

THE STOCKHOLM PAPYRUS

An English Translation with Brief Notes

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I. Introduction

In a recent issue of *THIS JOURNAL*, the writer had the privilege of publishing an English translation of the famous Leyden Papyrus X together with a few brief comments and notes on its history, contents, and significance.¹ The present article is a similar translation of the contents of the less well-known Stockholm Papyrus. This papyrus likewise has never been translated into English as far as the writer is aware, although Stillman in his interesting "Story of Early Chemistry," has paraphrased several of the most representative recipes. It is offered here in the hope that it will prove of some interest to teachers and students of the history of chemistry. The contents of the papyrus are equally important for the early history of technical chemistry and, if anything, are more varied and comprehensive than those of the one at Leyden. As a matter of fact the two papyri are complementary and taken together they give an excellent cross-sectional view of the operations and aims of chemical technology in the beginning centuries of the Christian Era. They are the only original laboratory documents that have come down to us from that period and hence their great value for the history of chemistry, especially on account of the light they throw upon the beginnings of alchemy.

Both of these earliest chemical manuscripts were brought to light in the early years of the last century by Johann d'Anastasy, the vice-consul of Sweden at Alexandria, Egypt. This collector sold the major portion of his invaluable collection of papyri to the Netherlands government in the year 1828. Included in this collection of papyri was the Leyden Papyrus X, first translated (into Latin) and made public by Leemans in 1885. At that time it was believed by historians of chemistry that this was the sole original document relating to chemical technology that was dated as early as the third century A.D. In the year 1913, however, Otto Lagercrantz, a Swedish philologist, published the Greek text with a German translation and an extended commentary of a very similar chemical papyrus.² His investigations as to the source of the papyrus developed the fact that it had been presented by Johann d'Anastasy, the discoverer of the Leyden Papyrus, to the Swedish Academy of Antiquities at Stockholm in the year 1832. Here it had unfortunately remained unnoticed for some seventy-five years until it was transferred

¹ See *THIS JOURNAL*, 3, 1149-66 (Oct., 1926).

² Otto Lagercrantz, "Papyrus Graecus Holmiensis," Almquist and Wiksells, Uppsala, Sweden, 1913.

to the Victoria Museum at Upsala, Sweden, in the year 1906. It was there brought to the attention of the above-named scholar, who first published its contents in the year 1913 giving it the title *Papyrus Graecus Holmiensis* or in other words the Stockholm Papyrus. This philologist made a very thorough study of the contents, language, and symbols of the papyrus and carefully compared it with the one at Leyden. His philological studies made it evident that the two papyri were both written at the same period and indeed in part at least by the same unknown writer. The Leyden Papyrus, however, deals chiefly with metals and alloys and makes little or no mention of some of the other phases of technical chemistry. This singular fact was remarked by Berthelot in his studies of the document.³ The Stockholm Papyrus, on the other hand, deals only slightly with metals and alloys and emphasizes the arts of dyeing, imitating precious stones, and other operations. Taken together they form a technical recipe book of the chemical arts as they were known and practiced about the third or fourth centuries A.D.

The Stockholm Papyrus is formed of fifteen loose papyrus leaves measuring about thirty centimeters in length and about sixteen centimeters in width. These correspond very nearly in size with the double sheets of the Leyden Papyrus X. Like the Leyden Papyrus it is in an excellent state of preservation. There are from forty-one to forty-seven closely written lines of Greek capital letters on each page. The pages are numbered consecutively although the separate recipes are not. It is purely and simply a collection of recipes like the Leyden Papyrus with but few traces of any theoretical considerations. There are numerous duplications, abbreviations, and omissions in these recipes as though, as was probably the case, they were simply intended as reminders to those already skilled in the practice of the arts they deal with. A total of one hundred fifty-four recipes is contained in the papyrus. Only nine of these deal with metals. There are some seventy recipes treating of the art of imitating precious stones and of improving the appearance of genuine ones. The remaining recipes deal chiefly with the mordanting and dyeing of cloth. The last one is of quite a different character than the remainder and its significance will be discussed in the brief commentary following the translation.

The translation which now follows is based upon both the Greek text and the German translation of Lagercrantz. An endeavor has been made to give a faithful English version as far as possible although the exact nature of some of the substances mentioned in the papyrus is difficult to determine with accuracy. For these cases and for others where a little explanation is deemed necessary brief notes follow the recipe containing

³ Berthelot, "Introduction a l'Étude de la Chimie Des Anciens et du Moyen Age," Paris, 1889.

them. Words in parentheses are lacking in the original but are added to give a true meaning in English where it has been thought necessary. For purposes of greater convenience in referring to them the translator has taken the liberty of numbering the recipes consecutively although in neither the original nor in the German translations of Lagercrantz was this done. A few short comments upon the chemical aspects and the general technical significance of the recipes will follow the translation.

II. The Translation

1. *Manufacture of Silver.*

Plunge Cyprian copper, which is well worked and shingled for use, into dyer's vinegar and alum and let soak for three days. Then for every mina of copper mix in 6 drachmas each of, earth of Chios, salt of Cappadocia and lamellose alum, and cast. Cast skillfully, however, and it will prove to be regular silver. Place in it not more than 20 drachmas of good, unfalsified, proof silver, which the whole mixture retains and (this) will make it imperishable.

Many of the substances used in ancient times were named according to their place of origin rather than from their chemical nature. This is well shown in this recipe. The island of Cyprus was a famous source of copper in ancient times. The term alum or "alumen" referred to a variety of natural products which were usually impure mixtures of iron and aluminum sulfates put up in various forms. The "earth of Chios" was probably a kind of a clay, while "salt of Cappadocia" was our common salt, from a chemical point of view.

2. *Another (Recipe).*

Anaxilaus traces back to Democrites also the following recipe. He rubbed common salt together with lamellose alum in vinegar and formed very fine small cones from these and let them dry for three days in the bath chamber. Then he ground them small, cast copper together with them three times and cooled, quenching in sea water. Whatever comes out will show a purification.

3. *Another (Recipe).*

Purify white tin four times and melt together 6 parts of this and 1 mina of white Galatian copper; rub off and make what you wish. It will be silver of the first quality, except that the artisans can notice something (peculiar) about it because it is formed by the procedure mentioned.

4. *Purification of Tin.*

The purification of tin, which enters into the alloy with silver, is done in the following way. Let pure tin cool, coat it with oil and bitumen, and melt it four times. Lay it aside after washing in a clean manner. Alloy 6 parts of this and 7 parts of Galatian copper with 4 parts of silver and it will be regarded as wrought silver.

5. *Doubling of Silver.*

It is done by different procedures. Melt Cyprian copper, which is purified with "coral," six times and add silver for the purpose of doubling.

6. *Another (Recipe).*

Dip clippings from small copper plates into brine and let them soak six days in alum and brilliant earth which have been previously dissolved in fresh water. Melt it afterwards and gradually alloy silver with it.

The exact nature of the shining or brilliant earth mentioned in this recipe and the following one is impossible to determine.

7. *Another (Recipe).*

In addition to these recipes (is) also the following. Galatian copper $\frac{1}{2}$ part, silver, and ordinary tin, which the western Iberians among whom it is produced call bulla just as the Romans do. The copper is first melted, then the silver, and after two heatings, the tin. Then when the whole has become soft, remelt it many times and cool with brilliant earth, held in readiness, which is previously dissolved in spring water. Take out and quench the resulting lumps, heat them again, and indeed many times, until very white silver comes from them. Remove then and shingle, rub and polish with talc, and work up the silver thus doubled. And tripling is done in the same way with the above-mentioned distribution of weights.

8. *(No Title.)*

On the other hand, an inexhaustible mass can be prepared from the foregoing recipe for doubling. Take off 8 drachmas from the lump, mix just as many drachmas of silver with the lump, and remelt it at the same time. Do this three times, cool, and set away in talc.

