



Contributions to the Dublin Congress
7-11 September 1998

**PAINTING TECHNIQUES
HISTORY, MATERIALS AND
STUDIO PRACTICE**

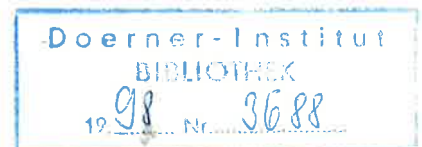
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6 Buckingham Street, London WC2N 6BA



THE RELATIONSHIP BETWEEN ALBRECHT DÜRER'S PALETTE AND FIFTEENTH/SIXTEENTH-CENTURY PHARMACY PRICE LISTS: THE USE OF AZURITE AND ULTRAMARINE

Andreas Burmester and Christoph Krekel

ABSTRACT

The pigments used in 13 paintings by Albrecht Dürer have been identified: azurite, ultramarine, verdigris, lead-tin yellow, brown and, occasionally, yellow ochres, cinnabar, red lead, red lakes, basic lead white as well as plant and bone black. Dürer mentions only four of these in his diaries and letters, and, except for ultramarine, there are no indications of where he obtained his pigments. Mediaeval documentary sources indicate that artists' pigments were available from pharmacies. Examination of fifteenth/sixteenth-century pharmacy price lists shows that all the pigments Dürer used were available. The composition of the palette depended to a certain degree on the cost of the pigments. This is exemplified by the blues, and we focus on Dürer's use of azurite and ultramarine. The nomenclature, origin, production and trade in azurite in late mediaeval times are discussed in more detail.

INTRODUCTION

An exhibition of paintings by Albrecht Dürer (1471-1528) in the collection of the Alte Pinakothek München afforded us the opportunity to study his palette in the light of documentary sources [1]. Only very few data on Dürer's colorants have been published, although two reviews on workshop practices and the materials used by other German artists around 1500 have been published recently [2,3]. Dürer described his own workshop practice in correspondence with Jakob Heller and Willibald Pirckheimer dating from the first two decades of the sixteenth century and in the diary of his journey to the Netherlands (1520/21) [4]. His comments reflect a division of labour typical for Nuremberg in that period. His colours, mostly in an oil medium, were prepared by an assistant, sometimes hired specifically for this purpose: '*Jch hab meister Joachim für 1 gulden kunst geschenckt, darum das er mir sein knecht und farb geliehen hat*' [4, p. 152]. The pigments or prepared oil colours may have been stored in shells and powder horns which he bought in Antwerp. In Dürer's writings, the pigments are not specifically named except for *ultramarin*, *loth*, *kesselbraun* and *ziegelfarb*. One might have expected to find more information about his pigments in his *Lehrbuch der Malerei* which Dürer had planned to write after his second trip to Italy (1505-07) [5]. Unfortunately, this three-volume treatise remained unfinished.

THE USE OF PIGMENTS IN DÜRER'S PAINTINGS

To fill this gap in our knowledge of Dürer's work, over the last 35 years the Doerner-Institut has investigated the pigments used in 13 paintings covering the period of production from 1495 to 1526. The 11 paintings in the collection of the Alte Pinakothek, Bayerische Staatsgemäldesammlungen München, are: *Maria als Schmerzensmutter*, dated 1495/98 (Inv. No. 709), Paumgartner Altar, c. 1498 (Inv. No. 706, 701, 702), *Bildnis Oswald Krel*, 1499 (Inv. No. WAF 230, 230a, 230b), *Glimsche Beweinung*, c. 1500 (Inv. No. 704), *Selbstbildnis von 1500* (Inv. No. 537), *Bildnis eines Jungen Mannes*, 1500 (Inv. No. 694), Jabach Altar, 1503/05 (Inv. No. WAF 228, 229), *Muttergottes mit der Nelke*, 1516 (Inv. No. 4772), *Selbstmord der Lucretia*, 1518 (Inv. No. 705), *Bildnis Jakob Fugger*, c. 1520 (Inv. No. 717), *Die Vier Apostel*, 1526 (Inv. No. 540, 545). The two paintings from the Metropolitan Museum of Art, New York, are *Salvator Mundi*,

dated 1504/05 (acc. no. 32.100.64) and *Madonna mit Kind und hl. Anna*, 1519 (acc. no. 14.40.633).¹

Our pigment analyses have revealed a restricted palette, which remained unchanged during the artist's lifetime. In our modern nomenclature the pigments identified are: azurite, ultramarine, verdigris, lead-tin yellow, brown, and occasionally yellow ochres, cinnabar, red lead, red lakes, basic lead white as well as plant and bone black (for detailed results see [1]). The nature of a copper-containing brown pigment has not been determined so far, but it might be identified with *kesselbraun*, a pigment Dürer bought on his trip to the Netherlands. Compared with the many other German paintings of this period, the composition of the palette is typical, except for the use of ultramarine.

