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THE SALT PRODUCTION OF THE LATÈNE PERIOD SALT-WORKS IN BAD NAUHEIM (GERMANY)

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When man started producing his food-supply the long way of deteration in quality began and still continues in the genetic manipulation of our food resources. The preneolithic tribes had a natural diet, which contained all the necessary minerals. By reducing the food supply towards breeded cattle and cultivated plants this natural intake was not given any more. One of the first signs was certainly the reduced intake of minerals, especially of salt (NaCl). The minimum survival intake for the salt intake is only 0,025g per day and the offer scarcely wasn not below that level. On the other hand the optimum rate of the daily intake is said to be 5-6 g (**HEUBERGER** 1994, p.65)[1]. It seems to be quite obvious that the physical competitiveness increases with a well balanced food intake. Consequently man started looking for an artificial substitute, which was found in salt springs and the sea. Hence the first salt-works we know belong to the neolithic period (**DUMITROAIA** 1994, p.7-82).

The prehistoric salt works present large layers of ashes and, *briquetage* called, pottery. In Bad Nauheim these relicts were discovered in 1837 (**LUDWIG** 1865, p.48). During the 1960´s a number of exavations were carried out and gave a fairly good impression of the prehistoric salt production.[2] Besides an early middleaged salt works there was a large latèneperiod industry. Unfortunatelly these excavations are still not published comprehensively yet. Eventhough the premallary reports give a good impression of the site(**SÜß** 1973, p.167-180). It was 20 years later when construction works forced excavation in Bad Nauheim again. This time it was possible to excavate a well preserved kiln. Unfortunatelly it was damaged at both ends (**WEISSHAAR** 1985,

[1] This rate even will increase enourmously considering the use for conservation, use in handycraft and so forth.
[2] W.Jorns, Germania, 38, 1960, p.178-184.

p.1-9). In 1990 excavations started on an 10 m x 30 m sized area in the Kurstraße 2. This time it was possible to discover numerous kilns and quite a number of them was very well preserved (**VOGT** 1996).

Bad Nauheim is situated on the banks of the Usa about 30 km north of Frankfurt/Main (Fig.1). The Usa river floats via the Wetter and Nidda into the Main river. The prehistoric salt works are placed in the Usa Valley and extend over an area of 300 m width about 1 km along the western bank of the river Fig.2). Most of the salt springs can be found on the other side of the River. It is quite remarcable that there is no salt stock in Bad Nauheim. The saltwater rises through caverns and crevasses to the surface (**KÜMMERLE** 1976, p.253-270). Therefore the salt content is only about 2,6% up to 3,3%. This is very little considering that other salt springs contain up to 25% e. g. in Lüneburg. Nevertheless the Nauheim springs were exploited. This means that there must have been a great shortage of salt, which made this low salt spring attractive as it required more effort to produce the salt at this place. This high effort is documented by the high layers of ashes and *briquetage*. Furthermore the Nauheim site presents a very specialized type of kiln, which can be seen as a tribute to the very poor salt springs.

The first kilns were described by **LUDWIG** (1865, p.50). By the following excavations the knowledge of the construction and technique of these kilns increased and the reconstructions became more distinctive (**VOGT** 1996, p.56). Fortunately a couple of kilns could be excavated in very good condition during the last excavations. The interior of the kilns was about 3 m long and 0,6 m wide (Fig.3). They were built of loam which formed the 0,3 m thick walls. The loam was available in the Usa valley. At the inner part of the kilns the loam was baken so that a temperature of app. 300° C must have been exceeded. Especially the inner 5 cm were burnt very firm. This high grade of the burning suggests an even higher temperature. Along the longitudinal axis there were traces of 10 cm x 10 cm in size (Fig.4). Between them there was distance of 10-15 cm. They show where the pedestals for the salt moulds stoud.

In the middle of one longitudinal side was an opening for the firing. The fireplace was in front of the opening. It worked in the same way as it is known by a roman *praefurnium*. At both ends of the kiln there

was another opening, which can be seen as the chimneys where the hot air went outside again (Fig.5).

Contrary to the hitherto opinion (**SÜß** 1973, p.179) the kiln was a closed system with a cover on top. The previous reconstructions showed a kiln without a cover. This means that the hot air was floating away, before the moulds could have been heated. The new reconstruction presents a kiln with a cover which shows a few holes on a line where the moulds were placed. The moulds stood on the pedestals to prevent their weight overloading the cover (Fig.5). This construction forces the hot air to float through all the kiln and heat the moulds before escaping via the chimneys[3]. Further more this means a most efficient use of the firewood.