9. *Manufacture of Silver.*

Buy charcoal which the smiths use and soften it in vinegar one day. After that, take 1 ounce of copper, soak it thoroughly in alum, and melt it. After that, take 8 ounces of mercury but pour out the mercury thus measured into a secretion of poppy juice. Take also 1 ounce of silver. Put these materials together and melt; and when you have melted them, put the lumps so formed in a copper vessel with the urine of a pregnant animal and iron filing dust (for) 3 days. And the singular cloudiness which you will get on taking out is a sign of the natural fluctuation by which the mixture finds itself of equal composition by weight.

10. *Whitening of Pearls.*

To make brownish pearls white when this is due to smoke. Take about 1 obulus of honey which is unadulterated and add to it 2 cups of cistern water. Make honey water out of this and pour it in a small jar. Bruise fig root small and put it in. If it pops while you are cooking it remove away from the fire and calm it with the liquor. After you have made it really soft, and have stirred and measured it with the nail, smear the pearls with it and let it harden. Wipe it off with a pure linen rag and the pearls will at once show their whiteness. If they do not yet appear to you to have become entirely white, coat them anew, for the more you coat them and wipe them off the whiter they become. However, when it is cooked, do not cook it again, but use it all at once (and) at the same time.

11. *Another (Recipe).*

Take the pieces of mother of pearl or the pearls and put them into bitch's milk. Put the cover upon the vessel and leave it there 2 days and 2 nights. Draw them out, as they lie there strung on asses' hair, and observe whether they have become white. If not, put them in again until they become excellent in this respect. If you afterwards besmear a man with this he becomes leprous.

12. *Another (Recipe).*

By the following procedure one likewise makes papyrus sheets, which are written upon, clean again so that they appear as though they never had been written upon. Take and dissolve natron in water. Then put in, when the soda solution has formed, 1 part of raw earth, 1 part of Cimolian earth, and cow's milk in addition so that all of it comes to a glutinous mixture. Then mix in oil of mastic and daub it on with a feather. Let it dry and then scale it off and you will find the pearls white. If they are a deep yellow, daub it on again. If dealing with a papyrus sheet only coat the characters.

The "nitron" of the Greeks referred to the natural deposits of alkaline salts from various sources. The uses to which it was put shows it to have been essentially sodium carbonate so that the term natron as used here is not thought inappropriate as an inclusive term for all such alkaline deposits. Cimolian earth was perhaps a kind of a clay.

13. *Another (Recipe).*

First take and etch the pearls in the urine of an uncorrupted youth; coat them with alum, and let dry on them what remains of the corrosive. Then take and put mercury and fresh bitch's milk into a clay vessel, heat all together and in doing so regulate what takes place. Use only foreign coals and a gentle fire.

14. *Preparation of Carnelian.*

Dissolve alkanet in oil. After that, put in the blood of a pigeon, and fine Sinopian earth and a little vinegar in order that the blood does not coagulate. Place selenite in it, close the vessel and place it amidst the dew for ten days. If you wish to make the stone very brilliant, arrange it so as to wrap it in horse hair, tie this on, and put it in the dye bath.

It is not certain whether what we term as selenite was used here, but at any rate it was some kind of a transparent stone capable of absorbing color, and it appears very probable that our selenite was used.

15. *Preparation of Lapis Lazuli.*

The lapis lazuli employed is first dipped in the bile of a tortoise and then placed in the dye bath for amethyst for just as many days as for this and so forth.

16. *Purification of Crystal.*

The purification of a smoky crystal. Put it in a willow basket, place the basket in the boiler of the bath and leave the crystal there 7 days. Take it out when it is purified, and mix warm lime with vinegar. Stick the stone therein and let it be etched. Finally, color it as you wish.

17. *Preparation of Emerald.*

Take and put so-called topaz stone in liquid alum and leave it there 3 days. Then remove it from this and put it in a small copper vessel in which you have placed pure unadulterated verdigris along with sharp vinegar. Put the cover upon the vessel, close up the cover, and gently keep a fire under the vessel with olive wood for 6 hours, otherwise the longer you maintain the fire, the better and deeper will the stone be—only, as I say, with a gentle fire. Cool and lift the stone out. Its condition will show whether it has become emerald. That is to say, you will observe that a green film has formed upon it. Let it become slowly cooled, however; if not, it soon breaks. Put oil in a small box-tree vessel many days beforehand so that the oil is purified and the product from it can be taken off. Put in the stone and leave it under cover 7 days. On taking out you will have an emerald which resembles the natural ones.

18. *Manufacture of a Pearl.*

Take and grind an easily pulverized stone such as window mica. Take gum tragacanth and let it soften for ten days in cow's milk. When it has become soft, dissolve it until it becomes as thick as glue. Melt Tyrian wax; add to this, in addition, the white of egg. The mercury should amount to 2 parts and the stone 3 parts, but all remaining substances 1 part apiece. Mix (the ground mica and the molten wax) and knead the mixture with mercury. Soften the paste in the gum solution and the contents of the hen's egg. Mix all of the liquids in this way with the paste. Then make the pearl that you intend to, according to a pattern. The paste very shortly turns to stone. Make deep round impressions and bore through it while it is moist. Let the pearl thus solidify and polish it highly. If managed properly it will excell the natural.

19. *Production of Ruby.*

The treating of crystal so that it appears like ruby. Take smoky crystal and make the ordinary stone from it. Take and heat it gradually in the dark; and indeed until it appears to you to have the heat within it. Heat it once more in gold-founder's waste. Take and dip the stone in cedar oil mixed with natural sulphur and leave it in the dye, for the purpose of absorption, until morning.

20. *Preparation of Green Stone.*

Take and work crystal—(that) with the surname, chimney (crystal)—weighing not more than two drachmas, into ordinary stones. Take and grind Macedonian verdigris and the leaves of wintercherry to suitable fineness. Dissolve the rubbings in sharp vinegar and heat the vessel with a gentle fire until the stones become green. These stones also should hang in a basket so that one can take them out and see whether they have become green. If not, put them in again until they become so.

21. *Another (Recipe).*

Verdigris and vinegar, verdigris and oil, verdigris and calves' bile; these form emerald.

22. *Preparation of a Pearl.*

Etch crystal in urine and alum for several days. Take and boil together over a gentle fire with the crystal the juice of the scarlet pimpernel, which bears blue flowers, of houseleek, and of spurge; and besides the juices, mercury in addition.

23. *Preparation of a Pearl.*

Etch crystal in the urine of an uncorrupted youth and round alum; then dip it in mercury and woman's milk.

24. *Corroding of Stones.*

A corrosive for any stone. Equal amounts of alum and natron are boiled in an equal amount of water. The small stones are then etched. Previously warm them slightly near the fire and dip them in the corrosive. Do this for a while once to three times while the corrosive boils; dip and leave again three times but no more, so that the small stones do not break.

25. *Whitening of a Pearl.*

A dark pearl is made white by the following method. Give it to a cock to swallow, cut him open immediately, and you will find that the pearl has become white.

26. *Corrosion of Sunstone.*

A corroding of sunstone which boils it at the same time. Boil together seeds of mezereon and vinegar with the stone until a third of the fluid remains behind.

27. *Opening Up of Stones.*

Make sure that the stones are receptive; and that the dense stone is loosened up. Place it in a soft fig, lay upon the coals, and the stone will immediately change.

28. *Preservation of Crystal.*

In order that small stones which are prepared from crystal do not break into pieces, take and open a fig, put the stone therein, and lay the fig upon the coals to roast.

29. *Corroding of Stones.*

Let urine and alum putrify and remain together with the stones for 30 days. Then take the stones out and stick them in soft figs or dates. These stones should also be worked on the coals. Therefore, blow with the bellows until the figs or the dates burn and become charcoal. Then seize the stone, not with the hand but with the tongs, and put it directly into the dye bath

while still warm, and let it cool there. Make as many stones as you wish of, however, not more than 2 drachmas (each in weight). The dye bath should, however, be like paste.

