

Shedding some new light

on the blue pigment ‘vivianite’ in technical
documentary sources of northern Europe

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Introduction

The interpretation of pigment terminology in historical documentary sources has often been problematic and began as early as the ancient times (e.g. Pliny, Vitruvius, Theophrastus) continuing all the way into the nineteenth century. The terminology of blue pigments, in particular natural ultramarine, azurite, artificial copper blue pigments, smalt, indigo and vivianite, has proven to be especially confusing.

Since the 1980s, technical literature has often described the blue pigment vivianite, a hydrated iron phosphate mineral, as rarely used despite the fact that it can be identified in numerous works of northern European art from the Romans to c. 1800.¹ Very few studies describe the occurrence of vivianite in documentary sources, and indeed identification has proven to be very difficult due to the many synonyms such as ‘azur’ (also ‘lasur’ or ‘lazur’) or ‘ashes’ that were commonly used for various blue pigments and dyestuffs. This article will attempt to shed new light on this very elusive pigment by re-evaluating a selection of northern European documentary sources.

It will also discuss a number of terms that have been used for blue pigments in order to properly acknowledge indications of vivianite. The secure identification of vivianite in a few documentary sources proved significant for our understanding of the terminology, historical deposits, use and colour of this pigment. An up-to-date table on identifications of vivianite in western European painting and polychromy will also be presented (see Table 1).

Mineral and deposits

Vivianite, originally called 'Blau-eisenstein' or 'Blau-Eisenerde', was named in 1817, after its discoverer J. G. Vivian, by Abraham Gottlob Werner (1749–1817).² It is a hydrated iron phosphate ($\text{Fe}_3(\text{PO}_4)_2 \cdot 8\text{H}_2\text{O}$) of a pale blue, greenish-blue, dark-blue or blackish-blue colour and is found principally in two environments. In oxidation zones of metalliferous ore deposits it may appear as radiating prismatic crystals, tabular masses or concretions and crusts with fibrous structure (fig. 1).³ It also occurs in an earthy form in organic, phosphate rich environments such as peat deposits in bogs and marshes, as well as in lacustrine sediments.⁴ In these areas, oxygen depleted, iron rich water wells up into organic matter-rich layers. The iron reacts with the phosphates from the water or from the organic matter to form vivianite. The blue to green colour occurs after the initial exposure of virtually colourless vivianite to air. This partially takes place through oxidation of Fe^{2+} to Fe^{3+} . The blue colour becomes deeper when oxidation increases. This colour transformation is a special feature of vivianite found in peat bogs.⁵ The mineral is generally stable in colour although the alteration of vivianite from its blue hue to a yellow colour has been observed in medieval wall paintings in Germany and England as well as seventeenth-century Dutch paintings.⁶

In Germany, deposits of vivianite exist in Bavaria (e.g. Oberpfalz, Bodenmais, Samerberg) as well as in Cologne, Westphalia, Hessen, and Saxony. The earthy deposit in Samerberg (Inntal), is blue in colour (fig. 2).⁸ In Saxony it is found as an indigo blue earth near Eckartsberg (Weißenfels), which was described in detail already by Werner in 1774.⁹ In Johann Heinrich Hagen's study 'Chemisch-Mineralische Untersuchung einer merkwürdigen blauen Farberde aus dem Preußischen Torfbrüchen' (1772), vivianite is described as a blue ferrous pulverant in specific peat bogs near Königsberg (today Kaliningrad) in East Prussia.¹⁰ The hydrated iron phosphate also occurs in its earthy form in the peat bogs close to Franzensbad in Bohemia (today Czech Republic).¹¹ In Austria vivianite is found in the iron rich

areas of Erzberg (Styria) and areas close to Salzburg.¹²

In the Netherlands deposits of the mineral have been discovered along the Maas River near Venlo, in the area between Wageningen and Veenendaal and in the polders near Almere and Lelystad.¹³ These earthy deposits are typically found in waterlogged clay or peat layers that appear mottled with white spots of vivianite that turn an intense blue when subjected to air. In the past such environments also occurred locally, in the whole of the western Netherlands, where the land between the towns consisted largely of peat bogs. At the beginning of the seventeenth century, it is documented that these bogs were of the utmost importance. The peat was scooped out, dried and used for heating the houses of the town's inhabitants. This was done on a large scale leading to the formation of large pools or lakes, which became a danger to towns such as Haarlem, Alkmaar, Leiden and Amsterdam, making it necessary to drain the peat bogs.¹⁴ This was also the case in Dordrecht where a very active peat industry has been documented.¹⁵ It is quite possible that during the peat cutting and draining the inhabitants discovered deposits of vivianite that were easily extractable for pigment preparation. In connection with this it is interesting to note that Simon Eikelenberg, a painter and town historiographer in Alkmaar, describes a blue mineral ('Blau as') in his notes on painting from 1700, which is found on the surface of the ground in a ditch.¹⁶

Noteworthy is also the recent discovery of a bright blue substance excavated on the Grote Markt in the centre of Dordrecht in a ground layer dated between 1400 and 1450, which proved to be vivianite (fig. 3).¹⁷ It is difficult to say if these remains were part of a larger deposit, but vivianite is quite common in the soil of Dordrecht and its outskirts. Deposits are also found in the Ardennes in southern Belgium and the Campine in the north that stretches from the northern part of Belgium across the confines of the Netherlands.¹⁸ Deposits in England are found in South Humberside, Yorkshire and Cornwall, where it occurs as a secondary mineral in association with tin.¹⁹ A substantial occurrence of vivianite as a blue pulverant has been found close to Airdrie in Scotland.²⁰ In Russia, it occurs in large amounts in the bog ore deposits close to Moscow and today this vivianite is used to prepare a very high quality artists' pigment. Of special interest is also the vivianite found in bog iron ore in the area around Riga (Latvia), which appears to have been prepared and used as an artists' pigment since the seventeenth century.²¹

Thoughts on preparation

Today the dark blue vivianite used for preparation of artists' pigments is mainly collected from ore deposits of

Table 1 Identifications of vivianite in works of art

Location, object, artist and date	Description, Pigment, Binding media	Analysts, Reference
Schafelach (Bavaria), Germany, Parish church Heilig Kreuz, polychrome wooden crucifix, c. 1050-1100	Blue areas on the loincloth, vivianite	Heike Stege, Doerner Institut, (personal communication, Karbacher 2005)
Cologne (North-Rhine Westphalia), Germany, St. Maria im Kapitol: polychrome wooden door, polychromy from 1065	Red area of an angel's wing, dark red paint layer on brownish yellow lead white-calcite ground (drying oil/ proteinaceous medium) followed by a greyish-blue layer composed of lead white and vivianite	Elisabeth Jägers, Fachhochschule Köln (Schulze-Senger, Jägers, Hansmann, 1991) ⁷⁵
Prague, Czech Republic, National Library, Codex Vischradensis (coronation evangelist or gospel book), 1085	Blue area, vivianite with natural ultramarine	Doris Oltrogge, Fachhochschule Köln (personal communication Oltrogge 2003)
Schloß Lichtenstein (Württemberg), Germany, polychrome wooden crucifix, second half of 12th century	Loincloth (first overpainting), blue area with vivianite	Ernst-Ludwig Richter, Heide Härlin, Staatliche Akademie der bildenden Künste Stuttgart (Richter 1988)
Freudenstadt (Swabia), Germany, Stadtkirche (Schwarzwald), polychrome wooden lectern, c. 1150	Blue garment of St. Matthew, vivianite on grey underpainting (organic black pigment and lead white)	Ernst-Ludwig Richter, Heide Härlin, Staatliche Akademie der bildenden Künste Stuttgart (Richter 1988)
Winchester, United Kingdom, Winchester Cathedral (Holy Sepulchre Chapel), wall painting, c. 1175	Joseph of Arimathea, blue panelled background, vivianite layer on layer of natural ultramarine.	Helen Howard, G. Cressy, London (Howard 2003) ⁷⁶
Lorch (Württemberg), Germany, Lorch Monastery, polychrome wooden crucifix, approx. 1180	Vivianite	Ernst-Ludwig Richter, Heide Härlin, Staatliche Akademie der bildenden Künste Stuttgart (Richter 1988)
Basel, Switzerland, Cathedral, Gallus portal, polychrome sculpture, approx. 1180	Blue areas of three of four evangelists (Matthew, John, Mark), vivianite, small amount of natural ultramarine, lead white	Andreas Küng, Basel (Küng 2002) ⁷⁷
Soest (Westfalia), Germany, Hohnkirche, polychrome wooden disc-shaped panel crucifix, 1180-1220	Vivianite	Hermann Kühn, Munich (Richter 1988)
Winchester, United Kingdom, Winchester Cathedral (Holy Sepulchre Chapel), wall painting, c. 1220	Deposition scene, blue panelled backgrounds, vivianite was applied over grey underpaint of charcoal black combined with lime white.	Helen Howard, G. Cressy, London (Howard 2003)
Vienna, Austria, St. Stephan, west gallery, wall painting, 1230	Vivianite	Helmut Richard, Hubert Paschinger, Bundesdenkmalamt Vienna (Richard, Paschinger, Koller 2005)
Limburg (Hessen) Germany, Cathedral, wall painting, 1235	Vivianite	Hermann Kühn, Munich (Richter 1988)
Stuttgart (Swabia), Germany, Württembergischen Landesmuseum?, polychrome wooden Virgin Mary with Child, approx. 1250	Blue lining of Mary's mantle, vivianite	Ernst-Ludwig Richter, Heide Härlin, Staatliche Akademie der bildenden Künste Stuttgart (Westhoff 2002) ⁷⁸
Regensburg (Bavaria), Germany, Alte Kapelle, Virgin Mary of the so-called Miraculous Image of Regensburg, first quarter of the 13th century	Blue garment of the Virgin Mary, vivianite was used in the thin undermodelling beneath the blue layer of azurite	Andreas Burmester, Christoph Kreckel, Doerner Institut (Burmester, Kreckel 2001) ⁷⁹
Tingelstad, Norway, Tingelstad Church (Hadeland), Oppland, painted frontal, c. 1275-1300	Mixture of vivianite, azurite and lead white (underpainting)	Unn Plahter, Oslo, Norway (Plahter 2004) ⁸⁰
Mästerby (Gotland), Sweden, village church, wall painting, 13th century	Probable identification of vivianite (identification of iron phosphates)	Anders Nord, Kate Tronner, National Heritage Board, Stockholm (Nord, Tronner 2000) ⁸¹
Urschalling (Bavaria), Germany, wall painting, approx. 1370	Vivianite in altered state	Hermann Kühn, Munich (Pursche 2000) ⁸²
Nuremberg (Bavaria), Germany, St. Sebald church, polychrome stone portal, first half of the 14th century	Polychromy of the blue areas, vivianite	Stefan Simon, Munich (Simon, van Aaken, Exner, Fritsch, Holter 2002) ⁸³
Vienna, Austria, St. Stephan, west gallery, Polychrome "View of City", 14th century	Blue area, vivianite	Ulrike Bültemeyer (Academie der Bildenden Künste, Vienna) (Bültemeyer 2003) ⁸⁴
Schwäbisch Gmünd (Swabia), Germany, Holy Cross Minster, polychromed portals, 14th century	Blue areas, vivianite and smalt	Bläuer Böhm (Hauff 1988, Howard 2003)
Pöding (Bavaria), Germany, Filialkirche, polychrome wooden Virgin Mary with Child, c. 1400-20	Mixture of vivianite and azurite	Hermann Kühn (personal communication Quast 2005)
Schweigggers, Austria, Parish church, wall painting, 1420	Vivianite	Helmut Richard, Hubert Paschinger, Bundesdenkmalamt Vienna (Richard, Paschinger, Koller 2005)
Vienna, Austria, Votivkirche, polychrome altarpiece from Antwerp, 1480	Vivianite	Helmut Richard, Hubert Paschinger, Bundesdenkmalamt Vienna (Richard, Paschinger, Koller 2005)

