Note from the Making and Knowing Project:

This essay was written for "The Art Technological Source," an 8-week graduate course at the University of Amsterdam offered by Dr. Marjolijn Bol in 2015 and 2016 to students enrolled in an MA program in either Technical Art History or Conservation and Restoration. Students worked on various recipes from BnF Ms. Fr. 640 on the following five topics: 1) tracing and painting on glass, 2) yellow dyes and their applications, 3) dragon's blood, 4) painters' varnishes, and 5) sieves.

This is an un-edited student paper that relies on an earlier state of the Making and Knowing Project's transcription and translation of Ms. Fr. 640. For an updated version of the text, see:

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'Juice of weld'

Research into an undefined ingredient of yellow lake pigment

In collaboration with:
The Making and Knowing Project: Craft and Science in a Sixteenth-Century Artist's Manuscript: An Open-Access Digital Edition and Translation of BnF Ms. Fr. 640 (Columbia University, directed by Prof. dr. Pamela Smith)

Hedwig Braam (Hedwig.Braam@student.uva.nl)

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Lecturer: Marjolijn Bol

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Images in this annotation are courtesy of the author unless otherwise stated.

Content

BnF Ms. Fr. 640 folio 10r

Transcription[1]

<id>p010r_2</id>
<head><m>Scudegrun</m></head>
<ab>Il se faict a <pl>lyon</pl> avecq du <m>suc de gaulde</m> & de la <m>croye</m>
incorporee<lb/>
ensemble ou pour mieulx avecq de la <m>ceruse</m> qui est propre a<lb/>
destrempe et a <m>huile</m></ab>

Translation[2]

<id>p010r_2</id>
<head><m>Scudegrun </m></head>
<ab>It is made in <pl>Lyon</pl> from the <m>juice of weld</m> mixed with <m>chalk</m>
or better yet with <m>ceruse</m>, which is appropriate for <m>tempera</m> and <m>oil</m>.
</ab>

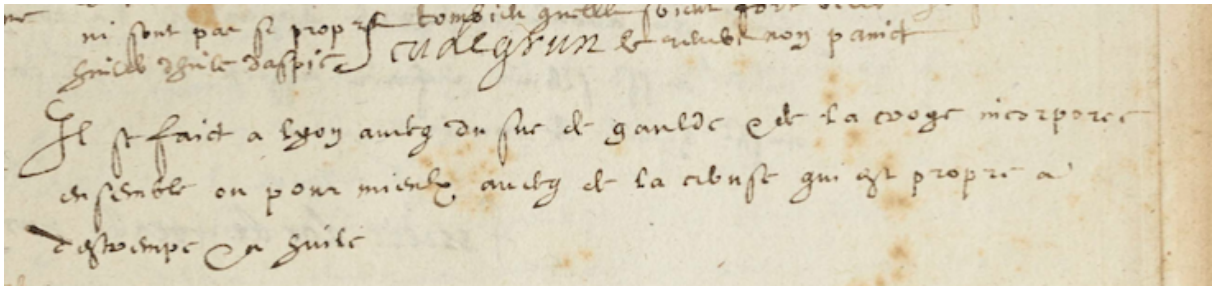

Fig. 1 The recipe for Scudegrun. on fol. 10 in BnF Ms. Fr. 640. Image by The Making and Knowing Project.

[1] Tc_p010r, version 16 February 2016. Transcription by Soersha Dyon and Heather Wacha. *The Making and Knowing Project.*
[2] tl_p010r, version 16 February 2016. Translation by Soersha Dyon and Heather Wacha. *The Making and Knowing Project.*

Introduction

BnF Ms. Fr. 640 is a French manuscript from the sixteenth century and resides in the Bibliothèque nationale de France in Paris. It is written by an anonymous author and contains a number of artisanal recipes. *The Making and Knowing Project* is aiming to provide an open-access digital transcription, an English translation, and a critical edition of the manuscript. As part of this project, historical reconstructions of the recipes in the manuscript are performed, and critical reflections on the recipes are written in the form of annotations. This academic research into historical art technological recipes gives us insight into medieval practices.

One of the recipes in BnF Ms. Fr. 640 is for making 'scudegrun', a yellow lake pigment made from the dyestuff extracted from weld (botanical name *Reseda luteola*) and chalk.[3] The process to make this lake pigment is very briefly described in the recipe as 'mixing the juice of weld with chalk'.[4] It is however unclear what the author-practitioner exactly means by 'juice of weld'. Although a lot of research is done into historical practices of making lake pigments, a survey of art technological publications on medieval painting practices shows that there seems to be no research specifically focused on extracting the dyestuff from the plant based material.[5] To contribute to this field it is interesting to investigate the historical practices of processing plant based material for making lake pigments, and to find an answer as to what the author-practitioner might have meant with 'juice of weld'.

