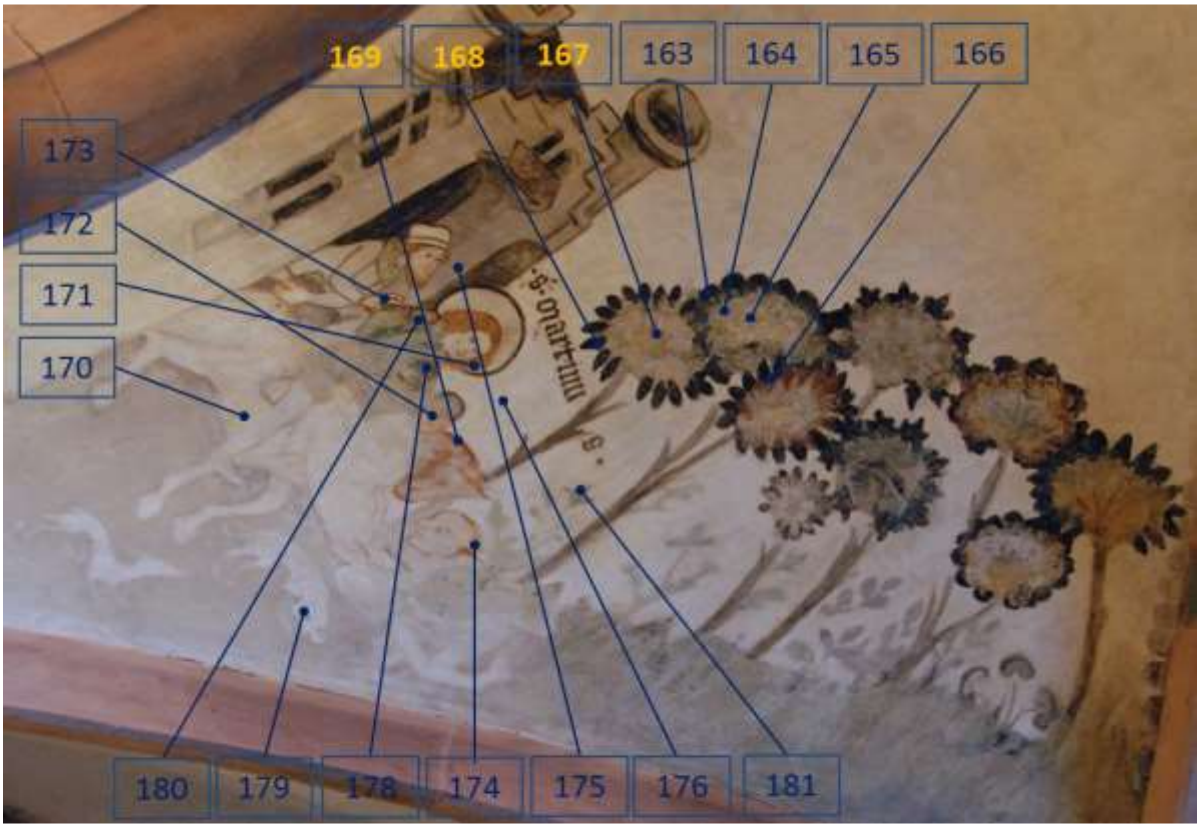


Figure 3.14: Localisation of XRF analysis on PB2 wall painting, sections of S. Martin with the horse

3.3.3.2 Conclusion/discussion

According to these results, the following hypothesis on the stratigraphy of this wall painting can be formulated.

The ground layer for the all wall painting consists mainly of gypsum. Analyses carried out outside and insides the scenes show that Pb was detected in addition to Ca and S only inside the painted scenes. This fact leads to the hypothesis that a lead white layer was applied on the gypsum ground layer in order to give more chromatic effect to the colours used for the scenes.

The white paint layer has the same composition as the addition of the ground layer and the lead white layer, indicating no addition of further pigments to obtain the white.

Yellow, orange and red tones are mainly composed of iron oxide and lead oxide, in different proportions, according to the desired colour. Without complementary analyses it is not possible to precisely characterise precisely the type of iron or lead xides.

Flesh tones contain mainly lead white (due to the colour of carnation lead oxide should be excluded as main pigment) and iron oxide.

Blue and green colours contain copper based pigments mixed with mainly lead white, in different proportions according to the colour shade (light or dark).

Brown tones contain iron oxide and lead based pigments in different proportions.

The spectra of the grey and black painted zone did not show other chemical elements than the neighbouring paint layers. Grey and black layers should thus contain mainly black carbon.

Some spectra of specific painted parts, as the crosier of bishop Saint Martin, the halo in the Saint Margareta scene and details of flowers show the presence of arsenic. This result permits to affirm that orpiment was used in order to give a bright yellow tone.

The occasional presence of chemical elements such as titan or zinc in the wall painting is an attestation of former restoration works, done in late XIX and during the XX centuries.

According to the results obtained by non-destructive analyses of the wall painting performed with XRF, it is possible to affirm that the palette of colours is a classical medieval colour palette which contains: gypsum, lead white, probably lead oxide, red, brown and yellow ochre, azurite for blue, copper pigments for green, and carbon black.

This wall painting should be made of a unique polychromy which should be original except from some small restoration works.

3.3.4. PB3 Wandbild Christus vor der Kreuzanheftung, Vierungskrypta

This fragmentary wall painting is located in the crypt beneath the crossing; it represents Christ before his crucifixion (Figure 3.15).

Visual examination of this wall painting highlighted the presence of coarse grey-beige stucco (with sand additive) overlaid by a second, finer stucco (thin whitewash).

Analyses wereperformed by ARTAX during a first measurement campaign; later on, few complementary analyses were carried out by Niton. Precisely, 20 spectra were acquired on the upper part of the wall painting (16 by ARTAX and 4 by Niton) while on the bottom part 5 analyses were performed (3 by ARTAX and 2 by Niton). Two samples were taken from a red “Mü Kreuzaneft 1” and a greyish blue “Mü Kreuzaneft 2” to realise cross sections.

3.3.4.1 Results of the non-destructive analysis

The localisation of the XFR investigation is shown in Figure 3.15.

The elemental composition of each spectrum was evaluated comparing spectra to each other as it was not possible to take a reference spectrum from the plaster. Indeed, this latter was covered with paint layer everywhere. The only visible plaster without paint layer was a modern concrete applied for the consolidation of the wall painting.

The palette of colour includes white (ground layer), light pink, orange, red, flesh tones, blue, blue-grey, brown and black.

The ground layer is composed of Ca and Fe, thus this two elements are present in each spectrum. The white present in the waistcloth should be composed mainly of Ca with Fe and Pb. The flesh tones, on Christ's body, contain lot of Ca and some Fe. For the reddish tones (red, orange, brown) there are two different compositions, one on the sword of the soldier to the left of Christ, which is mainly composed of Fe and Ca. The second one, on the tunic of the soldier behind the Christ, is rich in Pb, with fewer amounts of Fe and Ca. As for the blue shades, there are also two different compositions. The blue of the tunic of the soldier to the left of Christ, is Cu-rich with Ca, Fe and traces of Pb; the lighter blue on Christ's tunic (at his right side) has no Cu but only Ca with traces of Fe and Pb. Finally, for the black, the analysis shows systematically the chemical composition of the underlying colours, suggesting the use of black carbon.

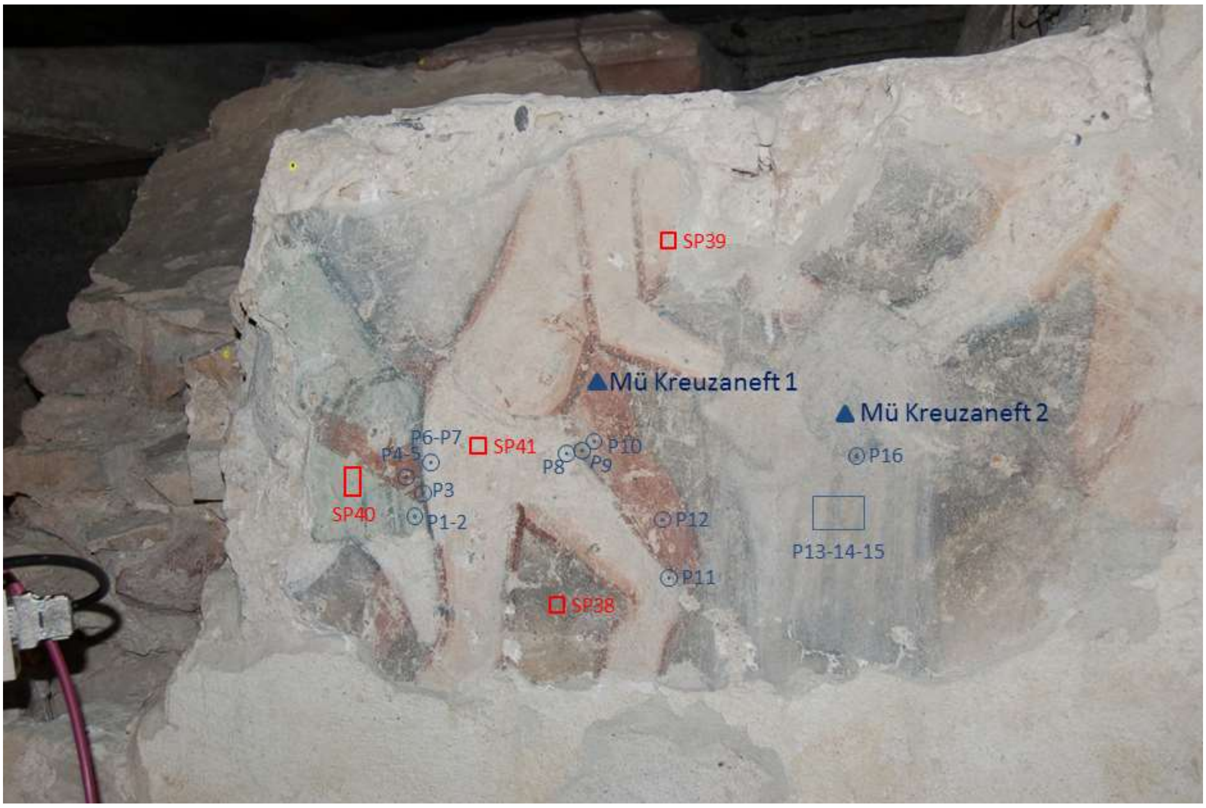


Figure 3.15: Localisation of XRF analyses on PB3. Sp. Analysis with Niton, P: ARTAX.

3.3.4.2 Results on complimentary study on cross sections

Two cross sections were realised, the first one positioned on the red tunic of the soldier behind Christ "Mü Kreuzanheft 1", the second of the light blue tunic of Christ "Mü Kreuzanheft 2" (Figure 3.16). Both present only one polychromy.

For the cross section "Mü Kreuzanheft 1", unfortunately no information arises from the red layer (layer 3). Instead it was possible to detect the presence of a first layer mainly composed of gypsum and a second one made of calcite.

For the cross section "Mü Kreuzanheft 2", three layers were found, the first one mainly composed of gypsum, a second one rich in calcite, traces of gypsum and black carbon. The third layer is mainly composed of black carbon. This finding explains the absence of the characteristic elements usually giving a blue colour, such us Cu and Fe, in the light blue tunic. Indeed the blue appearance is given by the chromatic dispersion of black carbon particles in the white matrix.

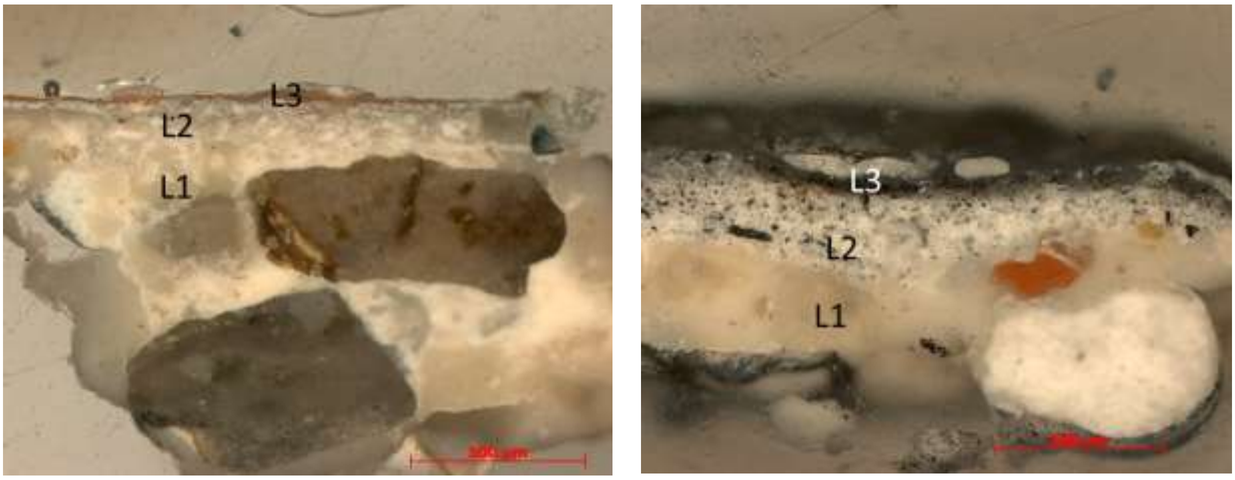


Figure 3.16: Cross sections "Mü Kreuzanheft 1" (left) and "Mü Kreuzanheft 2" (right) under visible light.

3.3.4.3 Conclusion/discussion

According to the first results, the following hypothesis on the stratigraphy of this wall painting can be formulated.

The background is composed first of gypsum and then of calcite with iron oxide particles.

The white present in the waistcloth should be composed mainly of lead white.

The flesh tones, on Christ's body, contain a mixture of mainly calcite with iron oxide.

For the reddish tones (red, orange, brown) there should be two different colour layers, one on the sword of the soldier to the left of Christ, which is mainly composed of iron oxide and calcite. The second one, on the tunic of the soldier behind Christ, is rich in lead oxide (red lead).

As for the blue shades, there are also two different ones. The blue of the tunic of the soldier to the left of Christ should be a mixture of azurite and calcite; the lighter blue on Christ tunic (at his right side) is a mixture of calcite and black carbon.

Finally, the black should be mainly composed of black carbon.

So it is possible to affirm that this is a classical medieval colour palette: lead white, calcium carbonate (chalk), red, brown and yellow ochre, azurite for blue and carbon black. It can be concluded that this wall painting is made of a unique polychromy which should be original.

3.3.5. PB4 Vincentiustafel, äusseres Nordseitenschiff

This is a stone bas-relief representing the passion of St. Vincent (Figure 3.17). The stone used for this piece is the Wiesentaler sandstone.

For this stone bas-relief, as there are no visible traces of polychromy except in very deep cavities, the selection of the measured points was done using the UV light hand lamp. 19 spectra were acquired using the ARTAX, on points presenting high fluorescence.

Two samples were taken to realise cross sections.

3.3.5.1 Results of the non-destructive analysis

The reference spectrum used for the evaluation of the acquired spectra was taken on the Wiesentaler stone reference (sp. 5).

In each of the 19 measured points (Figure 3.17), Ca, Fe, and to a lesser quantity some Pb and S were detected. In some isolated spectra very low traces of Cu and Zn were observed.

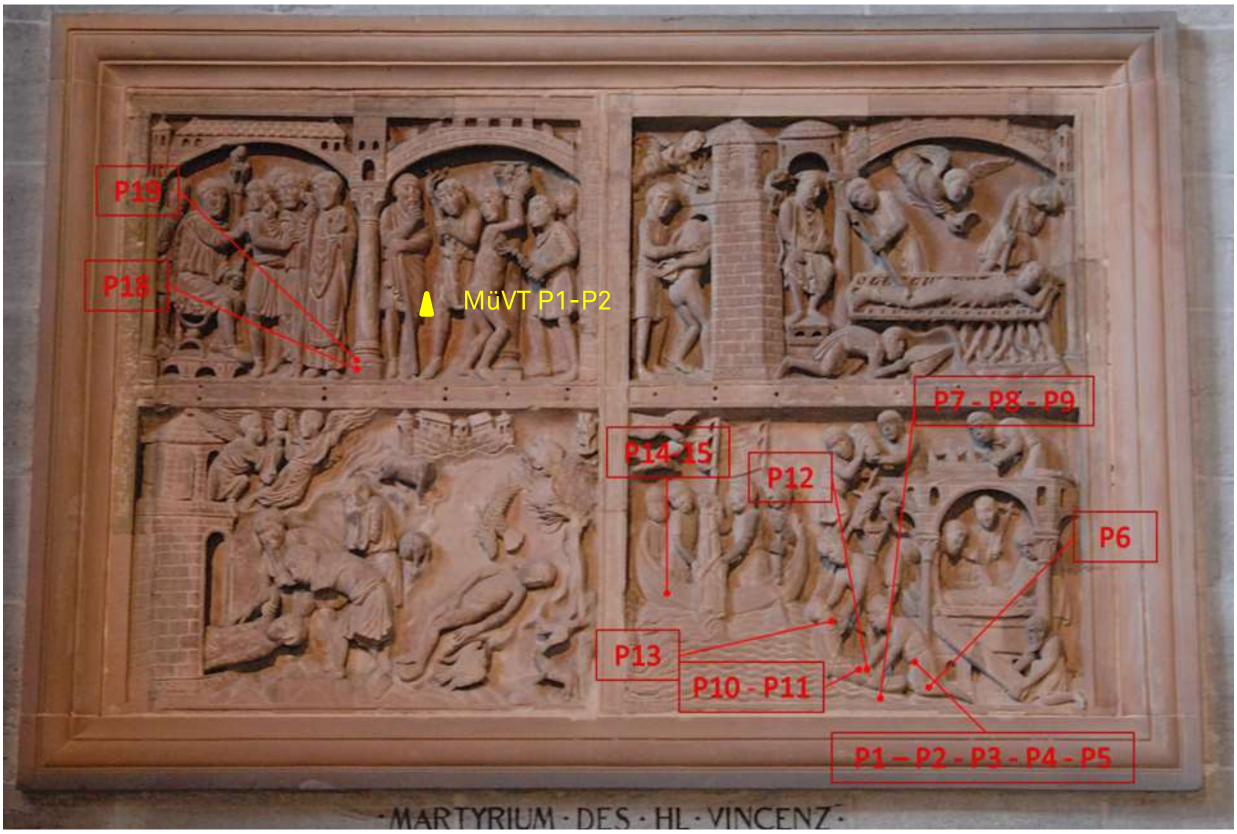


Figure 3.17: Localisation of XRF analyses on object PB4 and sampling for cross section.

3.3.5.2 Results on complimentary study on cross sections

Two cross sections were realised, both were taken from a pleat of the robe of one figure from the upper left part of the bas-relief “MüVT P1” and “MüVT P2” (Figure 3.17).

For the cross section “MüVT P1” (Figure 3.18), two layers are visible. The first layer is attributed to the sandstone. The second, thin and inhomogeneous, is composed of gypsum with some grains of black carbon.

Figure 3.18: Stratigraphy of sample “MüVT P1” under visible (left) and UV (right) light

For the cross section “MüVT P2” (Figure 3.19), two layers were found. The first, thick, beige with some red, yellow and black grains is mainly composed of gypsum with haematite, black carbon and probably other iron oxide particles. The second layer, red, thin with fine crystals consists mainly of haematite and gypsum.

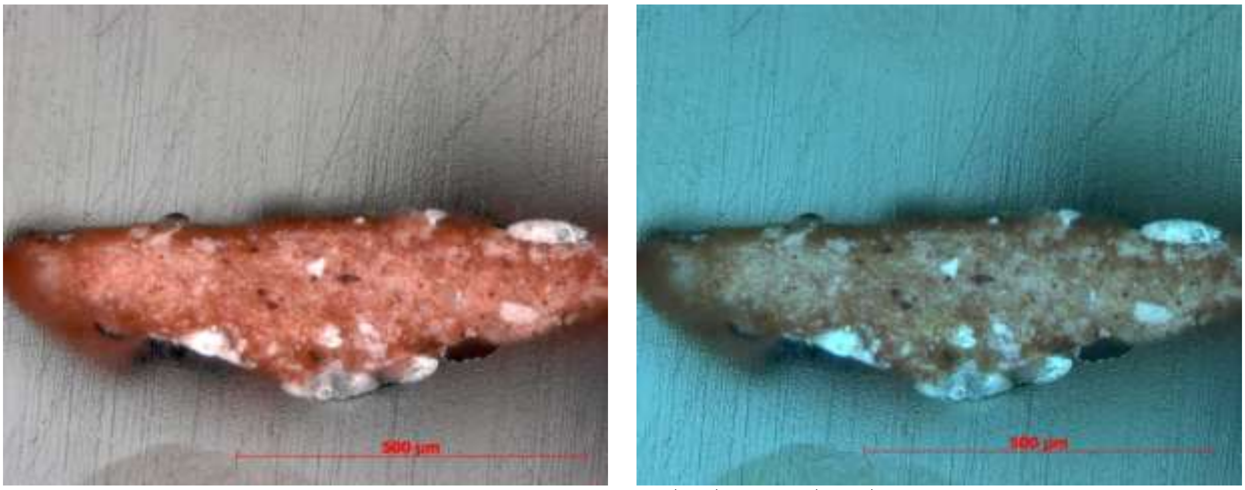


Figure 3.19: Stratigraphy of sample “MüVT P2” under visible (left) and UV (right) light

3.3.5.3 Conclusion/discussion

Based on the XRF data and on the study of the cross sections, a palette of colours could not be defined. Nevertheless, because of the ubiquitous presence of an excess of Ca and Fe compared to the raw stone and to the additional presence of traces of Pb and S, it is possible to affirm the existence of former polychromy(ies) which have been removed. This hypothesis is supported by the observations under UV light which show the presence of remains of organic binder and of very thin colour layers in the cross sections

The former polychromy was painted on a gypsum rich base coat applied directly on the stone, as also confirmed by the analysis of the cross sections. As for the presence of Fe and Pb it is difficult to draw a clear conclusion about the type of used pigment except that haematite was used.

3.3.6. PB5a Aposteltafel

This is a stone bas-relief representing 6 Apostles: Peter, John, Bartholomew, James, Simon and Judah (Figure 3.20). The stone used for this piece is the Wiesentaler sandstone.

For this stone bas-relief the analyses were carried out with the ARTAX, 26 spectra were acquired. As on PB4, on this bas-relief there are visible traces of polychromy solely in cavities or pleats inaccessible to the ARTAX. Thus the selection of the measured points was done under the use of the UV-light hand lamp on accessible high fluorescent zones.

Four samples were taken from rests of polychromy located in very deep areas, to realise cross sections.

3.3.6.1 Results of the non-destructive analysis

Each spectrum was interpreted by comparison to a spectrum taken on the Wiesentaler reference stone (spectrum 5).

In 19 of the 26 measured points, Ca and Fe were detected. Cu or/and S and sometimes Pb were present in some spectra (Figure 3.20). In 7 of 26 measured points only the elements present in the stone matrix were detected. With those results, a palette of colours could not be defined.

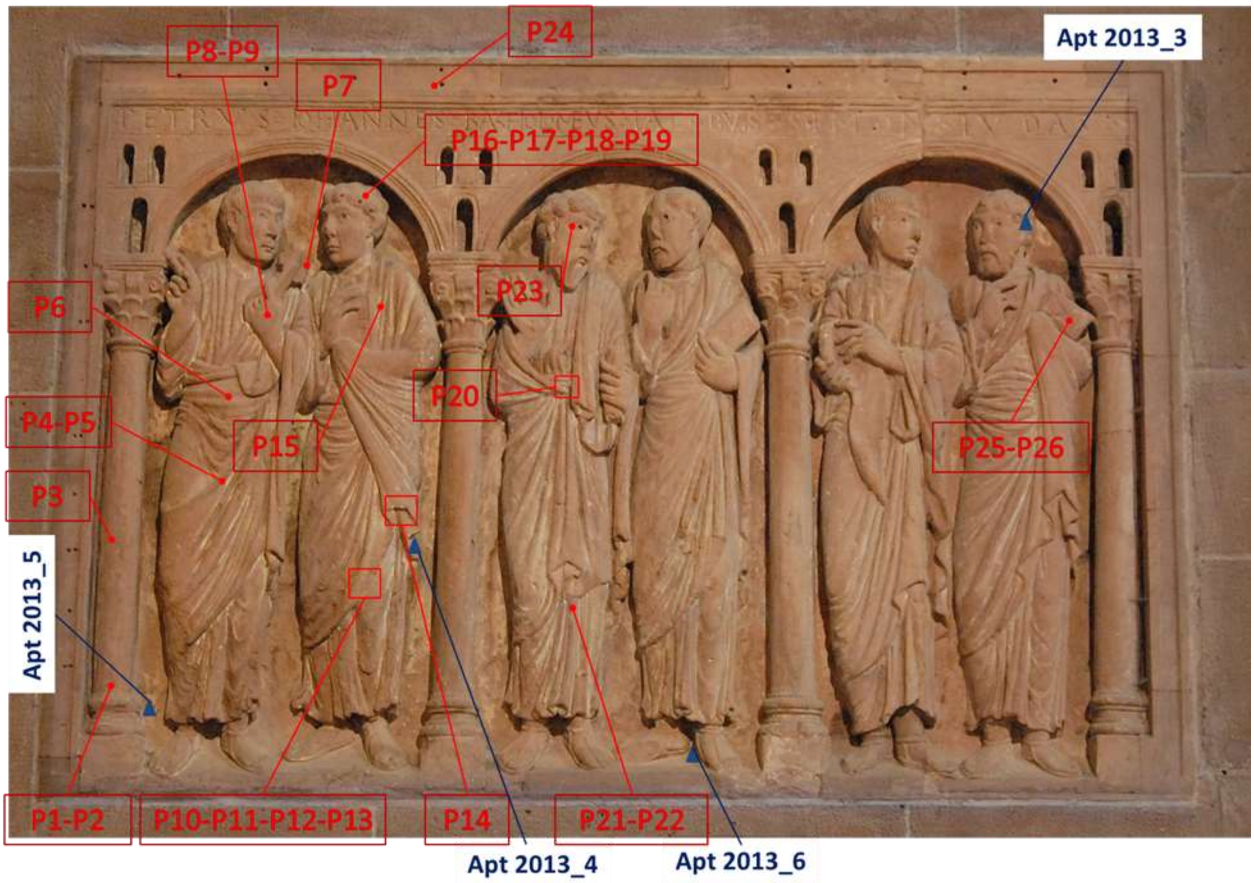


Figure 3.20: Localisation of XRF analyses and cross sections on object PB5

3.3.6.2 Results on complimentary study on cross sections

In order get more information about a former polychromy four samples were taken (Figure 3.20) on deep cavities. A first one on the left side of the hair of apostle Judah "MUApTf P3", a second one in a pleat on the left part of the tunic of apostle John "MUApTf P4", a third at the bottom between the base of the first right column and apostle Peter "MUApTf P5", and a last one between the feet of apostle James "MUApTf P6".

For the three cross sections, "MUApTf P3", "MUApTf P4" and "MUApTf P6" it was possible to detect the presence of a single layer mainly composed of gypsum directly applied on the stone (Figure 3.21).

Figure 3.21: Cross sections "MUApTf P3" (left), "MUApTf P4" (middle) and "MUApTf P6" (right), visible light

For the cross section “MUApTf P5” (Figure 3.22), two layers were found. The first one was directly applied on the stone and is mainly composed of gypsum, a second one, a very thin red layer, composed of haematite.

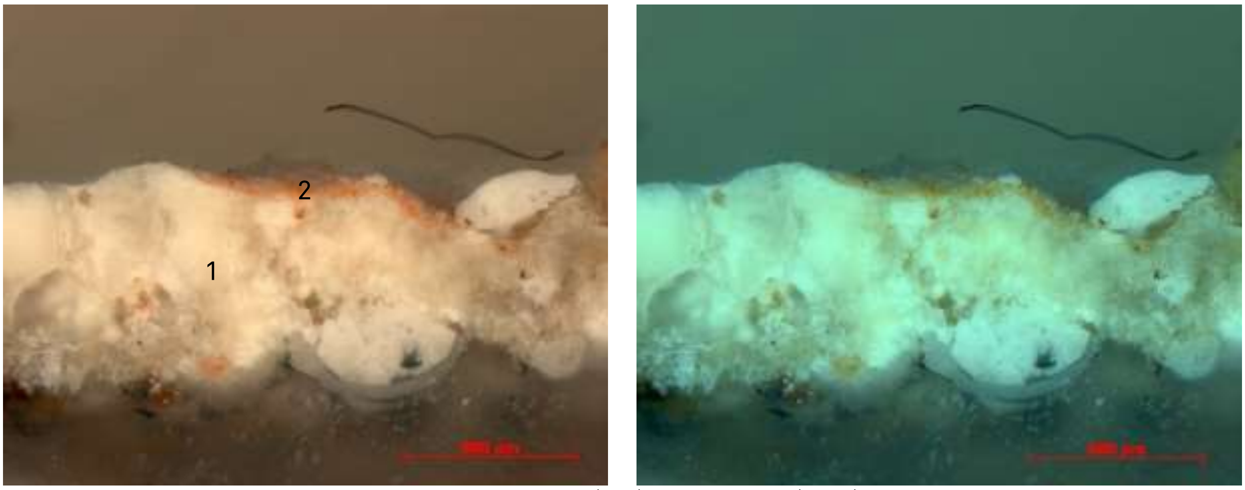


Figure 3.22: Cross section ”MUApTf P5” under visible (left) and UV-light (right).

3.3.6.3 Conclusion/discussion

Based on the evidence of the systematic presence of Ca and Fe (in excess compared to the raw stone), S and more rarely Pb, and sometimes Cu, and the observation of high fluorescence under UV light, it is possible to conclude about the existence of a former polychromy.

The polychromy was paint on a gypsum rich base coat applied directly on the stone, as also confirmed by the analyses of the cross sections. The presence of a red layer made of haematite was also confirmed, but it is not clear if it comes from a localised layer (as suggested by the fact that it is present in only one cross section out of four) and/or a generalised one suggested by the presence of Fe in each spectrum). Green and/or blue colours were also used on this bas-relief as suggested by the presence of Cu.

Finally, these analyses highlight some similarities between PB4 and PB5 as in both cases a gypsum rich base coat was used.

3.3.7. PB6 Baumeistertafel

This is a bas relief composed by two different parts made of Molasse sandstone (above) and Early Triassic sandstone (below).

For this stone bas-relief the analyses were carried out with the ARTAX precisely, 16 spectra were acquired. Some spectra were acquired on tiny rest of polychromy, but the majority was chosen according to UV light fluorescence.

Three samples were taken from rests of polychromy, inaccessible with the XRF, to realise cross sections.

3.3.7.1 Results of the non-destructive analysis

As this object is made of two different stones for which no reference stones exist, reference spectra were taken directly on the object. For this, areas with no evident polychromy were chosen. Unfortunately, the reference spectra from the lower part of the bas relief contain high amounts of Fe which made it impossible to conclude about the presence of this element in the other spectra.

In 7 of the 16 measured points (Figure 3.23), where thin and tiny rests of polychromy were visible, Ca, Fe and Pb were detected. Only for the red parts where an excess of Fe was detected it can be concluded that iron oxide pigments were used. In the other 11 measured points only Ca could be detected. No clear conclusion could be dressed for Fe in zone with no visible paint layers.

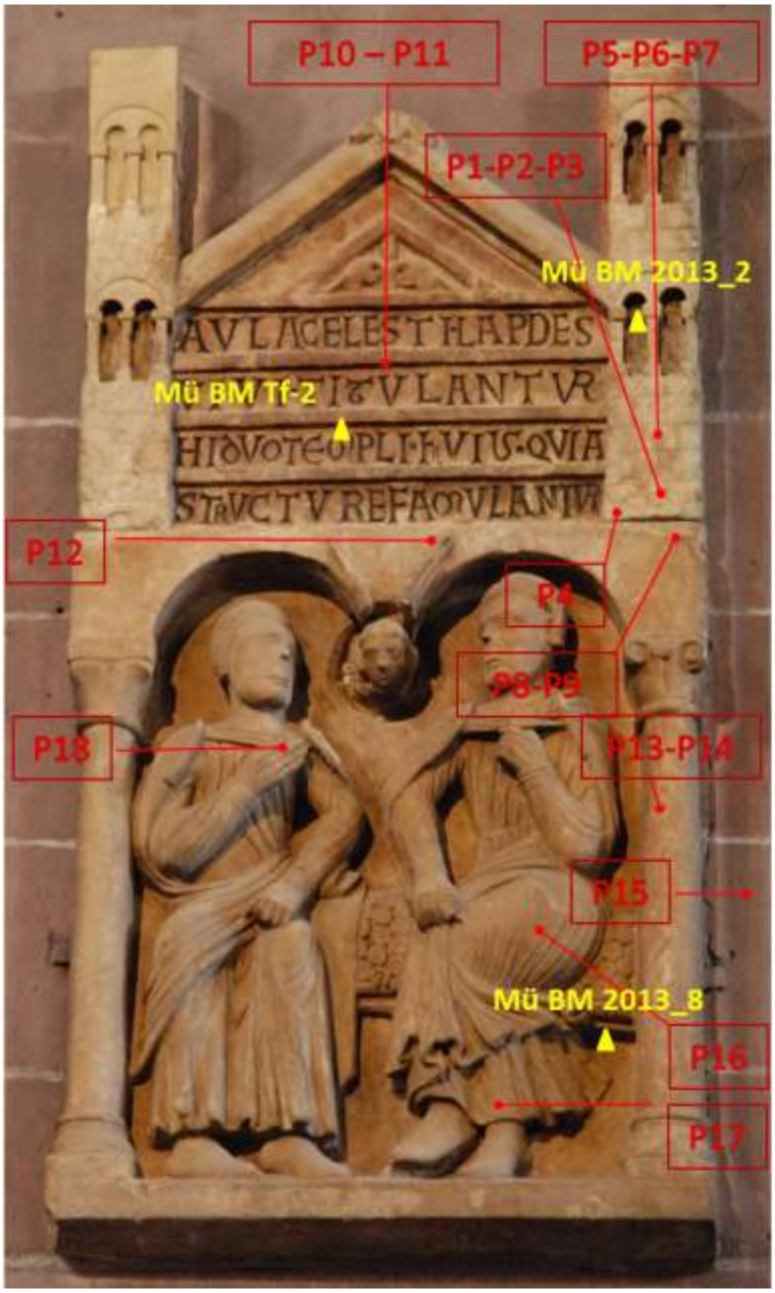


Figure 3.23: Localisation of XRF analyses on object PB5 and sampling for cross sections

3.3.7.2 Results on complimentary study on cross sections

Due to the scarcity of information arising from XRF data, a sampling of obvious rests of polychromy was undertaken. Three samples were taken, from the upper part in the middle of inscription “Mü BM Tf P2”, from the lower part, right edge of the bench “Mü BM 2013 P8” and from the upper part, left tower lower window “Mü BM 2013 P2” (Figures 3.23).

For the cross section “Mü BM Tf P2”, three layers were found (Figures 3.24). The first layer, pinkish and only partially present, is mainly composed of lead white and haematite. The second layer, white and homogeneous, consists of calcite. The third layer, deep red, consists mainly of haematite with lesser quantities of calcite and gypsum.

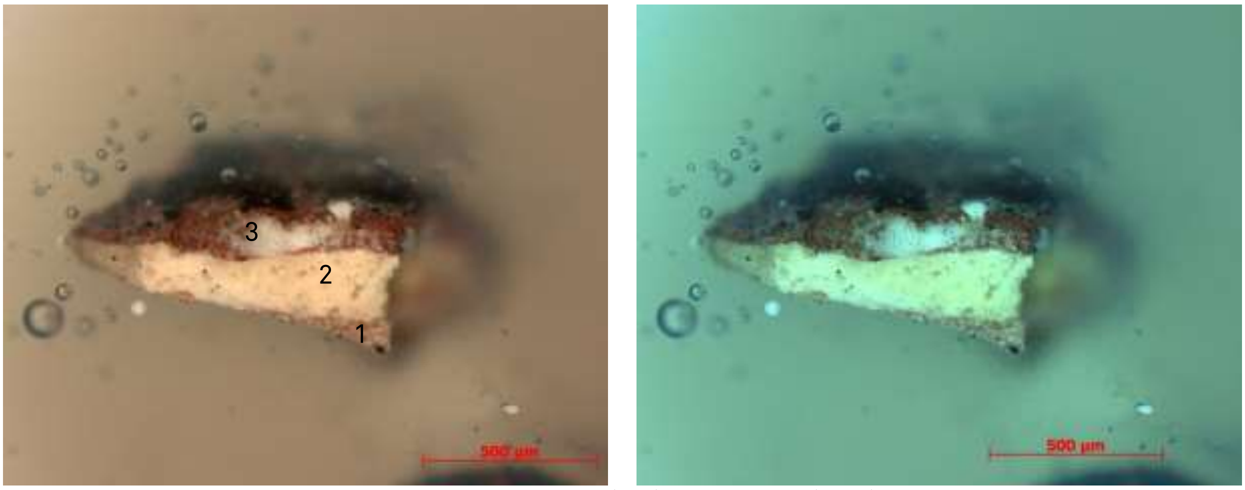


Figure 3.24: Cross section ”Mü BM Tf P2” under visible (left) and UV-light (right).

For the cross section “Mü BM 2013 P8” four layers were found (Figures 3.25),. The first, white and black, is mainly composed of calcite, gypsum and black carbon. The second layer, deep red and thick, consists of haematite. The third layer, white and homogeneous, is composed of calcite. The fourth layer, deep red and thin consists mainly of haematite.