Table 1 Identifications of vivianite in works of art

Location, object, artist and date	Description, Pigment, Binding media	Analysts, Reference
Obdach, Austria, Spitalkirche, Pietà, polychrome sculpture, 15th century	Vivianite	Helmut Richard, Hubert Paschinger, Bundesdenkmalamt Vienna (Richard, Paschinger, Koller 2005)
Klagenfurt, Austria, Kärntner Landesmuseum, Austria, polychrome wooden relief, 1510-20	Specific areas in carved andscape of relief, vivianite was identified in a pigment mixture of verdigris and yellow ochre	Ulrike Bültemeyer, Akademie der bildenden Künste, Vienna (Bültemeyer 2003)
Emmerthal (East Westphalia), Germany, Schloss Hämelschenburg, wall painting, 1588-1613	Vivianite	(Bültemeyer 2003)
Salzburg, Austria, Cathedral, north tower façade, architectural polychromy on stone, 1630	Blue paint on tower clock, vivianite	Helmut Richard, Hubert Paschinger, Bundesdenkmalamt Vienna (Richard, Paschinger, Koller 2005)
The Hague, The Netherlands, Mauritshuis, panel painting, Susanna, Rembrandt van Rijn, 163(?)	Grey-green foliage: vivianite, yellow lake, smalt, quartz, earth pigments, bone black, red lake, vermilion	Annelies van Loon, FOM Institute AMOLF, Amsterdam (Noble, Van Loon 2005)
Copenhagen, Denmark, Statens Museum for Kunst, panel painting, Landscape with Two Windmills, Aelbert Cuyp, 1640-41	Greenish yellow foliage in the foreground: mainly yellow lake, a little red lake, vivianite, and cassel earth	Marika Spring, National Gallery, London (Spring 2001)
London, United Kingdom, Dulwich Picture Gallery, panel painting, View on a Plain, Aelbert Cuyp, 1644	Greyish green foliage in the foreground: mainly yellow lake, some vivianite, silicon rich yellow earth, a little cassel earth, and lead tin yellow	Marika Spring, National Gallery, London (Spring 2001)
London, United Kingdom, The Trustees of Dulwich Picture Gallery, canvas painting, Herdsmen with cattle, Aelbert Cuyp, c. 1645	Grey-green foreground: Yellow lake, vivianite, cassel earth, yellow earth, a little vermilion; Yellow green hill: yellow lake, some silicon-rich yellow earth, a little vivianite, lead white, and red earth	Marika Spring, National Gallery, London (Spring 2001)
Munich (Bavaria), Germany, Alte Pinakothek, canvas painting, Praying Hermit, Gerrit Dou, 1646	Green foliage: vivianite and other pigments (unknown)	Heike Stege, Doerner Institut (Stege, Klaas, Kutzke, Tilenschi, Burghammer 2006)
London, United Kingdom, The National Gallery, canvas painting, The large Dort, Aelbert Cuyp, 1650	Greyish green of the grass in front of the cow: yellow lake, vivianite, silicon-rich yellow earth, a little green earth, lead white, lead tin yellow, and cassel earth	Marika Spring, National Gallery, London (Spring 2001)
London, United Kingdom, The National Gallery, panel painting, The small Dort, Aelbert Cuyp, 1650-1652	Yellow green of the grass in the foreground: yellow lake, vivianite, silicon-rich yellow earth, a little lead tin yellow, and bone black	Marika Spring, National Gallery, London (Spring 2001)
Washington, USA, National Gallery of Art, canvas painting, Lady and Gentleman on Horseback, Aelbert Cuyp, begun c. 1655, completed 1660 / 1665	Dark green of the burdock leaf: yellow lake, vivianite, lead white, charcoal black, yellow earth, lead-tin yellow; green of the uppermost burdock leaf: yellow lake, vivianite, orpiment, lead-tin yellow	Marika Spring, National Gallery, London (Spring 2001)
London, United Kingdom, Collection of her Majesty Queen Elizabeth II, canvas painting, Evening Landscape, Aelbert Cuyp, late 1650s	Foliage at the right edge of painting: yellow lake, vivianite, yellow earth, cassel earth, a little lead white	Marika Spring, National Gallery, London (Spring 2001)
The Hague, The Netherlands, Huis ten Bosch Palace, Oranjezaal, canvas painting, Part of the triumphal procession with gifts from east and west, Jacob van Campen, 1648-1650	Blue skirt: vivianite was used in underpainting below top layer of natural ultramarine	Annelies van Loon, Lidwien Speleers, Ester Ferreira, Katrien Keune, Jaap Boon, FOM Institute AMOLF, Amsterdam (Van Loon, Speleers, Ferreira, Keune, Boon 2006)
The Hague, The Netherlands, Huis ten Bosch Palace, Oranjezaal, canvas painting, Part of the triumphal procession with sacrificial bull, Pieter de Grebber, 1650	Vivianite	Annelies van Loon, Lidwien Speleers, Ester Ferreira, Katrien Keune, Jaap Boon, FOM Institute AMOLF, Amsterdam (Van Loon, Speleers, Ferreira, Keune, Boon 2006)
London, United Kingdom, National Gallery, painting, View of Delft with a Musical Instrument Sellers Stall, Carel Fabritius, 1652	Vivianite	Marika Spring, National Gallery, London (exh. Cat., Fabritius, 2004)
London, United Kingdom, National Gallery, painting, Self-Portrait, Carel Fabritius, 1654	Grey background: vivianite in mixture	Marika Spring, National Gallery, London (exh. Cat., Fabritius, 2004)
Dresden (Saxony), Germany, Gemäldegalerie Alte Meister, canvas painting, The Procureess, Jan Vermeer, 1656	Blue-grey and green-grey areas of rug: vivianite, smalt, lead white	Heike Stege, Doerner Institut (Stege, Klaas, Kutzke, Tilenschi, Burghammer 2006)
London, United Kingdom, The National Gallery, canvas painting, River Landscape with Horseman and Peasants, Aelbert Cuyp, c. 1660	Grey green of the burdock leaf in the foreground: yellow lake, vivianite, yellow earth, some lead-tin yellow, bone black, and umber	Marika Spring, National Gallery, London (Spring 2001)
Munich (Bavaria), Germany, Alte Pinakothek, painting, The Adoration of the Shepherds, Cornelisz van Poelenburgh (ca. 1594-1667), date unknown	Mantle of the Virgin Mary, greyish-blue: vivianite was identified in the underpainting, on top is a layer of natural ultramarine	Heike Stege, Doerner Institut (Stege, Klaas, Kutzke, Tilenschi, Burghammer 2006)



Fig. 1 Specimen of vivianite from the Ukraine
The sample displays impressively long greenish-blue crystals over a blackish-blue crust of vivianite on sandstone base



Fig. 2 Blue pulverant vivianite on clay substrate, from a bog in Samerberg (Bavaria), Germany

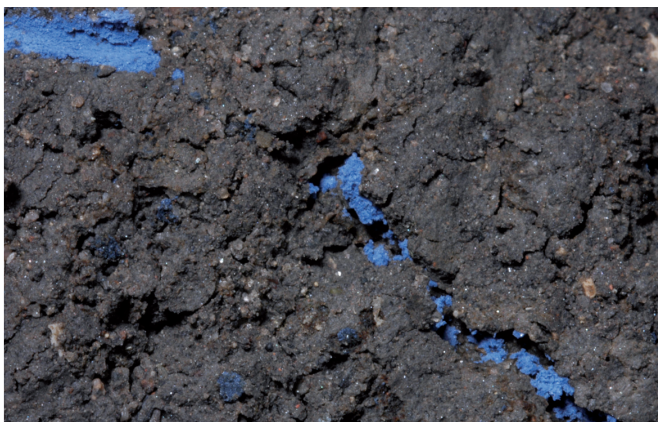


Fig. 3 A bright blue vivianite found in the soil of an excavated ceramic Siegburg jar (dated between 1400 and 1450) from the Grote Markt, Dordrecht

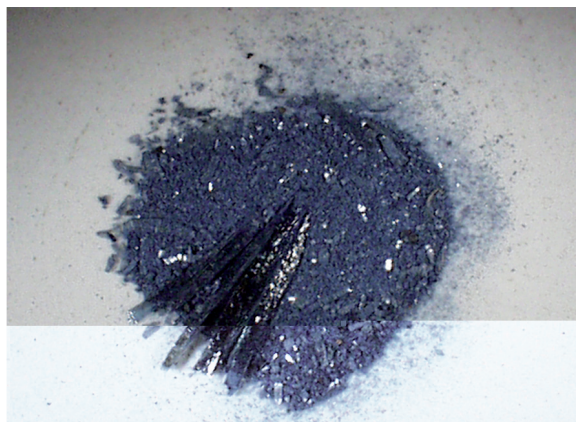


Fig. 4 Vivianite from the Ukraine
Pulverised blackish-blue clump of vivianite, which resulted in an intense indigo-like blue pigment

peat bogs. Vivianite in the form of crystals is not suitable for making a pigment.

