Dossier

The Making and Knowing Project
BnF Ms. Fr. 640 French Manuscript
Program leader: Pamela Smith

A research of the use of “spat” in the preparation of molds in Manuscript BnF Ms. Fr. 640

Elisabeth Kuiper
10446907
Ingeborg Kroon
10597565

University of Amsterdam
Master conservation and restoration of cultural heritage
Specialization metal

Instructors:
Tonny Beentjes
Tamar Davidowitz
Ellen van Bork
Content

Introduction........................................................................................................................................2
Folios ..................................................................................................................................................3
Annotations .........................................................................................................................................10
Conclusion ..........................................................................................................................................20
Further research .................................................................................................................................21

Appendix 1  Logbook ..........................................................................................................................22
Literature study .....................................................................................................................................22
  Week 1  4-9 February .......................................................................................................................22
  Week 2  10-16 February ...................................................................................................................23
  Week 3  17-23 February ...................................................................................................................25
  Week 4  24-2 March ........................................................................................................................27
  Week 5  3-9 March ..........................................................................................................................35
Conclusions literature study ...............................................................................................................41

Experiments  week 6 and 7  10-23 March ..........................................................................................45
  Experiment 1: Characteristics ...........................................................................................................45
  Experiment 2: Preparation of spat ....................................................................................................46
  Experiment 3: Grinding the balls .....................................................................................................49
  Experiment 4: Soaking the powders ...............................................................................................51
  Experiment 5: Making sand- and liquid molds.............................................................................52

Appendix 2  Photos ..............................................................................................................................55

Literature...............................................................................................................................................59
Introduction

This dossier covers the research on manuscript BnF Ms. Fr. 640 done by students Ingeborg Kroon and Elisabeth Kuiper of the University of Amsterdam, department conservation and restoration of cultural heritage. Manuscript BnF Ms. Fr. 640 is a French document, dated to approximately the 1580s, and comprises a large collection of recipes and techniques relating to a wide range of subjects. Subjects vary from medical remedies, pigment-making or general instructions for painters and metalworkers to all techniques involved in the molding and casting of plants and animals (Smith and Beentjes 2010). Our focus is on the latter topic. As the author of the manuscript explores a variety of recipes and ‘ingredients’, it is of interest to understand which components these are. This dossier aims to document the process of thinking about these outmoded materials and all steps involved in the research to find out what the author might have meant to describe.

The main focus of the research in this dossier is the study of a material which the author of the manuscript uses in the preparation of his molds for casting. The author seems to be inconsistent in his terminology, which leads to the question if he is actually talking about the same material in the first place. To find out what he might have meant, we consulted both contemporary sources and specialists to gain more insight. We ended with a selection of candidates for the material and by experimentation tried to find the most suitable. The whole process is described documented in this dossier. We have decided to arrange the document as follows: starting with the summary of all folios where the term is used with annotations about the subject, as requested by professor Pamela Smith of the University of Colombia. An overview of our experiments and its most important results is added to these annotations. As a supplement, a logbook of our activities and thinking processes is added to the dossier.

This research has been carried out in conjunction with ‘The Making and Knowing Project: reconstructing the 16th - century workshop of BnF Ms. Fr. 640 at Colombia University New York. We would like to thank Pamela Smith for our opportunity to collaborate with this unique project. We are especially indebted to prof. dr. N. Tennent, mrs. K. E. van Lookeren Campagne and dr. D. Braekmans for their help and our instructors E. van Bork, T. Davidowitz and T. Beentjes for their encouragement.
Folios

041r (aspersale), 058r (laspalthe), 066r (aspersale), 085v (laspalthe), 106r (laspalthe), 108r (le spat, le spalt), 119r (laspalt), 119v (Aspalspat, aspersale, le spat), 13718r (le spat).

1. **Transcription [tc_p041r, 12 March 2015]**

   <title id="p041r_a3">Sable</title>

   <ab id="p041r_b3">Le sable doibt estre jeete pour gecter choisi non pas si aride qu'il naye poinct de prise Ne trop gras aussy Et combien quil sen trouve de naturel Touteffois ce nest pas par tout Et si tu es en lieu quil ne sen trouve poinct Tu le peulx composer Mays non pas avecq terre grasse car le sable nen veult aucunement car elle faict soufler bien fort Mays tu luy peulx donner liaison avecq de la brique fort broyee sur le mable ou plastre ou albastre calcine ou chose semblable ou moelle de corne de boeuf bruslee ou aspersale brusle parmy Si tu le broyes bien subtillement sur le porphire il s adquiert prinse & puys tu le peulx brusler avecq aspersale ou le mesler dune quarte partye de tripoly Garde qu'il ne tumbe de pain dans ton sable Car cela faict fort soufler.</ab>

   **Translation [tl_p041r, 12 March 2015]**

   <title id="p041r_a3">Sand</title>

   <ab id="p041r_b3">The sand to be used for casting should be chosen such that it is not too dry for it won’t hold together, nor should it be too fat. And although you find some in nature, however, it is not everywhere. And if you are in a place where it is not found, you can put it together yourself but not from fat earth, because the sand should contain none at all, since it causes a lot of air bubbles. But you can make a connection by mixing it with brick well ground on marble, or plaster or calcinated alabaster or something similar, or the burned marrow of ox horn or burned asphalt. If you grind it quite finely on porphyry, it holds together better & then you can burn it with asphalt or mix it with a quarter of tripoli. Make sure no bread falls into your sand because this causes a lot of air bubbles.

2. **Transcription [tc_p058r, 12 March 2015]**

   <ab id="p058r_b1c">Le cristallin estant broye a eau semble avoyr corps Mays a huile il nen ha point Il se broye aveq la laque et aveque laspalthe qui ne seicheroient de fort long temps sans cela.</ab>
Translation [tl_p058r, 12 March 2015]

<ab id="p058r_b1c">
Crystalline ground with water seems to be thick unlike when it is ground with oil. It can be ground with some lacquer and aspalth which wouldn’t dry but after a long time without any of it. </ab>

3. Transcription [tc_p066r, 12 March 2015]

Ombres </title>

<ab id="p066r_b2">
Pour femme aspalte terre dumbre et un peu de laque </ab>

Translation [tl_p066r, 12 March 2015]

Shades </title>

<ab id="p066r_b2">
For woman, shadowed areas can be made from asphalt, umber and a bit of lacquer </ab>

4. Transcription [tc_p085v, 12 March 2015]

<title id="p085v_a3">Sable de mine</title>

<ab id="p085v_b3">Il veult estre bien recuict pour les grands metaulx Aulcuns<br />
le bruslent au four jusques a ce quil soict bien noir Et le<br />
subtilient sur le porphire Aultres le bruslent avecq de<br />
aspalte Mays quand il est trop brusle il ne moule pas si net<br />
pourcequil nha pas de corps et est trop maigre tu luy en pourras donner avecq du tripoly<br />
ou<br />
feultre brusle</ab>

Translation [tl_p085v, 12 March 2015]

<title id="p085v_a3">Sand from a mine</title>
It wants to be well recooked for big metal objects. Some people burn it inside a furnace until it becomes quite black and they grind it on the porphyry. Other people burn it with asphalt, but when it is too burned, it does not mold so cleanly, because it lacks body, and is too thin. You can give body to the sand with tripoli or burned felt.

laspalte

5. Transcription [tc_p106r, 12 March 2015]

Pour gect

Asphalt is the most excellent sand you can find for molding in a box frame, because it is fitting for silver & for gold. And the more you use it and the older it is, the better it is. With it, one molds very slender & subtle things.

Translation [tl_p106r, 12 March 2015]

To cast

Asphalt from Germany is the most excellent sand you can find for molding in a box frame, because it is fitting for silver & for gold. And the more you use it and the older it is, the better it is. With it, one molds very slender & subtle things.

6. Transcription [tc_p108r, 12 March 2015]

Le spat est une pierre blanchastre qui se trouve en Allemaigne est le plus excellent sable pour mouler en chasssi qui se puisse trouver Car il est propre pour l argent & pour l or & tant plus il sert et est vieulx il est meilleur On y moule fort tanvre & subtil

Translation [tl_p108r, 12 March 2015]

Spalt

Le spalt est blanc comme plastre cuict Et se trouve en monceaulx & pierres faictes a longues escailles & longs filets il est fort tendre
Une sorte quavecq longle on le peult racler & en faire pouldre comme de nostre croye de champagne. Et pourque toute chose qui provient des la terre est mellee de quelque aultre substance pour le purifier on le broye venant de la piererie asses grossiere[nt] puis on le destrempe avecq de l'eau de sel armoniac. En mectant la grosseur d'une noix diceluy dans une grande bouteille deau Et

_Translation [tl_p108r, 12 March 2015]_

Spalt is a whitish stone which can be found in Germany, mainly in Augsburg from which can be made the most excellent sand that can be found for casting lead, tin, copper, silver and gold. And the more it is used, the better it is. It is clean for casting flat things in a frame. For rounded things, it is not as attractive [because it] does not hold in the fire as the aforementioned [things] composed of plaster.

_Spalt_ is white like cooked plaster and one can find it in mounds and stones made in long stairs and long veins. It is very soft such that with a fingernail and it makes a powder like that of our chalk from Champagne. And because everything which is provided from the earth is mixed with some other substance, to purify it [the spalt], one boils it with somewhat large gemstones then tempers it with essence of sal ammoniac. One puts [a lump of it] the size of a walnut in a large bottle of water and

_Transcription [tc_p119r, 12 March 2015]_

Le bon sable ne prend point a la main en le pressant estant humecte

Le parfaict sable pour le chassis est laspalt qui se trouve en Allemagne qui est doux co{mm}e farine & presque estant mouille & presque tous les autres sont grumeleux
Translation [tl_p119r, 12 March 2015]

<ab id="p119r_b1e">Good sand when moistened does not stick at all to the hand when pressed.</ab>

<ab id="p119r_b1f">The perfect sand for the box frame is the asphalt found in Germany, which is soft as wet flour, & almost all the rest are lumpy.

---

8.  Transcription [tc_p119v, 12 March 2015]

<title id="p119v_a1">Facon dacoustrer Aspalspat</title>

<ab id="p119v_b1">Il se trouve en terre en allemaigne de couleur de plastre cuit fait a longs filets fort doux a manier Et pourcequ'il est mesle de terre et ordure On le pile grossierement et on en faict des pelotes layant pour ces effect destremper en eau de sel armoniac de telle composition quil ta este dit cy dessus on met recuire ces pelotes a feu de la fornaise des potiers Puys on le destrempe encore en mesme eau la terre et le grossier et ordure bout a fonds et le pur aspalte qui est leger et doux et maniable comme farine destrempe adhaere avec leau et a la superficie en brouillant leau laquelle trouble se vuide en un vase a part Ayant rester on vuide leau par inclination ou bien on la retire avec un esponge Et le pur aspalte demeure au fonds dessicche le et emplye en chassie estant humecte deau de sel armoniac et lessaye au chassie dans lequel sil se retire estant recuit ou desseeiche c'est adire quel il fault encore recuire a bon feu et le rougis ainsi pour medaille et choses plattes serioi de cestuy cy car c'est le plus parfait de tous pour or argent cuivre plomb letion et estain Car il soustient le feu et se rougis quand il est besoin sans se corrompre Et tant plus il sert tant plus il est meilleur et ne se gaste point Au commancement il est blanc et servant il vient gris toutefois prens gare de metre a part celuy qui a servi pour gecter plomb et estain et leton car lor si aigriroit et ne viendroit pas bien et pour mieux faire tu pourras metre a part diceluy pour servir a chaque metal</ab>

<note id="p119v_c1a">Il endure dix ou douze gects sans se corrompre il soustient le feu et se rougis il est propre pour tous metaux Il est si tenace que pour peu quen […] chassie soict canelle il tient. </note>

<note id="p119v_c1b">Le spat ne faict presque point de prise bien qu'il soit espece de plastre ou il se rompt aysement avecq les doigts </note>

<title id="119v_a2">Excellent secret pour mouler creux et fort subtil en or fin</title>
Jecte avec ton sable susdict ton animal et lezard ou autre chose avec argent de billon et viendra fort net Mays advise de le muler creux ou ly laisser a tout le moins un trou dans laquelle ou autre endroit apres dore le dor fin le plus uniment quil te sera possible trois ou quatre ou cinq fois et jusque a ce que ton or puisse avoir lesespeusse duns papier ou autre suffisante et toutes les escailes se nousteront tousjours esgalle Apres met le dans leau fort bonne qui par ce trou corrodra le billon et lor demeurera creux et leger et admirable.

Translation [tl_p119v, 12 March 2015]

Way to rework Aspalt

You find an earth in Germany, the color of plaster, but have long and soft filaments which are easy to handle. Grind them coarsely because they are mixed with earth and filth. Then soak them into sal ammoniac’s water, following the above indication, and make balls. Heat these balls in a potter’s furnace. Then soak it in the same water again. Filth will remain at the bottom, and the very asphalt, which is light, soft and malleable as flour is, stick to water, remain on the top, and make water cloudy. Pour this cloudy water in another pot. Then empty water, to do that tilt your pot, or sponge the water up. The very asphalt will remain at the bottom of your pot, dry it. Then soak it into sal ammoniac’s water, and use it for moulding box. If this matter shrinks in the moulding box, even if reheated and dried, you must reheat it on a good fire again, and redden it as you did for medals and flat things. This asphalt is the best matter to cast gold, silver, copper, lead and tin. Because it holds fire and reddens whenever you want, without changing. The more you use it the better it is, and does not change. First it is white, and becomes grey after being used. Take the reused asphalt for lead, tin and brass, but gold would get brittle, and wouldn’t easily be stripped of casting. Put away each asphalt separately depending on each metal.

Asphalt enables 10 or 12 casts without changing, it holds fire and reddens. It is usable for every metals. […]

Asphalt hasn’t so much body, even if it is a kind of plaster, and you can easily break it with your fingers.

