Care and conservation of manuscripts 13
Proceedings of the thirteenth international seminar held at the University of Copenhagen 13th-15th April 2001
Edited by M.J. Driscoll
Museum Tusculanum Press, 2012
pp. 147-165

Between boon and bane: The use of chemical reagents in palimpsest research in the nineteenth century

by Felix Albrecht Academy of Sciences, Göttingen

When dealing with palimpsests one frequently encounters various kinds of damage to the support. Most manuscript catalogues, even the most recent ones, treat these blemishes in an unsatisfactory or even incorrect fashion. To understand this phenomenon we have to know something about methods of palimpsest studies in the nineteenth century.[1]

The discovery of important palimpsest manuscripts at the beginning of the nineteenth century sparked a veritable boom in interest in these manuscripts. Cardinal Angelo Mai (1782–1854) counts among the great scholarly personalities of the early period. Mai discovered and published various fragments of Cicero, and then in 1815 found the letters of Marcus Cornelius Fronto and speeches of Quintus Aurelius Symmachus as well as fragments of Plautus's comedies. In 1819 Mai discovered considerable fragments of Cicero's *De re publica*, which he published in 1820. Great interest was furthermore aroused by the discovery by Barthold Georg Niebuhr (1776–1831) of the *Institutiones* of Gaius in Verona in 1816. The deciphering of these palimpsests posed problems, however, as they could be read only with difficulty (see Fig. 74). And so experiments were made using chemical reagents to make the traces of the metallic inks on the parchments more legible.[2] This was done with some success, but later the damaging effects to the parchment began to appear. Three substances were mainly used: 1) tincture of oak-gall, 2) various liver of sulphur tinctures and, in particular, 3) the so-called 'Giobert tincture'. Other procedures were also used, but to a much lesser degree. The present paper will first explain the history of the discovery, application and effects of these chemicals and then discuss the damage to the manuscripts treated in this fashion.

Fig. 74. *Untreated script* (scriptio superior & inferior) *@ 50 × enlargement – UB Leipzig, Cod. Lips. Gr. 2, f. Xr.*

Oak-gall tincture

Oak-gall tincture (German *Galläpfeltinktur*), an alcohol-based essence of oak galls, also known as oak apples,[3] was the first method[4] to be employed (Fig. 75). It enhances old metallic inks so that the faded writing becomes more legible (Fig. 76). It also renders the unwritten-on parchment a brownish colour, sometimes quite strongly. Franz Ehrle had this to say about the effects of oak-gall tincture:

> Gallic acid colours the parchment a yellowish brown and when applied in large quantities in a strongly concentrated solution and heated, a dark brown or even altogether black.[5]

Ehrle correctly notes that tannic acid ($C_{76}H_{52}O_{46}$, tannin) brings about corrosion of the ink. The inks of the *scriptiones superiores* were particularly prone to such damage.[6] Mainly these were iron-gall inks, which are known to be particularly reaction-friendly.[7] Cardinal Angelo Mai especially used oak-gall tinctures in his work on manuscripts.[8]

Liver of sulphur tinctures[9]

The bad experience with oak-gall tincture led to the use of substances that were thought to be less damaging. In 1826–27 Wilhelm Grimm treated in the university library at Göttingen a palimpsest fragment of early German courtly poetry from the 12th century, the 'Graf Rudolf', with a reagent produced from heating calcium carbonate, sulphur and sal ammoniac (ammonium chloride, NH_4Cl). This substance had however the negative property of leaving a white mineral film on the parchment that was difficult to remove (Fig. 77).[10] The mixture of calcium polysulphide[11] (CaS_x) and calcium sulphate ($CaSO_4$), produced by a combination of calcium carbonate ($CaCO_3$) and sulphur, is normally referred to as calcic liver of sulphur (*hepar sulfuris calcareum*, calcic sulphuret of potassium, Germ. *Kalkschwefelleber*). It possesses the property of retreating when in contact with sulphides with corresponding metal ions, but at the same time the calcium sulphate ($CaSO_4$) crystallises in contact with water as gypsum ($Ca[SO_4] \times 2\,H_2O$). The resulting damage demonstrates the ravages caused by the formation of crystals where this treatment has been used. The example of the 'Graf Rudolf' (*Cod. Gottingensis MS. Philol.* 184:7, SUB Göttingen) shows clearly the crystallisation of the calcium sulphate (Fig. 78).

In addition to calcic liver of sulphur normal liver of sulphur produces the effect of precipitating metal ions as sulphides. Liver of sulphur (*hepar sulfuris*, sulphuret of potassium, Germ. *Schwefelleber*), produced from potash (potassium carbonate, K_2CO_3) and sulphur is basically a mixture of potassium polysulphide[12] (K_2S_x) and potassium sulphate (K_2SO_4) that was applied as a solution to parchment. The traces of potassium carbonate left as a rule in this process form potassium hydrogen carbonate ($KHCO_3$) when in combination with water.[13] Both salts produce a sediment in the form of a thin film on the surface of the parchment (Figs. 79 & 80). Otto Posse had these terse words to say on the subject of the harmfulness of the solution: 'attacks the parchment badly'.[14] Among others Barthold Georg Niebuhr used liver of sulphur on various manuscripts.[15]

Fig. 75. *Sample of a page treated with oak-gall tincture – UB Leipzig, Cod. Lips. Gr. 16, f. 51r.*