The soft, friable vivianite concretions are extracted in a time-consuming process from the viscous, dense clay-like soil. It is necessary to thoroughly flume these concretions in order to remove clay and organic residue from each particle of vivianite. After repeating this process several times a high-quality blue pigment is obtained.

Despite the fact that the blue earthy deposits of peat bogs are much more appropriate for the preparation of this pigment it cannot be ruled out that the blackish blue deposits of globular or encrusting masses, which reveal a beautiful indigo-like colour when pulverized, were also used for this purpose (fig. 4).

The quality and colour of vivianite varied according to the deposit itself, how it occurred and how it was pre-

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Location, object, artist and date	Description, Pigment, Binding media	Analysts, Reference
Munich (Bavaria), Germany, Alte Pinakothek, canvas painting, The Pasture, Aelbert Cuyp, third quarter 17th century	Green leaf of foliage, depth of drapery fold, both samples revealed vivianite	Heike Stege, Doerner Institut (Stege, Klaas, Kutzke, Tilenschi, Burghammer 2006)
Riga, Lithuania, Protestant church St. John, canvas paintings, Kord Meyer (Lüneburg), painted between 1692-1702	Presumably vivianite	I. Sakne, Z. Sokolova, D. Temerova (1997)
Vienna, Austria, Catholic parish church St. Gertraud, high altarpiece, canvas painting, Glorie hl. Laurentius, Peter Strudel, 1695	Vivianite	Helmut Richard, Hubert Paschinger, Bundesdenkmalamt Vienna (Richard, Paschinger, Koller 2005)
St. Pölten, Austria, town hall, canvas painting, Allegorie der Malerei, Peter Strudel, 1698-1699	Vivianite	Helmut Richard, Hubert Paschinger, Bundesdenkmalamt Vienna (Richard, Paschinger, Koller 2005)
Vienna, Austria, Kunsthistorisches Museum, canvas painting, Allegory of the Wedding of Joseph I, Peter Strudel, 1698/99	Three-layered undermodelling with vivianite followed by a glaze with natural ultramarine (blue drapery of puttos)	Helmut Richard, Hubert Paschinger, Bundesdenkmalamt Vienna (Paschinger, Richard 1995)84
Laufen/Salzach (Bavaria), Germany, town hall, canvas painting, Urania und Klio, J. M. Rottmayr, 1700	Vivianite	Helmut Richard, Hubert Paschinger, Bundesdenkmalamt Vienna (Richard, Paschinger, Koller 2005)
Landshut (Bavaria), Germany, Castle Hofburg near Landshut, architectural polychromy (facade), approx. 1700	Reveal of façade, vivianite, red and yellow iron oxide pigment, calcium carbonate, mica, casein	Hermann Kühn, München (Pursche 2000)
Vienna, Austria, Palace Liechtenstein, room 106, canvas painting, Adonis im Olymp, M. Franceschini, 1705	Vivianite	Helmut Richard, Hubert Paschinger, Bundesdenkmalamt Vienna (Richard, Paschinger, Koller 2005)
Lambach, Austria, Stiftsmuseum, pastiglia on wooden panel, Georg Dallinger, 1708	Vivianite	Helmut Richard, Hubert Paschinger, Bundesdenkmalamt Vienna (Richard, Paschinger, Koller 2005)
Vienna, Austria, Palais Schwarzenberg, Marmorsaal, canvas painting, Still-life Flowers, Franz v. Tamm, 1711	Vivianite	Helmut Richard, Hubert Paschinger, Bundesdenkmalamt Vienna (Richard, Paschinger, Koller 2005)
Henndorf am Wallersee, Siebenbürgen, St. Brigida, high altarpiece, canvas painting, Jacopo Zanusi, 1715	Vivianite	Helmut Richard, Hubert Paschinger, Bundesdenkmalamt Vienna (Richard, Paschinger, Koller 2005)
Lorch, Austria, Parish church, canvas painting, Prospekt der Stadt Enns und Heilige, anonymous, 1728	Vivianite	Helmut Richard, Hubert Paschinger, Bundesdenkmalamt Vienna (Richard, Paschinger, Koller 2005)
Helmstedt, Germany, polychrome wooden doors, Kaisersaal in the cloister St. Ludger, first half of 18th century	Blue frame and panel of doors, vivianite, selenite, casein and linseed oil	Analysts are not mentioned (Fünders 1989)86
Gmund (Bavaria), Germany, Catholic parish church St. Giles, polychrome wooden relief from the high altarpiece, Ignaz Günther or his workshop, approx. 1780	Light blue polychromy on frame applied on lead white undermodelling, blue paint consisting of vivianite, Prussian blue and lead white	Klaus Rapp, Mark Richter, Munich (Merz, Richter 2004)

pared. It is worth mentioning that Dutch vivianite is mostly extremely fine with a very small particle size unlike many of the examples found in German and Austrian works, which exhibit a larger particle size and a different shape. In Romanesque art (wall paintings, panel paintings, polychrome sculpture) the blue vivianite was often encountered in good condition and still exhibited quite a blue colour.

Terminology for blue pigments in documentary sources

Vivianite proves to be elusive when trying to recognise it in documentary sources up until the nineteenth century. This is due to the enormous variety of terms and synonyms that have been used for blue pigments and dyestuffs throughout the centuries. In the early and late Middle Ages the terms ‘azur’ (also ‘lasur’, ‘lazur’) mostly indicated the colour blue, but could also indicate specific

pigments such as natural ultramarine, azurite and synthetic copper blue pigments, as well as plant dyestuffs (e.g. indigo, blue dye from *folium* or cornflower). Vivianite should not be ruled out in connection with these terms since it has been identified in works of art from the ancient times onwards. If the preparation of a pigment/dyestuff is described in a recipe, identification may be possible, although distinguishing between the inorganic blue pigments could still be problematic. For example, in a number of German recipes from the late Middle Ages only azurite is explicitly mentioned.²²

The same problems occur with the term ‘menesc’ (derived from Persian: *banaschi*)²³, which is described as a dark blue by Theophilus in his *De Diversis Artibus* (c. 1115–1130).²⁴ It is also mentioned in Le Begue’s treatise²⁵ (1431) as ‘menech’ or ‘menesch’ and in the Munich Painters’ guild ordinances of 1448 as ‘menschenplab’ (also ‘meinsch’ in the slightly altered ordinances of 1461). The Munich guild ordinances describe it as a colourant very similar to ‘Bergblau’ (mountain blue = azurite).²⁶ The context as well as the colourant’s etymological derivation suggests a dark blue colour which lies between the darker *folium* and the lighter ‘lazur’ or ‘azur’ (natural ultramarine, natural and synthetic copper blue, blue lake pigment). It is possible that an organic blue dyestuff or lake pigment is meant. Theophilus describes *menesc* as an alternative to indigo or the juice of elder berries (*Sambucus nigra* L.). Therefore one should not rule out the possibility that under this name Theophilus could have meant the mineral vivianite, which can also have an indigo-like colour and has been identified together with natural ultramarine in Romanesque painting and sculpture polychromy.²⁷ Since Theophilus recommends painting *menesc* on a gray underpainting (‘*veneda*’²⁸), it is interesting to note that vivianite has been identified on grey underpaintings from his time (e.g. Freudenstadt, polychrome wooden lectern from approx. 1150).²⁹ In connection with the Munich guild ordinances and the term ‘menschenplab’ it is also important to point out that vivianite has been identified in fifteenth and sixteenth-century southern German and Austrian paintings and polychrome sculptures.³⁰ There has been considerable discussion in the nineteenth century and currently, as to what is meant in early documentary sources by ‘ashes’ with reference to blue pigments. The German nomenclature was ‘*eschplo*’ (also ‘*Lazur eschen*’ or ‘*Ascherblau*’), the Dutch ‘*asblauw*’ or ‘*aschblau*’, the French ‘*chendre d’azur*’ or ‘*cendres bleues*’, in English sometimes corrupted to ‘*Sanders blue*’. Some of the northern European sources that mention ashes are:

Strassburg Manuscript (c. 1400): *lazur eschen*; Guild ordinances of painters, Tournai (1480): *chendre d’azur*; Painting Niklaus Manuel Deutsch (1516): *esch*; Invoice of Lucas Cranach the Elder (1523): *Ascherblau*; Boltz von Ruffach (1549): *eschplo*, *schmeltzeschen*; Carel Baten (1600): *Aschblau*, *asblauwe*; Gerard ter Brugghen (1616): *ascus*, *aschblauw*; Théodore Turquet de Mayerne (1620–46): *cendre d’azur*, *cendrée*, *aschen*; Pierre Le Brun (1635): *cendrées*; Inventory of Trijntge Pieters (1648): *blau assen*, *engels as*; Christopher Merret (1662): *blaù assen*; Claude Boutet (1673): *cendres*; Samuel van Hoogstraten (1678): *asblaauw*, *assen*; Pierre Pomet (1694): *cendres bleu*; Simon Eikelenberg (1700): *asblaauw*, *as*, *Duitze As*, *Engelse As*; Anonymous (Kunst-Übung, 1715): *Englische Asche*, *Bergasche*; Antoine-Joseph Pernety (1757): *cendre bleue*, *cendre d’azur*; Robert Dossie (1758): *Sanders blue*; Jean-Félix Watin (1772): *cendre bleue*; Christian Friedrich Prange (1782): *Aschblau*, *Eschblau*, *Bergasche*; Johann Georg Krünitz (1773–1858): *blaue Asche*.