Excellent secret to mould hollow and very finely fine gold

Cast your animal or lizard or other thing with the above mentioned sand, with alloyed silver you’ll get a very neat cast. But be sure to mould hollow, or at least make a hole. Then gild your animal with fine gold, it must be the most homogeneous possible, gild 4 or 5 times, until your gold becomes as thick as a piece of paper, scales must remain as they were. Then dip your cast into aqua fortis or into good water, it will corrode the alloyed silver through the
hole, but gold will be hollow, light and wonderful. </ab>

9. **Transcription [tc_p137v, 12 March 2015]**

Les rascleures des moules peuvent encore servir lemploya{n}t au lieu de brique apres les avoir recuits & les lopins aussy des moules qui ont servy On en lute aussy les choses des ouvrages dor ou dargent On le recuit aussy & on lacoustre avecq se eau de sel armoniac comme le spat dallemagne & est excelelnt sable pour chassis pour tous metaulx

**Translation [tl_p137v, 12 March 2015]**

The scrapings of the mold can also be used instead of bricks after being reheated, and also the leftover bits of the mold that have already been used. You can also pat it over important things, like works in gold or silver. You can also reheat it and blend it with water diluted with sal ammoniac, like spar from Germany, and is excellent sand for box molds for all metals.
Annotations

The manuscript of BnF Ms. Fr. contains quite a few recipes on how to prepare molds for casting processes. Although the most common recipe seems to consist of four parts plaster of Paris, two parts tiles and one part *alum de plume*, when lacking one of these materials the author often experiments in adding varying materials to the mold, such as calcined oyster, burned marrow of ox horn and other elements. One of the materials offered for the composition of the mold is a ‘sand’ called *Laspalte* (folio 106r). According to the description that follows this term, it “*is the most excellent sand you can find for molding in a box frame*” and it comes from Augsburg, Germany (106r, 108r, 119r). Although these are the first times in the manuscript that the author specifically indicates its molding qualities, the term is used earlier in the document already. On folios 041r, 058r (*laspalthe*), 066r the material *aspalte* is named, but in the last two cases it seems that it is used in a different way, that is as a filler or ground for paint. On folio 066r “umber and a bit of lacquer” are added to the *aspalte*, which renders it usable as a paint for shadowed areas. After that, on folio 085v again, the material *laspalte* is used as an additive to a sand mixture, “Other people burn it (sand from a mine) with aspalte”. Folios 106r and 108r name its the provenance, Germany, and on this latter page for the first time a description is added to the terms. On this page 108r the material is mentioned twice, the first time as *le spat*, the second time as *spalt*. On folio 119r, the manuscript again repeats the provenance, Germany, and on a page further offers “a way to rework” the *laspalt*. Interesting about this specific case is that the author has corrected himself in his writing. It seems like he starts out, writing *Le Spa(...)* than crosses this through and writes *spat* instead. The use of the term *Spat* is mentioned again, on page 137v (folio 138r). Like before, the *aspalte* is being said to originate from Germany. It is because of these recurring and corresponding characteristics ascribed to the materials that make it likely that the author is actually meaning the same thing when he changes inconsistently between terms.

From the descriptions on the previous pages one can conclude that the material *spat/spalt/aspalte* is used for three applications:
- Asphalt as a color preparation, used as a primer and, adding umber and lacquer, for the painting of shades (folio 058r and 066r).
- Burned asphalt, added to the sand mixture and used for mold that are used to cast big metal objects. Used as a binding agent for the molding sand. It should not be burned too much, because this renders it too thin. It is unclear what the author means with this (there is no description of characteristics or colors, only that it should be ‘burned’ and that it is used as a bonding agent for sand mixtures). It seems that the author is not referring to life-casting, but rather to the casting of big objects (folio 041r and 085v).
- The *spalt/spat* from Germany. Very soft, an excellent sand for molding (folio 106r until 137v).

The classification of the first two categories is incidentally the first four pages on which the ‘spat term’ is used. Assuming that the pages are arranged in chronological order and (except for additions in the margin) were more or less written this way, this
might indicate that the author is referring to another material in this first description. It might also be possible that the author is confused about terminology and the same material was actually put to more than one use. As there are no specific descriptions of the material before the third category, this concept can be put aside for now. In the descriptions throughout the manuscript the following can be found characterize the material spalt/spat:

- It is from Germany, mainly Augsburg.
- It has long and soft filaments which are easy to handle (119v) and is found in stones with long stairs and veins (108r).
- It is a whitish stone (107r, 108r).
- It has the color of plaster (119v) or is a white like cooked plaster (108r).
- It is very soft such that with a fingernail it makes a powder like that of chalk from Champagne (108r). It is soft, light and malleable as flour (119v).
- It is mixed with filth, for purifying it, it should be ground and soaked in Sal Ammoniac (119v).
- It is one of the best sands for casting metals (107r, 137v); an excellent sand to cast subtle and slender things (106r, 119r).
- For casting gold, silver, copper, lead, tin. (106r, 107r, 119v)
- The more it is used the better it is (106r, 107r, 137v).
- The material might also be used as a filler in the preparation of paints and pigments.

To start this research into spat, not only is it thought interesting to examine the manuscript closely, it is also considered useful to explore other historic and contemporary sources that talk about (life-)casting techniques. Important works of reference are for example Johannes Kunckel’s Ars Vitraria (1689), Hugh Platt’s The jewell House of Art and Nature (1594), letter correspondence of Constantijn Huygens (1629) and Johann Georg Krünitz’ Oekonomische Encyklopädie (published between 1773 and 1858), because these works both describe a material which might be associated to the spat from the BnF Ms. Fr. 640 and discuss the casting of metals. Platt (spawde), Kunckel (spath) and Huygens (spaet) all mention the use of a material that is added to the molding material.

As a basis Platt uses finely powdered alabaster, plaster of Paris and brick. For more sharp castings, he states further, gypsum, alumen plumosum or spawde can be added to the mixture.

“I have seen sometimes many good patternes of metal, cast off very sharply in spawde alone, but you must heat the flaskses well, before you poor in the metals, and you must sprinkel the spawde with some moisture, wherein there is some Sal Armoniack, before you do imprint your patterns, some commend a light and downy substance, finely gathered from the upper most part of the ashes of old coales.”

(The jewell House of Art and Nature Platt 1594, 52).

Finally, Platt mentions that it is important to play with the proportions of the powders, and to measure and weigh until one finds a good mixture.

Kunckel comments on the use of “(a well-rinsed) Spath (a certain kind of earth or mineral which can be obtained)” (Kunckel 1689, 405), which should be made into a very fine matter. It should then be deposited in a copper kettle which is
suspended over a fire and which will make the water dry up. As long as the kettle is over the fire, one needs to stir well until the substance is as hard as it was in the beginning.

One part of this burned Spath and another part Federweiss should be mixed. (…) placed in the fire and afterwards pulverized again.

Huygens (Huygens 1629 in de Heer 1993, 282) describes the use of spat from England of which, like the manuscript, he forms balls adding Sal Ammoniac. He describes the spat from Germany being less translucent in comparison with spat from England.

It becomes clear that similarities can be found between the materials described in these historic sources and the information given in the manuscript. A certain material must have been well known among metallurgists, from Germany and France to England. Information from the science of natural history and mineralogical works of reference should mention the matter as well.

A search into a whole range of historic sources leads indeed to the discovery that the term spat is not used anymore today, but was commonly used to describe some sort of mineral in the past. Johann Georg Krüinitz, for example, in his comprehensive Oekonomische Encyklopädie (published between 1773 and 1858) distinguishes a difference between the materials spat/spalt and spath, but notes at the end of the section that these might actually be the same materials.

**Spalt**

“In mineralogy Spalt, after Jakobson, is a shiny, scaly stone that is almost like Krystalgyps from Montmartre, though it is a lot whiter. one can find it in Augsburg and in England. The smelter uses it to melt metals faster. This type of rock seems not to be anything else than a spath?”

**Spath**

Spath DDC-Icon, Spat; Spathum; Fr. Spath; Engl. Spar; Ital. Spato; an old mineralogy term used to refer to lode deposition or rock which easily break or cleave into diamond-shaped fragments, occurs in different colours (white, yellowish, red, brown and greenish), varies in hardness, but is always heavy in weight. Since it often contains metal and is one of the foremost ‘mother lodes’/principal veins or zones of veins of (gold or silver) ore, when it is seen as an indication of the presence of ores, so will all metals and minerals in Spath break. This name is especially used to describe all stone that have the same crystallization, which is always composed of shiny surfaces like a mirror and with steel, except the Feldspath, gives no fire. Spath is also nothing more than an oxygen-containing limestone, with strange additions such as acids or gravel, but also clay, talc and metals. In modern mineralogy and chemical dictionaries the name Spath is no longer used, except in compositions with earth or minerals, the acid that causes its nature. Therefore in the new mineralogical and chemical dictionaries one finds the name Spath no more, although it is still used in connection to soil types or minerals, the acids, that takes its nature.”

(Oekonomische Encyklopädie Krüinitz, 1773-1858)
The previous sources hand the research of the material spat some information to investigate further. In order to keep this preliminary literature study well-organized, it is subdivided in categories of different minerals and materials that are thought of as being a candidate for *spalt/spat*.

**Fluorite**

Another source that dedicates a whole chapter on “*Du Spalt*” is *Histoire générale des drogues* by Pierre Pomet (1694).

“Spalt *Spalt* (or *spaad*) is a scaly bright stone, very like parget stone, except that this is whiter. They find abundance of these stones in Germany, especially about Augsburg. It should be in long, brittle scales, that may be easily crumbled to powder with the nail of one’s thumb (...). Spalt is used by several sorts of workmen, being said to be good to assist the founders in melting of their metals; which I cannot affirm to be fact, having never seen it tried."


Interesting about the aforementioned texts by Krünitz and Pomet are both the confirmation of the location of Augsburg and also, the use of the material as a flux for the melting of ores and metals. This last characteristic is not used or named in any of the sources we know that actually use the material in practice. In combination with the colors described by Krünitz (white, yellowish, red, brown and greenish) one could end up at the mineral fluorspar.

“*Under the rocky mountain stretches, that are thread-like or scaly, with certainty can be found the ‘Spaat-steen’, that the High-Germans call Spath. Some Spath-stone is white, half transparent, grown in broad and flat threads, that like scales lie on top of each other lengthwise, and from below grow straight upwards. Spath-stone that is this way, resembles much the gyps that grows in threads. (...) The spath is like the flux or *fluor*, capable of smelting the ores, which is a rough indication that spath, like albast, the marble, etc is a ‘rennet’ where nature has used salts and parts that have been set into motion by fire, that try to detach from one another, and that they mean to break.***”

(*Kabinet der natuurlyke historien, wetenschappen, konsten en handwerken*, W. van Ranouw 1723, p. 102).

To test this concept, more contemporary literature tells us the following:

“**Fluorite** (*flu’-o-rite*) A transparent to translucent mineral: CaF$_2$. It is found in many different colors (often blue or purple) and has a hardness of 4 on the Moh scale. Fluorite occurs in veins, usually as a gangue mineral associated with lead, tin, and zinc ores, and is commonly found in crystalline cubes with perfect octahedral cleavage. It is the principal ore of fluorine, and is used as a flux, **in preparation of glass and enamel**, in the manufacture of hydrofluoric acid, and for carved ornamental objects. Syn: *fluorspar*, fluor; Derbyshire spar.”

(*Glossary of geology*, Jackson 2005, p.246)

The addition that fluorspar is used in the “preparation of glass and enamel” is interesting because two historic sources, both Kunckel and Agricola’s *De re metallica* (1556), do comment on this utilization in the glass industry. Kunckel, as mentioned
earlier, was both a German alchemist and a practiced glass artist, but uses spath in relation to casting metals as well. Agricola (1494-1555), a German scholar and scientist, was known as ‘the father of mineralogy’ and could therefore shed some light on the material.

In *De Re Metallica* (Agricola 1556) the author names a material which he calls *Spatum* (Latin). It is the third category of three types of stones, which find utilizations in metallurgy. Agricola unfortunately does not comment on metal casting. “The third genus is the material from which glass is made, although it can also be made out of the other two.”

“(…) it is necessary, for this kind of ore, to have a very hot furnace in which slags, or cakes melted from pyrites, or stones which melt easily in the fire, are first melted, so that the ore should not settle in the hearth of the furnace and obstruct and choke up the tap-hole (…)”

*(De re metallica*, Agricola 1556, p.380)

In *De Re Metallica* these stones are not further explained, but in *Interpretatio* (1612) three types of these stones, with their German equivalent, are clarified:
- ‘lapides qui igni liquescunt primi generis’ or *schöne flüsse*.
- ‘secundi’, -flüsse zum schmelzen flock quertze.
- ‘tertii’, -quertze oder kesselstein.

In the 1912 translation of this work the editors Herbert and Lou Henry Hoover provide extensive explanatory footnotes. Confessing their inability to understand most of the substances, they try to list al characteristics and information given. As said, in *De Re Metallica* the third category is called *Spatum*. “Tertium Spatum appellat, quod politius & densius est”; “Spatum is called the third order, which is polished and thick.” (Agricola 1556, 129). About the materials furthermore is said that the third variety must have embraced varieties of quartz, flint, and silicious material generally. In *De Natura Fossilium* he further explains the three orders (genera).

“Glass is made from the stones of the third order and particularly from sand. For when this is thrown into the heated furnace it is smelted by the fire (…) This kind of stone is either found in its own veins, which are occasionally very wide, or else scattered through the mines. It is less hard than flint, on account of which no fire can be struck from it. It is not transparent, but it it is of many colours - that is to say, white, yellowish, ash-grey, brown, black, green, blue, reddish or red. This genus of stones occurs here and there in mountainous regions, on banks of rivers, and in the fields. Those which are black right through to the interior, and not merely on the surface, are more rare; and very frequently one coloured vein is intersected by another of a different colour – for instance, a white one by a red one; the green is often spotted with white, the ash-grey with black, the white with crimson. Fragments of these stones are frequently found on the surface of the earth, and in the running water they become polished by running against stones of their own or another genus. In this way, likewise, fragments of rocks are not infrequently shaped into spherical forms. (…) This stone is put to many uses; the streets are paved with it, whatever its colour; the blue variety is added to the ash of pines for making those other ashes which are used by wood-dyers. The white variety is burned, ground, and sifted, and
from this they make the sand our of which glass is made. The whiter it is, the more useful it is”

The editors of the work see there is little doubt a to the first or second order being in part fluor-spar. In De Re Metallica it is said “the miners call them fluoresses, by the heat of fire, like ice in the sun, they liquefy and flow away”. “The third kind, as you see here, is white. A fourth is a yellow colour, a fifth ash colour, a sixth blackish. (...) It is indeed not made far from here, at Breitenbrunn, which is near Schwarzenberg. Moreover, from fluoresses they can make colours which artists use.”

Barite or heavy spar

Different from what they say in the above text, in the 1912 translated volumes the authors provide a translation or interpretation of spat as the mineral Barite. It is unclear why exactly they added this, but it is repeated in other sources as seen in the following source by Nicholas (2004). Baryte, occurring mainly as a gangue mineral in metalliferous hydrothermal veins, is also found as veins or cavity-filling concretions in limestone, sandstones, shale and clays and can indeed be associated with fluorite, galena and calcite (Deer et al. 1967, 609). Baryte/barite, further more, is the naturally occurring form of barium sulfate, BaSO₄. Baryte generally occurs white, but can also be found tinted in other colors like pale yellow, brown or red as a result of impurities (ibid., 608). Also, like the manuscript, barium sulfate is used as filler for the preparation of paints.