The high perfection of the kilns caused a development of the other supplies, as can be seen in the moulds and pedestals. Both are burnt at a very low temperature and the clay is traditionally coarse-grained since neolithic times. The technological improvement can be seen in the shape of the moulds. This development is well comprehensible in the saltworks of Halle/Saale. From the late Bronze Age to Iron Age, the moulds become higher and finely they were seperated from the pedestals (**GOULETQUER** 1974, p.5, fig.3,4; **REIHM** 1969, p.105 f, fig.5). These two piece units represent just the type we have to deal with in Bad Nauheim. The separation into pedestal and mould gives a great advantage for the process of evaporation. Now it is possible to change the moulds individually while the kiln is kept on fire. So the kiln could work continuosly even though the moulds were changed. This means a more effective process of the evaporation and a reduction of the requested energy.

It was **H.-J. WEIßHAAR** (1985, p.4), who noticed already in 1983, that most of the kilns were leveled after they came unusable. This observation was made again during the last excavations. One object, which was damaged in recent times, still presented a couple of baked traces in the loam (Fig.3 and 6). Each of them followed the shape of the kiln or next inner trace in a distance of 5-10 cm from its outer shape. Between these oxidized traces there was yellow loam. In some cases these

[3] During an experiment with an reconstructed kiln it became quite obvious, that the kilns did not work without a cover and the chimneys. Only after the chimney were added, the kilns worked satisfying (**VOGT** 1998).

traces layed side by side, hardly distinguishable by a weak dusty groove. So it was possible to distinguish several phases within one kiln. This order of succesive built kilns showes that the older kilns must have been much larger than the younger ones. There is no well preserved example of a kiln of the oldest phase, as they were distroyed most of the part by building the next younger sone. As the older kilns were much longer and wider it is quite likely that they had a capacity of many more salt moulds which would have been placed in several rows in these kilns. With this arrangement these kilns must have produced a multiple quantity of salt at each evaporation process as those we find in good condition on excavation. The final phase of a kiln was so small, that its capacity only lasted for one row of salt moulds. As it was not possible to built a smaller kiln inside, this complex was given up and a new kiln was built somewhere else.

In some cases the baked loam of a previous kiln disappeared and the two phases were recognizable only by the dusty groove within the yellow loam. This phenomenon can be explained in that the prehistoric salt workers rebuilt the baked parts of the previous kiln before constructing the new one. The purpose of this effort can be seen in the attempt to increase the efficiency of the production process. One has to consider, that a certain amount of the brine will spill all over the kiln during the filling process of the salt moulds. Due to the hot surface the brine will vaporise immediately and the pure salt will remain on the kilns jacket. When the kiln became unusable the salt workers endeavered to recover all the salt, which had accumulated in the loam.

This process was combined with the first step of graduating the salt water. For this purpose the salt water was let into flat basins. In these basins some water was evaporated by sun and wind. By this method the percentage of the salt could be increased to a certain degree. This slightly concentrated liquid still was not worth the effort to be processed in the kilns. As a next step the *briquetage* of the demolished kilns were placed into the basins to wash out the concentrated salt. Given optimal conditions using this method could have achieved there an almost saturated solution. In Bad Nauheim two of these basins were partly excavated. They exceeded 30 m² each and it is very likely, that there were quite a number in use at the same time.

In several cases there were unburnt sherds of salt moulds near the kilns. Due to this observation it can be assumed that the moulds were not burnt in a pottery kiln but they were put into the salt kilns unburnt to be fired there. According to the reconstruction of the salt kilns given above it was possible to change the salt moulds during the evaporation process quite easily. The fact that the moulds had not been burnt, shows that the temperature of the salt kilns must have been high enough that the burning of the moulds could have happened right before the moulds were filled and the evaporation in the salt kiln started. In regard to the evaporation process we can conclude a rather high temperature which is not compatible to the hitherto views (**MESCH** 1990, p.468 f.)[4]. Considering a lower temperature would not have burned the pottery, the unburnt moults could not have endured the weight of the salt liquid.