THE PHARMACY AS THE MAIN SUPPLIER FOR ARTISTS' PIGMENTS AROUND 1500

Although artists' treatises of Dürer's time report numerous recipes for the production of pigments, German artists like Dürer usually would not have produced their own pigments. The colorants would have been produced by local craftsmen or imported. Some of the pigments or raw materials for their production can be found in account books of trading companies acting throughout Europe. The leaders of these *Handelsgesellschaften* such as the Fugger or the Paumgartners from Augsburg, all of whom were painted by Dürer, owned pigment producing mines, for example in Schwaz/Tyrol (Fugger) or in Idria/Slovenia (Paumgartner). Idria produced mercury and cinnabar in huge amounts. Other pigments found in the trade accounts are verdigris traded by the Nuremberg Meder from Antwerp, *miegen* and *rott* (madder) from Szeland (Netherlands), *grana* (kermes) from Poland and the Mediterranean area via Nuremberg to Antwerp and Venice, *Brasilig holz* (brazilwood) and *lacca* (lac dye) from Asia via Antwerp and Venice, and azurite directly from the mines [6, 7].

It is possible to show that in the Nuremberg of Dürer's time other colorants were being produced by local craftsmen. In particular, we have found evidence for a painter making red lead from lead white with the permission of the Nuremberg council [8] and, for the first time, evidence for the profession of a 'colour burner' (*farbprenner*) [1, 9]. This *farbprenner* bought lead and tin from a local metal dealer which was presumably meant for the manufacture of lead-tin yellow.

Artists' treatises report that pigments and binding media could have been bought either from grocers (*kram*), spice traders (*wurzkrämer*) or pharmacies (*apotekken*) [10, 11]. For reasons discussed elsewhere [1], pharmacies were forced by the local governments to provide a price list (*taxa*) of all their products. These *taxae* included almost all the pigments used in Dürer's time. In our field of research, *taxae* have not been assessed before now. They give an idea of the products available from German pharmacies of the fifteenth to sixteenth centuries. These offered pharmaceutical preparations (*composita*) and the basic materials (*simplicia*) for these medicines. The *simplicia* included spices, herbs, liquors, fragrances, oils, resins, plasters and so on, as well as materials which could be used as pigments. A *taxa* of Lignitz (East Prussia) from 1584 has a subsection literally entitled '*colores*', which proves that these materials were sold not only for pharmaceutical purposes but also as pigments for painters. In

¹The authors are grateful to Hubertus von Sonnenburg for permission to use the results relating to the New York paintings. The analyses were conducted by Hermann Kühn, Karin Junghans, Carola Komar, Andrea Kaser and the authors.

Table 1 Prices of pigments listed in the *Münchner Taxe* from 1488.

Pigment	Modern name	Amount	Amount (gram)	Price (pfennig)	Price per gram (pfennig)
Cerusa	lead white	1 Unze	30	2	0.07
Es ustum	burned copper, <i>kesselbraun</i> (?)	1 Unze	30	3	0.10
boli armeni	Armenian bole	1/2 Unze	15	2	0.13
flos eris	verdigris	1 Unze	30	6	0.20
Lithargyrum lotum	lead-tin yellow	1 Unze	30	6	0.20
Viride eris	verdigris	1 Unze	30	6	0.20
Lithargyrum auri	lead-tin yellow	1 Unze	30	8	0.27
Radix rubae tinctorum	madder root	1/2 Unze	15	4	0.27
Cinobrii	cinnabar	1 Unze	30	12	0.40
Lazurum	azurite	1 Unze	30	16	0.54
Sanguis draconis	'dragons blood'	1 Unze	30	28	0.94
Auripigmenti	orpiment	1/2 Unze	15	16	1.07
Calx di tistis ovorum	chalk from egg shells	1 Drachme	3.75	6	1.61
Spody	ivory or bone black	1 Drachme	3.75	6	1.61
Lapidis Emathitis	haematite	1 Drachme	3.75	8	2.14
Lazurum di optimo	azurite (of the best quality)	1 Unze	30	64	2.15
Lapidis lazuli	mineral azurite	1 Drachme	3.75	10	2.68
Grana tinctorum	scale insects	1 Drachme	3.75	12	3.22

the Lignitz *taxa*, the colorants are listed with prices and their German names only, which again proves their non-pharmaceutical use.