“Apart from the frequently used form ‘barytes’, baryte has many synonyms including baratine, barite, caulk, cawk, boulder, Bologna stone, Bolognian spar, heavy spar, schwerspath, Spath pesant, stinking stone, Terra ponderosa vitriolata, Tiff (...). In the sixteenth century the German author on mining subjects, Agricola, calls it spat.”


Feldspar

Another mineral that is used in the production of glass throughout history, after comment from Kunckel and Agricola, is Feldspar. Although literature does not present us with a connection of feldspar to a use in metallurgy or molding, multiple specialists in the fields of ceramics and experimental archaeology do offer the possibility of feldspar being our spat. Indeed feldspar is a greyish or yellowish white mineral, which would meet the requirements to some degree. According to Krünitz the feldspar in French would be called Spath des Champs. Feldspaths are a group of rock-forming tectosilicate minerals that can be found composed of a variety of major elements. There really are three kinds of feldspars, with the main element varying from kalium, sodium to calcium (Deer et al. 1967). This diversity does pose a problem for the experiments, but as discussed earlier we might be looking for a material that is used in the glass industry. Therefore, the choice of material will be made in agreement with the ceramics department and will be a feldspar that is and was used for glass and/or glazes of ceramics.
A problem concerning feldspar is that it is a 6 on the Moh’s scale of mineral hardness and is too hard to be scratched with a nail, as the manuscript describes (ibid.).

Pozzolana

Another option presented by a consulted specialist, an assistant professor on the university of Leiden specialized in archaeological ceramics, mineralogical provenances and chemical analyses Dr. Braekmans, is the material pozzolana. Pozzolana is a soft, volcanic sediment and one of the primary deposits of volcanic ash. It can be found in Germany and Italy and was used by the Romans already in the production of cement. Pozzolana is a siliceous material which in a chemical reaction called the pozzolanic reaction reacts with calcium hydroxide in the presence of water (Gambhir 2013, 44). Vitruvius indeed indicates four kinds of pozzolana: a black, white, grey and red form that can all be found in the neighborhood of the Mount Vesuvius (Vitruvius in Hewlett 1988, 3). Today the definition of pozzolana encompasses any volcanic material, pumice or volcanic ash. Because characteristics like hardness, approximate color and provenance seem to correspond to the material spat, it might be interesting to study this material further. A problem concerning pozzolana is that there is no indication of etymological connection in the terminology of the two words.

Calcite

Often referred to in literature is also the ‘calcareous’ spar. It would be interesting to explore this further for multiple reasons. Calcite, although slightly too hard (3 on Moh’s scale) is a white mineral, a carbonate mineral, and the most stable polymorph of calcium carbonate, CaCO$_3$. Other crystal forms are aragonite and vaterite. Limestone, for example, consists of calcite and aragonite. Calcium carbonate, in its rough form, finds utilization in the construction industry and for road building. It also finds applications for ceramics and glazing and as decorating fillers.

“Spatum, spath or spar is thus described by Walerius and Hill: When pure, it is pellucid and colourless, and its particles are for the most part disposed in pyramids or oblong parallelepipeds (...) calcines in the fire very readily and freely, but does not upon calcination attract the moisture of the air so soon as Limestone, nor heat in water so soon: otherwise in water and with Sal Ammoniac, it exhibits the same appearances as Limestone.”

(An Essay Towards a Natural History of the County of Dublin, J. Rutty 1772, p. 79)

Throughout the manuscript the author is often burning or calcining materials, which are then used as molding material. It even seems that the terms ‘burning’ and ‘calcining’ are used alternately, as seems to be the case with the oyster shells. Seeing as the author mentions “burned asphalt” (folio 041r) and “burn it with asphalt” (folios 041r, 081v) multiple times, it would be interesting to experiment with a mineral that is composed of calcium as well. Regarding the chemical reaction when heated, some predictions can be made beforehand. In the thermal decomposition reaction of calcium carbonate (the main constituent of calcite or limestone) the material forms calcium oxide, or quicklime, releasing carbon dioxide in the process. When, like the manuscript describes, this material is submersed in water the calcium
oxide reacts to form calcium hydroxide. Calcium hydroxide, or slaked lime, is used in plasters and for cement. Also, this material is used as an addition to sand to produce mortar. The manuscript does mention few times that “sand from a mine” should be burned together with asphalt (folios 085v and 041r), which might be an indication of this preparation.

After careful consideration and in line with advice from experts and specialists the materials that will be tested on characteristics and behaviour will be the following:

A: Pumice stone powder  
B: Heavy spar / barite  
C: Feldspar potassium  
D: Feldspar soda/natron  
E: Calcium carbonate

Fluorite is not a part of this list, for the following reasons: after setting up a table of candidates and possibilities for the material spat we conclude that fluorite is both too hard (a four on the scale of Moh’s) and the colors in which it occurs are considered too varied. Also, further research is needed to determine which or what kind of fluorite should be tested. For this reason we will not continue with this material in these experiments.

Our experiments start with a characterization of the different materials based on the color, weight, structure and softness [Fig. 1 and 2]. The author of the manuscript reports on these four aspects and describes the spat as a white stone “(…) which is light, soft and malleable as flour (…)” (folio 119v_b1). As a result from weighing the powders it becomes understandable there are some differences. The pumice proves to be the lightest material, closely followed by the calcium carbonate. Between the feldspar potassium and feldspar soda there is a minor difference. Finally the heavy spar is, not surprisingly, the heaviest material of them all. Since the author of the manuscript describes the color of spat as similar to plaster of Paris, we compared the shades of these materials with each other and with plaster of Paris. Although most materials are white, the shade of the feldspar potassium proves to be the best match with the plaster of Paris, closely followed by calcium carbonate. The pumice, which is more brownish, resembles plaster of Paris the least. The structure of calcium carbonate is the finest and consists of the smallest granules, pumice is composed of the biggest granules. We examine the softness of the materials by passing it through our fingers. The softest and driest powder is the feldspar soda and closely behind it is the calcium carbonate, which is a little more viscous. The pumice proves to be the least soft material.

In the second experiment we decide on testing the first part of the recipe, which the author mentions on folio 119v: “a way to rework aspalt”. The first step is to make the sal ammoniac water described on folio 118r, the second step to mix this with the powders and the third step is trying to form balls [Fig. 3, 4 and 5]. Since the author does not report the exact proportions for this step we decide to add 10 milliliters of fluid at a time. Each different material needs another amount of moisture before we are capable of making balls. Pumice requires the most water and becomes
dark brown. Both the feldspars require the same amount of fluid and become a compact ball that cracks when squeezed, because of the lack in plasticity [Fig. 6]. The heavy spar and the calcium carbonate absorb the moisture very fast and both become malleable like clay. The final step is heating the balls in a potter’s furnace [Fig. 8]. We select a heating process, which would reconstruct the recipe as accurate as possible. Because the heating process of the calcium carbonate balls is presumed to lead to a chemical reaction, we decide to heat these separate from the others.

The third experiment is to take the balls out of the oven and grind them. The balls have changed a lot by the heating process [Fig. 7 and 9]. The size of the pumice balls is greatly reduced and it has become hard like stone. The color has furthermore changed to a more dark/reddish brown. Since it is impossible to grind the pumice balls we are forced to stop experimenting with pumice. Also, the results from the earlier experiments are mostly negative, pumice proves to be an incorrect candidate for spat. The heavy spar turns into dark grey and has formed a shell during heating which has broken off on the top. It takes an extensive effort to grind the heavy spar balls into fine powder, but we succeed eventually [Fig. 10]. A soft, powdery substance covers the surfaces of feldspar potassium and feldspar soda. The feldspar balls are quite easy to crush into powder. The color of feldspar potassium turns out to be pink and the color of feldspar soda more orange. The calcium carbonate balls, which expectantly have become calcium oxide through the heating process, are not visibly changed much after removing them from the furnace, although they have some cracks. During crushing in a mortar though, we notice the same kind of shell around the ball as we have seen on the heavy spar [Fig. 11]. It is not easy to grind the calcium balls: it even takes quite an effort. The powder of the calcium has become more beige [Fig. 12].

In the following and fourth experiment the powders are soaked in the sal ammoniac water. In his recipe the author is unclear about whether the spat is soluble or insoluble in water. His description about the behavior of the spat in the water can be interpreted in several ways. He both talks about “the very asphalt, which is light, soft and malleable as flour is, stick to water, remain on the top, and make water cloudy.” as well as “The very asphalt will remain at the bottom of your pot”. Mainly because of this ambiguity we decide to monitor the behavior of the heavy spar, feldspar potassium and feldspar soda. The heavy spar makes the water very cloudy but finally everything sinks to the bottom, leaving a layer of almost clear water on the top. The feldspar potassium and soda make the water a bit cloudy in the beginning, but become submerged quite fast after that [Fig. 13 and 14]. This experiment shows the insolubility of all three materials. We choose another approach (more controlled and safer) for the experiment with calcium oxide, since this reaction is supposed to produce heat. The calcium oxide mixed with water reacts to form the slaked lime we hoped for. The powder of calcium oxide gets completely dissolved in the water and forms a milky, white substance [Fig. 15 and 16].

The fifth and last experiment is meant to examine the utilization of these matters as a molding material. We make two different types of molds with each material: one with a sand structure to imitate sand-casting, and one in a more liquid state to reconstruct life-casting in a plaster [Fig. 17 and 18]. In the sand molds we try
to make an imprint, but this is unsuccessful for the feldspar potassium and soda. Besides, the feldspar’s sand molds show many large air bubbles and cracks after drying [Fig. 19]. It is possible to make an imprint in the heavy spar but the granules are too coarse which made the print less detailed. After drying, the texture of the sand mold of heavy spar is still too rough and lacks cohesion. It is also difficult to make a print in the sand mold of the slaked lime: the form keeps adhering to the material. After drying the print in the sand mold, it shows some sharp details [Fig. 20]. The reconstruction of the life-casting is done by leaving a simple, round releasable figure on the bottom of the form and pouring the liquid mixture of each material on top of it. Despite the liquid mold of heavy spar turning out less rough than seen in the sand mold, the material shows many gaps inside the print. Although it is impossible to take the figure out of the tray without breaking the mold, the prints in both feldspars result in quite sharp details around the edges [Fig. 21 and 23]. Also, the density of the feldspars from the mold that was poured as a liquid is quite compact and has a lot less air bubbles than the other ones. Unfortunately it is not possible to take the liquid molds of slaked lime out the forms. For this reason we can not analyze the print which it has made in the bottom of the mold [Fig. 22].
Conclusion

From the previous literature study and subsequent experiments can be concluded that a search of the material *spat* is not as straightforward as one might think. Although the material seems to have been common in the time of the manuscript and various sources can be found to account its use and existence, a few hundred years later the term has become quite unclear. All that is left are descriptions of characteristics and utilizations. Therefore, the research done in this study focusses on these indications. Based on a survey of relevant literature combined with the descriptions from the manuscript a number of minerals and materials were selected and tested on properties and behaviour. From these experiments can be concluded that (both varieties potassium and soda) feldspar could be a material that is suitable as molding material, although the temperature with which it was prepared in the oven was too low to lead to any chemical changes. This raises the question why the materials were heated at all. The temperature of these experiments was based on an estimation of temperature that could be reached in a late 16th century potter’s furnace. The chemical change of feldspar, like with the preparation of the pigment *smalt*, would presumably lead to a glassy material that would not be suitable for molding, because of this change and property. The calcite, or calcium carbonate, that was tested leads to more positive expectations, because during the preparation there is both a chemical change and a utilization of the obtained product in plaster and cement. Also, the calcium hydroxide that is produced gives a sharp impression, but the material is fragile and brittle, which would make it unusable for sand casting. The materials pumice and baryte did not prove satisfactory in the experiments or in the cast simulations, and are therefore considered unsuited as a candidate for the material *spat*. 
Further research

We would recommend doing further research on the subject *spat* in the manuscript. There are still a lot of uncertainties and although there are results to show for the experiments, there are still a range of experiments which could be carried out for a better understanding of the behaviour of the different candidates for *spat*. It is hardly possible to say in this stage, if the materials tested are the ones we are looking for. Some do correspond to the characteristics more than others though.

The next step in our research would be to examine the fire resistance of the remaining materials. Like the author of the manuscript describes, spat is an excellent sand for casting because "(...) it holds fire and reddens whenever you want, without changing." (folio 119v_b1). It would subsequently be interesting to analyze the color change of the materials, since the spat is supposed to turn from white into grey after being used (folio 119v_b1). If these experiments result in a likely candidate for *spat*, a final suggestion would be to try the material in a mold for casting metal. Although it is unsure whether *spat* was used in the mold alone or if it was mixed with earth or the regular plaster mixture, Platt describes *spat* being used some times alone and sometimes mixed. (Platt 1594, 52) Both these options could be tested in a later stage.
Appendix 1  Logbook

Literature study

Week 1  4-9  February

The first week of this project is started with an assignment on reading and interpretation of historic texts. These texts are chosen from well-known works and discuss primarily the use of furnaces in order to smelt ores or metals for further production.

*El Arte de los Metales*, Alvaro Alonso Barba (first published in 1640)

Alvaro Alonso Barba was Master of Arts and curate of the Parish of San Bernardo, Potosí, Bolivia. *El Arte de los Metales* was approved in 1637 and recommended to the crown for publication. First published in Spain in 1640 and reprinted in 1675 and 1729. Translated from the Madrid Edition of 1729 into English in 1923 by Ross E. Douglas and E. P. Mathewson, it was the earliest published work on American Metallurgy.

*El Arte de los Metales* consists of five books. The first book summarizes geological knowledge of Barba’s time. Many Latin mineralogical terms, amongst others are taken from Pliny, Dioscorides, Strabo, Galen. The Latin mineralogy of Encellius in *De Re Metallica* has been found to be of help in translating the first book. Books two to five are based on his knowledge, acquired by years of active work in mining and ore treatment in a region of rich silver mines.

Chapter six. Furnaces for smelting with charcoal (p. 197). Barba discusses three kinds of furnaces. Hornos Castellanos/Spanish furnaces for smelting all sorts of ores, Guayras or wind ovens and Tocochimbos, which are ovens like the muffle furnaces used by silversmiths and for cupelation. He describes the construction of these ovens, how they were built and used. The text also provides some illustrations, but it is not sure if these were part of the original work.

