Technical-Historical Comparison of Pottery Districts: Desiderata and Experimental Archaeological Research Prospects

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The study of industrial landscapes holds great potential for the development of experimental archaeology. Connecting the three following research areas yields both advantages as well as challenges:

- The reconstruction and technological evaluation of production processes and production facilities
- The contextualization of the applied techniques within the pottery industry and the strategy of use for resources which were available in the region
- The development of transparent documentation standards which would allow for the comparison of the applied techniques and material properties of products from different industrial areas

This research approach is a clear negation of any technological deterministic view of history. Instead, technological acts – understood as the capability to use and change material as a means to solve problems – are examined as aspects of human behaviour. Accordingly, they can be analysed only while taking into account further components, especially those that are social and economic in nature. Furthermore, the interrelations with the environmental conditions of an industrial area must also be kept in mind.

The challenges which result from this, especially for the examination of pottery areas, can be summarized as follows:[1]

- With every year of excavation, the number of archaeologically documented production facilities from pre-modern periods is multiplied.
- Despite a multitude of experimental archaeological test firings in reconstructed kilns, up until now there is no valid performance data for even one European industrial area with supra-regional markets which would allow tracing kiln technology diachronically.
- Even today, extremely subjective characterisations are being used for the description of functional features of pottery products, for example 'robust, heat resistant kitchen pottery'. The same is true for the classification of wares. The classification as 'proto' or 'almost' stone ware is not only ill-defined from a material scientific point of view, but there are also no equivalent terms in the pottery profession.

This stocktaking shows an urgent need for the development of methodological procedures. A transparent data base would allow for a comparison between the ceramic technologies of different pottery areas.

The ceramic technology of the pottery workshops in Mayen is especially suitable for a model study in this field of research:[2] From about 300 AD, the potteries of Mayen

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Fig. 1: Shaft kiln, type B 1c after Redknap, excavation plan. Red circle: a slate plate marked the height of the kiln wall.

produced more and more wares for export and were able to assert their markets until the Middle Ages.[3] Thanks to large-scale excavations during the 1970s and 80s, a broad stock of archaeological material is available. A series of comparatively well or very well preserved pottery kilns is especially suitable for reconstruction.[4] Also, the current state of research can be described as above average compared to other European pottery centres. Therefore, this area fulfils the ideal prerequisites for a diachronic experimental archaeological study.

The research approach of this study was defined as follows:

a) The reconstruction and technological evaluation of kiln types which, according to the current state of research, mark a technical historical evolutionary step and/or appear in a transition period of social or economic history.

b) The determination of the maximum spectrum of uses for the available raw material in terms of their ceramic technological properties in relation to the practical usage of materials during the respective operation period. For this, the analysis data from raw

Fig. 2: Construction of the firing chamber using upside down pots.

material and material studies has to be connected to the actual forming, drying and firing behaviour of the plastic masses. The objective is the development of generally applicable methodological tools which can be used to deduce the possible spectrum of vessels (for example their probable form, size and function) by looking at the ceramic technological analysis of raw materials.

During the first phase of the project, an updraft shaft kiln with a spoked floor – Type B1c after Redknap[5] – was reconstructed and subsequently fired. The kiln was reconstructed based on finds[6] which had been uncovered in Mayen, Siegfriedstr. 53 (fig. 1).

The kiln was in use from ca. 500 AD until around 520/30 AD.[7] Its height was 1.70 m; the diameter at the upper end of the firing chamber was 1.60 m. The walls of the firing chamber were erected using whole and/or broken bottoms of so-called Wölb- and Wölbwandtöpfe, which were stacked upside down in rows and embedded in clay (fig. 2).[8] The basic construction principle of this kiln type was known in the Mayen region as early as the beginning of the Common Era.[9] However, starting in the second half of the 5th century AD, the shaft kiln with spoked floor began to replace the formerly dominant elongated oval or rectangular kiln types.[10] The early appearance of the wheel-like spoked floor supported by a central pillar in Mayen and the duration of use seem to be unique for the German-speaking area.

Two elements which influence the function of the reconstructed kiln will be presented here: the way of stacking the firing goods and the dome.

Fig. 3: Stacking the pots.