30. *Preparation of Emerald.*

To prepare emerald from crystal. Take a clay vessel, mix in it round alum with water, and put it aside. Take transparent wax of equal weight with the crystal—of this latter not more than 2 drachmas can be transformed—melt, and put it aside in a vessel. Take the crystal and put it in the alum a day and a night. In this way it becomes, of course, bluish. Then take it out and coat it with the wax. Then take the crystal out of the wax and put it in verdigris, but have the 1 ounce of verdigris pulverized; and boil the crystal for 6 hours in a small vessel containing 6 cups. Then place it in the verdigris a day and a night. Take it out on the next day.

31. *Boiling of Stones.*

If you wish to make ruby from crystal, which is worked to any desired end, take and put it in the pan and stir up turpentine balsam and a little pulverized alkanet there until the dye liquid rises; and then take care of the stone.

32. *Preparation of Emerald.*

Unadulterated verdigris; copper green; bile of tortoise (and) of steers 2 parts; smoky crystal.

33. *Preservation of Crystal.*

So that it neither splits nor breaks. Take and mix the white of a goose's egg with talc. Make it of pasty thickness and smear the crystal with it. Then put it in linen, bind this around it and leave 3 days in the dew and the sunshine. Untie after the three days and work the stone.

34. *Preparation of Emerald.*

Boil for 1 hour, 1 part of roasted copper, 2 parts of verdigris, (and) as much Pontic honey as is needed.

35. *Another (Preparation).*

Take rainbow-colored Indian crystal, shape from it the small stones that you desire, and soften them. Afterwards, take equal weights of flaky alum and "garlic" and rub them fine with very sharp vinegar until the whole becomes pastelike in thickness. Put the small stones in it and leave them there 3 days. After this, pour vinegar upon the mixture so that it becomes fluid, pour it over into a foreign pot, hang the stones there in a basket so that they do not touch the bottom of the vessel, and gently boil upon the coals. However, the pot should be provided with a cover and be coated with tallow. Blow with the bellows so that the fire does not become extinguished. Heat for two hours. Then take equal parts of both Macedonian copper green and verdigris and $\frac{1}{2}$ a part of the bile of a calf and grind all extremely fine. Then pour thereupon the oil from unripe olives, measuring with the eye. Then take wax, rub the stones over with it, and leave them with the oil alone, or with castor oil besides, which you place in the small pot. Again hang the stones in a basket and heat for 6 hours. Rehang the stones once more on a horse hair and let them remain in the mixture over night. Then take them out and you will find that they have changed to emeralds.

The true meaning of the term "garlic" is explained in recipe No. 51. This is an excellent example of the use of veiled terms and hidden meanings, a practice which was common among the early workers.

36. *Softening of Crystal.*

To soften crystal take goat's blood and dip crystal, which you have previously heated over a gentle fire, into it until it suits you.

37. *Softening of Emerald.*

Stick hard emerald into wax for 14 days. After this period, grate "garlic" and make a cake out of it. Take the stone out (of the wax) and stick it into the cake of "garlic" for 7 days. Take leek and extract the juice out of it. Mix with the leek juice an equal amount of oil, put this in a new pot, put the stones in it at the same time and boil 3 days (or) until they become satisfactory to you. The stones should be in a basket so that they do not touch the bottom of the pot.

38. *General Preliminary Corrosion.*

The plant heliotrope along with its blossom serves for the corrosion of every stone; for opening up, agglomeration and corroding. For without this plant, which the stones absorb, neither crystal nor the so-called topaz, that is carried down from Egypt, can be opened up. Apply also the juice of the plant for the preliminary corrosion and you will have luck with the coloring.

39. *Preparation of Beryl.*

Take rock crystal, string it on a hair, and hang it in a jar with the urine of a she-ass in such a manner that the stone does not touch the urine. The jar should be closed 3 days. After this lapse of time place the jar over a gentle fire and you will find an excellent beryl.

40. *Special Corrosion of Crystal.*

Dissolve sulphur, quicklime, (and) alum in vinegar. Do this three or four times, let it absorb the solution for 3 or 4 days, and then use in the following recipe.

41. *Preliminary Dipping.*

Dip the stones beforehand in this:—salt 1 part; water $\frac{1}{10}$ part. The stones (are) to be previously plunged in this material. Warm them again, after they are dried, over the opening of the oven. Then make out of the stones what you desire.

42. *Preparation of Emerald.*

Mix 1 part of roasted copper (and) 2 parts of verdigris with honey and place it upon the ashes. Let it cook and place the crystal in it.

43. *Another (Preparation).*

Mix $\frac{1}{2}$ a drachma of copper green, an equal quantity of Armenian blue, $\frac{1}{2}$ a cup of the urine of an uncorrupted youth, two-thirds of the fluid of a steer's gall, and put into it the stones weighing $\frac{1}{12}$ of a drachma each. Place the cover upon the vessel, lute the cover with clay, and heat for 6 hours with a gentle fire of hard olive wood. However provided that this sign appears—(namely) that the cover becomes green—then heat no further but let the stones cool down, lift them out and you will find that they have become emeralds. The stones are of crystal. If crystal is boiled in castor oil it becomes black.

Armenian blue was probably some kind of a copper mineral or an oxidation product of the same.

44. *Preparation of Amethyst.*

Corrode the stones beforehand with three times as much alum as stone. Cook them in it until it boils thrice, and let them cool down. Take and soften krimnos with vinegar. Then take and boil the stones in it as long as you like.

The substance "krimnos" is frequently mentioned in these recipes. It was evidently a red dyestuff, but its exact source and nature is unknown to us.

45. *Preparation of Chrysolite.*

Heat crystal, dip it in liquid pitch and cedar oil, and it will thence become chrysolite.

46. *Preparation of Lychnis.*

Corrode the stones beforehand as set forth above. In this manner take archil, alkanet, and vinegar and place the stone therein as long as desired.

According to Pliny (Natural History XXXVII, 103) this stone was red in color like the ruby.

47. *Preparation of Beryl.*

Mix Indian black with resin and heat crystal. If you let it cool in the mixture then excellent beryl comes forth from it.

48. *Another (Preparation).*

Make a solution from the bile of a tortoise together with the milk of a pregnant animal, copper, and sharp vinegar; and in this solution beryl will come into existence from stone. Only the experts can discover (the fraud).

49. *Preparation of Jasper.*

Heat the stone, then corrode it in alum along with vinegar and put it in verdigris and calves' gall.

50. *Preparation of Sunstone.*

Boil liquid pitch and alkanet, put the stone in it and it will thence become sunstone; or in the juice of mulberries; or in ground kermes with vinegar; or in Armenian blue with calves' gall.

51. *Corrosion of Crystal.*

Before one puts it in for coloring. Grind 1 part of quicklime and 1 part of natural sulphur. Add vinegar and put the stones in it. And in the third place it states thus; human excrement is, as they say, garlic.

This latter sentence, which appears to have no connection with the remainder of the recipe, is apparently a reference to some other work. It is of value in showing the use of cryptic words and secret meanings.

52. *Preparation of Sunstone.*

Take equal parts of sulphur, vinegar, and calves' gall. First-class, flawless sunstone is turned out with this mixture.

53. *Corroding and Opening Up of Stones.*

Grind alum and melt it carefully in vinegar. Put the stones therein, boil it up, and leave them there over night. Runse them off, however, on the following day and color them as you wish by use of the recipes for coloring.

54. *Another (Recipe).*

Put the stones in a dish, lay another dish on it as a cover, lute the joint with clay, and let the stones be roasted for a time under supervision. Then remove the cover gradually and pour alum and vinegar upon the stones. Then afterward color the stones with the dye as you wish.