Fig. 76. *Illustration of the effects of oak-gall tincture @ 200 × enlargement – UB Leipzig, Cod. Lips. Gr. 16, f. 51r.*

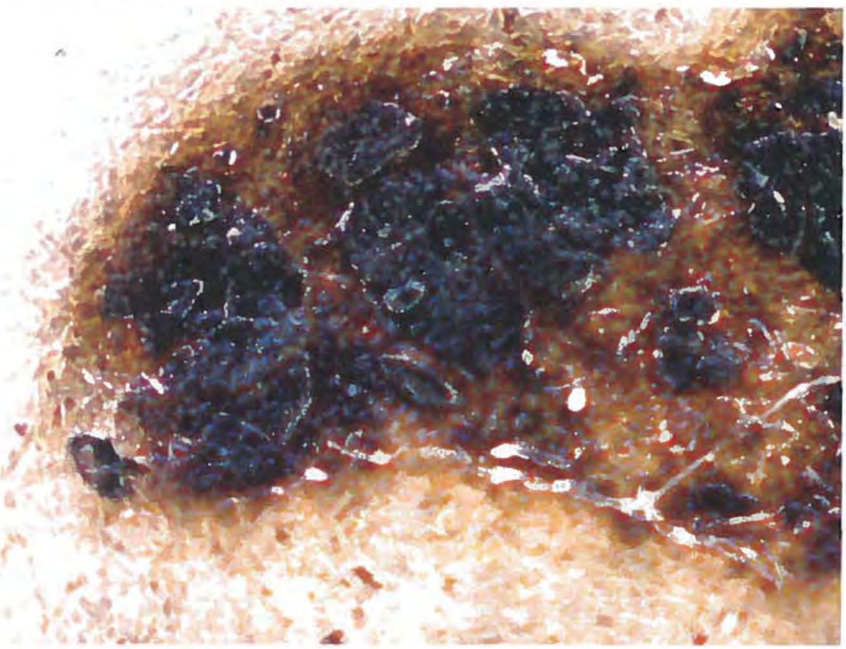


Fig. 77. *Sample of a page treated with calcic liver of sulphur – SUB Göttingen, Cod. Gotting. MS. Philol. 184:7.*

Fig. 78. *Damage caused by calcic liver of sulphur @ 50 × enlargement – SUB Göttingen, Cod. Gotting. MS. Philol. 184:7.*

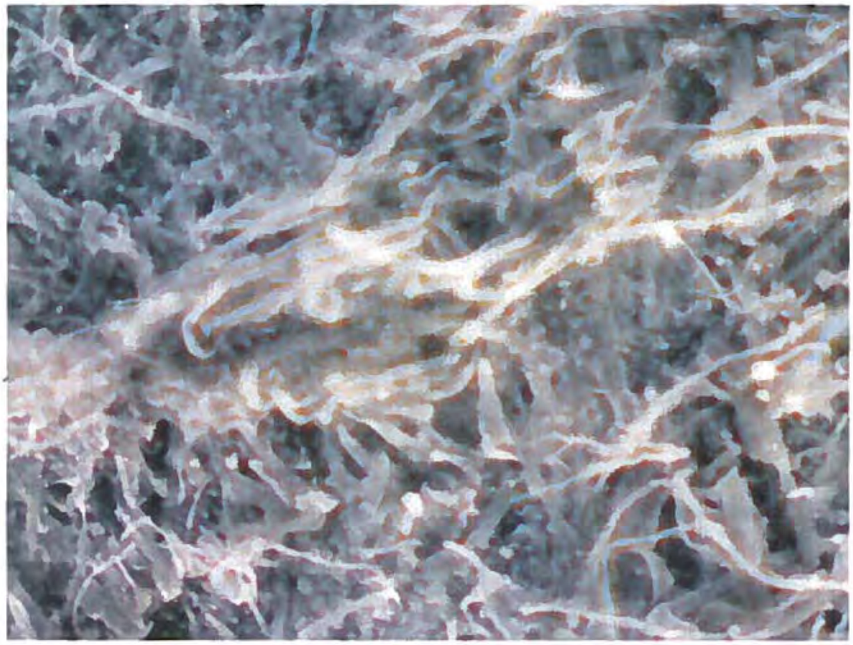
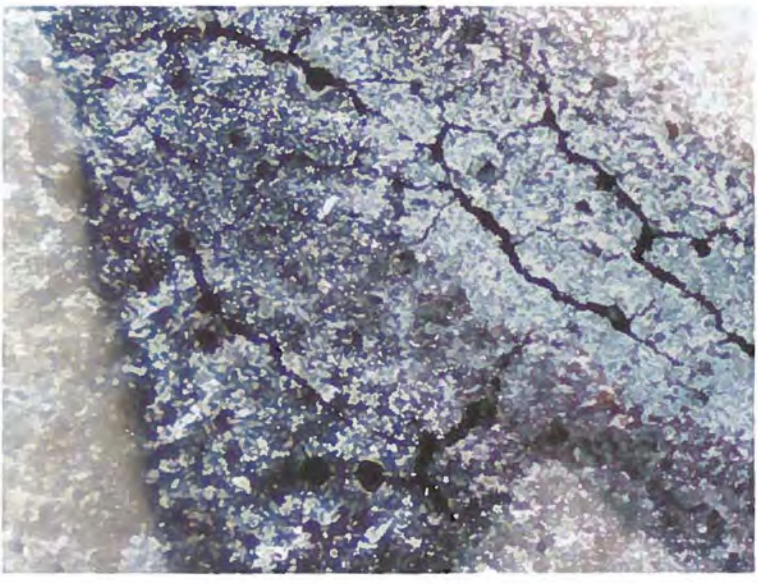