First, the definition and making process of lake pigments will be discussed as well as the lake pigment 'scudegrun'. Then I will investigate the extraction of color from plant based materials for making lake pigments. Following this I will look into some historical sources to see how the recipe for scudegrun relates to other contemporaneous recipes. Finally, I will describe a performed historical reconstruction of the recipe for 'scudegrun' from BnF Ms. Fr. 640. To conclude this, I will try to answer the following question: What could the author-practitioner of BnF Ms. Fr. 640 have meant with "juice of weld"?

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[3] Fol. 10r, BnF Ms. Fr. 640.

[4] 'Il se faict a lyon avecq du suc de gaulde et de la croye incorporee' Transcription by Soersha Dyon and Heather Wacha. *The Making and Knowing Project.*

[5] See for example Kirby, Jo, Maarten van Bommel, and André Verhecken. *Natural Colorants for Dyeing and Lake Pigments: Practical Recipes and Their Historical Sources.* London: Archetype, 2014, p. 28.

Lake pigments

Historically, a lot of natural material was used for painting. Yellow pigments or dyes for instance could be made from weld, broom flower, saffron, safflower or buckthorn berries.[6] Processing these plants could consist of soaking, heating, boiling, crushing, grinding, fermenting, diluting and many more.[7] Some plant based material is not soluble in water and can be used directly after being processed using one of these steps. Examples of this are indigo and saffron. But most other plant based colorants, like weld, are soluble in water and require a substrate to bind the organic dyestuff and give it body.[8] When the dyestuff is precipitated onto the substrate an insoluble pigment is formed. This is what distinguishes a lake pigment. After this they can be mix with an oil or aqueous binder and made into a paint or glaze.

Scudegrun

The author-practitioner of BnF Ms. Fr. 640 calls the weld lake pigment described on fol. 10 'scudegrun'. There are no other known sources in which the term scudegrun is mentioned.[9] The name could be derived from the German 'schütgrun', although this refers to a Green color. In comparable recipes for yellow lakes the names 'arzica' (Spanish), 'stil de grain' (French), 'pinke' (English) 'schüttgelb' (German) or 'schijtgeel' (Dutch) are used. These names however are also not specific for recipes using weld, but can also be used to describe yellow lake pigments derived from other plants sources.[10] These can include broom flower, buckthorn berries, goatsbeard and other plants. We can also see this in BnF Ms. Fr. 640: there is another recipe in the manuscript that is called 'scudegrun'. This describes a recipe for a lake pigment made by extracting color from broom flower.[11]

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[6] Kirby, Van Bommel, and Verhecken 2014, p. 28.
[7] Bommel, Maarten Van. "Organic Colorants: Dyes and Pigments." Science 1 Lecture, University of Amsterdam, Amsterdam, September 21, 2015.
[8] Kirby, Jo. "Dyes, Dying and Lake Pigments – Historical Background," (Presentation, *Back tot the Roots* - Workshop on the Preparation of Historical Lake Pigments, Doerner Institut, Munich, March 23-25, 2011) http://doernerinstitut.de/downloads/Back_to_the_Roots/Back_to_the_roots_Kirby_I.pdf; Kirby 2014, p. 69.
[9] Kok, Cindy, and Yuan Yi. "Color for Green Leafs." Fall 2015. The Making and Knowing Project, p. 8.
[10] "Pigment Glossary," in *Trade in Artists' Materials: Markets and Commerce in Europe to 1700,* eds. Jo Kirby, Susie Nash and Joanna Cannon. London: Archetype, 2010, p. 452.
[11] See BnF Ms. Fr. 640 fol. 63.

All yellow lake pigments are made in a similar way. Before the eighteenth century, most of them were made with a calcium salt, like calcium carbonate.[12] In the recipe for scudegrun the author-practitioner mentions both chalk and lead white as options to mix with the juice of weld. Lead white was more often used in yellow lakes, for example in the fifteenth century Bolognese Manuscript.[13] Medieval authors stated that weld lakes pigments were more opaque compared to other yellow lake pigments (like that of buckthorn), but when lead white was used, the color was more transparent and brilliant.[14]

'Juice of weld' extraction

How can color be extracted from plant based material? Daniel V. Thompson, professor in art history and an authority on medieval painting, described it in his book *The materials and techniques of medieval painting.* He writes the following:

> The whole plant, flowers, stems, and all, is dried and sold in bundles, and for dyeing or colour-making it is broken up and stewed in water or a weak solution of alum.'[15] He also notes that 'weld lakes were often precipitated out of the decoction of the plant in alum solution by the addition of chalk, which gave a mixture of an alumina lake with calcium sulphate.[16]

This describes two different extraction methods: stewing or boiling the plant material in water or extraction through a solution of water and alum (after which chalk was added). Raymond White and Jo Kirby, scientific officers at the National Gallery in London, describe a third method: extracting of the dyestuff in an alkali solution, a lye made from wood or plant ash with water. Although this is used for the processing of many lake pigments this is not a common procedure for yellow lakes.[17] They also mention a fourth method: simply letting the dyestuff soak in an