Willen van Laer: *Weg-wyzer voor aankomende Goud en Zilversmeeden*, 1721.

Van Laer was one of the first who has written down all about the gold- and silversmiths practices in the Netherlands. The book contains the original text written in Old Dutch in the 18th century and was widely sold and released in 1721, 1730 and 1786. His recipes are written from his own knowledge and experiences.

On pages 200 until 203 he describes how a wind-furnace should be built for melting metal. To understand the descriptions of van Laer about his wind-furnace the text should be read several times. In general, the explanation of building up the furnace is clear and expanded. The drawings, which are included in the beginning of the book, are relevant to the interpretation of his text, although they had to be studied various times in order to understand it.

One problem with interpreting his instructions of building the furnace is the measurements in ‘feet’, a length that is time-limited and not conclusive. The greatest difficulty in the interpretation is the order of the text: it is not chronological and logical. It is clearly a description that is written from his own thoughts without having applied a logical structure of how to build the furnace.

Conclusion:

The reading and comparing of these previous texts, makes clear that interpretation can be difficult. Also, interpretation can vary from one reader to another. When working
with historic texts, you must be careful not to interpret without thought. It is important to understand who exactly wrote the piece and what his or her motives might have been. Texts can be translated in multiple ways and interpretation also is dependent on background. Are illustrations original or added later, does the author write from experience or theory?

**Week 2 10-16 February**

At the start of this week we have discussed the texts that were read during the week. Afterwards, the assignments regarding the Making and Knowing project are divided amongst the students. The central focus of this study at this point is the use of spath in the production of molds used to life-cast animals and plants.

We started this study with a visit to the Rijksmuseum, Amsterdam, to see the table piece (1549) by Wenzel Jamnitzer. His work is an outstanding example of the technique of life-casting plants and small animals. The work of Jamnitzer is related to the instructions in the Manuscript, not only for the life-casting technique that was used for great parts of the piece, his work was also contemporaneous to the manuscript. Furthermore, like the author of the manuscript, Jamnitzer also worked from central Europe and might have made use of a similar selection of materials.

**Manuscript, BnF Ms. Fr. 640**

Having access to the manuscript through Google Drive, we set out finding all pages where the manuscripts mentions molding of sand mixtures and talks about the material ‘spalt’ (folio 108r) and ‘alum de plume’.

Making sand mixture:
The author of the manuscript describes which sand mixture should be used for life-casting and casting medals. An important thing for this mixture is grinding the different ingredients as fine as possible. After grinding it should be sieved for the best result. (106v)
The sand mixture consists of:
- 4 parts ground plaster (preheated)
- 2 parts red tiles from roofing
- 1 part stone alum

The best plaster is the hard one, from raw stones, which does not crumble into powder when rubbing it with the fingernails. The plaster should be cleaned very accurately to remove dirt. To prepare the plaster it is best to boil the stones in the fire while stirring. The plaster will turn from heavy to light and becomes manageable, as if it were water. Boil and stir the plaster until its heavy and thick again. Cool the plaster off before you mix it with the rest. (106v)
The plaster from Paris is a good material to use and also is the one from Spain, which is a very hard stone and looks like white salt. (159v)

The tiles which should be used in the mixture are the ones that cover houses. They are hard and should be cleaned of stones and large gravel. Before grinding and sieving them, it is necessary to reheat them until they have been quite red for a couple of hours. (106v)

Stone (or: rock/feather) alum is a very important ingredient in the mixture because it binds the sand and allows the sand to withstand the fire without cracking or breaking the mould. At this point it is not clear which material the author is referring
to, it might be interesting to investigate this further. It is difficult to grind and sieve this material (because it is woolly and fat), it must be grinded on a marble slab or in a mortar. Another benefit of stone alum is that it will soften the mold (107r). Before using stone alum it must be reheated in fire, so that the impurities will be burned out. After this it can be crushed in a mortar and ground more finely on marble (108v).

All these powders should then be mixed. Do not forget to moisten the sand with a little sal ammoniac (117v).

Contemporary sources
To start our research into spat, not only do we find it interesting to examine the manuscript closely, we also think it useful to explore other historic and contemporary sources that talk about (life-)casting techniques. Important works of reference are for example Hugh Platt’s *The jewell House of Art and Nature* (1594), letter correspondence of Constantijn Huygens (1629), Johannes Kunckel’s *Ars Vitraria* (1689) and Johann Georg Krünitz’ *Oekonomische Encyklopädie* (published between 1773 and 1858).

In his book *The Jewell House of Art and Nature* from 1594 Platt describes stepwise how to prepare a mixture, composed of different kind of materials, which could be used for life-casting. Before you can mix the plaster with other powders, it should be roasted and broken into small pieces. The composition of ‘the pap’ consists of burnt and finely powdered alabaster, plaster of Paris and brick. For more sharp casting gypsum, alumen plumosum or spawde could be added to the mixture. “I have seen sometimes many good patternes of metal, cast off very sharply in spawde alone, but you must heat the flaskes well, before you poor in the metals, and you must sprincke the spawde with some moisture, wherin there is some Sal Armoniack, before you door imprint your patterns, some commend a light and downy substance, finely gathered from the upper most part of the ashes of old coales.” (Platt, 1594, 52). Finally, Platt mentions that it is important to play with the proportions of the powders, and to measure and weigh until one finds a good mixture.

Johannes Kunckel, *Ars Vitraria* (1689)
On p. 405 Kunckel mentions the use of “(a well-rinsed) Spath (a certain kind of earth or mineral which can be obtained)”, which should be made into a very fine matter. It should then be deposited in a copper kettle which is suspended over a fire and which will make the water dry up. As long as the kettle is over the fire, one needs to stir well until the substance is as hard as it was in the beginning. One part of this burned Spath and another part Federweiss should be mixed. (...) placed in the fire and afterwards pulverized again.

Brief summary on contemporary sources
Materials that are used for molding range in terminology from spalt, spath, spawde, plaster, alumen plumosum, alum de plum to federweiss. An observation in our research is the confusion of terms that are associated to the translation of these words. What are these materials and to what extent are they similar or related? For this reason we have decided to proceed with an etymological study of the names and a research into their mineralogical background. The following information is divided into two separate files, one concerning the material spat and one on alum de plume. We decide to concentrate on the latter material as well, because it raises questions about the materials used by Kunckel and Platt. Additionally, it is the only one of the
three basic materials that the Manuscript uses repeatedly and is still unclear to us at this point.

**Brief summary of definition of spalt (see document spalt)**
- Spalt/spat is possible fluorspar or fluorite, a flux of metals.
- Spath is possible the same as calcite/chalkspar, or feldspar and is used as a kind of plaster for moulds.

**Candidates for alum de plume (see document alum de plume)**
- Asbestos
- aluin
- soapstone

**Notes:**
- Need to find more about spath
- The difference between calcite/chalkspar, feldspar
- More research about difference between spalt and spat. Does the author make a distinction or is it incorrect spelling?
- Which mineral is specific from Augsburg?
- Three options for alum de plume, but this is not our main subject, should we do more research or not?
- More research on asbestos.
- Could federweiss (kunkel) be the same as feather alum = alum de plume?
- We should research the word ‘aspalth’, which the author used at least one time (index: folio 106r). What does he means with aspalth? Could it be the same as spalt/spath?

**Week 3 17-23 February**

Week 3 started with a meeting with Joosje van Bennekom (Rijksmuseum), Tonny Beentjes, Tamar Davidowitz and Ellen van Bork about the research this far.

- Our results up to this week were discussed:
  - Manuscript is clear on a basic recipe, which it uses to make molds for casting plants and small animals and primarily consists of alum de plume, plaster and tiles (from a roof).
  - Platt also adds alabaster, “aleblaster”, to his mixture.
  - Alum de Plume: According to our research; Alum de plume could be meaning the Dutch aluin, English alum or asbestos. It is very resistant to fire.
  - Spath: According to the sources found in contemporary and historic literature we conclude that there is a distinction between spath and spalt/spat. Spat is often described in relation to the fusion and flux of metals, which is something that the manuscript does not mention, for as far as we know. Spath on the other hand, is predominantly used to describe a stone, like chalk. Regarding this distinction we decided to examine the original text of the manuscript more closely, and since there is just one mention of the material, we are not perse convinced that he specifically means to add the spat to his mold. To contradict this theory though, the author does mention that “the more, the better” should be used, which is odd if it did in fact concern a flux.
  - Two pages before the title of ‘Le Spalt’ there is mention of Aspalt, which is described having the same features as spat, in the sense that both “are better
the more it is used” and “mold very slender and subtle things”. Are these materials possibly the same or similar?

- On folio 108r the manuscript first uses “spat” and than in the title and following description “spalt”. This could mean either that the author was confused or mistaken and means the same thing, or he is actually describing two different materials.

Important questions at this point:

- What kind of molding material is already tested?
  - Plaster, pulverized tiles, salmiak. Plaster as a binding agent, the tiles as an inert filler, salmiak to try to guarantee a cleaner casting skin of the metal.

- What does the author mean when he describes aspalt?
- What is the significance of ‘spalt’/’spath’. Joosje van Bennekom, who has done research on the table piece by Jamnitzer, tells us to have found an article by Kunckel that describes a different recipe from the time and region of Jamnitzer. In samples from clay-like materials in between the plants on the Jamnitzer piece were found a substance that did not yield much conclusive results, except that it was yliet(?). Remarkable about the Jamnitzer piece is particularly the lack of air bubbles on the cast plants and figures. In comparison to the try-outs (of columbines) by Tony Beentjes, the Jamnitzer only has few bubbles, where the modern version had more. Does this mean there is an ingredient missing in the sand mixture?

Still to be done/found out:

- Making of an outline
- Regarding spat/spat:
  - Examining aspalt more closely in all sources
  - Making the distinction between spat/spath even more clear. How resistant is spat to the heat of fire according to the manuscript? Making a distinction between the degree in which spat and spaat are resistant to heat.
  - Finding a mineralogist that might help us further regarding the distinction of these minerals.
- Mail from Pamela Smith suggests that there are more recipes regarding ‘aspalt’. Up until this point we only know of the one on page 106r, which is only a short piece.

Continuation study

Because in an earlier stage we already found out that the Index (provided by the BnF Ms. Fr. 640) was not complete with regard to all pages on which certain materials were used, we decided this week to leaf through the whole manuscript manually in order to find out for sure if there are no more uses of the words ‘spat’, ‘spalt’ or ‘aspalt’. Additionally and unfortunately we found the translation of these words not translated consistently. Alternately translations were used like ‘spar’, ‘spath’ or ‘spat’. For this reason we looked up all original pages, to try to find out exactly where and how the manuscript mentions these terms.

We found the manuscript to mention ‘asphalt’/’aspalt’ (inconsistency in translation) on the following pages:

041r (asalpte), 058r (laspalthe), 066r (asalpte), 085v (laspalte), 106r (laspalte), 119r (laspalt), 119v (Aaspalspat, aspalte, le spat), 138r (le spat).
All these pages and specifically the place where the author mentions the terms are assembled in one separate document. Because translation is dependent on the way the author has written the word, we decided to add photos of every word. With this data a comparison can be made, which might shed light on the question if the author means to make a distinction between the terms ‘spalt’, ‘spat’ and ‘aspalt’. The study of his handwriting resulted in one specific case where the author has written the start of a word, crossed it through and writes ‘Aspalt’ instead. It is our interpretation that the author starts out, writing Le Spa(...) than crosses this through and writes spat instead. Although this is just a tiny lead to go on, it might be an indication that the author might be confused about the terminology that he uses. Our research of mineralogy has not given the idea that naturally occurring asphalt is the same material that the author is referring to.
As becomes clear from the previous, the author of the manuscript constantly uses a different spelling for the material aspalt. Also, at one point he seems to be confused in writing and corrects what he means to say. We are now in the process of finding out what the author says about asphalt on these pages, the characteristics and use. In this order we can find out what he possibly could have meant by “the use of asphalt”.

We sought contact with the Naturalis Biodiversity Center, Leiden, but unfortunately they could not help us further. Therefore we have had mail contact with a geology lecturer of the University of Leiden, faculty of archeology, Dr. Joanna Mol. Dr. Mol has given us some information about veldspaat, aluin and asbestos, but has forwarded our email to a colleague called dr. Dennis Braekmans. At this point we are awaiting his reply.

**Week 4 24-2 March**

Asphalt document processed:
This week, we improved the asphalt document (the document including small pictures of all places where the author writes [le] spat/[a]spalt[e]) , printed the pages and cut them in fragments. We did this because the author is not consistent in his terms and we are under the impression that he might be confused about terminology himself. We think the author might actually be meaning the same thing when he says spat, spalt or even aspalte. To prove this, we highlighted all words or phrases that keep returning throughout the document in cases where the author is referring to either one of the ‘spalt terms’ with a yellow marker. Examples are that he keeps commenting on “the more is used, the better it is”, also “it is an excellent sand” and the material is white in color and plaster-like. We arranged the fragments first in chronological order and then tried to make clusters of similar descriptions. This lead to development of three categories:

1. Folio 058r and 066r.
   Asphalt as a color preparation, used as a primer and, adding umber and lacquer, for the painting of shades.
   <ab id="p066r_b2">
   For woman, shadowed areas can be made from asphalt, umber and a bit of lacquer </ab>

2. Folio 041r and 085v.
Burned asphalt, possibly the same material as 1., but added to the sand mixture, used for molding for casting big metal objects. Used as a binding agent for the molding sand. It should not be burned too much, because this renders it too thin. It is quite unclear what the author means with this (there is no description of characteristics or colors, only that it should be ‘burned’ and that it is used as a bonding agent for sand mixtures). It seems that the author is here not referring to life-casting, but rather the casting of big objects. Although we are not sure, for now we will leave it at, because there are no specifics on color or appearance and there are no more clues.

3. Folio 106r until 137v

The spalt/spat/aspalt from Germany. Very soft, excellent sand, kind of plaster, white, malleable as flour.

Our classification of number 1 and 2 are incidentally the first 4 pages on which the ‘spalt term’ is used. Assuming that the pages are arranged in chronological order and, except for additions in the margin, were more or less written this way, this might indicate that the author is referring to another material in this first description.

Regarding categorie 1:

On pages 058r and 066r the author mentions the material twice. Both times he describes the material in connection to primers and shading of paintings. A meeting with the conservation department of paintings lead then to the discovery that ‘asphalt’ is used in manuscripts and texts more often as a pigment.