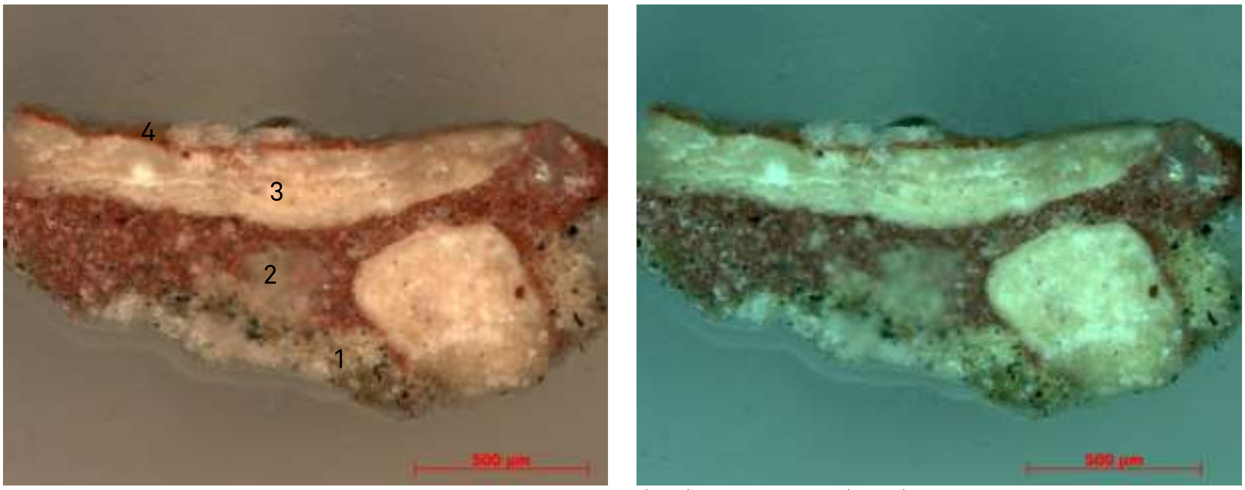


Figure 3.25: Cross section "Mü BM 2013 P8" under visible (left) and UV-light (right).

For the cross section "Mü BM 2013 P2", seven layers were found (Figures 3.26). The first, black and partially present, is mainly composed of black carbon. The second layer, deep red and thick, consists of haematite. The third layer, pinkish with white grains, is composed of haematite and white lead. The fourth layer, deep red and thin consists mainly of haematite. The fifth layer which could not be investigated (due to high fluorescence) with Raman spectroscopy and is clearly visible under UV light could be an organic layer. The sixth layer, white and homogeneous, is composed of calcite. The seventh layer, thin and deep red, consists of haematite with probably calcite (due to the thinness of the layer, calcite could also derive from the sixth layer). The eighth layer, black and partially present contains mainly black carbon and gypsum.

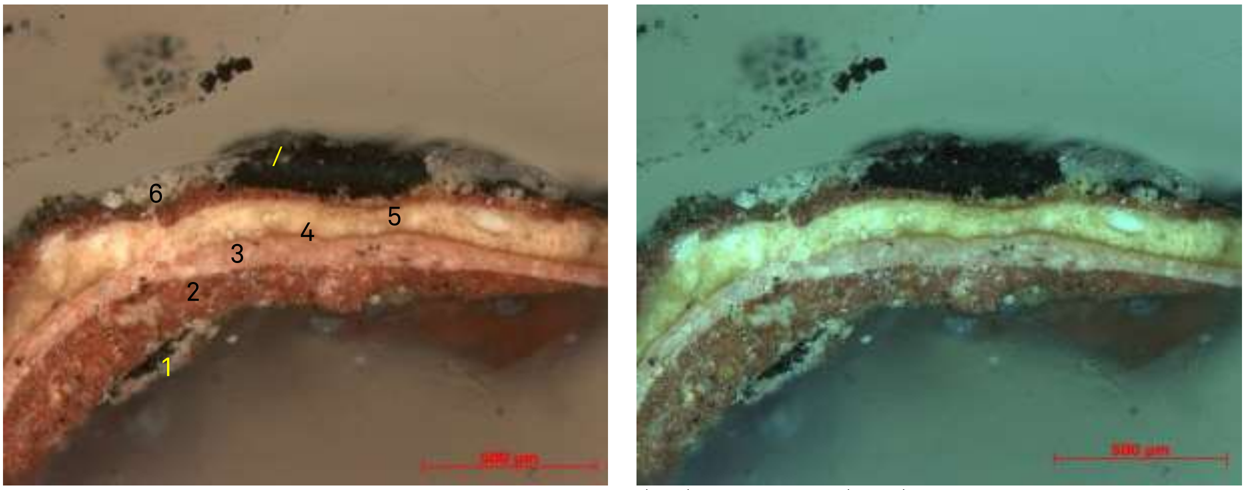


Figure 3.26: Cross section "Mü BM 2013 P2" under visible (left) and UV-light (right).

3.3.7.3 Conclusion/discussion

Based on the evidence of the systematic presence of Ca, Fe and Pb on the bas-relief, on the tiny red remains of the painted part and on the observation of high fluorescence under UV light, the existence of at least one or even several former polychromy(ies) can be affirmed. A palette of colours could not be defined except for the use of haematite.

The stratigraphy on three cross sections is in each case different. The first layer, which could be identified as a ground layer in the cross section “Mü BM 2013 P8”, is made of calcite mixed with gypsum and black carbon. The two other cross section, show a pinkish first layer made of haematite and lead white in the case of the cross section “Mü BM Tf P2” and a partially black (black carbon) or deep red haematite for the cross section “Mü BM 2013 P2”.

The two last cross sections have the same sequence of three layers, pinkish (haematite and lead white), white (calcite) and deep red (haematite). The two samples belong to the upper part of the bas-relief which was built of Molasse sandstone (). The sample of the cross section “Mü BM 2013 P8” was taken from the lower part of the bas-relief which was made of early Triassic sandstone. In order to unify the polychromy of the bas relief, it could be possible that different ground layers were applied to get a chromatic harmony. This hypothesis could justify the differences observed between the cross sections from the upper part and this from the lower part of the bas-relief.

The last layers of both cross sections “Mü BM 2013 P8” and “Mü BM Tf P2” and partially of cross section “Mü BM 2013 P2” are similar and composed of haematite with lesser quantities of calcite and gypsum. This last layer could have been applied during the Reformation time.

This hypothesis suggests the existence of at least two polychromies, a first partially present and a second layer made of haematite. This reasoning could also include the white layer made of calcite. During the Reformation the bas–relief with remains of polychromy could have been covered with a new polychromy, made of first a ground layer based mainly of calcite and a haematite layer on top.

3.3.8. PB7a Schlussstein Männerkopf, Inneres Südseitenschiff

This is one of the keystones of the inner southern aisle of the Münster. This is a coloured bas relief, representing a man’s head, sculpted into Wiesentaler sandstone.

The analyses were carried out with the handheld XRF (Niton XLt). Precisely, seven spectra were acquired. The selection of the measured points was done in order to analyse each colour present on the keystone.

No sample was taken for cross section.

3.3.8.1 Results of the non-destructive analysis

The elemental composition of each spectrum was evaluated taken as reference a spectrum taken on a Wiesentaler block (sp. 18).

The palette of colours includes white, yellow, red, flesh tones, blue, green, brown and black (Figure 3.27). The white present in the eyes could not be analysed, due to the lack of a plane surface.

The yellow tone on the architectural element presents an excess of Pb with in lesser quantities of Hg and Cr. The flesh tone present on the face is composed mainly of Pb with Hg and S. On the cheek more Hg was analysed as on the forehead. The red tone analysed on the architectural elements presents an excess of Hg with S and Pb. The blue and green tones are both rich in Pb with in lesser quantities of Cr and Hg only for the green colour. Therefore, the green tone could have been obtained by mixing yellow and blue. The brown tone is mainly composed of Hg with lesser quantities of Pb, Fe and S.

Figure 3.27: Localisation of XRF analyses on object PB7

3.3.8.2 Conclusion/discussion

According to the results, the following hypothesis on the stratigraphy of this keystone can be formulated.

Based on the fact that Pb is detected in all spectra, it could be inferred that there is a ground layer made of Pb. The yellow part is composed of chrome yellow and cinnabar. The flesh tones should be a mixture of lead white and cinnabar. The red layer is made of cinnabar. The blue could be made either of organic pigments or of a kind of lazurite, as for organic compounds the main elements are not detectable by XRF and in case of lazurite no differentiation is possible due to the fact that both the stone and the lazurite contain the same elements. The green should be a mixture of yellow and blue. Finally the brown is made of cinnabar and ochre.

Nevertheless, taking into account the observations of Paul Denfeld who observed in 1998/99 the presence of another polychromy (beneath the visible one) in several keystones of the inner southern aisle, it is not possible to exclude that Pb and Hg come from some hidden layers.

3.3.9. PB7b Epitaph Johann Rudolph von Hallwil, Südseitenschiff

This is the epitaph for Johannes Rudolph von Hallwil (1460-1527), provost and curator at the cathedral chapter. In 1527 he was elected to be deputy of the bishop but died before starting this task. The underlying stone is the Wiesentaler sandstone. This object is situated close to the PB7, a keystone with a man's head and it shows the same kind of modern polychromy. From the written sources[5] it is almost sure that epitaphs and keystones were treated the same way. To prove this and to find out more details about the pigment used in PB7a, a sample was taken from the left bottom corner of the epitaph (see Figure 2.11) to realise a cross section.

3.3.9.1 Study on cross section

The cross section shows seven layers (Figure 3.28).

Azurite and lead white were detected in the first layer that is light blue, very thin and partially present on this cross section. Between the first and the second layer, a piece of gold leaf is partially visible (attested by XRF analysis[6]). The second layer, light orange and inhomogeneous, contains red lead, cinnabar and lead white. The third layer, orange is made of a mixture of cinnabar, red lead and perhaps litharge. The fourth layer, due to the high fluorescence, contains certainly mainly binding media with ochre, cinnabar and calcite. The fifth layer, yellow and very thin, is a mixture of cinnabar and chrome yellow. The two last layers are mainly constituted of lazurite.

[5] 1854, Protokoll des Baukollegiums vom 25. September 1854, Bemalen von Schlusssteinen und Gewölberippen.

[6] The remains of a gold leaf were detected between the first and second layer on the right part.

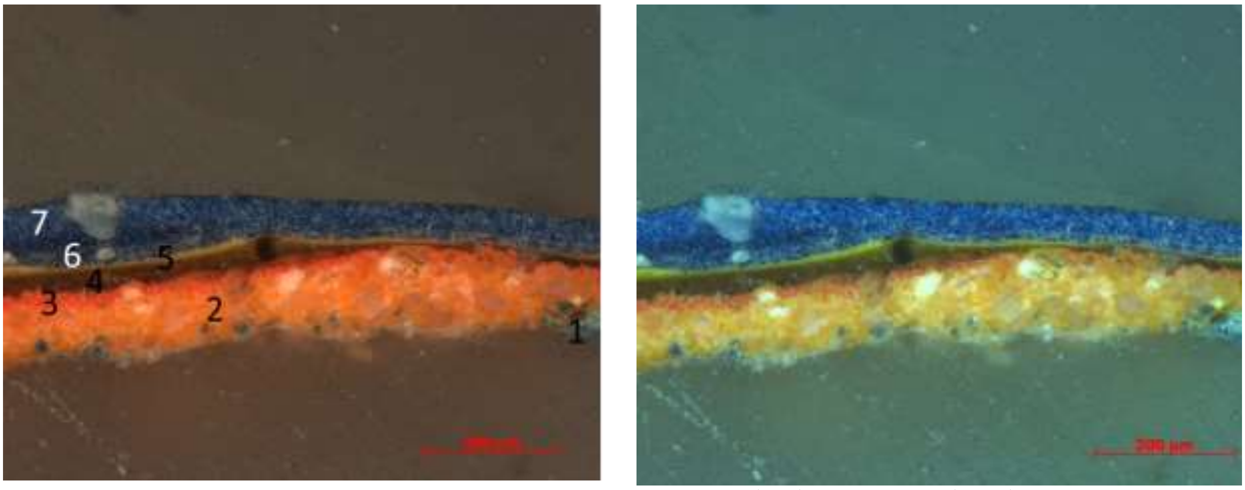


Figure 3.28: Cross section "Epitaph Hallwil 2016 blau" under visible (left) and UV light (right).

3.3.9.3 Conclusion/discussion

Due to the stylistic similarity between PB7a and PB7b, it is possible to take into account the results of this cross section to better understand the polychromy on the keystone PB7a. In particular it is now possible to suggest that the blue on PB7a is probably made of lazurite, or more precisely of its synthetic form called ultramarine (Bell at al., 1997; Plesters, 1993[7]). This cross section also shows the use of chrome yellow in association with mercury on the same painted layer. Finally, the presence of two Pb containing pigments (red lead and lead white) in the ground layer of the cross section supports the hypothesis of a lead rich base coat also for PB7a.

3.3.10. PB8 Schlussstein Blattgesicht, Äusseres Südseitenschiff

This is one of the keystones of the outer southern aisle of the Münster, located next to PB7a. This is a coloured bas-relief representing a leaf-framed face sculpted into Wiesentaler sandstone.

Due to the position of this keystone analyses were carried out with the handheld XRF (Niton XLt). Precisely eight spectra were acquired. The selection of the measured points was done in order to analyse each colour present on the keystone. Also, because analysis must be done on a flat surface, the spectra were all taken at the base of keystone (Figure 3.29) behind the mask. Furthermore, this choice is due to the ideaOne sample was taken for cross section "PB8 Blattgesicht 1", Figure 3.30) in a black area on the side of the keystone.

3.3.10.1 Results of the non-destructive analysis

[7] In "Artists' Pigments, a handbook of their history and characteristics", vol 2.

The elemental composition of each spectrum was evaluated in comparison to two spectra taken as reference on a Wiesentaler block (sp 246 and sp 18).

Although the palette of colours includes white, yellow, red, flesh tones, gold, green, brown and black, only colours present on the side of the keystone (red, yellow, green and black) could be analysed because the analyses had to be carried out on a flat surface.

The yellow tone on the architectural element presents an excess of Pb with lesser quantities of Hg, Zn and Cr. Rof Zn and Pb. The green tone is rich in Pb with lesser quantities of Zn and Cr. The elemental composition of the black tone is similar to the one of the yellow tone.

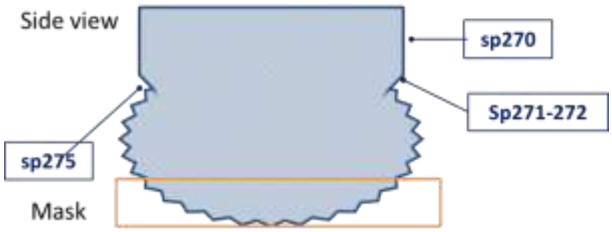


Figure 3.29: Localisation of XRF analyses on front and sampling for cross section (left) and side (right) of the object PB8

3.3.10.2 Results on complimentary study on one cross section

In order to characterise the green layer, a sample was taken for a cross section "PB8 Blattgesicht P1" which shows five layers (Figure 3.30).

Raman analyses indicate a mixture of haematite and cinnabar with calcite and gypsum in the first layer which is light orange, very thin and partially present on this cross section. The second layer, due to its high fluorescence contains certainly mainly binding media. The third layer, light green is made of chrome yellow, Prussian blue[8] and a little amount of lead white. The fourth layer is quite similar to the third; it contains chrome yellow, Prussian blue and lead sulphate (Kühn and Curran, 1986[9]). The analysis performed on the very thin and partially present fifth layer gave no conclusive spectrum.

[8] The mixture chrome yellow and Prussian blue it also known under the name of Chrome green (Kühn and Curran, 1986)

[9] In "Artists' Pigments, a handbook of their history and characteristics", vol. 1.

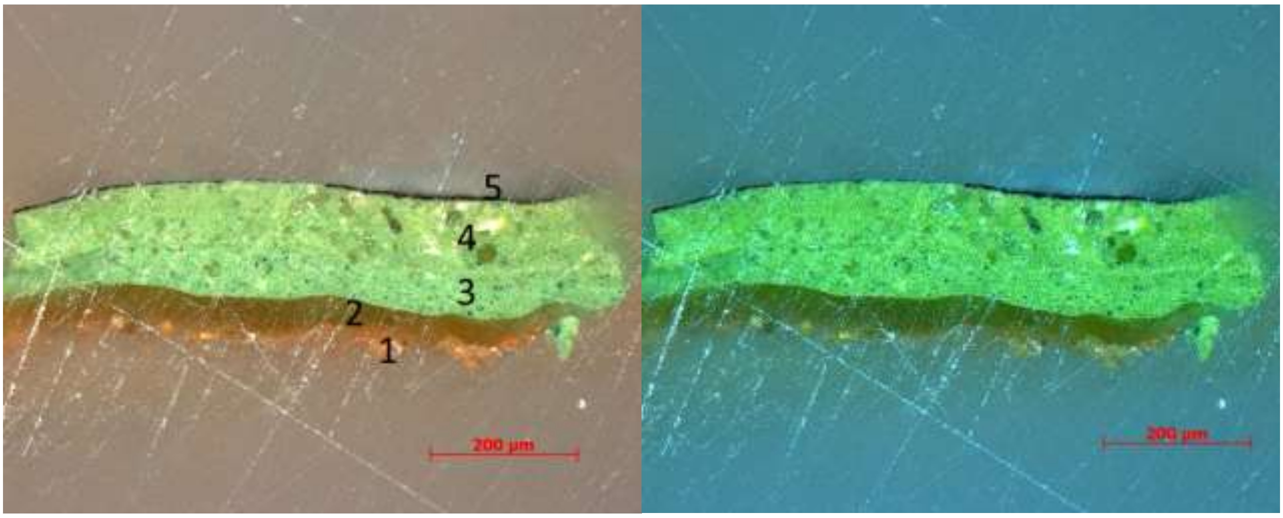


Figure 3.30: Cross section”PB8 Blattgesicht P1” under visible (left) and UV light (right).

3.3.10.3 Conclusion/discussion

According to the results, the following hypothesis on the stratigraphy of this keystone is formulated.

Based on the fact that Pb is detected in all spectra, it could be inferred that there is a ground layer made of Pb.

The yellow part is composed of chrome yellow and cinnabar as for PB7a and b. The red layer is made of cinnabar. The green is a mixture of chrome yellow and Prussian blue. Finally the black which is applied on the yellow should be made of black carbon.

The presence of an organic layer in the cross section which can be considered as a “imprimatur” suggests the possibility of another polychromy beneath the visible one. The presence of a thin discontinuous red layer made of haematite, cinnabar, with grains of calcite and gypsum beneath the “imprimatur” confirmed this hypothesis.

During the restoration campaign of 1998/99 managed by Paul Denfeld, the presence of a probable post-reformatory monochrome red layer was not observed but the presence of a light red thin layer. The absence of the post-reformatory red layer and the existence of the light red layer are confirmed by the cross section “PB8 Blattgesicht P1”.

The presence of chrome yellow and Prussian blue indicates a late polychromy after 1818. This fact is corroborated by the working report from 1854 about repaint of keystones and ribs in the cathedral (StABS Protokolle H 4.5, p 190).

3.3.11. PB9 Anna Grab, Hochchor

This is the funerary monument of Anna von Habsburg (around 1225-1281), wife of Rudolf von Habsburg, and her son Karl. It is a monumental ensemble composed of a tomb with a horizontal slab with two sculptures representing the queen and her son (Figure 3.31). All around the tomb several coats of arms are present (Figure 3.36). The entire ensemble is made of fine Wiesentaler sandstone. On photos of the 19th century there are traces of two painted angels visible in the upper part of the slab in the two corners on both sides of the arches.

The analytical study of the funerary monument was divided in two parts, first the slab and second the tomb with the four coats of arms.

3.3.11.1 Results of the non-destructive analysis on the slab

Nine analyses on different positions were performed on the slab where only traces of Pb, Ca and S were detected (Figure 3.31).

On the two figures and on the pinnacle ornaments, traces of polychromies are visible. The visible palette contains white, red and green.

The white present on the right pinnacle of the gravestone contains mainly Ca and S. The red tones on Anna's pillow and her hand have different compositions. The red parts of the pillow consist mainly of Pb, Hg, Ca and S, whereas the red tone noticed on the hands of Queen Anna consists mainly of Fe, Ca and S. The analyses of green tones were performed on both pillows. The green tones contain Pb Cu, Ca and S. On the pillow of Prince Karl more Pb was detected than on the pillow of Anna von Habsburg.

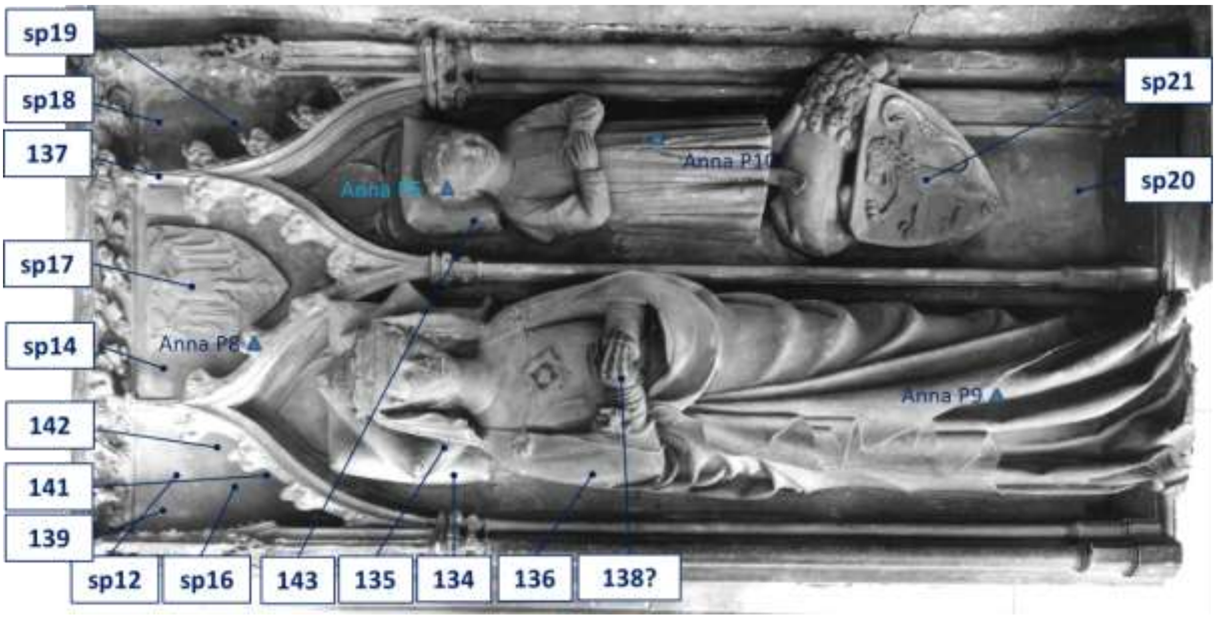


Figure 3.31: General view of the tomb slab with the localisation of XRF analyses and sampling for cross section of the object PB9 (photo credits: Erick Schmidt)

3.3.11.2 Results on complimentary study on cross sections on the slab

Due to the inaccessibility of this polychromy part for the ARTAX, four samples were taken in order to study the polychromy on the slab (Figure 3.31). The sample for the cross section “Anna P5” was taken where traces of white and yellow in the pleats of the hair of Prince Karl were visible. The cross section “Anna P8” was prepared with a sample taken from the floral ornament of the pinnacle, above the head of Anna von Habsburg. Two samples from the red dresses of Anna von Habsburg and Prince Karl were taken and two cross sections were prepared respectively, “Anna P9” and “Anna P10”. All cross sections were investigated by Raman spectroscopy and the cross section “Anna P5” was also analysed by FTIR.

The cross section “Anna P5” shows three layers. The three layers are similar and are mainly composed of white lead with some iron oxide grains (Figure 3.32). FTIR in reflexion was performed on the three layers and dried oil was detected. No “separation” layer between the three layers is noticeable like for example a “dirt” layer.

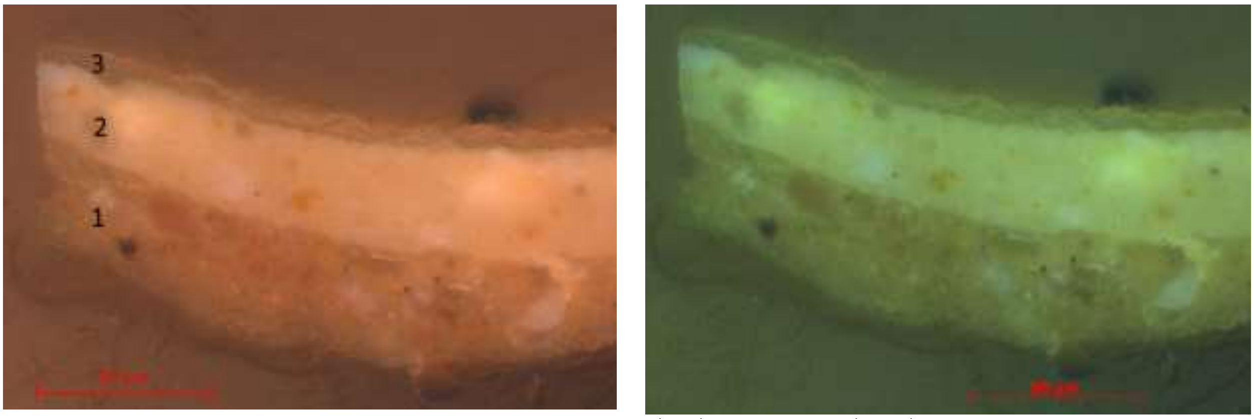


Figure 3.32: Stratigraphy of sample “Anna-P5” visible light (left) and UV light (right)

The cross section “Anna P8” presents a single layer made of haematite, calcite and dolomite (Figure 3.33).

The dresses of Anna von Habsburg and Prince Karl were also investigated. Both cross sections “Anna P9” (Figure 3.34) and “Anna P10” (Figure 3.35) consist of a single homogeneous layer with haematite, dolomite and with traces of gypsum and calcite.

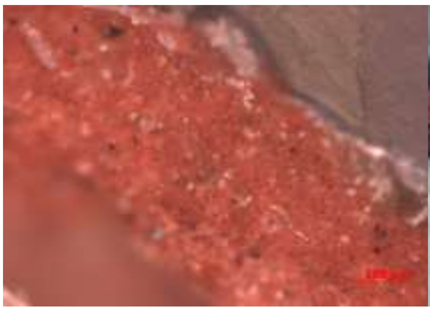


Figure 3.33: Stratigraphy of sample Anna-P8, visible light

Figure 3.34: Stratigraphy of sample Anna-P9, visible light

Figure 3.35: Stratigraphy of sample Anna-P10, visible light

3.3.11.3 Conclusion/discussion on the slab

According to the results obtained by in-situ XRF measurements and the study of the cross sections, the following hypothesis could be proposed.

Due to the detection of Pb, Ca and S on the slab confirm the presence of a at least a polychromy which possibly covered the all slab. This consists probably of a first layer of gypsum,. The presence of lead on the slab could be explained by the previous existence of painted figures, as the angels previously mentioned.

Based on the analysis of the remains of polychromy, a hypothesis can be proposed for the red and green painted colours. There should be two different red layers, one on the pillow of Anna von Habsburg made of cinnabar and lead pigment. It could be first a white lead ground layer or cinnabar mixed with white lead or with lead oxide. The second detected red layer, discovered on the hand of Anna von Habsburg, consists mainly on iron oxide. The green paint layers on both pillows should be made of green copper pigments.

The cross section Anna P5 shows that the hair of Karl was painted. The presence of the three similar paint layers could be explained as a succession built in order to give an optical effect of deepness and relief to the hair As there is no “dirt” layer between each layer, this may indicate that they all belong to the same polychromy. Furthermore, the cross section shows that the three layers were worked “wet on wet” probably in order to highlight the hair of Prince Karl.

The last three cross sections, Anna P9 and Anna P10 from both dresses and Anna P8 from the pinnacle are similar in their composition; they consist of haematite with dolomite and calcite. This could be an indication of a red layer uniformly applied during the Reformation, a second polychromy.

3.3.11.4 Results of the non-destructive analysis on the tomb

In Figure 3.36, the measurement positions as well as the sampling sites for the tomb are shown. At first, position Sp119 was used as a reference, assuming that the stone in this position was “naked” and would not have any traces of polychromy. Nevertheless, Ca and S were detected in excess compared to the spectrum from the reference stone. Therefore all acquired spectra were compared to the Wiesentäler reference spectra.

Four coats of arms were analysed, Löwenstein (first from the left, in Figure 3.36), Austrian Bindenschild (second from the left), Reichsadler (third form the left) and Steier (first from the right).

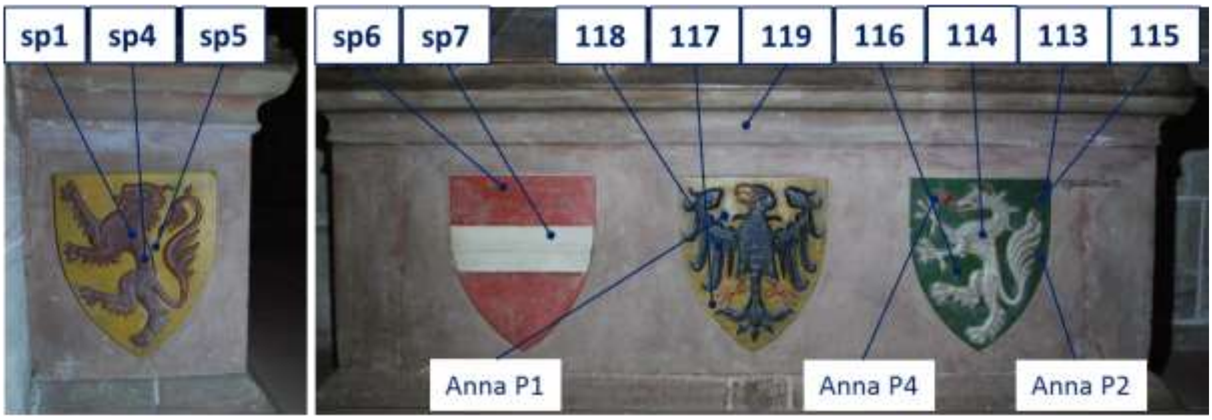


Figure 3.36: General view of the gravestone with the localisation of XRF analysis and sampling for cross section of the object PB9

On the “Löwenstein” coat of arms, three analyses were performed; two analyses on the red painted lion, where Pb and Hg with some traces of Zn and Ba were detected, and one analysis of the yellow layer of the background, which shows mainly the presence of Pb, Zn, Cr and Sn with traces of Hg.

On the “Bindenschild” coat of arms, the red and the white were analysed. On the red tone mainly Pb, Hg and S with traces of Sn were detected. The white consists of Pb and Zn with probably traces of Sn.

On the “Reichsadler” coat of arms, the yellow and black paint layers were analysed. The yellow consists mainly of Pb with Zn, Hg and traces of Cr whereas on the black layer mainly Pb (less than on the yellow) with Ca were detected.

The two dominant colour tones on the “Steier” coat of arms were analysed, which are green and white. The white tone on the animal figure is mainly composed of Pb and Zn. As the green painted surface of the coat of arms presented different levels, which could have been an indication of different polychromies, analyses were performed on three positions. Nonetheless, in each of the three measurements, the same elements Pb, Cu, Ba, S, and traces of Cr were detected.

3.3.11.5 Results on complimentary study on cross sections of the tomb

Three samples were taken from the front of the tomb in order to study the polychromy; one sample on the “Reichsadler” “Anna P1”, Figure 3.36) and two on the “Steier” coats of arms “Anna P2” and “Anna P4”, Figure 3.36).

The cross section “Anna P1” of the yellow painted part on the Reichsadler is composed of six layers (Figure 3.37). The first layer is white and made of lead white and calcite with traces of gypsum. The second layer, which is yellow, is composed of lead tin yellow and lead white. In the third layer, which is yellow, only lead white could be identified. Another pigment could not be characterised, but seems to be a lead compound probably massicot (Raman peaks at 107, 468 and 830 cm^{-1}). The fourth layer, which is thin and yellow, is a mixture of chrome yellow, traces of lead white and probably vermillion. In the fifth layer only chrome yellow was characterised. Due to the extreme thinness of this layer, it cannot be excluded that the chrome yellow signal was coming from the upper or below layers. The last layer, which is yellow, contains chrome yellow and vermillion. The cross section shows between layer 2 and 3 and also between 3 and 4 a layer of “dirt”, which indicates that they belong to chronological different polychromies. The results of the analyses of this cross section match with the XRF analysis and show that five different yellow layers were applied on the coat of arms at different periods.

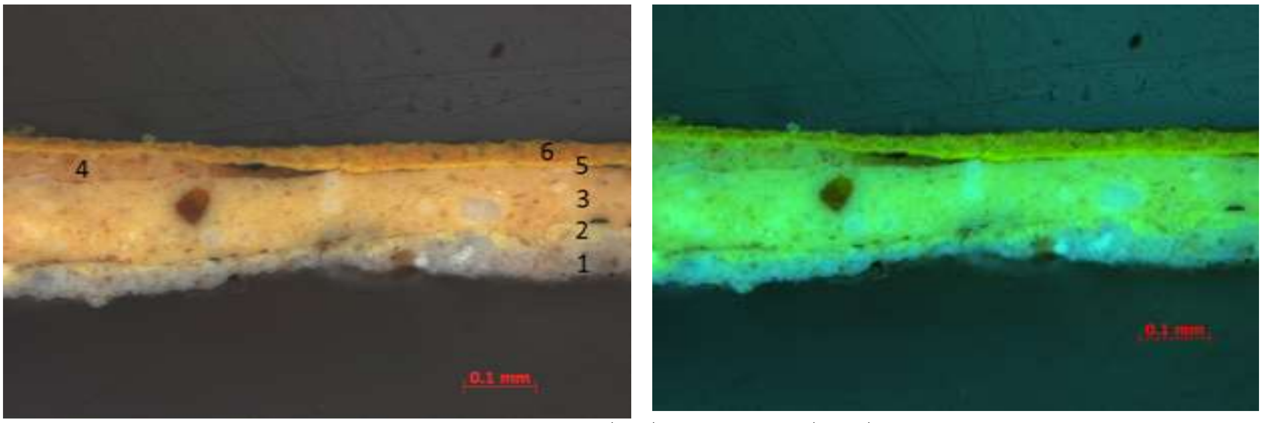


Figure 3.37: Stratigraphy of sample “Anna-P1”, visible (left) and UV-light (right)

The cross section “Anna P2” was prepared in order study the exact stratigraphy of the green part. The cross section is composed of eight layers (Figure 3.38). The first, inhomogeneous and light grey; layer is composed of barite, calcite and some traces of gypsum. The second layer, white with some bigger grains, is made of lead white, calcite and traces of gypsum. The third layer, which is green with rare blue grains, is mainly composed of malachite with few grains of blue copper compounds (not precisely characterised). The fourth layer which is thin, light grey and partially present in this cross section could not be characterised due to high fluorescence. The fifth layer, white, is mainly composed of white lead. The sixth layer, green, is made of malachite, lead white and some grains of lead red. The seventh layer, white and homogeneous is made of lead white. The last green layer is composed of lead white, chrome green and probably some grains of barite.

These results match with the XRF analyses performed on this green paint layer.

The stratigraphy of these eight paint layers lead to the indication that three different polychromies were applied on the coat of arms. Each polychromy composed of a succession of white and green layers.

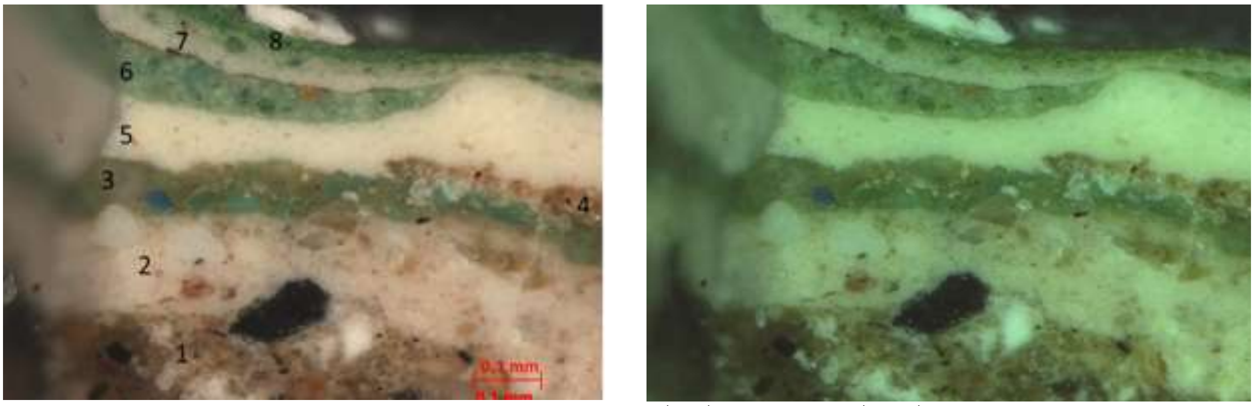


Figure 3.38: Stratigraphy of sample "Anna-P2", visible light (left) and UV light (right)

The sample "Anna P4" was taken from a zone astride the red part of the tongue of the animal and the green ground layer of the coat of arms. Three layers are visible (Figure 3.39)

The first layer, green and inhomogeneous, is composed of lead white and an unidentified copper mineral. The second layer consists mainly of this unidentified copper mineral. The red layer is a mixture of haematite, gypsum and dolomite.

