Translator's Corner

J. Durban Odhner, Editor

Continuing the serial publication of the first English translation of Swedenborg's little work, *De Sale Communi*, "On Common Salt," we are pleased to offer the next eight articles. After this, there are twelve more, which will appear soon.

It is also a pleasure to announce that a revision of the Latin text, with corrections of 136 misreadings occurring in the first Latin edition, is also in place. The English translation, by Michael V. David/J. Durban Odhner was effectively done from the original manuscript, alongside of the A. Acton edition.

Both the English translation and the new Latin edition are targeted for publication in the not too distant future.

§ 40

THE DISTILLATION OF COMMON SALT INTO PHLEGM, VAPOR, AND DEADHEAD[144]

Take one part of salt with three lumps either of fine clay or powdered brick (others use alum or fine sand). Make the lump or piece of clay into little balls and let them dry in the sun. Fill a retort two thirds full with these, so that one third of it is empty. Apply fire to it, first a moderate fire, then more, so that the heat is increased gradually. Only then, a tasteless water will go out, having little acidity, and this is called *phlegm*.

Then some very white vapors arise, which supply the desired *spirit* of salt. Increase the fire until no more vapors appear. This spirit can also be refined. Some use only two parts of clay.

[144] "*Caput mortuum* . . . Old chemistry: the residuum after distillation or sublimation; hence, worthless residue." (*Webster's*)

The retort must be sealed well at its joints. Some report that this distillation process goes best if two or three parts of salt are mixed with one part of calcinated alum. Unless the right proportions are observed, it is said that a lesser amount of spirit will be obtained.

Some report that a lot of spirit of salt is obtained if part of the salt is first dissolved in water and then hot coals are repeatedly put out in that solution, which may then be drained through the retort. But it is doubtful whether actual practice will fulfill this promise.

Spirits of salt must be distilled in a glass retort, for it penetrates clay retorts and breaks their sides.

Attempts have been made to obtain by distillation a quantity of spirits of salt and phlegm together weighing more than half of the weight of the salt thrown in—to be exact, the weight of the phlegm and spirit being seven and the weight of the salt distilled twelve. Some also report that this distillation process can be carried out without mixing in clay, and the said weight of phlegm and spirits still be obtained.

If spirits of salt are distilled from cracked salt that had previously been exposed to the sun, more phlegm is obtained than spirits of salt.

A quantity of spirits is supposed to be obtained if spirits of unrefined vitriol are mixed with the salt in the retort.

What remains after distillation is called "deadhead." If this is exposed to the air, it can be distilled again into spirits of salt. It is said that some have recently distilled this "head" again, and gotten from it a quantity of phlegm and spirits greater than the original quantity of salt.

M. L'Emmeri accurately reports on this method of distillation. His very words are: "Salt is to be dried either on a cooking fire or by the sun. Two pounds are reduced to a fine powder, and six pounds of pulverized clods or clay are mixed with it. The mixture is brought to the consistency of porridge using rainwater, and shaped into globules, which are then exposed to the sun. When they are fully dried, a glass retort is filled two thirds full with them. The retort is placed in a kiln with an appended receptacle, and the joints are not sealed. Moderate heat is first applied, so that the retort can warm up, while stale water drips out. When white vapor appears, throw out the phlegm or whatever has collected in the receiving vessel, put the fire under it and seal the joints of the retort very well. Then increase the fire as much as you can, continuing for twelve or

fifteen hours. Meanwhile the receptacle will heat up and fill with little white clouds. When it has cooled off and the clouds disappear, the job is finished. When the joints are loosened, you will have a pound and a half of spirits of salt, which can be put in a glass bottle and sealed well with wax."

L'Emmeri observed that spirits of salt can be had more easily by this operation than by the usual one. Unless a space is left in the retort and the receiving vessel is big enough, the distilling instruments can easily be broken. If after distillation is finished, the spirits of salt are poured out into a glass distilling container, a lid is put on it, the receiving vessel is put back with the joints well sealed and a third of the liquid is extracted by distillation in hot sand, a weaker form of spirits of salt will result, which tastes quite good. The remainder in the distilling container is so much the stronger, and its acidity increased, as more is extracted from the container. With this operation the spirit comes out more yellow.

But to get more spirits out of the "deadhead," it must be washed thoroughly in hot water until this dead earth is tasteless. The liquid is then filtered, the moisture evaporated, and a white salt remains, which can be used in place of common salt in food, although it is somewhat sharper in flavor.

It is reported that in 1672 an apothecary in Rochelle by the name of Seignette brought some sea salt from which, with a very moderate fire, and distilled without anything mixed in, he was able to obtain, in the course of two hours, three and a half ounces of the best spirits of salt in the retort, from six ounces of salt. Two and a half ounces of material remained after the retort was broken. It was put in an open pottery vessel and exposed to the air for fifteen days, and the spirit was distilled as successfully as before, yielding half the weight of equally strong spirit as before. The material left over this time, exposed to the air again, could again be distilled, and spirit gotten from it. The inventor M. Seignette is reported to have distilled the same material nine times. Still this kind of salt is not common but artificial, although it is very much like common or sea salt. Others recount that from salt that is well cracked, left for several days in the air, and distilled without anything mixed in, one can get a spirit like the first, in almost the same quantity. Nevertheless, it does not seem that one can obtain any but a weak and phlegm-like spirit in that way, the salt remaining in the retort. This spirit of salt dissolves gold leaf, which nitric

acid cannot do. This spirit can be sweetened with alcohol. This much is from L'Emmeri.

M. Febure, in describing this distillation process, says that the said mixture of salt and clay must be allowed to grow moist by a solution of salt poured into and melted in water in a container. In place of this, L'Emmeri says to use rainwater. Then the globules or paste should be dried in the fire of a furnace, but slowly. A globule should then be broken to see whether it is dried all the way to the center. He also says to take out the phlegm and spirit at the same time into one receptacle, but then to separate the phlegm into a distilling container using a *bain-marie*. Only then, the volatile spirit rises with an odor like sulphur, forming little crooked veins on the top. When straight veins appear, and drops form not having that odor, the receiving vessel should be changed so as to get the phlegm. The fire should then be increased, since it is harder to raise than the volatile spirit. When the drops show acidity, the fire should be removed. If spirit is still being given off, then there remains in the bottom of the distilling container a yellow, heavy substance with a bitingly strong acidity capable of dissolving metals and especially stones, and is improperly called "oil of salt."[145]

Le Mort directs that one take two pounds of salt, three of clay, one pound of colchothar or deadhead from vitriol, and mix them well, putting them in a clay retort. He says that some phlegm goes out, then a volatile spirit, and then acid, which two can be separated by refinement. He says that the spirit will be stronger if instead of clay only colchothar is used, and if impure salt is used, not refined salt; and that the spirit comes stronger from cracked salt. By this method four ounces of spirit can be obtained from a pound of salt.

Others say to take half a pound of salt and four ounces of refined oil of vitriol, and as much water as is needed to dissolve the salt. These are mixed and distilled in a glass retort with an alembic. The water that comes out first is taken away, and when acid spirits come out, a receiving vessel is put in place, and the distillation continues until it is dry.

But *Glauber* treats of two methods for making spirits of salt. The *first* is with salt dissolved in water, placed on coals in a special furnace, to which

[145] i.e. oil of vitriol, or sulphuric acid.

the receiving vessel is fitted. It is alternately melted, and then cooled to condense the vapor into spirits. In this way the spirit is hardly contaminated with the soot of the fire. The *second* is as follows: Take one pound of common salt, eight ounces of oil of vitriol, and as much spring water as needed. Then distill the salt until dry in a retort made of glass from sand. If the spirit is still too weak, then it should be put in the distilling container, and distilled with the cap on. When the drops begin to come out acid, then remove the distilling container to cool it off, and you will have a strongly acid spirit in the bottom of the distilling container. *Differently* in Glauber: *Concentr*: p. 491:[146] Two parts of vitriol or alum are to be mixed with one part of finely powdered common salt. Make a fire of coals, and in place of the receiving vessel, use lead containers. He reports that not only spirit of salt is obtained from this, but also acrid flores, used in extracting minerals. Two lead vessels are put in place, one inside the other. In the outer one put cold water, placing the other one into it. It is thought that by cooling, more spirit is obtained.

It is done differently by Mr. Boerhaave: Sea salt, very pure, and cracked, four ounces. Oil of vitriol, three or four ounces, is mixed with four ounces of rainwater, and this mixture is poured on the sea salt in the retort. Immediately white fumes arise, of which one must beware, and heat and boiling also begin. A large receiving vessel is used, and the distillation from sand is done by degrees. At first white fumes arise, if the fire is increased to the maximum, and they gather into a very acid spirit, which produces spirit of sea salt, and carries no oil of vitriol, obviously, for if spirit of vitriol is poured into spirit of salt, it does not dissolve gold, yet this dissolves gold perfectly. This spirit can be put to use wherever spirit of salt is required, and is made so easily, where otherwise it would take a very large fire.