55. *Corrosion of Crystal.*

Crystal, which undergoes uninterrupted corrosion a day and a night, becomes bluish.

56. *Bleaching of Crystal.*

Dissolve rice in water, put the crystal in, and again boil the solution with it.

57. *Softening of Crystal.*

Soften crystal by cooking in goat's blood. The same recipe also applies to glass.

58. *Preparation of Sunstone.*

First etch smoky stone in alum and water for 7 days, then heat it gradually and put it in cedar oil with the tongs.

59. *Substitute for Castor Oil.*

All crystal becomes dark by boiling in castor oil. On that account do not use the substance where it states "with castor oil," for the material is to be substituted. Use olive oil instead of castor oil.

60. *Cleaning of a Pearl.*

When perchance a genuine pearl becomes faded and dirty through use the Indians are accustomed to cleaning it in the following manner. They give the pearl to a rooster as food in the evening. In the morning they search for it again in the excretion and ascertain that the pearl has become clean in the crop of the bird; and, moreover, has acquired a whiteness which is not inferior to the former.

61. *Another (Recipe).*

Quicklime, which if not yet slaked in water after burning in the oven, curiously carries over the imperceptible (and) transmissible fire. They dissolve (it) in dog's milk—from a white she-dog, however. They then knead the lime and rub it around about the pearl and leave it 1 day in this manner. After they have wiped off the lime, they find out that the pearl has become white.

62. *Preparation of Sunstone.*

Mix dragon's blood, ordinary sap of balsam tree, resin of Palestine—or if that is not at hand (resin) of Tomi—and Pontic alkanet; and soak the opened-up crystal therein. Now if the preparation is unmixed sunstone comes forth. If, however, a little fluid pitch is mixed with the above mixture then ruby is likely to result.

63. *Preparation of Beryl.*

Crystal has a considerable relationship with beryl on the basis of resemblance and you will get beryl out of crystal if you open up this stone, cool down after heating, and put it inside the fore-named resin and the indigo mixed with it. If it is put inside the preparation (while) still hot, then colored hyacinth is formed from it.

64. *Preparation of Chrysoprase.*

If celandine is mixed with indigo a green color results. Take, however, resin besides—it is a suitable substance for dyeing—put crystal in this mixture after the opening up of it, leave it to absorb therefrom and chrysoprase stone comes forth.

65. *Preparation of Chrysolite.*

Chrysolite results when you heat crystal and put it in fluid pitch and celandine mixed.

66. *Corrosion of Stones.*

The corroding of stones should be done in about the following manner. Put the stones in open clay pans and lay covers upon them. Close them with clay and place them upon the grate. Then gradually take the covers off and dip the stones in alum soaked in vinegar. Then heat them again and put them in the dyes made lukewarm.

67. *Another (Recipe).*

Finally in another way. Put the stones in a pan, lay thereupon another pan as a cover, and heat them gradually. Then gently take the cover off and pour alum along with vinegar over the stones. Color them with the color that you desire.

68. *Corrosion of Crystal.*

A special corrosion of crystal. It is put in sulphur, quicklime, and alum together with vinegar, three or four times. However, leave it to absorb therefrom 3 or 4 days and then apply the following recipe.

69. *Corrosion of All Kinds of Stones.*

The plant heliotrope, which produces clusters, serves for the general opening up and corrosion of every stone. Extract the juice from it, open up the stones therein, and you will have good luck with the coloring of every stone.

70. *The Kinds of Stones to Color.*

The suitable stones for coloring are crystal and topaz. Pyrites has the tendency to become gradually red. Boil (the stones), however, whilst you exclude everything, in a small protected house which stands opposite to any adverse wind.

The pyrites mentioned here is certainly not the mineral that we call by that name. Great uncertainty exists as to just what the Ancients did mean by their term pyrites. Compare Pliny, Book XXXVII, 189, and Book XXXVI, 137, with Dioscorides V, 84, to see the confusion concerning this word.

71. *Preparation of Emerald.*

Mix copper green, the urine of a boy, and calves' bile in a new pot. Lute the cover with clay, but previously put the crystals in the pot, and cook it for 5 hours with a gentle fire of olive wood. You will suddenly see by the cover when it is to be heated no more. Cool and take them out. The cover of the pot should, however, be unbaked.

72. *Another (Preparation).*

Preparation for another rough emerald. Stick the stone in natron for 5 days. Then stick it in a lump of ground "garlic" for 7 days. But after the lapse of this time draw the juice from a leek and mix along with it an equal quantity of oil. Put this in a new pot and boil it 3 days until the stones absorb it. The cover should be unbaked.

73. *Another (Recipe).*

Rub with vinegar: 1 part of very fine verdigris; an equal amount of alum; roasted copper, a quantity equal to both the other materials; and bring it to a pasty thickness. Put the small stones therein and let them be baked for 7 days.

74. *Preparation of Verdigris for Emerald.*

Clean a well-made sheet of Cyprian copper by means of pumice stone and water, dry, and smear it very lightly with a very little oil. Spread it out and tie a cord around it. Then hang it in cask with sharp vinegar so that it does not touch the vinegar, and carefully close the cask so that no evaporation takes place. Now if you put it in in the morning, then scrape off the verdigris carefully in the evening, but if you put it in in the evening, then scrape it off in the morning, and suspend it again until the sheet becomes used up. However, as often as you scrape it off again smear the sheet with oil as explained previously. The vinegar is (thus rendered) unfit for use.

75. *Preparation of Beryl.*

Tie crystal around with a hair and hang it in a pot along with the urine of a she-ass for 3 days, but the crystal is not permitted to touch the urine. The pot should be closed, however. Then place the pot over a gentle fire and you will find a very good beryl.

76. *Preparation of Emerald.*

Take pure pyrites or rock crystal and make the composition in the following way: Verdigris, 2 drachmas; celandine, 1 drachma; Scythian black, 3 drachmas; liquid resin,

which one holds in the mouth, as much as necessary. Pulverize the dry materials, mix the resin with them, and set it aside. Take liquid alum, pour water upon it so that it becomes very watery and preserve it in a clay vessel. Heat the stone in an earthen vessel and cool it off in the alum. Heat the stone and put it in the above-named composition. However, if you desire that it should be greener then again mix pulverized verdigris with it.

The chemical nature of Scythian black is unknown.

77. *Another (Recipe).*

Grind scraped-off verdigris and soften in oil a day and a night. Boil the stones therein with a gentle flame as long as desired.

78. *Preparation of Emerald.*

Dissolve alum with vinegar in an earthen vessel and set it aside. Take crystal and leave it therein a day and a night. Then take it and coat it with wax or clay. After that, cook it in oil. If, however, the stone is hard hang it in honey. Then lift it out and put it in copper green a day and a night. Take it out and cover it so that no evaporation occurs. After that, smear it again with the materials until it becomes emerald.

79. *Preparation of Emerald.*

Mix: copper green, 9 drachmas; celandine, 1 drachma; verdigris, 1 drachma; indigo, 3 oboli; (and) resin. Coat the stones with this mixture.

80. *The Dissolving of Comarum.*

Take and put lye from ashes upon comarum. Place it upon the fire a night and a day and it will become dissolved. The lye from ashes is, however, according to the following preparation. Place ashes in sufficient water and put this in a pot. Make a cavity and put quicklime in the hole. Pour in it the lye from the ashes and it will flow pure through the palm flower wrapping. Apply this material for dissolving.

The substance called "comarum" was used as a mordant in coloring stones and cloth. Its exact nature is not known.

81. *Another (Recipe).*

Several have also undertaken the dissolving with this, namely "capnelaion," which is a very dear substance; others again with the sap of balsam trees.