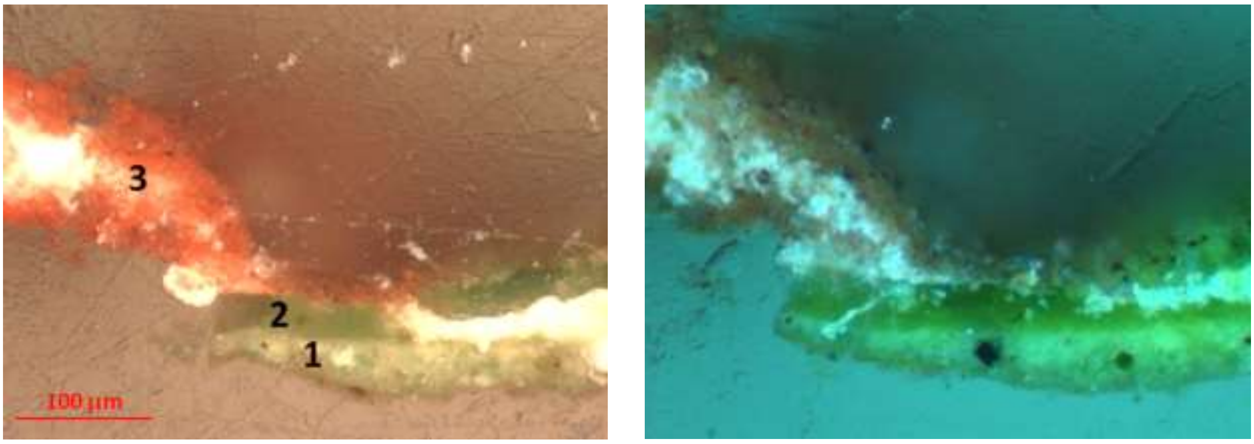


Figure 3.39: Stratigraphy of sample" Anna-P4", visible light (left) and UV light(right)

3.3.11.6 Conclusion/discussion on the tomb

Due to the detection with XRF of Ca and S on the tomb, it can be concluded that at least a layer based on gypsum was applied on the gravestone.

The coats of arms, fixed on the gravestone are all painted. Based on the results obtained by XRF analysis and by the study of the cross section, the following palette of pigments can be suggested.

The white layers are based on lead white, calcite and gypsum. The pigments used for the yellow colour should be lead tin yellow, chrome yellow and massicot. The red tones should be obtained with haematite and/or red ochre, cinnabar and possibly minium.

The green pigments are malachite and chrome green.

Except Pb, no chemical element was detected on the black painted part on the coat of arms of the Reichsadler. The black colour was probably realised by the use of black carbon.

The study of the stratigraphy of the three cross sections shows clearly that several polychromies were applied on the coats of arms. A broad palette of pigments was used and some of them were introduced and used for painting at different times. In the cross section Anna P1, lead tin yellow and chrome yellow are present in separated layers. Their presence demonstrates several polychromies at different periods. Indeed the origin of lead tin yellow is dated to the XIII century (Kühn, 1993[10]) and chrome yellow began to be used widely after 1825 (Kühn and Curran, 1986.)[11]. The same reasoning can be applied to the cross section Anna P3, where malachite is detected in several layers and chrome green which was introduced in the beginning of the XIX century is present in the last layer.

The use of chrome based pigments on the coats of arms demonstrates newly applied polychromies in the XIX century.

3.3.12. PB10 Grabmal Georg von Andlau, Nordquerhaus

This is the funerary monument of Georg von Andlau (around 1390.1466), provost of the cathedral, chapter and first rector of Basel University. It is composed of a horizontal slab underpinned by two pillars (Figure 3.40), and from a vertical coloured epitaph on the wall above (Figure 3.44). On the slab, colours are only partially visible in correspondence the two coats of arm and on the collar of the dog located at the feet of the main figure. The whole ensemble is made of Wiesentaler sandstone.

3.3.12.1 Results of the non-destructive analysis

The Slab

- 31 analyses on different positions were performed with the ARTAX on the slab (Figure 3.40).

[10] In “Artists’ Pigments, a handbook for their history and characteristics”, vol. 2.
[11] In “Artists’ Pigments, a handbook for their history and characteristics”, vol. 1.

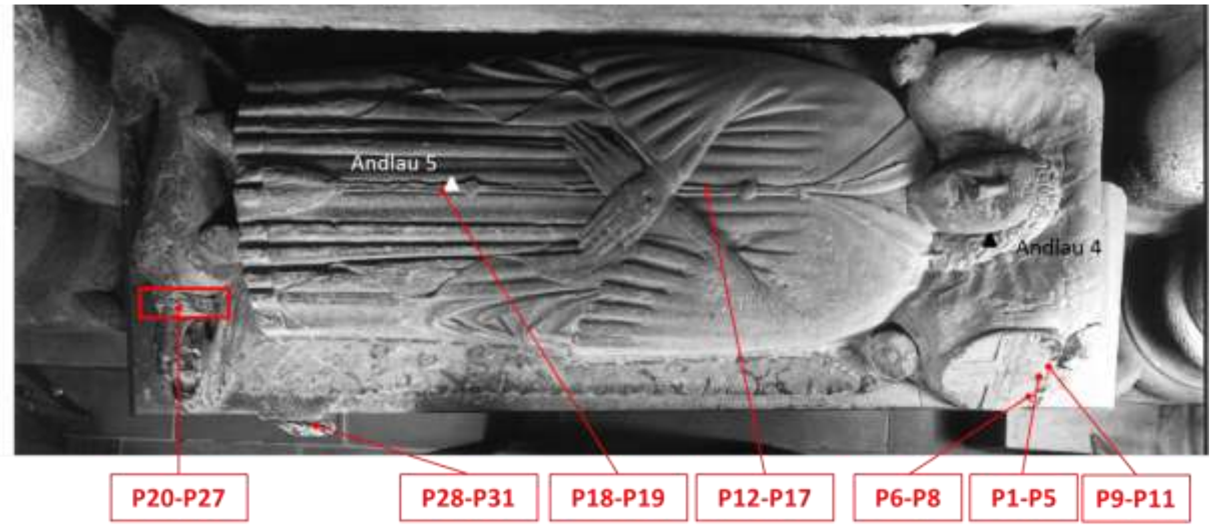


Figure 3.40: General view of the Slab with the localisation of XRF analyses and sampling for cross section of the object PB10 (photo credits: Erik Schmidt)

The reference spectrum used for the evaluation of the acquired spectra was taken on the Wiesentaler stone reference (sp. 5).

On each of the 7 measured points on the figure of G. von Andlau Ca, Fe, and to a lesser quantity some Pb, Cu and Zn were detected.

On the collar of the dog, eight analyses were performed (Figure 3.41).

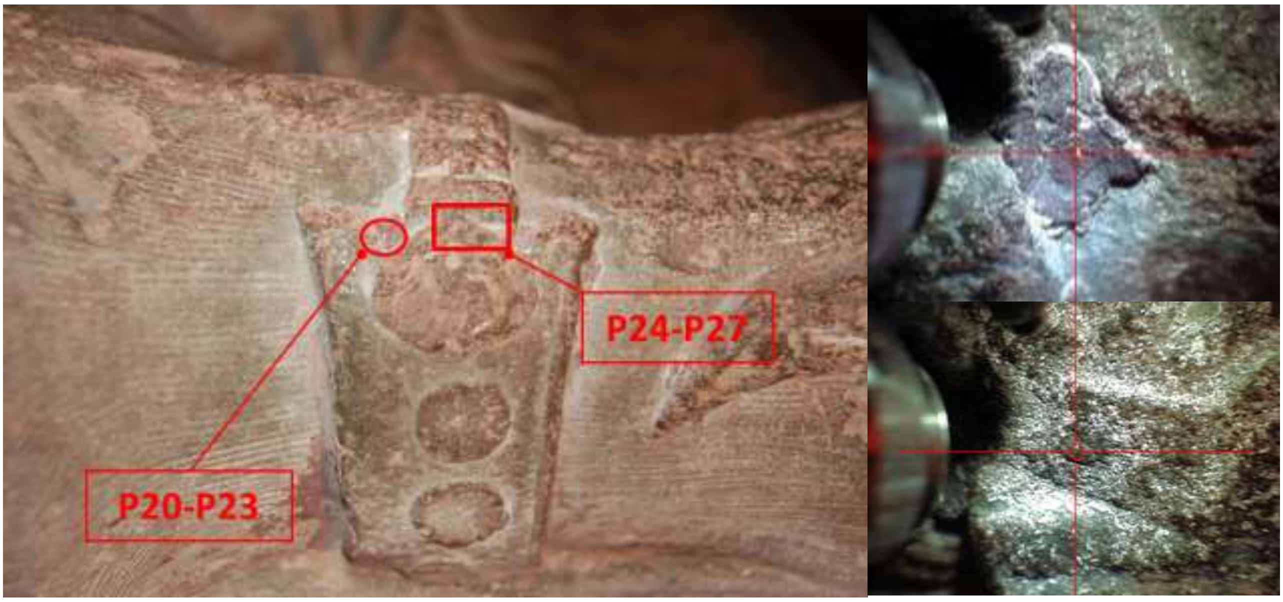


Figure 3.41: View of the collar of the dog with localisation of the XRF analyses and magnification of two of the measurement spots with polychrome traces.

Three layers were visible on a detail of the collar (measured points P20-P23, Figure 3.41 upper right), first a supposed ground layer, second a dark red layer and at last a dark layer. In the ground layer, mainly Ca and in lesser quantities Zn and Pb were detected. The two red layers are composed mainly of Fe with lesser quantities of Ca and Pb.

The other polychrome traces on the collar (measured points P24-P27, Figure 3.41) consist mainly of Ca, Fe and Pb with traces of Cu.
The two coats of arms present polychrome remains. The first is the von Andlau's coat of arms, which is situated on the right side of the slab and the second is the Flachslanden coat of arms on the left front of the slab. Analyses on the Andlau's coat of arms were performed on red and yellow remains of polychromy (Figure 3.42). Three layers were visible on the red traces (measured points P1-P5 and P9-P11 (Figure 3.42): first a supposed white ground layer and a light red layer followed by an intensive red layer. In the ground layer, mainly Ca, Pb and Fe and in lesser quantities Hg were detected. The two red layers consist mainly of the same chemical elements with an excess of Hg and in lesser quantities Pb, Ca and Fe.

Two layers were visible on the yellow traces (measured points P6-P8, Figure 3.42, right): first a yellow layer and then light grey stripes applied on the yellow layer. Analyses show the same chemical composition for both layers; mainly Pb and lesser quantities of Zn, Hg, Cr, Ca; in some spectra traces of Fe and Cu were detected.

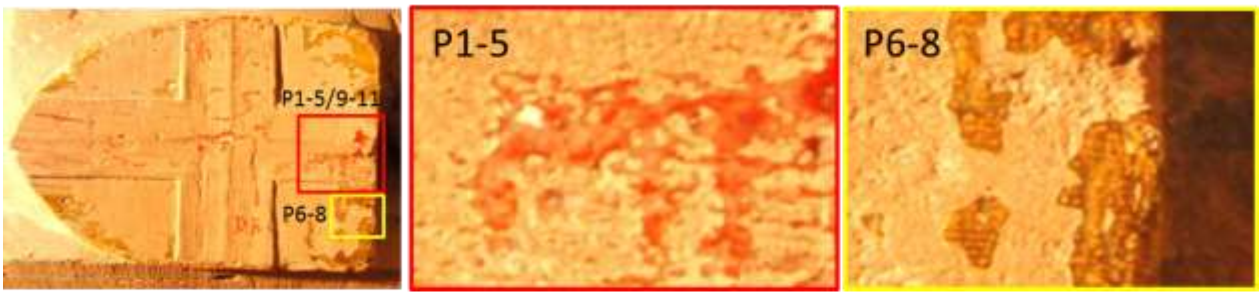


Figure 3.42: View of the right coats of arms with localisation of the XRF analyses and magnification of the measurement with polychrome traces.

Four XRF analyses were performed on the black rests of polychromy on the Flachslanden coat of arms (Figure 3.43). Three layers were visible, first a light green layer, followed by a grey layer and at last a black layer. The light green and the grey layer contain mainly the same chemical elements, an excess of Cu, in lesser quantities Pb, Ca, and traces of Fe. The black layer is mainly composed of Pb and Cu with in lesser quantities of Fe, Zn, Cr, and Ca.

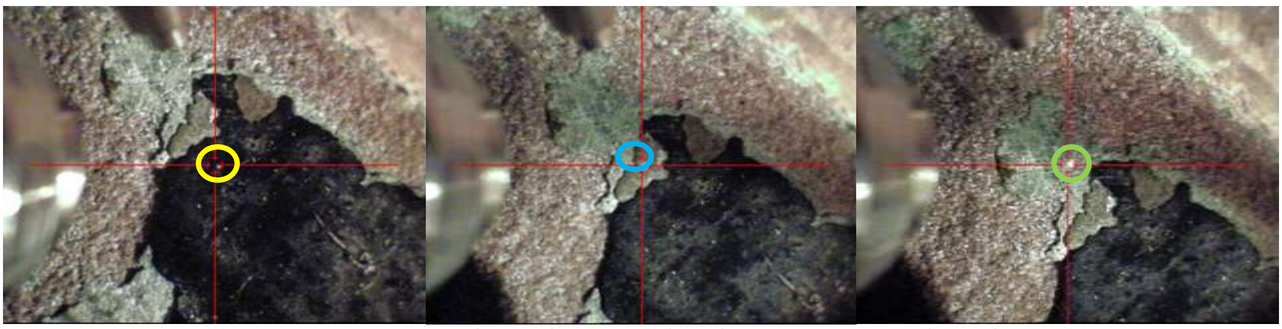


Figure 3.43: Measured points on the black (yellow), the grey (blue) and on the green (green) layers

The vertical polychrome Epitaph

The nine XRF analyses were performed by using the Niton. The reference spectrum used for the evaluation of the acquired spectra was taken on the Wiesentaler sandstone reference (sp. 246).

The polychrome palette of the floral ornament is composed of white, yellow and green (Figure 3.44).

The white tone is composed mainly of Pb with lesser quantities of Zn, Ca and S. The yellow tone is composed of Pb with lesser quantities of Zn, Hg, Ca and S and some traces of Cr. The green tone is mainly composed of Pb and Cu with lesser quantities of Ca and S and traces of Cr.

The two coats of arms were also analysed. On the Andlau's coat of arm, the red and the yellow were analysed (measured points 125-126, Figure 3.44). An excess of Hg and S was detected on the red tone with lesser quantities of Ca and Pb. The yellow tone consists mainly of Pb with traces of Hg and Cr. On the Flachslanden coat of arms, the black and the yellow were analysed (measured points 127-129, Figure 3.44).The black tone is mainly composed of Pb, with lesser quantities of Ca and S. The yellow tone was investigated in two positions, in the upper and in the lower part of the coat of arms. Both parts contain the same chemical elements, mainly Pb and Hg with S and traces of Zn.

Figure 3.44: General view of the vertical polychrome epitaph with the localisation of XRF analyses and sampling for cross section of the object PB10.

3.3.12.2 Results on complimentary study on cross sections

In order get more information about the presence of a former polychromy on the slab and to study the stratigraphy two samples were taken in cavities, the first from a curl of von Andlau's hair "Andlau P4", (Figure 3.40) and the second from his dress "Andlau P5", (Figure 3.40).

On the cross section "Andlau P4", two layers were found (Figure 3.45). The first is mainly composed of calcite with grains of black carbon. The second layer, deep red and inhomogeneous contains haematite and grains of calcite.

On the cross section "Andlau P5", three layers were found (Figure 3.46). The first is mainly composed of gypsum and black carbon. The second layer, deep red, thin and discontinuous consists of haematite. The third layer, light red, is composed of a mixture of haematite and lead white.

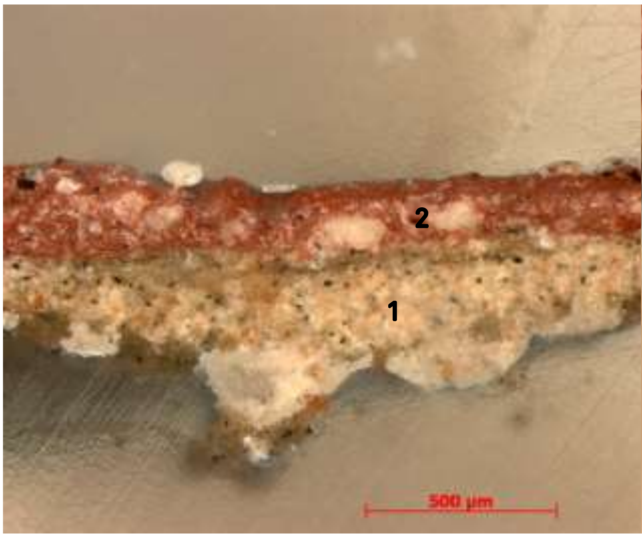


Figure 3.45 : Stratigraphy of sample "Andlau P4", visible light

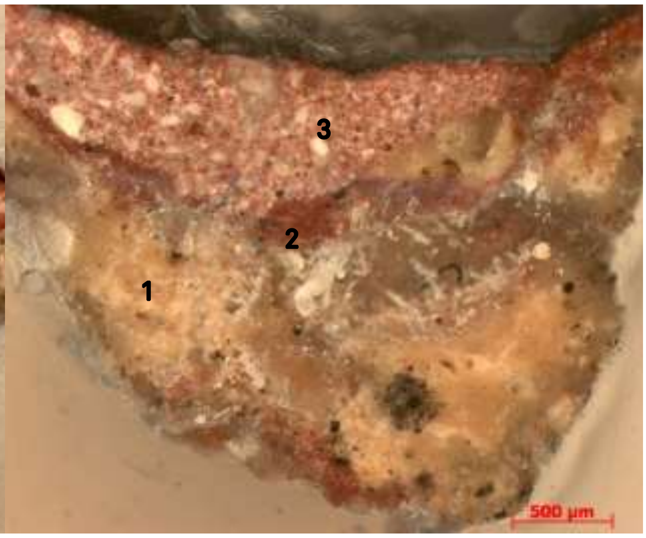


Figure 3.46 : Stratigraphy of sample "Andlau P5", visible light

In order to get more information about the polychromy of the Flachslanden coat of arms, two samples for cross sections were taken. The first sample was taken from the black painted part and the second from the yellow painted part, below the black diagonal stripe (Figure 3.47)

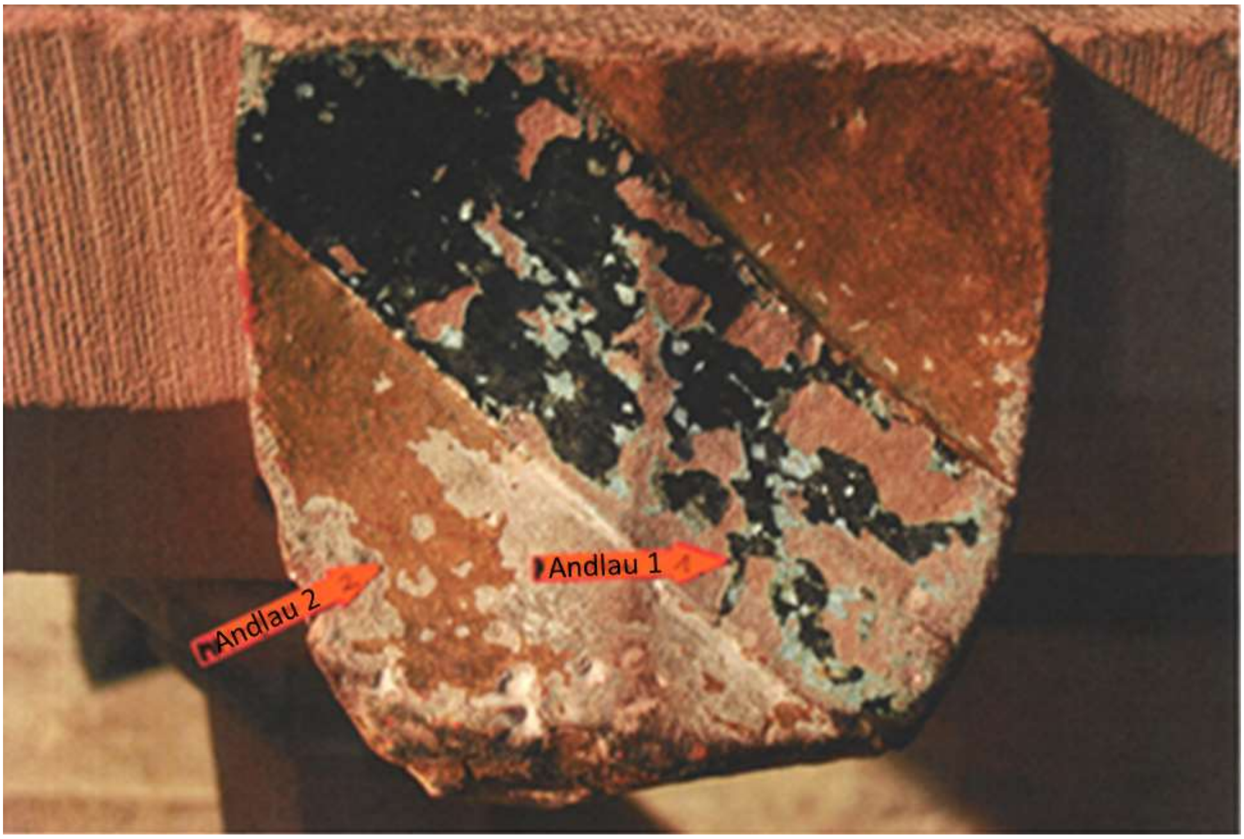


Figure 3.47: Localisation of cross sections "Andlau 1" and "Andlau 2" on the Flachsladen coat of arms.

The cross section “Andlau P1” shows seven layers (Figure 3.48). The first layer, deep red and only partially visible, is a mixture of haematite and calcite. The second layer, light green and quite inhomogeneous, with white and green grains is composed of malachite and other not characterised copper pigments. The third layer, green and thin and the sixth layer could not precisely be characterised, it could be a copper pigment. The fourth layer, pink is a mixture of haematite and lead white. The layers five and seven contain mainly black carbon.

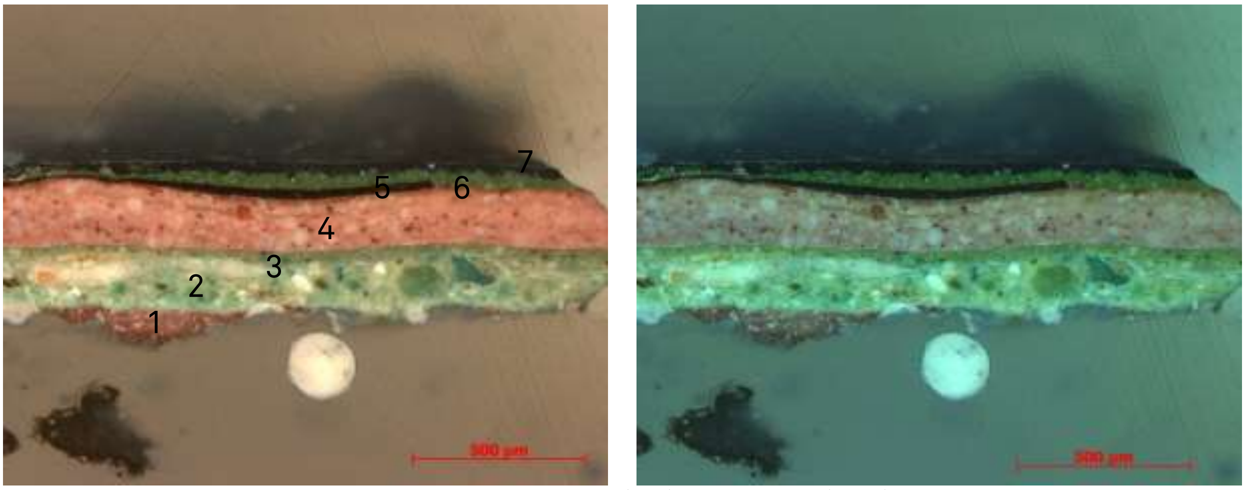


Figure 3.48: Stratigraphy of sample “Andlau P1”, visible (left) and UV-light (right).

The cross section “Andlau P2” shows 6 layers (Figure 3.49). The first layer, light grey could not be characterised. The second layer, pink and thin is mainly composed of haematite. The third layer, thin and white contains lead white. The fourth layer, yellow, thick and inhomogeneous is composed mainly on lead tin yellow. The fifth layer, olive green could not clearly be characterised, some peaks suggest chrome green pigment. The last layer, black, could not be characterised.

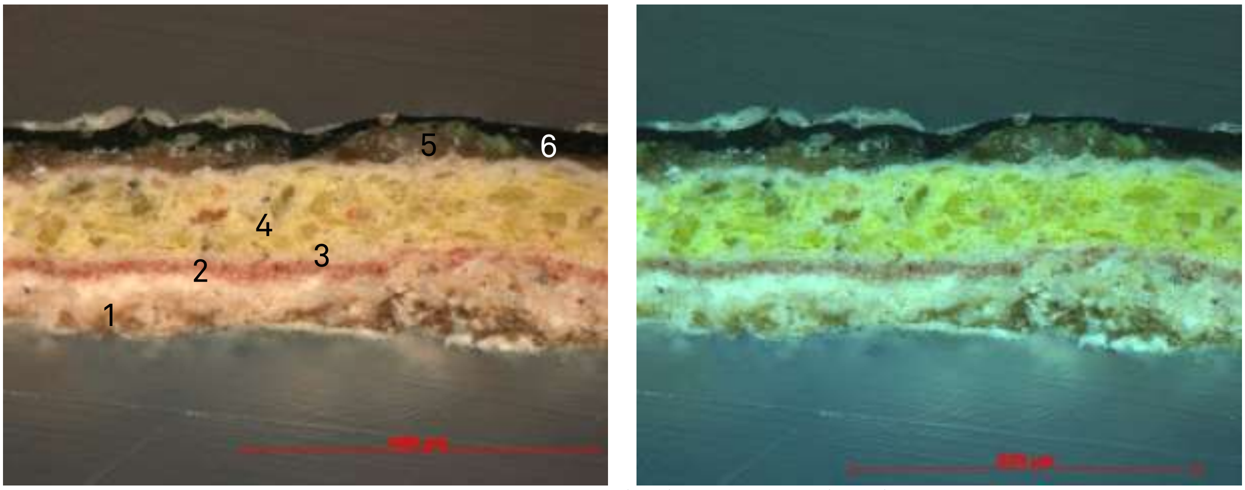


Figure 3.49: Stratigraphy of sample “Andlau P2”, visible (left) and UV-light (right).

In order to get more information about the stratigraphy of the vertical epitaph, two samples were taken), the first “Andlau P6c” from the upper floral frieze on the white part of a petal and the second close to the first, from the green leaf of the same flower “Andlau P6b” (Figure 3.44).

Eight layers were found in the cross section “Andlau P6c” (Figure 3.50). The first layer, deep red, is mainly composed of cinnabar. The second layer, white, is made of calcite and lead white. The third layer, white and pink and inhomogeneous, is a mixture of cinnabar and lead white. The fourth and fifth layers, both white, are composed mainly of lead white. The sixth layer, pink with white and deep red grains, is a mixture of haematite and lead white. The two last layers, the seventh and the eighth, contain mainly lead white. On the sixth layer, pink, FTIR analysis in reflexion was performed in order to characterise the binding media. The presence of characteristic bands for C-H stretching and C=O stretching suggests that the binder is probably a drying oil.

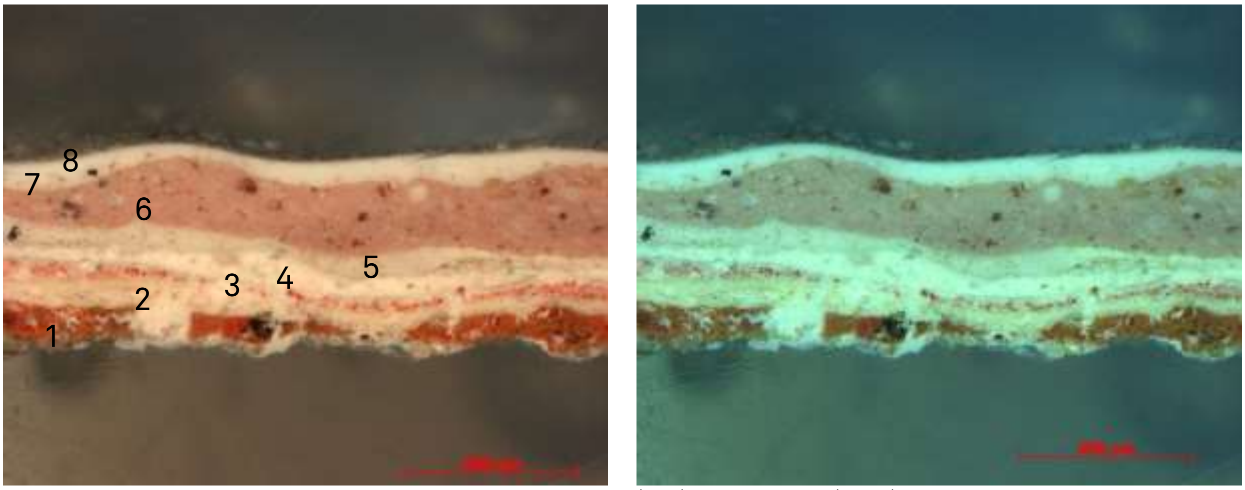


Figure 3.50: Stratigraphy of sample “Andlau P6c”, visible (left) and UV light (right).

Two layers were found in the cross section “Andlau P6b” (Figure 4.51). The first layer, very dense and deep red is mainly composed of haematite. The second layer, green, is a mixture of Prussian blue and chrome yellow.

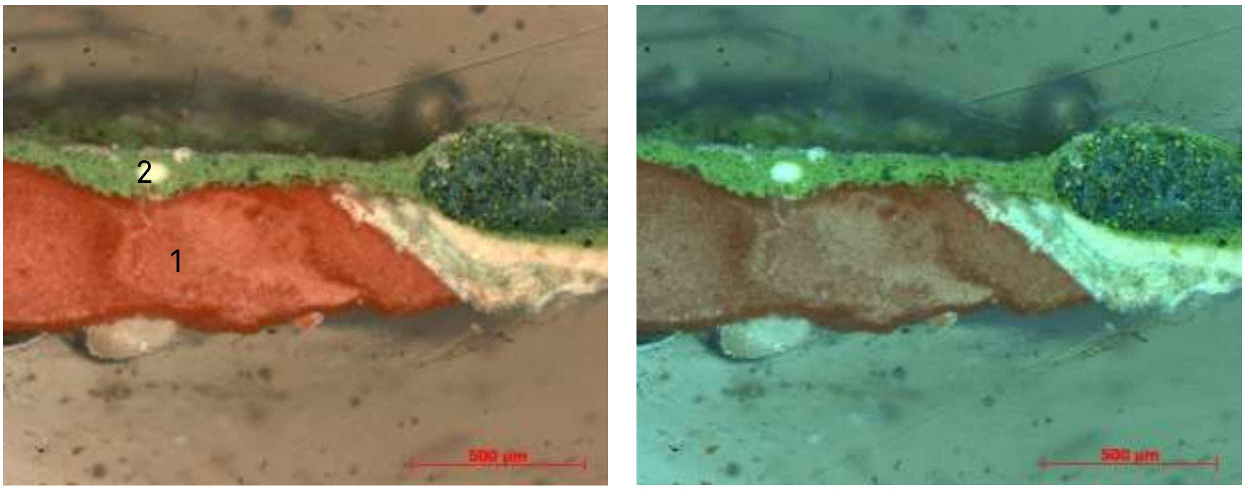


Figure 3.51: Stratigraphy of sample “Andlau P6b”, visible (left) and UV light (right).

3.3.12.3 Conclusion/discussion

According to the first results obtained by in situ XRF measurements on the slab and the study of both cross sections “Andlau P4” and “Andlau P5”, the following hypothesis could be formulated.

It can be inferred that, the slab was polychrome. A ground layer based on calcite and/or gypsum was applied with one or several paint layers of iron oxide, lead white, copper pigment and zinc (zinc white). The presence of haematite rich layer as it was founded in other cross sections, such as the gravestone of Anna von Habsburg, could give the indication of a red layer applied during the Reformation. The absence of such red Reformation layer on the coat of arms could be explain by the fact that coats of arms were important at this time and should be kept colourful.

The study of both cross section shows that several polychromies were applies on the coats of arms. At the end of XVII century, Hieronimus Falkeisen had reported that the coat of arms of Flachslanden was wrongly painted. The diagonal stripe was painted in green instead of black. This information is confimed by the stratigraphy “Andlau P1”. This cross section shows at least five polychromies, first a green layer made of malachite and other copper pigments; secondly a red-pink layer was applied. The third black polychromy which respects the colour of Flachslanden coats of arms was done. For an unknown reason, it was painted later in green and corrected with a new black polychromy.

The cross section “Andlau P2” confirms the existence several polychromies. Indeed three polychromies are presents. The first polychromy is composed of a ground layer with on the top a red and thin cinnabar layer. The second polychromy consists of a yellow thick layer of lead tin yellow. The third polychromy is mainly composed of an uncharacterised olive green layer probably a chrome green pigment.

According to the results obtained by XRF in situ measurements on the epitaph and the study of both cross sections “Andlau P6b” and “Andlau P6c”, the following hypothesis could be formulated.

The Epitaph is fully painted and the main issue is if there are previous polychromies. Based on the XRF results, it can be suggested that the ground layer was mainly composed of gypsum. The palette of pigments includes for white pigments, lead white and probably zinc white. The yellow colour was obtained with chrome yellow, massicot and probably with cinnabar. Copper pigments and chrome green were the pigments used for the green painted part of the epitaph. Due to the variety of colours founded in the cross sections Andlau 6b and 6c, it cannot be excluded that other colours as, white, yellow and green were previously present on the epitaph.

The cross section 6c shows three polychromies. Some remains of the stone matrix are present below the first polychromy made of cinnabar. Then a second polychromy were applied, which was composed of a ground layer based on white lead and calcite and a pink layer based on mixture of cinnabar and white lead and probably some white stripes of lead white. The third polychromy consists of a ground layer mainly composed of lead white with a pink layer made of haematite and lead white on which white details were painted with white lead touch.

The cross section 6b shows two green polychromies, a first polychromy composed of lead white and a copper green pigment uncharacterised and then a polychromy was applied with a hiding ground layer made of lead white with a layer of Prussian blue mixed with chrome yellow.

As for the Anna von Habsburg Gravestone, the use of chrome based pigments and Prussian blue on the coats of arms demonstrates newly applied polychromies in the XIX century.

3.3.13. PB11 Gewölbemalereien, Äusseres Südseitenschiff / Fröwlerkapelle

This is a wall painting on the vaults of the outer northern aisle in the Fröwler Chapel that shows parts of an angel and ornamental floral like spiral roses and gothic tracery (Figure 3.52).

3.3.13.1 Results of the non-destructive analysis

Analyses were carried out with the handheld XRF (Niton XLt), twelve spectra were acquired (Figure 3.52). The selection of the measured points was carried out in order to analyse each colour present on the wall painting. The elemental composition of each spectrum was evaluated comparing the spectra to a reference spectrum made on the Wiesentaler sandstone.

The palette of colour includes white (ground layer), yellow, orange, red, blue, green and black.

The ground layer should be composed of Ca and S. Both chemical elements are present in each spectrum. In the white part of the wall painting, Ca and S were detected associated to traces of Pb and As. The yellow tone contains mainly Pb, with lesser quantities of Ca and S. The orange tone has a similar elemental composition to the yellow one. The red tone is rich on Fe with lesser quantities of Ca and S. The blue and blue green tones are mainly composed of Cu, with Ca and S and traces of Pb for the blue and traces of Cr for the green blue. The black tone contains the same chemical elements as the white tone.

Figure 3.52: General view of the Gewölbemalerei PB11 with the localisation of XRF analyses.

3.3.13.3 Conclusion/discussion

According to the results, the following hypothesis on the stratigraphy of this wall painting can be formulated.

The background as well as the white tone should be composed of gypsum. The yellow and orange tones should contain a lead oxide, perhaps minium. Iron oxide, as red ochre or haematite should be the main pigment for the red tone. The blue and the green tones contain a copper pigment. Finally, the black should be mainly composed of black carbon as there is no hint of an inorganic pigment.

Therefore it is possible to affirm that this is a classical medieval colour palette: gypsum, red ochre or haematite, copper pigments for blue and green blue and carbon black. The results permit to suggest that this wall painting was made of a unique polychromy and should be original with exception of some retouches made with modern pigments such as chrome yellow.

This affirmation is confirmed by the observations of Andreas Arnold and Paul Denfeld in 1998 (Andreas Arnold in Jahresbericht Münsterbauhütte 1998).

3.3.14. PB12 Wandmalerei und Barockinschrift Orgelempore

This is a medieval wall painting with baroque inscription (Figures 3.53 and 3.54). It consists of two triangular remains of plasterwork situated above the vaults, just beneath the wooden ground floor of the organ loft.

This part of the organ loft was only open for a short time in 2002 when a new organ was installed in the cathedral. It was only then that samples could be taken, because the ground floor was then closed again.

Figure 3.53: Localisation of sampling for the cross section “Mü Orgelempore P1”.

Figure 3.54: Localisation of sampling for the cross section“Mü Orgelempore P2”.

3.3.14.2 Results on complimentary study on cross sections

Raman and XRF were performed on the cross section.

The cross section “Mü Orgelempore P1” shows 7 layers (Figure 3.55). Raman analyses indicate the main pigment as red lead in the first layer, which is light orange and inhomogeneous. The second layer, orange, is composed of a majority of cinnabar with red lead. The third layer, white and thin, is mainly composed of lead white. The fourth layer, black and thin is made of black carbon. The fifth layer, white and homogeneous is made of calcite. The sixth layer is a very thin organic layer visible under UV light. The seventh layer, white, is made of gypsum.