During Dürer's lifetime about 10 pharmacies were active in Nuremberg. However, an official *taxa* was not released until 1592, although we were able to find individual prices for a few pigments such as lead white (*plyweyß*) or verdigris (*Viride eris*) [1]. There are good reasons to suppose that the pharmacy prices were similar in Nuremberg and other German cities. One interesting example is the *Münchner Taxe* [12, 13] from 1488 (Table 1). A comparison with the *Münchner Taxe* from 1505 (Table 2), which was still valid in 1519, shows that the prices were almost stable.² The *Dresdner Sammeltaxe* from 1553 (Table 3) lists different qualities for some products like Armenian bole and in addition mentions silver and gold leaf [14].

The analysis of the *taxae* has to be done carefully. In particular, the translation and evaluation of mediaeval names are difficult. We used the very few bi-lingual *taxae* and pharmaceutical or alchemical sources. Although an assessment of these and other *taxae* is not yet complete, some observations may be made here:

- 1 Our tables show that all the pigments found on Dürer's palette, except ultramarine, were available in pharmacies.

The occasional use of ultramarine and the term *lapis lazuli* will be discussed in the next section.

- 2 Lead white, verdigris and lead-tin yellow always belong to the group of cheaper pigments, while cinnabar, azurite, bone black and the scale insects are more expensive.
- 3 Our investigations of late mediaeval German paintings prove the frequent use of lead-tin yellow, whereas orpiment has been found rarely. Aside from purely practical reasons [15], the preference for lead-tin yellow shown by Dürer, as well as other German artists, can be related partly to the price of the pigments given in our *taxae*. Orpiment is always more expensive than lead-tin yellow. According to our analyses, the only German artist around 1500 who used orpiment was Lucas Cranach³ who, it might be noted, owned a pharmacy [16].
- 4 Bone black is supposed to have been used rarely in the fifteenth and sixteenth centuries. Since *spodium* (ivory or bone black) is documented in all *taxae*, its use by artists is very probable. This has been confirmed by many occurrences, not only in Dürer's paintings.

Table 2 Prices of pigments listed in the *Münchner Taxe* from 1505.

Pigment	Modern name	Amount	Amount (gram)	Price (pfennig)	Price per gram (pfennig)
Boli armeni	Armenian bole	1 Unze	30	2	0.07
Radix rubae tinctorum	madder root	1 Unze	30	2	0.07
Cerusa	lead white	1 Unze	30	3	0.10
flos eris	verdigris	1 Unze	30	6	0.20
litargirum lotum	lead-tin yellow	1 Unze	30	6	0.20
viride eris	verdigris	1 Unze	30	6	0.20
lapis ematite	haematite	1 Unze	30	8	0.27
litargiri auri	lead-tin yellow	1 Unze	30	8	0.27
lapis lazuli	mineral azurite	1 Unze	30	10	0.34
Cynobrium	cinnabar	1 Unze	30	12	0.40
auri pigmentij	orpiment	1 Unze	30	16	0.54
lazurum	azurite	1 Unze	30	16	0.54
Spodij	ivory or bone black	1 Unze	30	32	1.07
calx de testis ovorum	chalk from egg shells	1 Drachme	3.75	6	1.61
lazurium de optime	azurite (of the best quality)	1 Unze	30	64	2.15
Grana tinctorum	scale insects	1 Drachme	3.75	12	3.20

²The *Münchner Taxe* from 1505 (Stadtarchiv Memmingen, Medicinalia A 402/2, dated 1505) was copied and sent to Memmingen in 1519.

³Lucas Cranach d.Ä., *Portrait Friedrichs des Weisen* (1507), Germanisches Nationalmuseum Nürnberg, Inv. No. Gm223.

Table 3 Prices of pigments listed in the *Dresdner Sammeltaxe* from 1553.

Pigment	Modern name	Amount	Amount (gram)	Price (pfennig)	Price per gram (pfennig)
Minij Mennige	minium, red lead	1 Lot	15	1	0.07
Cerussae albae Bleiweis	lead white	1 Lot	15	3	0.20
Cerussae Citrinac	lead-tin yellow	1 Lot	15	3	0.20
Boli armeni Communis	common Armenian bole	1 Lot	15	4	0.27
Viridis aeris Grünspan	verdigris	1 Lot	15	4	0.27
Auri pigmenti	orpiment	1 Lot	15	6	0.40
Cinabaris Cynober	cinnabar	1 Lot	15	6	0.40
Lapis haematitis nostrae regionis	haematite from our region	1 Lot	15	6	0.40
Rote Wurzel	red roots	1 Lot	15	6	0.40
Lapis haematitis orientalis prepa.	haematite from abroad, prepared	1 Lot	15	18	1.21
Boli armeni veri	real Armenian bole	1 Lot	15	24	1.61
Lapides lazuli	mineral azurite	1 Lot	15	24	1.61
Spodij de osse preparati	bone black	1 Lot	15	24	1.61
Sanguis Draconis	'dragons blood'	1 Lot	15	24	1.61
Foliorum Argenti	silver leaf	1 Blat	1 leaf	2	—
Foliorum Auri	gold leaf	1 Blat	1 leaf	4	—