Only two small stacking props, which probably served as spacers for engobed goods, are known from late antique contexts in Mayen.[11] The coarse ware pottery vessels which were produced primarily for export during the operating period of the kiln could be stacked directly on top of each other without additional support (fig. 3). This stacking technique requires a high level of experience so that flames and fuel gas are conducted through the kiln in a way that ensures an even temperature distribution and prevents the vessels being damaged due to stacking pressure. This stacking pressure also limits the height to which vessels can be stacked and thus provides a further indication for the reconstruction of the kiln.

In some archaeological contexts in Mayen, a slate plate can be seen at the top of the wall of the firing chamber. This has been suspected to mark the upper rim of the furnace wall. When taking this height into account, around 550 vessels of the contemporary variety of shapes could be stacked in the furnace. As a rule of thumb, particularly for this type of kiln, the stacking technique is as important as the construction of the kiln for the physical processes which occur during firing.

The original hypothesis of the excavators was that the furnace was constructed with a permanent dome. However, there were no indications of this in the archaeological context. Following general ceramic technological considerations, such a dome is also not necessary for the production of the export pottery preferred during the operation period and therefore a temporary dome was chosen for the reconstruction. From historical and

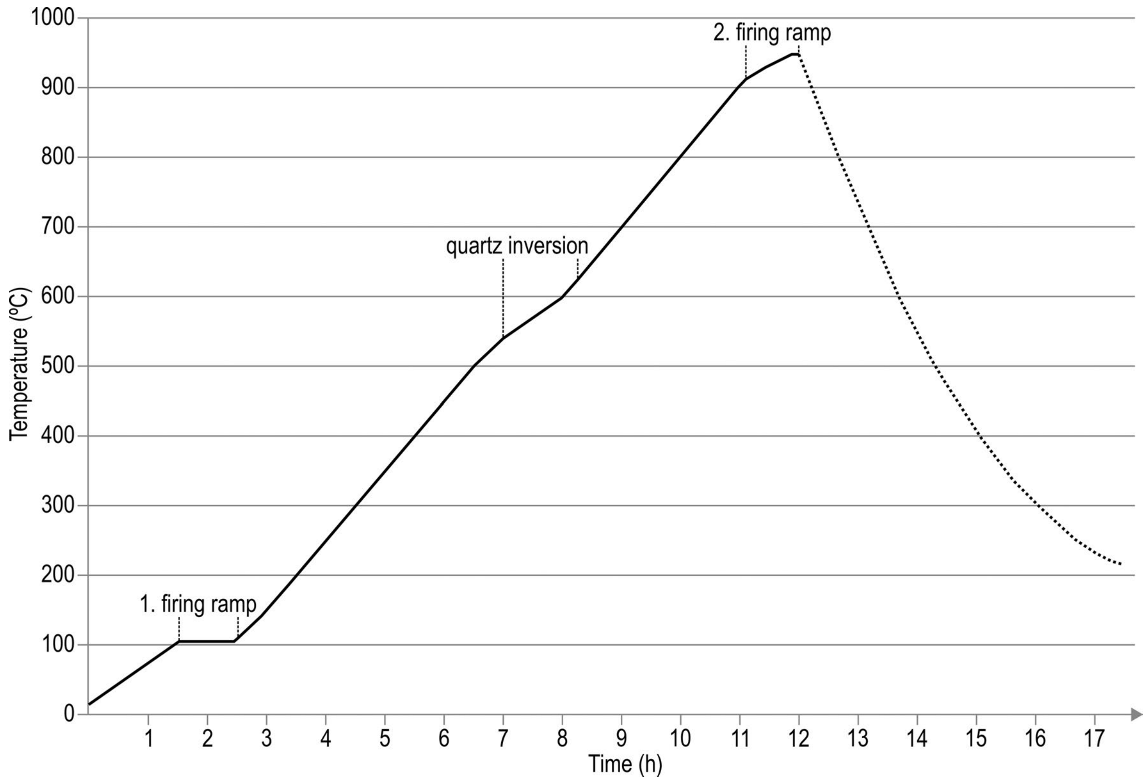

Fig. 4: Ideal firing schedule for the production of Mayen export wares from 500 AD. First firing ramp is to allow for the evaporation of mechanically bound water, the second firing ramp is critical for the quality of the ceramic in that enough time elapses before the final temperature is reached.

ethnoarchaeological analogies, a temporary dome can be constructed by covering the loaded chamber with large shards from the pottery's waste dump.[12] We decided on large, shallow, unglazed ceramic bowls and fragments thereof, which fulfilled the same purpose as large shards.