Fig. 79. *Damage caused by liver of sulphur tincture @ 50 × enlargement – UB Leipzig, Cod. Lips. Gr. 3, f. 169v.*

Fig. 80. *Damage caused by liver of sulphur tincture @ 200 × enlargement – UB Leipzig, Cod. Lips. Gr. 3, f. 169v.*



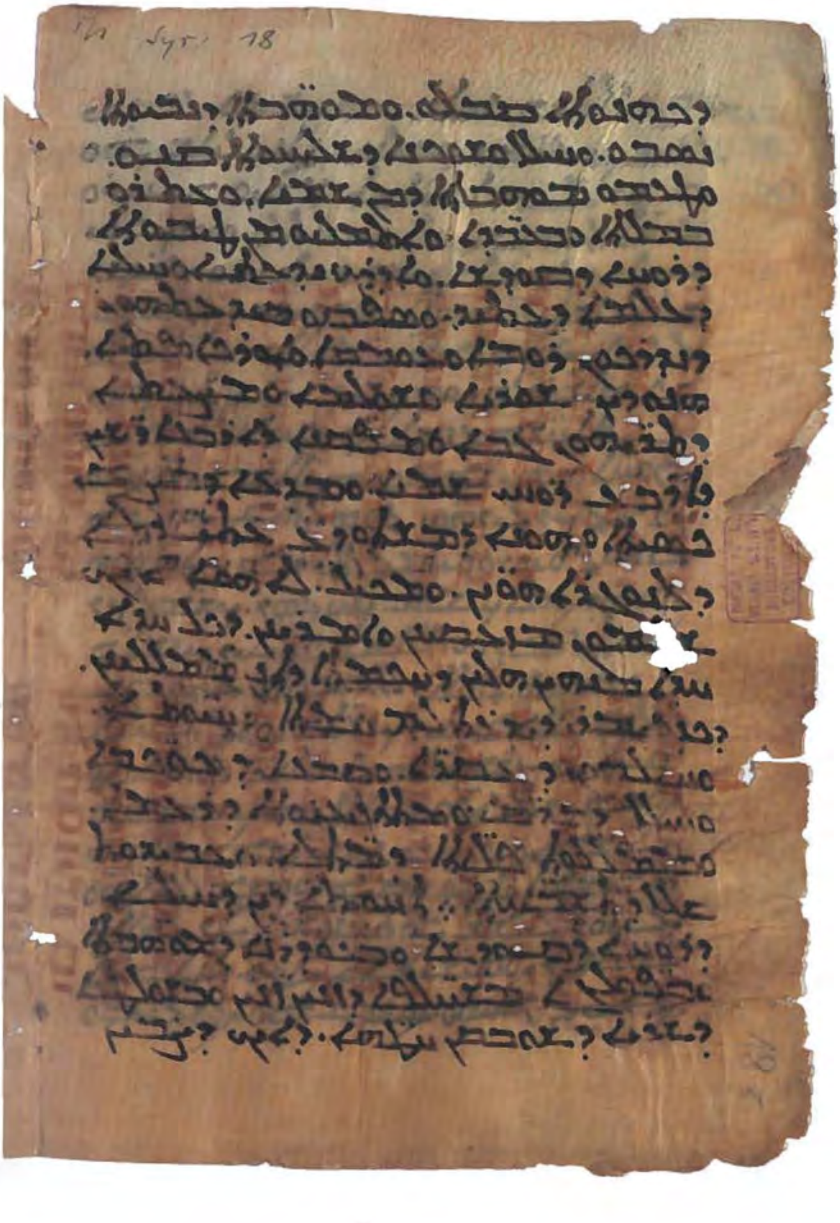
In addition, so-called volatile liver of sulphur (Germ. *Flüchtige Schwefelleber*) was used, consisting of ammonium hydrogen sulphide in solution ($NH_4HS + H_2O$). The ammonium hydrogen sulphide solvent in water is also referred to as sulphuretted ammonia or hydrosulphuret of ammonia (Germ. *Schwefelammonium, Schwefelwasserstoffammoniak*). Otto Posse notes: 'Probably the best agent that does not cause damage to the parchment, when used with care.'[16] On the use of the solution he remarks:

> Sulphuretted ammonia, diluted with 40–50 % water. Should not be used on all parchments, not even undiluted; the process has to be done quickly, all excess fluid to be absorbed with good blotting paper from the surface of the parchment or paper. The writing will not go a dark black but only brown, which is all that is needed. Using a brush one dampens the parchment with pure water, in order to make the parchment receptive for the application of the sulphuretted ammonia. The brush is dipped in the thinned reagent and the parchment wetted as quickly as possible but without letting the moisture go right through. After a few seconds the script goes a darker colour, then the moisture is removed by the application of blotting paper (at least two sheets) and the parchment is then put in the press between a new layer of dry blotting paper. If the script is not clear enough, the process can be repeated, which is at all events better than using the undiluted agent. On a sheet so treated one must not apply any solution of blue vitriol or iron vitriol, otherwise the area will become black through the combination with sulphur and will render the script completely illegible. The ammonia process with metallic inks is to be preferred above all others.[17]