The latèneperiod salt-works of Bad Nauheim were developed to a high technical standard. This development is due to the poor salt content, which needed much more effort to evaporate the water. This means that the salt works of Bad Nauheim must have worked very efficiently to make the production worth the effort. This balance between the effort and the productivity was dependant on the demand, which might have been increased by the nearby *oppida* Dünsberg and Heideträntal (Fig.1). So this high demand of salt must have been the reason that the salters had to utilize even the very poor saltspring of Bad Nauheim. The high effort they put into their work still can be seen in the up to 4,5 m high layers of ashes and *briquetage*.

Zusammenfassung

Bei Ausgrabungen in der keltischen Saline von Bad Nauheim, 30 km nördlich von Frankfurt/Main wurden bei jüngsten Ausgrabungen mehrere Siedeöfen freigelegt, die eine neue Rekonstruktion des Ofenaufbaues und damit auch neue Einblicke in die vorgeschichtliche Salzproduktion ermöglichen. Die Öfen hatten einen etwa 3 m langen und 0,6 m breiten Innenraum. Die Wände bestanden aus einer 0,3 m breiten Lehmpackung, die an der Ofeninnenseite stark verziegelt und an der

[4] **SÜß** (1973, p.170, 179 f.) argues that the high temperatures were achieved at the final stage during the drying of the salt cakes.

äußeren Hälfte unverziegelt war. Im inneren Ofenbereich ließen sich die Standspuren der Tonstützen nachweisen, auf denen die Siedegefäße gestanden haben (Abb.4). Anhand der themischen Strömungsverhältnisse kann auf einen oberen Ofenabschluß geschlossen werden, in dem analog der Standspuren der Tonstützen Öffnungen für die Siedegefäße zu rekonstruieren sind (Abb.5).

Weitere Verziegelungen außerhalb des Ofens lassen darauf schließen, daß die Öfen mehrphasig waren (Abb.6). Es wurde, nachdem ein Ofen unbrauchbar geworden war, der neue Ofen in die Ofenkammer des Vorgängers errichtet. Dabei wurde der jüngere zwangsläufig immer etwas kleiner als der ältere. Im Befund hat sich jeweils immer nur die jüngste Ofenphase erhalten. Daraus kann erschlossen werden, daß der zuerst gebaute Ofen wesentlich größer gewesen sein muß, als die jeweils letzte Ausbauphase.

Die latènezeitliche Saline von Bad Nauheim läßt auf eine sehr effektive Siedetechnick schließen, die auch verschiedene Stufen der Vorgradierung, welche ebenfall im Befund dokumentiert werden konnten, einbezog. Die Ursache mag in den mit einer nur 2,6% bis 3,3% Salzquelle in den schlechten natürlichen Voraussetzungen liegen. Dennoch war mit der Ausbeutung dieser Quelle ein hoher technischer Aufwand nötig, der sich in den bis zu 4,5 m hohen Abfallschichten aus Asche und *Briquetage* manifestiert hat. Dieser hohe Aufwand wird durch eine gesteigerte Nachfrage gerechtfertigt gewesen sein. Der Mehrbedarf an Salz mag durch die in der Nähe gelegenen zeitgleichen oppida Dünsberg, Heidetränktal entstanden sein.

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Fig. 1. Bad Nauheim is situated in the Usa valley. The distances to the next oppida Dünsberg and Heidetränktal are within a one days trip.

Fig. 2. The latèneperiod salt works in Bad Nauheim cover a large area along the western Usabanks.

Fig. 3. A salt kiln of Bad Nauheim. The loam at the inner side of the mantle was baken. At the northern end the base of the chimney is recognizable. (Legend see fig. 6).

Fig. 4. A slat kiln of Bad Nauheim. Along the longitudinal axis the traces of the pedestals can be seen. In the middle of the western side there is the opening of the firing. The fireplace is right in front of it. (Legend see fig.6).

Fig. 5. A reconstruction of the salt kiln type Bad Nauheim. Experiments have prooved that the kiln was covered. At the ends the kilns had two chimneys for the essential draft.

Fig. 6. The kilns of Bad Nauheim showed several phases. In this case the kiln was reconstructed for 5 times so that there were 6 phases distinguishable.

yellow loam

baked loam

sandy loam

sandy soil

ashes

ashes with charcoal

ashes with humus

humus

humus with ashes and charcoal

humus with loam

charcoal

charcoal with loam and ashes

ceramic, *briquetage*s

pedestals

fused glass

oxydation level

sintered ashes