- Material asphalt is a puzzle in a historical, chemical and physical way.
- Asphalt is transparent brown “(...) current research into the properties of asphalt in both conservation and science is still in its infancy.” (p. 111)
- Asphalt is a color preparation which consist of a mixture of organic and inorganic materials. Organic (binding medium) = bitumen = viscous dark brown residue produced by the evaporation of petroleum. Inorganic materials = various and serves as filler. Due to their extreme complexity: no chemical formula can be established. (p.111)
- “Scientific literature is not alone in having difficulty finding the correct terminology; the confusion of terms is also present in the literature of conservation and technical investigation of art.” (p. 113)
- Result of old treaties, and manuscripts is: enormous array of contradictory statements, and synonymous terms: bitume de Judee, Judenpech, erdpech, bergpech, bergteer, aardpek, bergharz, judenharz, judenleim. (p.113-115)
- First references to use of asphalt as a pigment: 1584 roma. Paint called: spalto, aspalto. (p.113)
- Valuable for underpainting, and recommends asphalt for shading skin.
- “Asphalts with a high mineral matter content and little bitumen are, in contrast, brown to gray, the intensity and the tone of the color being influenced by the quantity, type, and size of the mineral particles. The colors of pulverized asphalt correspond to those of the lump: whereas pure bitumen and bitumen-rich asphalts are deep black in their pulverized state, asphalt containing much mineral matter is dark gray to brown.” (p. 121)
Conclusions from asphalt as a color preparation:
It is chemically and physically unclear what the material asphalt is in the context of art and paint. The most important conclusion regards the color of the raw asphalt, which is brown to grey. It is used as under paintings and shadows in paintings. This could mean that the author of the manuscript distinguishes different kinds of asphalt; when he describes asphalt as an excellent sand, the color is white. This supports the idea that we had: with the word asphalt related to casting he probably means the same as with the word spalt and spat.

The 1849 publication *Original treatises dating from the XIIth to XVIIth centuries, on the arts of painting, in oil, (...)* by Mary Philadelphia Merrifield, also redirects us in the index from *spalto* to *asphaltum*, which is an indication that at least in the craft of art and paintings, these terms were used alternately.

Asphalt category 3:
Different kinds of spellings but the descriptions and characteristics correspond. (see below)

Spelling chronological in manuscript:

<table>
<thead>
<tr>
<th>Page</th>
<th>Spelling</th>
</tr>
</thead>
<tbody>
<tr>
<td>106r</td>
<td>Laspalte</td>
</tr>
<tr>
<td>107r</td>
<td>Le Spat</td>
</tr>
<tr>
<td>108r</td>
<td>Spalt</td>
</tr>
<tr>
<td></td>
<td>Le spalt</td>
</tr>
<tr>
<td>119r</td>
<td>laspalt</td>
</tr>
<tr>
<td>119v</td>
<td>L espa(...)</td>
</tr>
<tr>
<td>137v</td>
<td>Le Spat</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Laspalte/ laspalt</th>
<th>Le spat / spalt</th>
</tr>
</thead>
<tbody>
<tr>
<td>From Germany, excellent sand to cast subtile and slender things. (106r, 119r)</td>
<td>From Germany, mainly Augsburg, and one of the best sands for casting metals. (107r) (137v)</td>
</tr>
<tr>
<td>The older and more used, the better it is. (106r)</td>
<td>The more it is used the better it is. (107r, 137v)</td>
</tr>
<tr>
<td>The color of plaster, with long soft filaments. (119v)</td>
<td>It is white like cooked plaster (108r, 119v) and found in stones with long stairs and veins. (108r)</td>
</tr>
<tr>
<td>Mixed with filth so to purify it, it should be ground and soaked in Sal Amoniack. (119v)</td>
<td>To purify it: boil it with gemstones and temper with essence of Sal Ammoniack. (108r, 137v)</td>
</tr>
<tr>
<td>It is soft, light and malleable as flour.</td>
<td>It is very soft and breakable with the</td>
</tr>
</tbody>
</table>
Concluding from the previous chart it becomes clear that the author might be confused about the spelling of the word. *Lasplalt* for example, could also be read as: *le spalt*. The description of the material is quite similar, we could assume that he does mean the same material when he writes *lasplat/lasplatelle spatle spalt*. In order to be consistently ourselves, from now on we will use the word *spat* when we refer to the material the author writes about.

**Contact with dr. Dennis Braekmans, mineralogy specialist on the University of Leiden**

We received an answer from dr. Dennis Braekmans, a geochemical specialist in minerals at the University of Leiden. In his e-mail he describes feldspar as being a very hard mineral which doesn’t correspond with the description of the author of the manuscript. A material being soft could possibly be talc, gypsum, pumice, travertin or other volcanic ash stones. If we include the geology around Augsburg we see mainly shale and some volcanic deposits, according to Braekmans. Without much background or experimental knowledge, Braekmans presents the option of pozzolana (a Si-Al compound which reacts with Ca-hydroxides in plaster). It could improve the properties and detail quality of the mold.

Although the e-mail contact with Braekmans answers some of our questions regarding mineralogy and properties, it also raises further questions. For this reason we decided to make an appointment to speak in person to discuss the possible candidates of *spat* and the geochemical details of the materials.

**Overview of possible experiments**

The next thing point of action was to set up an overview of possible experiments that we could do when we find the right candidates:

1. Testing ‘spat’

**Candidates for Spat**
- Feldspar
- Calcite
- Fluoriet
- Pozzolana
Testing on:

Charactersitics:
- Should be white, like plaster, be very soft and should easily pulverize into a powder with the fingernail (not much body).
- Origin: should have a specific origin in Germany, Augsburg. Is found in mounds/stones made in long stairs and veins.

In combination with mold material:
- Fire resistance: should hold fire and redden.
- After using: it should be better when its older/more used. It should turn from white to grey after use.
- Result casting: should cast more subtle, slender things.
- Suitability metals: should be suitable for every metals.

2. Testing alum de plume (probably the same as federweiss: Kunckel)

Candidates for alum de plume
- Asbestos (not safe to try: replacement?)
- Aluin
- Talc (soapstone)

Testing on:

Charactersitics:
- Should be soft, white, shiny, made of long pieces, fragile, woolly, fluffy, fat. Would not pass through a sieve.
- Grinding: the raw stone should be difficult to grind, but the powder from a pharmacy can be easily crushed in a mortar.

In combination with mold material:
- Binding with the other powders: should be a binding medium.
- Softness of the mold: should make the mold softer.
- Cracking and breaking: should be very resistant against fire without cracking or breaking.

For testing the two in combination with mold material this are the options:

1. Experiments with sand mixtures made by ourselves with recipes from the manuscript. Test: adding alum de plume, and ‘spath’.

Making/ testing sand mixture recipes
The author of the manuscript describes which sand mixture should be used for life-casting and casting medals. An important thing for this mixture is grinding the different ingredients as fine as possible. After grinding it should be sieved for the best result. (106v)
The sand mixture consists of:
- 4 parts ground plaster (preheated plaster from Paris)
- 2 parts red tiles from roofing
- 1 part alum de plume

2. Experiments with old/used mold material from Tonny Beentjes. Molds are without alum de plume. Test: Adding alum de plume and ‘spath’. 
B: Testing *Alum de plume*
C: Testing ‘spath’

3. Experiments with old/used mold material. Test: adding ‘spath’.

C: Testing ‘spath’

**Required materials**

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand mixture</td>
<td><strong>Spath</strong></td>
<td><em>Alum de plume</em></td>
</tr>
<tr>
<td>Plaster from Paris</td>
<td>Feldspar</td>
<td>Asbestos replacement?</td>
</tr>
<tr>
<td>Red roof tiles</td>
<td>Calcite</td>
<td>Aluin</td>
</tr>
<tr>
<td></td>
<td>Fluorite</td>
<td>Talc (soapstone)</td>
</tr>
<tr>
<td></td>
<td>Pozzolana</td>
<td></td>
</tr>
</tbody>
</table>

**Historische Mineralogie, Volkelt 1775**
We have also consulted the following 18th century German publication on minerals and stones: *Historische Mineralogie: oder beschreibung der Mineralien* (Volkelt, 1775). The author of this book describes all different minerals and stones to his knowledge, which were used in the past.

p. 87
‘2. Plaster-like rock
Plaster-like or selenitic rock (...) gives no fire (...) consists of a chalk-earth which is mixed with vitriolic acid.
Also can be found:
1. The plaster/gypsumstone
2. --- alabaster
3. --- gypsum spath
4. *Das fraueneis*
5. *Der Bononische Stein*

**Research candidates spat:**
This week we did more research on possible candidates for spat. All our new information was added to our documents. The following is the most important information in summary:
Spat is a collective term referring to interconnected crystals that will cleave or break easily.

- **Gypsum spat**
  Tough, difficult to break into powder.
- **Feldspat**
  Hardness on Moh’s scale: 6.
  Orthoclase feldspar (KAlSi₃O₈), plagioclase feldspars (with respective compositions NaAlSi₃O₈ to CaAl₂Si₂O₈).
  Melting point: 600 to 750 °C.
  Soft, easy to grind, falls into dust when it’s in contact with water.
Suggested by Loe Jacobs in e-mail contact with Joosje van Bennekom about the ‘spath’ which Kunkel describes.
Also called in French ‘spath des champs’.

- **Chalkspar/calcite**
  Hardness on Moh’s scale: 3.
  CaCO$_3$
  Colorless, white and variously tinted.
  Calcite is calcium carbonate. Not possible to scratch with fingernail, but can be scratched with a cent.
  Melting point: (decomposes at 899°C) 1339 °C
  Insoluble in water

- **Vloespat/ fluorite**
  Hardness on Moh’s scale: 4.
  CaF$_2$
  Colorless, green, yellow, pink.
  Occurs in veins.
  Used as a flux for metals.

- **Baryte spat/ heavy spar**
  BaSO$_4$
  Hardness Moh’s scale: 3-3.5.
  Colorless, white, blue, yellow, red.
  Characterized by its unusually heavy weight.
  Heavy spar: mineral consisting of barium sulfate.
  Insoluble in water.
  Mentioned in H.C and L.H. Hoover’s translation of Agricola’s *De Re Metallica*, where they translate “Marmor in metallis repertum” as spat, Barite: heavy spar, (p.115).
  Not possible to scratch with fingernail, but it could scratch with a cent.

- **Seleniet/ satin spar**
  CaSO$_4$·2H$_2$O
  Hardness Moh’s scale: 2.
  Calcium sulfate dihydrate
  Four crystalline varieties: selenite, satin spar, gypsum rose, desert flower.
  Related to gypsum.

- **Pozzolana**
  Option brought forward by geologist Dennis Braekmans.

Spat can be find in Augsburg and England. This is mentioned by:

- Krünitz (1773-1858).
- Huygens, 1629: Huygens describes the use of spat from England of which he makes balls and adds Sal Ammoniac (Huygens 1629 in de Heer 1993). He describes the spat from Germany being less translucent in comparison with spat from England.

**Preparing our interview with dr. D. Braekmans**
Fortunately Dr. D. Braekmans is available for an interview within a short-time period.
In order to prepare this interview we assembled the most important information this far in an overview:

**Characteristics described in the manuscript:**

- White stone, after use it becomes grey.
- Found in: mounds and stones made in long stairs and long veins. Long soft filaments which are malleable.
- Very light and soft, easily crumbled into powder with the fingernails.
- From Germany, mainly Augsburg.
- Excellent sand for casting in a box frame.
- White like cooked plaster, color of plaster, kind of plaster.
- Holds fire and reddens.
- The more it is used, the better it becomes.
- For casting slender and subtle things.
- For casting: lead, tin, copper, silver, gold.
- Has to be purified before use with sal ammoniac.

Way to rework spat:
1. Grind them coarsely because they are mixed with earth and filth.
2. Then soak them into sal ammoniac’s water, following the above indication,
3. and make balls.
4. Heat these balls in a potter’s furnace.
5. Then soak it in the same water again. Filth will remain at the bottom, and the very asphalt, which is light, soft and malleable as flour is, stick to water, remain on the top, and make water cloudy.
6. Pour this cloudy water in another pot.
7. Then empty water, to do that tilt your pot, or sponge the water up.
8. The very asphalt will remain at the bottom of your pot, dry it.
9. Then soak it into sal ammoniac’s water, and use it for moulding box.
10. If this matter shrinks in the molding box, even if reheated and dried, you must reheat it on a good fire again, and redden it as you did for medals and flat things.

Candidates:
Gypsum spat
Feldspat
Chalkspat
Fluorite
Barytspat
Seleniet/ satin spat
Pozzolana

Augsburg:
Spat can be found in Augsburg and England.
Online we found a *An Alchemists Glossary of Terms, Definitions, Formulas & Concoctions*, created by The Third Millenium Online. This glossary offers an entire overview of terms.

**Spar**
A class of compounds characterized by a crystalline form that features shiny reflective plate surfaces.

**Spath (Spat) Stone**
A naturally occurring mineral solid, containing mostly Calcium Sulfate (CaSO₄).

It describes Selenitic spar or selenite as:

**Selenitic Spar**
Any mineral assigned to the family of "spars" that could be calcined like gypsum (CaSO₄ · 2H₂O).

Calcium Sulfate (CaSO₄): The hemihydrate (CaSO₄ · ~0.5H₂O) is better known as **plaster of Paris**, while the dihydrate (CaSO₄ · 2H₂O) occurs naturally as gypsum. It is prepared by heating the mineral gypsum to about 150°C.

\[
\text{CaSO}_4 \cdot 2\text{H}_2\text{O} + \text{heat} \rightarrow \text{CaSO}_4 \cdot 0.5\text{H}_2\text{O} + 1.5\text{H}_2\text{O} \text{ (steam)}
\]

This burned plaster, calcined gypsum, can be hydrated with water, by which procedure the mold hardens.

Plaster of Paris is named in the Manuscript as a basic ingredient to the sand mixture for molding.

If the author of the document really means the same thing when he calls the material aspalt, spalt, le spat or aspalte, we have a recipe on how to prepare the ‘excellent sand’ for the ‘moulding box’:

1. Grind them coarsely because they are mixed with earth and filth.
2. Then soak them into sal ammoniac’s water, following the above indication,
3. and make balls.
4. Heat these balls in a potter’s furnace.
5. Then soak it in the same water again. Filth will remain at the bottom, and the very asphalt, which is light, soft and malleable as flour is, stick to water, remain on the top, and make water cloudy.
6. Pour this cloudy water in another pot.
7. Then empty water, to do that tilt your pot, or sponge the water up.
8. The very asphalt will remain at the bottom of your pot, dry it.
9. Then soak it into sal ammoniac’s water, and use it for moulding box.
10. If this matter shrinks in the moulding box, even if reheated and dried, you must reheat it on a good fire again, and redden it as you did for medals and flat things.