There are few clear indications of the composition of ‘blue ashes’ in documentary sources, since it was simply a term used to refer to one of many different blue pigments. Pierre Pomet (1658–1699), a merchant of spices, medicinals, animals and minerals, gives a striking account of his difficulties in trying to ascertain what blue ashes really are, but in the end his efforts were to no avail.³¹ In the case of the sources where it is clear which pigment is meant, it is either azurite, lesser qualities of ultramarine, or sometimes blue verditer, an artificial blue copper pigment.³² The Strassburg Manuscript (c. 1400) proves to be one of the earliest sources where ashes (‘*lazur eschen*’) is recommended for use. The recipes suggest azurite, or perhaps another type of copper blue pigment (e.g. blue verditer).³³ One artist of particular interest is Lucas Cranach the Elder (1472–1553), the Wittenberg court artist, who made use of a wide variety of blue pigments including ‘*ascherblau*’, which are mentioned in invoices.³⁴ It is not quite clear which pigment is meant with the name ‘*ascherblau*’, but it appears to refer to a finely grained, impure and thus greyish appearing azurite which Boltz von Ruffach called ‘*eschplo*’.³⁵ Boltz von Ruffach goes on to say that there are many other types of ash blue, which could also include vivianite. In connection with *eschplo* the finding made on two panel paintings by Nikolaus Manuel Deutsch (1484–1530) is of interest. Deutsch indicated the colours he planned to use by writing the first letter of each word on designated areas of the panel. An exception was made on the *Martyrdom of St. Ursula* (1516) where he used the full word ‘*esch*’ for a blue pigment.³⁶ Another example from this time can be



Fig. 5 Vivianite was identified in the now gray upper layer of the right flag. Pieter Fransz. de Grebber, *Triumphal procession, with sacrificial bull*, (signed and dated 'P. DE GREBBER F 16..' and '1650', oil on canvas, c. 390 x c. 262.5 cm)
Royal Collections, Huis ten Bosch, The Hague

found in the Tournai guild ordinances from 1480 which contain a remarkably comprehensive list of colourants used for painting, including a selection of blue colourants which included '...azur, chendre d'azur, florée, inde, lecquemous...'.³⁷ Another blue pigment of interest with an unknown composition is 'fellig bla' which is mentioned in the inventory of Mathis Neithard-Gotharddt, called Grünewald (c. 1460-1528), compiled in 1528 in Frankfurt-am-Main.³⁸ A total of 7.57 kg of this blue is documented, making it the second largest quantity of pigment of the entire inventory. The designation 'fellig bla' is not documented in any other source and therefore not easy to determine, but according to the price it suggests azurite, possibly of lesser quality. The word 'fellig' could indicate the production process with which different pigment qualities were obtained e.g. by

fluming the mineral in water in order to remove impurities, similar to the description in Boltz von Ruffach's recipe of *eschplo*.³⁹

The documentary sources of the seventeenth and eighteenth centuries revealed a wealth of recipes where the term 'ashes' was used frequently. A source of particular interest with regard to blue pigments and especially ashes is Samuel van Hoogstraten's *Inleyding tot de Hooge Schoole der Schilderkonst* published in 1678. In his book, he lists the blue pigments smalt, blue lakes, indigo, natural ultramarine and three different types of blue ashes ('English, German and Haarlem ashes'), that seem to have differed in their composition.⁴⁰ In connection with this it is particularly interesting that Van Hoogstraten (Dordrecht, 1627 - Dordrecht, 1678), a successful painter of landscapes, marines, animals, flowers and still-life, used a broad selection of blue colourants and pigments in his famous *Peepshow with Views of the Interior of a Dutch House* (National Gallery, London). This includes natural ultramarine, the mineral azurite, smalt and the tentatively identified indigo.⁴¹ If these results are compared with Hoogstraten's treatise, then it would seem reasonable to presume that one type of 'ashes' is the mineral azurite (possibly 'German ashes'). The other two types are much more difficult to interpret. In her book Harley has summarized the available evidence on 'ashes' and, although it would seem quite logical to presume that another of Hoogstraten's three types of ashes might be ultramarine ash⁴², she supports Eastlake's view that this term was not applied to this substance in the seventeenth century, and instead, a copper carbonate blue such as blue verditer (possibly 'English ashes') was more likely.⁴³ However, it should be pointed out that the pigment 'ashes of ultramarine' is specifically mentioned in Theodore Turquet de Mayerne's treatise *Pictoria sculptoria et quae subalternarum atrium* supporting the fact that this may be one of Hoogstraten's types of 'ashes'.⁴⁴ The third, and for this study most significant type is 'Haarlem ashes' which may refer to azurite or another blue copper carbonate, but a pigment such as vivianite could also be possible. Jacob Campo Weyerman (1729) comments that the monotonous grey observable in Jan van Goyen's works, 'were not like that in the beginning; but at that time a paint was in fashion, called Haarlems blaauw' which, not being very stable was the cause of this alteration in colour'.⁴⁵ It seems quite likely that Weyerman's 'Haarlems blaauw' refers to smalt⁴⁶ which is known for its tendency to discolour in an oil medium, however it would also be wrong to rule out vivianite whose colour alteration in seventeenth-century Dutch painting has

Prange goes on to say that one can purify this blue by simple washing or fluming. In this category is also the 'Blaauwe assche' mentioned in a late eighteenth-century Dutch source, which is especially interesting because of some of the properties described: '6. Blue ashes. A known English colourant; also being found in Auvergne in France, and is a kind of copper ochre: turns more blue (if) mixed with oil; however does not mix so well with it as Berlin blue. Also does not cover so well; so it needs to be brushed on thickly. If she is sandy, she must be washed first.'⁵³ Despite the difficulties interpreting what pigment is really meant in this particular case it can be stated that this recipe does not describe the more common interpretation of 'English ashes' (= copper carbonate blue), but rather a natural earthy mineral found in the ground, like an ochre. It might also suggest the pulverant vivianite since it is found in the Auvergne region (France). The comparison with Prussian blue is also interesting since vivianite has occasionally also been called 'native Prussian blue'. The documentary sources mentioned above clearly show how complex the terminology of blue pigments really is. One cannot rule out the blue pigment vivianite in at least half the cases although this is difficult to say with absolute certainty.

Vivianite and the documentary sources

A blue earth pigment, most probably vivianite, is mentioned in a small number of seventeenth, eighteenth and nineteenth-century sources. In seventeenth-century sources vivianite is not always as clearly recognisable as in the eighteenth and nineteenth-century documents where it is mostly described as a blue earth pigment, and in some cases as a blue iron earth since it was known to contain iron. The only other pigment commonly used by painters that might conceivably be called a blue earth is the mineral azurite, but it is unlikely that azurite would be described in most of the following sources. One should also not completely rule out the use of other inorganic blue pigments that may have been in occasional use in the eighteenth century, such as the rather similar ilsemannite ('molybdenum blue').⁵⁴

A selection of sources where vivianite is meant or most probably meant:

Théodore Turquet de Mayerne (1620-46): *Verddeterre*; Inventory of Trijntge Pieters (1648): *haerlaems oltomarijn*; Edward Norgate (1648-1649): *Harlem ultramarine*; Ms. Add. 12461 (1653-1657): *terra de Harlem, verditerra*; Richard Symonds (1651-53): *Harlems Oltramarin*; Simon Eikelenberg (1700): *Blaù as*; Johann Heinrich Hagen (1772): *blaue Torferde, blaue Erde, Preußisch blaue Erde*;

Johann Melchior Wyrsh (1773-1784): *blaue Erde, Bayrisches Blau*; Abraham Gottlob Werner (1774): *Indigblau, blaue Eisenerde*; Ignaz von Born (1775): *Caeruleum Berolinense nativum*; Martin Heinrich Klaproth (1807): *Blau-Eisenerde, natürliches Berlinerblau, Indigblau*; Jean Felix Watin (1851): *blauer Ocker*.

Seventeenth-century sources

The seventeenth-century sources proved to be very informative and revealed important information in the search for vivianite. In the treatise by Edward Norgate *Miniatura, the Art of Limning* (1648-1649) the use of a number of blue colourants is recommended, including the pigment 'Harlem ultramarine'. A manuscript related to Norgate's 'Miniatura' is the Ms. Add. 12461 (1653-1657, British Library), which describes a similar pigment with the name 'terra de Harlem'.⁵⁵ Both of these pigments are mentioned in instructions for landscape painting, especially shading, but their composition is not mentioned.⁵⁶ The treatises describe these pigments in combination with a yellow lake pigment ('pincke'), which would produce a green colour. It is quite likely that they are one and the same pigment, possibly vivianite. Interesting is also the term 'verditerra' that is found in a list of blue colourants in the manuscript Add. 12461, which includes Sappgreens, Pinke & blue verditer, Green bice and Cedar green. *Verditerra* is also mentioned at the end of a list of pigments with the title 'To be washed' in a subgroup of blue pigments, which includes 'Ultramarine, Blow bice, Smolt'. The name 'verditerra' suggests the colourant to be an earth pigment and the fact that it is always mentioned in connection with blue colourants gives a clear indication that it is blue in colour. This is supported by the De Mayerne manuscript where the same name can also be found in a short note in one of the margins. De Mayerne describes the earth pigment 'verddeterre' as being blue in colour, and it was to be mixed with a yellow lake pigment ('pinke' or 'schitgeel').⁵⁷ This is the only mention of this pigment in the entire De Mayerne manuscript. The note goes on to say that this blue coloured earth is very similar to 'blue ashes'.

A blue earth pigment that clearly suggests vivianite is mentioned by Richard Symonds, who documented his travels in Italy (1649-1651) in a series of notebooks. In one of these (Ms. Egerton 1636, British Library) Symonds recorded a conversation with a Mr. Remee (probably the French artist Remy van Leemput), who describes a pigment called 'Harlems Oltramarin' as 'a blew clay earth that is washt as Mr. Remy tells me, & tis not any way produc'd from Lapis Lazuli [...]'.⁵⁸ This source is of great significance because he clearly states that 'Harlems

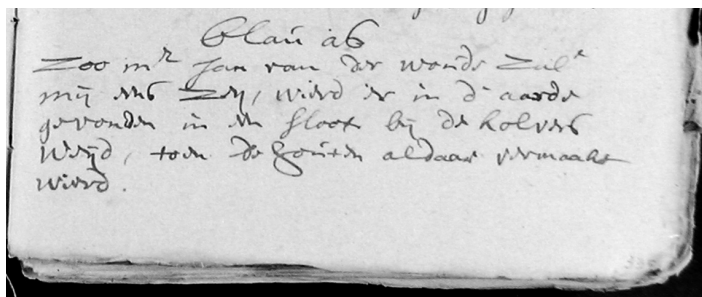
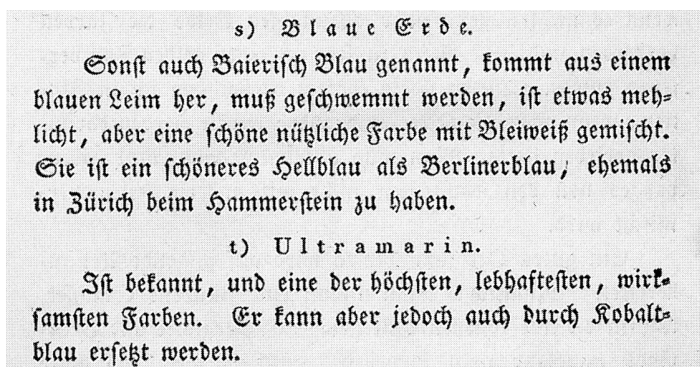