A final judgement concerning the technological efficiency of the reconstructed shaft furnace of Mayen, which is based on the experiences gained during the test firings between 2014 and 2016, must take into account the type of products which was produced in this type of kiln around 500 AD. The robust, rough-walled domestic ware was fired in an oxidizing atmosphere and intended for export. The evaluation by means of experimental archaeology has proven that for this usage, the kiln construction principle was robust and comparatively unsusceptible to faults. A worker could have gained the experience needed for the management of the furnace quite quickly within a training period of several months. This was made possible by the nearly linear combustion process, which shows retention times only at 80 to 120℃ and at the intended final temperature between 800 and 900℃ (fig. 4; fig. 5).

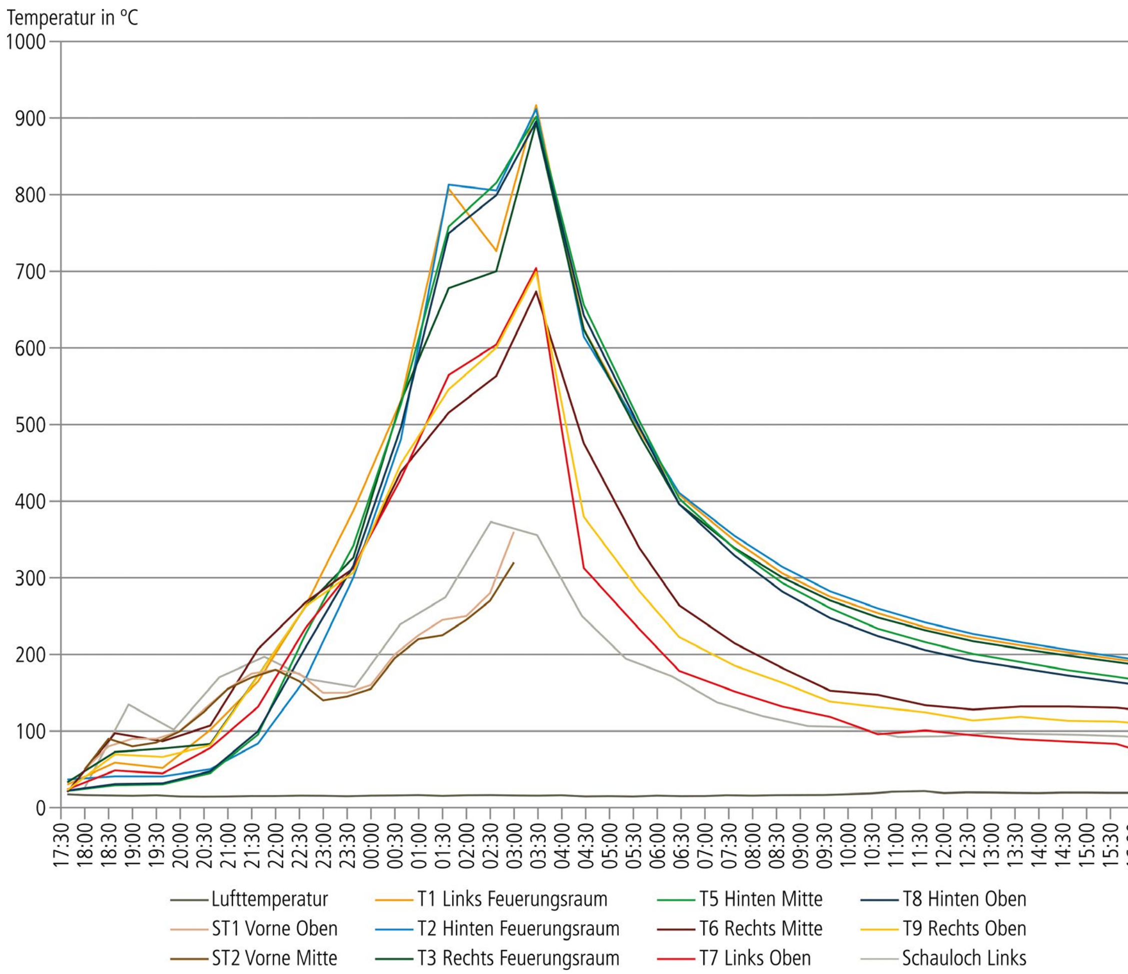

Fig. 5: Pottery firing in 2016 – Temperature curve: measurements taken at 12 fixed points.