On spirit of salt with oil of vitriol. The distillation of this spirit with oil of vitriol is best done from a glass distilling container through an alembic. Because of its enormous effervescence and foaminess, it cannot be conveniently distilled from a retort, since the foam must be prevented from going over. Some common water is added, which helps the oil of vitriol to penetrate into the common salt, working so well that a rather large amount

[146] A. Acton footnote: "The same thing is found in *Teutschlandz Wohlfahrt* ('Prosperity of Germany'), part V App.—Ed."

of spirit can be produced. Rectification can be done from a retort; a green spirit emerges from the yellow, and this is its true color, and the coarser elements of sulphuric acid remain in the bottom. This tinges the clay with a pink color.

By a gentle heat, also with the use of a bain-marie, it passes over the alembic and exhales from the open glass containers so that it soon fills the whole room. Without the addition of any common salt, the most firmly compact gold can be dissolved by this acid.

This spirit, with twelve parts of highly rectified wine, produces a sweet mixture, with a most pleasant odor and taste.

§ 41

ON SWEET SPIRIT OF SALT

Take some of the best spirit of salt and an equal part of alcohol, or one part of spirit of salt and two of alcohol. Mix them, and evaporate them completely from a retort. From that you will get sweet spirit of salt. You must take care towards the end that the fire does not get stronger than needed, for it you do not, the retort will be broken. The following day, if you wish, you can pour the distilled spirit back into the cooled retort, and again distill until it is dry. If the same process is repeated a third time, these spirits can be reduced so well as to yield the best smell and a clear color. The sweet spirit can also be had if the liquids are distilled only once.

Another way. Take four ounces of spirit of salt, rectified until two and a half ounces are left. Let them digest for a few hours, then distill them in a retort with a moderate fire in the sand. First use a gentle heat, until the alcohol has gone up. When this is finished, there will appear in the receiving vessel contractions, or linear forms. When these go away, the distillation of the alcohol is also finished. Then the fire may be increased, with some caution so that the retort does not break, and the process continued until all the liquid has gone out and the retort is dry. Conserve this remaining spirit. It has been observed that the longer the liquids

digest, the sweeter the spirit becomes. Also the spirit sweetens somewhat by pure digesting[147], for example, if it is left to digest in a hot place for three or four weeks; and if it is not sweet enough, distillation can be repeated. Also, the less water there is in the spirits, the more quickly they are combined and grow sweet.

Another way. Take four ounces of calcinated common salt, four ounces of rectified spirit, and [an ounce] of rectified oil of vitriol. Put the calcinated common salt in a glass retort, pour on it the rectified spirit of wine [= alcohol], and then, a drop at a time, the oil of vitriol. Distill it in a gentle fire until dry. It is said that with this spirit various tinctures can be extracted, from all three kingdoms, including minerals and metals.

Elsewhere, sweet spirit of salt dissolves the oxide of gold, and dissolves coral especially well.

Hoffmann reports that this solution, gradually evaporated with a gentle heat, paints a picture like the "Philosophic Tree" on the sides of the glass.

According to Basil Valentinus, as M. L'Emmeri says, it can be prepared from equal parts of spirit of salt and of wine, which may be digested for three or four days in the heat of the sand, in two connected vessels, called *vaisseaux de rencontre* in French. It is said that the best spirit of salt is obtained this way.

§ 42

ON ANOTHER KIND OF SPIRITS OF SALT

Coagulated spirit of salt of Mynsicht is made by taking spirit of common salt, and salt of finely ground absinthe in the same quantity, mixing them together and letting them coagulate. It is said that Rhumelius coagulated spirit of salt with volatile salt of amber.

According to M. Febure: Take a large retort full of salt, made of the best clay, so as to best resist the fire. The size of the neck is three inches in

[147] Acton misread *nudam digestionem* as *crudam digestionem.*

diameter, so that the spirits can come out in quantity. Into the retort put four pounds of sea salt, well purified and dried. A large receiving vessel should also be fitted, with a pound of distilled rainwater in it. Seal the joints with clay, and let the clay dry, being careful that there are no cracks anywhere. The fire is gradually increased, eventually to such a degree that it melts the salt inside. When this happens, put in a few drops of cold water, using a feather, through a channel, which is immediately closed off. Then a lot of vapor can be seen entering the receiving vessel, and when it appears clear, some drops of water can be put in it, otherwise it will break, endangering the bystanders. This operation is repeated until all the salt has gone up as spirit or vapor. Then remove the fire and let the vessel cool off. Filter all of the liquid held in the receiving vessel, and put it in a distilling container, and in the bain-marie, all of the rainwater that was added is thrown off. Put what is left in a cold place, so it can crystallize. What does not crystallize can be evaporated again and put in a cold place to crystallize. These crystals are sweet and should be kept in a well-closed bottle. Part of the crystals may be dissolved in a container into a liquid. The crystals and the liquid have the same properties, both give off sweat, etc.

Essence of spirit of salt, and stomachic spirit of salt. According to M. Febure, it is prepared in this way: Take salt that has been purified, well dried, and calcinated in an open fire until it glows. Put it in a container and let it absorb oil of salt, which is the same oil as the spirit that is left in the distilling vessel after rectification. Stir the vessel, until they are well mixed. Smear this container with garlic, and let the contents digest on a moderate and even fire of coals, until the oil of salt has combined well with the calcinated salt. Repeat the previous operation, namely, let the liquid be absorbed, digested, and dried out as before, until the salt cannot be mixed in any more, so that the oil floats on top. A true sign that the salt is ready for distillation is when it has a lovely yellow and gold color, and when it has a sweet and pleasing odor. When these things happen, the contents can be put in the retort and distilled with a gradually increasing fire, producing bright white fumes and clouds, which gradually turn into liquid. When the distillation is finished, this spirit should be rectified in a bain-marie so that the phlegm can be separated from it. In this way one gets essence of spirit of salt, and stomachic spirit of salt.

§ 43

ON GLAUBER'S WONDERFUL SALT

Glauber's method of distilling spirit of salt, which was presented in chapter 40 at the end, is the method carried out by mixing in oil of vitriol, then dissolving the deadhead that remains after distillation in hot or warm water. If this method is used, care must be taken that the glass does not break. The solution is filtered through paper and then evaporated, until a third of it is gone. The rest is put in a cold place for twenty-four hours, which causes the liquid to turn into crystals, especially on the surface. But under that, separated from the crystals, a quite corrosive liquid remains. The crystals are not corrosive, but are either salty or sweet with some saltiness. If they are corrosive, it is a sign that too much water had evaporated. So they must be dissolved again in water, and the solution filtered again as before. Be careful that too much water does not evaporate again, but just a small part, so that the salt can easily solidify into crystals.

As for the rest, unless the required amount of oil of vitriol had been added to the common salt, one would not get crystals of just one type from that residue. If a little too much was added, cubical crystals tasting like salt would come out. But with the right amount, one gets long, stick-like crystals, but still rectangular, with a rather bitter taste.

Although these crystals are shaped like niter, they will not burn, even when placed on glowing coals. It is of no help, in making this salt, to pour too much oil of vitriol on the common salt. For in this case, when the residue is put on the fire, and when it no longer gives off smoke, it is dispersed in the air.

This wonderful salt, once dried in the sun or by a gentle heat, falls by itself into powder. To this, add a double or triple amount of water, beer or a similar liquid, then dissolve them over a fire, and put in a cold place they will solidify into a mass, which in its outward form looks just like ice. This is from Mr. Barckhusen.

Glauber's wonderful salt, made from oil of vitriol and spirit of salt of Amen[148] is said to produce a dry resolution of metals, such as gold.

[148] "Originally obtained from a region near the temple of Amen, Libya": **AHD** at *ammonia*.

Glauber himself reports that with it he formed gold into a little lump. Mazzotes reports that he obtained phosphorus from it. If gold is amalgamated with washed mercury, and an equal amount of salt of Amen is added, and the mixture is put in a smeared crucible with another one on top of it and calcinated for twenty-four hours, then a splendid, very bright material, or luminous stone is obtained.

When it is prepared correctly, according to Glauber, it forms long crystals like niter, is transparent, dissolves on the tongue like ice, has a sharp or astringent taste, does not melt on hot coals, nor does it combust like saltpeter, but glows in the fire without spreading an odor.

A green tincture of gold has been made using this salt. Using this salt, all kinds of metals, stones, bones and even coals are supposed to dissolve, which otherwise could not be dissolved by any acid solvent. It gives a green solution, and with some materials, a yellow or red solution.

If one part of gold is mixed with five, six or eight parts of the wonderful salt, and these are allowed to flow together for a quarter of an hour, and then poured out, you will see a purple colored salt. If the remaining gold is again and again mixed with the wonderful salt, all the salt will be rendered purple. From this purple salt, salt is precipitated into iron, if it is poured out with the iron.

If quite hard pieces of wood are put in a solution of the wonderful salt for a few days, and this is repeated several times, the salt penetrates the pores of the wood and fills them with salt. As a result, the wood can hardly burn in a fire at all, unless the fire is coaxed time and again. More can be seen about the wonderful salt in the works of the author himself.