Fig. 7 Passage where Eikelenberg describes 'Blau as' (blue ashes), which is found on the surface of the ground in a ditch near the 'Kolver Weyd' in Alkmaar.
Simon Eikelenberg, *Aantekeningen over schilderkunst*, 661-662 (modern page nos)

Fig. 9 Description of vivianite as 'Blue earth' in Johann Melchior Wyrsh's *Treatise on Portrait Painting with Oil Colours*, which probably originated between 1773 and 1784



Oltramarin' is a blue earth pigment of natural origin and that it was not natural ultramarine. It is also listed as 'Haerlaems oltomarijn' in the inventory from Trijntge Pieters (1648) where it is mentioned along with the blue pigments 'as' and 'English as'.⁵⁹

Another important source is Simon Eikelenberg's comprehensive work *Aantekeningen over Schilderkunst* (Notes on painting). In his writings Eikelenberg also describes 'Engelse As' (English ash) and 'Duitze As' (German ash), which is very similar to Van Hoogstraten's text.⁶⁰

Different is the third type of 'As', which he refers to as 'blue ashes' which was found in the ground close to the surface in a ditch near the 'Kolver Weyd' (figs. 6-7).⁶¹ The fact that this source describes a blue mineral in the ground in an area where waterlogged clay or peat layers are quite typical does suggest that vivianite is being described here. Furthermore, it is important to point out that Eikelenberg's manuscript is also one of the very few sources that would classify this pigment as a type of blue ashes and that it could be obtained locally.

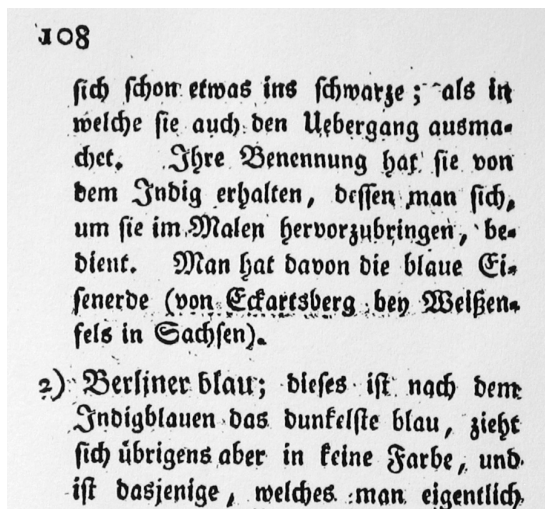


Fig. 8 Abraham Gottlob Werner's description of vivianite as 'indigo blue' and as 'blue iron earth' (from Eckartsberg near Weißenfels in Saxony), 1774

Eighteenth and nineteenth-century sources

German sources of the eighteenth and nineteenth century revealed some of the most clear and detailed information on vivianite, describing it as a blue earth pigment and as having various synonyms: 'Caeruleum Berolinense nativum', 'blaue Torferde', 'Preußisch blaue Erde', 'Blaueisenerde', 'Indigblau', 'natürliches Berlinerblau', 'blaue Erde', 'blauer Ocker' and 'Baierisch Blau' (native Prussian blue, blue peat earth, Prussian blue earth, blue iron earth, indigo blue, native Prussian blue, blue earth, blue ochre, and Bavarian blue).⁶²

Abraham Gottlob Werner describes in his work from 1774, *Of the external characteristics of fossils*, the various colours of minerals and arranges them according to their colour. He refers to vivianite as indigo blue: '1. Indigo blue is one of the darkest of blue colours, the darkest being rather blackish; and is actually something like a blend of both colours. [...] Of this one has the blue iron earth (from Eckartsberg near Weißenfels in Saxony)' (fig. 8).⁶³ Another eighteenth-century source of importance is Klaproth's detailed description of vivianite in his *Beiträge zur chemischen Kenntniss der Mineralkörper* from 1784. In one passage he states that vivianite is an iron phosphate: 'Since the blue iron earth is phosphoric iron and the older term native Prussian blue is not appropriate, which I pointed out in the year 1784'.⁶⁴

A very detailed and fascinating account on vivianite is found in the treatise of the painter Johann Melchior Wyrsh (1732-1798).⁶⁵ In his *Treatise on Portrait Painting with Oil Colours*, which probably originated between 1773 and 1784, he refers to the pigment with the names 'Blaue Erde' and 'Baierisch Blau' (figs. 9-10).⁶⁶ Wyrsh also describes in what form vivianite occurs and how it is pre-



Fig. 10 Johann Melchior Wyrsh (1732-1798), *Self-portrait at the easel* from 1767, oil on canvas, c. 55 x c. 44.8 cm
Nidwaldner Museum (NM 10127), Stans, Switzerland

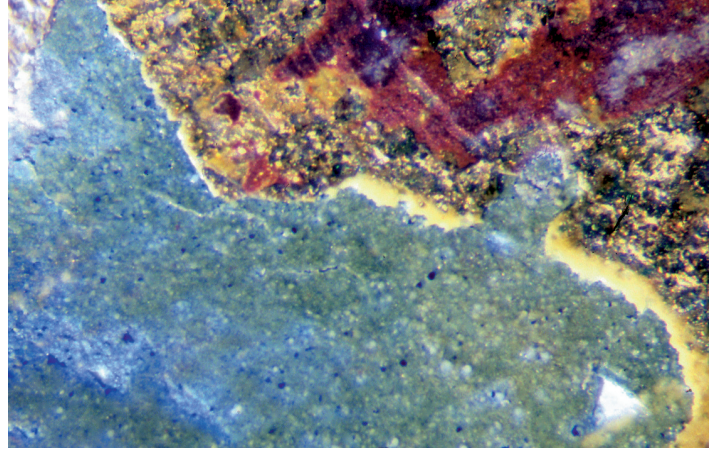


Fig. 11 Gmund, Catholic parish church St. Giles, Good Samaritan Relief. Photomicrograph of the light blue paint of the outer frame of the relief revealing a mixture of vivianite, Prussian blue and lead white

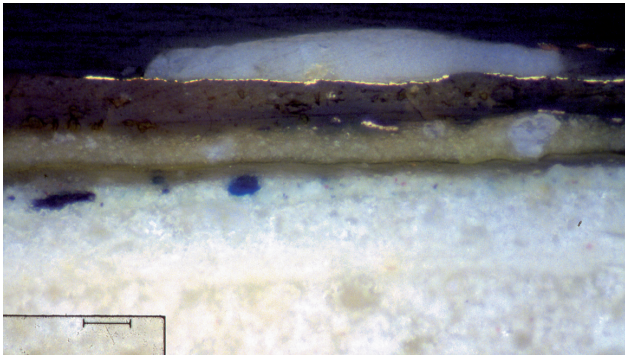


Fig. 12 Gmund, Catholic parish church St. Giles, Good Samaritan Relief. Paint cross section showing the layer structure of the light blue polychromy with "bronzing" and overpaintings applied on top: 1. yellowish white ground; 2. lead white underpainting; 3. light blue layer with vivianite (long dark blue particle to the very left) and Prussian blue particles (to the right) embedded in lead white; 4. yellowish transparent isolation layer; 5. yellow underpainting; 6. translucent green layer with embedded metal particles (copper-zinc alloy); 7. later mordant layer with gilding; 8. white overpainting. Viewed in unpolarised normal light. Photographed at a magnification of 500x

pared and employed: 'Otherwise called Bavarian blue, it is derived from a blue clay that needs to be flumed. It is slightly mealy, but a nice useful colour when mixed with lead white.' With the term 'Leim', Wyrsh refers to a type of clay or earth, which refers to how the mineral occurs. He also concludes that the use of vivianite results in '[...] a more beautiful light blue than Prussian blue [...]'. Wyrsh also mentions a source of supply for this pigment: 'it could be acquired in Zürich at Hammerstein'. An apothecary is meant here, which at the time of Wyrsh's stay in Zürich (1758-1760) had the company

name 'David Schultthess Zum Oberen Hammerstein'.⁶⁷ At this time and earlier, artists normally did not prepare their own pigments but bought them from specialized suppliers who sold artists' materials. In German-speaking countries these suppliers were apothecaries ('apeteke'), shopkeepers or grocers ('kramer'), or millers ('müller' or 'pfister'). Vivianite is also described with the term 'blue ochre' in the German translation of Jean-Félix Watin's recipe book *L'art du peintre, doreur et vernisseur... pour la fabrication et l'application des couleurs* from 1851.⁶⁸ In the section on

colours the following is said: 'Blue ochre, a rarely occurring natural mineral colour consists of basic phosphoric iron and is found in England and in North America. This blue possesses, like other ochres, the same consistency, but more transparency with significant depth. It can be used both in water and oil and dries well.' In Watin's first edition the name 'blue ochre' does not appear but instead the term 'cendre bleue' (in the early German translations 'Bergblau' = Mountain blue) appears.⁶⁹ He goes on to describe that this soft blue stone can almost be pulverised to powder in your own hand and that it can be found in the copper mines in Poland and also in specific areas around Auvergne.⁷⁰ This description might also suggest the pulverant vivianite since it can literally be crushed and pulverised by hand and is found in the Auvergne region (France), as well as in the iron ore districts of Poland.

In some sources the pigment vivianite was given the name 'native Prussian blue' since it was known to contain iron and is mineral of origin. Martin Heinrich Klaproth ('natürliches Berlinerblau') and the Austrian mineralogist Ignaz von Born ('Caeruleum Berolinense nativum') used this term in their works on minerals.⁷¹ The pharmacist Johann Heinrich Hagen makes use of the term 'Preußisch blaue Erde' in his comprehensive investigation of vivianite as a blue mineral and as an artists' pigment. In this context it is interesting to note that vivianite and Prussian blue were identified together with lead white in a light blue paint on the frame of a late eighteenth-century wooden relief in Gmund, Bavaria (figs. 11-12).

This naturally occurring mineral was also described in early nineteenth-century English sources as 'blue ochre' or 'native Prussian blue'.⁷² George Field (1835) described a mineral colour called 'blue ochre' saying that it was found as a rare occurrence in Cornwall, and also in North America.⁷³ In 1841 he adds that this mineral is a 'sub-phosphate of iron', which clearly refers to the vivianite.⁷⁴

Conclusion

The pigment vivianite represents a perfect example of the great difficulties one can encounter when interpreting the terminology of colourants in historical documentary sources. This is why a multi-faceted approach was chosen; including a small study on the historic as well as present deposits of this mineral and researching how often vivianite has in fact been used in painted works of art up until the present time. Combined, this information revealed that vivianite is actually more common as a mineral and as a pigment than at first thought. The artists most probably acquired their vivianite from local sources, but it is documented that it could be bought at an apothecary, which suggests that it was also traded as a pigment.