[12] Kirby, Van Bommel, and Verhecken 2014, p. 77-78.
[13] Merrifield, Mary. *Medieval and renaissance treatises on the arts of painting.* New York: Dover, 2003, p. 484.
[14] Thompson 1956, p. 187-188. The binding medium is not mentioned; this can also have great influence on the appearance.
[15] Ibidem.
[16] Ibidem.
[17] White, Raymond, and Jo Kirby. "Some Observations on the Binder and Dyestuff Composition of Glaze Paints in Early European Panel Paintings." In *Medieval Painting in Northern Europe: Techniques, Analysis, Art History*, edited by Jilleen Nadolny. London: Archetype, 2006, p. 216.

aqueous solution of water and alum until a yellow matter settled out which could be used in a mixture with glue or gum.[18]

In her book *Natural Colorants,* Jo Kirby describes specific examples of historical recipes for lake pigments of weld. Here she divides the recipes into three general variations based on historical sources: plant material extracted with water and treated with potassium carbonate and potash alum, plant material extracted with water and treated with potash alum and calcium carbonate and plant material extracted using lime water after which chalk and potash alum is added.[19] In the first two variations the plant material is boiled in normal water, in the last recipe the plants are pre-soaked in lime water before boiling.

Lastly, it is interesting to look at the other recipe for scudegrun in BnF Ms. Fr. 640 on fol. 63: 'it is made with the broom flower well boiled in water, putting in it enough alum, then some ceruse.'[20] In contrast to the processing of weld, here the processing of broom flower is described, although 'well boiled' is not specific when it comes to the duration of the boiling. At no other occasions does the author-practitioner mention 'juices' of plants or soaking or boiling them to extract their color.

Historical sources

To look at what the author-practitioner might have meant by 'juice of weld' one can look at other contemporaneous recipes for the making of lake pigments, to see what was common practice. Since terminology differs greatly in different manuscripts (as we saw with the term 'scudegrun') it is hard to come across comparable recipes from the same period and location as BnF Ms. Fr. 640. However, looking at the following historical sources from different geographical locations and time periods we can see a broad array of processes to turn plants into lake pigments, which we can compare to the recipe for scudegrun in BnF Ms. Fr. 640.

One important treatise on art is *Il libro dell'arte* by Cennino Cennini (c. 1360 – before 1427), written around the turn of the fifteenth century. Cennini describes a yellow lake pigment which is called "arzica". He writes:

[18] White and Kirby 2006, p. 217.
[19] Kirby, Van Bommel, and Verhecken 2014, p. 78-80.
[20] BnF Ms. Fr. 640, fol. 63r.

> A color known as arzica is yellow; and this color is made alchemically, and is but little used. Working with this color is chiefly a matter for illuminators; and it is used more in the neighborhood of Florence than anywhere else. This is a very thin color. It fades in the open; it is not good on the wall; it is all right on panels. It makes a lovely green if you mix in a little azurite and giallorino. Like the other choice colors it wants to be ground with clear water[21].

Different authors believe Cennini here describes a lake pigment made from of weld.[22] The only thing Cennini states about the making process is that it the arzica is made alchemically.[23]

'Another recipe for 'arzica' can be found in the *Bolognese Manuscript*, also from the beginning of the fifteenth century:

> To make good and fine arzica. – Take one pound of weld, which the dyers use, cut it very fine, then put it into a glazed or tinned vase, and add to it enough water to cover the herb. Make it boil until the water is half wasted, and if there is not enough water add a sufficient quantity and no more; then take 2 oz. of travertine finely ground, or 2 oz. of white lead, and 12 oz. of roche alum ground very fine, then put all these things together a little at a time to boil in the vase directly, before the water cools, and stir the water continually, remove the vessel from the fire, and when nearly dry, pour off the water. Then take a new brick hollow in the middle, lay the arzica on it, and let it settle perfectly; then put it on a small and well polished board to dry, and it is done.[24]

In this recipe it is stated that arzica is made by using 'herba gualda', the Spanish name for weld.[25] The Bolognese Manuscript is more detailed about how the lake pigment is made. The weld is boiled in enough water before a mixture of travertine (a form of limestone consisting of calcium carbonate) or white lead and roche alum are added while boiling. A different order of this procedure can be seen in the fifteenth century *Simone manuscript* by Simone de Monte Dante:

> To make the yellow "arzicha". Take very well ground eggshells and put them in the

[21] Cennini, Cennino. *The Craftman's Handbook "Il Libro Dell'Arte"*. Translated by Daniel V. Thompson, Jr. New York: Dover, 1960, p. 30.
[22] Thompson in: Cennini 1960, p. 30 and Ball, Philip. *Bright Earth: The Invention of Colour.* London: Vintage, 2008, p. 113.
[23] This could mean it is made by the artificial process of of precipitation the dyestuff in a chemical reaction with the mordant in comparison to 'natural' vegetable colors which are made by simply soaking and dissolving in water. We see similar divisions between paints that are 'natural' or 'made by art' in other historic texts.
[24] Merrifield 2003, p. 498.
[25] Eastaugh, Nicholas, Valentine Walsh, Tracey Chaplin, and Ruth Sidall. *The Pigment Compendium: A Dictionary of Historical Pigments.* Oxford: Elsevier Butterworth-Heinemann, 2008, p. 400.