5 The great difference in the price of scale insects (*grana*) when compared to madder (*Rubia tinctorum*) makes it probable that madder was used more frequently for the production of red lakes in Germany. This has been confirmed by analyses reported by the National Gallery in London [17].

ALBRECHT DÜRER'S USE OF AZURITE AND ULTRAMARINE

To exemplify the usefulness of the *taxae* in a specific case, we have selected Dürer's blue pigments. In exchange for woodcuts, worth 12 *florin* (about 30 grams of gold), Dürer acquired one *Unze* of ultramarine (about 30 grams) during his stay in the Netherlands [4, p. 156]. As in contemporary Italian contracts, this pigment plays an important role in letters to his customers. The attention Dürer paid to ultramarine does not agree with our analytical findings (Table 4): we have identified this pigment on only three panels. In one case, ultramarine formed a thin glaze over a layer of azurite.

From the paintings investigated to date, Dürer's favoured blue was azurite of an extraordinarily high quality, while smalt, indigo and blue verditer were not found. Dürer's occasional use of ultramarine is nevertheless exceptional for German painters around 1500. Ultramarine could be identified in only one other panel, by

Jakob Elsner⁴; on all the other 60 German paintings between 1450 and 1550 which have been investigated at the Doerner-Institut to date, azurite is the only blue pigment used.

German documentary sources like the *Illuminierbuch* of Boltz von Ruffach (1549) confirm our analytical findings, emphasizing the rare use of *ultra maryn plo* (ultramarine) and *schmeltze* (smalt) [10, p. 77]. Boltz's use of the unambiguous term *ultra maryn plo* is not typical. In general, the blues are not differentiated and blue pigments – natural or artificial – are called *lazur* or just *plo* (blue). This was noted by Emil Ploss who discussed the terms *lazur* and *lapis lazuli* some 40 years ago [18]. Unfortunately, the terms are still often misconstrued. In our modern interpretation *lazur* could mean any blue pigment and *lapis lazuli* (literally 'blue stones') may refer to the non-purified blue mineral. But since both terms were often used in the sources they must have meant a particular product in mediaeval times. What is the nature of *lazur* and *lapis lazuli*? Azurite, which was mined extensively in Germany, is always called *lazur* in the relevant documents. It was traded under this name throughout Germany, whereas in the international trade the terminology was more precise. For example, in 1462 King René demanded the use of *azur bonum de allemagna* (good blue from Germany) for a

⁴ Attributed to Jakob Elsner, *Bildnstriptychon des Conrad Imhof* (1500), Bayerisches Nationalmuseum München.

Table 4 Results of the pigment analysis* of samples taken from blue areas of paintings by Albrecht Dürer.

	Colour	Layers	Azurite	Quartz	Ultra-marine	Cinnabar	Red lake	Lead white	Plant black	Bone black
Maria als Schmerzensmutter	blue		O					O		
	blue-green		O				##	O		
Glimsche Beweinung	blue		O					O		
	Paumgartner-Altar, Mitteltafel	blue	O	O				O		
	blue, dark		O				O			
Paumgartner-Altar, HI. Georg	blue, pale		O					O		
	blue		O			#		O	#	
Paumgartner-Altar, HI. Eustachius	blue		O	O				O	#	
Salvator Mundi (New York)	blue				O			O		
Madonna mit der Nelke	blue, with white		O					O		
Selbstmord der Lucretia	blue, dark					O				
	red									
	blue		O					O		
Madonna mit Kind (New York)	black		✱							O
	blue		O		#			O		
	blue	blue	O				#	O		
Vier Apostel, rechte Tafel	blue, thin layer				O					
	blue		O		O					
Bildnis Jakob Fugger d. Ä.	blue		O							

*Microscopy, microchemistry, scanning electron microscopy, energy dispersive X-ray microanalysis, X-ray powder diffraction.