It was found that the colour of vivianite can vary quite dramatically in hue, depending on the deposit itself, how it occurred (e.g. concretions or pulverant), and how it was prepared (removal of impurities to obtain a better colour). This is seen quite clearly in some of the images (figs. 1-4). The variety of colour hues probably also added to the confusion of terminology and the proper description and identification of vivianite.

The documentary sources mention a great wealth of synonyms for blue pigments. Some of them may have been used for vivianite, in particular the names 'Harlems Oltramarin', 'terra de Harlem' or 'Haarlems blaauw', which seem to indicate the presence of a local source in or around Haarlem. However, there are also clear identifications of vivianite in a small group of documentary sources, such as the De Mayerne manuscript (1620-1646), the notebooks of Richard Symonds (1649-1651), Van Eikelenberg's manuscript (1700), the work by Johann Heinrich Hagen on a strange blue earth (1772), and the treatise written by Johann Melchior Wyrsh (1773-1784), which all proved significant for our understanding of the terminology, historical deposits, use and varying colour of this mineral.

Acknowledgements

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Fig 3: Bureau Monumentenzorg en Archeologie, Gemeente Dordrecht
Figs. 6, 7: Netherlands Institute for Cultural Heritage, Amsterdam
Fig. 5: Koninklijk Huisarchief, The Hague
Fig. 10: Nidwaldner Museum, Museum für Kunst, Stans, Switzerland

Notes

- 1 Vivianite was identified by both Nauer (1984) and Eggert (1989) in Roman paint residues from Germany. G. Nauer, 'Untersuchungen des Inhalts eines römischen Gefäßes (Farbtiegel) aus dem RMLB', *Beiträge zur Archäologie des römischen Rheinlands*, 4, (Cologne, 1984), 77–82; G. Eggert, 'Den Römern in die Farbtöpfe geschaut: Untersuchung römischer Farbreste aus Bonn', *Schriften des Rheinischen Landesmuseum Bonn*, 3 (1989), 45–47.
- 2 Vivianite was first found in Cornwall (at Wheal Jane, near Truro) by J. G. Vivian, after whom Abraham Gottlob Werner named the species in 1817. K. L. Weiner, R. Hochleitner: 'Steckbrief: Vivianit', *Lapis*, Vol. 4, no. 4 (1979), 6.
- 3 G. Strübel, S. H. Zimmer, *Lexikon der Minerale*, (Stuttgart, 1991), 364.

- 4 Vivianite is a naturally occurring mineral, which is often found in the oxidized upper layers of the ground and hence was easily extractable for pigment preparation.
- 5 H. Schröcke, K. Weiner, *Mineralogie - Ein Lehrbuch auf systematischer Grundlage*, (Berlin/New York, 1981), 635; C. McCammon, R. Burns, 'The oxidation mechanism of vivianite as studied by Mössbauer spectroscopy', *American Mineralogist*, 65 (1980), 361–366.
- 6 P. Noble, A. van Loon, 'New Insights into Rembrandt's Susanna', *ArtMatters*, 2 (2005), 76–96; G. Seelig, A. van Suchtelen, 'Catalogue' in *Carel Fabritius 1622–1654*, F. J. Dupare ed., [exh. cat., Mauritshuis] (The Hague, 2004), 132; H. Stege, C. Tilenschi, A. Unger, 'Bekanntes und Unbekanntes - neue Untersuchungen zur Palette Vermeers in der "Kupplerin"', in *Jan Vermeer - Bei der Kupplerin*, U. Neidhardt, M. Giebe, eds., [exh. cat., Gemäldegalerie Alte Meister Dresden] (Dresden, 2004), 76–78; H. Stege, J. Klaas, H. Kutzke, C. Tilenschi, M. Burghammer, 'Vivianit - Neue Nachweise des Pigmentes und seine charakteristischen Veränderungen in der Niederländischen Malerei des 17. Jahrhunderts', *Archäometrie und Denkmalpflege* 2006, *Kurzberichte der Jahrestagung an der Staatlichen Akademie der Bildenden Künste Stuttgart*, (22–25 March, 2006), 81–83; A. van Loon, L. Speleers, E. Ferreira, K. Keune, J. Boon, 'The relationship between preservation and technique in paintings in the Oranjezaal', in *The Object in Context. Crossing Conservation Boundaries*, Preprints to the IIC Munich Congress, D. Saunders, J. H. Townsend, S. Woodcock eds., (London, 2006), 217–223.
- 7 Important deposits are in the Oberpfalz (e.g. Hagendorf, Pleystein, Amberg iron district, Waldsassen) as well as in Hessen (e.g. Heuchelheim, Weckesheim im Wetterau, Spessart). Vivianite also occurs in the historical iron district of Amberg and Sulzbach in the Oberpfalz where mining probably began in the fourteenth century.
- 8 I am grateful to curator Dr. Gilla Simon (Mineralogische Staatssammlung München) for giving me the chance to study the large earthy chunk of vivianite

- from Urfahrn near Rosenheim (Inventory no. H867 from 13/15). The famous mine Bodenmais im Silberberg is also known for its vivianite. The origin of the silver mine goes back to the twelfth century. In the sixteenth century it was well-known for its iron vitriol. T. Hirche, F. Pfaffl, 'Die Vitriol-Mineralie der Sulfidzerlagerstätte Silberberg bei Bodenmais (Bayerischer Wald)', *Geologische Blätter für Nordost-Bayern und angrenzende Gebiete*, Vol. 55, 1–4, (Erlangen, 2005), 257–262. I am grateful to Prof. Herbert Scholz and Dr. Günter Grundmann, Lehrstuhl für allgemeine, angewandte und Ingenieur-Geologie, Technische Universität München for bringing the Samerberg vivianite sample to my attention.
- 9 A. G. Werner, *Von den äußerlichen Kennzeichen der Fossilien*, (Leipzig, 1774), 107–108.
- 10 In this chemico-mineralogical investigation the pharmacist Johann Heinrich Hagen examines various deposits of vivianite. Each bog ore deposit revealed a blue earth, each with a different hue. Hagen not only examines vivianite as a mineral, but also studied its properties as an artists' pigment. J. H. Hagen, *Chemisch-Mineralogische Untersuchung einer merkwürdigen blauen Farberde aus den Preussischen Torfbrüchen*, (Königsberg, 1772), 4–5.
- 11 J. G. Sommer, *Kingdom of Bohemia*, Vol. 15, (1847), I–LIV.
- 12 Vivianite has been discovered in Erzberg (Styria), Austria. The history of ore mining in this area has been documented since the thirteenth century. R. Exel, *Die Mineralien und Erzlagerstätten Österreichs*, (Wien, 1993); F. Bernhard, 'Vivianit, Goethit, Markasit und Rozenit von der Umfahrungsstraße Unterfladnitz, südlich Weiz, Steiermark', *Der Steirisch Mineralog*, 20 (2006), 41; The mining of iron ore around Salzburg stretches back to the Iron Age. The year 1537 was important for the rebirth of iron ore mining in this area. A. Strasser, *Die Minerale Salzburgs*, (Salzburg, 1989).
- 13 Personal communication from Hans Huisman, RACM (Netherlands Heritage), Amersfoort.
- 14 On this subject see: F. Stokhuyzen, Molens, (Bussum, 1962), 23; J. W. de Zeeuw, 'Peat and the Dutch Golden Age. The histor-

- ical meaning of energy-availability', *A.A.G. Bijdragen* 21, (Wageningen, 1978), 3–31.
- 15 J. van de Vries, 'The Dutch Rural Economy and the Landscape', in *Dutch Landscape. The Early Years, Haarlem and Amsterdam 1590–1650*, C. Brown ed., [exh. cat., National Gallery London] (London, 1986), 83. See also Spring 2001, 66.
- 16 'Blau as. Zoo mr Jan van der Woude zal t mij eens zey, wierd ier in d'aarde gevonden in een sloot bij de Kolver Weijd, toen de houten aldaar vermaakt wierd.' S. Eikelenberg, *Aantekeningen over Schilderkunst* (Engl.: Notes on Painting) from 1700 (Manuscript at the Regionaal Archief Alkmaar, Collection acquisitions nr. 390, Photo: ICN) 662. Simon Eikelenberg wrote this very comprehensive work between 1700 and 1732. He describes in great detail artists' materials (pigments, dyes, binding media) as well as recipes on colourants and varnishes.
- 17 The intense blue vivianite was found in the soil in a ceramic Siegburg jar, which can be dated between 1400 and 1450. I am grateful to senior archaeologist Mark Spanjer and archaeologist Tom Hos (Bureau Monumentenzorg en Archeologie, Gemeente Dordrecht) as well as Dr. Luc Megens (ICN) for this information, 17.10.2006.
- 18 G. Stoops, 'SEM and light microscopic observation of minerals in bog ores of the Belgian Campine', *Geoderma*, 30 (1983), 179–186.
- 19 M. E. Smith, 'Vivianite from South Humberside and Yorkshire', *Journal of the Russell Society*, Vol. 5, No. 2, (1994).
- 20 J. J. Stevenson, 'Interrelations of the Fossil Fuels', *Proceedings of the American Philosophical Society*, Vol. LV (Philadelphia, 1916), 66.
- 21 Evidence that the deposits in and around Riga had already been used for the preparation of an artists' pigment for quite some time is supported by the probable identification of vivianite on the canvas paintings of the painter Cord Meyer from Lüneburg in the protestant church St. John in Riga, Lithuania. As documented in St. John's church court records from the years 1659–1702, the paintings were made between 1692 and 1702. The iron content was identified with microchemical methods. Since the paintings were completed before the discovery of Prussian

blue the identification of vivianite is probable. I. Sakne, Z. Sokolova, D. Temerova, 'Investigation of nine paintings from the loft of the organ in the St. John Church', <http://www.kanut.ee/toimetised/konverentsid/consasinvest/sakne.rt.f>, (1997), 3.

22 R. Fuchs, D. Oltrogge, 'Das Blau in der mittelalterlichen Buchmalerei – Quellenschriften als Basis naturwissenschaftlicher Farbuntersuchungen', in *Blau – Farbe der Ferne*, H. Gercke ed., [exh. cat. Kunstverein Heidelberg] (Heidelberg, 1990), 107.