Volatile liver of sulphur was used by Hugo Duensing (1877–1961), Martin Flashar (1885–1914), Karl Pertz (1828–1881) and others (v.i. § 'Perspectives').[18] An example is the Christian-Palestinian-Aramaic palimpsest fragments in the university library in Göttingen (Fig. 81).[19]

The methods just named, which are best referred to as liver of sulphur tinctures (Germ. *Schwefellebertinkturen*), all have one thing in common: they are based on the principle that the metallic traces of the ink so removed, i.e. of the *scriptio inferior*, precipitate through contact with the various sulphide solutions and thus help to freshen up the optical effect of the old ink traces.[20] The cations present in the remaining traces of ink, of magnesium, cobalt, zinc (Mn^{2+}, Ni^{2+}, Co^{2+}, Zn^{2+}) etc., are precipitated as their corresponding sulphides (MgS, NiS, CoS, ZnS). An unpleasant side-

Fig. 81. *Sample of a page treated with volatile liver of sulphur – SUB Göttingen, Cod. Gotting. MS. Syr. 18.*



effect of the use of these substances is the formation of gaseous hydrogen sulphide (H_2S), which produces the characteristic smell of rotten eggs. The stench of this agent was almost unbearable, as Grimm writes on 26 April 1827:

> The very smell of the reagent had such a strong effect that I had to give up this winter and had to wait until milder weather allowed me to work with the windows open.[21]

Whereas calcic liver of sulphur can cause permanent damage to parchment treated with it by the depositing of calcium sulphate and simple liver of sulphur through deposits of potassium carbonate or potassium hydrogen carbonate, the palimpsests treated with volatile liver of sulphur display no damaging changes to the parchment surface worth mentioning. But as the parchment, in the process of being made into a palimpsest, can show a few traces of calcium carbonate residue, which can come from the primary treatment of the writing material and then in some cases can result from the secondary stage of preparing the palimpsest, a harmful reaction cannot be ruled out even with the use of volatile liver of sulphur. Therefore it is worth considering volatile liver of sulphur also as a source of damage.[22]

Giobert tincture[23]

When the classical scholar Amedeo Peyron (1785–1870) found traces of some hitherto unknown Cicero orations in a Turin manuscript, he sought advice from his colleague Giovanni Antonio Giobert (1761–1834), who was a chemist of some importance as well as a mineralogist. Giobert then produced a weak acid solution of potassium hexacyanoferrate (II), the 'Giobert tincture' (Germ. *Giobertische Tinktur*), which is named after him.[24] How this came about is described by Peyron himself in the *Praefatio altera* to his Cicero edition of 1824:

> But when I looked more closely at the codex, traces of an older script became visible that had been replaced by a more recent cursive, and this was so faded that I could only just make out the odd syllable. I used an oak-gall tincture, but without any noticeable effect. For once one has established that a scriptorium has used an ink mixed of iron sulphate and oak-gall and the iron in the course of time has oxidised through exposure to the air (I would rather say this in a

scientific fashion than in Latin), then, if the oxidation has been only weak in nature, the iron can easily be treated, stimulated by the oak-gall solution, but of course not when the oxidation is quite violent. The same can be said of ammonium cyanide, for if it only contains a small amount of Prussic acid it cannot prevent the iron from being oxidised to a lasting extent. Therefore I turned to my colleague, the chemistry professor Giobert, a man of whom one cannot say whether one should more admire his extraordinary knowledge or his fine manners. In a word, he prepares the agent. He washes the parchment pages first with ordinary water, then he dips them in hydrochloric acid, which alone can remove the highest degree of oxidation from the iron; then he dips these pages in yellow prussiate of potash, which due to the iron takes on either a bluish grey or a green coloration according to the different kinds of parchment pages; then finally he washes them repeatedly with water to prevent harmful drops of hydrochloric acid from adhering to the pages. [...] I repeat, that this worked with the first pages, because the top script retains a black coloration and through this the one below turns a bluish grey or green and one can distinguish one script more easily from another.[25]

Giobert tincture consists of six parts of water (H_2O), one part of hydrochloric acid (HCl) and an eighth part of potassium hexacyanoferrate (II) ($K_4[Fe(CN)_6]$, yellow prussiate of potash).[26] The weak acid solution of potassium hexacyanoferrate (II) reacts in contact with the iron (II) sulphate ($FeSO_4$, copperas) of the ink to produce a deep blue precipitate, so-called Prussian blue or iron (III) hexacyanoferrate (II) ($Fe_4[Fe(CN)_6]_3 \times n\,H_2O$).[27] The deep blue, almost black, discoloration of the *scriptio superior* comes about through both of the oxidation stages of the iron (Fe^{2+}, Fe^{3+}). The greenish discoloration of the *scriptio inferior* has to do with the precipitates of the iron (II) sulphate in form of hydrous copperas ($FeSO_4 \times 7\,H_2O$, heptahydrate of iron [II] sulphate). Heptahydrate of iron (II) sulphate represents only the simple stage of the oxidation of iron, bivalent iron (Fe^{2+}), that shows a blue coloration. But partial oxidation to trivalent iron (Fe^{3+}) produces the green coloration. This very Giobert tincture has caused the greatest damage. The large patches of light to dark-blue/greenish-blue discolorations are typical, especially when little care has been exercised (Figs. 82 & 83). A sad example of its use is the *Codex Ephraemi Syri rescriptus*.[28] In addition to Amedeo Peyron, Ferdinand Florens Fleck (1800–1849) and others, Constantin Tischendorf (1815–1874) made frequent use of the Giobert tincture.[29]