§ 44

ON KINDS OF SALT THAT ARE MIXED WITH COMMON SALT, TO BE FOUND IN WATER, SPRINGS, BATHS AND HOT SPRINGS

The spring at Seidlitz

Mr. Hoffmann, in his *Opuscula Medica*, investigating the nature of the *spring* and *salt of Seidlitz*, found that it contained cooking salt mixed with

lime salt, etc., speaking of it in this way: First, he poured water into a vessel of pure and clear glass, which showed the greatest transparency and translucency. Moreover, when the taste was tried, it had an extraordinarily bitter and salty flavor. Then he poured on rather strong acid spirits, namely of vitriol and niter, and observed that no boiling motion resulted, thereby determining that it did not have an abundance of the alkaline principle. He also established that little or nothing changed when he added violet syrup to it. No purple color came to view in a mixture of galls, an indication that none of the substance of Mars [iron] was in this water. Putting in liquefied oil of tartar[149] clouded the transparency somewhat, which always happens if any lime is hidden within the water. Having finally come to evaporating it, this being done gently, he got from one pound two drachms and a few grains of a moderately bitter salt, which was like the quite famous English Epsom salt.

Not so long ago, when they searched more carefully the surrounding soil and the ground near the fountain, they found yet another salty and bitter spring. This leaps forth from a generous vein in an open field near the village of Seydschütz, a short interval from Seidlitz. But this spring is situated higher than the former, and its taste is more intensely bitter and salty. The elements and nature of the salt in either spring are not different, but when examined, both exhibit the same phenomena. The latter spring, however, bears a somewhat richer supply of salt, and a weight of one pound holds two drachms, ten grains, as well as six grains of fine chalky soil.

A comparison was also made between this salt of the Seidlitz spring and the English salt from the spring of Epsom, which is such a strong purgative, about which the English physician Mr. Grew has written a booklet. The salt prepared from the spring at Seidlitz is opaque, snowy and milky. Epsom salt enjoys greater transparency and contains more water, exceeding Seidlitz salt in specific gravity as a result, and also absorbs moisture from the air much faster. When the taste is tested, Seidlitz salt, in water solution as much as in solid form, not only is more bitter than Epsom salt, but has a nauseating flavor as well. When put in a heated crucible, both melt, and give off half their [weight] in the form of

[149] i.e. tartaric acid.

water vapor. This fiery liquid is very clear and like water in Seidlitz salt, but in Epsom salt is more sticky and thick. Well-rectified alcohol of both absorbs not a grain. Either salt, treated sufficiently in a hot crucible with crushed ashes and coal powder, yields a mass looking like liver of sulphur.[150] If the sediment prepared from Epsom salt is put in water, it will color it all a much more intense green than it will if made from Seidlitz salt. Likewise, Epsom salt mixed with a few drops of acid shows a much richer quantity of milk of sulphur than Seidlitz salt. If either salt is mixed with vitriol that has been calcinated until red and put in a glowing crucible, it first gives off a vapor not unlike spirit of salt, but after a little time has passed, releases volatile spirit of vitriol. Mixed with syrup of violets, Seidlitz salt takes on a green color, but Epsom salt a blue one. A solution of either salt with liquefied oil of tartar turns into a mass so thick that when the glass is turned over, almost nothing flows out. But Seidlitz salt coagulates more. An equal amount of a solution of either salt, originally very clear, by the addition of spirit of salt of Amen, comes out somewhat cloudy, and many coarse flecks become visible. An ounce of ordinary water absorbs an ounce and two scruples of Seidlitz salt, but just an equal amount [one ounce] of Epsom salt. The more saturated solution of Seidlitz salt shows a lemon yellow color, but not Epsom salt. Its solution retains the same clearness as the water had before. The crystals that solidify from either solution after it dries out, do not grow much differently, except that those from Epsom salt are bigger and look more like niter. If Epsom salt is left for a few days in a hot furnace it loses all its clarity, and comes out with an appearance like Seidlitz salt. From this it may be clear that Seidlitz and Epsom salt are very similar, not only as to elements and principles, but also as to their nature and goodness.

But if any kind of salt when prepared seems to approach the quality and goodness of native Seidlitz, or artificial Epsom salt, this much is certain, that they borrowed the name from Glauber, and prepared it from dilute oil of vitriol and common salt, first removing the spirit of salt in an alembic with gentle heat, and then washing out the "deadhead." It will then indeed be that salt if one hits the exact point of saturation, its usual quality, its bitter taste and its detergent and cleansing properties. Yet, if

[150] See ***OED*** at *Liver*, sb.[1].

the matter is looked at closely, it differs considerably from Seidlitz and Epsom salts. For the taste strikes the tongue far more sharply than Seidlitz and Epsom salts, although it keeps much more moisture in its embrace, so that if three ounces of it are put in a hot furnace, it melts and flows like water, barely two ounces remaining. Furthermore, if it is dissolved in an equal amount of water and left in a cold place, it turns into a lump that is almost solid, so that it cannot be poured out. But on the other hand, if liquefied oil of tartar is dropped into the solution, it does mix in the same manner[151] as it does with a solution of Seidlitz or Epsom salt. Again, if that saltily earthy sediment that is extracted from the waters of Seidlitz is again dissolved in water, it also leaves a pure stony matter. If that liquefied oil of tartar is dropped into a solution of Seidlitz and Epsom salts, a rather thick and white mass comes out. When this is diluted with enough ordinary water and put through blotting paper, it leaves a very white earth in the filter. This is dissolved again, with great effervescence, when spirit of vitriol is poured on it, again yielding a bitter laxative salt. But this latter solution, which is made from a solution of Seidlitz salt, when it is mixed with liquefied oil of tartar, likewise coagulates into a third kind of salt, which nevertheless has less bitterness and laxative property than the prior salt. He considers this experiment a confirmation that this chalky earth does not adhere so firmly and intimately to the acid, and that this earth is of a highly alkaline nature, and remains completely whole and undiminished if it is freed from its conjunction with the acid.

[The spring at Epsom]

About the salt from the spring at Epsom. Mr. Nehem. Grew, Prof. Ad. Wedel, and Rosin. Lentilius have written about Epsom salt. It was first obtained from springs not far from London, but not at present. It is made today both from sea salt and oil of vitriol, and from the brine of common salt and the "deadhead" from making vitriol. It has an equivalent in Glauber's wonderful salt. (*Bresslauische Natur- und Medicin-Geschichte*, for the year 1717.)

[151] For *eodem more* Acton read *eadem non*.

The nature and quality of this salt has already been treated of above, yet it can become still better known from the English authors. Mr. Grew wrote about it, and Mr. Lister, in *De Fontibus Medicatis Angliae*. Mr. Lister concluded that two kinds of salts were to be found in the spring waters of England which he investigated. These were *nitrous*, of course, *lime salt*, and *common salt*. And two kinds of soil, ochre and limestone. But since a pound of this water at Epsom yields no more than half a drachm of salt, it is certain at any rate that the salt exported from England in large containers, or casks, a pound of which costs scarcely 8 groats, is not prepared from the water of this spring, but made artificially. And it is made not only in England by the famed chemist Hanckwitz, from the brine left over from boiling common salt, but also in Germany an exeptional quantity is made by the celebrated Leipzig scientist and doctor Lehmann, at Sulz in Thüringen. Nor is there doubt, but that an aluminous acid, reacting with the alkaline earth of common salt, is contained in this brine. Still it is to be noted that this medium salt cannot be prepared at all salines, because the aluminous minerals are lacking in the underground places that the salt water goes through. This is from Hoffmann.

Elsewhere, it is recorded in *Historia Academiae Regiae Angl.* for the year 1718, that what is called Epsom salt could not possibly be that salt which Grevius, in a treatise brought out in 1697, taught how to extract from the mineral waters of Epsom, since Grevius was only able to extract his in the ratio of 1 to 128 parts of water. Someone investigating its preparation finally learned, after much experimentation, that it is very easily made from liquefied oil of tartar, which process this investigator said he also found in the work of Mr. Hartmann. See *Acta Lipsiensa* for the year 1718, p. 16.

When niter is crystallized, a thick and sharply bitter brine remains, which the workers call *Mutterlauge*. From it magnesia is made, which is an earthy powder, fine and white. The brine left over after boiling common salt in an iron pan is no different, but is almost the same in all its properties. The salt-boilers call this *Muttersoole*. This differs from a solution of common salt in this respect—in which it resembles the brine of niter—that it is of a gold color, has a thicker consistency, a very sharp and bitter flavor, and is comparatively heavier. It will yield no more common salt, and is very difficult to solidify, but if reduced to dryness by keeping it on the fire,

it goes back to liquid in a short time. It is not like any known member of the family of salts, in that it so quickly takes up moisture from the air and completely liquefies, although it is not alkaline salt, nor is it a pure acid, but has an intermediate nature.

The thickened brine of this salt, just like the brine of niter, immediately rushes into combination with pure alcohol, by which it is evident that that salt is extremely sulphurous, or composed of greasy, sulphurous or rather fine particles.

Then if oil of vitriol is poured into the salt brine, a vehement effervescence is aroused, with a fine exhalation of spirit of salt, and the liquid—just as takes place with niter brine—turns into a white mass, and if enough water is poured onto this, a lot of white powder settles to the bottom.

Again, when a very bitter salt brine (after all the common salt has been removed by evaporation and crystallization) is mixed with a solution of alkaline salt or liquefied oil of tartar (in the same way that it would be mixed with niter brine), immediately a large mass forms, and the liquid turns into a thick white lump. When ordinary water is poured on this, a very fine white powder settles to the bottom. When the liquid floating on top, which comes from adding alkaline salt to this brine, is thickened and left to crystallize in a very cold place, a salt comes out which does not liquefy in the air.