The following observation can be made about the energy balance of shaft kilns for pottery production:[13] Shaft kilns are less energy efficient at higher temperature ranges. The retention of temperatures at higher ranges, especially over 800°C, is directly connected to high fuel consumption in the combustion chamber (fig. 6). In this state, firing systems are subject to extremely high thermic strain. This is due to the fact that a raise in the quantity of the combustion material (in this case wood) only leads to a delayed rise in temperature, but also to an increased reducing atmosphere within the furnace. This is caused by the construction principle of shaft kilns, and that two types of energy loss decrease the firing efficiency of wood-fired systems:

- Thermic loss due to heat emission
- Chemical loss due to incomplete burning

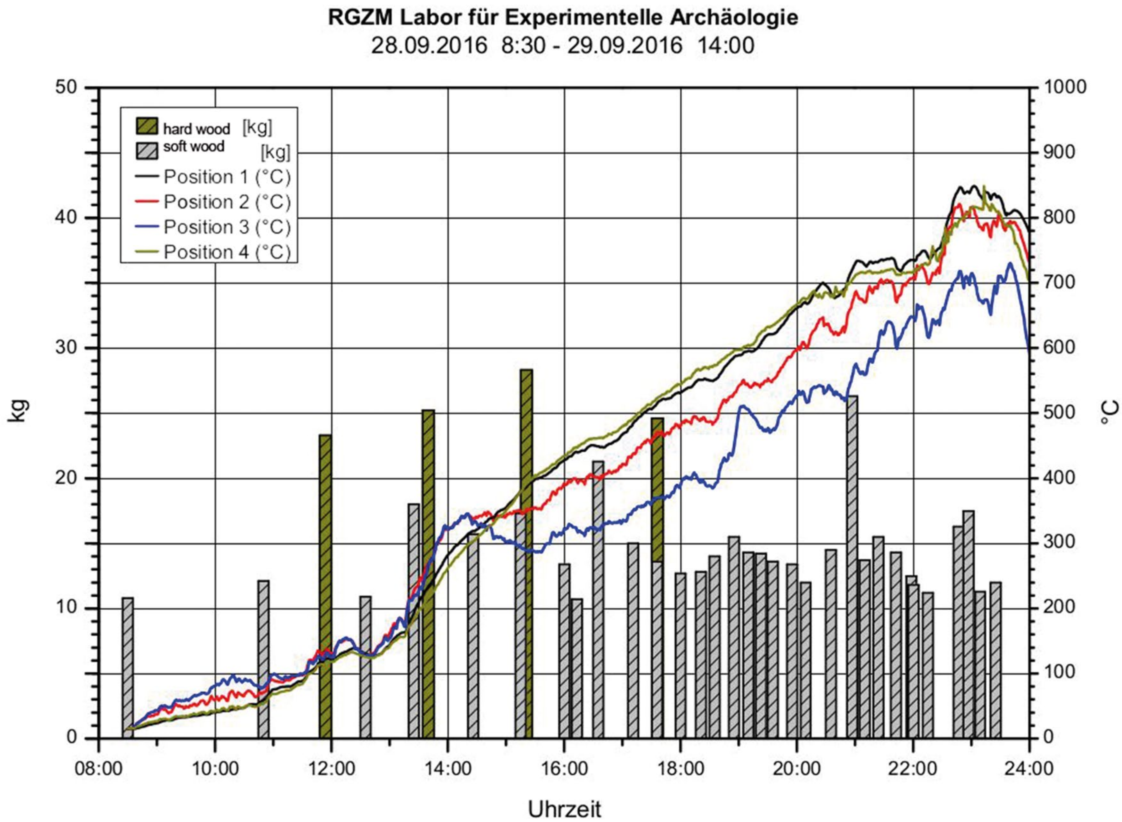

Fig. 6: Fuel diagram. Additional wood did not lead to a notable increase in temperature when the temperature in the kiln was above 800°C.

The thermic loss due to heat emission to the environment occurs at the opening of the firing chamber and can only be partially reduced because otherwise the draught behaviour of the furnace would be affected. But the dependence of the firing temperature on the oxygen level within the kiln, as well as on wood humidity (which is around 12 to 14%), is of more importance for limiting the final burning temperature of shaft furnaces. Covering the fired goods causes a lack in sufficient oxygen supply in the firing chamber which would be needed for raising the temperature. But not covering the goods would lead to a high thermic loss due to heat emission and at the same time to such a large surplus of air that it would induce additional cooling. The relation between supplied combustion material and usable performance increases disproportionately, even with longer retention periods or a slight raise of the final firing temperature.