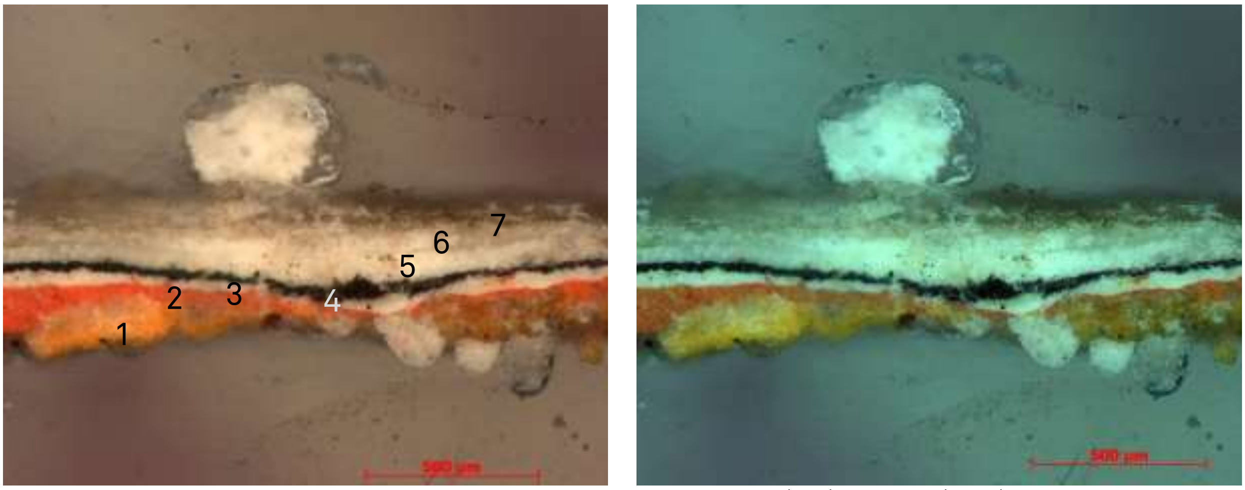


Figure 3.55: Stratigraphy of sample “Mü Orgelempore P1”, visible light (left), UV light (right)

The cross section “Mü Orgelempore P2” shows 7 layers (Figure 3.56). Raman analyses indicate a mixture of quartz particles, calcite, lead sulphite and some lead oxide pigments (not characterised due to the high fluorescence) in the first layer, which is light brown and inhomogeneous. XRF analysis was performed on this layer and shows that the main chemical elements are Ca and Fe with lesser quantities of Pb, K and Zn. The second layer, thin and blue, is composed of azurite. The third layer, white and thin, is mainly composed of calcite. As fourth layer, an organic layer is visible under UV light. The fifth layer, white and homogeneous is made of calcite. Another organic layer, the sixth, is visible under UV light and the seventh layer, white, is made of gypsum.

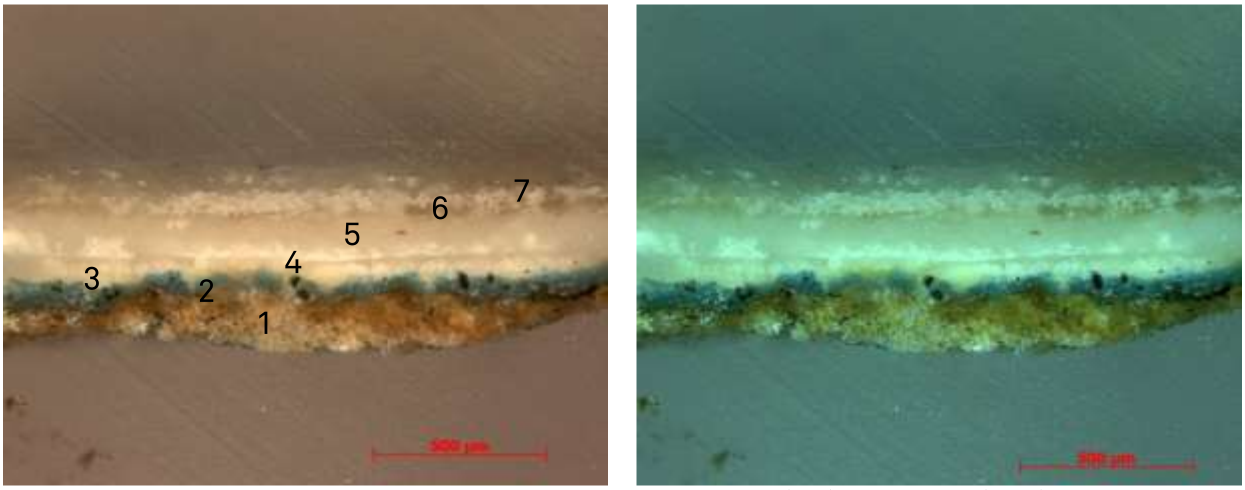


Figure 3.56: Stratigraphy of sample “Mü Orgelempore P2”, visible light (left) and UV light (right)

3.3.14.3 Conclusion/discussion

On the cross section “Mü Orgelempore P1”, there is a succession of the layers 1, 2, 3, 4, which suggests first an orange painted part of the wall painting made of two layers (lead red and cinnabar) applied on a ground layer which is not present in the cross section. This orange part of the wall painting was covered with a lead white layer which serves as a ground layer for a baroque inscription realised in black carbon. Later, this inscription was covered with two layers, first with calcite and then with gypsum. Due to the lack of a dirt layer between these two white layers it can be concluded that these layers were applied at the same time.

The same reasoning can be drawn for the second cross section, "Mü Orgelempore P2". On a ground layer, made of a mixture of calcite, iron oxide and lead oxide a blue layer made of azurite was applied. Later a white layer of calcite covered this blue painted part of the wall painting. Due to the similarity of the succession of calcite and gypsum layers of the cross section "Mü Orgelempore P1", both successions of layers could be contemporary.

From a reference from the XVIII century (Niklaus Falkner, 1785)[12] it is known that the inscription (black layer 4 in cross section "Mü Orgelempore P1") was getting powdery. In order to apply a new inscription the surface was covered with first calcite and then gypsum layers as ground layers for the new inscription. It is well known that the combination of calcite and gypsum was often used because it dries rapidly.

It can be concluded that there are three polychromies. The first one was a colourful wall painting which was covered with a second polychromy constituted of lead white or calcite in order to paint a black baroque inscription on it after the Reformation. This inscription was then covered with two layers, first calcite and then gypsum, at the same session in order to apply a new inscription as a third polychromy.

3.3.15. PB13 Bischofsthron, Südquerhaus

This is architectural ensemble constitutes the Bishop's seat. The seat and the canopy are sculpted in Wiesentaler sandstone.

The XRF analyses on this object were carried out with the ARTAX (canopy) and the Niton (seat). Only one sample was taken from the blue on the canopy in order to realise a cross section.

[12] Memoriale von Niklaus Falkner, Dompropsteischaffner, an die Haushaltung, 12. September 1785 (StABS Bau JJ 1): „Die von Eüeren Gnaden anbefohlene Ab- und Ausstäubung des Schiffs, der NebenGängen und des Chors in dem Münster, wäre insofern nun beendiget, daß auch der wöchentliche Gottesdienst darinnen widerum gehalten werden könte; da aber hin und wider, an der Deke sowol als denen Wänden, theils der Bestich herunter gefallen ist, <u>theils die daran gemalten Schriften entweders beschädiget, oder gar zerloschen seyen, auch sonsten hie und da etwas der Ausbesserung bedürtiges sich erzeiget hat</u>; so ist biß auf näheren, durch Eüere Gnaden hierüber etwann einzunehmen beliebenden Augenschein, die erforderliche Reparation dieser Dingen einstweilen in denen NebenGängen und übrigen Orten veranstaltet werden [sic], welche nicht hindern daß auch die VorbereitungsPredigten in dem Münster gehalten werden können; sonsten aber"

3.3.15.1 Results of the non-destructive analysis

The results of the 14 XRF analyses on the canopy with the ARTAX are summarised in Figures 3.57 and 3.58).

The elemental composition of each spectrum was evaluated comparing the spectra to a reference spectrum on a Wiesentaler block (sp5).

The palette of colours present on the canopy includes gold, light and deep blue (Figure 3.58).

The ground layer contains Ca and Pb, both elements are present in all spectra. The light blue tone contains mainly Pb with lesser quantities of Ca and Cu. The deep blue tone is composed of Pb, As, with Co, Cu, K, Ni Ca, Fe, K in lesser quantities. The gilded part contains Fe and Au.

Figure 3.57: Localisation of the XRF (ARTAX) analyses and of sample "Bisch P1" on the canopy.


Figure 3.58: localisation of ARTAX analyses on the light blue part (left), gilding (middle) and deep blue part (right).

On the lower part of the bishop's throne no visible traces of polychromy are present except for some deep red rests. The selection of measured points was carried out by using a UV lamp. Nine spectra were acquired using the Niton XL3t and three using the Niton XLt on points presenting high fluorescence or on red polychrome remains. The localisation of the XRF analyses are summarised in Figure 3.59. The reference spectrum used for the evaluation of the acquired spectra with XLt was taken on a Wiesentaler stone reference (sp 246). For the XL3t the elemental composition was evaluated by comparison the spectra with a spectrum recorded on a probably unpainted part of the stone.

In each of the twelve spectra Ca, S, Fe and Pb were detected.

Figure 3.59: Localisation of the XRF(Niton) analyses on the seat of the Bishop

3.3.15.2 Results on complimentary study on cross sections

A sample was taken from the left rib of the canopy (Figure 3.57) in order to better understand the polychromy and to characterise the pigments present in the blue tone.

The cross section shows four layers (Figure 3.60). The first layer, which can be considered as a ground layer, is made of calcite with some grains of black carbon. The second layer is made of calcite and lead white. The third layer is mainly composed of azurite mixed with lead white. The last layer contains smalt and lead white. smalt is easily recognised through his characteristic appearance (Mühlethaler and Thissen, 1993[13]), clear fractures and confirmed by the detection of cobalt and arsenic (Mühlethaler and Thissen, 1993[13]; Robinet et al., 2013) by XRF measurement performed on the cross section.

[13] In "Artists' Pigments, a handbook of their history and characteristics", vol. 2.

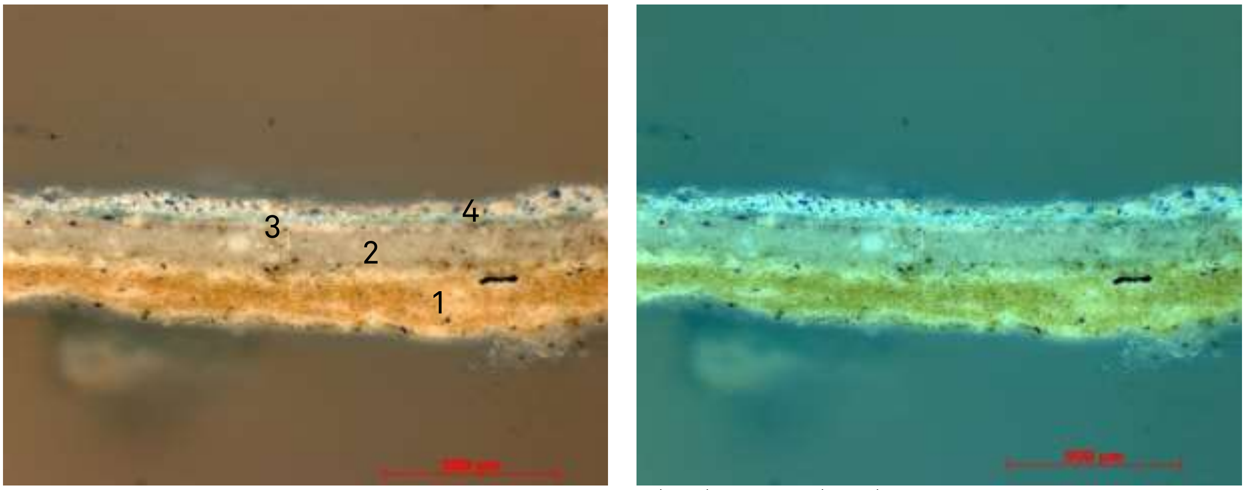


Figure 3.60 : Stratigraphy of sample “BischP1” visible light (left), UV light (right)

3.3.15.3 Conclusion/discussion

According to these results, the following hypothesis on the polychromy of the bishop’s throne can be formulated.

The ground layer should be mainly composed of calcite. The palette of colours which are still present is limited to two colours, blue and gold.

A primary blue layer composed of lead white and azurite was applied on specific parts of the canopy, followed by a second blue layer based on white lead and smalt. There are no organic or even dirt layers between both blue layers on the cross section, which could indicate a time interval between both applications. Therefore the use of this two overlaying layers seems to be intentional.

The gold was applied on the canopy as gold leaf on a bolus layer, according to the presence of Fe and Au.

As for the presence of a polychromy on the lower part of the object, the seat it-self, although no precise polychromy could be described, it is possible to affirm that in former times the seat was coloured.

3.3.16. PB16 Taufstein, Südquerhaus

This is a stone baptismal font, highly curved with figures representing the baptism of Christ by John the Baptist, assisted by an angel, and saints such as Vincent or Laurence, Jacob the Elder, Paul, Peter and Martin (Figure 3.61). Nowadays it looks like made of naked Wiesentaler sandstone, but some small rest of polychromy can be found in hollow parts.

The analyses were carried out with the ARTAX precisely, 27 spectra were acquired. On this baptismal font there are no visible traces of polychromy except in cavities or pleats inaccessible to the ARTAX. Thus the selection of the measured points was done under the use of the UV light lamp.

2 samples were taken from rests of polychromy located in very deep areas, to realise cross sections.

3.3.16.1 Results of the non-destructive analysis

All the spectra of the 27 measured points show the presence of Pb, Ca and Fe sometimes only in traces. Cu is sporadically present as traces except on a vegetal ornament where higher amounts are present.

With those results, a palette of colours could not be defined.

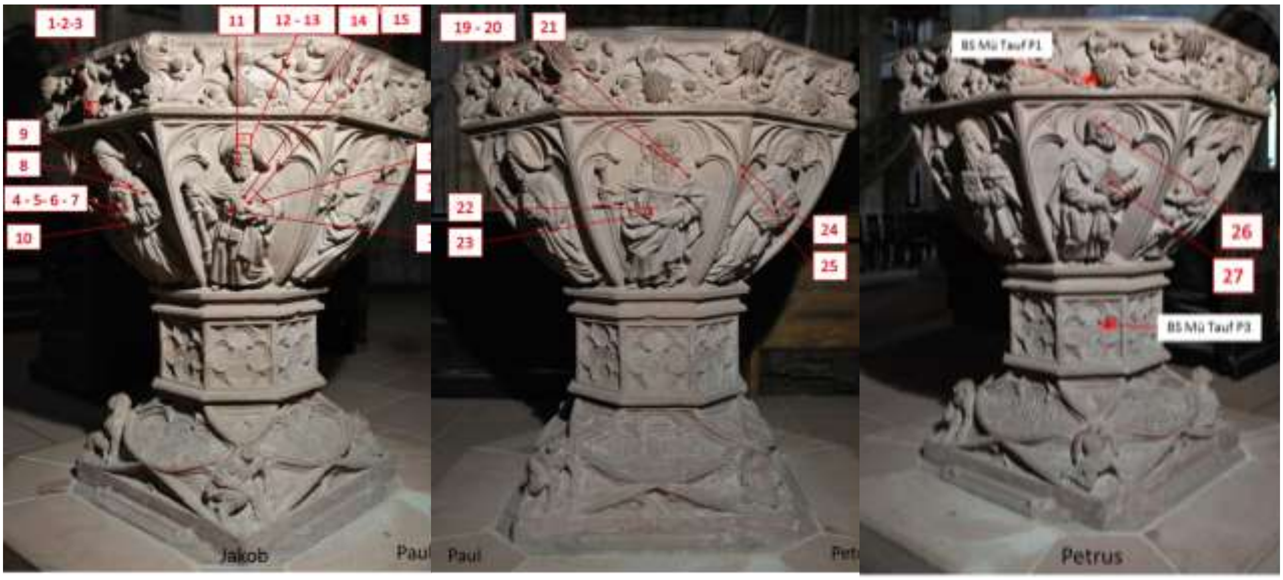
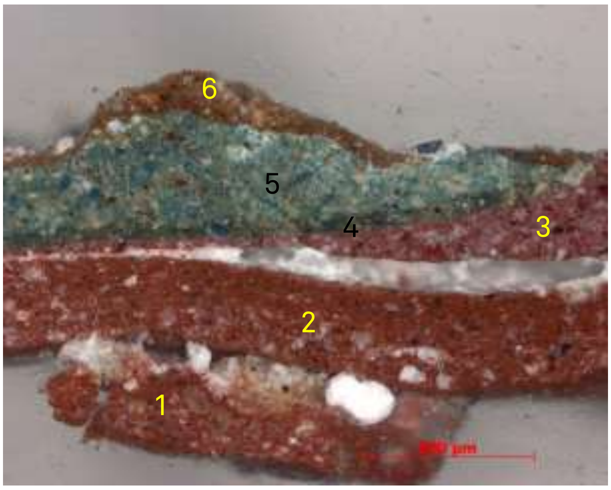


Figure 3.61: Localisation of XRF analysis and sampling for cross section on the baptistery PB16

3.3.16.2 Results on complimentary study on cross sections

In order to get more information about a former polychromy, two samples were taken on deep cavities. A first one is situated on the upper part of the Saint Peter side, left to the central vegetal ornament "BS Mü Tauf P1" (Figure 3.61). The second sample was taken on the below part of Saint Peter on a trefoil "BS Mü Tauf P3" (Figure 3.61).

The cross section "BS Mü Tauf P1" shows 6 layers (Figure 3.62). The first and second layer, are similar, deep red is composed of haematite. The third layer is lighter as the first and second layers; it consists mainly of haematite mixed with lead white and gypsum. The fourth, thin blue-green is composed of azurite, calcite and lead white. The fifth layer, thick and blue is composed of azurite, calcite and lead white. The spectra obtained on the fourth layer show an high fluorescence in comparison with the spectra obtained from the fifth layer, which could be indicate that the fourth layer is also rich in organic. The last layer, partially present consists of haematite and calcite.



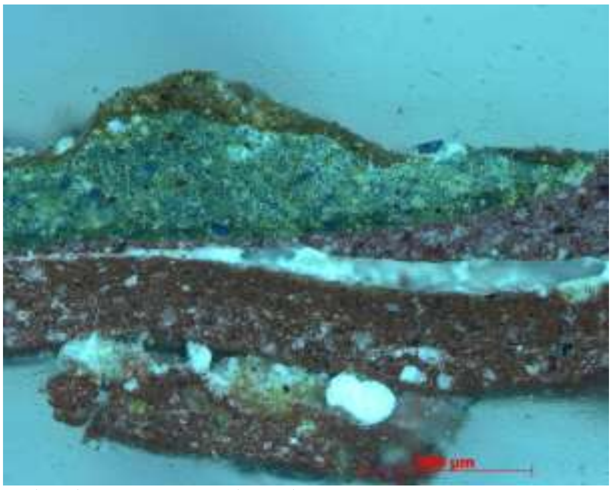
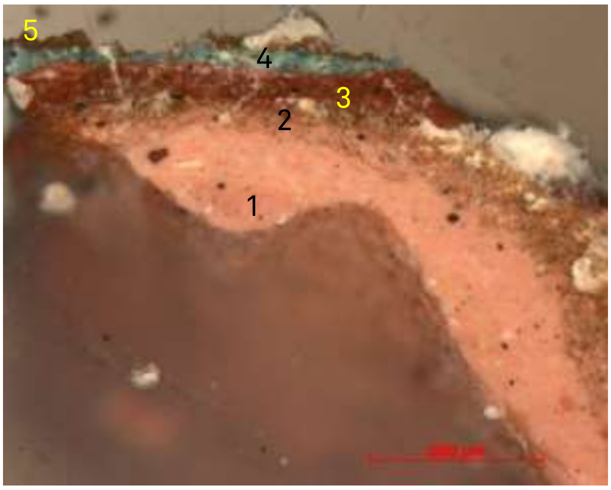


Figure 3.63: Stratigraphy of sample “BS Mü Tauf P1” visible (left) and UV-light (right).

The cross section “BS Mü Tauf P3” shows 5 layers (Figure 3.63). The first layer, rosa contains mainly lead white. An FTIR analysis on this layer was carried out in order to characterise the binding media which is dried oil. The second layer, inhomogeneous and light brown could not be precisely defined due to high fluorescence; it could be an organic imprimatur. The third layer, deep red, is mainly composed of haematite. The fourth layer, blue and thin, is constituted of azurite. The fifth layer, red and partially present, is mainly made of haematite.



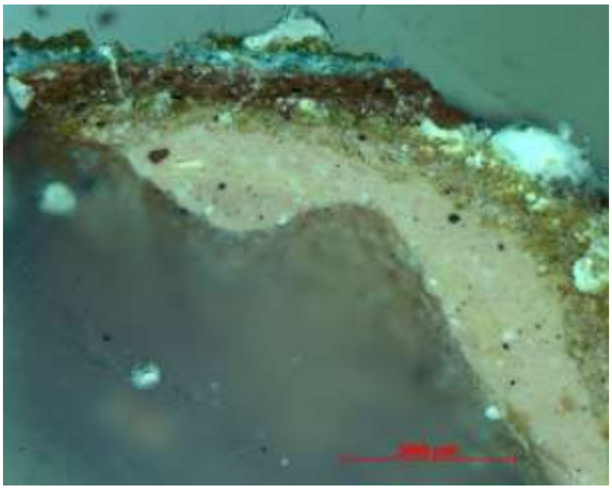


Figure 3.63: Stratigraphy of sample “BS Mü Tauf P3” visible (left) and UV-light (right).

3.3.16.3 Conclusion/discussion

According to these results, it can be assumed that the baptistery was polychrome. Both cross sections did not have a “conventional “ground layer as the other cross section in this project; there are no calcite or gypsum ground layer. There are two different first layers. One is light pink, made of lead white and haematite the other is deep red and mainly contains haematite. In both cross sections a layer of azurite was found.

Because of the absence of a “conventional” ground layer, and because there are no written traces confirming the existence of a former polychromy, the following hypothesis can be formulated. First a reddish layer was applied only to give a uniform appearance to baptistery, while the blue and/or green pigments were used to highlight some specific decorative parts. In post reformatory times, a second red layer was applied.

3.3.17. PB17 Kanzel

This is a monumental, tulip-shaped pulpit, highly sculptured and covered all over with fine gothic tracery and foliage. Hands and figures representing prophets holding letter bands are visible (Figure 3.64). It is composed of several pieces of Wiesentaler sandstone. Although it general appearance is naked stone, some traces of polychromy can be found in hollow parts.

The analyses were carried out with the ARTAX precisely, 11 spectra were acquired.. 4 samples were taken from rests of polychromy located in deep areas, to realise cross sections.

3.3.17.1 Results of the non-destructive analysis

As the rests of polychromy were almost inaccessible to the ARTAX, only 11 spectra could be acquired during the measurement campaign. The reference spectrum used for the evaluation of the acquired spectra with the ARTAX was taken on a Wiesentaler block.

All the spectra of the 11 measured points show the presence of Pb and sometimes excesses of Ca and Fe in comparison with the Wiesentaler block. Otherwise, no other chemical element could be detected.

With those results, a palette of colours could not be defined.

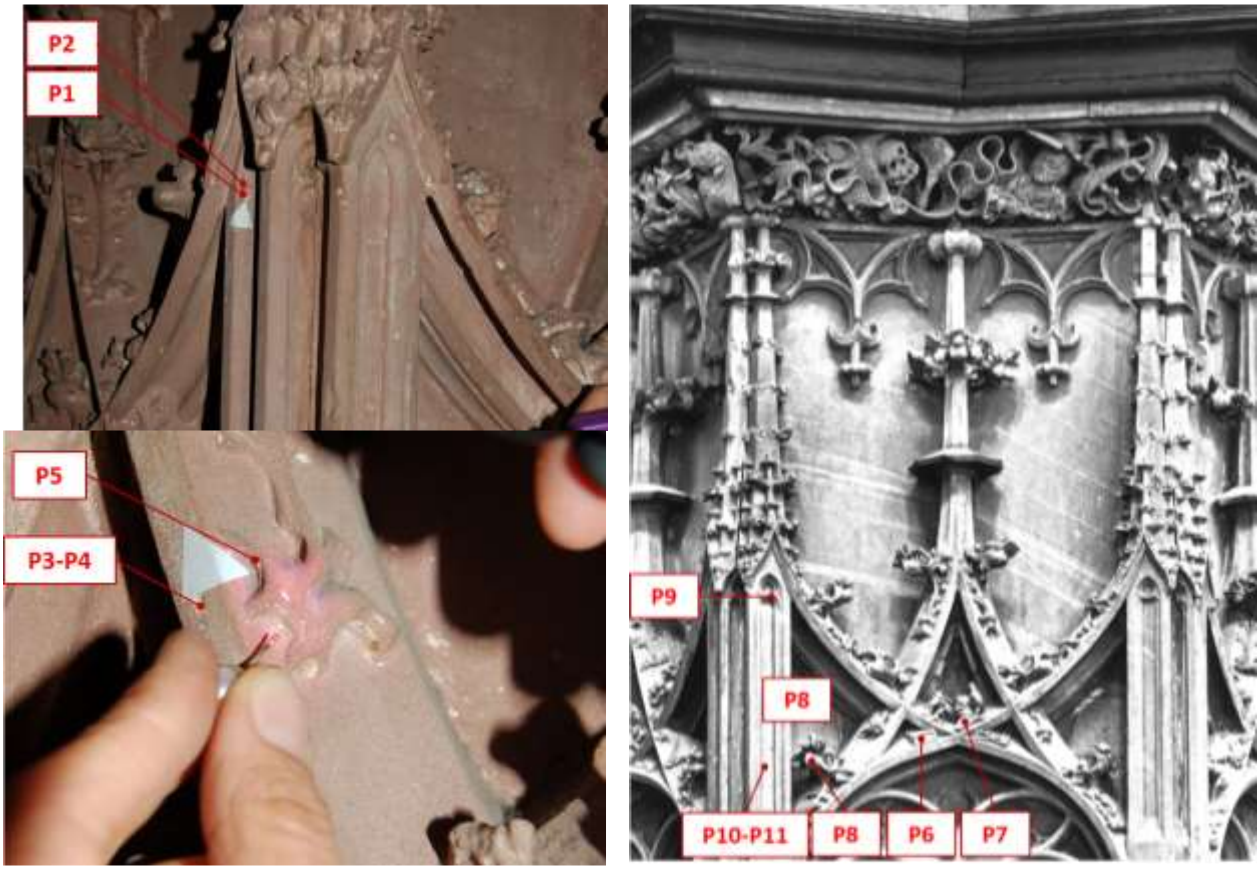


Figure 3.64: Localisation of the XRF analyses on the BP17 (right, photo credits: Erik Schmidt)

3.3.17.2 Results on complimentary study on cross sections

Due to the inaccessibility of the rests of polychromy, four samples were taken in order to realise cross section and to study the stratigraphy on the pulpit. The cross sections “MU Kanz P1” and “MU Kanz P2” were taken from the below part of the stairs (Figure 3.65 left). While the cross sections “MU Kanz P8” and “MU Kanz P9” were taken from a gothic floral ornament on the frieze below the handrail of the pulpit (Figure 3.65 right).

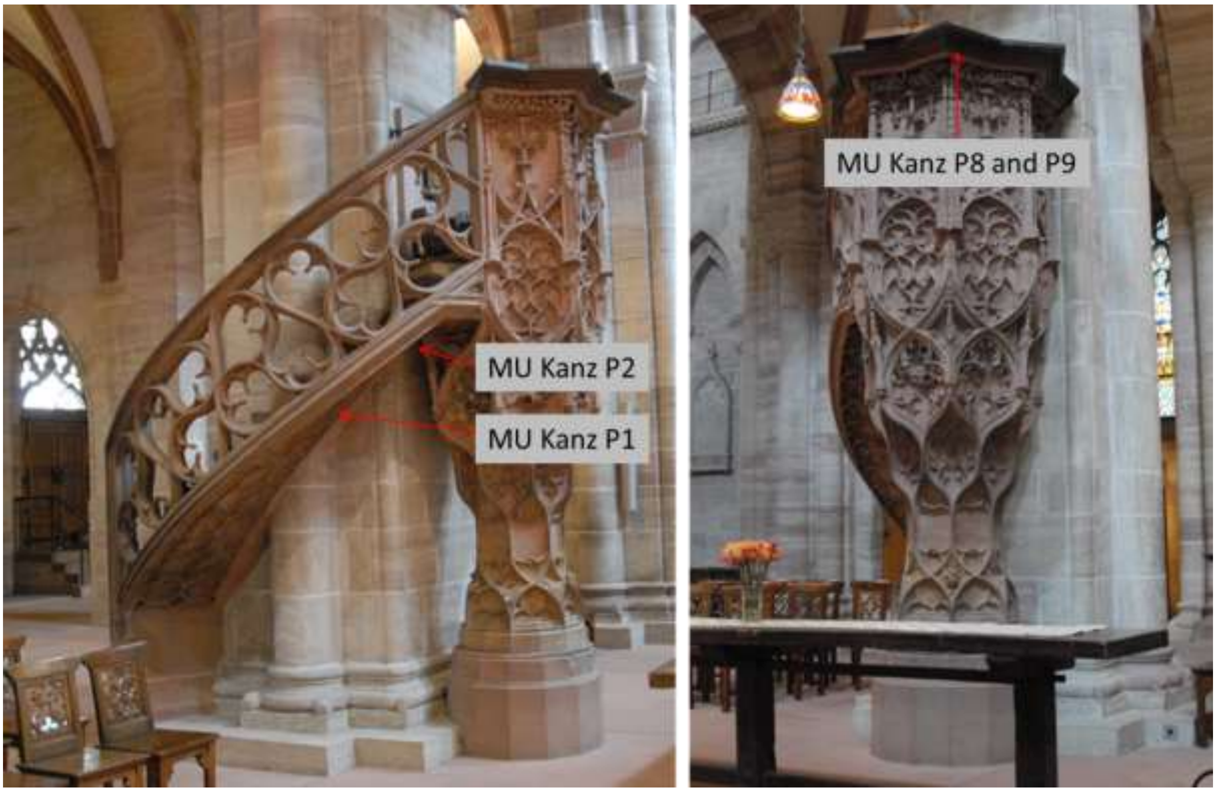


Figure 3.65: Localisation of the sampling on the BP17 for cross sections

The cross section “MU Kanz P1” shows 4 layers (Figure 3.66). The first layer, which can be considered as a ground layer, is made of calcite with black carbon and perhaps iron oxide. The second layer has the same composition as the first. The third layer, deep red, is mainly composed of haematite. FTIR analyses of this layer showed that the binding media is dried oil. The last layer, thin and pink, contains haematite and white lead.

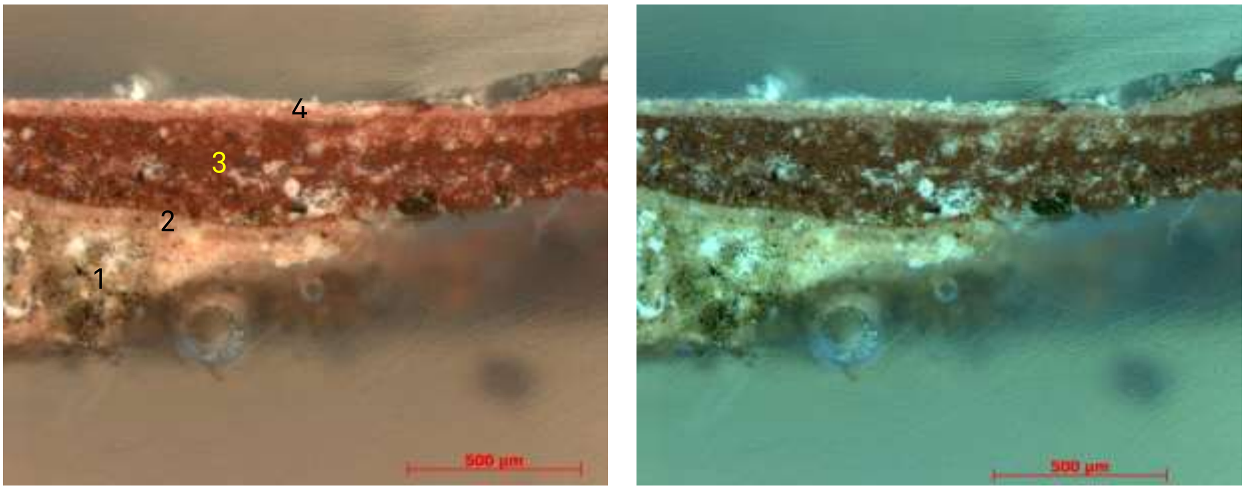


Figure 3.66: Stratigraphy of sample “Mu Kanz P1” under visible (left) and UV-light (right)

The cross section “MU Kanz P2” shows 3 layers (Figure 3.67). The first layer, pink and thick, is made of haematite and lead white. An FTIR analysis on this layer was carry out in order to characterise the binding media which is a dried oil .The second layer, deep red and thin, is composed of haematite with some particles of lead white. The third layer is discontinuous and due to a high fluorescence, not really precisely characterised. Only calcite could be detected. This layer should be made of a mould release agent layer which was only partially removed after the moulding taken in1998 of this pulpit[14].

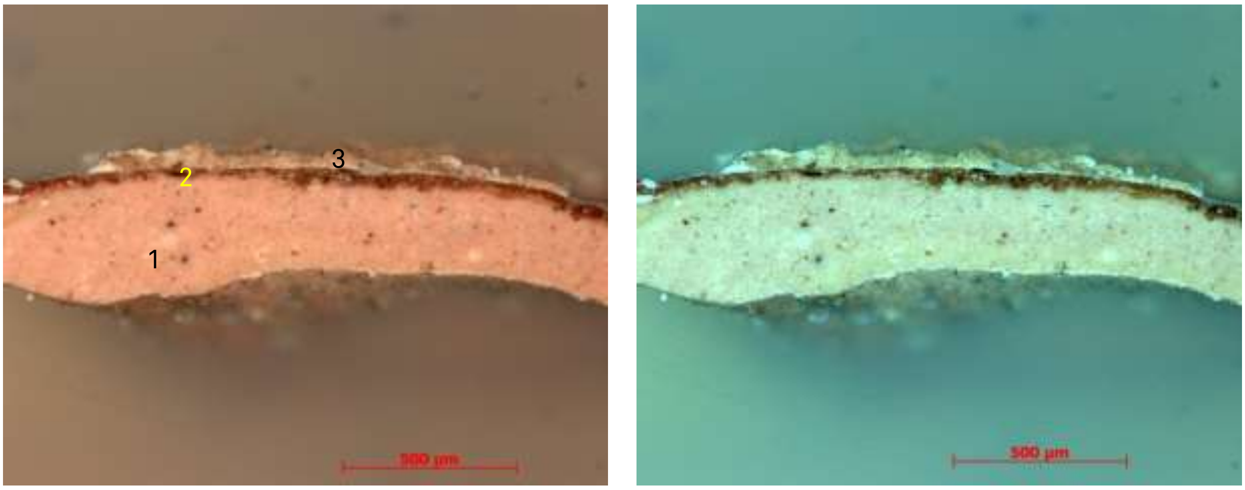


Figure 3.67: Stratigraphy of sample “Mu Kanz P2” visible (left) and UV-light (right)

The cross section “MU Kanz P8” shows 3 layers (Figure 3.68). First a thick, inhomogeneous, deep red layer composed mainly of haematite with grains of calcite and lead white. A second layer, pink and thin, contains haematite and lead white. The third layer, light pink and discontinuous was not easy to characterised, only haematite and calcite could be detected. This layer should a mould release agent layer as for cross section “Mu Kanz P2”

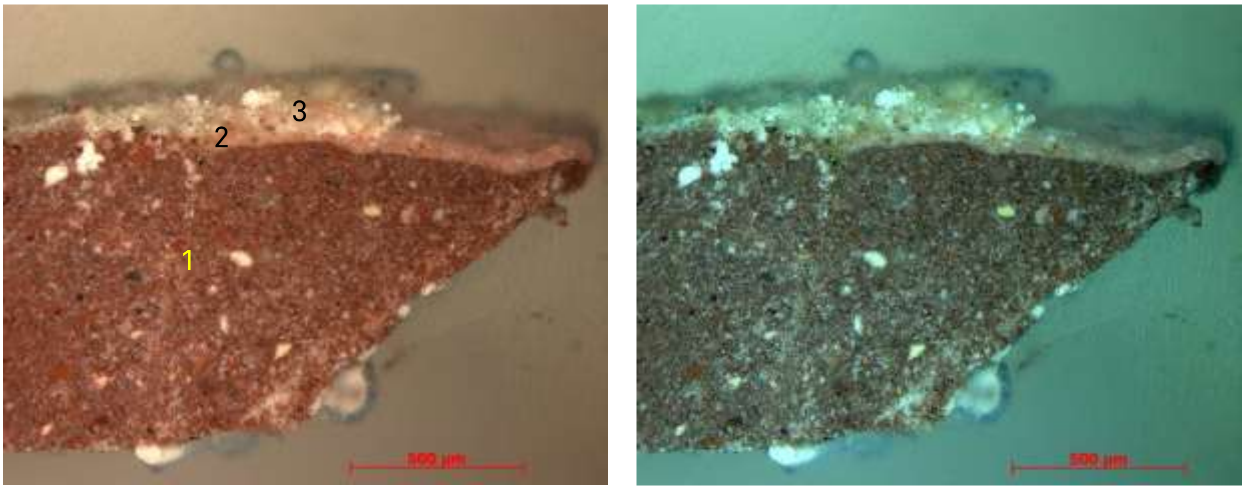


Figure 3.68: Stratigraphy of sample “Mu Kanz P8” visible light (left) and UV light (right)

The cross section “MU Kanz P9” shows 4 layers (Figure 3.69). First a thick, inhomogeneous, light pink layer composed mainly of haematite with black carbon and lead white. A second

[14] oral report from Herr Baumgartner, freelance worker at the “Bauhütte” 2016

layer, deep red and thin were applied which contains haematite. In the third layer, which looks like a thick organic layer, and in the fourth, beige and discontinuous, only calcite could be detected. Both last two layers could be identified as mould release agent, which the worker could not remove correctly due to the friability of the red layer.