Besides this, if we take three ounces of thickened, briney salt, precipitated with liquefied oil of tartar, and sufficiently decanted with water, we obtain six drachms of a very fine, earthy white powder, which, no differently than the magnesia produced from niter brine, when spirit of niter is poured on it, reacts violently and is changed into a neutral, mildly bitter salt.

In both kinds of brine, there is hidden a chalky earth, well mixed with the acid salt. In boiling cooking salt, a considerable amount of chalky earth accumulates on the bottom of the iron pan. The workers call this "*der Schäb*." It is probable that the salt water, especially at Halle, flows through a large tract of chalky earth underground, and picks up a small amount of the chalky rocks.

If a rather large amount of this chalky salt is mixed into [the spring] and is not separated by boiling, the resulting cooking salt will not stay hard and solid in especially humid air.

For the rest, the fact should not be overlooked that the Epsom salt which is made artificially in England and shipped out in great quantity at a low price—nor is its enjoyment limited to only a few—is made from the brine of common salt by a certain technique, adding other salts. But that common salt really does go into it, will be shown clearly by the following experiments. 1. If it is mixed with oil of vitriol, it bubbles up with a thin white smoke, no differently from the effervescence when it contacts common salt. 2. A solution of this salt, no differently from common salt, precipitates a solution of silver into a white powder, and sends it to the bottom. 3. That artificially made salt is also easily dissolved in ordinary water, which absorbs more of it than of common salt. This is not an unclear indication that this salt has been freed of its more fixed earths and is more subtle than common salt. This is from Mr. Hoffmann.

[The hot springs of Pisa]

About the baths or hot springs of Pisa where *rock salt*, *chalky niter*, etc. is found, one may consult the investigations of Joseph Zambeccari, in these words: Among the baths scattered around the hills of Pisa, one finds the *Balneum de Aquis*, commonly called '*il Bagno a Acqua*,' sixteen miles away from the city of Pisa. To throw light on the natural condition of this water, its temperature was investigated with a thermometer of fifty degrees, and this was discovered: *First.* The temperature went up to the thirty-sixth degree, which the Syrian desert[152] and the human body also reach. *Second.* It comes out shining like crystal. *Third.* It was found to be tasteless, and drinking it induced no nausea. *Fourth.* When the water is distilled in lead instruments and mixed into a solution of sublimated mercury, or well mixed with oil of tartar, it shows a milky color. This verges on yellow, if it receives a solution of vitriol in ordinary water. *Fifth.* When it is evaporated, a sediment weighing one drachm per pound of water sticks partly to the sides and partly like a veil on the bottom of the glass. It is very white, like gypsum, with very thin, clear filaments like crystals. *Sixth.* Before this

[152] *Syrius ardens*, probably a play on the word *Sirius*, the "Dog Star," supposed by antiquity to be the hottest star (see footnote 159).

sediment dried out completely, it manifested a sharp salty taste, which, however, was like the tastelessness of the quickly-vanishing saltiness of grains of sand. *Seventh.* With spirit of vitriol it produces an effervescence like that when the same spirit comes together with oil of tartar. *Eighth.* When the same sediment is dissolved with water of vitriol, its greenness and clarity are muddied with a rather intense dark and yellow color. *Ninth.* But when mixed with a tincture of galls, it gives this a dark greenish color, with some ashy matter going to the bottom, like gypsum, and diluting the tincture of galls. *Tenth.* This very same thing happened with the same sediment when carefully sweetened and stripped of all salt and taste. *Eleventh.* There is also gypsum to be found in the vicinity of those baths. *Twelfth.* But those very thin and clear filaments, when talc is sprinkled on them, are formed into threads, commonly called *Spechio d'Asino*, and the surrounding ground bears much of it. *Thirteenth.* The water by which the sediment was sweetened even to tastelessness, when filtered through paper, shows rock salt and common salt, obvious from its taste and cubical shape. Niter salt also shows up, in hexagonal crystals and a sharp cooling taste, also sticking to the sides of the glass, while a mesh or texture of the filaments occupies the bottom. *Fourteenth.* This water has a peculiar property, coloring white linen a color between yellow and verdigris, like vitriol water, and coloring the stones at the bottom of the bath. *Fifteenth.* Around the sides, which are washed by the surface of the water, there is a substance the color of vitriol, of a harsh and styptic taste. *Sixteenth.* Finally, the water carries a greasy material, and the ground washed by this water is so smeared with it that they put cleats on their feet against slipping. On the basis of these observations he concluded that in the water there was *common salt*, *niter*, *talc*, *gypsum* or *white earth* and *vitriol* at the same time. Since the salt from hot springs will burn when put on burning plates, it is not hard to prove that it contains some flower of very pure *sulphur* or *bitumen*, coming from petroleum or some similar substance.

On the Baths of Pisa at Mount St. Julian. The first, the bath called *Bagnetto*, reaches the thirty-seventh degree on a thermometer of fifty degrees. The second, *Bagno Caldo*, thirty-nine. The third, *Bagno Grande* or *Balneum ad Scabiem*, thirty-seven. The fourth, the Bath of the Little Well of the Great Bath itself, *del Pozzetto del Bagno Grande*, thirty-seven. The fifth

and sixth, the *Balnea de Duciis, della Doccia*, of which one is set apart for males and the other for females, thirty-six. The seventh, the Queen's Bath, forty. The eighth, the source of the latter bath, thirty-seven. The ninth, the Bath of Nerves, thirty-four. The tenth, The Bath at Tinea, thirty-six, growing gradually hotter. These baths lack red earth and talc, in the absence of which they agree with the *Bath of Waters*. *Common salt*, *niter*, *vitriol*, *bitumen*, *sulphur* and *gypsum* are all abundantly contained in Mount St. Julian. They smell of sulphur, but mildly, and not offensively to the nose. From the ducts of the bath, niter salt effloresces, which starts a warm bubbling combined with blue vitirol.[153] From all the waters a coal-black grease separates out, going to the bottom and attaching to the sides of the containing vessels. This sediment, analyzed by using an appropriate fire, with oil of tartar neither effervesces nor puts out foam or bubbles.

A mixture of these waters with vitriol water shows a yellow tint, rendered much darker by the water of the Little Spring of the bigger bath itself. Dissolved with sublimate,[154] they turn white, and when mixed with a solution of gall or alum they do not change the color, which is rendered milky by oil of tartar and rose water. The waters give differing amounts of sediment. From thirteen pounds of water from the Little Bath, six drachms settle out. From nineteen pounds of water from the larger Bath of the Little Spring, the same amount is produced. And thirteen pounds of water from the Queen's Bath show five drachms. All these sediments, except those derived from the water of the Little Spring, have no detectable taste, or at least are less intensely salty. The latter sediment changes vitriol water to a darker yellow color, and by previous fermentation precipitates a vivid yellow material. The same thing dissolved with ordinary water and with sublimate produces a whitish color. With a tincture of gall it turns green, hardly distinguishable from a mixture of vitriol. In the water of the Bath of Nerves, a certain amount of sulphur is apparently dissolved, which tinges silver coins with a gold color, no differently from what the water at Bath in England and others in Germany do.

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[153] i.e., copper sulphate.

[154] Probably mercuric chloride.

[The bath of Lucca]

The Bath of Doccia at Lucca. The tartar that adheres here is of two kinds. One is thick and hard like wine tartar. The other is very fine, rising out of the water like vapor, and solidifying on the surface like a thin veil, which can be broken easily into a fine crumbly powder having a slight taste of niter. When this powder is mixed with the water it acquires a fleshy texture. The sediment that settles out of the water of Lucca hardly amounts to one drachm per pound, and in the process of evaporation it gives off a nasty odor, which can also be detected from the dried sediment. From this, together with the flavor of the sediment itself, it may be inferred that the mixture is composed of *rock salt* in abundance, *sulphur*, *bitumen* and *earth*. It does not effervesce at all with oil of tartar, and gives off no bubbles or foam, because it completely lacks alum.

About the bath of Villa and other baths of Lucca. The heat of the waters of Villa is thirty-seven degrees. They are clouded by pouring in vitriol, and tinged with a deep yellow, which is removed in matter settling to the bottom. They are not changed by alum-water, and are whitened by a solution of sublimate. With oil of tartar they become like milk, and with rose water, become pure shining white. With gall-water there is no perceptible change. The sediment obtained by evaporation from nineteen pounds of water weighed fourteen drachms, was bright white and intensely salty with a sharp salt flavor. This sediment, poured into blue vitriol water, turned clear yellow, in the manner of rock-salt, which the precipitated material also resembled. With a solution of sublimate this water turns white, but with some redness in it. When mixed with gall-water, it is tinged with a dark red color, and clear as it was, becomes opaque. From these observations it may be deduced that the waters of Villa are saturated with rock salt, which abounds in the rest of the mountain and in the other baths, most strongly in the bath "*Bernabo*" on the same mountain. But another tasteless substance, a kind of mined gypsum, which is separated from the salt, seems to be counted among the transparent stones, for the powder of this stone does not differ in brightness from the sediment of that water, nor as to the change and precipitation by an infusion of galls; and its dark red or black color when diluted does not indicate, as some would have it, the presence of blue vitriol water. Perhaps some amount of

niter is not lacking, which is indicated by the absence of a manifest strong salt flavor, and from the water's sediment, which displays a red color upon infusion of a sublimate.