Around 500 AD in Mayen, shaft kilns with spoked floors were a perfectly suitable installation type for a clearly defined purpose: the production of coarse ware export ceramics. The potters relied on proven construction principles for their kiln installations which allowed production that exceeded their personal need. When needed, new personnel could be trained for the firing process with relative ease.[14] The building material for the kilns could be acquired from local raw material sources. As long as the distribution channels were open, supra-regional markets could then be steadily supplied. The challenge was to develop a product based on the available raw materials that could be sustainably established on supra-regional markets.

Determining the maximum ceramic technological spectrum of uses of the available raw material is necessary to make qualified assumptions about how far the success of a pottery area was dependent on conscious decisions and not only on resources.

In Central European research and publications, there are several single-case studies and observations that broach the issue of clay gathering, the usage of different clays or their mixture at one production location.[15] For Mayen, archaeometric studies have provided hints for the mixture of clays used to generate materials for pottery production.[16] Nevertheless, when investigating the intentional processing of clay batch compositions and their development in a diachronic perspective, natural scientific and ceramic technological methods are still too rarely applied to ancient and medieval potters' workshops in Central Europe.[17] Anglophone studies are more often based on ethno-archaeological and archaeometric approaches. This systematic research focuses on the extraction of raw clay and its processing into ceramic raw material and can contribute to the understanding of human behaviour and the development of working models.[18] Incentives for such research have often come from representatives of archaeometry.[19] Against this background, in 2015/2016 ceramic technological experiments with clay from the Mayen area were started to determine the maximum spectrum of uses of the available raw materials and the differences between individual clays for usage in pottery production.

A single clay deposit can contain several different clay types. Thus, it was possible to gather different clays from the city area of Mayen which were visually distinct from one another in terms of colour, texture, and macroscopic composition. Vulcanites have been mentioned by other authors as a tempering element for pottery from Mayen,[20] but could not documented in any of the shards and clays that were recently examined.[21]

Testing of Raw Material

Extensive ceramic technological tests are still ongoing, but preliminary results concerning the suitability for engobes and the thermal shock resistance of pottery made from Mayen clay are given below.

Even though they were well-known throughout the Roman Empire, engobes were of minor importance for the decoration of export wares from Mayen during the time period of this study. However, the ceramic technological analysis of certain clays from Mayen led to remarkable results: Clays 0002 and 0003 proved to be