So, could it be that the above recipe is a method of extracting a sulfate, same as is done with gypsum? Could the mineral with which the recipe starts be a selenitic spar, of which calcium sulfate can be made? Barite, which is Agricola’s translation of the material ‘spat’, is also called heavy spar, BaCO₄, and consists primarily as a barium sulfate. Would this sulfate react in the same way as would the calcium sulfate?

- Barium sulfate is a white crystalline solid that is odorless and insoluble in water.
- In metal casting, the molds used are often coated with barium sulfate in order to prevent the molten metal from bonding with the mold.
Interview dr. D. Braekmans 3 march 2015 University Leiden

On folio 108r the author describes where the stone is found: in Germany and mainly in Augsburg. Can you tell us something about the minerals or stones which are found around Augsburg?

Before this interview I looked at the geological map of Augsburg. Mainly shale, sedimentary deposits and clay sources are found in this area. My advice would be to send an e-mail to the geological department of the University of Augsburg, I’m definitely sure they know which material refers to spat on the basis of the descriptions from the manuscript.

We already sent them an email, in English, but we didn’t got an answer. But maybe it is a good idea to send the email again but this time in German.

The author of the manuscript describes on folio 119v a ‘way to rework spat’. What does this process tells us about the material he uses?

The fact that the author rolls small balls of the spat, indicates that the material must have a degree of plasticity. There must be a fraction of clay in it, otherwise you would not be able to roll balls. Sand or loam would fall apart.

The manuscript also mentions these sand balls to be heated, there is no indication of temperature. This can not have been higher than approximately 500 degrees Celsius, a higher temperature will cause the clay in the mixture to harden. After the heat treatment the material is rinsed again with water. The mixing with water leads to an emulsion, which is placed in another pot. This process removes the dirt and a residue remains. This residue eventually is to be used for molding. To me, this process is not obvious and I can not understand why the author would be doing this.

One of the possible candidates for spat is feldspar, what is your opinion about feldspar according to the descriptions of the manuscript?

The author of the manuscript describes the stone being very soft, from this fact it cannot be feldspar. This mineral is very hard: number six on the hardness scale of Moh. Feldspar is unable the scratch with your fingernail, therefore it should have number 1 to a maximum of 2.5 on Moh’s scale of mineral hardness.

One other possible candidate is barite, different historical sources describes this as being spar/spat. Is this a plausible possibility?

I don’t think the mineral barite is found around Augsburg, but only in northern Africa.

In the email contact you suggested pozzolana as a candidate for spat, can you tell us more about this material and the reasons why this could be the spat?

Pozzolana is a white siliceous and aluminous compound, which could improve the properties and detail quality of the mold. It reacts with water and is found around Augsburg. The only problem is the name: it is etymologically or otherwise unrelated to traditional spars. It is a mixture of claystone, but also other minerals. Nowadays is being used primarily in the cement industry.

Can any of the other characteristics that are described in the manuscript lead to any clues?

- Long stairs and veins is not helpful, still many possibilities.
- Long soft fibers: not a lot of minerals are soft.
- It reddens: suggesting it is red-hot or iron oxide present?
White is the most common color in which minerals occur.

To the water is added ‘sal ammoniac’, Ammonium Chloride (NH₄Cl). Why is this used? What is the function exactly? This addition could be purely out of habit, or it could have a purpose. You could try to figure this out.

An alternative method, proposed by Braekmans, is to analyze samples of other life-cast objects using XRF or SEM to see what elements can be found in potential residue on the object.

Still to research:
- Minerals that form thread-like fibers.
  webmineral.com
  Chemical composition of all minerals in the world.

The author does not indicate a regular clay, otherwise he would have probably just said this. Clay also, is not found in the long filaments that are described.

Lou Jacobs of the University of Leiden indicates not to use a mineral that is calcareous or has calcium in its composition, because calcium gets decomposed when heated to a certain temperature and when this happens it produces gasses which cause the mold to crack or break. This will happen around 670 degrees Celsius. So, if you want a mold that can withstand heat, you should not use a calcareous clay. Regarding calcite in cement, this is another reaction and could therefore be an option.

Sources indicate a connection between English and German spath, it occurs in both countries, but is slightly different in appearance. A mineral that can be found in England, as well as Germany is fluorite. Fluorite though, is both quite hard, number 4 or 5 on Moh’s scale of hardness and it occurs in many colors. We can also think of a type of metamorphic rocks. In the south of England, and in Germany in the region of Eiffel and Augsburg we find all kinds of sedimentary deposits and minerals, which have formed under pressure. Therefore per definition they are not crystallized nicely, but appear as slate or shale, schist.

Advice:
- Try contacting the university of Augsburg, department of geology, and asking for geological information about the region. They should know plenty about the subject.
- Try finding out what could be the purpose of the sal ammoniac in the recipe.
- Try finding information regarding technical analyses done on deposits that are found on other historical life-cast objects.
- The material spalt might be pumice. It is very soft. Although it is not a mineral, the author regarding the time in which he lived, might be confused himself about sediments and minerals. The author does say “you find an earth”, which would not indicate it being a mineral. On the other hand, he also mentioned “a white stone” multiple times. Although it is also does not occur in long soft filaments, it is found like thin veins in the earth’s crust. It is relatively rare. He also indicates it being “like our chalk from Champagne”. Chalk = soapstone? Does occur in Germany.
Continuing our research of spalt

Moh’s scale of mineral hardness
This qualitative scale indicates the scratch resistance of various minerals. It consists of 10 minerals arranged on hardness. A fingernail would be 2.5. The Moh’s scale is a purely ordinal scale. Corundum, for example, is twice as hard as topaz, but diamond is four times as hard as corundum.

1=Talc
2=Gypsum
3=Calcite
4=fluorite
5=Apatite
6=Orthoclase, porcelain
7=Quartz
8=Topaz, tourmaline
9=Corundum (naturally occurring aluminum oxide), ruby, sapphire
10=Diamond

Kunckel’s Spath
Edgar Lein can be found to have shed light on the process of casting from life. In his Ars Aeraria: Die Kunst des Bronzegießens und die Bedeutung von Bronze in der florentinischen Renaissance (Lein 2004) he examines the late seventeenth-century Ars Vitraria of Johann Kunckel (1630–1703) and of an anonymous author (probably Kunckel) who reprints Kunckel’s recipes. In this research it becomes clear, that although Lein investigated the publications by Kunckel extensively, he does not discuss bother with technical terms and materials. The work is more about the art historical background and does not learn us anything new about the material spat.

Still to do this week:
- Explore the book ‘An introduction to the rock-forming minerals’ by W. A. Deer et all. (1967). There is an extensive chapter written about feldspars in this book. Good for figuring out characteristics about the material that we would be testing.
- Finding out more about pozzolana. There are 5000 sorts of tufa. What kind could we use and how do we figure out which one to test. Maybe we can ask the department of ceramics, historical interiors or paintings.
- Make a step by step plan of how we will test our materials.

Addition to literature study
In De Re Metallica Agricola (1556) describes the following:
“(…) it is necessary, for this kind of ore, to have a very hot furnace in which slags, or cakes melted from pyrites, or stones which melt easily in the fire, are first melted, so that the ore should not settle in the hearth of the furnace and obstruct and choke up the tap-hole (…)”

In De Re Metallica these stones are not further explained, but in Interpretatio three types of these stones, with their German equivalent, are named further:
- ‘lapides qui igni liquescunt primi generis’ or schöne flüsse.
- ‘secundi’, -flüsse zum schmelzen flock quertze.
- ‘tertii’, -quertze oder kesselstein.
The translators of this work, confessing their inability to understand most of the substances, try to list al characteristics and information given. In De Re Metallica the
third category is called *Spatum*. “Tertium Spatum appellat, quod politius & densius est”; “Spatum is called the third order, which is polished and thick.” (Agricola 1556, 129).

About the materials furthermore is said that the third variety must have embraced varieties of quartz, flint, and siliceous material generally. In *De Natura Fossilium* he states that there are three orders (genera).

“The first resembles the transparent gems; the second is not similar and is generally not translucent; it is translucent in some part, and in rare instances altogether translucent. The first is sparingly found in silver and other mines; the second abounds in veins of its own. The third genus is the material from which glass is made, although it can also be made out of the other two. The stones of the first order are not only transparent, but are also resplendent, and have the colors of gems, for some resemble crystal, others emerald, heliotrope, lapis lazuli, amethyst, sapphire, ruby, chrysolithus, morion, and other gems, but they differ from them in hardness (…) To the first genus belongs the lapis alabandicus, if indeed it was different from the alabandic carbuncle. It can be melted according to Pliny, in the fire, and fused for the preparation of glass. It is black, but verging upon purple. It comes from Caria, near Alabanda, and from Miletus in the same province. The second order of stones does not show a great variety of colours, for it is generall white, greyish, or yellowish. Because these (stones) very readily melt in the fire, they are added to the ores from which the metals are smelted. The small stones found in veins, veinlets, and the spaces between the veins, of the highest peaks of the Sudetic range (Suditorum montium), belong partly to this genus and partly to the first. They differ in size, being large and small; and in shape, some being round and angular or pointed; in colour they are black or ash-grey, or yellow, or purple, or violet, or iron colour. All of these are lacking in metals. Neither do the little stones contain any metals which are usually found in the streams where gold dust is collected by washing (…) In the rivers where are collected the small stones to be found, all somewhat rounded and very light weight, and devoid of all metals. The largest are black, both on the outside and inside, smooth and brilliant like a mirror; the medium-sized are either bluish black or ash-grey; the smallest are of a yellowish colour, somewhat like a silkworm. But because both the former and the latter stones are devoid of metals, and fly to pieces under the blows of the hammer, we classify them as sand or gravel. Glass is made from the stones of the third order and particularly from sand. For when this is thrown into the heated furnace it is smelted by the fire (…) This kind of stone is either found in its own veins, which are occasionally very wide, or else scattered through the mines. It is less hard than flint, on account of which no fire can be struck from it. It is not transparent, but it it of many colours - that is to say, white, yellowish, ash-grey, brown, black, green, blue, reddish or red. This genus of stones occurs here and there in mountainous regions, on banks of rivers, and in the fields. Those which are black right through to the interior, and not merely on the surface, are more rare; and very frequently one coloured vein is intersected by another of a different colour – for instance, a white one by a red one; the green is often spotted with white, the ash-grey with black, the white with crimson. Fragments of these stones are frequently found on the surface of the earth, and in the running water they become polished by running against stones of their own or another genus. In this way, likewise, fragments of rocks are not infrequently shaped into spherical forms. (…) This stone is out to many uses; the streets are paved with it, whatever its colour; the blue variety is added to the ash of pines for making those other ashes which are used by wood-dyers. The white
variety is burned, ground, and sifted, and from this they make the sand our of which glass is made. The whiter it is, the more useful it is”

The editors of the work see there is little doubt as to the first or second order being in part fluor-spar. In De Re Metallica it is said “the miners call them fluores, by the heat of fire, like ice in the sun, they liquefy and flow away”. “The third kind, as you see here, is white. A fourth is a yellow colour, a fifth ash colour, a sixth blackish. (…)

It is indeed not made far from here, at Breitenbrunn, which is near Schwarzenberg. Moreover, from fluores they can make colours which artists use.”

Interestingly, Kunckel (1689) also connects the material spath to the glass industry.
**Conclusions literature study**

We started this week making an overview of the pending experiments. We put together a chart with columns including characteristics like composition, color, hardness on Moh’s scale, melting point, solubility in water and provenance, in comparison with information from manuscript. From this table we would like to argue which materials we will be testing.

**Feldspar soda**

Pro: Has the right characteristics.
Con: is very hard.

**Feldspar kali**

Pro: Has the right characteristics, but a higher melting point than the soda feldspar. Testing to see the difference.
Con: Same hardness as soda feldspar.

**Pumice**

Pro: Good candidate on many fronts, except for the nomenclature.
Con: The one we are using (from the department of ceramics) is somewhat too brown in color.

**Baryte/heavy spar**

Pro: Right in color, used as a filler for paints.
Con: Too hard on Moh’s scale.

**Calcite**

Pro: From our chart and the findings we conclude that calcareous spar is named in literature more than a few times. Also, none of the above has calcium as a component in its chemical structure and since the manuscript is often calcimining materials, it would be interesting to have a material that is made up of calcium as well.
Con: Calcium can cause these balls to burst or even explode in the oven due to the gasses that are produced. Therefore, after a meeting with the ceramics department, we have decided to do this experiment separate from the other materials.

**Materials that will not participate in the experiments:**

-Fluorite, due to its colors, its hardness and the advice of Dennis Braekmans.
-Selenite, because this mineral is closely related to gypsum and is a calcium sulfate. This would therefore be the same as the Plaster of Paris that the author already uses and calls by that name.