82. *Another (Recipe).*

The dissolving of comarum. Put in a pot about two pints of spring water. When this has been boiled once, put in the pot a third of gum tragacanth and a third of cleaned and washed comarum which you have finely pulverized. However, when this has boiled six times take it away from the fire—but boil with a gentle fire. Place it again upon the ground, let it cool off for several days and use it thus. The solution of comarum is also useful as a preliminary coating for every stone.

83. *Preparation of Emerald.*

Mix and put together in a small jar $\frac{1}{2}$ a drachma of copper green, $\frac{1}{2}$ a drachma of Armenian blue, $\frac{1}{2}$ a cup of the urine of an uncorrupted youth, and two-thirds of the fluid of a steer's gall. Put entire stones therein, indeed (about) 24 pieces, so that they weigh about $\frac{1}{2}$ an obolus. Lay the cover upon the pot, lute the cover all around with clay, and boil it with a gentle fire for six hours, at which olive wood is to be burned. But if this sign appears, namely, that the cover becomes green, then heat no more, but cool off and take the stones out. Thus you will find that they have become emeralds. The stones are of crystal. All crystal, however, changes its color by boiling.

84. *A Dye Liquor for 3 Colors.*

A dye liquor from which three dye solutions can come. Bruise and mix with water $\frac{2}{3}$ of a part of Krimmos and 1 part of dyer's alum. Put the wool in and it becomes scarlet red. If it is to be leek green add ground sulphur with water. If, however, it is to be quince yellow then add unadulterated natron along with water.

85. *Cleaning with Soap Weed.*

Cleaning with soap weed is done in the following way. Take and bruise soap weed, put it in water and heat it. Then put the wool in and shake it a little. Lift out and dry it. Then mordant it afterwards.

86. *For Purple.*

Boil asphodel and natron, put the wool in it 8 drachmas at a time, and rinse it out. Then take and bruise 1 mina of grape skins, mix these with vinegar and let stand 6 hours. Then boil the mixture and put the wool in.

87. *Mordanting.*

Boil chalcantum and skorpiurus and employ for any desired color. These substances, however, also mordant all kinds of stones and skins.

The term "chalcantum" was used to denote various products of the weathering of iron and copper pyrites and hence was either copper or iron sulfate or mixtures of these salts. The Greek word "skorpiurus" was, according to some, a name given to one of a species of sapindaceous plants.

88. *The Dissolving of Alkanet.*

Alkanet is dissolved by oil, water, and nuts. The best of all dissolving mediums is, however, camel's urine. For this makes the alkanet dye not only fast, but also durable.

89. *Another (Recipe).*

Bruise alkanet and mix natron with it until it gets blood-colored. The boiling is done with water. Then dye what you desire. Or else bruise alkanet in the same way with safflower, afterwards put it in and let the blood color be absorbed. And if you bruise alkanet with telis then proceed likewise. Alkanet in company with chalcantum, however, dyes linen as well as cambric. For with chalcantum, alkanet red changes into purple.

"Telis," a certain species of a plant of flower.

90. *Making Purple Brilliant.*

To make purple brilliant cook alkanet with purging weed and this will dissolve it; or with wild cucumber, purgative cucumber or hellebore.

91. *The Dissolving of Alkanet.*

Take alkanet and grind fine with barley malt. The barley malt should, however, be fresh. Then mix the alkanet with vinegar and let it remain in it over night. Heat the alkanet again in the morning, steep it in vinegar and leave it until it gives up the color. After that take the wool and put it in lime water and then in the dye liquor. After you have then put it in an extract of archil, treat it then in the same way as has been explained in detail in passage 26.

This latter sentence is apparently a reference to another work or collection of recipes now lost to us.

92. *The Dissolving of Comarum.*

To dissolve comarum. Grind tartar with water, put it in a small dish and stir it. Pour the clear water in another vessel, put ground comarum in it, stir it and it will give up its color at once. Then let it clarify until the following day and you will find purple.

93. *Mordanting for Sardin Purple.*

For a mina of wool put in 4 minas of dross of iron (and) 1 choenix of sour pomegranate; but if not this (latter) then (use) 1 chus of vinegar (and) 8 chus of water (heated) over the fire until half of the water has disappeared. Then take the fire away from under it, put the cleaned wool in and leave it there until the water becomes cold. Then take it out, rinse it and it will be mordanted.

94. *Mordanting for Silician Purple.*

Put in the kettle 8 chus of water, a half a mina of alum, 1 mina of flowers of copper (and) 1 mina of gall-nuts. When it boils put in 1 mina of washed wool. When it has boiled two or three times take the wool out. For when you leave it therein a longer time then the purple becomes red. Take the wool out, however, rinse it out and you will have it mordanted.

In ancient times, and among the alchemists, the term "flowers of copper" referred to copper oxide.

95. *Mordanting and Dyeing of Genuine Purple.*

For a stater of wool put in a vessel 5 oboli of alum (and) 2 kotyles of water. Boil and let it (become) lukewarm. Leave it until early morning, then take it off and cool it. Then prepare a secondary mordant (in which) you put 8 drachmas of pomegranate blossoms and two kotyles of water in a vessel. Let it boil and put the wool in. However, after you have dipped the wool in several times, lift it out. Add to the pomegranate blossom water about a ball of alumed archil and dye the wool by judging with the eye. If you wish, however, that the purple be dark, add a little chalcantum and let the wool remain long in it. In another passage it is in the following way: But if you wish that the purple be dark, then sprinkle natron and a little chalcantum in the dye bath.

96. *Dyeing in Purple.*

Purple. Roast and boil Phrygian stone. Leave the wool therein until it becomes cold. Then lift it out, put 1 mina (each) of archil and amarant in another vessel, boil then and let the wool cool down in it.

Phrygian stone was evidently some kind of a mineral capable of yielding soluble salts. It may have been a type of alunite according to Berthelot. This would explain its use in mordanting.

97. *Another (Recipe).*

Take the wool and clean with soap weed. Take blood stone and put it in a kettle. Put therein previously boiled chalcantum. Put in the wool previously mordanted in urine, alum, and misy. Lift the wool out, rinse it with salt water, let it become cold, and brighten the purple with gall-nut and hyacinthe. It has a very beautiful foreign appearance.

Bloodstone is identical with our hematite while misy was either iron or copper pyrites or oxidation products of these (see Pliny, N. H. Book XXXIV, 31). Hyacinthe was some kind of a vegetable dyeing material.

98. *Another (Recipe).*

Take and boil grain weevils, dross of iron and laurel berries. Put in 2 minas of wool, which you have previously mordanted, and now have boiled. Take it out and let it cool off. Brighten the color with limewater.

99. *Another (Recipe).*

Phrygian stone is roasted and boiled. The wool is put in and left there until it becomes cold. Then lift it out, place in another vessel 1 part of archil and 1 part of amaranth blos-

soms, boil it again, put the wool in and let it become cold there. Lift it out and rinse it with salt water.

100. *Another (Recipe).*

To dye with mulberries. Take and crush unripe bunches of grapes and mordant the wool therein for 3 days. On the fourth day put this grape juice in another pot and boil the wool therein, but when it boils lift it out, rinse it with water and let it become cold. Then take juice of mulberries and boil up until it boils twice. Put the wool in and let it become cold therein and it will be a fine excellent purple.

101. *Cold Dyeing of Purple Which Is Done in the True Way.*

Keep this as a secret matter because the purple has an extremely beautiful luster. Take scum of woad from the dyer, and a sufficient portion of foreign alkanet of about the same weight as the scum—the scum is very light—and triturate it in the mortar. Thus dissolve the alkanet by grinding in the scum and it will give off its essence. Then take the brilliant color prepared by the dyer—if from kermes it is better, or else from kirmnos—heat, and put this liquor into half of the scum in the mortar. Then put the wool in and color it unmordanted and you will find it beyond all description.

102. *Dyeing in Good Purple.*

Take the wool and clean with soap weed. Then mordant it in filtered limewater. Boil it then in alum and water. This should, however, be sharp acetous alum. Then boil it according to the procedure for mordanting with urine. Next, unravel it. Rinse it out with water, then with salt water, and lay it aside.