Fig. 82. *Example of a page treated with Giobert tincture – BnF Paris, Cod. Paris. Gr. 9, f. 58r.*

Fig. 83. *Damage from Giobert tincture @ 50 × enlargement – UB Leipzig, Cod. Lips. Gr. 2, f. XIr.*

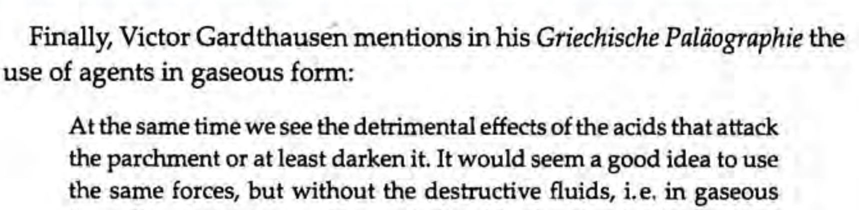
Further procedures

In addition to those already mentioned, potassium sulphocyanide (Germ. *Schwefelcyankalium*) was also used, known today under the name of potassium thiocyanate (KSCN, potassium rhodanide). Otto Posse writes on this subject:

> Potassium sulphocyanide, consisting of one part of potassium sulphocyanide, 15 parts of spring water with a few drops of hydrochloric acid added. The solution is applied with a brush, and the letters will appear reddish for a few minutes, but will soon disappear again.[30]

Through the use of potassium thiocyanate (KSCN) the iron cations (Fe^{3+}) left in the remaining ink residue are precipitated, producing blood-red iron (III) thiocyanate ($Fe[SCN]_3$, iron [III] rhodanide).[31] The addition of hydrochloric acid has the further effect – if the ink happens also to contain copper – that the cations of the copper (Cu^+) precipitate as white copper (I) thiocyanate (CuSCN, copper rhodanide).[32] If more than one agent was used on one spot, the result was disastrous and the text was quite often rendered illegible (Fig. 84).

Fig. 84. *Damage resulting from the combination of oak-gall tincture and Giobert tincture – HAB Wolfenbüttel, Cod. Weissenb. 76, f. 71v.*



Finally, Victor Gardthausen mentions in his *Griechische Paläographie* the use of agents in gaseous form:

> At the same time we see the detrimental effects of the acids that attack the parchment or at least darken it. It would seem a good idea to use the same forces, but without the destructive fluids, i.e. in gaseous form. Practical tests that I have tried in this direction in the chemical lab here, with friendly help, have shown that this method is effective, if not applicable to all cases and of sufficient effectiveness.[33]

The 1898 'International Conference on the Conservation and Repair of Ancient Manuscripts' in St. Gall marked a turning-point in research in this area:[34]

> Anyone who has had the chance of seeing the barbaric fashion in which irreplaceable manuscripts have been destroyed [...] by the application of reagents should see the urgent need for chemical methods to be supplanted by ones that do not damage the manuscript. Photography, which has become an essential tool for scholarly research, is the most applicable.[35]

It took years before the old methods were discarded, however. As late as 1914 Hugo Duensing and Martin Flashar used volatile liver of sulphur on two valuable palimpsest manuscripts in the library of the Orthodox Patriarchate in Jerusalem.[36] For *Cod. Hierosolymitanus* Ἁγίου Τάφου 2 Flashar noted in his account of the journey:

> The older writing, a nicely regular and well-formed majuscule that possibly goes back to the 4th century, could be read clearly in some places, but in others it had been carefully washed off and covered by the writing over it. There was nothing for it but to use sulphuretted ammonia, which, apart from the trouble and the terrible smell, is always a dangerous business if the top script is not to be destroyed.[37]

The use of photography recommended in St. Gall was first tried out on a large scale in palimpsest research at Beuron. Here the Palimpsest Institute of the Abbey of Beuron was founded in 1912.[38] Raphael Kögel developed a new photographic process that he named the 'contact oxidisation method' (Germ. *Kontaktoxydationsmethode*).[39] In the last analysis he also used the inks' reaction to chemical processes. Kögel wrote:

> My experiments have shown me new paths. White paper, soaked in various dilute solutions of aniline and bleaching agents produces in contact with inks very good white impressions of scripture.

The acidic and metallic inks react in combination with an aniline solution (C_6H_7N), with the aniline salts being precipitated. Using this method the *Codex Sangallensis* 193 was treated photographically and the results were published as a volume of plates in 1913.[40] The First World War interrupted the work at Beuron, however, and since then people have mostly been content to use ultra-violet light for decipherment purposes.