> hollow of a new brick. Take the weld herb of the textile dyers and let it boil in water with a little bit of alum. Pour it on the eggshells and thus make it as light or as dark as you wish.[26]

Here the weld is boiled in water with a little bit of alum (before adding it to an alkaline, the ground eggshells). Another recipe for a yellow lake, which according to translator Mary Merrifield could be made from various plants like goatsbeard, broom flower or weld, is mentioned in the 'Paduan manuscript' which dates from the seventeenth century.[27] The recipe is for 'giallo santo' and goes as follows:

> Take the berries of the buckthorn towards the end of the month of August, boil them with pure water, until the water is loaded and thick with colour: add a little burnt roche alum and then strain it. You may boil the strained liquor to make the colour deeper, mixed with it some very pure gilder's gesso; then make the colour into pellets, and dry them in the shade.[28]

Although this recipe clearly mentions buckthorn, Merrifield argues that since giallo santo in the Nuovo Plico (a book called *Nuovo plico di ogni sorta di tincture: arricchito di rari e bellissimi secreti per colorire animali, vegetabili, e minerali* by Galipidio Tallieri from ca. 1704, ed.) is said to be made of the flowers of the goatsbeard, it is safe to assume that this lake could be made with various type of plants.[29] Here the plant material is boiled before any alum is added. After that it is mixed with gilder's gesso, which consisted of chalk.[30] As we can see in the two recipes for scudegrun in BnF Ms. Fr. 640 the plant material for certain yellow lake pigments (like scudegrun) can be exchangeable, since the plants were processed in the same way in making similar lake pigments. This is also acknowledged by Jules Lefort who writes that 'stil de grain' could consist of grain d'avignon, buckthorn berries, weld, birch leaf, chestnut rose etc.[31] We

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[26] *Libro Secondo de Diversi Colori e Sise da Mettere a Oro: A Fifteenth-Century Technical Treatise on Manuscript Illumination,* quoted in Wallert, Arie. "The Getty Conservation Institute in Historical Painting Techniques, Materials, and Studio Practices" University of Leiden, June 26-29, 1995, p. 41.
[27] Merrifield, 2003, p. clxiv.
[28] Merrifield, 2003, 708.
[29] Ibidem.
[30] Gilder's gesso is mentioned in Cennini's 'Il libro dell'arte'. (See Cennini, 1960: p. 119.) It is thought to be a fine grade of levigated chalk. See: Weber, F. W. *Artists' Pigments.* New York: Van Nostrand, 1923: p. 125-126.
[31] 'Lorsqua la preparation des ces couleurs etait encore a l'etat de secret, on les designait toutes sous le nom de stil de grain; ainsi, on avait le stil de graine de graine d'avignon, de gaude, de baies de nerprun (vert de vessie), de

therefore can also consider the following recipe for a 'splendid yellow' from the Bolognese Manuscript.

> To make a splendid yellow, finer than orpiment or German giallolino. – Take berries of buckthorn, when they are quite ripe, extract the juice from them, and keep it in a glass jar well closed for a fortnight. When you wish to use it, take strong ley, clear and fine, and for each mezzetta of ley take an ounce of orche alum in powder, and make it boil with the ley for the space of one parternoster in a glazed vase; then remove it from the fire and let it cool. Next take for every tumbler of ley with alum one-third of a tumbler of the juice, and incorporate it well with the ley and alum, which will become a sort of dark green water, and let it stand thus incorporated for a night or more. (…)[32]

Just like the recipe in BnF Ms. Fr. 640, the extraction of the juice of the berries is not specified.[33] It is interesting to note that the recipe mentions storing this juice for two weeks after 'extraction'. It is possible that this refers to a soaking of the berries. After that it was to be added to a mixture of ley and alum which was boiled for the duration of one prayer.

In addition, we can look at a recipe for 'schytgeel', the Dutch version of a yellow lake pigment like 'scudegrun', which could also be made from different kinds of plant based material. In this recipe from 1835 we can read the following making process with the use of berries:

> The schyt-geel, by some called English yellow, is made by soaking and boiling of yellow or so-called French berries, by alunwater, etc.: in that dark yellow juice grounded chalk is mixed, and totally bulky, that is can be processed with the hands; one kneads it until it resembles human dung, which is why it is called 'schyt-geel (translation by author).[34]

Here also soaking and boiling is mentioned. It is interesting to note how the writer explains this making process as "by alumwater etc.". This suggests that this addition of alum to the solution might have been a common and known practice for the people reading his recipes. There is

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feuilles de bouleau, de chataignier rose, etc.' *in:* Lefort, Jules. *Chimie de couleurs pour la peinture a l'eau et a l'huile.* Paris, Masson, 1855: p. 117.

[32] Merrifield, 2003, p. 428.

[33] 'Trannj o sugo et serbalo in una ampolla de vetrio ben turata et lassa cusi stare per 15 di'. Transcription by Merrifield 2003, p. 429.