Regarding the characteristics of and experimentation on the mineral Calcite:

Calcite, in German *kalkspat*, is the most stable form of calcium carbonate, CaCO₃.
Calcite is a common constituent of sedimentary rocks, limestone in particular, and is found in England, and Germany as well. Limestone is composed of the two different minerals aragonite and calcite, both crystal forms of calcium carbonate.
Chemically, when calcium carbonate is heated it decomposes. The thermal decomposition of calcite occurs above approximately 825 degrees Celsius. The material then breaks up in calcium oxide and carbon dioxide. Calcium oxide with water converts into calcium hydroxide. Calcium hydroxide, or slaked lyme, in turn is used in plasters and cement and has a long history of this utilization (Hamer and Hamer 2004). The process of this preparation, might correspond to the recipe from the manuscript in which spat is prepared.
<table>
<thead>
<tr>
<th>Name</th>
<th>Color</th>
<th>Composition</th>
<th>Hardness (Mohs’ scale)</th>
<th>Melting point</th>
<th>Solubility in water</th>
<th>Provenance</th>
<th>Manuscript</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feldspar, mineral</td>
<td>Ranges in colors, also white</td>
<td>Mineral</td>
<td>All three kinds: 6-6.5</td>
<td>- Alkali: 1150°C</td>
<td>Insoluble</td>
<td>- Alkali and plagioclase: Abundant worldwide</td>
<td>Advantage: Also used in glass industry (Kunckel, Agricola)</td>
</tr>
<tr>
<td></td>
<td>- Alkali: normally colorless or white</td>
<td></td>
<td></td>
<td>- Plagioclase: 600-750°C</td>
<td></td>
<td>- Bariumfeldspar: Japan, Wales, Scotland, New Jersey, Namibia</td>
<td>- Suggested by Lou Jacobs (about Kunckel) - Clay</td>
</tr>
<tr>
<td></td>
<td>potassium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Disadvantages: - Hardness 6</td>
</tr>
<tr>
<td></td>
<td>sodium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>alkali</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plagioclase: normally colorless or white</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Bariumfeldspar:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>colorless, white</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>or yellow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pozzolana/ Tuffa/ Pumice stone</td>
<td>Ranges in colors, also white</td>
<td>Vulcanic sediment</td>
<td>-Soft</td>
<td>-</td>
<td>Soluble</td>
<td>- Name origin from Italy - Mainly from Eiffel Germany - Found around Augsburg</td>
<td>Advantage: - Soft, easy to break - Clay - isolating - light weight</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Disadvantages: - Name</td>
</tr>
<tr>
<td>Mineral</td>
<td>Color or Hardness</td>
<td>Formula</td>
<td>Melting Point</td>
<td>Solubility</td>
<td>Abundance</td>
<td>Advantage</td>
<td>Disadvantages</td>
</tr>
<tr>
<td>------------------</td>
<td>-------------------</td>
<td>-----------</td>
<td>---------------</td>
<td>------------</td>
<td>----------------</td>
<td>---------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Calcite/Chalkspar</td>
<td>Colorless or white</td>
<td>CaCO₃</td>
<td>1339 °C</td>
<td>Insoluble</td>
<td>Abundant worldwide</td>
<td>- Calcium, like plaster</td>
<td>Disadvantages:</td>
</tr>
<tr>
<td>Fluorite/Flüsspat</td>
<td>Extremely variable</td>
<td>CaF₂</td>
<td>1403 °C</td>
<td>Insoluble</td>
<td>England, Germany</td>
<td></td>
<td>Advantage:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Named by various sources in relation to 'spalt' (Krüntz, etc)</td>
<td>Disadvantages:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Often used as a flux for ores?</td>
<td></td>
</tr>
<tr>
<td>Baryte/Heavy Spar</td>
<td>Various (included white)</td>
<td>BaSO₄</td>
<td>1580 °C</td>
<td>Insoluble</td>
<td>Germany, China, Africa</td>
<td>Advantage:</td>
<td>Disadvantages:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Agricola</td>
<td>Disadvantages:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Hardness 2.5-3.5</td>
<td>Characterized by its unusually heavy weight.</td>
</tr>
<tr>
<td><strong>Selenite/ satin spar</strong></td>
<td><strong>Transparent, white</strong></td>
<td><strong>Mineral ( \text{CaSO}_4 \cdot 2\text{H}_2\text{O} )</strong></td>
<td>2</td>
<td>-</td>
<td><strong>Soluble</strong></td>
<td><strong>Abundant worldwide</strong></td>
<td><strong>Advantage</strong>&lt;br&gt;-Related to gypsum.&lt;br&gt;-Was commonly used in Germany in medieval times (Marienglas).&lt;br&gt;<strong>Disadvantages</strong>&lt;br&gt;- Insoluble in ammoniac</td>
</tr>
</tbody>
</table>
Experiments Week 6 and 7 10-23 March

As can be seen in the table (see table p. 42-44) we made a selection of possible candidates for spat which we want to subject to a number of experiments:

- A: Pumice stone powder
- B: Heavy spar / barite
- C: Feldspar potassium
- D: Feldspar soda
- E: Calcium carbonate

**Experiment 1: Characteristics**

Before we want to carry out a variety of experiments on the different materials, it is important to look at the characteristics. What is the color, weight, structure and softness of the powders and how does this relate to the properties of plaster of Paris?

1.1 **Weight**

We filled plastic cups with the different kind of candidates with 50 grams each. By comparing the level until where the material filled the cups, we got an estimate about the density. The materials in order of increasing weight:

- Pumice
- Calcium carbonate
- Feldspar potassium
- Feldspar soda
- Heavy spar

These results correspond to what we expected of this experiment. The difference in density between potassium feldspar and soda feldspar is hard to find with this experiment. We decided to compare the weight of the materials to plaster of Paris, because the manuscript specifically names a resemblance between the two. By weighing 50 gram of plaster of Paris for comparison, it turns out that this material corresponds the most in density to pumice powder and calcium carbonate.

1.2 **Color**

The color of spat, according to the manuscript, should be ‘white like cooked plaster’. In numbers, of which 1 resembles plaster the most in appearance, consistency and feel, and 5 the least:

- Feldspar potassium: 1: looks like plaster the most in shade of white.
- Calcium carbonate: 2: similar white color as plaster but somewhat more grey.
- Feldspar soda: 3: whiter than plaster.
- Heavy spar: 4: somewhat grey/pink in the color white.
- Pumice: 5: is more brownish in color, least resembles plaster of Paris.

1.3 **Structure**

Structure increasing from coarse to fine:

- Pumice: Biggest granules. Dry, not entirely, but form loose grains.
- Heavy spar: Fairly big granules, not much correlation between the grains.
- Feldspar potassium: Small granules.
- Feldspar soda: Small and fine granules.
- Calcium carbonate: Finest structure and smallest granules, very atomizing.

1.4 **Softness**

Softness increasing from hard to soft, also including the stickiness:
Pumice: The least soft, not very sticky, more like sand.
Heavy spar: Soft but oilier, more dense.
Feldspar potassium: Soft and more oilier, sticks to the finger.
Calcium carbonate: Very soft and very sticky to the finger.
Feldspar soda: The most soft and dry, more like sand.

Experiment 2: Preparation of spat
The main experiment we want to carry out is the ‘way to rework asphalt’, which the author describes in folio 119v. The powders we use in these experiments are fairly pure and not mixed with earth and filth as the spat the author describes, but it is interesting to examine how the different kind of powders react in the sal ammoniac water and if it is possible to make balls out of them. The first step in this recipe is making sal ammoniac water, the second process is moisturizing the powders with this water in order to make balls of it. The second step in this experiment is heating the balls in a furnace.

2.1 Making the sal ammoniac water
Recipe from the manuscript:
"But I did refine upon marble what seemed to me too coarse, and having thus prepared it (reused sand from core molds), I moistened it with the sal ammoniac water made of sal ammoniac the size of two walnuts, in a bottle of common water the size of a bottle in which one boils ground barley, or in a good pot of water. You should find the water fairly salty. I mixed in half a glass of sal ammoniac two silver spoonfuls of spirits. Having thus moistened the sand in order to give it a nice hold, though it still came apart easily." (folio 118v)

Interpretation of the recipe from the manuscript:
In addition to this recipe it is relevant to compare it with the Platt’s recipe from 1594 and of Huygens from 1629. Platt describes mixing every bottle of water with an ounce of sal ammoniac and some also mingle it with aqua vite (Platt 1594, 52-53). Huygens describes mixing half a bottle water with two ounce of sal ammoniac (Huygens 1629 in de Heer 1993, 283). Sal ammoniac is ammonium chloride (NH₄Cl), which is soluble in water. It is not clear why the author of the manuscript, Platt, Huygens and others add this to the mixture. Professor of chemistry of conservation and restoration dr. N. Tennent could not think of any chemical reason why sal ammoniac is added. The author adds the sal ammoniac to many different kinds of things. We can assume that it has more to do with a kind of superstition. Nonetheless we decided to add sal ammoniac because we want to reconstruct the recipe of the manuscript as precisely as possible.

Because sal ammoniac could be harmful when swallowed, we decided not to taste the saltiness of the water after adding sal ammoniac, although the manuscript advices to do. By spirits the author means eau de vie which is French for a clear, colorless fruit brandy. We decided a cognac would meet this description.

Sal ammoniac water we made:
- 800ml water
- one tablespoon sal ammoniac
- 200ml of this mixture
- mix it with 2 tablespoon of cognac (Hennessy Fine de Cognac, Qualite rare, 40% vol)
2.2 Mixing the powders with sal ammoniac water

On the next folio the author describes the follow proceedings:

“You find an earth in Germany, the color of plaster, but have long and soft filaments which are easy to handle. Grind them coarsely because they are mixed with earth and filth. Then soak them into sal ammoniac’s water, following the above indication, and make balls.” (folio 119v_b1).

The materials we use for this experiment are very pure. For this reason we do not have to grind them before mixing with the sal ammoniac water. Before soaking the powders in the sal ammoniac water we need more information because the recipe does not describe the proportions which are used. The author describes that “Good sand when moistened does not stick at all to the hand when pressed.” (folio 119r)

Platt report that the pap should not be too stiff (Platt 1594, 52) and Huygens mingle the powders with the sal ammoniac water until it sticks to the fingers when pressed. It should not be too wet though (Huygens 1629 in de Heer 1993, 283). From this information we can conclude that the authors reports this mixture differently.

For our experiment we decided to add the sal ammoniac water per 10 milliliters and making notes after each turn. In this manner we can control and monitor the experiment. We decided to moisten the powders until we could make a ball out of them. It is also not evident why the author makes balls of the spat, there is no explanation in the manuscript and it is also unclear what size the balls should be. Huygens also makes balls of the spat: as big as a fist (Huygens 1629 in de Heer 1993, 282). Since this is the only description, we decided to make similar balls of each powder, which are a little smaller than a fist because this size would be more practicable for the experiments. We want to make three balls of each material in order to compare the balls after the following experiments. Since the powders differ in weight, we decided to fill a plastic cup with each powder and make one ball with that quantity. For the best monitoring of this experiment we made the balls one by one.

A Pumice stone powder
Filled plastic cup: 100 gram
Adding the sal ammoniac water:

- 10 ml good absorption
- 20 ml granules getting bigger
- 30 ml
- 40 ml Still sand-like
- 50 ml
- 60 ml Almost perfect for making ball, a little fragmentation
- 65 ml Enough moisture for making ball

Ball A1 weight: 149 gram
Ball A2 weight: 146 gram
Ball A3 weight: 155 gram

Notes: it turns very dark brown when moistened. It is not like sand or clay, more similar to loam. When breaking the ball, it is a hard brittle fracture. Cracking when squeezing it.

B Heavy spar / barite
Filled plastic cup: 196 gram

- 10 ml very fast absorption
- 20 ml bigger granules and more wet consistency
- 30 ml like clay, very sticky, enough for making ball
Ball B1  weight: 210 gram
Ball B2  weight: 218 gram
Ball B3  weight: 225 gram
Notes: it turns more grey when moistened. Plastically, clay-like and sticky. It is heavy and high in density. When breaking the ball it is very similar to how clay would react: a ductile fracture. It reacts fast with the moisture to become solid in state.

C  Feldspar potassium
Filled plastic cup: 150 gram
- 10 ml absorption but not very fast
- 20 ml not much happen
- 30 ml
- 40 ml
- 50 ml wet enough for making ball
Ball C1  weight: 189 gram
Ball C2  weight: 187 gram
Ball C3  weight: 180 gram
Notes: It turns a little beige when moistened. It is a little plastically, but not clay-like. When breaking the ball it has a more brittle fracture. Also cracking when squeezed. This can be explained by the quartz, which is present in the feldspar.

D  Feldspar soda
Filled plastic cup: 160 gram
- 10 ml absorption but not very fast
- 20 ml
- 30 ml
- 40 ml turns wet
- 50 ml wet enough for making ball
Ball D1  weight: 199 gram
Ball D2  weight: 200 gram
Ball D3  weight: 208 gram
Notes: the characteristics of the feldspar soda are similar to the behavior of feldspar potassium. It turns more beige comparing to feldspar potassium.

E  Calcium carbonate
Filled plastic cup: 100 gram
- 10 ml very fast absorption
- 20 ml almost wet enough for making ball
- 25 ml good for making ball
Ball E1  weight: 114 gram
Ball E2  weight: 120 gram
Ball E3  weight: 118 gram
Notes: when moistened it becomes grey. It is very plastically, looks and feels like clay. When breaking the ball it is very similar to how clay would react: a more ductile break.

2.3 Heating the balls in a furnace
“Heat these balls in a potter’s furnace.” (folio 119v_b1).
Because the author of the manuscript or other publications mentioned earlier, do not give any information about the temperature or time of which the balls should be heated, we decided to ask Mrs. K. E. van Lookeren Campagne, coordinator of the
department of ceramics. Mrs. van Lookeren Campagne is lecturer in conservation of ceramics and glass at the University of Amsterdam and has a lot of experience and knowledge of pottery and the use of furnaces through the ages. Van Lookeren Campagne advised us to choose a temperature between 800 and 950 degrees Celsius and heat it for one hour, because this was the highest temperature, which could be reached around the 16th century. She also advised us to heat the calcium carbonate balls in the oven separate from the other materials, because the calcium carbonate might explode and cause materials to get mixed and contaminate the experiment. Also, she advised us to choose a long procedure of warming the oven, for that the gasses, which will develop, will be able to pass gradually from the balls.

For the pumice, heavy spar, feldspar potassium and feldspar soda we think the heating of the balls has everything to do with purifying them from filth and earth. For this reason we decided to put the balls of these four different kinds of powders in the furnace and heating them for one hour at 850 degrees Celsius. For safety reasons we choose a warm-up procedure of five hours up to 500 degrees Celsius. We used a ceramic plate on which we put the balls.

According to the process of slaked lime, the heating process of the calcium carbonate has another reason. The calcium carbonates decomposes in calcium oxide and carbon dioxide around 820-840 degrees Celsius, according to van Lookeren. The advice of van Lookeren was to choose a warm-up procedure of five hours up to 750 degrees and one hour 850 degrees Celsius.

**Experiment 3: Grinding the balls**
The next step in the recipe, which is described on folio 119v, is soaking the powders. Before this is possible we need to grind the balls into powder. The author does not report this procedure, but Huygens does. Huygens mentions that the balls should be crushed as small as possible (Huygens 1629 in de Heer 1993, 282). The first step in this experiment is to report the characteristics of the balls after the heating and the next step is grinding the balls as finely as possible.

3.1 **Characteristics of the balls after heating**

We took the pumice, heavy spar, feldspar potassium and feldspar soda balls out the furnace and determined the changes:

A **Pumice**
- Size is greatly reduced.
- It has become very hard: like stone
- It has a white film only on the top of the balls
- On the downside very dark brown
- The color changed to a more reddish/dark brown

B **Heavy spar**
- A sort of thick shell (0,5 cm) has formed on the surface of the balls, which at some points has crumbled off into pieces.
- Size is a little bit reduced
- The color of the surface changed into dark grey and the core has turned into pink

C **Feldspar potassium**
- Size did not visibly change much
- The surface is covered with a powdery substance, which is very soft
- The color of the surface changed from beige to white; the downside has become white/pinkish.