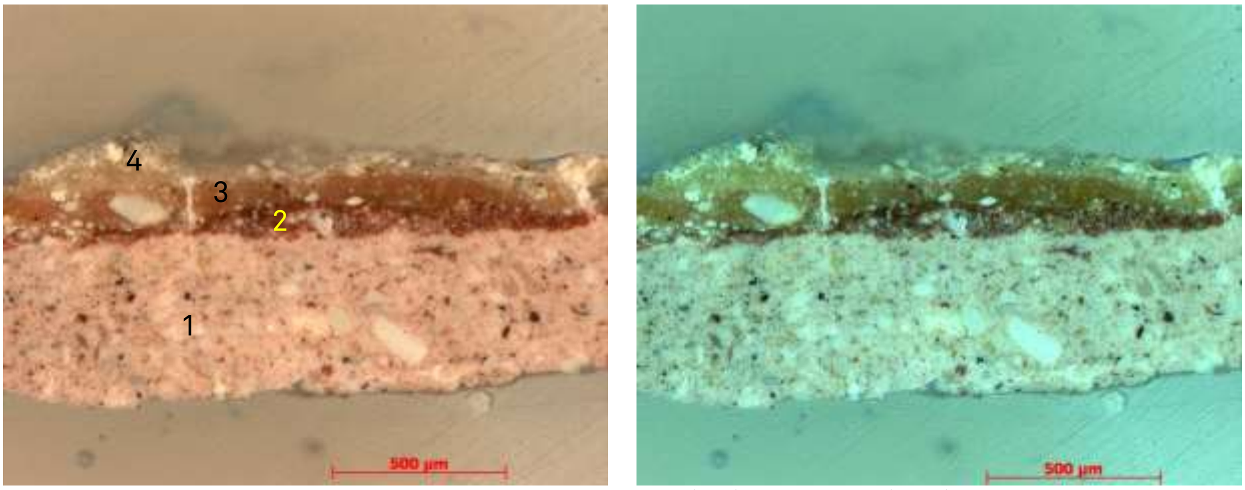


Figure 3.69: Stratigraphy of sample "Mu Kanz P9" visible light (left) and UV light (right)

3.3.17.3 Conclusion/discussion

Due to the detection of Pb in different parts of the pulpit as pinnacle, or trefoil ornament, it can be concluded that at least one paint layers was present. Perhaps first a ground layer composed of gypsum or/ and calcite due to the occasionally presence of Ca. One of the four cross sections confirms this hypothesis by showing a ground layer with calcite, black carbon and perhaps iron oxide.

Both post reformatory red and pink layer were observed but a logical chronological explanation could not be found.

As for the baptistery, there is no information about an original first polychromy composed of various colours. May be a monochrome original red layer was applied in order to make uniform the natural colour of the Wiesentaler stone.

3.3.18. PB18 Abendmahlstisch, Crossing

This is the altar of the protestant era of the Münster (Figure 3.70). It is composed of several pieces of Wiesentaler sandstone. Although it general appearance is naked stone, some traces of polychromy can be found in hollow parts. Thus the selection of the measured points was done under the use of the UV light lamp. The analyses were carried out with the ARTAX; precisely 8 spectra were acquired. The reference spectrum used for the evaluation of the acquired spectra with the ARTAX was taken on a Wiesentaler block.

Three samples were taken from rests of polychromy located in deep areas, to realise cross sections.

3.3.18.1 Results of the non-destructive analysis

All the spectra of the 8 measured points show the presence of Pb and sometimes excesses of Ca, Fe, S and Fe in comparison with the Wiesentaler block, and traces of Zn. With those results, a palette of colours could not be defined.

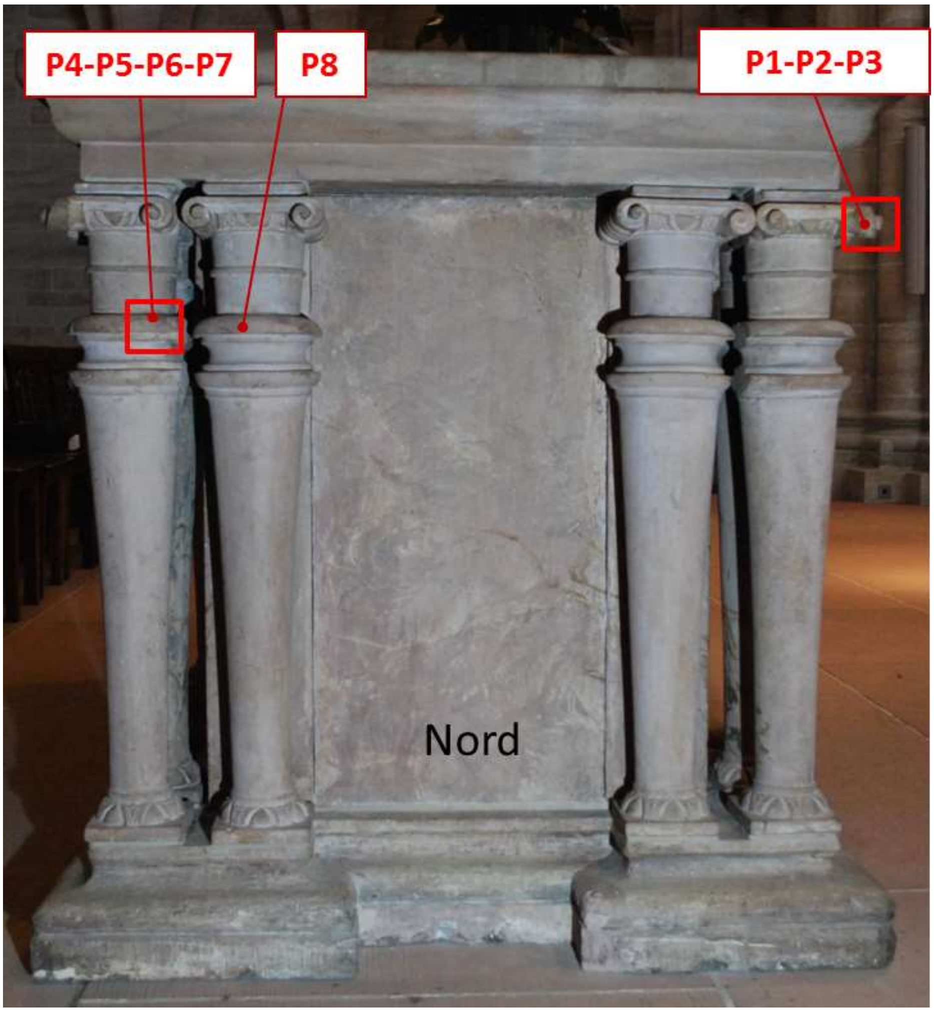


Figure 3.70: Localisation of the XRF (ARTAX) analysis on the northern side of the Altar

3.3.18.2 Results on complimentary study on cross sections

Due to the inaccessibility of the rest of polychromy, three samples were taken in order to realise cross section and to study the stratigraphy on the altar (Figure 3.71). The cross section "MU AT P1" was taken on the echinus of the first column from the right on the Northern side of the altar. The cross section "MU AT P3" was taken from the cornice of the table top of the east side of the altar. The cross section "MU AT P4" was taken from volute-like ornament of rear warded eastern side of the altar.

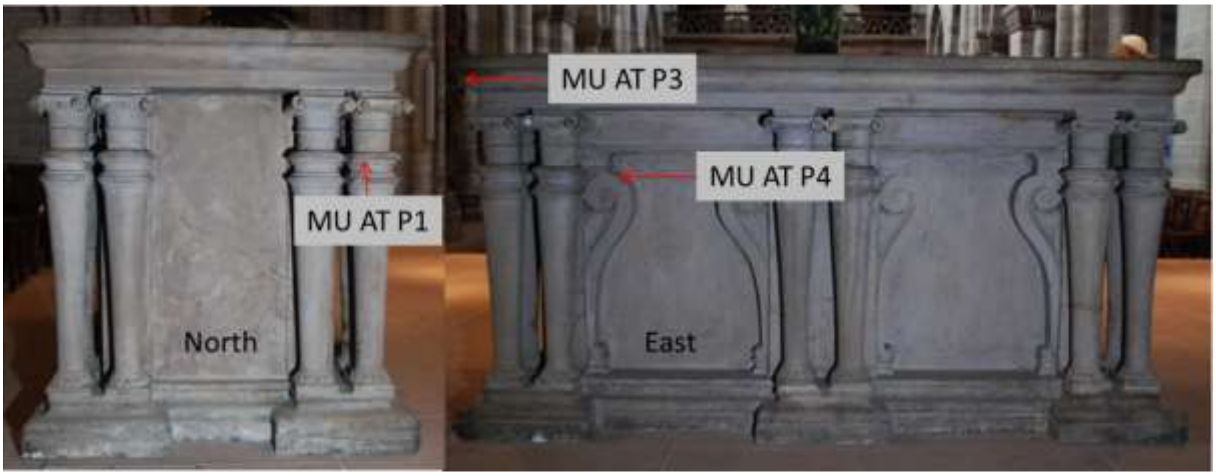


Figure 3.71: Localisation of the sampling for cross sections on PB18.

The cross section "MU AT P1" shows 2 layers (Figure 3.72). The first layer, inhomogeneous, thick, white and black, is made of black carbon with white lead and some grains of haematite. The second layer, orange, thin and discontinuous, is composed of red lead, calcite and haematite.

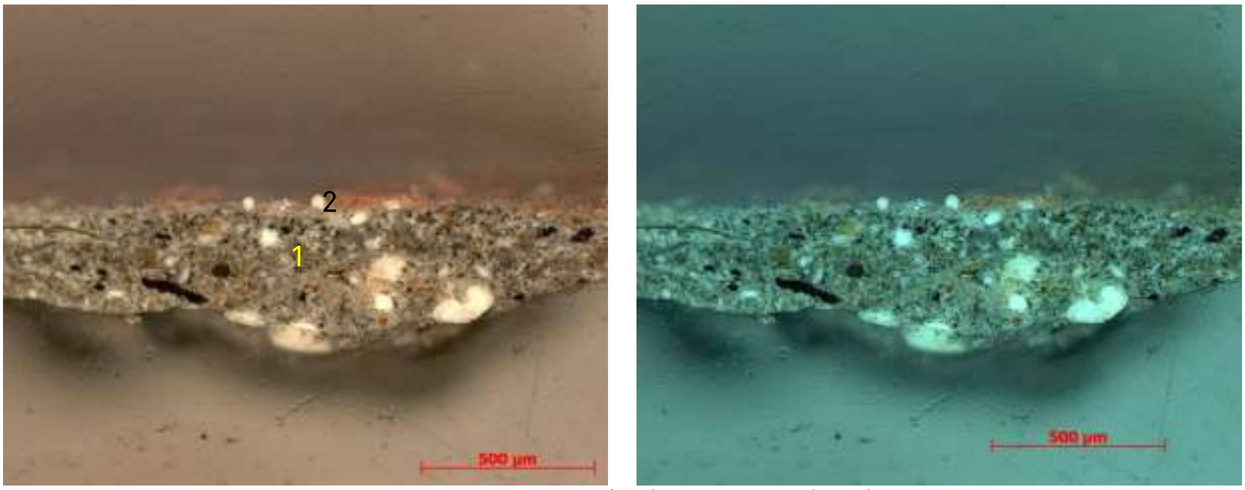


Figure 3.72: Stratigraphy of sample "Mu AT P1" visible (left) and UV-light (right)

The cross section "MU AT P3" shows 3 layers (Figure 3.73). The first layer is thick and inhomogeneous. It is composed of white lead, haematite and black carbon. The second layer, less inhomogeneous than the first, deep red, is made of haematite, calcite and white lead. The third layer due to a high fluorescence was difficult to analyse, only calcite could be detected.

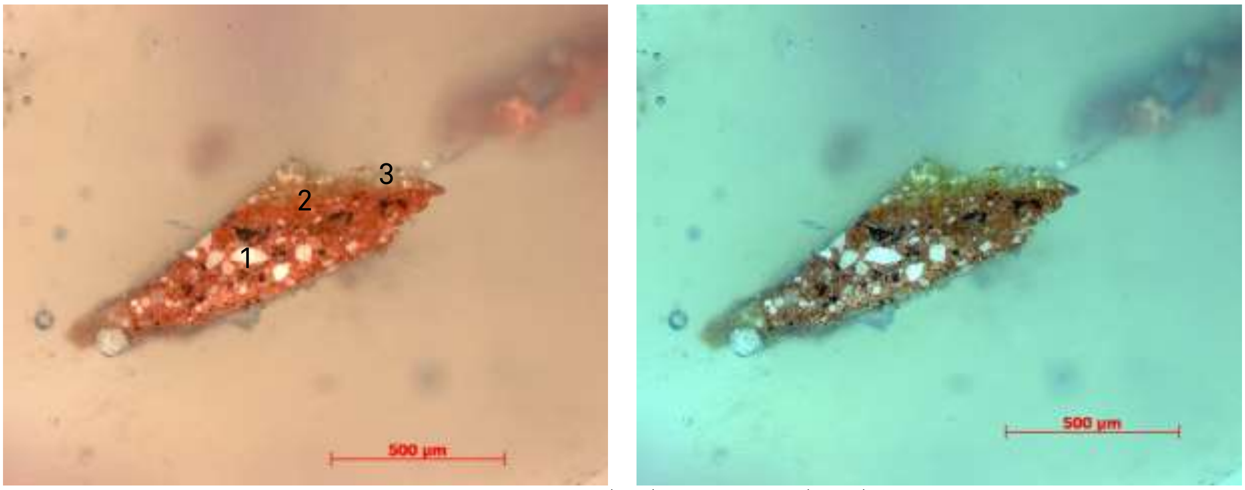


Figure 3.73: Stratigraphy of sample “Mu AT P3” visible (left) and UV light (right)

The cross section “MU AT P4” shows 9 layers (Figure 3.74). The first layer, light orange is mainly composed of calcite, barium white and iron oxide. The second layer, deep black and homogeneous is composed of magnetite (Cornell and Schwertmann; 1996; Froment et al., 2008; Hanesch, 2008). The Raman spectra obtained for the layers 3, 4, 5, 6 and 7 despite of the different colour are similar. Calcite and barium sulphate are present together with an uncharacterised pigment. Only calcium and barium could be detected by XRF analysis on those layers. Thus, it can be suggested that organic pigments was mixed with calcite and or barium white, in order to get those different colours. Due to the similarity of the Raman spectra obtained for yellow and green colours, it could be concluded that they are made with the same type of pigment which should belong to the phthalocyanine family (Aibéo et al., 2008). The eighth layer is similar to the second layer as well as the ninth to the first one.

The repetition of the succession of light orange, yellow-green, green and black layers was applied in order to get a marbled effect.

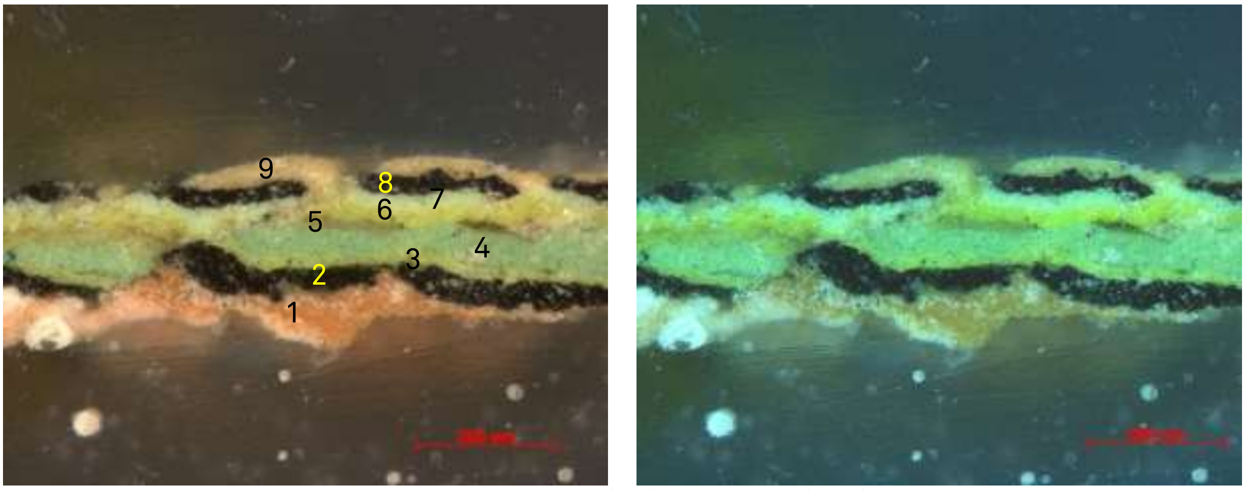


Figure 3.74: Stratigraphy of sample “Mu AT P4” visible (left) and UV light (right)

3.3.18.3 Conclusion/discussion

Due to the detection of Pb in different parts of the Altar (column, pillars) it can be concluded that paint layers were present. Perhaps a first ground layer was composed of gypsum and/or calcite due to the occasionally presence of Ca. Some traces of Zn were also detected in almost all spectra which could be due to modern painting.

Each cross section shows one of the polychrome phases that the altar experienced along his history. The altar is good documented with pictures, and the descriptions of the different polychromic ornaments are well known. As the first phase, the altar was red, than red “Mu AT P3”, green and beige. During the third renovation of the Basler Münster in 1852/1857 the Altar was moved to the Sankt Peter Church, were it get a new polychromy a black and white marble imitation “Mu AT P1”. In 1975, when the altar came back to the Basler Münster, it was covered with a green marbled painting “Mu AT P4”. At this time a freelance conservator was in charge to remove all the polychromies. As he could not entirely remove all the paintings, he applied some “touches” of red colours in order to unify the colour of the altar[15].

3.3.19. PB22 Blaue Hand einer weiblichen Skulptur

This is the hand of a female sculpture (Figure 3.75) which was found in 1974 during the excavation under the floor in front of the former jube. The stone is the Wiesentaler sandstone.

3.3.19.1 Results of the non-destructive analysis

The analyses were carried out with the ARTAX precisely, 21 spectra were acquired. The reference spectrum used for the evaluation of the acquired spectra with the ARTAX was taken on a place where the sculpture was broken in order to be sure about the absence of painting.

The palette of colour is flesh tone, yellow, gold, blue and black. Each of those colours was investigated.

The flesh tone is composed of essentially of Pb and in lesser quantity Hg. The yellow tone is made of Fe, Cu, Au, Pb and As and Ca. The gold tone is made of Au, Fe and Pb. The blue tone contains mainly Cu with in lesser quantities Zn, As, Pb and Ca. The black tone presents the same chemical element as the blue tone.

[15] Oral communication of Martial Lopez, an ancient work-master of the “Bauhütte”.

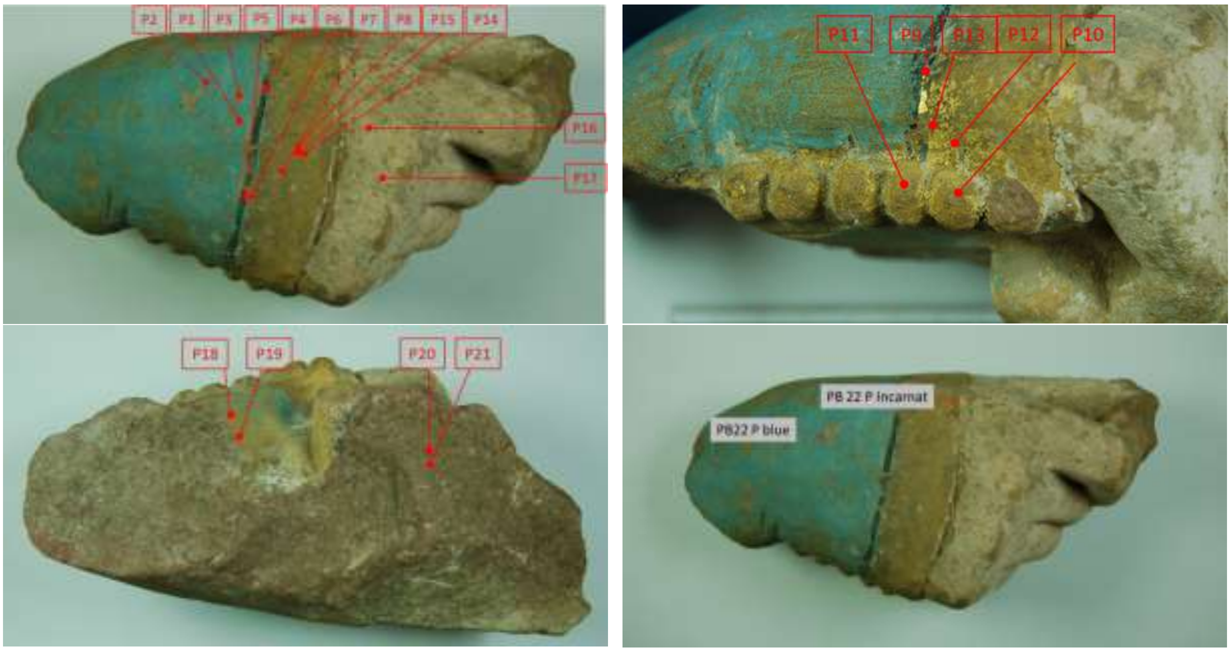


Figure 3.75: Localisation of XRF analysis and sampling for cross section on the hand PB22

3.3.19.2 Results on complimentary study on cross sections

Two samples were taken from the blue and the flesh tone painted parts (Figure 3.75).

The cross section "PB 22 P blue" shows 4 layers (Figure 3.76). The first layer, yellow, is mainly composed of goethite, massicot and calcite. The second layer is thin and black and it is made of black carbon. The third layer, which look like the first one, is thin and yellow, mainly made of calcite, massicot and yellow ochre. The fourth layer, blue, thick and homogeneous is made of azurite with some grains of calcite.

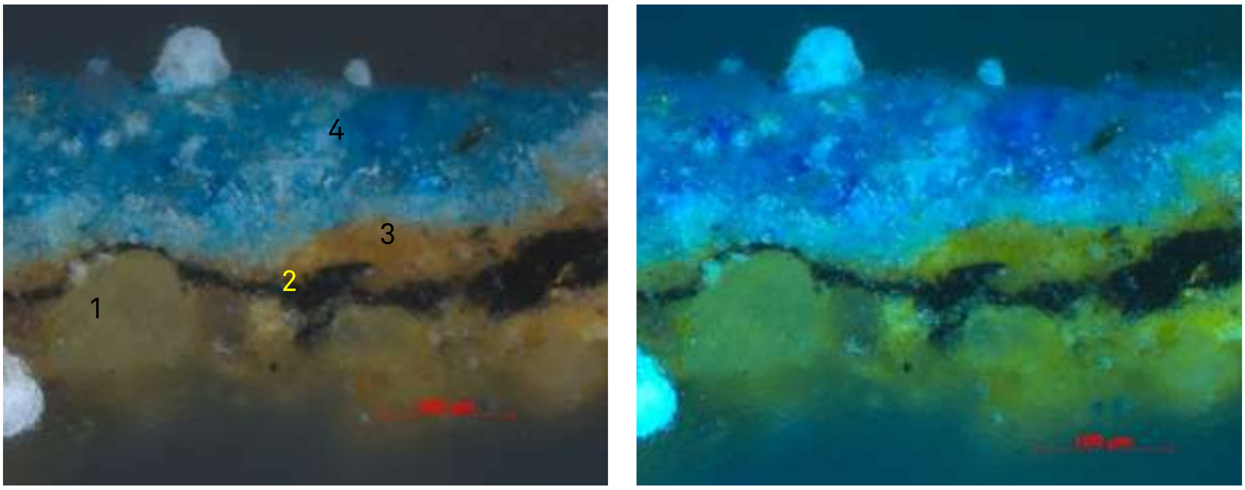


Figure 3.76: Stratigraphy of sample "PB22 P blue" visible (left) and UV-light (right)

The cross section "PB 22 P incarnat" shows 6 layers (Figure 3.77). The first layer, yellow, is mainly composed of iron oxide, minium, and calcite. The second layer, thin and white, was not identified because of the high fluorescence signal. The third layer, which is inhomogeneous, black, with some red orange grains is made of black carbon with red lead particles. The fourth layer, light brown was not characterised. The fifth layer, thin and yellow is mainly composed of iron oxide, minium, and calcite. The sixth layer, thin, white, with little red particles, consists mainly of white lead with few cinnabar grains and calcite.

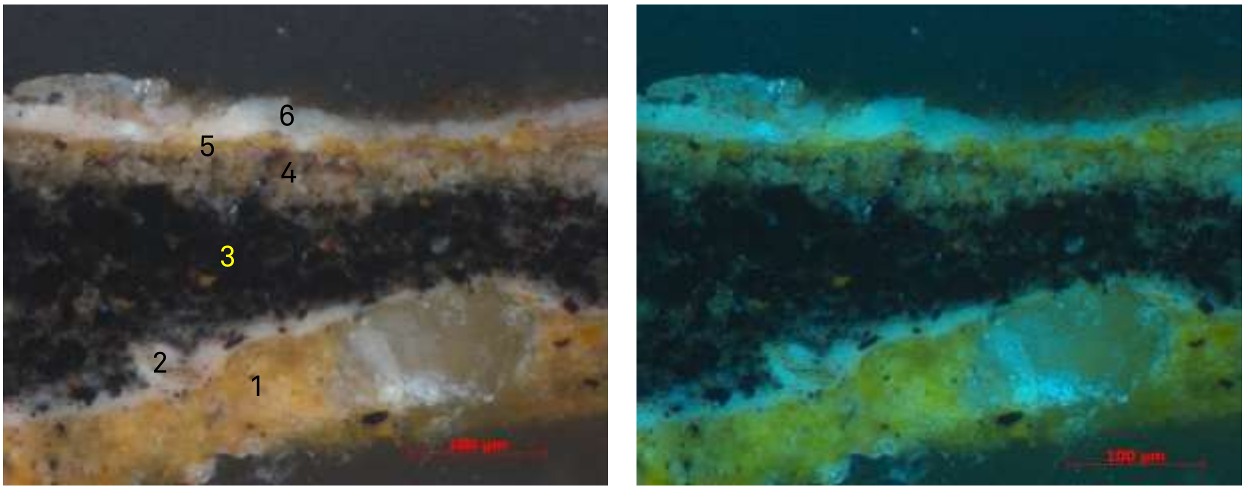


Figure 3.77: Stratigraphy of sample PB22 P incarnat visible (left) and UV light (right)

3.3.19.3 Conclusion/discussion

According to those results, the following hypothesis can be formulated on the stratigraphy of this hand.

The ground layer should be a mixture of calcite and iron oxide, probably goethite, and lead oxide (minium and/or massicot).

Flesh tone is made of a majority of lead white mixed with cinnabar.

The yellow tone is made with the same pigments as the ground layer. The presence of Cu, detected by XRF, is not explained.

The gilded part which contains Au, Fe and Pb, is a gold layer on a bolus made of iron oxide.

The blue pigment is azurite, mixed with a little of calcite.

The black is made of black carbon.

On the cross section only one polychromy can be observed and should be original.

It is possible to affirm that the palette of detected pigments on this hand belongs to a classical medieval colour palette.

The presence of As in some part of the polychrome hand is not clearly explained. It could come from orpiment, but this pigment was not detected in the cross sections.

3.3.20. PB23 Thronender Christus/Skulpturenfragment vom Tympanon des Hauptportals

This is a fragment of a bigger statue representing Christ being enthroned, formerly located in the main portal (Figure 3.78). It is composed of Wiesentaler sandstone.

Three XRF spectra were acquired. Two micro samples, as grains, were taken from rests of polychromy located in deep areas, in order to analyse them directly without any preparation with Raman spectroscopy.

3.3.20.1 Results of the non-destructive analysis

Although it general appearance is naked stone, some traces of polychromy can be found in hollow parts. The analyses were carried out with the ARTAX precisely, 3 spectra were acquired. The reference spectrum used for the evaluation of the acquired spectra with the ARTAX was taken on this fragment on a place where the sculpture was broken in order to be sure about the absence of painting.

The palette of visible colour includes red and blue. The red tone was composed mainly of Hg, than in lesser quantities Pb, Ca and S. The blue tone was made of essentially of Cu, than in lesser quantities Pb, Ca and S.

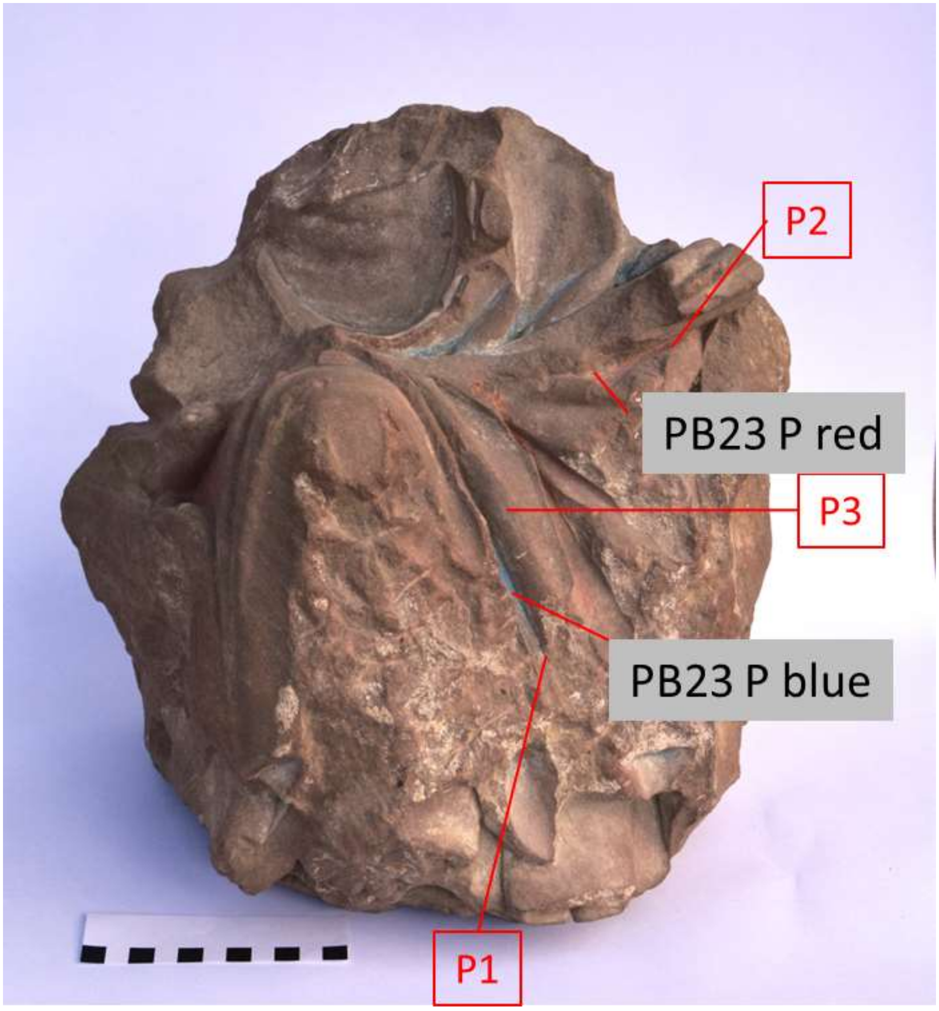


Figure 3.78: Localisation of the XRF analysis (P, ARTAX) and sampling for Raman spectrometry on PB23.

3.3.20.2 Results on complimentary study on pigment grains

Few blue grains were taken (Figure 3.78, “PB23 P blue”). They contain mainly azurite with in lesser quantities calcite and lead white.

Few red grains were taken (Figure 3.78, “PB23 P red”). They contains exclusively cinnabar.

3.3.20.3 Conclusion/discussion

The fragment of the Christ was polychrome. The visible palette of colour is blue made of azurite and red made of cinnabar. Some calcite and lead white pigments detected in grains as well as the detection in each measuring spot of Ca, S, Pb by the XRF measurement allow formulating the hypothesis of a ground layer made of gypsum and/or calcite, and that lead white was either mixed with blue pigments or applies as a second layer below the both blue and red layers due to his strong hiding effect.

3.3.21. PB28a Wandmalerei Triumphbogen, Dachboden

This huge wall painting, “Wandmalerei Triumphbogen, Dachboden” most probably showing Mary and the angel of annunciation and dated between 1270 and 1401.It is situated on the southern spandrel of the former triumphal arch that divides the crossing from the nave. When after the earthquake of 1356 the construction of new vaults in the transept was finished in 1401 this wall painting was only visible from the attic. Some remains of it were already mentioned and described by Stehlin (Stehlin/Wackernagel 1895, S.58). In 1999 the northern and southern spandrel was investigated by Urs Weber and Paul Denfeld under UV-light and some samples were taken.

Three samples were taken representing the whole perceptible chromatic palette (Figure 79). “DACH P1” was taken on the black painted contour of a vegetal ornament on the left. “DACH P3” and “DACH P4” were taken on the tunic of the standing figure on the right, “DACH P3” on the red part and “DACH P4” on a fragment of a gilded star on this red tunic.

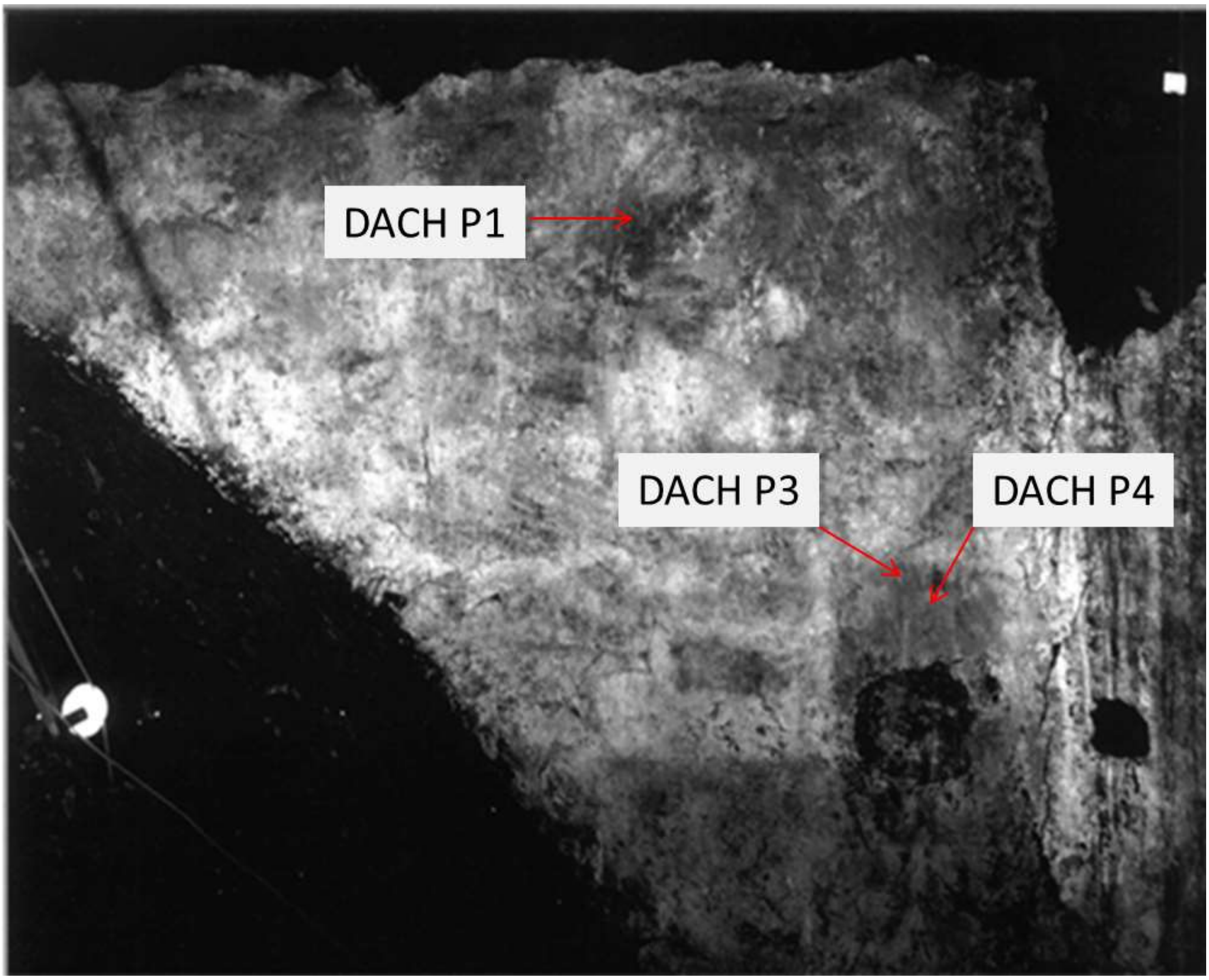


Figure 3.79: Localisation of the sampling for cross sections analyses on the BP28 illuminate under UV light (photo credits: Erik Schmidt).

3.3.21.1 Study on cross sections

The cross section “DACH P1” shows 2 layers (Figure 3.80). The first layer, inhomogeneous, thick, white and turquoise, is made of azurite, another copper pigments, probably atacamite, and black carbon. The second layer is inhomogeneous and black, is mainly composed of carbon black.