Some success can be achieved with modern multispectral photography. In the main, three types of apparatus are used: the stationary instruments 'Mondo Nuovo' of the Italian firm Fotoscientifica Record (Parma), the American 'EurekaVision' system (Equipoise Imaging, LLC/MegaVision, Inc.) and the portable 'MuSIS' camera of the Greek manufacturer Forth-Photonics (Athens).[41] The European research project under Dieter Harlfinger, 'Rinascimento Virtuale', which ran from 2002 to 2004, has without doubt given impetus to research. The scope of this technology is limited, however, especially when the parchment has been damaged through the use of chemicals, so that the use of conventional ultra-violet lamps as well as the use of daylight achieves almost the same or even better results.

Notes

1. Recent literature: F. Lo Monaco, 'In codicibus ... qui Bobienses inscribuntur. Scoperte e studio di palinsesti Bobbiesi in Ambrosiana dalla fine del settecento ad Angelo Mai (1819)', in: *Aevum* 70 (1996), 657–719, pp. 709–717 and B. Gullath, 'Handschriftenkunde', in: *Lebendiges Büchererbe. Säkularisation, Mediatisierung und die Bayerische Staatsbibliothek* (München 2003), 80–85, pp. 83–85. Older surveys: cf. above all W. Wattenbach, *Das Schriftwesen im Mittelalter* (Leipzig ³1896), pp. 310–315; O. Posse, *Handschriften-Konservirung. Nach den Verhandlungen der St. Gallener Internationalen Konferenz zur Erhaltung und Ausbesserung alter Handschriften von 1898 sowie der Dresdener Konferenz Deutscher Archivare von 1899 bearbeitet* (Dresden 1899), p. 4, n. 1; V. Gardthausen, *Griechische Paläographie. Band 1: Das Buchwesen im Altertum und im byzantinischen Mittelalter* (Leipzig ²1911), pp. 106–109.

2. V. Gardthausen rightly notes in *Paläographie*, p. 108f.: 'Alle diese Versuche, erloschene Schrift wieder herzustellen, setzen natürlich den Gebrauch metallischer Tinten voraus und würden auf die schwachen Spuren der Rußtinte auf Papyrus gar keinen Einfluß ausüben. Von der metallischen Tinte ist gewissermaßen selbst nach Entfernung der schwarzen Schrift ein kleiner Teil noch latent vorhanden im Pergament. Dieser kleine Rest von Eisen verbindet sich mit dem Blutlaugensalz, Schwefelammon usw. und tritt nun wieder verstärkt zutage'. On the exact chemical reactions cf. the account below of the individual chemical reagents. On the chemical composition of inks cf. R. Fuchs, 'The History of Chemical Reinforcement of Texts in Manuscripts. What Should We Do Now?', in: *Care and Conservation of Manuscripts* 7 (Copenhagen 2003), 159–170, pl. XXVI–XXX.

3. O. Posse, *Handschriften-Konservirung*, p. 4, n. 1 notes on oak-gall tinctures the following: 'Galläpfeltinktur. Rezept bei Chassant, Paléographie des chartes S. 66: une dissolution hydroalcoolique de noix de galle, qu'on obtient en faisant macérer, pendant 3 à 4 jours, dans

4 onces d'ésprit de vin à 22 degrés six noix-galles grossièrement pulvérisées'. – The effect of oak-gall tincture can, according to Otto Posse, also be achieved by a simple tannin solution: 'Tanninlösung, Tannin in einer mässig concentrirten wässerigen Lösung, etwa 1:20, ist identisch in der Wirkung mit Galläpfeltinktur' (l. c.); cf. V. Gardthausen, *Paläographie*, p. 108.

4. Cf. W. Wattenbach, *Schriftwesen*, p. 311. Oldest mention in P. M. Canepari, *De atramentis cuiuscunque generis. Opus sane novum hactenus a nemine promulgatum in sex descriptiones digestum* (Venedig 1619), p. 179; on this R. Fuchs, 'History', pp. 159–163.
5. F. Ehrle, 'Über die Erhaltung und Ausbesserung alter Handschriften', in: *Centralblatt für Bibliothekswesen* 15 (1898), 17–33, p. 19f.
6. Cf. F. Ehrle, 'Erhaltung', p. 20: 'In allen diesen, in so trauriger Weise geopferten Palimpsesten ist ganz augenscheinlich die Tinte der zweiten Schrift der hauptsächlichste Träger der fortschreitenden Korrosion'.
7. A more recent survey of research into iron-gall ink and ink damage in: J. Hanus et al., 'Survey of Historical Manuscripts Written with Iron Gall Inks in the Slovak Republic', in: *Restaurator* 30 (2009), 165–180, pp. 165–167. – De-acidification of the writing material can help against this, cf. the method of deacidifying by means of calcium and magnesium hydroxide nanoparticles: E. Stefanis & C. Panayiotou, 'Deacidification of Documents Containing Iron Gall Ink with Dispersions of $Ca(OH)_2$ and $Mg(OH)_2$ Nanoparticles', in: *Restaurator* 31 (2010), pp. 19–40. Already Franz Ehrle considered the neutralisation of acids as a possible counter-method, but his experiments were fruitless; cf. F. Ehrle, 'Erhaltung', esp. p. 21f.
8. W. Wattenbach, *Schriftwesen*, p. 311f. has the anecdote on Angelo Mai: 'Die von Angelo Mai behandelten Codices sind so schwarzbraun, daß man ihm nachgesagt hat, er habe sie absichtlich verdorben, damit man ihm keine Fehler nachweisen könne'.
9. The reagents discussed here still carry in the older secondary literature their alchemical designations. 'liver of sulphur' is referred to in abbreviated form as potassium sulphide (K_2S, Germ. *Schwefelkalium*) and 'volatile liver of sulphur' as sulphur ammonia ($NH_4HS + H_2O$, ammonium hydrogen sulphide solution, Germ. *Schwefelammonium*). Cf. O. Posse, *Handschriften-Konservirung*, p. 4: 'Als Reagentien sind im Laufe der Zeit Schwefelkalium, Schwefelammonium, Schwefelcyankalium und Blutlaugensalz verwendet worden'; On 'Schwefelcyankalium' and 'Blutlaugensalz' v. i. §§ 'Giobert tincture' and 'Further procedures'.
10. G. Brannahl, 'Schwefelleber, Flüchtige Schwefelleber, Schwefelammonium, Spiritus antipodagricus', in: *Mitteilungen der Internationalen Arbeitsgemeinschaft der Archiv-, Bibliotheks- und Graphikrestauratoren* 3 (1973), 405–415, p. 410. Friedrich Ebert notes (l. c.): 'Man hat aber darauf zu achten, dass die Tinctur möglichst frei von Sediment sei, weil sonst dieses die Oberfläche des Pergaments mit einer schwer wegzubringenden kalkartigen Masse überzieht'.
11. Calcium polysulphide (CaS_x) = Calcium disulphide (CaS_2), Calcium trisulphide (CaS_3), Calcium tetrasulphide (CaS_4), Calcium pentasulphide (CaS_5).
12. Potassium polysulphide (K_2S_x) = potassium disulphide (K_2S_2), potassium trisulphide (K_2S_3), potassium tetrasulphide (K_2S_4), potassium pentasulphide (K_2S_5), potassium hexasulphide (K_2S_6).
13. Potassium carbonate reacts with water