[34] 'Het schyt-geel, van sommige Engelsch geel genoemd, wordt gemaakt van, of wel getrokken en afgekookt uit, geele of zoogenoemde Fransche beziën, door aluinwater, enz.: in dat donker geele sap wordt gemalen kryt gedaan, en geheel lyvig, ja zoo styf, dat het met handen bewerkt kan worden; men kneedt het tot de gedaante van menschen-drek, al waarom het ook de naam van schyt-geel gekregen heeft' in: Simis, Lambertus. *Grondig onderwijs in de schilder- en verwkunst.* Amsterdam: Gartman, 1829, p. *50.*

another method of using the weld which can be found in literature. A recipe from 1836 mentions that the weld can be boiled with 'alum or with alum and mother of wine' to obtain a yellow color.[35] Although this is a known procedure for other pigments, it seems to not have been common in historical recipes for yellow lakes.

As we have seen historical sources mention different recipes for obtaining a lake pigment from weld or other plant based material. Like the division stated by Kirby and White, the main difference is the order in which the materials (most often alum and a calcium salt) are added, and the extraction by boiling in either pure water of water with alum. Most recipes do not mention soaking the material before extraction.

Reconstruction

Since the recipe of scudegrun gives no clarity about the extraction of the dyestuff from the plant, this called for experimentation in reconstructing the recipe. Since senior research scientist Jo Kirby is renowned for her study of pigments and paint materials, a recipe described by her was used for the historical reconstruction of the yellow lake pigment (see appendix 1).[36] In this recipe the weld is presoaked overnight in demineralized water, next some alum is added and after heating the solution chalk is added to precipitate the pigment. Although no alum was mentioned in the recipe for scudegrun, it was decided to follow this reconstruction guideline since research into the making of lake pigments shows that alum is essential for the precipitation of the color onto the substrate and some form of alum is mentioned in all recipes. We incorporated samples with the addition of alum (following the recipe by Kirby) and samples without any added alum (true to the recipe in BnF Ms. Fr. 640).

By making several reconstructions with small differences we tried to assess which factors determine the outcome of the color of a weld lake pigment. Several of these variables concerned making the 'juice of weld' by extracting color from the weld. The following variables were investigated in extracting the color from the weld: duration of boiling, pre-soaking, the ratio weld

[35] 'De schoonste geelen, na datze met aluin alleen gezoden zyn, of met aluin en wynmoer, kleurt men met den wouw, dewelke in vele landschappen van vrankryk wast, (...).' in: *De volmaakte verwer, aller lerende wat er vereischt wordt.* Amsterdam: H. Moolenijzer, 1836, p. 12.
[36] Kirby, Van Bommel, and Verhecken 2014, p. 90.

versus water and the presence or absence of alum.[37] Tested methods were overnight soaking in demineralized water, overnight soaking and boiling for ten minutes, overnight soaking and boiling for thirty minutes, and letting the plant materials boil without pre-soaking (see appendix 2).[38] We made sure all test samples varied in only one variable from one other sample, in order to be able to evaluate the causes of potential different outcomes in the color of the lake pigment. Due to the limited availability of fresh weld in winter we could not test fresh weld in the use of this reconstruction.

Results

Jo Kirby states that the substrate of a lake greatly affects the visual, chemical and physical properties, like color and transparency.[39] However, also different methods of processing the weld turned out to result in visual differences in the finished scudegrun (see appendix 2). When looking at the applied lake pigments (mixed with linseed oil) on canvas and silver leaf one sees differences in the intensity and shade of yellow. Here it must be stated that it is hard to explain visual differences resulting from this reconstruction, since the project was limited in scale and many unforeseen factors could have been of influence in the outcome. The following results were obtained from the different variables when applied on canvas (see fig. 1 and 2, appendix 3). As expected the alum turned out essential for the yellow color to precipitate on the chalk. Also, as was already seen from the color of the aqueous solution, boiling the weld for a longer timeframe gave the final yellow lake a slightly darker color. Pre-soaking the weld in water for at least six hours before heating it resulted in a slightly warmer and darker yellow than the weld which was not pre-soaked. Lastly, doubling the amount of weld also seemed to make a big difference: the yellow color it produced was the brightest of all.

[37] We also carried out tests with different amounts of chalk and a reversed order of adding chalk and alum. The latter experiment was unfortunately not completed due to broken equipment and loss of the sample.
[38] One sample of weld was heated for ten minutes. When the remaining plant extract were re-heated on a later moment, there was still color coming out of the plants that colored the water yellow. This is why we decided to heat the other samples for a period of thirty minutes. Letting the weld simmer in water for a longer time resulted in a slightly brighter yellow colored liquid.
[39] Kirby, Van Bommel, and Verhecken 2014, p. 85.