In the other *Baths of Lucca*, specifically in the spring *Pozzetto*,[155] called the Little Spring, it reaches the forty-first degree on a thermometer of fifty degrees. In the tubes that pour out the water, it is at thirty-nine or forty. In the Women's Bath and in the bathing pool, it rises to the thirty-seventh degree. When the bottom of the Little Spring is stirred up, many airy bubbles come to the surface of the water. And in the bottom of the bath a greasy and coal-black, lightly verdigris-colored material settless, and the bronze pipes are cemented with a tartar-like material tasting like niter salt, which is also to be found in the vault of the bath itself. But when the waters of Villa are mixed with an infusion of vitriol, they become murky, colored light yellow, with a light yellow material settling. With sublimate they hardly turn white, with oil of tartar seem to turn milky, and with rose water turn white. With alum-water and gall-water they are not perceptibly changed. They are filled with a copious sediment, yielding a weight of fourteen drachms of bright white material from nineteen pounds of water, except for what sticks to the sides of the vessel, which becomes dark when dissolved with ordinary water. This sediment has an intensely salty taste. It gives vitriol water a yellow color, like that of rock salt, which the precipitate also resembles. With sublimate it turns white no differently from rock salt.

There is rock salt in the waters of Villa, for cubical crystals grow from a solution of the sediment in ordinary water, but before the filtrate from this solution was evaporated, a body was seen in the mother-liquid, hardening into crystals like niter. Indeed this salt was liquefying in the manner of niter, besides having a sharp salty taste along with a certain cool sensation on the tongue, which is a characteristic of niter. And that same salt produced by evaporation was liquefied with oil of tartar without bubbling, but put on hot plates it bubbled. Part of this salt while bubbling would harden into light white bubbles, which to Fallopius seemed to be a sign of alum. But from its meager flavor and failure to bubble perceptibly with oil of tartar, with which dried alum effervesces, it has been confirmed

[155] i.e. *Pozzuoli* (Latin *Puteoli*).

that it has not alum but niter in it. Besides this, Lister testifies that a kind of niter exists, which he called *calcareous niter*, that hardens while boiling in the manner of alum. But the part of that sediment that remains after filtration is a mixture combining earthy particles with a kind of gypsum or clear, white and shiny stone. The powder from this stone is as bright as this sediment, and it produces the same darkness, opacity, as the sediment itself by infusion of galls. The Hot Bath is called "*Bagno Caldo*" because it is hotter than the rest. The heat of the water in the spring itself can be measured by no thermometer. Then it is tempered by mixing with cold water, and reaches 44 degrees in the bath itself, a suitable temperature for dipping and showering, in which respect it seems not much different from the water of Villa.

A common characteristic of all these baths is that their bottoms are rendered smeary and slippery by material having a bituminous aroma, and the surface of the water is covered with a thin greasy film. Because a smell of sulphur is emitted by all these waters, not only at the source itself, but also in vessels closed against contamination for fifteen or twenty days, and also because a bituminous slime either floats on them or settles—considering also the seething of the water, which comes from sulphur being liberated and raised up, presumably caused by the internal motion of the other minerals composing the hot spring waters—therefore, unless we abandon faith in our senses, no one will doubt that sulphur is mixed into the said waters. Finally, the taste perceived of not one, but several salts pleasing to the palate and stomach, suggests that it is not pure salt and tasteless earth that composes the hot spring waters, but a mixture of flavors and salts, prepared by nature in a certain proportion, which no art can imitate, since no combination of the known artificial salts is able to provide such a savor.

The Content Camps of St. Peter, which the people call "Della Figatella," in the field at Bononia, from the most recent report of Mr. Jacob Zambeccari, containing these words: "Evaporation of five pounds and half an ounce of the mentioned water being done by fire, there remained in the bottom a very white powder, very much like sea salt in taste." Hence he thinks it obvious that nothing is contained in that water but earth and common salt. It dissolves soap well, not in the least impeded by a small quantity of earth which contaminates it.

The salt water of Onfia, in the field of Regia, written by Vallisnerius. The salt water spring of Onfia erupts so abundantly that it is enough to turn the mill-wheels of Molendini. There, in ancient times, they worked at mining rock salt that is perfect for human consumption. The lead vessels and other evidence of the work still survive. Sulphurous waters also gush out not very far from there, which caused death to the locals drinking it.

The hot springs and clays of Querciola in the field of Regia. To the north across the torrent of Ternario there is a hot spring. It bubbles up, wanes, and rumbles, constantly fuming and flowing. The inhabitants of Querciola call that water salty because of the salty calcinated rock which that perpetual and so to speak inexhaustible jug constantly cooks and spews out. You would say that a hidden fire had been kindled, especially at night. When it is raging, it belches forth flames together with stones and liquid mud. It occupies a space about one hundred feet in diameter, but its hottest point is not all over it and changes its location frequently. We threw stones, which descended into the abyss, not without a lot of deep clattering. Sometimes it has swallowed small animals and careless cattle, later belching them out cooked, wasted away and almost boneless. When it rumbles with more than the usual noise, this is a sure prediction of rain, and a sound like a bombardment reaches to the neighboring areas.

There is a somewhat salty water from here that the herds very much like to drink. Its salty mud is frequently used by our countrymen. From the base of the mountain there drips black petroleum, but it is dispersed unobserved, mixed with mud. At a distance from there a hill of ashes can be seen, which grows in height and sticks out farther every year, from the continual belching forth of boiled and sticky earth. The mentioned material mixed with salt water then vomits forth from seven conspicuous and very large gaps. The larger mouth, which is contantly bubbling and, at intervals, with a deep rumbling of vapors or smoke, and sometimes belching out balls of flame, is equal in perimeter to an ordinary well. A rivulet of water leaps from its double cavity, on which drops of very black and smelly petroleum float. In some of the air-holes, where the mud is thicker, and the slippery mud does not extrude so much from the water, bubbles do not appear continually, but swell up and explode at regular intervals, with visible smoke in them. At night, flame flickers in all of them. A short distance away in the side of a hill, there is a spring of clear water, like a jar,

under which it is as if a fire is kept. It bubbles constantly, although it is chilly to the touch. Where there is no water flowing, but the ejected mud lies drying, it blooms with white sea salt mixed with niter, and some chalky salt. In everything that comes out, water and mud, the hand detects no heat, although to the eye it presents a picture of constantly seething boiling.

Quars, or water bath warm springs, from Mr. Vallisnerius. The water is affected with a pleasing saltiness, is cool, has little odor of sulphur vapor, and is transparent in color. While the water is erupting from the narrow cracks of the rocks, at intervals it belches out bubbles like air bubbles. It smokes in the winter and is chilly in summer. At this time of year, he found a long, thin live worm looking outwardly not unlike our intestines, swimming peacefully there. It was darkish, a span in length, thick and with a square head. The water smells a little of sulphur. It sometimes reeks so much of sulphur and smells so sharply bituminous, that some have thought that it contained camphor. Nevertheless this water (though others will disagree), as a matter of fact, except for some little bits of sulphurous matter, contains nothing but *common salt*, *niter*, a little *lime salt*, and portions of *earth* or *stone* or *calcinate*.

On the Pozzuolan[156] *baths*. In a mountain village called Pozzuoli, clear, seething and obviously boiling water erupts. It does not give off any foul smell, and it all seems to contain alum without any salty sulphur.[157] In this water many bits of volcanic ash like stones are produced, and deposit a black material in the streams a long way from the spring. Among the hot springs, many cool ones gush forth, and are delightful to see.

[On French Waters]

On the waters of Evaux-les Bains in France. An experimenter had more than seven grains settle out of a pound of this water, half of which was earthy matter. M. Du Clos got almost twice the sediment. He thinks that the salt in this water is analogous to sea salt, although by performing many

[156] The manuscript has *Porcetani*.

[157] i.e., sulphate.

experinments, he concludes that the native alkaline salt, together with a little sulphur, was mixed in.

About the waters of Bourbon, France, by M. Bulet. This water bubbles perceptibly and gives off a lot of smoke. Its surface, when it is not stirred up, seems to be veiled over with a kind of grease, or to have an oily membrane on it, which is so thin and superficial that it cannot be collected by any amount of effort. Nor is there completely clear water within the cups, it is of almost no smell, of great heat, but still tolerable to the touch but tasting like liquid salt. When a barometer was immersed in the middle of the spring, the liquid went up twenty-four lines. This water stays hot for a long time, so that ordinary water heated to the same temperature, and very seething and boiling, cools off while this water is still more than luke warm. No one is wholly unaware that this water, when just taken from the spring and immediately put on a fire, does not come to a boil more quickly than completely cold plain water. Besides this it is known that the leaves of plants immersed in this seething water do not turn yellow. He mixed the water of the baths with a solution of filtered niter salt, and no virgin's milk, no solidification nor precipitation followed, but the water stayed clear. He added some drops of spirit of vitriol to this mixture, and immediately virgin's milk appeared, which soon precipitated into a white lump. A copper solution, which was becoming green in color, when mixed with the water of the baths immediately tinged it with a yellow color, and then solidified into flecks, which precipitated slowly, putting on a red color. This water did not change the color of a solution of heliotrope at all. Mixed with distilled vinegar, sulphuric acid, and other acids, it bubbled and fermented. Blue paper, made red by spirit of vitriol, regained its color in this water. A powder of gall-nuts (oak apples) made no change in this water. It colored syrup of violets the color of flax-blossoms. Mixed with a tincture of Damascus roses extracted without any acid, it does not change at all, but mixed with the same tincture made with spirit of vitriol, it gets a nice purple color. From these experiments it is deduced that this water contains nothing but alkaline salt.