23 The term 'menesc' is derived from Persian (Turkish: menekse). S. Waetzold, 'Systematisches Verzeichnis der Farbnamen', *Münchener Jahrbuch der Bildenden Kunst*, vol. III / IV (Munich, 1952/1953), 153.

24 The colour of menesc described in Theophilus Presbyter's treatise is comparable to the dark blue of indigo and the dark blue colourant obtained from elder berries. Its use is described in Chapters XIV and XVI. C. R. Dodwell, *Theophilus – De Diversis Artibus*, (London, 1961), 10–14.

25 M. P. Merrifield, *Medieval and Renaissance Treatises on the Arts of Painting*, Original Texts with English Translations, (New York, 1967), 31.

26 In the Munich painters' guild ordinances of 1448 the colourant —menschenplab' is mentioned: 'Item es sol auch ain jedlicher geferbtes golt oder zwysgold oder stanoil jedlichs geben und nemen in seiner arbeit für das, das es ist und sol das nit geben, raiten oder nennen für feingold noch perckplab für fein lasur und menschenplab für perck lasur, noch kain rösel oder paris rot für lack geben. Man sol auch kain waltglas oder scherbenblas für venedisch glas geben.' In the ordinances of 1461 that had only been slightly altered the term —menschenplab' has changed to —meinsch'. V. Liedtke, 'Die Münchner Tafelmalerei und Schnitzkunst der Spätgotik, Teil 1: Von den Anfängen bis zum Pestjahr 1430', *Ars Bavarica*, 17/18 (Munich, 1980), 123–124.

27 See also: M. Richter, 'The Use of Vivianite in Baroque and Rococo Polychromy and Painting', in *Historical Polychromy – Polychrome Sculpture in Germany and Japan*, M. Kühnlethal, S. Miura eds., (Munich, 2004), 211.

28 Veneda was used for blue pigments (e.g. Egyptian blue, syn-

thetic and natural copper blue pigments, natural ultramarine, smalt, vivianite) and increased their hiding power and brilliance.

29 E.-L. Richter, 'Seltene Pigmente im Mittelalter', *Zeitschrift für Kunsttechnologie und Konservierung*, 2, 1 (1988), 171–173.

30 In southern Germany vivianite has been identified in the original polychromy of the Virgin Mary with Child, dated approx. 1400–20 in the catholic church of Pöding. There also fifteenth-century findings in Austria: H. Richard, H. Paschinger, M. Koller, 'Nachweise von Farbpigmenten zur Kunstgeschichte Österreichs', *Restauratorenblätter*, 24 / 25 (2005), 47 and 58–59.

31 P. Pomet, *Histoire generale des drogues traitant des plantes, des animaux, & des mineraux; Ouvrage enrichy de plus de quatre cent figures en taille-douce tirées d'après nature; avec un discours qui, chez Jean Baptiste Loysen & Augustin Pillon*, (Paris, 1694), 821–822.

32 Palomino mentions the ash of ultramarine. A. Palomino, *El museo pictórico y escala óptica*, vol. 2 (Madrid, 1715–24), 52. De Mayerne describes *Cendre d'azur* or *Cendre* that suggest azurite (f. 86, f. 94r). Theodore Turquet de Mayerne, *Pictoria sculptoria et quae subulternarium atrium*, British Museum, Sloane Ms. 2052, in: J. A. van de Graaf, *Het De Mayerne Manuscript als Bron voor de Schildertechniek van de Barok*, [Ph.D. diss., Rijksuniversiteit Utrecht] (Mijdrecht, 1958), 148, 169. In another recipe (f. 91v and Graaf 1958, 151) he describes *Cendrée* in such a fashion that blue verditer is suspected.

33 In the Borrodaile translation of the Strasburg Manuscript 'lazur eschen' is referred to as 'azurite ash' and 'azurite pigment'. The Strasburg Manuscript, *A Medieval Painters' Handbook*, trans. V. and R. Borrodaile, (Munich, 1982), 50, 56, 58, 132. Ploss states that 'lazur eschen' is obtained with another preparation technique of 'Lasurblau' (i.e. lapis lazuli) where the mineral is calcined and then ground again resulting in a lighter colour. This type of blue, 'Lasurasche' is still a pure colour similar to the light blue of cobalt without the admixture of a white pigment. E. E. Ploss, 'Lasur', *Zeitschrift für deutsche Philologie*, 74 (Berlin, 1955).

34 Cranach made use of a wide variety of different blue pigments. His invoices verify different types and various grades: *schon blaw, lasur blaw, blau von feldung, gering plaw, oelblaw, ascherblaw, blaw glasurt farb, indich und waiblaw*. G. Heydenreich, *Lucas Cranach the Elder: Painting materials, techniques and workshop practice*, (Amsterdam, 2006), 157.

35 'Esch plo. Schmeltz esch, die sol man wol durch ein hor siblin siblen, das der sand suber dorus kumm, dann es vyl kiess in sich hat. Das rybt man an mit einem wenig plywys. Temperiers mit welcher temperatur du wöllest, ussgenommen mit perment lym. Dises plo ist füglich angestrichen zu harnischen, wassern wolcken und waffen. 'Es sind sunst vil andere Eschplo, die wol zu finden und brüchlich sind, darvon un not hie vyl zu schriben, dann man würdt sy in den mixturen wol finden.' V. Boltz von Ruffach, *Illuminierbuch*, (Basel, 1549), C.J. Benziger ed., (Munich 1913; reprint, Vaduz, 1993), 77. In his recently published book on Lucas Cranach the Elder Heydenreich concludes that 'ascherblau' is quite possibly a 'greyish contaminated azurite (cinis lazuri) with small particles'. Azurite was in fact the most commonly used blue pigment in Lucas Cranach the Elder's workshop. Heydenreich 2006, 154–157.

36 E. Bosshard, 'Die Unterzeichnung der Gemälde von Niklaus Manuel Deutsch', *Restaura*, 3 (1983), 165, 168.

37 A. Goovaerts, 'Les ordonnances données en 1480, à Tournai, aux métiers des peintres et des verriers', *Académie Royale de Belgique, Compte Rendu des Séances de la Commission Royal d'Histoire ou Recueil de ses Bulletins*, 5^{me} série, tome 6, 1^{er} bulletin, (1896), 178–79, art. 44.

38 B. Müller Wirthmann Von Fellen, 'Farben und Vermischtem – Das Nachlassinventar des Mathis Gothart-Nithart', in *Das Rätsel Grünewald*, R. Riepertinger, E. Brockhoff, K. Heinemann, J. Schumann eds., (Augsburg, 2002), 80.

39 V. Boltz von Ruffach 1549 (reprint 1976), 77.

40 'Wy hebben tot ons blaeww, Engelsche, Duitsche, en Haerlemse Assen, Smalten, blaewwe Lakken, Indigo, en den onwaerdeerlijken ultra-

marijn.' S. van Hoogstraten, *Inleyding tot de Hooge Schoole der Schilderkonst: anders de Zichtbaere Werelt*, (Dordrecht 1678) (facsimile ed. Holland, 1969), 209 and 221.

41 C. Brown, D. Bomford, J. Plesters, J. Mills, 'Samuel van Hoogstraten: Perspective and Painting', *National Gallery Technical Bulletin*, 11 (1987), 81–82. It would be interesting to take another look at this sample and see if indigo is really present or if perhaps a pigment such as vivianite was in fact used.

42 Palest blue fraction left at the end of the extraction of ultramarine from lapis lazuli.

43 R. D. Harley, *Artists' Pigments c. 1600–1835: a study in English documentary sources*, 2nd ed., (London, 2001), 59. This assumption is also supported by Prange in his chapter on the pigment 'Aschblau, Eschblau, Bergasche, blaue englische Asche (Cendres bleues d'Angleterre)' in his 'Farbenlexicon'. He goes on to say 'Dem äusserlichen Ansehen nach kommt diese Farbe dem Berg- oder Kupferblau nahe, und ist bald blau, bald aber vielmehr grün oder grünlichblau, darum sie auch von einigen Schriftstellern les cendres bleues et vertes d'Angleterre genannt wird. Diese Eigenschaft aber verrät ein Kupfer, das auch in Bergwerken bald eine grüne, bald eine blaue Farbe annimmt, wenn es aufgelöst oder verrostet und präcipitirt ist.' C. F. Prange, *Farbenlexicon*, worin die möglichsten Farben der Natur nicht nur nach ihren Eigenschaften, Verhältnissen und Zusammensetzungen, sondern auch durch die wirkliche Ausmahlung enthalten sind. Zum Gebrauch für Naturforscher, Mahler, Fabrikanten, Künstler und übrigen Handwerker, welche mit Farben umgehen, (Halle, 1782), 23.

44 Van de Graaf 1958, 191

45 'Het is wel waar dat zijn stukjes wat eenkleurig of graauw vallen, hoewel zulks zijn schuld niet is, dewijl ze zo niet waaren in den beginne; maar op die tijd was er een verf in de Mode, Haarlems blaauw gedoopt, welke Verf niet bestendig zijnde, die verandering ten kwaade heeft veroorzaakt.' J. C. Weyereman, *De Levens-Beschryvingen der Nederlandsche Konst-Schilders en Konst-Schilderessen, met een yutbreyding over de Schilder-Konst der Ouden, door Jacob Campo Weyereman, Konst-Schilder [...]*, (in's Gravenhage,