Application of the test samples on a silver ground showed even more differences in color (see fig. 3 appendix 3).[40] Here we applied the yellow lake as a glaze, with a larger amount of binding medium (linseed oil). Right after application the yellow hues did not show major differences, except for the sample which was presoaked, which was by far the darkest and brightest yellow. This could also be due to a thicker application layer. However, when examining the colors one week after application major differences can be seen (see fig. 4 appendix 3). The sample which was boiled for thirty minutes was several shades darker than the batch that had only simmered for ten minutes, and seemed to have a strong pink undertone. The batch that had pre-soaked and simmered for thirty minutes was still bright yellow (but again, thick application may influence the brightness and opaqueness of this sample). Lastly the batch with double the amount of weld had darkened a bit, and also showed some pink hue. The pink hue is also strongly visible in the samples without alum, indicating it is related to the chalk.[41]

This experiment demonstrates that different methods to make 'juice of weld' result in different shades of yellow when used in combination with linseed oil and applied on canvas or silver leaf. Overall the samples which were not presoaked displayed more discoloration. Furthermore, both longer boiling and presoaking seemed to intensify the yellow color.

Conclusion

By studying contemporaneous sources as well as doing a practical reconstruction I tried to shed light on historical way to extract dye stuff from plant material, and to answer the question what the author most likely meant by 'juice of welt'.

It would be incorrect to explain color differences solely by looking at the extraction of the dye stuff, since there are many factors in producing and using the pigment that might be of influence: the size of reaction vessel, the rate at which substrates are added, the temperature, the substrate, and many others. Also when researching the extraction of juice of weld and the processing of the plant-based material one has to take the role of alum and chalk in this recipe in

[40] One of the purposes of the scudegrun from BnF Ms. Fr. 640 according to Cindy Kok (introduce) is application of the pigment on applied silver leaf to obtain a gold imitation. Kok 2015, 3.

[41] Since this annotation will not look into the role of the (amount of) chalk or the alum, and the effect of silver leaf on an applied lake pigment, explanation for these differences will not be posed. See for more experimentation on making yellow lake pigments: Kok, 2015.

mind. All recipes mention two additives to the weld solution: one alum-based and one calcium-based, varying in the order in which they are added. Since following the recipe for scudegrun exactly (without the use of alum) did not result in a yellow pigment, one can assume that alum should be used. With the art technological knowledge of the author-practitioner, as demonstrated in BnF Ms. Fr. 640, one can assume he was aware of the procedures to make a yellow lake. This can also be seen in the recipe for scudegrun on fol. 64 of BnF Ms. Fr. 640 where the author states 'It is made with the broom flower well boiled in water, putting in it enough alum, then some ceruse'.[42]

The reason why the author-practitioner might have not mentioned the alum in the recipe could be that the alum is already a part of the 'juice of weld' in the recipe. As we have seen, the dyestuff in weld can be extracted in different ways, one of which is extraction in a solution of water mixed with alum. Since the author-practitioner does not specify how this 'juice of weld' was produced, it could be the case that he meant not only a solution of weld in water, but weld in a water-alum mixture. This is also the same method as used for the broom-flower based scudegrun.

As we have seen, minor differences like presoaking and duration of boiling can affect the color of the weld lake pigment and its aging process. To know what causes this aging further research on the effect of silver leaf on lake pigments deserves further attention. In addition, another set of experimentation could be set up in making lake pigments, especially concerning the order in which alum and chalk are added and the weld juice extraction with limewater. The resulting visual effects could give further insight into probable medieval practices in creating lake pigments.

[42] 'Se faict avecq de la fleur de genest fort bouillie dans de l eau y mettant suffisament de l alum Puys de la ceruse.' Transcription fol. 63v, BnF Ms. Fr. 640.

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De volmaakte verwer, aller lerende wat er vereischt wordt. Amsterdam: H. Moolenijzer, 1836.

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Appendix 1 – Reconstruction recipe by Jo Kirby[43]

Presence of calcium salt in the substrate: addition of calcium carbonate to dye solution containing alum (code: WL-Al-Ch)

Enclose 2 g weld, broken into small pieces, in a polyester netting bag large enough to allow the plant material to move freely and the water to penetrate it easily. Place the bag in a 250 ml beaker and add 120 ml demineralized or distilled water. Soak it overnight, then bring the solution to the boil, while stirring, and boil for 30 minutes. Remove the bag. If necessary, filter the solution using a glass funnel and folded filter papers. Add 2 g potash alum and heat until the solution reaches 80 °C. Weigh out about 6 g calcium carbonate ($CaCO_3$). Add this very gradually to the alum-dye solution while stirring; this will cause effervescence at first. If calcium carbonate is added past this point, it acts largely as an extender, making the pigment paler although dye is also adsorbed onto the surface. The amount added can thus be a matter of choice, depending, for example, on the strength of colour desired. Leave to stand overnight for the precipitate to settle. Next day, filter (or centrifuge) the pigment, wash and allow to dry as described in the standard recipe above.

[43] Kirby, Jo. *Natural colorants*: 90.