103. *(No Tille.)*

For a stater of wool take a kotyle of urine (and) put in the bowl with the urine and mix there, 4 drachmas of alkanet bark, 1 drachma of native soda (and) 1 drachma of raw Cyprian misy until it appears to you to be good. However, take away the first scum, which is white and untouched by the mixture. But when the essences of the substances appears to have gone from them, then lift the basket up and press it out properly in the basin. Throw the substances away, but put the mordanted wool in and produce (the) purple on it. Make a test beforehand (that is), put a flock of wool in underneath (the surface) with the hand and look at it. The vessel in which the boiling is done should, however, on account of the frequent boiling over, contain sixfold (the volume). When the wool is suitable then hang and drain it until you have obtained the lustre.

104. *Collection of Woad.*

Cut off the woad and put together in a basket in the shade. Crush and pulverize, and leave it a whole day. Air thoroughly on the following day and trample about in it so that by the motion of the feet it is turned up and uniformly dried. Put together in baskets lay it aside. Woad, thus treated, is called charcoal.

The last word in the recipe probably referred to its appearance. It occurs again in the title of No. 106.

105. *Dyeing in Dark Blue.*

Put about a talent of woad in a tube, which stands in the sun and contains not less than 15 metretes, and pack it in well. Then pour urine in until the liquid rises over the woad and let it be warmed by the sun, but on the following day get the woad ready in a way so that you (can) tread around in it in the sun until it becomes well moistened. One must do this, however for 3 days together.

106. *Cooking of Woad Charcoal.*

Divide the woad charcoal into three parts including that which is above the infused urine.

Mix one of the parts in a convenient manner, put it in a pot and build a fire beneath it. You will perceive whether the woad is cooked in the following manner. When it boils, stir carefully and not in a disorderly fashion, so that the woad does not sink down and ruin the kettle. When the woad cracks in the middle the cooking is perfect. You should take away the fire from the underneath, but should nevertheless stir within the pot. Cool the under surface of the pot by sprinkling with cold water. Then take and put in the vat a half a choenix of soap weed. Pour enough of the cooked woad over (it), lay poles or reeds over the edge of the vat, cover with mats and build a moderate fire under it so that it does not boil over and (yet) does not become cold. Leave it 3 days. Boil up urine with soap weed, skim off the scum, and put in boiled wool. Then rinse off in a convenient manner, press out, card it, and put the wool in the dye liquor. When it appears to you to be right, take the wool out, cover up the vat again and build a fire beneath it in the same way. Put 2 minas of archil in the liquid, after you have boiled the archil and in doing so have skimmed off the scum. Then put the dyed wool in. Rinse off in salt water and cool it off. Dye in blue twice a day, morning and evening, as long as the dye liquor is serviceable.

107. *Dyeing in Rose Color.*

Rose color is dyed in the following way. Smear the rolls of wool with ashes, untie them, and wash the wool in the liquid from potter's clay. Rinse it out and mordant it as previously described. Rinse it out in salt water after mordanting and use rain water (which is so) warm that you cannot put your hand in it. Then take for each mina of wool a quarter of a mina of roasted and finely pulverized madder and a quarter of a choenix of bean meal. Mix these together by the addition of white oil, pour it into the kettle and stir up. Put the wool in the kettle and again stir incessantly so that it becomes uniform. When it appears to you to have absorbed the dye liquor, however, brighten it by means of alum, rinse it out again in salt water, and dry it in the shade with protection from smoke.

108. *Dyeing with Archil.*

To dye with archil. Wash the wool as is previously described. For a mina of wool take 4 chus of urine and a half a mina of alum. Mix these, and at the same time make a fire beneath them until they boil up. Put the wool in and stir incessantly, but when the wool sinks down and the liquor subsides then rinse the wool out. Boil in drinking water three times as much archil as the weight of the wool, take the archil out, put the wool in and stir up uniformly until the wool becomes soaked. Then pulverize a quarter of a mina of chalcantum for each mina of wool and mix them. Stir up incessantly and thereby make the wool uniform. Then take it out, rinse out and let the wool dry as in other cases.

109. *Dyeing in Phoenician Color with Archil.*

Roll up the wool and sift ashes over it. Separate the rolls in a convenient manner and again sift ashes over them until the wool becomes clean and branny. Shake it out on the following day and rinse it out. After the washing, boil it with 6 chus of salt water for each mina of wool, mix in half a mina of alum and mordant the wool therein in the way mentioned. Rinse it out. Then cook, in rainwater, until it boils, three times as much archil as the weight of the wool. Pour in goat's milk and stir up. Put the wool in and stir again until the color is thoroughly soaked in. Then take the wool out, rinse it and dry it, but in doing so protect it from smoke.

110. *Dyeing in Bright Red Purple.*

To dye in genuine bright red purple grind archil and take 5 cyathi of the juice for a mina of wool. If you wish a bright tint mix in ground natron (and) if you desire a still brighter one, chalcantum.

111. *From the Book of Africanus: Preparation of Bright Red Purple.*

Take and put the mordanted wool into 1 choenix of krimmos and 4 choenices of archil.

Boil these materials, put the wool in and leave it there until later. Take it out and rinse it with salt water, then with fresh water.

112. *Another (Recipe).*

Pulverize and cook 4 drachmas of chalcantum, 4 drachmas of Sinopian earth and 8 drachmas of krimnos. Put the mordanted wool in and it will become a fine deep red purple.

Sinopian earth apparently had several meanings. The description of Dioscorides (Mat. Med. V, 3) is that of an iron ochre although the term sometimes meant red lead.

113. *Another (Recipe).*

Dyeing in purple with herbs. Take and put the wool in the juice of henbane and lupines. The juice should be brought to boiling in water, which thereby becomes sour. This is the preliminary mordant. Then take the fruit clusters of rhamus, put water in a kettle and boil. Put the wool in and it will become a good purple. Lift the wool out, rinse it with water from a forge, let it dry in the sun and it will be purple of the first quality.

114. *Another (Recipe).*

After the wool has been mordanted then take 20 drachmas of good Sinopian earth, boil it in vinegar and put the wool in. Add 2 drachmas of chalcantum. Lift the wool out, put it in a kettle full of warm water and leave it there 1 hour. Lift the wool out and rinse it.

115. *Dyeing of Various Colors.*

To prepare Phoenician dye. Take and combine heliotrope with alkanet. Lay them in an earthen vessel and sprinkle them for 3 days with white vinegar. On the fourth day boil them, with the addition of water, until these float at the top. If you desire, however, to dye cedar color then take out the alkanet and boil lightly, but if you wish cherry-red then add krimnos soured with a little soap. Put the wool in and boil it together with the substances until it appears to you to be good.

116. *Cold Dyeing in Dark Yellow.*

Put 1 part of golden litharge (and) 2 parts of quicklime in a vessel and pour water in until it runs over. Stir until it is mixed and put the rinsed-out wool in, which after a time receives another color. If you mix alkanet in with it, the wool becomes better.

117. *Dyeing in Scarlet.*

Take the wool and mordant with woad, which dyes blue. Wash and dry it. Then take and crush kermes in water until it becomes dissolved. Then mix in rustic archil and boil thus. Put the wool in and it will become scarlet.

The exact sense of the word "rustic" in the above recipe is, according to Lagercrantz, that it refers to archil from the country as an inferior variety.

118. *To Produce a Gold Color by Cold Dyeing.*

Take safflower blossom and oxeye, crush them together and lay them in water. Put the wool in and sprinkle with water. Lift the wool out, expose it to the air, and use it.

119. *To Wash Raw Wool.*

The washing of raw wool is done in the following way. For a mina of wool take 9 minas of Cimolian earth, 2 kotyles of vinegar, and pour in water. Wash the wool therein and air thoroughly.