to produce potassium hydrogen carbonate and potassium hydroxide: $K_2CO_3 + H_2O \longrightarrow KHCO_3 + KOH$.

14. O. Posse, *Handschriften-Konservirung*, p. 4, n. 1.
15. B. G. Niebuhr (v. s.) used this reagent on palimpsests in Milan, cf. O. Posse, *Handschriften-Konservirung*, p. 4, n. 1 with reference to: 'Ciceron. Orat. frag. Romae 1820 p. 11'.
16. O. Posse: *Handschriften-Konservirung*, p. 4, n. 1. Similarly in Sir Edward Maunde Thompson's *Introduction to Greek and Latin Palaeography* dating from 1912: 'Of modern chemical reagents used in the restoration of such texts [*sc.* palimpsests] the most harmless is probably hydro-sulphuret of ammonia' (p. 65). Interestingly, this is the only reagent which Thompson mentions explicitly; otherwise he indicates only vaguely that chemical reagents have been used in palimpsest research (l. c.): 'yet slight traces of the text might remain which chemical reagents, or even the action of the atmosphere, might again intensify and make legible'.
17. O. Posse, *Handschriften-Konservirung*, p. 4, n. 1.
18. For H. Duensing cf. F. Albrecht, Art. 'Hugo Berthold Heinrich Duensing', in: *BBKL* 33 (Nordhausen 2012), col. 307–318; for M. Flashar cf. id., Art. 'Martin Johannes Gerhard Flashar', in: *BBKL* 33 (Nordhausen 2012), col. 418–420. Karl August Friedrich Pertz was the person who deciphered the Granius Licinianus palimpsest.
19. The palimpsest fragments of Christian-Palestinian-Aramaic provenance in the SUB Göttingen (*Codd. Gottingenses MS. Syr.* 17–20.23) are from Hugo Duensing's collection and have almost all been treated with volatile liver of sulphur.
20. Cf. R. Fuchs, 'History', p. 164f.
21. G. Brannahl, 'Schwefelleber', p. 408.
22. O. Posse, *Handschriften-Konservirung*, p. 4, n. 1: 'Bei der Diskussion über die Reagentien wird von Prof. Hansen bemerkt, dass bei Schwefelammoniak sich nach und nach eine weisse Schwefelschicht bildet, die gar keine Buchstaben mehr in Erscheinung treten lässt. Dr. Schneider: Die weisse Haut ist Schwefel. Wenn es nötig ist, sie zu entfernen, so könnte man den Versuch machen mit Schwefelkohlenstoff, indem man diesen vermittels Watte darauf bringt. Ich nehme natürlich an, dass die Schrift durch den Schwefelkohlenstoff nicht gelöst wird. Das müsste man aber auch erst durch Versuche in dem speziellen Falle feststellen. [...] Geh. Archivrath Könnecke tritt für die Verwendung des Ammoniums ein. Er behauptet, dass die weisse Haut nur durch ungeschickte Anwendung entsteht (Stenogr.). – Behandelt man, wie oben vorgeschrieben, das Blatt vorsichtig, so wird auch diese Erscheinung wegbleiben'.
23. On the following see F. Albrecht, 'Codex Ephraemi Syri rescriptus. Neue Lesarten zum Septuagintatext des Koheletbuches', in: *ZAW* 122 (2010), pp. 272–279.
24. A similar method had been invented already in 1787 by Sir Charles Blagden, 'Some Observations on Ancient Inks. With the Proposal of a New Method of Recovering the Legibility of Decayed Writings', in: *Philosophical Transactions of the Royal Society of London* 77 (1787), pp. 451–457.
25. A. Peyron, *M. Tullii Ciceronis orationum [...] fragmenta inedita* (Stuttgart 1824), therein: Ad fragmenta orationum Ciceronis praefatio, p. 3f.
26. Cf O. Posse's recipe, *Handschriften-Konservirung*, p. 4, n. 1: 'Giobertitinktur, bestehend aus 6 Theilen Wasser, 1 Theil Acidum muriaticum (Salzsäure),

⅛ prussiate de potasse (Kali zooticum, gelbes Blutlaugensalz)'.