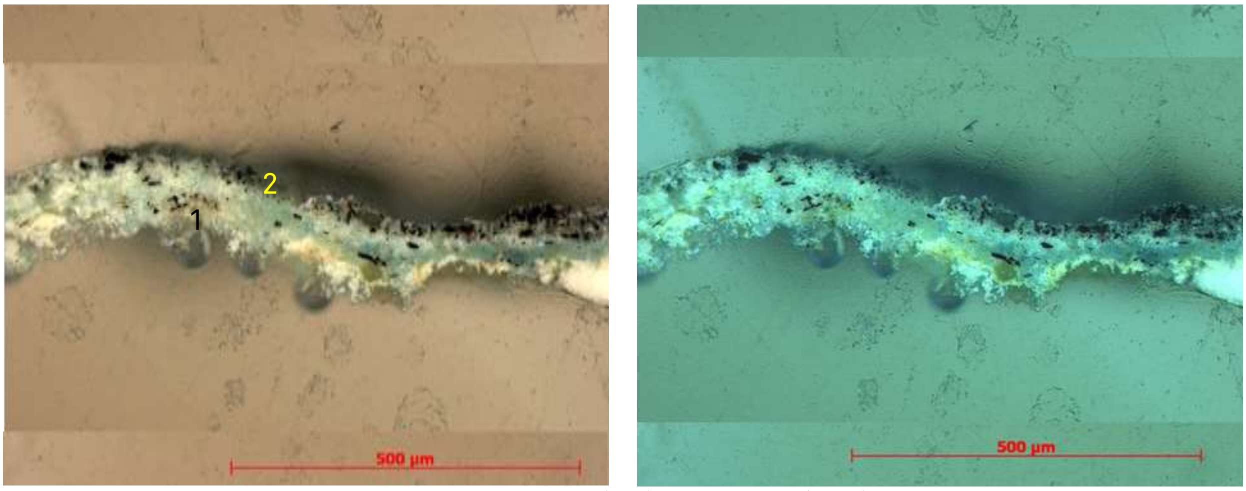


Figure 3.80: Stratigraphy of sample “DACH P1” visible (left) and UV-light (right)

The cross section “DACH P3” shows 2 layers (Figure 3.81). The first layer, light orange, could not be fully characterised due to the high fluorescence, only lead white and calcite could be identified. The second layer, inhomogeneous, thick, orange, is made of cinnabar, minium and massicot.

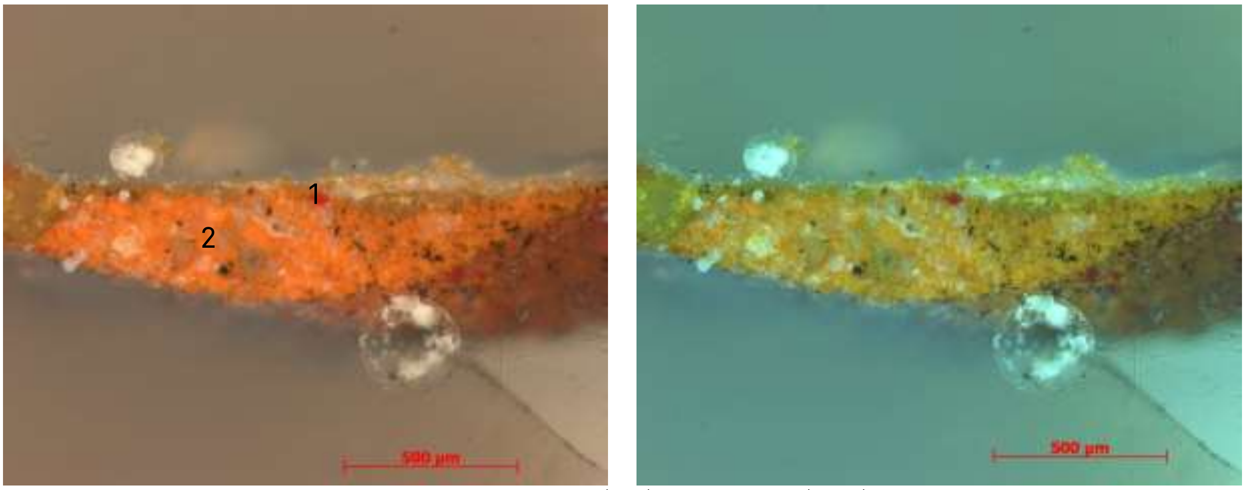


Figure 3.81: Stratigraphy of sample “DACH P3” visible (left) and UV-light (right)

The cross section “DACH P4” shows 3 layers (Figure 3.82). The first layer, inhomogeneous and light orange, could not be fully characterised due to the high fluorescence, only iron oxide could be identified. The second layer, inhomogeneous, thin, orange, is made of cinnabar and minium. The third layer, partially present consists of a gold leaf.

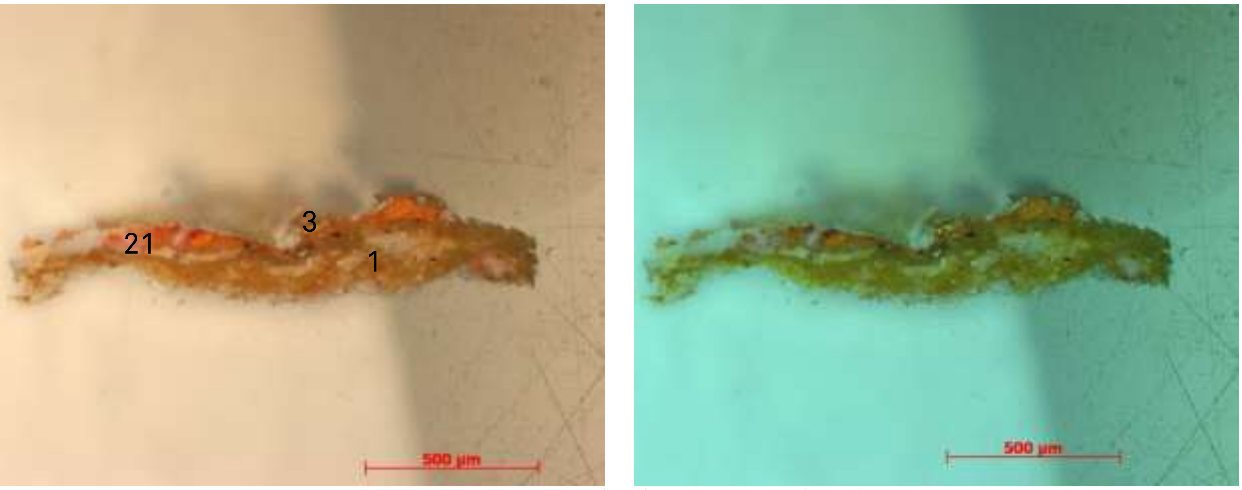


Figure 3.82: Stratigraphy of sample “DACH P4” visible (left) and UV-light (right)

3.3.21.2 Conclusion/discussion

The wall painting, “Wandmalerei Triumphbogen, Dachboden” was polychrome.

The visible palette of colour is blue-green made of azurite and other copper pigment such as atacamite, red and orange made of cinnabar, massicot and minium, black based on black carbon and contained a gilded part made with gold leaf.

It can be thus concluded that there is only one polychromy, consisting in a yellow layer, made of calcite, iron oxide and lead white, which could be considered a ground layer. On this latter different colour were applied. Gold leaf was used only in localised areas on the red gown of the figure.

These results clearly show that this is prober wall painting with the usual composition.

4 Development of an analytic method for the analysis of paint layer traces

As already discussed, in the post-Reformation period the aspect of the cathedral was totally changed and most of the painted layers (wall paintings, polychrome statues and architecture) were intensively cleaned in order to remove them. Two methods were used: a mechanical and a chemical one. As a final result most of the objects in the cathedral visually look as made of raw stone and if there is still some pigment left this is now considered as a trace[16]. In this way, the analysis of the polychromy is particularly difficult. For this reason, a specific task of this project (WP3) was dedicated to the analysis of traces. For this purpose some dummies were prepared and then investigated by XRF in the lab in order to understand the detectability of traces and if needed to set up an optimum measurement method to be applied in the field.

4.1 Bibliographic search of removal methods

To clean the walls and many of the sculptural objects of the cathedral, thick paint and plaster layers had to be removed in a very economical way. Two main methods were very luckily used according to the type of stone, a mechanical removal (for the Degerfelder) and a chemical cleaning (for the Wiesentaler)

For processing the surfaces of the coarse to medium grained, red to light grey banded Degerfelder sandstone (eg. PB9 Annagrab, Wall painting or PB28b Northern pillar) the choice thus fell on the so-called Stockhammer (bush hammer). This is a hammer-like hand tool with an interchangeable steel plate. Its surface reminds of a meat tenderiser with small tips. The impact of the bush hammer leaves small crater-like depressions on the surface of the stone and is normally used for single-planed, roughly pre-revised hard stones like marble and limestone. Usually, this tool is not used for sandstones because it can damage the stone surface so that as a consequence shell-shaped spalling can arise. Nonetheless, observations make clear that this practice was used consistently and its traces can be observed ubiquitous in the cathedral. By the firm hammering not only the remains of colour and plaster were removed but also most of the original medieval tool marks as well. The crater-like depressions appear as millions of small white dots that turn the natural red and grey character of the sandstones into a light greyish „bloom“- and it provides a very homogeneous and clean appearance (see Figure 2.1).

On sculptured objects of fine red Wiesentaler sandstone (eg. all tablets, PB4, PB5, PB6) this powerful method was no option[17]. It would have deeply damaged the neatly

[16] It is important to notice that here the word „traces“ is not used with the same meaning as in analytical chemistry; “traces” refers more to the visual appearance of the polychromy rather than to its amount.

[17] However there are evidences that, after the earthquake of 1356, Wiesentaler was also used as stone block for masonry; in this case treatment with bush hammer were conducted.

sculptured craftsmanship. Numerous observations undertaken during the project PolyBasel indicate that for those surfaces a chemical removal with the so-called soap stone (caustic soda) was chosen. Furthermore, it exist documentation about the use of soap stone for the colour removal at Georgs tower in 1880. The leach was applied on the paint coats with brushes, left for a few minutes, then rubbed and rinsed with plenty of water. For this reason only small residues with complete sequences of layers were preserved to the present day. Indeed, remains could only hold exclusively in hard to reach depths, undercuts, on curved or highly carved surfaces. Instead for smooth, flat areas, that could be rubbed vigorously with hard brushes or even wire brushes; usually only traces visible under UV-light remained. In addition to this treatment some objects, such as PB16 Baptismal Font and PB4 Tablet of St. Vincent were even reworked with sculptor tools to get rid of the colourization.

In this project, a practical experiment to simulate both removal methods was set up.

4.2 Conception of dummies

Two types of dummies were prepared to be used for two different set of experiments. All dummies were prepared on small blocks (≈5x5x2 cm) of Degerfelder and Wiesentäler sandstone.

A first set of dummies (5 for each stone type), so called “removal dummies”, was prepared in order to simulate a common polychromy and then proceed to its removal. This first type of experiment was set up in order to see if traces of pigments were detectable in the stone despite their removal.

A second type of dummies, named “haematite dilution dummies”, was created in order to access the analytical limitations of the XRF method. Indeed for most of the pigments present as trace, the possibility of detecting their constituting elements is linked to the detection limit of the spectrometer. To the contrary in case of pigments that contain Fe (e.g. ochre, green earth, Prussian blue) the limitation is bigger due to the fact that both stone substrates contains large amount of Fe (see section 3.2). It was thus important to determine how and to which dilution a distinction between haematite from the paint layer and haematite from the stone itself is possible by XRF. To be noticed that the results on the dummies are of great interest in the case of the study of the two objects which have no more visible polychromies, namely PB9-wall and PB28b whose analyses will be discussed in chapter 5.

4.2.1 Preparation of dummies

For the “removal dummies”, the imitated polychromy consisted in lead white, as ground layer, and haematite and malachite as separate colour layers. For all three pigments pure linseed oil was used as binder. All dummies were prepared on 5 sides (the frontal and the lateral ones) according to the following procedure. A primer of lead white was applied then let it dry for 48 hours. Afterwards, two 1 cm-wide stripes of malachite and haematite were painted (Figure 4.1). Samples prepared with this procedure were let dry first 10 days at the Basler Münsterbauhütte atelier, then 7 days in an artificial aging chamber at the Collection Centre of the SNM. The chamber is equipped with 10 “cool daylight” fluorescence lamps with 6500 K (T5 HE 28W/865 Lumilux by Osram) giving a total flux of 300-4000 lux. Climatic conditions were set at ≈23°C and 45% relative humidity.

After the drying, the dummies were treated using the main removal methods: Degerfelder sandstone were hammered using a similar tool as the one used in 1852/57 (hammer plate 4 x4 cm with 25 spikes) while the Wiesentaler dummies were leached with stone soap until no more polychromy was visible.

In order to prepare these dummies a deep reflection was carried out to establish, the force to be applied to successfully mechanical remove the polychromy, the optimal duration of the application of the chemical leach, the amount of water necessary to completely rinse out all excess of chemical treatment.

Figure 4.1: Dummies of Degerfelder (D4, left) and Wiesentaler (W4, right) prepared with a model polychromy

For the “haematite dilution dummies” small blocks of both Degerfelder and Wiesentaler were coated with a paint made of haematite and linseed oil at different concentrations. The highest concentration had a ratio of 1:10; then the paint was diluted by white spirit with steps of 1:1 repeated 10 times (Figure 4.2).

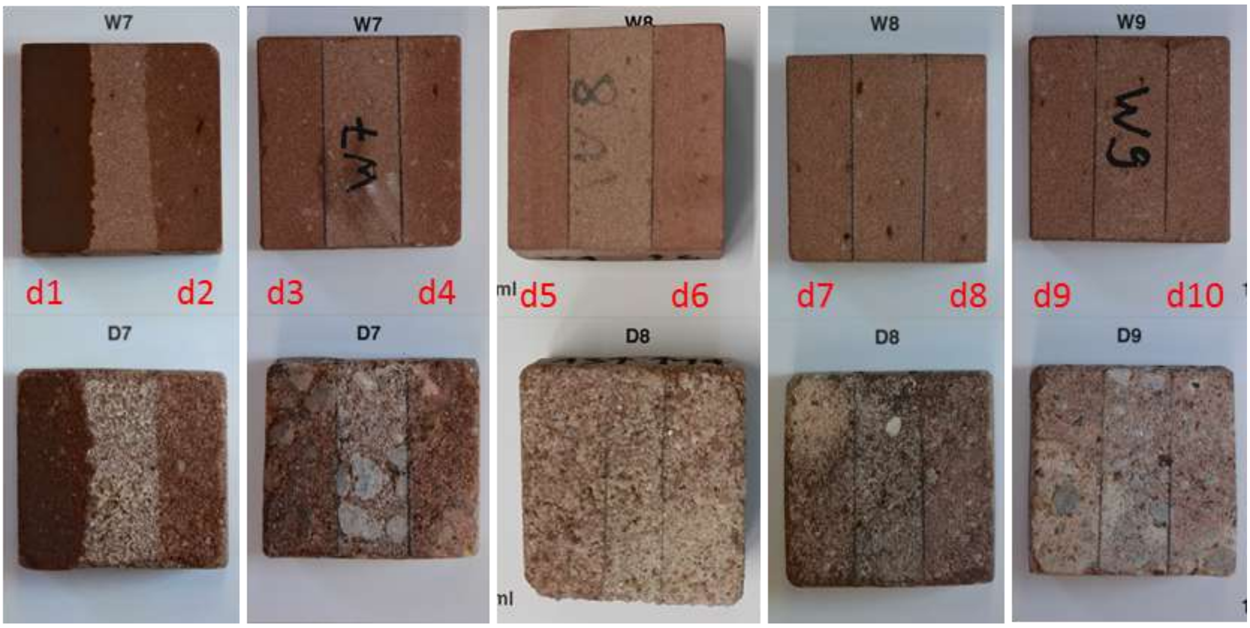


Figure 4.2: General view of dummies of Wiesentaler (W, top) and Degerfelder (D, bottom) on which different haematite dilutions (d1-d10) were applied.

4.2.2 Materials used for the preparation of dummies

The pigment used for the experiment were lead white (Kremer White Lead), malachite (produced at the Collection Centre), and haematite (unknown producer). The solvent was white spirit (Kremer Pigments) and the binder linseed stand oil without desiccant (Kremer Pigments). The used linseed oil is produced by blowing oxygen without any additives or heating[18]. Previous to use, white spirit and linseed oil were analysed by XRF (analysis on the residue after evaporation) in order to check the absence of impurities (such as Pb) which could affect the results.

All pigments were taken from the archive of the Conservation Research Laboratory of the SNM. They were ponded two weeks in linseed oil, manually rubbed on a glass plate and finally processed to colours. The painting was carried out with a fine natural hair professional brush, 10mm width. All layers were applied only once and always in the same direction to ensure comparability.

The pickling agent, the so-called soap stone, was made especially for this test, according to current historical recipe of the 19th century, using sodium hydroxide and sodium carbonate in the ratio 3:2 dispersed in water by the company Gehrig drugstore and colours, Lucerne[19]. The low-viscosity liquid (1 part pickling agent to 10 parts water) was applied with brushes, after 3 minutes rubbed vigorously with the bristle, and then amply rinsed with water until no colour remains were visible anymore.

[18] telephone information David Kremer, Kremer Pigments on 28.09.2015
[19] telephone counselling from Martin Gehrig, Gehrig drugstore and colours, Lucerne, on the 28.09.2015

4.3 Analysis on dummies

4.3.1 Methodology

Both types of dummies were analysed in the laboratory using XFR (ARTAX) using the general conditions those applied for in situ measurements: 50 kV and 600 μA.

For the "removal dummies" analysis were carried out in line scan mode.

Line scans on untreated dummies and on the Wiesentaler after chemical removal, were carried out from one paint layer to the other (Figure 4.3). Profiles were about 2 cm long (2.8 in the case of untreated Degerfelder), with spot distance of 0.2 mm, the number of measurement points oscillates from 104 to 141, duration 30 sec/point. In the case of the Degerfelder after mechanical removal, such long profile was not possible because, due to the irregularity of the surface, the X-ray beam would not be on focus at each single point. So in this case two distinct profiles were performed, both located astride from the removed paint layer (malachite or haematite) and the lead white ground layer. These two profiles were 6 mm long in total (3 mm on the paint layer/3 mm outside), spot distance 0.1 mm, with a total of 61 point and duration of 35 minutes.

Average net intensities of single element (Pb, Cu and Fe) were calculated per each section separately for the part with paint layer and for the part with lead white only.

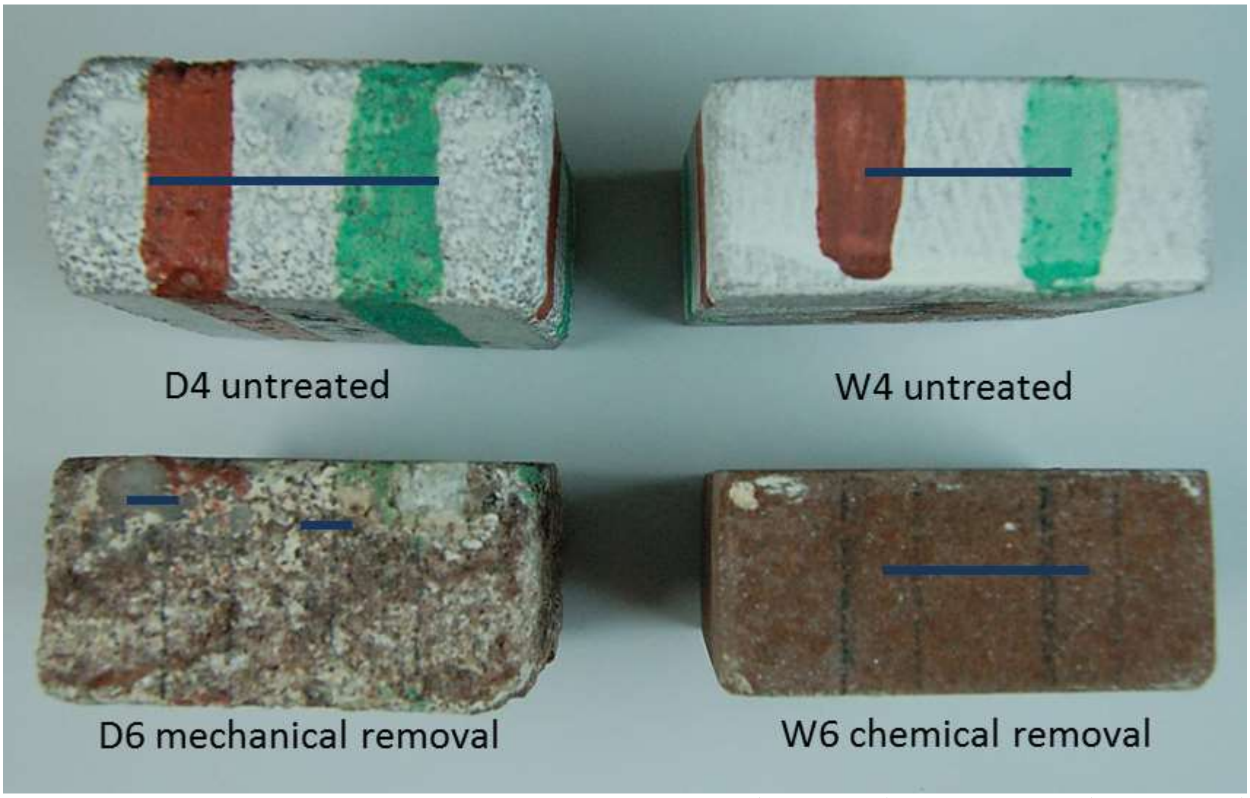


Figure 4.3: Localisation of the line scans performed on Degerfelder (D4, D6, left) and Wiesentaler (W4, W6, right) sandstones, untreated (D4, W4, top) and after paint removal (D6, W6, bottom).

To be noticed that the aspect of the surfaces of the stone after removal is quite different. On the Degerfelder mechanically removed, there is still some visible paint, while in the case of the Wiesentaler the surface looks similar to the untreated stone, perhaps only with a slight whitish aspect.

For the "haematite dilution dummies" a series of test has been set up to evaluate the most suitable methodology to analyse Fe traces. This methodology will be applied in situ to the two objects presenting no more visible paint layers (see Chapter 5). Indeed the focus should be put into the optimisation of a method adapted to Degerfelder sandstone (which is the stone found in both objects). Nevertheless, due to its extremely heterogeneous texture this task would have been difficult to achieve. Therefore, optimisation tests have been first developed on the homogeneous red Wiesentaler stone variety, than applied to Degerfelder substrata.

Among the different available dilutions, tests were carried out on dilution 6 (d6) as, it is still possible to perceive a slight chromatic difference between the haematite layer and the raw stone (Figures 4.4, as a comparison d7 and d8 are also shown in the picture).

The analyses were carried out in line scan mode. A fixed line of 2 cm was defined (1 cm on the stone and 1 cm on the haematite layer) (Figure 4.4, L1, left) over which several line scans were carried out, varying the number of total measurement points (50% on the stone, 50% on haematite) and duration of single analysis point (test results are summarised in Table 4.1). After acquiring a line scan, average Fe net intensities were calculated for the stone and the haematite layer respectively, then the difference (expressed in %) was calculated to estimate the Fe excess. By convention it was assumed that a positive difference shows an excess of Fe in the haematite layer, while a negative difference would testify of an excess of Fe in the stone. For this last point it has to be said that negative values are of course theoretically impossible, as when applying the haematite, the Fe content should be higher or at least equal to the stone (very high dilutions). However negative values are conceivable due the heterogeneity of Fe content in the stone (see section 3.2.1.1).

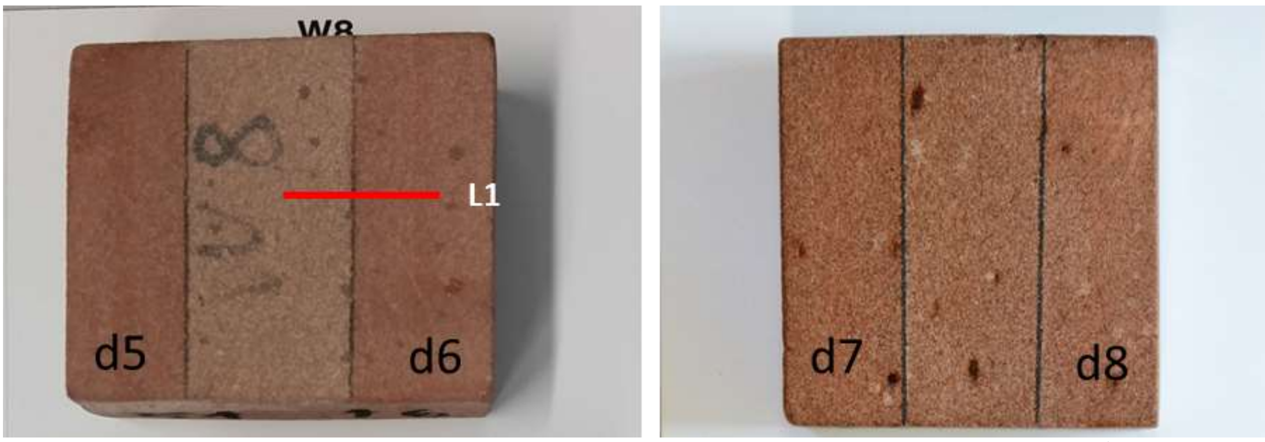


Figure 4.4: Detailed view of a Wiesentaler sandstone on which for haematite dilutions were applied (d5-d6 on the left, and d7-d8 on the right); and localisation of the position of a line scan (L1) for XRF analysis

The different tests carried out showed that low point measurements (Table 4.1, Figure 4.5), such as 10 points per each section (10 on haematite/10 on stone, 1 point each mm) lead to a very poor evaluation. Indeed the average Fe content between the two sections are not consistent, the first test (10-10 points, 60 sec/point) indicates an high excess of Fe on the stone, the second test (10-10 points, 300 sec/point) shows a slight excess on the haematite layer. This trend reflects the heterogeneity of the Fe distribution on the stone and shows that 10 points, 1 point each mm, are too few for a statistical sound evaluation.

Thus three new measurements were carried out incrementing the analysis step to 0.2 mm resulting in 50 points per sections. In this case, although the Fe signal oscillates quite significantly, the calculated Fe-excess is fairly similar (about 7.5%) for all three scans. 50 points per section seem to be statistically sufficient to highlight a difference between the stone and the diluted paint layer. These tests also showed that analysis time had more or less no influence on the results (Figure 4.6). Therefore, for security and time reasons, it was decide to perform the analysis of the Degerfelder dummies with 50 points per section, and duration of 30 sec. Results of the analysis are presented in section 4.3.2.

Table 4.1: Parameters used for the line scans on Wiesentaler stone with haematite dilution (d6), and calculated percentage of Fe excess in haematite paint compared to the stone (- values indicate a Fe deficiency in the paint)

Line	n. point stone/haematite	Step (mm)	duration/point (sec)	tot duration (h) theoretical (effective)	Fe-excess in haematite paint (%)
Test 1	10-10	1	60 sec	0h21’ (0h25’)	-50.4
Test 2	10-10	1	300 sec	1h45’ (1h26’)	3.5
Test 3	50-50	0.2	60 sec	1h52’ (1h35’)	8.4
Test 4	50-50	0.2	300 sec	8h30 (10h12’)	6.7
Test 5	50-50	0.2	30 sec	0h50‘ (1h00)	7.5

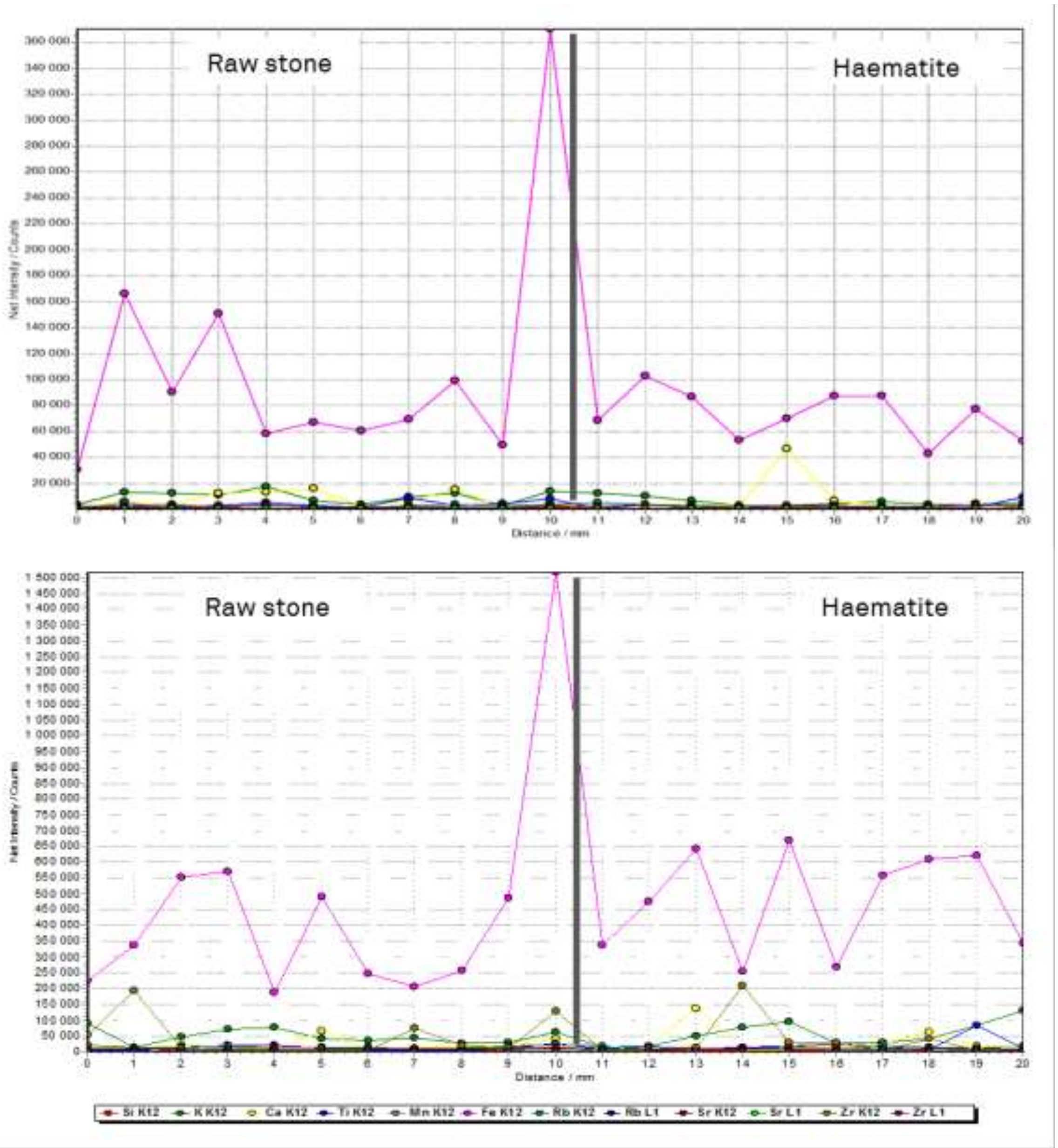


Figure 4.5: Line scanned obtained by XRF on Wiesentaler sandstone with a Haematite dilution 6, with analysis each mm and duration of single point measurement of 60 sec (top) and 300 sec (bottom). In pink Fe intensity profile.

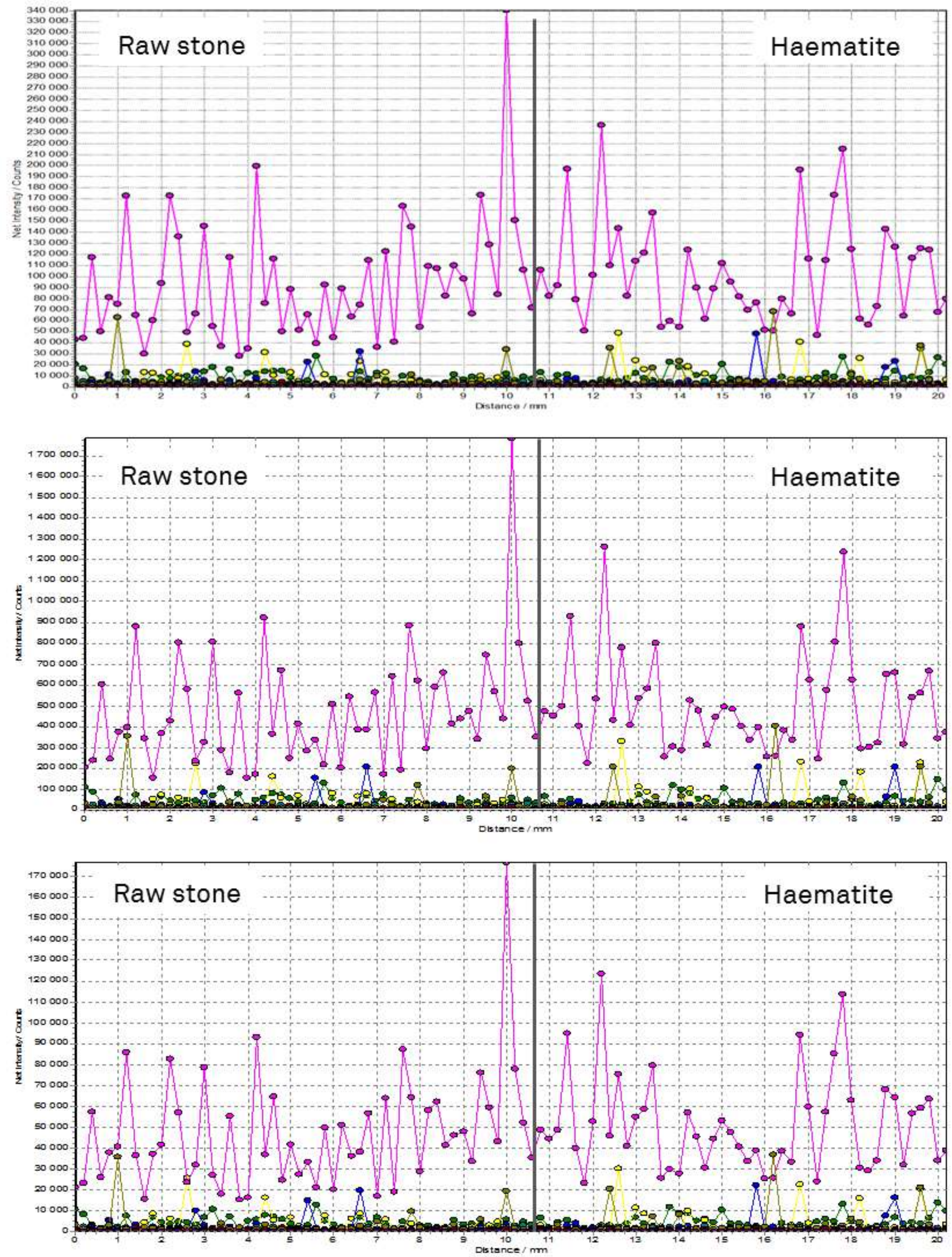


Figure 4.6: Line scanned obtained by XRF on Wiesentaler sandstone with a Haematite dilution 6, with analysis each 0.2 mm and duration of single point measurement of 60 sec (top) and 300 sec (middle) and 30 sec (bottom). In pink Fe intensity profile.

4.3.2 Results

4.3.2.1 Results “removal dummies”

The line scan performed on untreated Degerfelder show a coherent distribution of the 3 main elements, Cu, Fe and Pb (Figure 4.7). Fe profile presents high net intensities on the haematite (46 kcts average values), than decreases to 2.9 on the lead white and 1.5 kcts on the malachite layer. Cu presents high net intensities (on average 490 kcts) on the malachite layer than drop down to 500 cts in the other layers. Pb profile is more or less constant with an average of 300 kcts (slight lower intensities are detected below the paint layers and are due to the absorption of the Pb signal through the overlying layers).

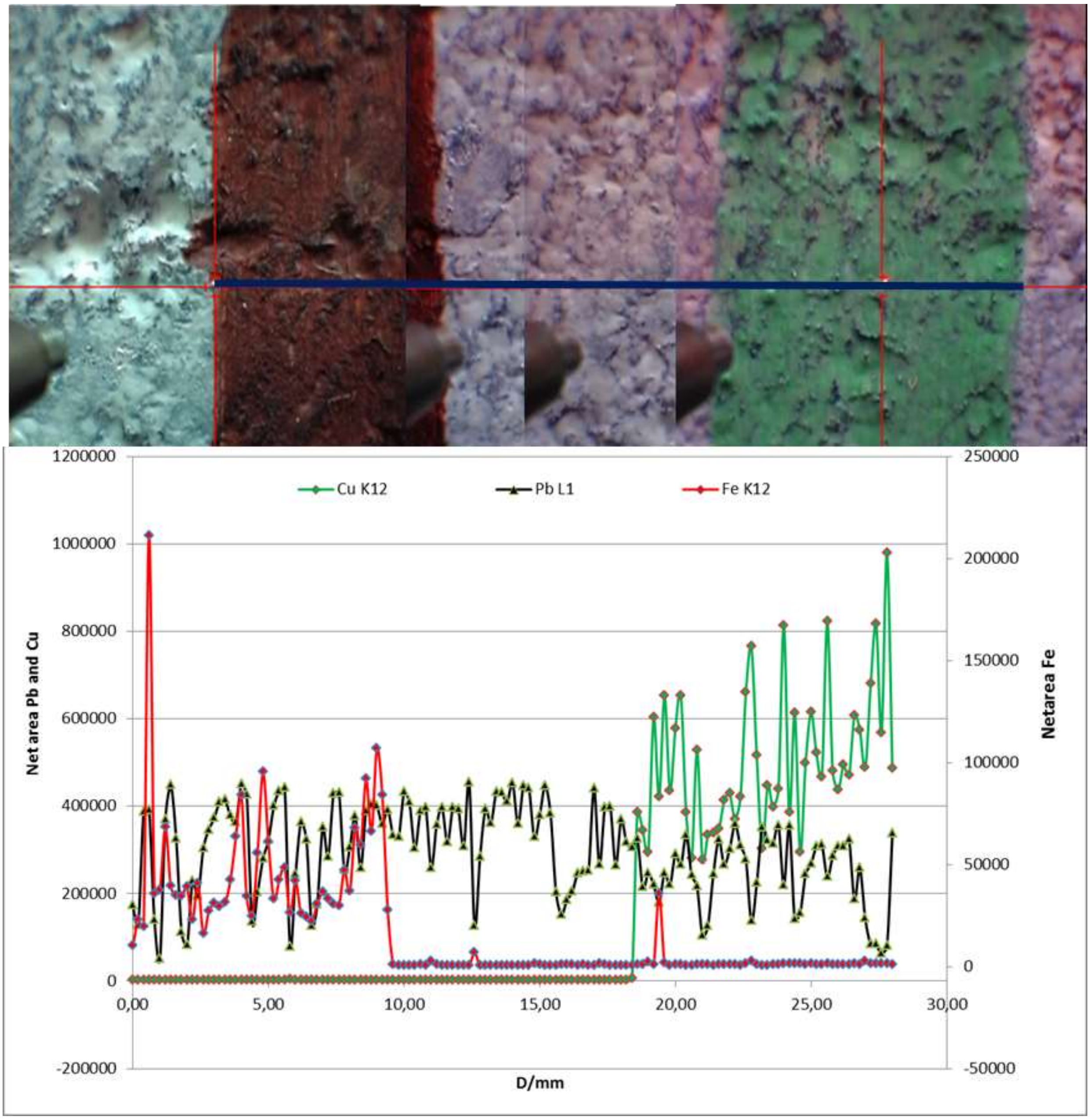


Figure 4.7: XRF line scan on the Degerfelder sandstone before removal and its localisation on the stone

The two line scans performed on Degerfelder sandstone mechanically treated are shown in Figure 4.8. The result for the malachite side shows that the Cu profile is more or less constant all along the line scan (green line Figure 4.6) its net intensity are in average 977 cts on the lead white side and 1700 on the malachite layer. Pb profile varies along the line scan, with average net intensity reaching up to 390 kcts on the lead white side and with average of 95 kcts and 53Kcts respectively on lead white and malachite side. The Fe profile is also quite oscillating with average net intensities of 19kcts and 32 kcts respectively on lead white and malachite side. Compared to the untreated dummy the treated one has much lower concentration of Cu, although still detectable as traces, and Pb content which can be in some spot as high as the in the untreated surface. Because of the heterogeneity of Fe content in the stone, no conclusion can be drawn.