Appendix 2 – Reconstruction variables

1.Test sample[44]
- Soaked overnight in tap water
- Not processed into lake pigment

2.1 No soaking, short simmering
- Without soaking
- 10 minutes of simmering (80 degrees)
- 6 grams of chalk
- Without alum

2.2 No soaking, short simmering
- without soaking
- simmering for ten minutes (on 80 degrees)
- 6 grams of chalk
- with alum

3.1 No soaking, 30 minutes simmering
- without soaking
- simmering for 30 minutes (on 80 degrees)
- 6 grams of chalk
- with alum

3.2 No soaking, 30 minutes simmering
- without soaking
- simmering for 30 minutes (on 80 degrees)
- 6 grams of chalk
- without alum

4.1 Pre-soaking and 30 minutes simmering
- six hours pre-soaking
- simmering for 30 minutes (on 80 degrees)
- 6 grams of chalk
- with alum

4.2 Half the amount of chalk
- six hours pre-soaking
- simmering for 30 minutes (on 80 degrees)
- 3 grams of chalk
- with alum

[44] Unfinished test sample, not according to the reconstruction recipe by Jo Kirby.

5.1 Double the amount of weld
- six hours pre-soaking
- simmering for 30 minutes (on 80 degrees)
- 6 grams of chalk
- with alum
- double the amount of weld

5.2 Reversed order[45]
- six hours pre-soaking
- simmering for 30 minutes (80 degrees)
- 6 grams of chalk
- first chalk added, then alum

[45] Unfinished sample. Experiment failed due to breaking of the glass jar while heating the sample.

Appendix 3 - Reconstruction results

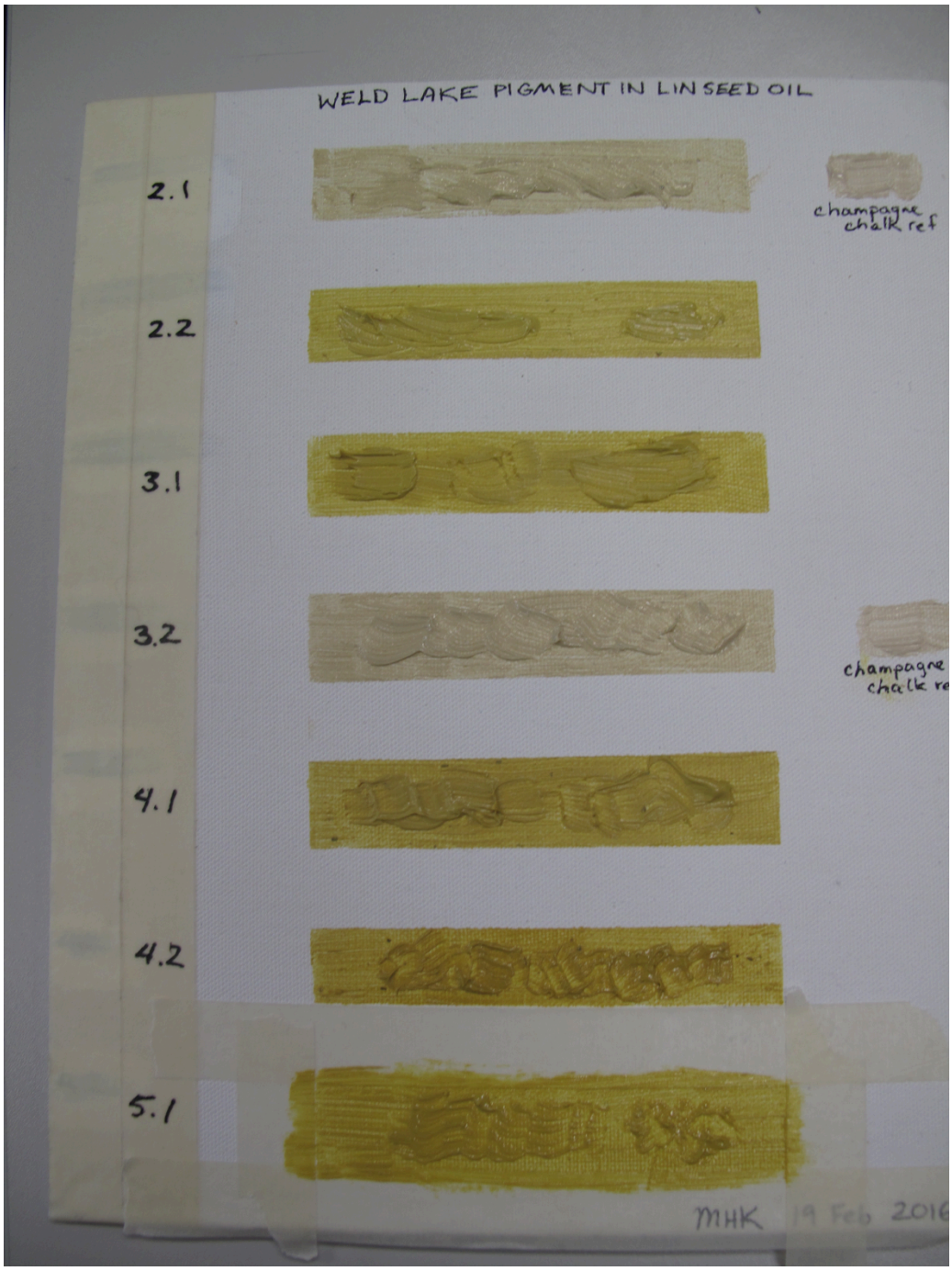

Fig. 2 Test samples of reconstructed 'scudegrun' applied on canvas

Absence of alum: Sample 2.1 and 3.2 do not contain alum, but only chalk as mentioned in the recipe in BnF Ms. Fr. 640. The result is a white paint, similar to the pure chalk and linseed oil test sample on the right.