He ordered that twelve pounds of water from the baths be put over a slow fire in an earthen dish to evaporate. As soon as it began to heat, it smelled like must. The more the moisture was taken away, the saltier it tasted. When the evaporation was finished, some whitish and tasteless

earthy matter stuck to the sides of the dish, which made a loud noise when crushed with the teeth. He filtered the liquid, which was reduced by heating to eight or nine ounces, and produced a dense, thick and sticky matter which stuck to the blotting paper. With the filtration finished, this weighed at least one drachm, fifteen grains. He put the filtered liquid on the fire again, and when it was consumed to the point that a membrane appeared on its surface, he put it in a wine-cellar. Very thin and brilliant crystals formed in it, looking like they had been sculpted. The total of this material, which he was able to collect, dried out, weighed five or six grains, and had a very mild and completely alkaline taste. Finally, with all the liquid consumed, the salty matter remaining in the bottom of the dish weighed about three drachms and two scruples. He analyzed all these materials, which taken together weigh about five drachms: two whole drachms and fifteen grains of sticky matter sticking to the blotting paper, five or six grains of crystal, three drachms and two scruples settling, and ten or twelve grains of whitish substance sticking to the sides of the dish when the water was consumed.

M. Du Clos in his experiments found in each one of the jars of these kinds of water which had been transported to him fifty-nine grains of sediment. M. Geoffroi, who examined the same waters near their spring, found sixty-three grains of the same sediment, but the author in our calculation found about the same weight [as M. Du Clos]. When an experiment was done on these substances, that whitish matter, which crunched when ground with the teeth, was found to be nothing else than *alkaline* earth, for it fermented with acids. The gluey matter that stuck to the blotting paper was judged to be of about the same nature, differing only in this, that it contained sulphurous matter mixed together with some quantity of iron. The sulphurous part of this material was evident enough, for it smeared paper with a greasy material, and when put on top of the coals, it turned first red, then black, while giving off sparks. From this material turned black after calcination, he extracted particles of *iron* with a magnetized knife. The saline matter that settled, weighing three drachms and two scruples, contained *alkaline salt* mixed with earth.

M. Seignette, after a most diligent examination of the waters of Bourbon, having separated the different kinds of salts, said without hesitation that he had found *an almost equal proportion of sea salt* and *alkaline salt*. From

fourteen pounds of the Bourbon water, when it was sufficiently evaporated and put in a cold place, he obtained long pentagonal and hexagonal crystals, which answered both in shape and in taste to the lime salt described by Mr. Lister, and were somewhat acidy[158] and somewhat sweet. Put in the fire, they swelled like alum, and they had no manifest acid or alkaline taste. Then, evaporating them again, he obtained crystals looking enough like *alkaline salt*, as well as heaps of *crystals of sea salt*, which were so apparent as to leave no doubt about their nature. The author found nothing like this, for from three drachms and two scruples of the salty sediment remaining, experimentation gave him nothing to isolate and recognize, except an alkaline salt which ferments in acids of every kind.

M. L'Emmeri examined *the mineral water of Vezelay in Burgundy*, and by distillation with a bain-marie noted that four pounds of it gave two scruples and just as many grains of the same kind of brownish salt, similar to *sea salt* in every way. Now it is evident that sea salt is neither acid nor alkaline, but composed of both. Moreover, the salt of this water contained a kind of earth, or a kind of alkali, which had not yet been penetrated or acted on by acid. For when spirit of vitriol was poured on that salt, a slight fermentation arose which did not occur when M. L'Emmeri purged the same material of its earthy matter. This salt was, as is, richer, though sharper and more biting in taste, than when purged of earthy matter. Because of that, the sea salt made by solidification in the salt-marshes of Rupella appears to be saltier and sharper than that obtained by evaporation in Lyon, France, which is very pure and white.

The observations of Joh. Pascal On the Hot Springs of Bourbon-l'Archambault. On the surface of the water some grease and oily matter is observed. One notices a significant bubbling and vehemence, and abundant smoke. If the water is poured into a glass, it shines with a crystalline transparency, without color or smell. If it is drunk, it is found to be warm, but not burning. The salty taste, less when the water is hot but stronger when it is cooled, strikes the tongue as mildly acid and salty. If it is to be brought to boiling over a fire, whether it is put on hot or cold, it takes the same amount of time as plain water requires. The springs never dry out, neither

[158] The Latin word is *substiticiae*, possibly for *substypticae*.

if the hottest Sirius[159] is burning, nor if a large amount of water is drawn out. The salt left when its moisture is evaporated, except for containing a little earth, he declared to be uniform and fine in contrast to the tenacity and solidity of some mineral salt. Just as it dissolves promptly in water, so it liquefies in the air and does not stay unspoiled long in a closed earthen vessel. He thinks that the *Sulphur* that is in it is not harsh or violent, but mild and balsamic, consisting of round and spherical particles. But the *salt* is neither sharp nor biting, but volatile and temperate, and he thinks it is shaped with light and benign points. He found further that a pint of the water leaves a residue of salt after evaporation which, when dissolved, filtered and evaporated renders fifty grains of salt, leaving seven grains of whitish and light earth in the filter. On the sides, a volatile salt adhered in the form of fine, shiny and pyramidal crystals, but a solid and not so white salt settled to the bottom. Analyzing all this, he observed that the volatile salt, without any salty taste, pricked the tongue like mildly acid salts, and that it could not liquefy easily in a humid place, but could dissolve more readily in water. However, since his solution does not effervesce with tartar salt, vipers' salt, powdered pearls, coral or calcinated goat's horn, nor the salt itself with sulphuric acid or spirit of vitriol, but does suddenly produce a harsh noise in a candle [flame], rendering the flame blue; and since a solution of this salt turns a solution of sublimated corrosive Mercury white and a tincture of heliotrope red, and precipitates salt of Saturn[160] into a white powder: therefore, he concluded that it was not an *acid salt*, nor an *actual alkaline salt*, but a *hermaphroditic salt*, having acquired a nature *intermediate between volatile and fixed*. Especially when it comes to solutions of oil of tartar, camphor and vitriol, it causes the same effects as niter. In the analysis of fixed salt, he noticed that this solute turned white after filtration and evaporation, that it possessed a subtle flavor, pungent, mildly acid and salty, sank in water when powdered, and turned to liquid in a humid place. It will penetrate an earthen vessel if it is kept in it for some time, and stick to its outside like crystal threads, which when dissolved, make water pungent and acid, so that it has a Mercurial flavor; and with grains of niter fixed with coals, it effervesces somewhat. Since, there-

[159] The "Dog Star," supposed to be the hottest, here meaning "heat spell."

[160] i.e., lead acetate.

fore, a solution of this salt with tartar salt, animal bile, iron filings, or with vipers' volatile salt, does not bubble, the Author concludes that it has an extremely loose texture, and that the combination results in a subtle acid. He further noted that the fixed salt mixed with sulphuric acid or rectified spirit of vitriol produces an effervescence. Mixed with strong vinegar, it creates an agitation and decreases its acidity. It precipitates tincture of coral prepared with distilled vinegar into a white powder. To oils solidified by the juices of lemon, sour sorrel and barberry, it restores their original fluidity. Poured on curdled milk, a solution of it dissolves the curds. And from all of this he concludes that this fixed salt acquires an *alkaline character*.

He also lets this water evaporate under the sun's rays, and says that he then observes results opposite to those produced by salt left after water has been evaporated on the fire: for the former he did not observe to cause the acid liquids to ferment noticeably, nor to precipitate solutions made with acid, nor to restore the original fluidity to a solidified mixture. Therefore, after the Author has demonstrated that this water is neither acid nor alkaline, he goes about proving that a hermaphroditic salt partaking of both acid and alkali is in it, and this by various arguments: [1] because the water does not effervesce with acid or with the solution of any alkaline salt; [2] because natural salt easily receives the intrusion of external matter, is promptly dissociated by the action of fire, and because of its loose structure, destroys acid particles; [3] because the salt that sticks to the sides during evaporation makes a crackling sound when put in a fire or candle flame, and renders the flame blue.

[On the Caroline Waters]

Hoffmann on the Caroline Waters says this: It can easily be proved that salts are associated with a chalky substance. Common cooking salt especially supports a lot of it. As a result, it happens that in the boiling of salt, especially that of Halle, a stony material clumps onto the sides of the pans, hard and abundant, so that after just one week on the fire, the salt-workers are forced to dry them out and then pound the deposit out with hammers. When the portion of salt that is left has been washed out, then it is reduced

to chalk by heating even more. That rocky alkaline and almost chalky material that is seen in abundance in the Caroline waters, is of the same nature, not only does it form in huge quantities in their most important spring, commonly called *Prudel*, as well as in the canals through which the water runs off, but also, around the estuary of the springs, where the water is thrown with great force against the surrounding wooden beams, it hardens into stones which, when polished to show the variegation, resemble the most elegant marble or the brightest jasper. The surrounding ground abounds with very fine and coarser chalky stone, looking like marble.