Key: O positive occurrence, # small amount, ## trace amount.

panel in Arles. Furthermore, in a fourteenth-century customs tariff from Avignon, both *Azur oltramarin* (ultramarine) and *Azur d'Alamaigna* (azurite) are mentioned [19]. German azurite was shipped as far as North Africa. In our opinion, the reason for the unambiguous terminology in the international trade must be the supply of two different blues – ultramarine and azurite – in southern Europe and France. Furthermore, the lack of differentiation in Germany must have had a reason, probably the absence of ultramarine on the market. This corresponds with our analytical findings. The interpretation of *lapis lazuli* as the non-purified mineral, azurite, and of *lazur* as the corresponding processed pigment can be confirmed by comparing the prices for ultramarine and azurite around 1500. As shown above, Dürer himself mentioned that ultramarine cost as much as gold. The most expensive blue in the *Münchner Taxe* of 1488 and of 1505 (Tables 1 and 2) – the *lazurium de optime* – was about 10 times cheaper than Dürer's *ultermarin*. Usually, *lazur* of lower quality and the unprocessed mineral *lapis lazuli* cost even less (Tables 1 to 3). Only in the *Münchner Taxe* of 1488 (Table 1) is *lapidis lazuli* more expensive than *Lazurum de optimo*. In our view, this might be a mistake: in the later *taxa* from Munich dated 1505 (Table 2) as well as in every other *taxa* we have examined, *lapis lazuli* is considerably cheaper than *lazur*. In conclusion, all our observations indicate that ultramarine was not generally available in Germany. In the light of these observations, documentary sources need to be re-evaluated. For example, the purification of *lapides lazuli* in the *Nürnberger Kunstbuch* – said till now to be the earliest German recipe for ultramarine found [20] – turns out to be a precise description of the preparation of azurite.

Germany was the main producer of azurite in Europe around 1500. This might be the main reason for the almost complete absence of ultramarine on the market. Large mines like those at Goldberg/Saxony and Schwaz/Tyrol guaranteed supplies of azurite of high quality. In the poem *Die fröhliche Heimfahrt* by Kaspar Scheit (1552) [4, p. 322] another mine is directly linked to Dürer's work:

*'Nach etlich tagen fueren sie
Vber ein wasser heißt die Sar
Darbey ein berg der ist blawfar,
Da man offft holt dem Dürer farb
Zu seinen tafflen, eh er starb'*⁵

The mine described in this poem is most likely the Blauberg at Wallerfangen/Saarland. Known since Roman times, this mine produced up to 5285 pounds of azurite per year from 1493 (Table 5). The mineral was processed in three different qualities and traded throughout Europe. On his way from a campaign in northern Italy in 1507 Duke Anton of Lorraine met some Germans transporting a huge amount of azurite (*azur*) from Wallerfangen [21].

In September 1997, we were able to obtain very high qualities of the blue mineral directly from the Blauwald mine at Wallerfangen. The azurite occurs as small blue spheres embedded in sandstone accompanied by green minerals (brochantite, malachite, antlerite) which were sold as *azur vert* for a much lower price.

CONCLUSION

Late mediaeval pharmacy *taxae*, examined here for the first time, turned out to be of considerable value. The *taxae* reflect the availability of pigments in certain areas, which explains, for example, the rare use of ultramarine and smalt by German artists

Table 5 The output of azurite during Dürer's lifetime from the mines in Wallerfangen [22].

Year	Output of azurite (pounds)	Year	Output of azurite (pounds)
1493	260	1511	5285
1497	470	1512	4395
1499	660	1513	3420
1501	688	1514	2400
1502	1020	1515	3190
1503	0	1516	3750
1505	556	1519	4680
1506	350	1521	4490
1507	674	1525	2650
1508	0	1526	0
1509	3608	1528	2742
1510	3610	1530	3400

The figures given are based on annual revenue. During epidemics of the plague no taxes were usually raised. One pound is equivalent to 477 grams.

around 1500. The frequent use of certain pigments is directly linked to their price. In other words, the price partly decided whether an artist would have used a pigment or not. Exceptions, such as the use of ultramarine by Albrecht Dürer, or the use of orpiment by Lucas Cranach, can be explained by the individual circumstances of the artist. As demonstrated for *lazur*, documents on mining and trading in combination with the information from the *taxae* can help to clarify cases of ambiguous terminology in documentary sources.

ACKNOWLEDGEMENTS

The authors are grateful to Dr Norbert Engel (Wallerfangen) and Michael D. Price (Munich).

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⁵ After a few days they crossed the river Saar. Close to this place, a blue-coloured mountain is sited where the colour for Dürer's panels was taken before he died....

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