- 1729), 395.
- 46** E. M. Gifford, 'Jan van Goyen en de techniek van het naturalistische landschap', in Jan van Goyen [exh. cat., Stedelijk Museum De Lakenhal, Leiden] (Leiden, 1996), 70-81.
- 47** Van de Graaf 1958, 169.
- 48** Stoops 1983, 179-186.
- 49** Van de Graaf 1958, 161.
- 50** Van de Graaf 1958, 156.
- 51** M. Spring, 'Pigments and color change in the paintings of Aelbert Cuyp', in Aelbert Cuyp, A. K. Wheelock ed., [exh. cat., National Gallery of Art] (Washington DC, 2001), 65-73; Noble, Van Loon, 2005, 76-96; Seelig, Van Suchtelen 2004, 132; Stege et al. 2006 81-83; Van Loon et al. 2006, 217-223.
- 52** Prange 1782, 21-22.
- 53** '6. Blaauwe assche. Een bekende Engelsche verfstof; wordt ook wel te Auvergne in Vrankryk gevonden, en is een soort van koperook: wordt met olie vermengd blaauwer: doch laat zich daar meede niet zo goed vermengen dan het berlyns blaauw. Dekt ook zo goed niet; dus het dik dient opgestreeken te worden. Indien ze zandagtig is, moet ze eerst afgewassen worden.' A.P.S., *Nauwkeurige beschryving van het schilderen der zwarte konstprinten, waarin de verschillende wyzen, om dergelyke printen doorschynende te maken, op het glas te brengen, en te schilderen, aan de hand worden gegeven. Beneffends den aart en bereiding van zommige verwen / alles uit eigene ondervinding opgemaakt, met noodige aanmerkingen verrykt, en ten dienste der liefhebbers beschreeven door A.P.S. - Groningen: by Petrus Doekema, (1770), 29.*
- 54** This is the black, blue-black or blue earthy substance called ilse-mannite ($\text{Mo}_3\text{O}_8 \cdot n\text{H}_2\text{O}$), also called 'molybdenum blue'. The mineral, which occurs in earthy masses or crusts, is found in Germany and England and was mentioned for the first time by J. C. Ilseman (1722-1822) who published a study on molydenite in 1787. To the author's knowledge it has not yet been identified as a pigment in painting, which stands in contrast to vivianite. See also Harley 2001, 59.
- 55** *Miniatura, or the Art of Limning, the maner and use of the colours both for picture by the life, landskip, history*, by Daniel King; dedicated to Mary, daughter of Thomas Lord Fairfax, [...], dated between 1653-1657, f. 50v. Marika Spring also mentions this manuscript concluding that it represents 'some notes about the practice of a landscape painter referred to as Seigneur Otto, most likely the Dutch painter Otto Hoynck.' Spring 2001, 67. The name Seigneur Otto is found in folio 50 of this manuscript. Otto or Ottho Hoynck (born c. 1630, The Hague, died after 1686, England) is described as an animal painter. He is documented as having lived in Amsterdam in 1686. According to Kramm he then moved to England and died there. C. Kramm, *De levens en werken der Hollandsche en Vlaamsche kunstschilders, beeldhouwers, graveurs en bouwmeesters van den vroegsten tot op onzen tijd*, III, (Amsterdam, 1859).
- 56** Norgates second version of his treatise from 1648-49 mentions Harlem ultramarine: 'Your Trees are to be dead coloured with a Mezzo tinto and deepned with blew Verditer or Pincke and a little Harlem ultramarine, and heighned with a faire Mastikot and a little of the Former Colours according to Discretion.' E. Norgate, *Miniatura or the Art of Limning*, J. M. Muller, J. Murrell eds., (New Haven & London, 1997), 87-88. The author of the British Library manuscript Additional 12461 uses the term 'terra de Harlem' in a rather similar recipe for landscape painting '[...] to make up your farthermost trees and dusky places with terra de Harlem, pinke [...] for dark clouds white, vermilion and smolt [...]'.
- 57** 'Verd de terre est une espece de bleu comme cendre qui faict un beau vert avec pinke ou schitgeel.' Van de Graaf 1958, 148.
- 58** R. Symonds: Notebook, 1651-1653 (British Library, London, Ms. Egerton 1636); fully transcribed in M. Beal, *A Study of Richard Symonds: His Italian Notebooks and Their Relevance to Seventeenth-Century Painting Techniques*, (London, 1984), 101-102 and 225. See also Spring 2001, 66.
- 59** 'Inventaris van Trijntge Pieters, widow of Crijn Hendricksz. Volmarijn / Isaac Furnerius, Rotterdam, 1648', in Abraham Bredius, *Kunstlerinventare, ('s Gravenhage: Nijhoff, 1917-1919)*, vols. 4-5, 1634-1647. (Original: Archief van de Weeskamer, inv. nr. 430, fol. 187v.)
- 60** Eikelenberg 1700, 781.
- 61** Eikelenberg 1700, 662. Simon Eikelenberg wrote this very comprehensive work between 1700 and 1732. He describes in great detail artists' materials (pigments, dyes, binding media) as well as recipes on colourants and varnishes.
- 62** The wealth of terms for vivianite as a colourant is quite remarkable. Native Prussian blue started to be used in Europe at the end of the eighteenth-century. *Caeruleum Berolinense nativum* (1772, Latin), *Bleu de Prusse nativ* (1783, French) and *natürliches Berlinerblau* (1784, German).
- 63** A. G. Werner, *Von den äußerlichen Kennzeichen der Fossilien*, (Leipzig, 1774), 107-108.
- 64** M. H. Klaproth, *Beiträge zur chemischen Kenntniss der Mineralkörper*, Vol. 4, (Posen, Berlin 1807), 120.
- 65** J. M. Wyrsh, *Gründliche auf eigene praktische Anwendung gestützte Abhandlung über Porträtmalerei in Oelfarben oder sichere Anleitung ein Modell genau in Farben darzustellen, und selbes in treffend Aehnlichkeit nachzubilden, die Farben aufzutragen, sie bereiten, Firnis, Retouschiröl zu machen, und die Malleinwand zu grundiren*, Herausgegeben, gedruckt und verlegt von J. B. Curti, (Rapperswyl, 1834). In his treatise on painting Wyrsh recommends the use of natural ultramarine, cobalt blue, and vivianite.
- 66** A. Stoll, *Hierauf folget das Malens* - Wyrsh als Maltheoretiker und Praktiker, in 'Gepudert und geputzt' Johann Melchior Wyrsh 1732-1798. Porträtist und Kirchenmaler, M. Vogel, R. Helbling, M. Baltensperger eds., [exh. cat., Nidwaldner Museum] (Basel, 1998), 316.
- 67** Stoll 1998, 321 and 337.
- 68** In this later edition of Watin's famous handbook a number of blue pigments including vivianite and Tungsten Blue are described. Jean-Félix Watin, M. Watin, *Die Kunst des Staffmalers, Vergolders, Lackiers und Farbenfabricanten. Ein für jeden Kunstgenossen und Liebhaber unentbehrliches Hilfsbuch. Zweite ganz veränderte Auflage. Nach der von Firmin Bourgeois umgearbeiteten und stark vermehrten eilften Originalausgabe aus dem Französischen übersetzt und mit vielen Zusätzen versehen von A.W. Hertel*, (Weimar, 1851), 137.
- 69** Jean-Félix Watin, *L'art du peintre, doreur, venisseur*, (Paris, 1793), 29.
- 70** Deposits of vivianite are located in Auvergne, France. G. Aubert, 'Les coupoles granitiques de Montebraz et d'Echassières (Massif Central Français) et la genèse de leur minéralisations', (BRGM, 1969).
- 71** Klaproth 1807, 120. Ignaz van Born, *Index Fossilium que collegit, et in Classes ac Ordinea disposuit...* Praga apud Wolfgangum Gerle, (Prague, 1775), 136.
- 72** Harley 2001, 59-60.
- 73** G. Field, *Chromatography: or a Treatise on Colours and Pigments, and of their powers in painting*, (London, 1835), 114.
- 74** G. Field, *Chromatography: or a Treatise on Colours and Pigments, and of their powers in painting*, (London, 1841), 114.
- 75** C. Schulze-Senger, E. Jägers, W. Hansmann, 'Neue Erkenntnisse zu der Bildertür von St. Maria im Kapitol', *Zeischrift für Kunsttechnologie und Konservierung*, 5, 2 (1991), 215-216.
- 76** H. Howard, *The Pigments of English Medieval Wall Painting*, (London, 2003), 35-38 and 225-231.
- 77** A. Kueng, 'Das Blaupigment Vivianit - Zu einem neuen Farbbefund an der Galluspforte', *Schwelle zum Paradies. Die Galluspforte des Basler Münsters*, H.-R. Meier, D. Schwinn, eds., [exh. cat., Museum Kleines Klingental, Basel] (Basel, 2004), 52-53.
- 78** H. Westhoff, 'Ein Kleinod romanischer Fassmalerei. Maltechnik und Restaurierung einer thronenden Muttergottes', *Restaura*, 1 (2002), 37.
- 79** A. Burmester, C. Krekel, 'Das Blaupigment Vivianit als Schlüssel für die Datierung und die Herkunft des Regensburger Gnadenbildes?', in: *Alte Kapelle Regensburg, Arbeitshefte des Bayerischen Landesamtes für Denkmalpflege*, Vol. 114 (2001), 84-85.
- 80** U. Plahter, *Painted Altar Frontals of Norway 1250-1350. Materials and Technique*, Vol. 2, (London, 2004), 71.
- 81** A. G. Nord, K. Tronner, 'Chemical analysis of medieval mural paintings in Sweden', *Art et chimie, la couleur, actes du congrès*, J. Goupy, J. P. Mohen eds., (Paris, 2000), 99.
- 82** J. Pursche, 'Konservierung und Restaurierung der Wandmalereien in Urschalling', in 'Die Spätgotische Wandmalerei der Michaelskapelle in Piesendorf. Zur

Erhaltung und Erforschung mittelalterlicher Wandmalerei im Ostalpenraum', *Salzburger Beiträge zur Kunst- und Denkmalpflege*, 1 (Salzburg, 2000), 157–159.

83 S. Simon, A. van Aaken, M. Exner, A. Fritsch, E. Holter, 'La polychromie du portail du Jugement Dernier de l'église Saint-Sebald à Nuremberg', in La

couleur et la pierre, Polychromie des portails gothiques, Actes du Colloque Amiens 12–14 octobre 2000, D. Verret und D. Steyaert eds., (Amiens/Paris, 2002), 200.

84 U. Bültmeyer, *Seltene Mineralpigmente in der fragmentarischen Originalfassung eines spätgotischen Schreinreliefs mit der Geburt Christi um 1500 aus dem Kärntner*

Landesmuseum, [unpublished diploma thesis, Akademie der bildenden Künste Wien] (Vienna, 2003), 112.

85 H. Paschinger, H. Richard, 'Blaupigmente der Renaissance und Barockzeit in Österreich', *Naturwissenschaften in der Kunst: Beitrag der Naturwissenschaften zur Erforschung und Erhaltung unseres*

kulturellen Erbes, M. Schreiner ed., (Wien, Köln, Weimar, 1995), 63–65.

86 W. Fünders, 'Aktuelle Befunde zur Verwendung "vergessener" Pigmente in niedersächsischen Raumfassungen', *Restaurierung von Kulturdenkmälern. Berichte zur Denkmalpflege in Niedersachsen*, Beiheft 2, (Hannover, 1989), 46.