These things have been said about common salt as it lies mixed and hidden in other kinds of salts, resulting in a salt that is unknown and of a divergent character; while in waters of this kind, it lies dissolved in small quantities, so that it floats as an acid separated from its saline body. Since the intention is to bring to the fore here experiments on salt, as many as have been done, and since innumerable experiments have been done with mixed salt, hence I have wished to compare such experiments, to the end that by means of them the nature of this salt may be discovered so much the better, not in itself alone, but also in its other appearances.

Elsewhere, common salt, if it is in water, is tested with reagents, for example, by pouring a tincture of water of Moon,[161] and if this turns white, it is a sign that the water contains some common salt. It is also done with a solution of sugar of Saturn,[162] which makes the water turn white like milk, afterwards turning into granules. It also somewhat changes the color of a solution of vitriol of Venus,[163] but only imperfectly, so that only the green color comes up, rather diluted. It turns a solution of the slag of regulus of antimony[164] opaline, makes a solution of resin a little coarser and thicker, while turning syrup of violets a little green, all of which are generally signs of common salt.

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[161] Probably silver sulphate.

[162] i.e., lead acetate.

[163] i.e., copper sulphate.

[164] "Pure regulus of antimony is a bright semi-metal resembling tin or dusky silver. It is one of the lightest of the metallic bodies." (***Howard Encycl.***, 1788)

§ 45

ABOUT OTHER SALT WATERS, LAKES AND ROCKS, OF WHICH THE AUTHORS MAKE FREQUENT MENTION

Albaro Alonso Barba records that there is a saline spring in the West Indies[165] called "Garci Mendoza," but it would better be called a lake, for it is said to be forty miles long and sixteen miles wide, and very deep. In the middle of it, or elsewhere, one notices leaping springs, which are supposed to be bottomless.

In Lipes he says that there is also a lake in a region called Tumaquisa. In the middle of the lake it is said that water bubbles out with a great noise, that its water is thick and extremely slimy, and where it flows through a canal, it turns into red colored salt, especially where it is scattered into smaller canals. He asserts that the salt is very strong, but thinks it is mixed with alum to some extent.

At a distance of a mile and a half from Julloma in the province of Pajages, he reports that there are many salt springs whose water, when poured out on the ground, turns to salt in a short time, so that salt accumulates and piles up. He says that there are still more salt springs in the same province near Caquingora. There is also a lot of rock salt possessing a crystalline transparency. The inhabitants in Curaguara de Carangas have a lot of rock salt, and it is dug near the river Langa Collo. The salt mountains near Jocalla not far from Potosi supply abundant salt, and he says that around the mining districts every day 1800 hundredweight are consumed [1500 *quintales*].

Baccius in his *Thermis*, Book Five, reports from Pliny, that salts are found in many colors, namely, red salt at Memphis, ruddy salt near the Oxus, yellow in Cappadoccia and purple in Sicily, not far from Gela, where it is amazingly shiny.

In a field of Taranto, salt is dried in the summer sun, and a whole swamp turns to the saltiest of all salts, to a depth up to the knees.

In Sicily, not only are there many salt springs, but also whole lakes, and flowing rivers of salt. Such is the swamp Cocanicus on the coast facing

[165] i.e. in Peru. See A.A. Barba, ***Treatise upon Metals, Mines and Minerals***: James Hodges, London: 1739.

Africa, and another similar one near the river Gela, which is therefore also called the Salty River; and on the opposite coast, another salty stream, which puts into the Tyrrhenian Sea, called the Himera River [Salso].

Salt is chipped also in Calabria from the deep caverns of the mountains, clear as crystal. Also in Wallachia, Cappadocia, and Armenia, where the river Halys is located, which means "salty" in Greek. In Meroë also, the largest island of the Nile, there is salt mining, and in Arabia. Pliny makes record of Oromenus salt, which is cut like stone from the mountain of that name.[166] Besides these, there are salines at the city of Tingui, in the province named Cardia, and likewise in Tartary salt is made from spring water. By way of the Western ocean, Alvise Cadamosto commemorates the rock salt in the farthest reaches of Black Africa, at a place called Tagaza, from which by a journey of thirty days they bring it to the Mediterranean lands, mostly to the people of Malta. It is sufficiently evident from the ancient authorities, that in the whole of Africa, salt is found here and there under the sand, especially near Mount Cyrene in Libya, from which Cyrenian salt is famous—also called ammoniac, for it is picked out around the temple of Jove or Ammon,[167] similar to alum in color, but unpleasant to the taste.

In Transylvania, it is a common occurrence that when salt is being cut out, they have found lost iron and wooden instruments that had been left behind for some years. In one place, a hen sitting on its eggs was found, preserved to that day under a layer of salt, and it is still displayed in perfect condition. Now a lot of coal is usually dug out of these mines along with the salt, and very ancient oak logs. Rock salt that is clearer than all the other salt, when it is found in the bottom, indicates to the miners that no more salt is to be found [further down], rather only impure earth as the mother layer or matrix.

There are many salines in Italy, very small and not very rich, which nature has filled with sea salts from both the Adriatic and Tuscan seas. There are such salines in Volterra, where water is gathered from very deep springs and boiled off in lead pans, which hardens a little at a time into a salt that is the whitest of all, and the choice of elegant tables. Near the Via

[166] In India (Pliny, ***Nat. Hist***. Bk. xxxi,39).

[167] See footnote 148.

Aemilia, in a field of Piacenza, they have salt-trenches, from which salt is likewise made by fire. There are other salty waters in Pizzo, one in the field Ascoli three miles from the village of Monzo, and another in Fermo beneath Castle of the Holy Angel, producing very white salt artificially. A very small salt spring is also in the field of Urbino near the town of St. Constant, which water is supposed to be sacred to the natives.

The castle of Mt. Catino, next to the town of Pistoia in Etruria, is celebrated for the same waters, which are named *Salmacidas* from the taste, and are good not only for bathing but also for drinking, according to Ugolino.[168] In times past, when they constructed workshops for making salt, and found them to be of inferior value and results for solidifying salt, they would use them for bathing and drinking purposes. Nevertheless, the water is exquisitely salty. When distilled, it leaves a thin, very white salt. The tamarisk, which loves swamps and this kind of naturally salty waters, springs up all around.

In the whole of Europe, no more beautiful salt is found than in the Gotholanic (now Catalonian) mountains, not far from the city of Barcelona in Spain, where there is a mountain endowed with this salt. (From Boerhaave.)

These things have been gathered from Pliny, Baccius, Barba and other authors, and although many fables are mixed with the truth, still I cannot forbear to bring them forward.

[The following portion appears at the end of the manuscript with an indication that it should be placed here. Place names we could not find in the available German and French encyclopedias are marked with +.]

ON THE PLACES WHERE SALT IS FOUND

In the *Bresslauische Natur- und Medicin-Geschichte* for August 1722, there was a listing of places where salt is obtained, such as at:

[168] i.e. Gherardesca.

Allendorf in Hesse
Antequera in Granada, Spain
+Artern in Mansfeld
Astrakhan in Russia
+Bärensdorff in Brunswick
Bibergeil in Westphalia
+Bosern in Meissen
[Brazil in America]
Kolomyja in Prussia
Cannstatt in Württemburg
Cattaro in Dalmatia
Krakow in Poland
Creuzburg in Eisenach
+Detfort in Brunswick
+Döpel in Bohemia
+Dues in Württemburg
+Erdeborn in Mansfeld
+Ermsdorff
+Gemünde in Austria
+Girona in Catalonia
Greifswald in Pomerania
Halicz in Russia
Hall in Swabia
Hallein in Salzburg, Austria
Heissen in Hildesheim
+Hayersdorf
Homburg in Hesse
Juliushall in Brunswick
+Kötschau in Saxony
+Lueder in Fulda
+Monsters in Savoy
Münder in Brunswick
Neustadt near Harzburg
Oldeslo in Holstein
Plaue in Schwarzburg
Reichenhall in Bavaria
+Alten Saltza in Meissen
Apolda in Weimar
Aschersleben
+Auleben in Thüringen
Belzig in Brandenburg
+Bodenfeld on the Werre
+Bracke in Silesia
Brittany in France
+Camp in Pomerania
+Cardona in Catalonia
Kolberg in Pomerania
Kronach in Bamberg
+Dedits in Saxony
+Diedelkopfen in Zweibruch
Döben in Meissen
Eperjes in Hungary
+Erlback in Meissen/Bohemia
Frankenhausen in Thüringen
Giebichenstein near Halle
Gothenburg in Sweden
Grosssalze in Magdeburg
Halle in Saxony
Hall in Tirol
Hallstadt in Austria
Heerschewitz in Bohemia
+Hölitz in Prussia
Huszt in Siebenbürgen
Kissingen in Franconia
+Lindenau in Heldburg
Lüneburg
+Münchkretzlitz in Bohemia
+Neuhelm near Frankfurt a/M
Nidda in Hesse
Offenburg
Rammberg in Hesse
Rochelle, La in France