D **Feldspar soda**
- Size did not visibly change much
- The surface is also covered with a powdery substance, but less in comparison to feldspar potassium
- The color of the surface changed from dark beige to white with/orange. The downside has become orange.

E **Calcium carbonate**
- Size did not visibly change much
- The color did not visibly change much
- The structure did also not visibly change

3.2 **Grinding the balls**
We decided to keep one ball of each candidate without grinding. This way we could always compare the heated balls to the powder at a later stage. The other two balls of each different kind of powder we grinded:

A **Pumice**
We were not able to grind the pumice stones: it was too hard to break into parts. It has become hard like pottery. Because the color changed into dark brown and it was impossible to grind the pumice stones we concluded it would be unlikely if pumice stone is the spat which the author refers to in the manuscript. We decided to cancel pumice stone in our further experiments.

B **Heavy spar**
Difficult to grind finely. The shell was easy to grind into powder, but the core was very hard. We had to crush it with a hammer several times. When we had broken the ball up into smaller pieces we could grind it more finely in a mortar. It took up to 20 minutes to achieve a powder.

C **Feldspar potassium**
As we expected from the appearance: the feldspar potassium could easily be grinded with a mortar into powder without any effort. The color of the feldspar potassium turned out to be white with a little pink in it.

D **Feldspar soda**
Grinding the feldspar soda turned out to be as easy comparing to the feldspar potassium. The powder of the feldspar soda has an orange color.

E **Calcium carbonate**
The calcium carbonate, which hopefully turned into calcium oxide by the heating process, was not very easy to grind. It turned out to have an thick shell around the ball, which fell off very easily. But the core, which had a beige color, was more difficult to crush into pieces. After some effort with the hammer and mortar it was possible to grind the balls into powder. The color of the powder is more beige and darker in comparison to the calcium carbonate we started with.
Experiment 4: Soaking the powders

The author describes the next steps in folio ‘how to rework spat’:

“Then soak it in the same water again. Filth will remain at the bottom, and the very asphalt, which is light, soft and malleable as flour is, stick to water, remain on the top, and make water cloudy. Pour this cloudy water in another pot. Then empty water, to do that tilt your pot, or sponge the water up. The very asphalt will remain at the bottom of your pot, dry it. Then soak it into sal ammoniac’s water, and use it for moulding box.” (folio 119v_b1)

The other authors, Platt and Huygens mention the soaking but do not give an description of this process. We tried to reconstruct the steps of the author as precise as possible with each spat candidate. The main reason of the process is probably to purify the spat from filth and earth, which is not necessary for our pure powders. It is very likely that our pure powders would sink into the bottom. We decided to skip the first part of the process because there would not be any heavy filth or earth, which would remain at the bottom.

It is not clear what the author exactly describes about the solubility of spat in water. The spat sticks to the water and will make the water cloudy, which would suggest it is soluble in water. But then the author describes both the spat remaining on the top and later on remaining at the bottom, which would suggest it is insoluble in water. Because the solubility in water is interpretable in various ways, we decided to monitor the behavior of the different kinds of candidates when mixed with water. We do know that heavy spar, feldspar potassium and feldspar soda should be insoluble in water.

If the calcium carbonate has turned into calcium oxide through the heating process it would be soluble in water. Calcium oxide turns into calcium hydroxide (slaked lime) when mixed with water. During this reaction the water could reach its boiling point and will release a lot of heat: CaO (s) + H$_2$O (l) -> Ca(OH)$_2$ (s) + heat. Because this experiment is not without risks and because we are uncertain if the calcium carbonate has indeed turned into calcium oxide by the heating process, we decided to choose another approach.

4.1 Soaking heavy spar, feldspar potassium and feldspar soda

We choose for this experiment the candidates B, C and D:
- 800ml water with one tablespoon sal ammoniac (as mentioned before)
- Powder of each candidate from 2 balls
- 600ml of this sal ammoniac water
- Powder mixed with this 600 ml
- Examining the behavior of the powders in the water (soluble or insoluble)

B Heavy spar
- It made the water very cloudy
- The biggest granules sunk very fast, it took more time for the fine granules to sink to the bottom
- After waiting a couple of minutes all the heavy spar did sunk to the bottom which would mean it is insoluble in water

C Feldspar potassium
- It made the water cloudy
- It sunk to the bottom quickly which indicates its insolubility in water
- The color turned pink
D  **Feldspar soda**
- It made the water a little cloudy
- It sunk to the bottom very quickly which indicates it is insoluble in water
- The color turned darker orange in the water than before

4.2  **Soaking calcium oxide: making slaked lime**
For safety reasons we decided to carry out this experiment in a fume hood since the gasses and heat could escape more easily. We wore gloves, a lab coat and safety glasses during the experiment. We decided to start with a small amount of calcium oxide and test it with a small amount of water, to see if there was a lot of heat produced. We did use the water mixed with sal ammoniac because this had already reacted with each other in an earlier stage. The only thing that happened was the forming of the gaseous ammonia, which went away in the fume hood. Since the first test is successful, we continued adding powder and water like in the experiment with the candidates B, C and D.

**Experiment:**
- First we tried a small piece of the shell (1cm by 1cm) with a couple of drops of water. The water did not react with the piece.
- Then we pulverized one ball and tested a little amount of the powder with a little amount of water (70 ml), but nothing happened either.
- We mixed all the powder of one ball with 300 ml water. The water did become cloudy but it sank very quickly at the bottom: it did not dissolve in the water. There was no heat produced which would indicate the reaction to calcium hydroxide. Because of this result we decided to continue with the experiment as we did with the candidates B, C and D.
- We added the second pulverized ball to the same mixture, without adding more water. During stirring it suddenly became very hot, which indicated the reaction finally taking place. It stayed very hot for approximately 12 minutes. The calcium oxide totally dissolved into the water, which became milky and thick.

**Experiment 5: Making sand- and liquid molds**
In this experiment we want to examine the various materials on shrinking and cracking. Unfortunately it is not evident for which exact casting the author uses the spat. On one hand he mentions ‘excellent sand for box molds’ which could indicate sand casting. But on the other hand he describes casting an animal or lizard with the spat (folio 119v_b2), which could suggest life-casting with plaster. In both techniques it is desirable to make a good imprint of an object. With this experiment we want to examine if it is possible to make an imprint and analyze the quality of it. For these reasons we decided to examine a more sandy structure and a liquid version of each material. For the sandy structure we try to make an imprint on top of it, and for the liquid we decided to put a simple form on the bottom of the mold. In this manner we could possibly analyze how the various materials act in two different casting techniques.

5.1  **Preparation of the molds**
After the soaking experiment we waited until all the powder remained at the bottom (except from the slaked lime), then we drained the water out of the glasses. We took a metal muffin form with 12 molds. We measured 1,5 centimeters from the bottom of
each mold and indicated this line with tape. In this manner we are able to pour the same amount into each mold. We choose a simple, round, releasable form (a plastic cap) of which we had 6 similar ones. Because of the limitations of 12 molds we started with the materials B, C and D, and after that experiment was finished, we did the same with material E.

Making sand molds
We waited until the water was evaporated and the powder turned more like sand. We filled two molds of heavy spar, two molds of feldspar potassium and also two molds of feldspar soda with this sand mixture. In this sand we tried to make an imprint.

Making liquid molds
We put down the 6 forms in the bottom of the other 6 molds. We moistened each material again with a little sal ammoniac water, until the mixture was liquid again, the consistency of yoghurt. We poured the liquid over the form in the mold, again two molds with heavy spar, two with feldspar potassium and two with feldspar soda.

We decided to dry the molds overnight at room temperature. Because the molds were not dry enough, the next day we chose to put the molds in an oven for two hours in 50 degrees Celsius.

5.2 Results of the molds

B: Heavy spar
The color of both molds is dark grey.
Sand mold:
It is possible to make an imprint, but the granules of the heavy spar are too coarse which makes the imprint less detailed. The whole mold is very granular and there is not a lot of cohesion, but many interstices. The mold of heavy spar does not seem to be a suitable material for sand casting.
Liquid mold:
The liquid mold is less rough compared to the sand mold. Also, it is less dark in color. There is a little bit more coherence between the granules but still a lot of big gaps inside the mold. When taking out the cap, one mold breaks in the center and the other also breaks into pieces. The liquid mold of heavy spar does not seem to be a suitable material for life-casting.

C: Feldspar potassium
The color of both molds is pink.
Sand mold:
In comparison with the other two materials the feldspar potassium did not evaporate very easily. It took a lot of time until it had the consistency of sand. The imprint was difficult to make, because the cap kept sticking to the sand. After removing the cap a part of the sand was also removed. Besides that, the imprint did not stay in the sand because of the insolubility of the feldspar potassium in water. The water remained at the top and made the imprint disappear. After drying there was nothing left of the imprint. The structure of the feldspar potassium is very dense, but there are a lot of big air bubbles in the bottom of the sand molds. There are also some cracks along the edges of the mold, and a little shrinkage of the whole mold. The mold of feldspar potassium does not seem to be a suitable material for sand casting.
Liquid mold:
The imprint of the cap in the liquid mold had sharp rounds along the edges with a lot of good detail. It is impossible to take the cap out of the mold without damaging it, the mold breaks easily into parts. The bottom of the liquid mold does not consist of big air bubbles, only a couple of small ones. Beside the shrinking and cracking, the liquid mold could possibly be a suitable material for life-casting.

D: Feldspar soda
The color of both molds is orange.

Sand mold:
The feldspar soda sand mold reacts exactly the same as the feldspar potassium, which means it is impossible to make an imprint. On the bottom of the sand mold there are also lot of air bubbles, the same as compared to feldspar potassium. The only difference between the sand mold of the two feldspars is that there has occurred less cracking in the feldspar soda.

Liquid mold:
The imprint of the liquid mold is, just like feldspar potassium, very detailed with sharp edges. But is also impossible to take the cap out of the mold without damaging it. The bottom of the mold consists of more and bigger air bubbles in comparison to the liquid mold of feldspar potassium. The liquid mold of feldspar soda could possibly be a suitable material for life-casting.

E: Calcium carbonate -> Slaked lime
The color of both molds is white with a little grey in it.

Sand mold:
It is difficult to make an imprint in the sand mold of slaked lime: the cap sticks to the sand. After drying it is unfortunately impossible to take the molds out of the muffin forms. Both the sand mold and the liquid mold stick in the forms. The little imprint, which is left on the mold, has sharp edges. The edges of the molds are cracked and there are some bursts in the center of the molds. We try to take one mold out of the form, but by doing that we broke the mold into pieces, which fell apart in powder. Beside the cracking and breaking, the small pieces with an imprint in it are detailed and sharp, which could indicate that slaked lime is possibly a suitable material for sand casting.

Liquid mold:
Unfortunately it is not possible to take the molds out of the form. For this reason we can not analyze if slaked lime would a possibility for a suitable material for life-casting.
Appendix 2 Photos

Experiment 1: Characteristics

Fig. 1: Weighing the materials

Experiment 2: Preparation of spat

Fig. 3: Preparing the balls

Fig. 4: Mixing the powder with the moisture, in this photo heavy spar.

Fig. 5: Making the balls, in this photo heavy spar.

Fig. 6: Break test, in this photo feldspar soda
Experiment 3: Grinding the balls

Fig. 7: The prepared balls before heating

Fig. 8: The furnace

Fig. 9: The balls after heating

Fig 10: Grinding the balls, in this photo heavy spar

Fig. 11: The calcium oxide ball after heating

Fig. 12: Comparing the powders after heating. In this photo left: calcium carbonate, right: calcium oxide
Experiment 4: Soaking the powders

Fig. 13: Mixing the powders with sal ammoniac water. In this photo feldspar potassium.

Fig. 14: Mixing the powders with sal ammoniac water. In this photo feldspar soda.

Fig. 15: Mixing the calcium oxide with sal ammoniac water.

Fig. 16: The reaction of calcium oxide with water formed slaked lime.

Experiment 5: Making sand- and liquid molds

Fig. 17: Preparing the sand molds (left) and liquid molds (right).

Fig. 18: The results of the sand- and liquid molds. From top to bottom: heavy spar, feldspar potassium and feldspar soda.
Fig. 19: The sand molds after drying

Fig. 20: The sand mold of slaked lime after drying

Fig. 21: The liquid molds after drying

Fig. 22: The liquid mold of slaked lime after drying

Fig. 23: Close-up of the liquid mold of feldspar soda
Literature

Agricola, Georgius
1612 Georgii Agricolae De ortu & causis subterraneorum lib. V ; De natura eorum quæ efluunt ex terra Lib. IV ; De natura fossilium Lib. X ; De veteribus & novis metallis Lib. II ; Bermannus, sive de re metallica dialogus, interpretatio Germanica vocum rei metallicae, addito indice facundissimo ; Scholiis margin. illustr. a Joa. Sigfrido ; acc. De metallicis rebus et nomin. observationes ex schedis Geo. Fabricii. Wittebergae.

Berrie, Barbara H.

Chomel, Noel

Deer, W.A., R. A. Howie and J. Zussman

Eastaugh, Nicholas


Hamer, F. and J. Hamer


Hill, John

Heer, A.R.E. de

Hoover, C.H. and L.H. Hoover (eds.)
1950 De re metallica / Georgius Agricola ; transl. from the first Latin ed. of 1556 ; with biogr. introd., ann. and appendices upon the development of mining methods, metallurgical processes, geology, mineralogy & mining law from the earliest times to the 16th century by Herbert Clark Hoover and Lou Henry Hoover. New York: Dover Publications.
Krünitz, Johann Georg

Kunckel, Johann

Lein, Edgar

Platt, Hugh

Ranouw, W. van
1723  *Kabinet der natuurlyke historien, wetenschappen, konsten en handwerken*. Te Amsterdam: by Hendrik Strik, p.102.


Trommsdorf, Johann Bartholomäus

Volkelt, Johann Gottlieb

Webster, Noah
1828  *A dictionary of the English language: intended to exhibit I. The origin and the affinities of every English word (...) : to which are prefixed an introductory dissertation on the origin, history and connection of the languages of Western Asia and of Europe: and a concise grammar, philosophical and practical, of the English language. Vol. II*. London: Black, Young, and Young.

Wilkes of Milland House Sussex, John
1810  *Encyclopædia Londinensis; or, universal dictionary of arts, sciences, and literature*. London: printed for the Proprietor, by J. Adlard, Duke-Street, West Smithfield; sold at the Encyclopædia Office, Ave-Maria-Lane, St. Paul's; by J. White, Fleet-Street; and Champante and Whitrow, Jewry-Street, Aldgate.