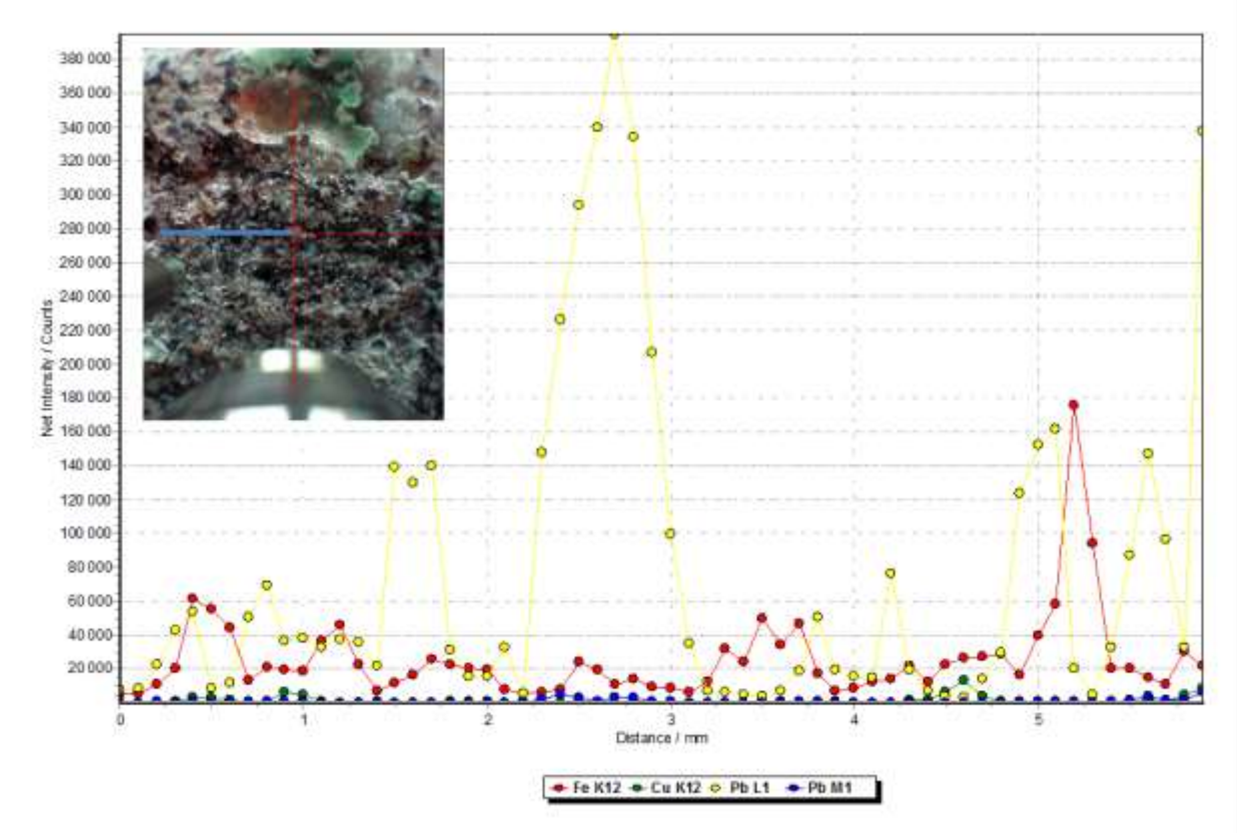


Figure 4.8: XRF line scan on the Degerfelder sandstone performed from the lead white ground coating towards the mechanically removed malachite layer and its localisation on the stone

The result for the haematite side show Fe profile reaches the highest intensity (33 kcts) where the haematite layer was removed (red line, Figure 4.9), also the average intensities are much higher in this part (39 kcts) compared to the lead white side (800 cts). Pb profile oscillates in a smaller extent and the average net intensities lay similar on the two sides (3.1 kcts on the lead white and 3.3 kcts on the former paint layer). The Cu profile stay quite constant with very low counts (200 cts for both section) all over the line scan. As the profile is performed on a quartz grain, no direct comparison with the untreated surface is possible, but it likely to affirm that the detected Fe and Pb come from the former pigments.

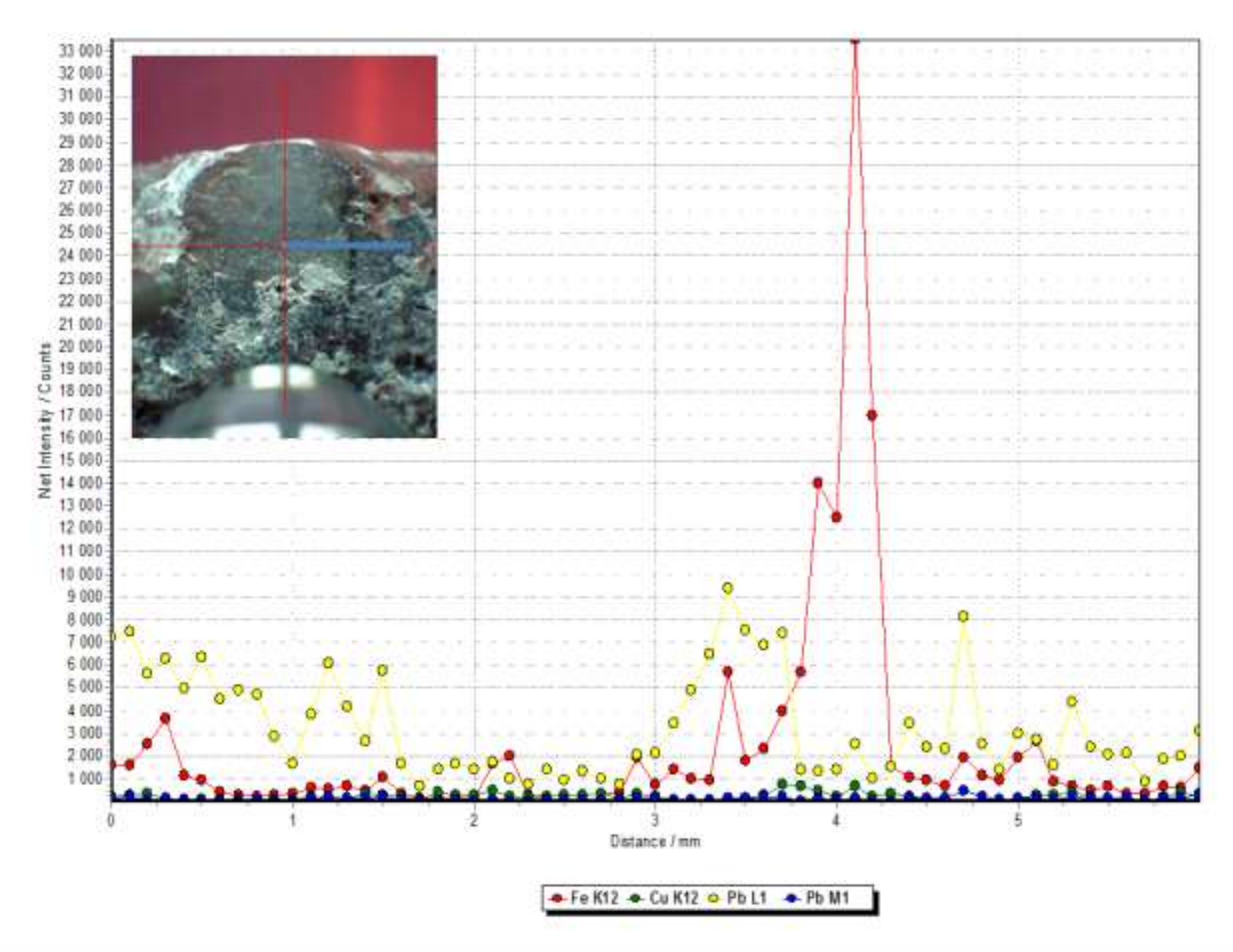


Figure 4.9: XRF line scan on the Degerfelder sandstone performed from the lead white ground coating towards the mechanically removed haematite layer and its localisation on the stone

For the line scan performed on the Wiesentaler before chemical removal (Figure 4.10) the Fe profile presents soundly the highest average net intensities on the haematite layer (73 kcts) and more or less the same average intensity in the other two layers (1.7 kcts in the ground layer and 1 kcts on the malachite one). Cu distribution is also quite logical with the highest average net intensity on the malachite layer (420 kcts), 1.2 kcts in the ground layer and 386 cts on the haematite one. As for the Pb, its profile lays more or less constant all over the line scan; average intensities are about 370 kcts on the lead white and decrease slightly, because of the absorption, in the other two layers.

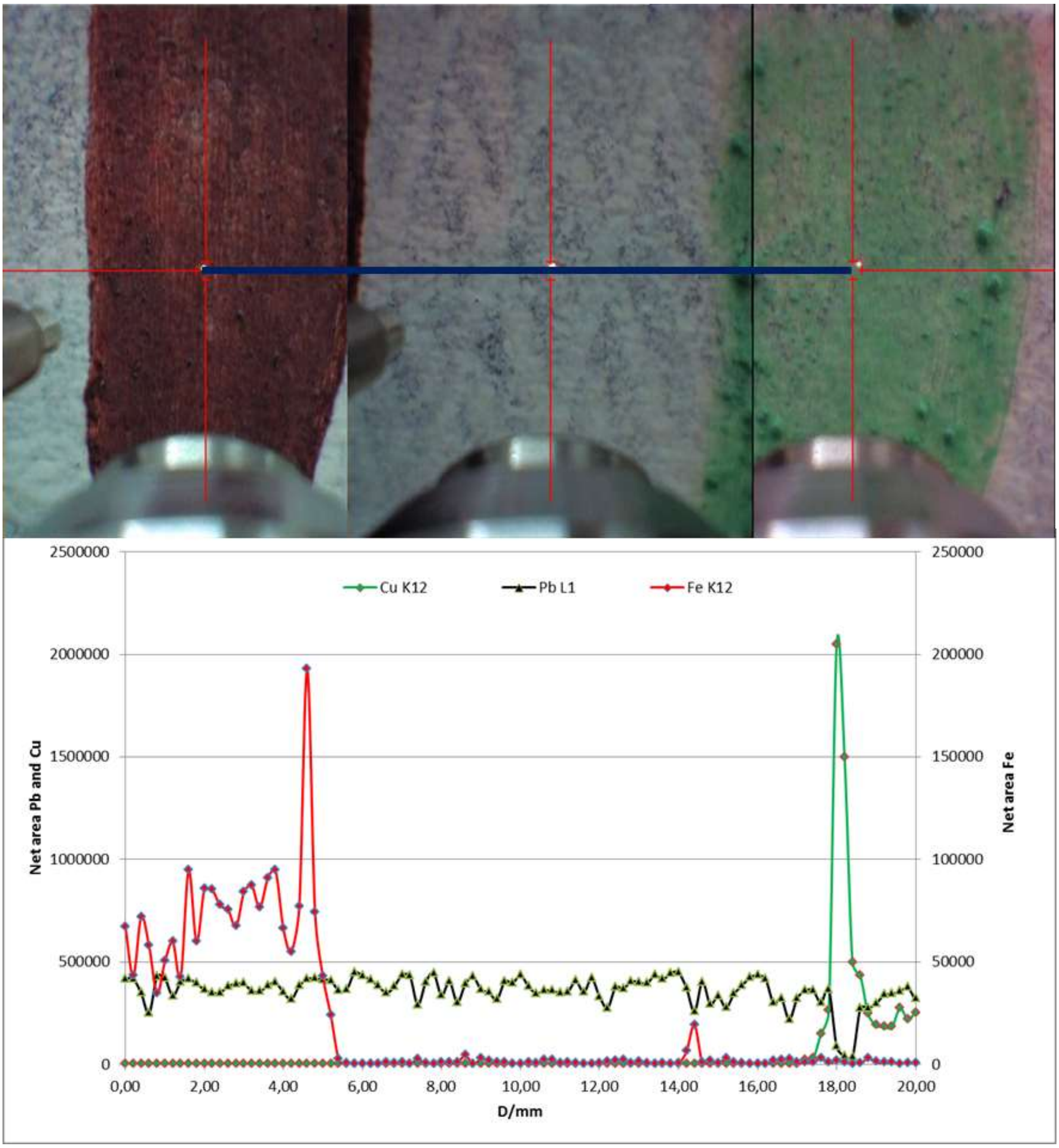


Figure 4.10: XRF line scan on the untreated Wiesentaler sandstone performed from the haematite layer to the malachite and its precise localisation

Line scan performed on the Wiesentaler after chemical removal (Figure 4.11) shows that the Fe profile has a fairly homogeneous distribution, with average net intensities oscillating from 46 to 41 to 34 kcts on the three encountered layers. Compared to the untreated dummy Fe intensities have decreased of 1.5 times in the haematite layer, but increased more than 25 times in the others two. This trend indicates a redistribution of the haematite pigments on all treated surface. As for the Cu the distribution decreases from the removed malachite (2.6 kcts) towards the lead white (1.2 kcts) to the haematite layer (600 cts). These two last values are similar to those evaluated on untreated samples. Although Cu content on the removed malachite has decreased a lot, it is still possible to detect it as traces. The distribution of Pb is again quite homogeneous (if absorption is taken into account) in all line scan. The average net intensities diminish from the white layer (9.7 kcts) to the malachite layer (6.7 kcts) to the haematite layer (3.1 kct). As for Cu, Pb has strongly decreased but it is still detectable.

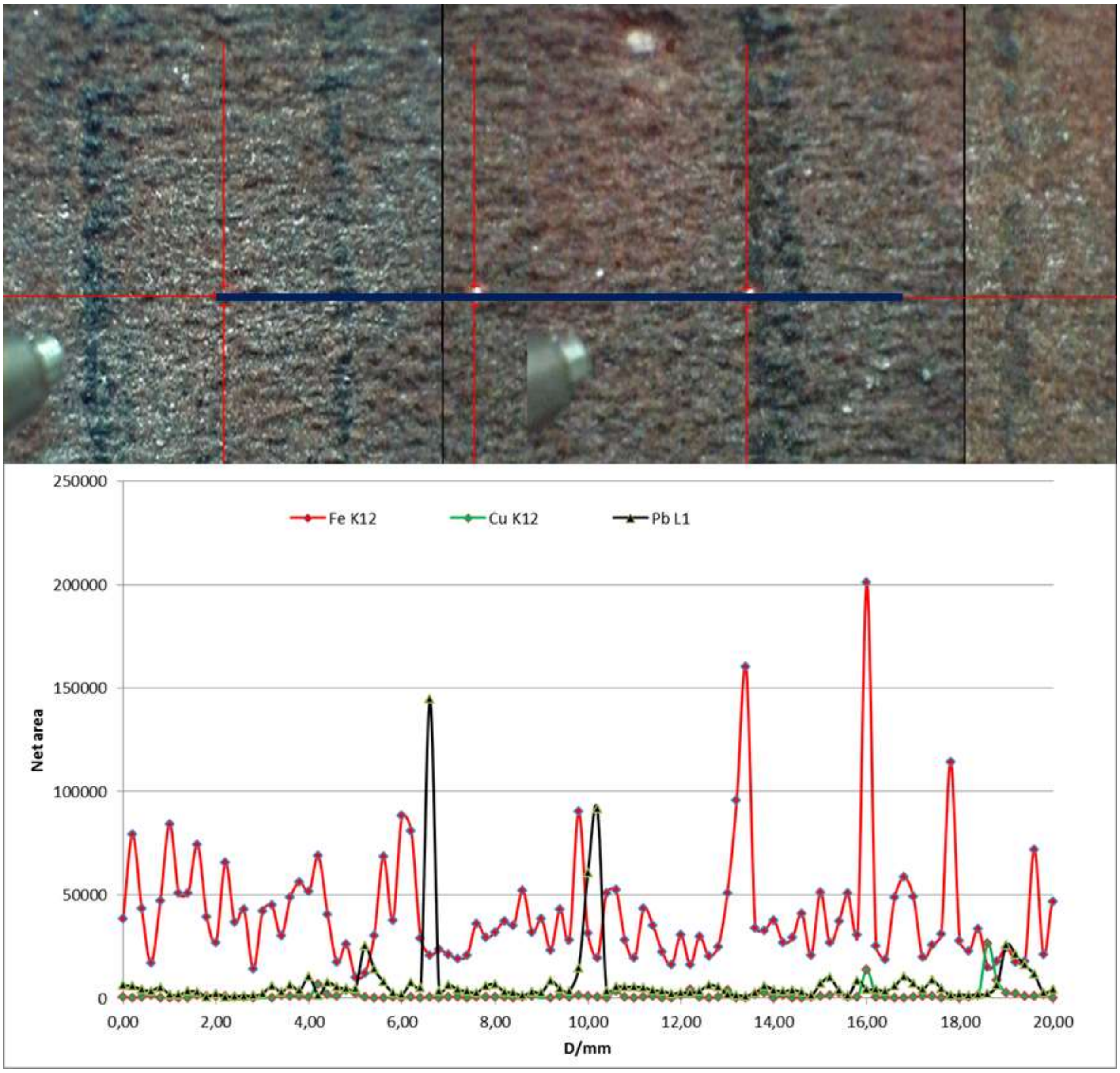


Figure 4.11: XRF line scan on the chemically treated Wiesentaler sandstone performed from the removed haematite layer to the malachite and its precise localisation

4.3.2.2 Results "haematite dilution dummies"

According to the test discussed in section 4.3.1, analysis were performed on the "haematite dilution dummies" made of Degerfelder sandstone, using the following conditions: Line scan mode, 2 cm long (1 cm in on the coloured part, 1 cm on the raw stone), 50 point each section, 0.2 mm spot distance, 30 sec/point, total duration 50 min (1 hour including dead time).

Analyses were carried out starting with the lowest dilution (d1) towards higher ones, incrementing one by one, until no more differences were detectable by XRF. Results are summarised in Table 4.2 and Figures 4.10 and 4.11).

On dilution 1, three line scans were run, showing clearly a strong enrichment in Fe on the haematite layer (minimum 92% Fe excess). On dilutions 2 and 3, 2 out of 3 line scans highlighted a Fe excess. However in both cases one line scan presented negative values. To understand this behaviour a close look at the location of the profiles was given, showing that both profiles with positive values (Fe excess) presented at least a medium to coarse grain on either side (haematite or stone), while negative values corresponded to profiles taken on matrix rich area (no big grain).

This ascertainment could be explained by the fact that the big grains, which are in most of the case quartz (and in a lesser extent Feldspars or lithic fragments), do not contain Fe (or they contain really low amounts as compared to the stone matrix) so they can be useful for the analysis of stone with low dilution. Indeed, if analysing on quartz grains it is possible to limit the contribution of Fe coming from the Fe-rich matrix and it should be easier to highlight the difference between the stone and the haematite layer. To prove this hypothesis some analysis on specific quartz grains were carried out (an example is given in Figure 4.11). These tests confirmed that line scans performed on big grain located on the raw stone present very low Fe content, while when analysing grains on haematite layer the present high Fe content.

Due to these finding, line scans performed on further dilution (higher than d4) were accurately chosen in order to contain some grains on either part, for this reason sometimes only 2 line scan were performed on stone contains only few inclusions. Results show that it is possible to highlight Fe-excess until dilution 6.

Table 4.2: Percentage of Fe excess in haematite paint compared to the stone measured on different haematite dilution on Degerfelder sandstones (- values indicate a Fe deficiency in the paint)

Dilution	Line 1	Line 2	Line 3
d1	92.3%	98.2%	92.2%
d2	64.2%	-3.9%	27.6%
d3	72.5%	-22.5%	68.5%
d4	97%	14.2%	79.6%
d5	27.5%	52.6%	-
d6	11.7%	29.9%	-
d7	-9.7	-16.7%	-

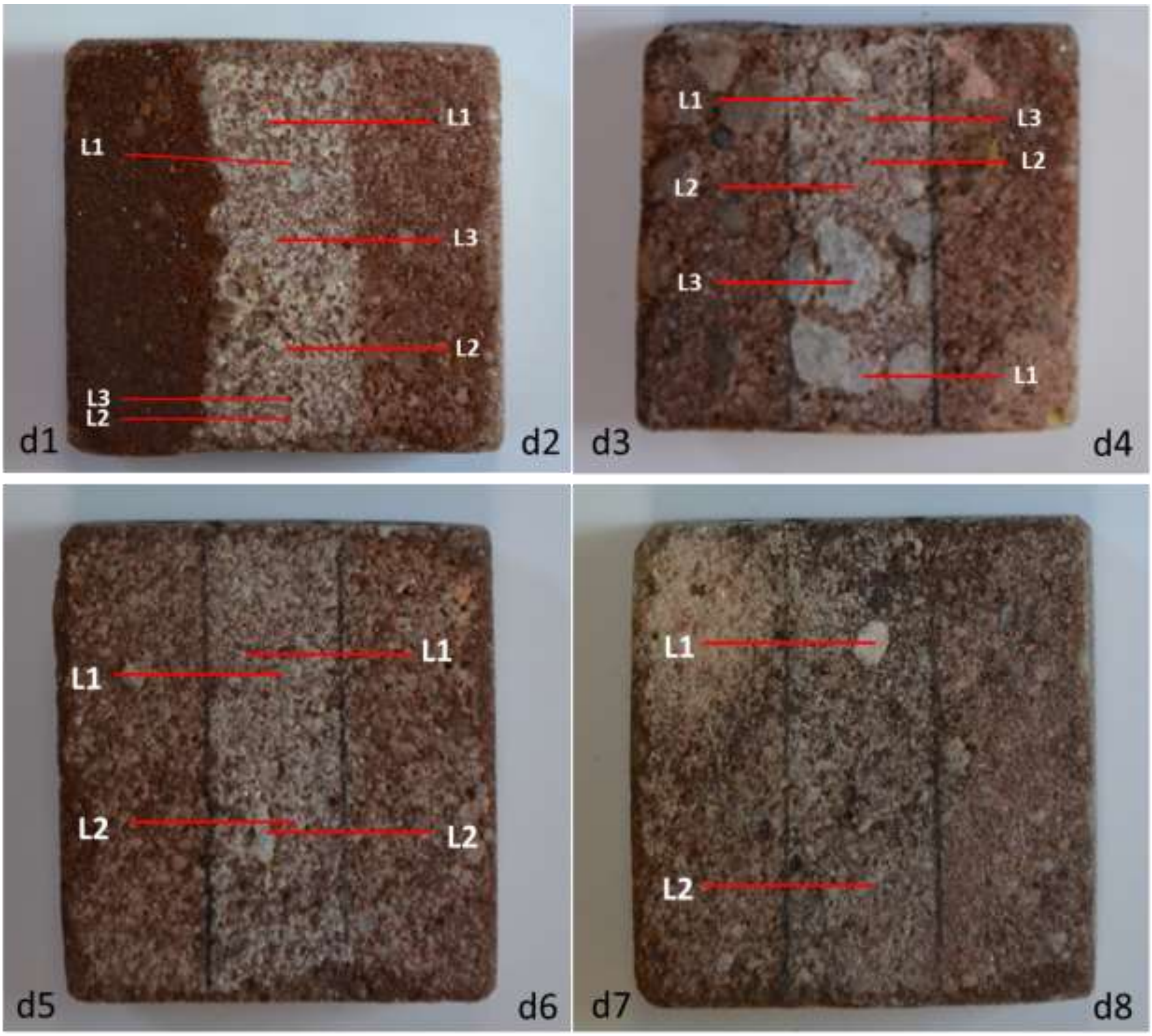


Figure 4.10: Position of XRF line scans performed on Degerfelder sandstones with different haematite dilutions

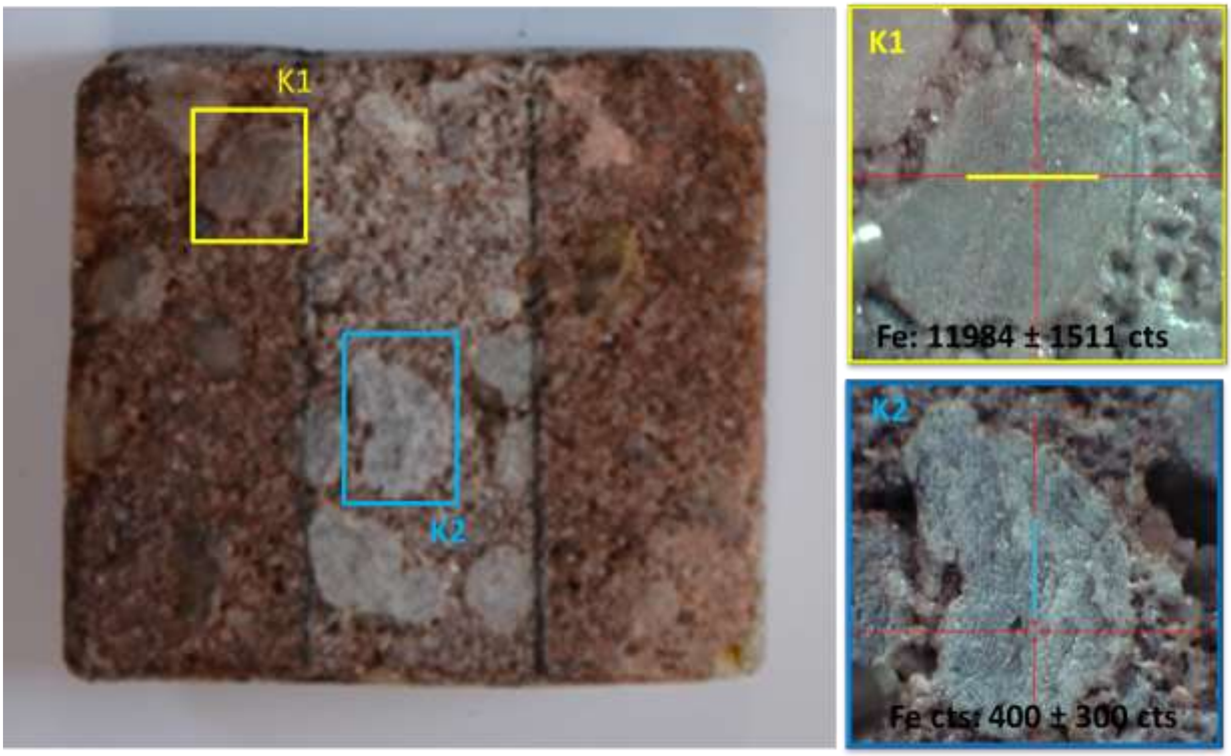


Figure 4.11: Position of XRF line scans performed on quartz grain present on Degerfelder sandstone: on haematite dilution 3 (K1, top right) and on the raw stone (K2, bottom right).

4.4 Conclusion

Experiments performed on the removal of paint layer ("removal dummies") shows that the two treatments lead to a totally different aspect of the surface. In the case of the mechanical treatment, the surface became obviously very irregular, and although the paint layer is overall removed, some localised fragments are still visible. In the case of chemical removal the treatment seems visually more efficient, as no paint is still visible except for a slight whitish appearance.

XRF analysis showed that in the case of chemical removal, it is possible to detect traces of Pb and Cu and high amount of Fe. A mixing of pigments it also highlighted especially for haematite and in a lesser extent for lead white and malachite. In the case of the mechanical removal, traces of elements can be found close to their original position (Cu close to malachite, Fe close to Fe, Pb everywhere). To be noticed that the mechanical treatment increasing the roughness of the surface, has as a consequence that it is almost impossible to perform long profile on the treated surface as most of the point would be out of focus.

Some technical considerations have arisen from the practical work performed during the removal of paint layers on Wiesentaler sandstone. A lot of water is required to rinse and wash away the chemical treated stones, indicating that most mobile or objects dismantled in 1852/57 (eg. the tablets, Bishop`s seat) were leached. On the contrary permanently installed objects, which are difficult to access or mounted at high levels (eg. keystones, ribs, crockets and funerary monuments) are therefore not flushable and were re-painted instead.

The haematite dilution test allowed setting up an ideal methodology to apply in the field. Analysis should be run in line scan mode, with a small step measurement in order to obtain a high number of points. Measurement per point as short as 30 sec are sufficient to obtain good results, therefore if will be possible to run several line scans per day during the field campaign. Optimally line scan should include both the “naked stone” and the “pigment layer” (or rather what is guessed to be remains of a pigment layer). Finally, to limit the signal coming from the Fe-rich matrix of the stone, line scan should be positioned on quartz grains.

5 Application of the optimised measurement method developed in WP3 to in situ XRF analysis of paint layer traces in Basel Cathedral

5.1 Choice of object studies

Observations repeated over the year by Bianca Burkhardt led to the hypothesis that wall paintings were present in specific locations of the cathedral. These observations were mainly carried out using a small UV-light pocket lamp. Indeed, UV-light observation allows discriminating areas with strong UV-fluorescence (dark areas), which contain rest of organic binder, from those with no fluorescence (light areas) (Figure 5.1). Unfortunately, this kind of lamps cannot be used of wide areas, so that only fragmentary imagining was possible.

Figure 5.1: Visualisation of traces of organic binder using a UV-light pocket lamp: area presenting UV-fluorescence (dark violet areas) correspond to zone where organic binders are still present.

During the PolyBasel project an intense field campaign took place using high-resolution SLR camera equipped with steep band-pass filter allowing observations of very wide surfaces. The campaign was led by Dr. Peter Fornaro, head of the “Digital Humanities Lab und Projektleiter "SNF-Digitale Materialität“. High resolutions digital pictures were taken in several locations in the Cathedral showing the presence of rests in few places like high choir, pillars of the nave and wall of the ancient sacristy. Among these, two locations were chosen for further investigations on polychromy traces, namely the wall behind queen Anna of Habsburg (PB9) and the pillar no. 4 (north) in the main nave (PB28b). Both wall paintings were executed on Degerfelder sandstone.

Figure 5.2: General view under UV-light of the wall painting overlying the queen Anna’s tomb. Collage obtained by sticking together two images with a slightly different focal plan (photo credits Peter Fornaro).

Figure 5.3: General view under normal (left) and UV-light (right) of the 4^{th} pillar (north) of the central navy (PB28b) (photo credits Peter Fornaro).

5.2 Analytical methodology

Investigations on the walls were carried out mainly using XRF technique; attempts with portable Raman and FTIR[20] were carried out but were unsuccessful. For XRF analyses were carried out with ARTAX and Niton® Spectrometers (for technical specification see section 3.2.1).

At first the ARTAX was used and analysis were performed applying the methodology developed in chapter 4, that is to say, line scan mode, 30 sec/point, with long scans (≈2 cm), small spot distance (resulting in high number of point), preferentially line scan should have been carried out half on the "pigment trace" and half on the "naked stone", in area presenting quartz grains. Three profiles (21 mm, 0.15 spot distance, 141 points in total, 30 sec/point) were thus acquired on PB28b. Unfortunately, these highlighted the presence of several constraints preventing the applications of this methodology. Indeed, the two walls was presented a very high roughness (certainly due to the mechanical removal of the paint by bush hammer) precluding the possibility of acquiring line scan on long lines. In addition, as the position of line scans was driven by the presence of UV-fluorescence (see Figures 5.1

[20] Raman and FTIR analyses were kindly carried out by M. Marc Dupayrat (Apc-Solution, Lonay) and M. Peter Stark (Portman Instruments, Biel-Benken) respectively.

to 5.3) the localisation on quartz grains was more difficult to take into account. Furthermore, observations in the field showed that the stone used on the two walls contains much less quartz grains compared to the one used for the laboratory test (in agreement with description section 1.3). For this reason, the acquisition of small measurement maps (2x4 mm, 0.5 spot distance, 45 points in total) was preferred. Due to their very small size, and taking into account the fact that the UV-fluorescence is usually seen in a quite diffused area, the localisation of maps at the border stone/traces was unmanageable. Thus maps were performed preferentially inside in the interior of dark or light UV zones. Finally it is important to notice that the interpretation of both line scans and maps was carried out in “accumulation mode”, that is to say that for each line or map, all acquired spectra were added to obtain a single comprehensive spectrum. In this case, no reference spectra were acquired and the evaluation is made by comparing spectra to each other, leading to some problem for the determination of Fe.

Due to the long duration of the analyses performed with the ARTAX, after a week of campaign only a limited number of analyses were carried out. In order to extent the analysis to a wider area, supplementary spectra were taken using the handheld Niton®. In this case, as the instrument was rented for a limited amount of time, no optimisation was performed in the laboratory. The spectrometer was used in the same conditions as described in section 3.2.1.2. Interpretation of spectra was made by comparing them to the reference spectrum obtained in the laboratory on Degerfelder sandstone.

5.3 Results

Results obtained with the ARTAX (both in line scan or map modes) and with the Niton® are discussed together in the following sections.

5.3.1 The tomb of Anna von Habsburg (PB9)

Analyses are presented in two sections one for each part of the wall painting.

On the left part (Figure 5.4) 8 spectra and 5 maps were taken on the two characters, which should represent a “canon” to the left and a “saint” to the right.

All spectra present traces of S, and variable amounts of Ca (all in excess compared to the reference stone) and Pb. No correlation has been found between the intensity of Ca and Pb signal and the location in the paint (outside or within areas with UV-fluorescence). On 4 maps and one spectrum, all located on the robe and on the upper part of the body of the saint, traces of Cu have been detected. As for Fe, it is present in 4 spectra (2 times in trace amount) 3 of which are located on areas presenting strong UV-fluorescence, namely on the robe of the canon (sp. 285 and 286), and on his headgear (sp 288). Cl traces were found only on 1 spectrum.

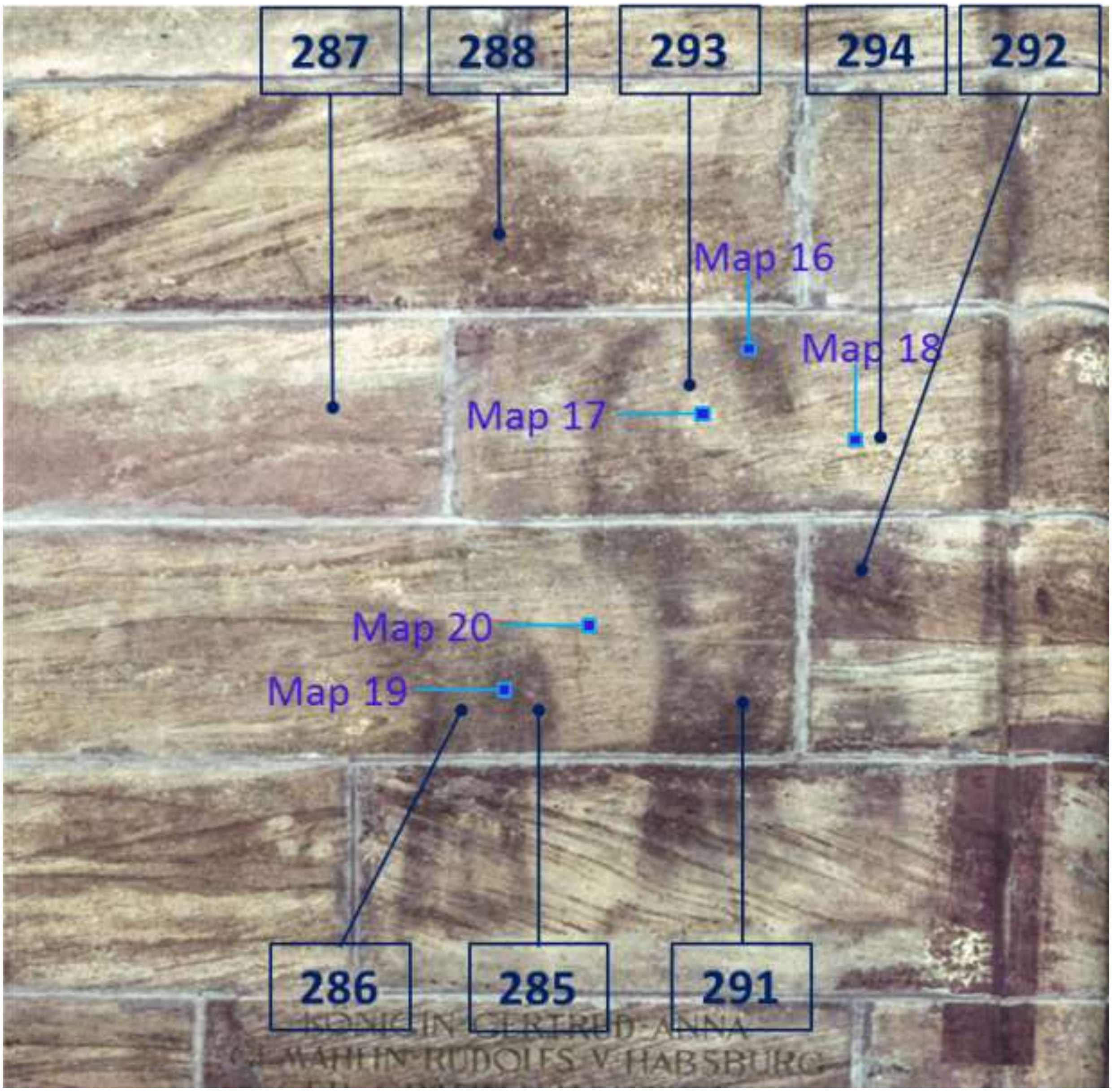


Figure 5.4: Localisation of XRF spectra and maps on the left part of the wall painting overhanging queen Anna's tomb (PB9).