120. *Examination of Dyestuffs.*

Heavy and dark blue woad is good, but the pure white and light (kind) is not good.

The examination of Syrian kermes. Take and crush that which is the lightest and the most finely colored. The black or white-spotted is, however, poor. Chew into pieces with natron and dissolve up the finely colored.

Pulverize the finest colored madder and thus make the test.

Purple-colored and fast archil is as if snail-colored, but the white-spotted and black is—take notice—not good. Now if you chew genuinely colored archil into pieces then take and hold it in the hand (to examine it).

Alum should be moist and very white. That which contains saltiness is, however, unsuitable.

Concerning flowers of copper, that is suitable which shows a dark blue color, a very green leek color or, in general, a very fine color.

121. *Dyeing Canusinian Wool.*

Boil, beforehand, in a leaden kettle 20 drachmas of krimnos, 8 or else 12 drachmas of thistle, (and) 1 chus of water for 1 mina of unmordanted wool. Then put the wool in, make a sample and it will be Canusinian wool.

122. *Dyeing of a Color.*

Take heat-dried quicklime and golden litharge, grind both substances in an earthen vessel and stir up. Put the wool in, leave it there a day and a night and the color will come up on it. You should rinse it off with soap weed. When it has been rinsed and you desire (to color) it further, then after the bath, dye it again in the aforementioned dye liquor.

123. *Dyeing in Purple.*

Bright red purple; juice of archil. If you desire a deeper shade then put in natron. If you desire a still deeper, (then put in) chalcanthum.

124. *Another (Recipe).*

One dyes an indelible purple by means of braids of seaweed with water.

125. *Another (Recipe).*

Purple which does not fade. Boil seaweed with archil and vinegar and put the wool in uniformly.

In the two above recipes the species of seaweed or algae used is not stated. Certain kinds can be used for this purpose, however.

126. *Another (Recipe).*

Red ochre dissolved in vinegar produces purple.

127. *Another (Recipe).*

Alkanet, madder, archil, and calves' blood dye purple.

128. *Another (Recipe).*

Purple. Phrygian stone is crushed and boiled. The wool is put in and left there until it becomes cold. Then lift it out. Put in another vessel 1 part of archil and 1 part of amaranth blossom, boil it again, put the wool in and leave it become cold there. Lift it out and rinse it with salt water. An excellent mordant for purple comes from Phrygian stone; for a kotyle of wool (use) a kotyle of stones.

129. *Another (Recipe).*

Cold-dyed purple. Pulverize quicklime in cistern water. Pour the lye off and mordant what you wish therein from morning until evening. Then rinse it out in fresh water (and) color it in the first place in an extract of archil. Then put in chalcanthum in addition.

130. *Dyeing of Dark Yellow Wool.*

Dyeing of all kinds of dark yellow wool so that it appears as if this were its color. Grind golden litharge finely and put a little of it in a clean vessel together with four times as much lime. Pour fresh rain water upon these so that it covers them and stir thoroughly until they

are well mixed. Rinse the wool out beforehand and now put it in. After a time it indeed gains another color, so that it appears as if this were natural and wonderful.

131. *Dissolving of Archil.*

Take and wash archil properly, air it and lay it aside. Then take and cook bean chips in considerable water. When they are well cooked then mix archil with the water from the bean chips. When you let the archil become cold together with this, then you will dissolve it in this manner.

132. *Dissolving of Alkanet.*

Take decorticated and pulverized alkanet and add the interior of Persian nuts. Pulverize these again and add a little lamellose alum. Grind everything together while moistening with water. Make a lump out of it, place it aside and leave it to imbibe color. Then take a vessel of water, put the lump in the water, stir up and leave it unbroken. Put your finger in and if the color is beautiful then use it.

133. *Preparing Genuine Purples.*

Iron rust, roasted misy, and pomegranate blossom adapt themselves to mordanting in water and make it possible to give the wool a good deep purple color in 4 hours.

134. *Another (Recipe).*

Let iron rust soak in vinegar for as many days as is necessary. Then mordant the wool in this liquor, which should be cold. Then boil krimnos and put the mordanted wool in.

135. *From Book 3 of Africanus.*

Mordanting for any color is done in the following way. First the animal, or else likewise only the wool is washed; then one can allow the mordanting agent upon it. One should then dissolve alum in vinegar and coat the wool, which one desires to dye, with it. After drying in the sun it is washed, and when it is freed from its moisture admit it to any coloring. One must pay attention to that which is mordanted for a day and a night during the mordanting.

136. *Dyeing of Colors.*

Lime, which is mixed and ground with litharge, produces many colors, yet in such a manner that the wool does not retain them. First, milk-white; then natural; and then deep by means of cold dyeing.

137. *Mordanting for Every Color Except Purple.*

Dissolve alum in vinegar, add raw misy, and use it.

138. *Mordanting for Purple.*

When you mordant for purple, then put in pure sulphur in lumps in addition, so that the purple (by trial) gains a brilliant shade; but in case it does not become bright (it is) because it contains something related with what one tests it with.

139. *Dyeing of Colors.*

By celandine one means a plant root. It dyes (a) gold color by cold dyeing. Celandine is costly, however. You should accordingly use the root of the pomegranate tree and it will act the same. And if wolf's milk is boiled and dried it produces yellow. If, however, a little verdigris is mixed with it, it produces green; and safflower blossom likewise.

140. *Dissolving of Alkanet.*

Alkanet is dissolved with the root of henbane. Some cook it with the root of the mulberry tree, others likewise with the root of the caper bush. Some cook alkanet with lentils, others with pellitory root.

141. *Fastness of Alkanet.*

Sheep's urine, comarum, or henbane are equally good.

142. *Fastness of Archil and Alkanet.*

Extract of leaves of the citron tree; extract of barley and navelwort; and onion juice. Each of these substances alone make (them) fast.

143. *Dissolving of Comarum.*

Take and soak pig manure with the urine of an uncorrupted youth. Boil up these and pour it off on the comarum.

144. *Another (Recipe).*

Dissolve calcined marble in cold water, put comarum together with it in milk and the comarum will become dissolved.

145. *Cleaning by Means of Soap Weed.*

Take and treat soap weed with hot water. Make a ball from it as if from tallow. Then steep this in hot water until it is dissolved. The water, however, should go above the wool. Then boil up the water. Put the wool in and prevent it from becoming scorched. Leave it there a little while until you see that it is clean. Lift out, rinse it and dry it.

146. *Mordanting.*

Then take lime and hot water and make a lye from it, let it stand and take away thereby the impurity existing upon it. When you see that the water has become crystal clear, then put the wool in, shake and leave it there again a little while. Lift it out and rinse it.

147. *Boiling (Wool).*

Then take two kotyles of fresh water and 8 drachmas of acetous alum for a stater of wool. Put the water, the alum in a small basket, and some barleycorn into the kettle and place it upon the fire until the barleycorn is cooked and the alum has dissolved. Take away the impurity existing in the liquid, put the wool in, dip it under and separate it with the rake. Arrange it uniformly, put on the cover and heat the kettle until you see that the wool is puffed up. Then lift it out, hang it up, again perform the same operation with the rake and heat the kettle. When it is to be taken out, then remove the kettle from the fire, hang the wool up and let it drain until you undertake the mordanting with the urine.

148. *Preparation of Tyrian Purple.*

Phrygian stone is pulverized and boiled. The wool is put in and left there until it becomes cold. Then lift it out and put a mina of archil in a vessel, boil it, put the wool in again and let it become cold there. Lift it out and rinse it with salt water.

149. *Cold Dyeing of Purple.*

Pulverize and dissolve quicklime with rain water, strain the water and mordant therein from early morning until late (in the day). Do not rinse out with salt water but with fresh water. Then dye with boiled archil. Then put in chalcantum besides and the purple will come forth from it.