Pre-soaking:
Samples 4.1 and 4.2 were presoaked overnight. The yellow color seems more intense than in samples 2.1 and 3.1, which were not pre-soaked.

Fig. 3 Test samples reconstructed ‘scudegrun’ applied on canvas

Duration of boiling: Sample 2.2 was boiled for 10 minutes, sample 3.1 was boiled for thirty minutes. Boiling the weld a longer amount of time gives a darker color yellow.

Amount of chalk: To see the influence of the amount of chalk compare sample 4.1 (6 grams of chalk) and 4.2 (3 grams of chalk). Half the amount of chalk made for a darker and brighter color.

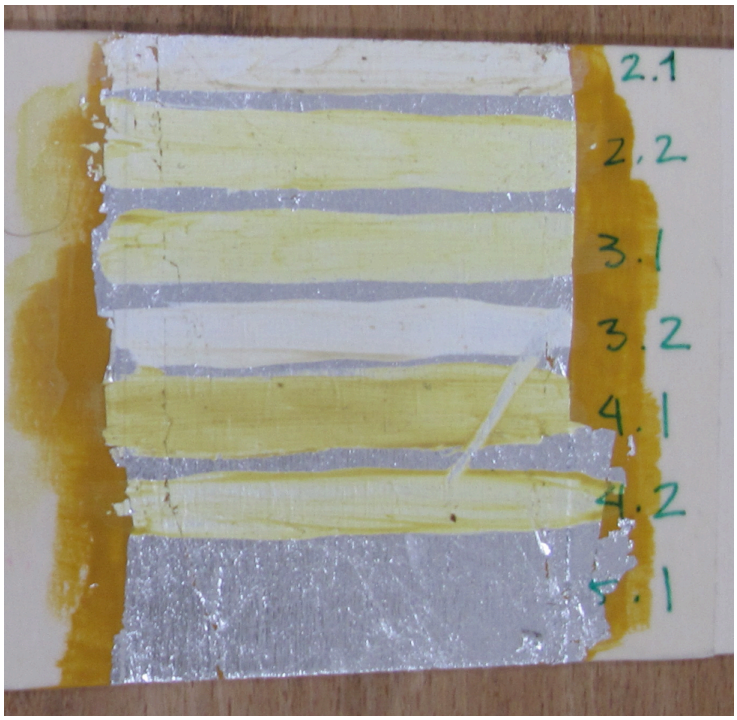

Fig. 4 Weld lake pigments applied on silver leaf

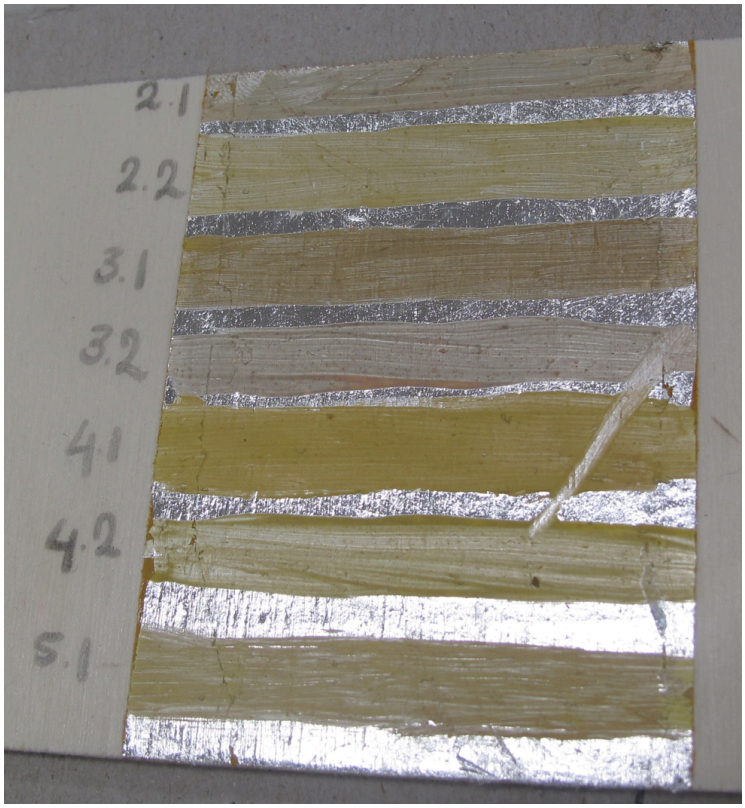

Fig. 5 Discoloration of weld lake pigments applied on silver leaf, one week after application. The samples are discolored and have a pinkish hue.