The right part of the wall painting illustrates three main characters, a sitting saint (to the left), a canon or bishop (in the middle) and another canon (to the right) inside an architectural frame (Figure 5.5). On this part 15 maps (Figures 5.5) and 20 spectra (Figures 5.6) were acquired. The analyses cover a much wider area than for the left part. The main characters as well as the architecture and its decoration were analysed, although a deeper investigation was performed on two canons.

Whatever their location is, all spectra or maps present traces of S, and variable amounts of Ca (all in excess compared to the reference stone) and Pb. Actually, Ca and S are also found in areas outside the apparent limit of the wall painting (Figure 5.X, sp. 304 not shown, 112 and 11). In addition, few maps show the presence of traces of Cu and Hg[21]; Cu is found in correspondence of the cape of the canon-bishop (map 7 and 8), and on the

[21] To be kept in mind that the interpretation is fairly difficult because ARTAX spectra are quite noisy in the region between 7 and 13 keV.

architecture frame (map 11) while Hg traces are located on the cape of the canon-bishop (map 8).

Figure 5.5: Localisation of XRF spectra and maps on the right part of the wall painting overhanging queen Anna's tomb (PB9).

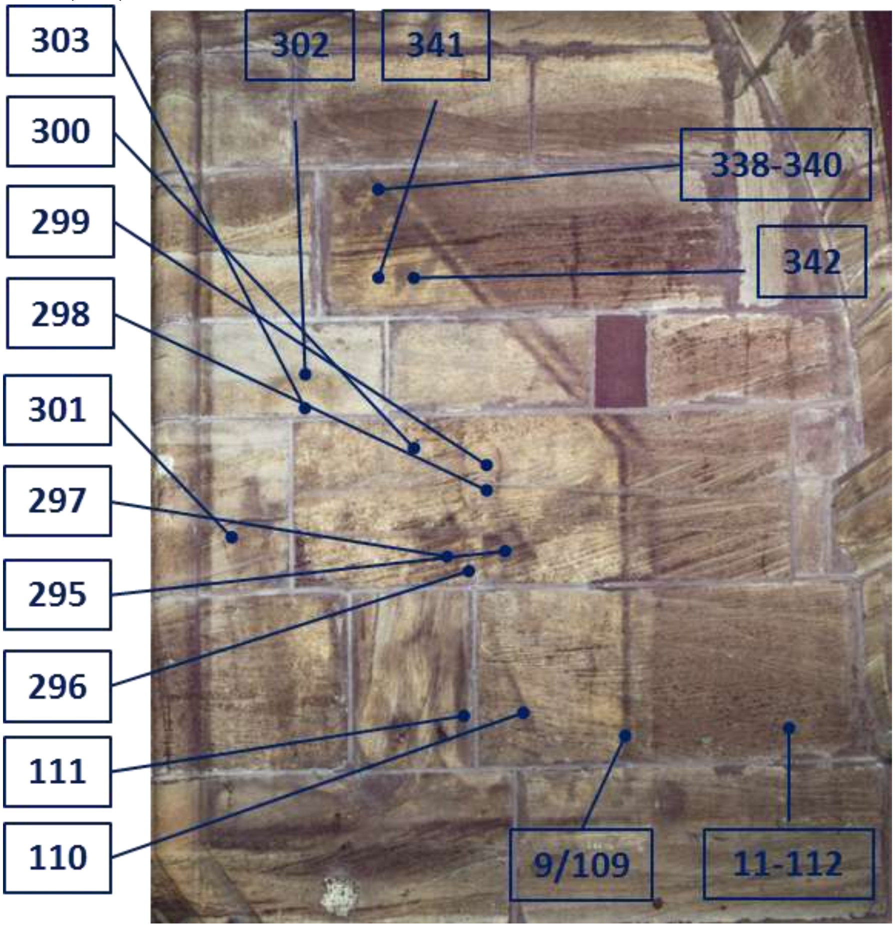


Figure 5.6: Localisation of XRF spectra and maps on the right part of the wall painting overhanging queen Anna's tomb (PB9).

5.3.2 The 4th pillar on the main nave

The UV-light pictures clearly show that the pillar was formerly decorated with a repetitive pattern, which should consist of a floral decoration based on the repetition of several rows of four collars or girdle of flowers and petals with at least eight blooms (Figure 5.7).

Analyses were carried out on 3 flower-collars on the 5th rows from the bottom and on 1 flower-collar on the 10th row (Figure 5.3); in total 2 line scans, 5 spectra and 8 maps were collected. In all analyses Ca and S are detected. Pb is present in 14 measurements, 5 of which in trace amounts. No correlation has been found between the amount of Pb (traces or major element) and the localisation neither in the wall painting nor with the intensity of the UV-fluorescence. Cu traces were detected in 7 measurements, all taken in correspondence of the petals of the flowers.

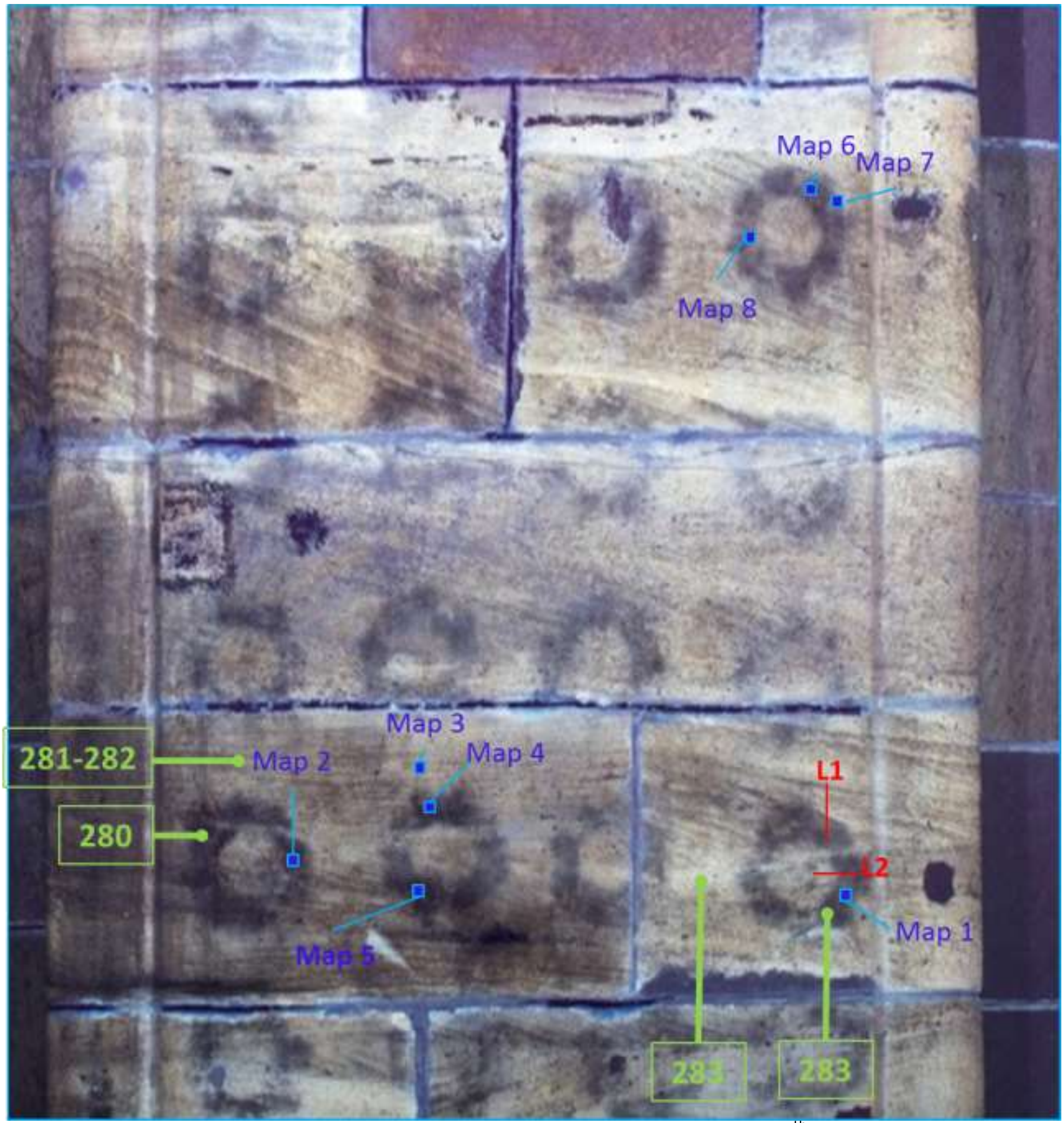


Figure 5.7: Localisation of XRF spectra, line (L) and maps on wall painting of the 4th Pillar (PB28b)

5. 4 Conclusion/discussion

The analyses performed on the two objects allow formulating the following hypothesis.

The wall painting over the queen Anna tomb (PB9) presented a continuous layer of gypsum all over the wall (also outside the figurative part). Probably this consisted in a fairly thick ground layer, necessary to cover the rough surface of the Degerfelder sandstone and also to allow a better workability of the rest of the polychromy. Together with this layer a Pb-rich layer was also present, but only limited to the figurative part. This could be a second thinner ground layer, which will help to give more intensity to the further applied colours and also to fasten the drying process (siccative). To be noticed that this technique was also used for the Margaretha wall painting (PB2). This layer could be made of lead white, but we cannot exclude the use of mixture with other pigment (e.g. ochre) in order to obtain a yellow ground layer. The traces of Cu could arise from green and/or blue pigments. In the case of the canon/ bishop cape the pigment was surely a blue and very luckily azurite (which has been found in other blue pigment in the cathedral). Finally, the only trace of Hg detected on the canon/bishops cape testifies of the use of cinnabar.

As for the wall painting discovered on the 4th pillar of the navy (PB28b), it presented a background gypsum layer too; confirming the necessity of such kind of substrate for Degerfelder wall. Compared to PB9, the use of Pb seems to be much more limited in this wall painting. So Pb was probably used as a siccative and/or in a discontinuous layer. Nevertheless, its uneven distribution could also be a consequence of an irregular removal process. Finally, the presence of Cu traces in the petals of the flower is undoubtedly due to the use of Cu based green pigments.

To be notice that on both walls no evidence of salt contamination were found. Indeed Cl was found only on one spectrum on the left part of Queen Anna and all the S it is assumed to arise from the gypsum substrate.

In general, although whole ancient polychromy of these two objects cannot be fully reconstructed (for instance no conclusion can be dressed for Fe containing pigments because the Fe content in the Degerfelder sandstone varies up to 3 orders of magnitude), it is possible to affirm that the two walls were painted using a typical mediaeval palette.

6 Zusammenfassung

Die hier vorgestellten wichtigsten Thesen fussen auf Erkenntnissen, die während der Projektphase durch die Zusammenschau historischen Quellenstudiums, kunsthistorischer Analyse, bereits erfolgten früheren Untersuchungen, makroskopischen und mikroskopischen Beobachtungen am Objekt, berührungsfreier spektroskopischer und optischer Untersuchung (mit XRF und UV-Licht) und gezielter Probennahme gewonnen wurden. Annahmen aus früheren Untersuchungen wurden nach Möglichkeit überprüft und in die Betrachtung einbezogen. Die vorab in den Datenblättern zu einzelnen Objekten formulierten Kernfragen dienten der Annäherung an diese komplexe Aufgabe. Dabei ist zu berücksichtigen, dass, wie bereits in Kapitel 2.4 erwähnt wurde, eine vollständige Auswertung der erhaltenen Untersuchungsergebnisse nur für die Objekte im Innern des Münsters durchgeführt werden konnte. Für die übrigen Objekte wurden die vorhandenen Resultate für eine weitere Interpretation herangezogen.

6.1 Erkenntnisse zu Wandmalereien

6.1.1 Drei technologische Gruppen

Bei Malereien auf Wandflächen lassen sich drei Gruppen unterscheiden. Zum einen Aussenanstriche mit klarer Schutz- und daneben ästhetischer Funktion (PB19 Südost-Chorwand, PB Pflanzenfries Georgsturm). Zum anderen Wandmalereien, die als Ölmalerei (vermutlich über eine sehr dünne, ebenfalls ölgebundenen Grundierung) direkt auf die Natursteinoberflächen aufgetragen wurden (PB9 Annagrab, PB28bNördlicher Langhauspfeiler). Es handelt sich dabei sowohl um ornamentale Malerei auf Architekturgliedern (PB28b) als auch um bildhafte Darstellungen auf quadergefügten Flächen (PB9 Wandmalerei Annagrab). Bei der dritten Gruppe geht es um Wandmalereien im klassischen Sinne, bei denen mittels auf einem Kalk- und/oder Gipsputz, meist über einer dünnen Grundierung aufgetragener Malfarben bildhafte, teilweise ornamental ausgeschmückte Szenen gezeigt werden (PB1a Bischofsbilder, PB1b Fundstücke, PB3 Christus vor der Kreuzanheftung, PB12 Wandmalerei Orgelempore, PB 15 sieben Heilige Niklauskapelle, PB20 Darbringung im Tempel, Grosser Kreuzgang, PB25b Darbringung im Tempel Maria-Magdalena-Kapelle, PB26 Utenheimgrabmal). Bei Objekt PB14 zwei Heilige Frauen wurde die Natursteineinfassung der Wandnische lediglich mit einer Tünche geweisselt und die Malerei direkt aufgetragen. Keine der untersuchten Wandmalereien ist freskal geschaffen worden, es kamen ausschliesslich Seccotechniken (Kalk-, Tempera-, Mischtechniken) zum Einsatz.

6.1.2 Möglicher Zusammenhang zwischen Maltechnik und Gebäudeteil

Bei der Anwendung der verschiedenen Maltechniken wurde ganz offensichtlich kein Unterschied gemacht, ob sich das Bildnis in eher feuchten Bereichen (Krypta, halboffener Kreuzgang) oder im Innenraum (Münster, Kapellen) befand. Nur für den frei bewitterten Aussenbereich wurden ganz klar ölgebundene Malmaterialien bevorzugt (Arnold, 1989 and 1998; Heydrich, 1988).

6.1.3 Befunde zu Putzen

Die Putze der frühen Wandmalereien um 1200 (PB 1a Bischofsbilder, PB1b Fundstücke) zeichnen sich aus durch eine qualitätvolle Vorbereitung des Malgrundes. Über einem gut verzahnten Grund- und Ausgleichsputz wurde ein sorgfältig abgeglätteter, weisser Feinputz aufgezogen und dieser direkt bemalt. Während die groben Umrisse der PB1a Bischöfe in den noch halbfeuchten Putz eingeritzt wurden, verzichtete man bei den ansonsten ähnlichen PB1b Fundstücken auf dieses Hilfsmittel.

Die Putze ab dem 14. Jahrhundert sind dagegen meist einschichtig, weisen eine weniger gut verzahnte Struktur auf, sind nur abgekellt und/oder mit einer dünnen Kalk- oder Gipstünche präpariert (PB3 Christus vor der Kreuzanheftung, PB15 sieben Heilige, PB 20 Darbringung im Tempel, Grosser Kreuzgang, PB25b Darbringung im Tempel , Maria-Magdalena-Kapelle, PB26 Utenheimgrabmal, Pb28b Triumphbogen).

6.1.4 Befunde zu Grundierungen

Während die frühen Wandmalereien um 1200 (PB1a Bischofsbilder, PB1b Fundstücke) ohne Grundierung auskommen, weil der Feinputz diese Funktion bereits erfüllt, sind an allen anderen Wandmalereiobjekten ab dem 14. Jahrhundert durchgehend Grundierungen zu finden. Kennzeichnend ist deren Gelbfärbung (PB12 Orgelempore, PB15 sieben Heilige, PB 20 Darbringung im Tempel, Grosser Kreuzgang, PB25b Darbringung im Tempel, Maria-Magdalena-Kapelle, PB28a Triumphbogen), die durch die Zugabe eisen- oder bleihaltiger Gelbpigmenten erzeugt wurde. Bleipigmente wirken sikkativierend und beschleunigen den Trocknungsprozess, was eine erwünschte Wirkung war. Womöglich spielte aber auch der ästhetische Zeitgeschmack eine Rolle. Gelbe Grundierungen können die darüber liegenden Farbschichten in ihrer Wirkung dämpfen (z.B. Blau tendiert ins Türkisfarbene, Schwarz wird warmtoniger) oder anfeuern (z.B. Rot erhält einen Orangestich). Eine Ausnahme bildet Objekt PB3 Christus vor der Kreuzanheftung in der Vierungskrypta. Hier wurde eine weisse Grundierung bevorzugt.

6.1.5 Befunde zu Malschichten in Gewölben und Wandmalereien

Zur Verwendung kommt die im Mittelalter übliche Pigmentpalette, nämlich Gips, Kreide und Bleiweiss als Weisspigmente, gelber Ocker und Massikot als Gelb, roter Ocker, Zinnober, Mennige und Hämatit als Rot, Malachit und andere Kupferverbindungen als Grün, Azurit als Blau sowie Pflanzenschwarz. Bei den frühen Wandmalereien (PB1a Bischofsbilder, PB1b Fundstücke) ist die Anwendung reiner Lokaltöne zu beobachten. Die Farbflächen liegen durch Konturlinien getrennt nebeneinander. Die Belebung der Oberflächen erfolgt durch Weisshöhungen, die entweder durch Weglassung oder durch Farbauftrag erzielt werden. Bei den Wandmalereien ab dem 14. Jahrhundert werden immer noch Konturlinien gezogen, allerdings nicht mehr mit schwarzer Malfarbe (PB3 Christus vor der Kreuzanheftung, PB25b Darbringung im Tempel, Maria-Magdalena-Kapelle) sondern auch in Braun (PB2 Margaretha/Martin Gewölbemalerei, PB15 sieben Heilige) oder Rot (PB14 zwei heilige Frauen). Die Tendenz, Oberflächen durch abgemischte Farben (z.B. Zugabe von Bleiweiss zum Aufhellen, Rottöne aus Zinnober und Mennige, mit Pflanzenschwarz und Kreide unterlegte Azuritschichten) zu modellieren, nimmt zu. Ebenso sind Blattmetallauflagen zu beobachten (PB15 sieben Heilige, PB28b Triumphbogen).

6.1.6 Beseitigung der Wandmalereien nach der Reformation

Die Aussenanstriche gingen durch natürliche Abbauprozesse (PB19) oder aber durch eine Kombination von Ablaugen und Verwitterung (PB24 Pflanzenfries, Georgsturm) verloren[22].

Ab wann die Ölfarbenmalereien im Münsterinneren nicht mehr zu sehen waren, bleibt ungewiss. Sicher ist nur, dass die 1597 zu beiden Seiten der Fensternische am Objekt PB9 Annagrab angebrachten Inschriften die ursprünglichen Wandmalereien klar überlappt haben müssen. Spätestens mit dem Abstocken der Oberflächen 1852/57 gingen alle dann noch vorhandenen Spuren verloren[22].

Von den Objekten mit Wandmalerei auf Putz/Tünche wurde nur eines zweifach übermalt (PB12 Orgelempore), alle anderen Wandbilder zeigen ihre ursprüngliche Fassung. Allesamt gingen nach der Reformation unter. Für das Beseitigen der buntfarbigen Oberflächen konnten verschiedene Vorgehensweisen beobachtet werden. Entweder wählte man die schnellste Variante, indem man mit einer einfachen Kalk- oder Gipsschlämme übertünchte (PB12 Orgelempore, PB21 Kreuzgangjoch, PB25b Darbringung im Tempel, Maria-Magdalena-Kapelle) und in einem Fall (PB12 Orgelempore) sogar neu mit Inschriften und Ornamenten zierte. Diese Malereien haben sich bis auf eine Dünnung der oberen Malschichten entsprechend gut erhalten.

Eine aufwändigere, aber nachhaltige Form der Beseitigung bestand im Aufhacken der Malerei mitsamt Putzgrund und dem Anwerfen einer neuen farblich neutralen Putzschicht. Davon zeugen die mit zahlreichen Hacklöchern übersäten Beispiele (gut sichtbar an den Objekten PB12 Orgelempore, PB15 sieben Heilige, PB20 Darbringung im Tempel, Grosser Kreuzgang).

[22] Protokolle des Baukollegium des Kantons Basel-Stadt, 10. September 1863 (StABS Protokolle H 4.9).

Eine dritte Gruppe von Wandmalereien wurde schlicht durch bauliche Veränderungen den Blicken entzogen (PB1a und PB1b Einwölben der Ostkrypta und bei PB1b eventuell Erdbebenschäden im Vorfeld, PB3 Christus vor der Kreuzanheftung, Niederlegen der Vierung, PB20 Darbringung im Tempel, und PB25a Epitaph für Maria Burckhardt teilweise Überdeckung durch Epitaphien, PB28a Triumphbogen Wandmalerei, Einwölben des Hauptschiffs).

An keiner Stelle konnte die Übermalung von Wand- oder Gewölbemalereien mit den beiden nachreformatorischen Rotfarben (siehe in Abschnitt Erkenntnisse zu gefassten Steinobjekten) nachgewiesen werden.

6.2 Erkenntnisse zu Gewölbemalereien

6.2.1 Technologie

Bei den untersuchten Gewölbemalereien diente der normale Gewölbeverputz als Malgrund. Während bei zwei Objekten die Malfarbe direkt auf den geglätteten Kalk/Gipsputz aufgetragen wurde (PB11 Wirbelrosetten äusseres Südseitenschiff, PB21 Südostjoch, Grosser Kreuzgang), hat man bei den Gewölbefeldern von PB2 Margaretha/Martin Gewölbemalerei die zu bemalenden Bereiche vorab zusätzlich mit einer hellen, bleiweisshaltigen Grundierung versehen und erst darauf die Malfarben aufgetragen.

6.2.2 Beseitigung der Gewölbemalereien nach der Reformation

Es gibt keine Hinweise wie Kratz- oder Schabspuren, die belegen würden, dass die untersuchten Gewölbemalereien zu irgendeinem Zeitpunkt mechanisch entfernt wurden. Man wählte den einfacheren Weg des Übertünchens (PB7 Fugenmalerei auf Gewölbe von Männerkopf, PB11 Gewölbemalereien, äusseres Südseitenschiff, PB21 Südostjoch, Grosser Kreuzgang), um die Farbigkeit verschwinden zu lassen. Verständlicherweise, denn schon ein Aufhacken und Neuantragen von Putz über Kopf ist ein mühevolles Unterfangen, das wahrscheinlich nach Möglichkeit vermieden wurde.

6.3 Erkenntnisse zu gefassten Steinobjekten

6.3.1 Technologie

Der Grossteil der untersuchten Steinobjekte war im Originalzustand mit Sicherheit farbig gefasst.

6.3.2 Möglicher Zusammenhang zwischen Maltechnik und Objektstandort

Verwendet wurden vorwiegend ölgebundene Farben, unabhängig davon, ob es sich um Objekte im Inneren (Münster, Kapellen) oder im halboffenen Aussenbereich (ehemalige Vorhalle des Hauptportals, Kreuzgang) handelt. Nur in einzelnen Fällen konnte eine Mischtechnik (z.B. PB13 Bischofsthron) nachgewiesen werden.

6.3.3 Befunde zu originalen Objektfassungen

Objekte, die nach dem Erdbeben 1356 oder im Zuge der Reformation 1529 entfernt oder verdeckt wurden, weisen allesamt nur eine und damit höchstwahrscheinlich ihre originale Fassung auf (PB22 Blaue Hand, PB23 Thronender Christus, PB26 Utenheimgrabmal, für letzteres basiert diese Annahme nur auf optischer Beobachtung).

Für die meisten frühen Objekte um 1200 (PB4 Vincentiustafel, PB5 Aposteltafel, PB6 Baumeistertafel) konnten nur noch Spuren einer ursprünglichen ersten Bemalung auf einer gipshaltigen Grundierung nachgewiesen werden. Bei der Baumeistertafel wurde offensichtlich der Versuch unternommen, die beiden unterschiedlich hellen Gesteinssorten durch eine monochrome beigefarbene Fassung optisch aneinander anzugleichen. Für einige Objekte des 13. Jahrhunderts (PB9 Grabplatte Anna Grab), des 15. Jahrhunderts (PB16 Taufstein) und des 16. Jahrhunderts (PB18 Abendmahlstisch) sind ebenfalls nur spärliche Spuren einer Erstfassung nachvollziehbar. Die übrigen Objekte enthalten unter der heutigen Sichtfassung zumindest fragmentarisch (14. Jahrhundert: PB9 Tumba Anna Grab, PB13 Bischofsthron und PB 27 Engelskapitell, 15. Jahrhundert PB10: Tischgrab Andlaugrab, 16. Jahrhundert: PB26 Utenheimgrabmal) oder sogar auf grösseren Flächen (12. Jahrhundert: PB7a Schlussstein Männerkopf, 14. Jahrhundert: PB8 Schlussstein Blattgesicht, 16. Jahrhundert: PB7b Epitaph Hallwil, 17. Jahrhundert: PB25a Epitaph Maria Burckhardt) Reste einer Originalpolychromie. Bis Anfang/Mitte des 19. Jahrhunderts entspricht die verwendete Palette an Pigmenten denen der Wand- und Gewölbemalereien und damit dem gängigen Kanon. Hinzu treten Blattvergoldungen (PB8 Schlussstein Blattgesicht, PB9 Anna Grab, PB13 Bischofsthron, PB22 Blaue Hand, PB21b Schlusssteine Grosser Kreuzgang, PB25a Epitaph Maria Burckhardt, PB26 Utenheimgrabmal[23]) und Zinnfolienauflagen (PB26 Utenheimgrab[24]). Der Bischofsthron und das Engelskapitell als Teil des ehemaligen Lettners werden im 16. Jahrhundert an einzelnen Partien mit blauer Smalte gefasst, die sonst nirgends nachgewiesen werden konnte und womöglich auf diesen Raumteiler beschränkt blieb. Bei den nach 1852/1873 neu gefassten Objekten weitet sich die Auswahl verwendeter Pigmente sprunghaft. Neu hinzu kommt Zinkweiss, künstlicher Lazurit als Blaupigment (PB7a Männerkopf, PB7b Epitaph Hallwil), Chromgelb (PB7a, PB8, PB9 Annagrab Tumba, PB10, PB21 Südostjoch Grosser Kreuzgang Gewölbekrabben) und Chromgrün mit Anteilen von Berliner Blau (PB8 Schlussstein Blattgesicht, PB9 Anna Grab, Tumba, PB10 Grabmal Andlau).

[23] Au wurde hier mit in-situ XRF nachgewiesen.
[24] Sn wurde hier mit in-situ XRF nachgewiesen.

6.3.4 Befunde zu ursprünglichen Grundierungen auf Steinoberflächen

Nach bisherigen Erkenntnissen waren alle untersuchten gefassten Steinobjekte ursprünglich mit einer Grundierung oder zumindest mit einer farblosen Imprimitur versehen, um den stark und unterschiedlich saugenden Sandsteinuntergrund vorzubereiten. Das Vorgehen gilt für Degerfelder, Molasse und Wiesentaler gleichermassen über alle Jahrhunderte hinweg. Auffallend ist ein hoher Bleianteil in einer Grundierung auf Kalkgipsbasis auf Objekten aus Degerfelder Sandstein (PB9 Wandmalerei Annagrab). Zum einen musste hier die Grundierschicht wesentlich dicker aufgetragen werden, um die grobkörnige Oberfläche bemalbar zu machen. Zum anderen musste die teils starke Bänderung des Natursteins gleichmässig abgedeckt werden. Vermutlich war daher Bleiweiss (oder ein anderes bleihaltiges Pigment) als Trocknungsbeschleuniger und gut deckender optischer Aufheller das Farbmittel der Wahl.

Auf einigen der Objekte lassen sich parallel zu den oben beschriebenen Wandmalereien ebenfalls gelbe Grundierungen auf eisen- und/oder bleibasierten Gelbpigmente beobachten (PB22 Blaue Hand, PB23 Thronender Christus, PB27 Engelskapitell). Der Einsatz erfolgt hier bereits im späten 13. Jahrhundert und wurde auch auf anderen Skulpturen des Hauptportals festgestellt (Meier/Schwinn Schürmann 2011).

6.3.5 Befunde zu zwei monochrom roten, nachreformatorischen Überfassungen

Auf vielen der untersuchten Objekte im Inneren des Münsters lassen sich ein bis zwei monochrom rote Fassungen nachweisen, die nach der Reformation vermutlich zur optischen Vereinheitlichung der Objekte aufgetragen wurden. Es sind die beiden Schichten, die auch schon bei Untersuchungen zur Galluspforte (Meier/Schwinn Schürmann 2002) und zum Hauptportal (Meier/Schwinn Schürmann 2011) im Aussenbereich belegt wurden. Bindemittel beider Anstriche ist trocknendes Öl, aller Wahrscheinlichkeit nach Leinöl. Die Gesamtauswertung ermöglicht die Zuordnung beider Fassungen zu zwei Renovationsetappen:

1. Rosé von 1597 (Innenrenovation[25])

Bei der ersten Rotfassung handelt es sich um einen hellen Roséton, der sich farblich an die leicht rötliche Tönung des Degerfelder Sandsteins anlehnt. Die Auftragsstärke der Farbe bewegt sich an den untersuchten Objekten in einer Schichtdicke von durchschnittlich 250 µm. Die Malfarbe setzt sich zusammen aus Bleiweiss, Hämatit, Kalzit und Pflanzenschwarz, Der hohe Bleiweissanteil und eine an manchen Objekten nachweisbare beginnende Verseifung sind kennzeichnende Merkmale des Rosés. Im Auflichtmikroskop lassen sich bereits unter dem 5fach-Objektiv in einer feinkörnigen, homogen rosa geprägten

[25] Siehe Kapitel 2.1 und 2.2

Matrix (Kalzit) vereinzelt winzige rote (Hämatit) und schwarze (Pflanzenschwarz) Pigmentkörnchen sowie insuläre, gerundete Bleiweissaggregate beobachten.

2. Dunkelrot von 1772 bzw. 1785/87 (Innenrenovationen[26])

Die zweite nachweisbare Rotfassung besteht ebenfalls aus Kalzit, Hämatit, Bleiweiss und Pflanzenschwarz. Allerdings ist das Verhältnis der farbgebenden Komponenten deutlich anders als beim Rosé. Bei gleicher Vergrösserung zeigt die hämatitrot geprägte Matrix eine gröbere Struktur, in der Bleiweissaggregate, teils längliche Pflanzenschwarzpartikel und ockerfarbene Körnchen, die Quarz enthalten, wie in einer Salami durchmischt zu gleichen Teilen nebeneinander liegen. Die Farbwirkung dürfte weit dunkler und insgesamt kräftiger als die des Wiesentaler Sandsteins gewesen sein. Die Schichtdicken des Dunkelrots an den untersuchten Objekten bewegen sich durchschnittlich um die 200 μm. Im Vergleich zum Rosé ist dieser zweite monochrome Anstrich erheblich spröder und zeigt kaum Verseifungstendenzen. Laienhaft lassen sich die beiden Farbtönungen am ehesten mit Schweinefleisch (Rosé) und Rindfleisch (Dunkelrot) beschreiben. In der Forschungsliteratur wurden bisher verschiedene Begriffe für das Dunkelrot verwendet: „Caput mortuum“, „Eisenoxidrot“, „Englischrot“, „Pariserrot“ und „Nürnbergerrot“, weshalb diese Bezeichnungen zur Klärung nun durch den aussagekräftigen Begriff „Dunkelrot“ ersetzt werden.

Nachgewiesen werden konnten beide monochrom roten, nachreformatorischen Fassungen oft in folgender Kombination: das Rosé auf mittelalterlichen Farbresten, darüber das Dunkelrot (PB16 Taufstein, PB17 Kanzel, PB27 Engelskapitell). Insgesamt scheint der Farbauftrag des Rosés etwas dicker gewesen zu sein, was damit zusammenhängen mag, dass etwaige Reste von Originalpolychromie überdeckt werden mussten, ohne sich als Inseln in der Oberfläche abzuzeichnen. Die dunkelrote Fassung fällt etwas dünner aus, vielleicht auch, um die Lesbarkeit der Steinbearbeitung nicht noch weiter herabzusetzen.

6.3.6 Allgemeine Befunde

Nach der Reformation verschwand die Buntfarbigkeit der liturgisch wichtigsten Einrichtungsgegenstände 1597 erstmals unter einem roséfarbenen Anstrich. Zusammen mit einer weiteren farblichen Neugestaltung des Innenraums wurden sie ein zweites Mal, wahrscheinlich 1785/87 einfarbig gefasst. Von diesen Massnahmen ausgenommen blieben die Epitaphien (PB7b Epitaph für von Hallwil), die Wappen der Grabdenkmäler (PB9 Anna Grab, PB10 Andlaugrabmal) und die Gewölbeschusssteine (PB7a Schlussstein Männerkopf, PB8 Schlussstein Blattgesicht). Hier wurde die Buntfarbigkeit weder überdeckt noch abgetragen sondern im Gegenteil über die Jahrhunderte hinweg instand gehalten oder neu gefasst. Gleiches gilt für die Schlusssteine im Grossen Kreuzgang (PB21b). Hingegen wurde eine Auswahl an Epitaphien in der Maria- Magdalena-Kapelle und den Kreuzgängen ungeachtet ihrer Originalfarbigkeit (stellvertretend PB25a Epitaph Maria Burckhardt) mit

[26] Siehe Kapitel 2.1 und 2.2

Ausnahme der Wappen zweifach monochrom (rosé im 18. und grau im frühen 20. Jahrhundert) vereinheitlichend gefasst, wie man heute noch sehen kann.

Den weitaus grössten Einfluss auf den radikalen Verlust polychromer Oberflächen im Münsterinneren hatte nach heutigem Erkenntnisstand die Innenrenovation von 1852/57. Während nach der Reformation vorwiegend überdeckende Verfahren ein neues Erscheinungsbild erzeugten, wurden im 19. Jahrhundert mit mechanisch-chemischen Methoden abtragende Verfahren eingesetzt. Im Streif- und UV-Licht sind nicht nur unterschiedliche Stockhammer-Hiebrichtungen erkennbar. Ersichtlich wird auch, dass Stockhammerplatten mit unterschiedlicher Zahnung im Einsatz waren. Je grösser die einzelnen pyramidal angeschliffenen Zähne eines Hammers, desto grösser die Wucht des Schlags und der damit einhergehende Gesteinsabtrag. Dies ist eine denkbare Erklärung, weshalb sich Bindemittelreste nur an einigen Objekten (PB9 Annagrab Wandmalerei, PB28b Vierungspfeiler und weitere in diesem Bericht nicht behandelte Objekte) erhalten haben. Immerhin aber liessen sich mit den angepassten berührungsfreien Verfahren innerhalb der „Bindemittelschatten" Spuren von Farbgebung mit beispielsweise den Elementen Eisen, Blei, und Kupfer nachweisen und teilweise zuordnen (so dürften etwa die blumenartigen Kranzdekore auf PB28b Nördlicher Langhauspfeiler grün gewesen sein).

6.3.7 Schlusskommentar

In den zur Verfügung stehenden zwölf Monaten der Projektphase wurde ein Testsystem entwickelt und erstmals eine Zusammenschau der am Münster vorhandenen gefassten Oberflächen unternommen. Eine sinnvolle Auswahl musste getroffen und längst nicht alle interessanten Objekte konnten berücksichtigt werden. Eine Ausweitung der Befunderhebung bleibt ein Desiderat für die Zukunft.

7. Dissemination

Several objects have been investigated, for each of them very interesting results have been found. These results are of high interest for different communities (historians, art historians, conservators, restorers, art scientists) and will be therefore published in international and national reviews and books and presented to international and national congresses and workshops.

For instance the results obtained using conjointly UV imaging and in situ XRF analyses, for the wall above queen Anna monument (PB9), allowed reveling the presence of an ancient wall painting. These could be published in the Zeitschrift für Schweizerische Archäologie und Kunstgeschichte ou Archeosciences, as well as in Journal of Cultural Heritage. The study of wall painting found in the Krypta (PB1a and b; PB2, PB3) can be published in or Journal of Archaeological Sciences of Archeosciences.

Furthermore an article on the pigment removal will be also published. This will include results of the three stone bas-reliefs (PB4, PB5 and PB6) and the wall painting traces found in PB9 and PB28b.

Most of the results of this project will be used in the book „Die Kunstdenkmäler des Kantons Basel-Stadt X – Das Basler Münster“ (by Hansruedi Meier, Dorothea Schwinn Schürmann, Carola Jäggi, Anne Nagel, Stefan Hess, Marco Bernasconi) which is foreseen for 2019.

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1442/43
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1479/80
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1480/81
Fabrikbüchlein des Basler Münsters, Staatsarchiv Basel-Stadt KA Domstift NN, 1480/81 (Apostelstatuen)

1785

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1853
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1853
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1854
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1863
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1899
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1915
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1939
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1970
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