27. The chemical reaction is as follows: $[Fe(CN)_6]^{4-} + Fe^{3+} \longrightarrow [Fe(CN)_6]^{3-} + Fe^{2+}$. Cf. R. Fuchs, 'History', p. 165.
28. Cf. F. Albrecht, 'Codex'. – On *Cod. Ephraemi* not only Giobert tincture was used. The typical brown discoloration of the parchment shows that, and presumably before treatment with the Giobert tincture, oak-gall tincture was used. Cf. f. 15r–18r; 20r–21v; 35rv; 110rv; 159r; 196v–197v and to some extent f. 203r.
29. For F. F. Fleck cf. F. Albrecht, Art. 'Ferdinand Florens Fleck', in: *BBKL* 33, (Nordhausen 2012), col. 420–423.
30. O. Posse, *Handschriften-Konservirung*, p. 4, n. 1 with reference to: 'Fleckeisen, Jahrb. 97. S. 546 Anm.'.
31. The chemical equation as follows: $Fe^{3+} + SCN^- + 5\,H_2O \longrightarrow [Fe(SCN)(H_2O)_5]^{2+}$. In that process hexathiocyanoferrate (III) anions $[Fe(SCN)_6]^{3-}$ are produced.
32. Sodium sulphite (Na_2SO_3) produced by hydrochloric acid in addition reduces the copper ions: $2\,Cu^{2+} + SO_3^{2-} + 3\,H_2O \longrightarrow SO_4^{2-} + 2\,H_3O^+ + 2\,Cu^+$. The cations of copper (Cu^+) react with the anions of the thiocyanate (SCN^-) to produce copper (I) thiocyanate (CuSCN): $Cu^+ + SCN^- \longrightarrow CuSCN$. – Without the addition of hydrochloric acid $Cu(SCN)_2$ would precipitate, showing a black coloration.
33. V. Gardthausen, *Paläographie*, p. 109.
34. Cf. the contribution of Margit J. Smith to this vol.
35. O. Posse, *Handschriften-Konservirung*, p. 4. – On the use of photography in palimpsest research cf. the outstanding article of C. Faraggiana di Sarzana, 'La fotografia applicata a manoscritti greci di difficile lettura. Origini ed evoluzione di uno strumento di ricerca e i principi metodologici che ne regolano l'uso', in: Á. Escobar (ed.), *El palimpsesto grecolatino como fenómeno librario y textual* (Zaragoza 2006), pp. 65–80.
36. *Cod. Hierosolymitanus Sancti Sepulcri* 2; *Cod. Hierosolymitanus Sanctae Crucis* 36. For H. Duensing and M. Flashar v. s. n. 18.
37. M. Flashar, *Bericht über meine Reise nach dem Orient im Januar – März 1914*, p. 6; edited by F. Albrecht, 'Die Handschriftenakquisitionen des Septuaginta-Unternehmens am Beispiel der Orientreise Martin Flashars im Jahr 1914', in: R. G. Kratz & B. Neuschäfer (eds.), *Die Göttinger Septuaginta. Ein editorisches Jahrhundertprojekt* (Abhandlungen der Akademie der Wissenschaften zu Göttingen N. F. 22), Berlin et al. 2012. Cf. id., 'Ein Novum Supplementum Euripideum? Die unbekannten Seiten des Euripides-Palimpsestes Codex Hierosolymitanus Sancti Sepulcri 36', in: *Aevum* 86 (2012), 3–27, p. 4f.
38. Cf. E. Mundig, 'Das Palimpsestinstitut in Beuron', in: *SMGB* 33 (1912), pp. 742–745. – Since 1917 Alban Dold (1882–1960) was the institute's director.
39. Cf. R. Kögel, 'Die Frage unleserlicher und unsichtbarer Schriften der Palimpseste', in: *SMGB* 33 (1912), pp. 309–315.
40. *Spicilegium palimpsestorum Bd. 1, Codex Sangallensis 193. Continens fragmenta plurium prophetarum secundum translationem S. Hieronymi* (Beuron et al. 1913).
41. www.fotoscientificarecord.com; www.eqpi.net or www.mega-vision.com and musis.forth-photonics.com. Cf. D. Deckers & J. Grusková, 'Zum Einsatz verschiedener digitaler Verfahren in der Palimpsestforschung', in: A. Bravo García & I. Pérez Martín (eds.), *The Legacy of Bernard de Montfaucon. Three Hundred Years of Studies on Greek Handwriting. Proceedings of the Seventh International Colloquium of Greek Palaeography (Madrid–Salamanca, 15–20 September 2008)* (Bibliologia 31 A–B), Turnhout 2010, pp. 353–362.