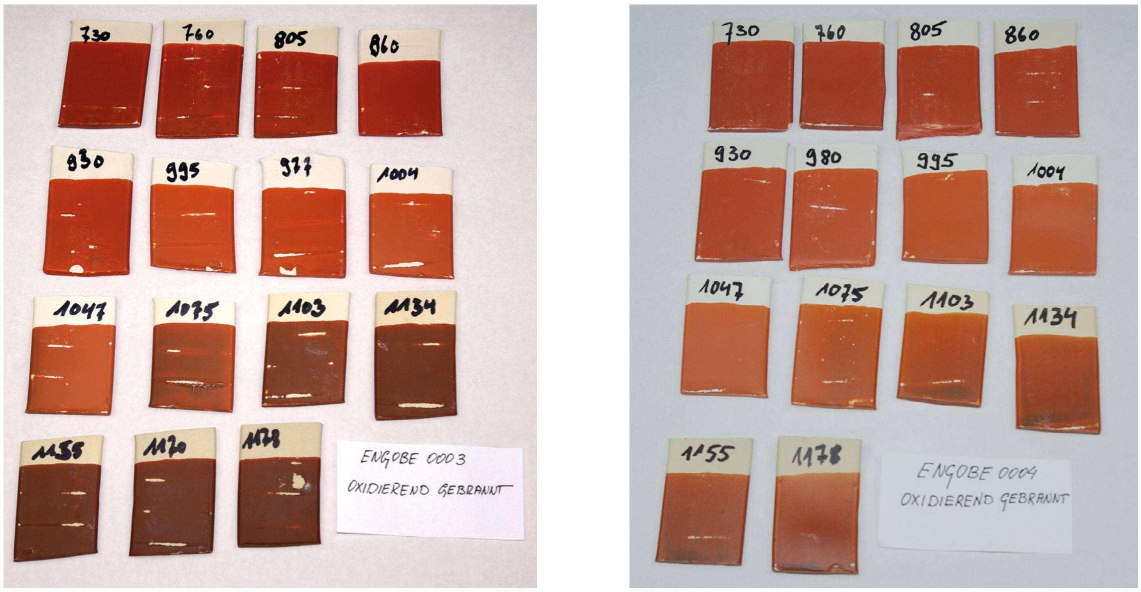

Fig. 7: The firing plaques from the laboratory tests. Left: Clay 0003 (Geishecker Hof), right: Clay 0004 (Eichenweg)

suitable for the production of engobes.[22] In 2016, another type of clay was gathered during construction work.[23] Natural scientific analyses of this strikingly red clay are ongoing, but first engobe tests have already been finished. After being fired at a temperature range from 1050℃ to 1100℃, the clay forms an extraordinarily thick, glossy coating (fig. 7).

Quartz sand was used as tempering agent for the batch composition of clays from Mayen. This mixture proved robust against temperature fluctuations during firing, as well as during the use of the vessels.[24] Thermal shock resistance is of utmost importance for the firing of the pottery as well as for its usage as cooking vessels. The experimental pots underwent a series of laboratory tests: Individual vessels were heated up to 500℃ in an electric laboratory kiln, and then quenched in a 20℃ water bath. This procedure was repeated ten times for each vessel and vessel form. All vessels made from the tempered batch composition passed this test series without damage (fig. 8).

The results of the engobe tests clearly show that around 500 AD a conscious use of the available raw material potential was made. The possible spectrum of uses therefore did not comply with the actual spectrum of production. Instead, there was a conscious decision to focus on one product group with properties that turned into a standardised product feature, i.e. production of robust coarse wares that were resistant to thermal shock. The studies on thermal shock resistance show that conscious material design based on the available raw material was used to increase a single quality feature.

Fig. 8: Experimental pot after going through ten rounds of thermal shock testing. Inv.-Nr. 2016-075, Clay: MV4/ White 50% – Red 50%.

There are two possible explanatory approaches for the conscious development of the pottery production of Mayen in order to reach standardised exports: collective decisions or singular power control of the production. Settlement archaeology in combination with experimental archaeological analyses will be used to determine which of the two is more likely.

Notes

[1] Basic: Herdick 2015.

[2] See also Hanning et al. 2014, 342.

[3] Grunwald 2011, 25–34; Grunwald 2012; Grunwald forthcoming; Glauben et al. 2009.

[4] Döhner – Grunwald 2018, 61–79.

[5] Redknap 1999, 34. 38.

[6] For a current interpretation of the kiln findings see in detail Hanning et al. 2014, 342–347. – Hanning et al. 2016.

[7] Grunwald 2016, 355–356.

[8] Hanning et al. 2014, 347. – Cf. Hampe – Winter 1965, 192–193.

[9] Grunwald 2012, 111.
[10] Döhner et al. 2018, 72.
[11] Grunwald 2016, fig. 6, 6–7.
[12] Hampe – Winter 1965, 186 kiln type A.
[13] Döhner et al. 2018, 74–76.
[14] Döhner et al. 2018, 76.
[15] e. g. Historic England 2015, 44; Schmid – Grolimund 2001; Sorge 2001, 23; Schwedt – Mommsen 2004; Hancock 1984; Winter 2010. – On the relevance of the mixture of clays for archaeometry: Mommsen 2017, 182.
[16] Xu 2012, 41; Kritsotakis 1986, 779.
[17] Döhner et al. 2018, 79.
[18] Exemplary: Arnold 1985; Arnold 2000; Arnold 2006; Arnold 2011; Arnold 2017; Harry 2011. – Further: Costin 2000; Gosselain 1994; Hegmon 2000; Stark 2003.
[19] e. g. Buxeda et al. 2003; Cau Ontiveros et al. 2014; Neupert 2000; Polito et al. 2015; Sillar 2000.
[20] Schneider – Rother 1991, 189–223.
[21] Xu 2012, 34–35. – But consider Döhner et al. 2018, 80–81.
[22] Döhner et al. 2018, 81–83.
[23] Döhner et al. 2018, 82–83.
[24] See in detail Döhner et al. 2018, 82.

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