150. *Dyeing of Galotian Scarlet.*

Alkanet and archil, 1 ounce each; 2 ounces of swine's blood; 5 drachmas of chalcantum; 2 drachmas of roasted orpiment; 8 pints of water.

151. *Dyeing of Tyrian or Guaranteed Superior Purple.*

Seven drachmas of alkanet; 5 drachmas of orpiment; 1 ounce of urine; 5 drachmas of quicklime; 1 kotyle of water.

152. *Shading Off of Colors.*

When you desire to shade off the brightness of a color then boil sulphur with cow's milk, and the color will be easily shaded off in it.

153. *Dyeing of Madder Purple.*

After bluing, sprinkle the wool with ashes and trample it down with them in a convenient manner. Then press (the) liquid out of potter's clay and wash off the blued wool therein. Rinse it in salt water and mordant it. You will know if it is sufficiently mordanted when it sinks down in the kettle and the fluid becomes clear. Then heat rain water so that you cannot put your hand in it. Mix roasted, pulverized and sifted madder root, i. e., madder, with white vinegar, a half a mina of madder to a mina of wool, and mix a quarter of a choenix of bean meal with the madder root. Then put these in a kettle and stir up. Then put the wool in, in doing so, stir incessantly and make it uniform. Take it out and rinse it in salt water. If you wish the color to take on a beautiful gloss and not to fade, then brighten it with alum. Rinse the wool out again in salt water, let it dry in the shade and in doing so protect it from smoke.

154. (No Title.) (On a separate leaf from the rest of the recipes.)

Sun, Berbeloch, Chthotho, Miach, Sandum, Echnin, Zaguel, accept me who comes before thee. Trust thyself (to the God), annoint thyself and thou shalt see him with thine eyes.

III. Commentary

The excellent translations of the Stockholm Papyrus into modern Greek and German by Lagercrantz leaves little to be desired in the way of a philological and etymological commentary. This translator, however, did not enter into the general and technical significance of the recipes of the collection. It is the purpose of these few paragraphs to discuss this phase of the collection in the briefest way possible, since space does not permit the extended treatment of these matters that could be given, especially in comparing them with the other authors and works in early technical arts, and in discussing their value for the early history of alchemy and technical chemistry.

It is very evident that the recipes in the collection can be grouped into three main classes. The first few deal with the manufacture of alloys and are nearly identical with those of this type that occur in the Leyden Papyrus X. On account of this similarity no further comments are needed upon them here. The second type deals with the cleaning and imitation of gems and precious stones, while the third group includes those treating of the various arts connected with the dyeing of cloth. These two groups will now be discussed separately.

There are exactly seventy-one recipes that deal with the cleaning and imitation of precious stones or with closely related operations. Ten of these, most of which follow immediately after the recipes for alloys, deal with cleaning genuine or making artificial pearls. The cleaning methods used were largely empirical in their nature. One method was to coat the pearl with some suitable glutinous mixture, then to peel this off again. This latter operation apparently removed the objectionable

dirt. Recipe No. 61, in which lime is employed in this manner, apparently contains some rudimentary attempt at chemical theory. Various liquids were also employed in cleaning. Perhaps the most curious and the least scientific of these cleaning methods is that described in Recipes No. 25 and 60 in which the pearl is given to a fowl to eat and is afterward recovered and found to be cleaned. This set of recipes contains the first account of the manufacture of imitation pearls. Recipe No. 18 describes their preparation in which shimmering scales from mica or ground selenite were incorporated in a paste made from gum, wax, mercury, and white of eggs. This was then shaped and dried, probably yielding an inferior imitation of the real thing, although the last sentence of the recipe assures us otherwise. Recipes No. 22 and 23 detail other methods of accomplishing the same end. The remainder of the recipes of the second group deal with the imitating of emerald, ruby, beryl, amethyst, sunstone, and other valuable gem stones. The base for nearly all of these imitations is the so-called crystal. This word in Greek is generally understood to mean quartz or rock crystal. Probably, however, its meaning in the papyrus was extended to other clear stones, notably to selenite, since the processes used depended somewhat upon having more easily corroded stones than quartz. At any rate, the first step in the manufacture of imitation precious stones, as practiced in ancient Egypt, was to treat the base used in such a way as to roughen it and to make the surface of the stones porous. Various substances and methods were used for this purpose. The heated stones were generally boiled or dipped in oil, wax, or solutions of alum, native soda, common salt, vinegar, calcium sulfide, or in mixtures of these. By this means the surface of the stone used was roughened and also, probably to some degree, mordanted for the application of dyes. After corroding or mordanting the stone in this manner some kind of a dyeing material was then applied. These latter fall into two classes, the inorganic and the organic substances. Copper salts, for example, were usually applied to form imitation emeralds from the base, while alkanet was used for red stones. Recipe No. 74 is of special interest in that it gives the method of preparing verdigris for this very purpose. This is probably the first detailed laboratory direction for the preparation of a chemical salt. Many vegetable dyes and other organic substances were employed in dyeing the treated crystal, among which were alkanet, celandine, cedar oil, pitch, and various resins. In some cases the two operations were combined in one. It is to be remarked that many of the recipes carry various detailed precautions concerning the processes, showing the presence of much experience in carrying them out. We may well question the beauty and the permanency of the imitation gems prepared by these methods, but probably they satisfied the people of that period. These methods of imitating precious stones seem

to imply strongly that the manufacture of colored glasses was not a developed art at the time of this collection and came at a later period.

The remainder of the recipes in the collection deal with a subject which was equally important in ancient times as it is with us, namely, the methods of dyeing or coloring cloths. The recipes of this collection and the few of the Leyden Papyrus are the earliest specific directions for the use of dyes. A glance over the recipes on this topic shows plainly that the art of dyeing was well understood from the practical standpoint. The first step in the dyeing process was the cleaning of the cloth to free it from dirt and grease. The various cleaning agents employed included native soda, soap weed, and others. That the importance of mordanting was well recognized is evident from the many recipes on the subject. The materials used included alum, limewater, iron and copper compounds, and some vegetable substances. There is no doubt that the theory of their use was but faintly understood, but there can be no question about their understanding of their practical use. The dyes used included alkanet, archil, woad, madder, and other less common ones together with various combinations of those named. It is evident from the recipes that purple was the favorite color in ancient Egypt at the time of this collection, but it is to be remembered, however, that this term then included red and some other shades also. One thing that the recipes on purple do show, however, is that the purple of the ancients was not obtained exclusively from a certain species of shellfish as has been generally believed. Other colors mentioned include blue, yellow, and scarlet. The use of different rinsing solutions and the preparation of some of the dyes used is also described in this collection. The remarkable nature of these recipes on dyeing as practiced in ancient times is seen when we remember that the methods mentioned here were essentially the ones used for a period of fifteen hundred years after, or up until the advent of our modern coal-tar dyes.

We are always somewhat interested in the personalities connected with any period or development of human knowledge and we may well ask ourselves as to the author or authors of the Stockholm and Leyden Papyri. The Leyden Papyrus X gives no hint as to its authorship, but the Stockholm Papyrus at least gives us some hint as to the probable character of the writer. The last recipe in the collection is on a sheet separate from the remainder and is not numbered like the other sheets. It contains a magical or theurgical formula entirely different from the other recipes. If it belonged to the owner of the remainder of the collection, and it is probable that it did, then it tends to show that chemical arts in ancient Egypt were largely in the hands of the priestly caste, a fact that has been deduced from other sources and of which this is the earliest direct evidence yet shown. The collection also mentions several

names of early workers in chemical arts, and indeed quotes from them, Africanus and Democritus in particular. In conclusion, then, it can well be said that from whatever angle we may view both the Stockholm and the Leyden Papyri there can be no question but that these earliest chemical manuscripts contain material of the greatest value for the history of the beginnings of chemistry.