Rotenburg in Münster
+Rosier in Lorraine
Salins[-les-Bains] in Burgundy
Salza by Harzburg [maybe Neustadt]
+Saltzburg in Lorraine
Salzderhelden in Brunswick
Salzgitter in Hildesheim
+Salt Island in Africa
Salzschlirff in Fulda
Salt valley in Hyrcania
+Sana in Württemburg
Sardinia
+Sastrupen in Westphalia
Schmalkalden in Henneberg
Schöningen in Brunswick
Schweiz Canton
Saint Ives in Portugal
Slany in Bohemia
+[Sol in Magdeburg]
+Solendorff
Stassfurt in Magdeburg
+Söldorff in Magdeburg
+Sultza in Ansbach
Sylt in Wester[land]?
Sulzbach in Nassau
Traunstein in Bavaria
Turkheim in Pfalz
+Unau in Jülich
+Weissbach in Hohenlohe
+Saintonge in France
+Rotscha in Switzerland
+Salces in France
+Salis in Savoy
Salzburg in Bavaria [Austria]
Salzhuffeln in Grosslippe
Salzdipper in Hildesheim
Salzhemmendorf in Westphalia
Salzkotten in Paderborn
+Salt Lake in Moscow
Salzungen in Thüringen
+St. Polet in Burgundy
Sassendorf in Cleves
+Saulbie in Burgundy
Schönebeck in Magdeburg
Schweidnitz in Silesia
Segeburg in Holstein
Sitten in Switzerland
+Sol in Prussia
Soltwedel [Salzwedel]
Sobor in Hungary
Suhl in Henneberg
+Sultza in Lüneburg
Sulz in Thüringen
Sulz near the Neckar
Sulzburg in Baden
Tarentaise in Savoy
Valencia in Spain
+Urb in Chur-Mainz
+Winnungen in Brunswick

§ 46

A METHOD OF PREPARING SALTPETER FROM COMMON SALT AND LIME

Take four parts of quicklime and one part common salt, mix well, and moisten with urine or dirty or common water, until it is a mixture like porridge. From that mass globules are to be formed, which are dried in the sun. Then they are put on a pile of wood, which is set afire, and then the salt is changed by the glowing heat and turned into saltpeter. When these globs have been glowing hot for some time, they should be put in a place where the rays of the sun and the air can reach them, but not rain, to a height of two or three feet, one layer on top of another, and moistened with urine or dirty brine or common water, and left this way for a few days. As a result those globs will melt together and dissolve. Then, when all the moisture has been driven out by the sun and that conflated mass has dried completely, it should again be moistened with urine or dirty water which contains something nitrous. This process should be repeated as many times as it seems to require. From this treatment saltpeter is generated in it, which can be extracted by the usual process of dissolving, and purified into crystallization in the common way. This process is not supposed to cost much in places where wood and limestone can be had cheaply. If a nitrous ferment is put on this limey and salty mass, when it has burned even more saltpeter will be generated there, and the quantity will grow. See further about this subject in *Nitrum*. This is the method of Mr. Ludwig Glaser, from whom Mr. Kellner got it.

Glauber's Method. Glauber also recounts the above method in the treatise called *Teuschlandz Wohlfart*, to the point that it coincides word for word with Mr. Glaser. But elsewhere he gives another method, namely: Take one part of common salt and mix it with two or three parts of dissolved limestone and place this mixture where it is safe from rain, but where air and the heat of the sun can penetrate, and let it lie there in piles. This mixture is moistened with brine of niter and then dried. This moistening and drying is continued until as a result of the fermenting action all the salt is transformed into a burning saltpeter, which happens more quickly or slowly according to the industry of the workers. Saltpeter is dissolved

out of it with water, and the saltpeter is gotten from the water by evaporation. The residue is set aside in that place and allowed to digest for a while. After drying it is sprinkled with ordinary water if nitrous brine is lacking, and from this saltpeter is generated again, which can in turn be extracted, and so on without limit.

A different way, according to Glauber: Dissolve common salt in water, and an equal amount of solid niter, but separately. The solutions are mixed in a wooden vessel, and digest there for a while. Then the solution of niter works like a ferment on the common salt, and as a result, niter of the best quality is obtained. This is from Glauber, who brings forward many more things besides.

A different way: One part of salt and two or three parts of sulphur pyrite are heated to glowing in a calcinating furnace for two hours, and the sulphur transforms the salt. It is dissolved and evaporated to a skin, from which rather long crystals like saltpeter form, the taste being also similar, and in hot air it collapses into powder. This can be made into saltpeter with quicklime, as above.

§ 47

OBSERVATIONS AND EXPERIMENTS COLLECTED FROM VARIOUS AUTHORS, ESPECIALLY CHEMICAL ONES, ABOUT COMMON SALT AND ITS SPIRIT, ETC.

1. About saline springs it has been observed that the deeper one goes, the more salt they contain, so that those that first contained 2, 3, or 4 loths in two pounds, would contain 8, 10, 12 or 14 loths at a depth of 30, 45 or 60 ells, namely at the bottom of the spring.

2. Mined salt is so hardened that pieces can be left in the open for several years and they are not dissolved, but seem to be undiminished, unless they were left where animals could lick them.

3. It is reported that in some places there are whole tracts where salt is sublimated out of the earth by the sun or by the heat of the day, which is supposed to be of the best quality, and that it lies as thick as the back of a

knife blade on the earth, like snow. The locals usually scrape this off with a kind of rod, and dissolve what is scraped off and evaporate it in kettles. It is said that this salt is so strong that it has more than double the strength of Lüneburg or Halle salt. But since it comes clinging to the earth, it is inevitable that some earth should be raked in together with it; nevertheless, from one measure of the native salt gathered in this way they can get half a measure of the best and strongest boiled salt. It is only boiled out once, so they do not need to boil it out repeatedly, but the collectors admit that the residue, which is thrown out, is just as salty.

It should be noted that in the spring, summer or autumn, when the weather is hot, and this saline material has been sublimated on the earth and, as said, has been removed once or repeatedly, then after two hours, depending on the temperature of the air, new saline material appears on the same ground, so that it seems to be covered or envoloped with whiteness, and this happens over and over.

But if the earth is dug out here and there, even to a palm's depth, no salt water is found, but, amazingly, fresh water. And the deeper one goes into that ground, the more fresh water there is. A well has been dug in this kind of location to depths of thirty or forty ells, for they thought they would eventually find saline veins, but they seem to have worked in vain, and only increased the supply of fresh water.

In the same places a salty plant, called *caly*, is seen sprouting, and three kinds are found, one kind consisting of rather long, thick and wide leaves, but very full of salt. But this plant is rarely found around very salty springs.

Almost all salty springs, with a few exceptions, are found in ground that is swampy, or that at least appears swampy here and there.

4. Almost all saline waters carry something other than salt with them, either some mineral, or something sulphurous, aluminous, limey or vitriolic, and hence one salt differs a lot from another in quality. These heterogeneous things cannot be separated from the salt by that method of secreting or fortifying called *gradeer-werck*, using straw or air, for the heavier elements are not dissipated, but go along with the dripping water.

5. It has been proved in some places that in large kettles, as at Halle and elsewhere, a salt of worse quality and nature is obtained than if the evaporation is done in smaller kettles, so there is a clear constraint against

using these large kettles, but smaller ones are to be used, although this requires a larger consumption of wood. Salt boiled in small kettles does not dissolve as easily in damp air as salt made in bigger ones. In the bigger kettles, salt seems to solidify in very small grains, it loses color and strength, and in damp air almost a third of it is lost.

6. Salt water can also be fortified, if warming vessels are used near the evaporating pan, where the salt water can warm up and evaporate a little at a time. This is done with one and the same fire, and as a result, much less wood is needed. But they say a warming vessel of this kind made of iron cannot be used for long, but a lead one lasts much longer. But salt warmed in lead vessels is also said to become harmful.

7. Salt that does not dry out well and quickly is usually of worse quality than that which dries quicker and better, so it is necessary to take pains that the salt removed from the kettles is well dried. About the things brought forth in points 1, 2, 3, 4, 5 and 6, see the anonymous little treatise called *Saltz und Berggeist*.

7.[169] In the Sea of Bothnia the water is not so very salty. A pound of water contains only one loth of salt. Toward the North Sea, near Bohus or the coast of Norway, the salinity is three to four loths per pound. Still it appears to vary a lot, and sometimes very fresh water is at the surface, sometimes very salty, and the salinity of the surface and the bottom varies according to the weather. In the winter salt goes to the bottom, but it is different in summer, but still in the summertime, when certain winds blow, the sea seems to be not very salty at the surface nor at the bottom, and the salt-boilers are often frustrated.

8. A pound of water cannot contain more than eleven loths of salt, unless more is gotten into it by heating it to a higher temperature. Still, as soon as it cools, the additional salt that dissolved settles to the bottom.

The more heat there is in the sea, the saltier it is said to be, so that the hotter its place of origin is, the sharper in taste is the salt that is produced; and the nearer to the equator, the saltier the water is. Baccius also reports that in the autumn the water is saltier than in the wintertime. Also, earth that is found in hotter regions, especially within the tropics, is supposed to

[169] We leave the numbering as found in the original.

contain more common salt than earth on northern shores, according to Mr. Hierne.

There is also thick and greasy sea water, which befouls clothing and linens rather than washing them. From Baccius.

Salt that is thrown on live coals increases their fire quite a bit, so it is stirred up as if a bellows has been used. Also salt thrown on live coals is sublimated into white smoke, which, when taken out and collected into a solid mass, has a salty taste. From Hoffmann.