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Introduction

1.1. Research topic and the study area

This book investigates the production technology of the Neolithic Majiayao-style pottery. It explores the possibility of social connectivity achieved through the sharing of technological knowledge and assesses the distribution of this style within large geographical areas. The Majiayao style consists of two main pottery ware types: fine painted ware and coarse ware with impressed decoration (**Fig. 1.1**). Majiayao-style pottery was found on the territories of modern Chinese provinces Gansu, Qinghai, Ningxia and northwest Sichuan (An 1987:137; Hung 2011:39). Based on radiocarbon dating, the time period when this pottery was produced and used falls between 5300-4000 cal yr BP (Dong et al. 2013). The Majiayao-style painted ware is one of the earliest painted pottery styles in northwest China and one of the many painted pottery styles identified in that region (Andersson 1925, Xia 1949, Zhang 1990, Ren 2016).

Majiayao-style pottery was first excavated and documented in the 1920s by a Swedish-Chinese expedition on the territory of modern Gansu and Qinghai Provinces (Andersson 1925, 1929; 1939; 1943; 1973:264; 1945; Bylin-Althin 1946; Xia 1949; Sommarström 1956; Chen 1997; Fiskesjö and Chen 2004). The painted pottery seems to have been a preferred funerary good (not counting potential unrecoverable organic materials) because it was deposited in graves in large quantities, more than 70 pieces in some individual graves (Allard 2001:17; Hung 2011). The burial customs appear to be similar across the geographical area where the Majiayao-style pottery has been found (Hung 2011). Because of the variation in the quantity of painted vessels, the fine painted ware has been interpreted as a symbol of wealth (Allard 2001; Hung 2011). However, it is not known if it was the vessels alone, or the content of those vessels (or a combination of both factors) that were regarded as symbols of wealth. The fine painted pottery looks aesthetically pleasing to the modern viewer and is regarded as a work of high craftsmanship by collectors. However, the perspective of the prehistoric viewer is unknown.

Very little is known about the organisation of pottery production and the location of production centres. Based on the pottery appearing in both graves and settlements in considerable numbers (Andersson 1925, 1943, 1945; Bylin-Althin 1946), it can be assumed that the demand was there for the pottery to be used in everyday life and as a grave good.

Archaeologists established relative chronologies for the Neolithic and Bronze Age based on painted pottery typologies. Majiayao-style pottery was a synonym for a Majiayao culture (Andersson 1925:23; Xia 1948, 1949; Fiskesjö and Chen 2004:112; Ding 2010:42). The culture-historical approach to prehistoric archaeology prevailed as an academic tradition in Chinese archaeology and remained largely unchanged (von Falkenhausen 1993; Hein 2016:34; Chen and Fiskesjö 2014; Ehrich 2017:47-48; Hein 2019:45). Theoretical approaches in Chinese archaeology are deeply rooted in history and entwined with politics

Figure 1.1. Examples of painted and impressed Majiayao-style vessels: a) Painted, K-05058, Banshan, bought by Andersson b) Impressed, K-06384, Zhujiazhai.

(Liu and Chen 2012:2f). Several scholars have laid out examples of archaeological finds being used to justify and legitimise political agenda (von Falkenhausen 1993:844-847; Trigger 2006:267; Hein 2016:26; Ehrich 2017:78; Hein 2019:46-47). The idea of equating archaeological remains with ancient ethnic groups was not unanimously accepted and was scrutinised by some Chinese scholars (cf. references in Ehrich 2017:67 and in Hein 2019:50-52). However, this approach is still applied for the analysis and interpretation of the prehistoric pottery in the study area (Chen and Fiskesjö 2014:1).

It is impossible to say whether by using the same pottery style the people in different valleys felt any sense of what we currently define as a 'community'. Potters who made Majiayao-style pottery in different river valleys may not have belonged to the same group of people who perceived themselves as one community (Dietler and Herbich 1994:461). The culture-historical approach complicates the investigation of prehistoric life from the perspective of a potter. If deemed as style specific, the technological sequence of the Majiayao-style could then be perceived as a cultural trait within the established culture-historical theoretical framework. Subsequently, there is a risk to view similarities and changes in pottery technology or typology in a larger geographical area through the lens of inter-cultural contact and influence on a large scale. The pottery technology would then also characterise the consumers of this pottery who are not potters, potentially leading to a bias towards the view that prehistoric people already shared social customs and technological knowledge. This study aims to investigate the issues of technological choices and technological knowledge in pottery production without the distorting lens of the culture-historical framework, and investigate whether technological knowledge inferred from the material analysis of pottery can shed light on the connectivity between the people from the three river valleys.

The technological perspective on the Majiayao-style production technology offered in this book is different from the stylistic approach to painted ware that dominated previous research. Typological studies of the Majiayao-style pottery study the change of vessel shapes and decorative design and focus largely on the painted ware (Zhang 1990; Li 1998; Ren 2016). This focus on painted ware limits and renders the typology of the Majiayao-style incomplete, especially when painted and non-painted pottery appears to be excavated in relatively equal amounts across the study area.[1] The PhD study by Ren (2016) includes unpainted pottery and other stone tools in his discussion of relative chronologies of Neolithic and Bronze Age painted pottery in northwest China. His work is strictly typological and provides little new information about the technology or usage of the vessels. Nevertheless, typological studies provide a foundation for the investigation of a style-specific technological sequence. In contrast to typology, the study of technological sequences of this style focuses on the invisible technological characteristics such as clay paste recipe, forming technique and firing conditions. The wide distribution of the sites in Gansu and Qinghai, where the Majiayao-style pottery was found (Fang 1991; Ding 2010; Wang 2012; **Figs 1.2, 1.3**), opens the question of whether the technology to produce this pottery was as widely spread as its product.

This book focuses on material from sites located in three river valleys stretching across Gansu and Qinghai provinces in northwest China: Tao River Valley, Huangshui River Valley and the upper reaches of the Yellow River Valley. The sites in question are: Majiayao 马家窑遗址, a habitation site and the type-site for Majiayao pottery, Waguanzui 瓦罐嘴遗址, a burial site, Zhujiazhai 朱家寨遗址, a habitation and burial site, and Luohantang 罗汉堂遗址, a habitation site (**Fig. 1.4**). Investigating the geographical spread of technological knowledge implies that the people who shared this knowledge lived contemporaneously. There are no absolute dates for the archaeological remains from these four sites. The reliability of the radiocarbon dating in northwest China is questionable due to difficulties with the dating of wood of an unidentified type (Dong et al. 2014) and might be inaccurate in some cases. There are many more sites in the study area where Majiayao-style pottery was found (**Figs 1.2, 1.3**), and the relative chronology established by stratigraphy and typological classification of pottery remains the most reliable dating information for the study area for now. In this case, the present study must rely on relative chronology and assume that people's activity using/producing Majiayao-style pottery at Majiayao, Waguanzui, Luohantang, and Zhujiazhai fell approximately in the same period.

The material analyses are conducted using macroscopic examination, thin-section petrography, geological survey and experimental archaeology to investigate the technological choices made at every step of the chaîne opératoire to produce Majiayao-style pottery. The following questions are in the focus of this study: are there evident similarities in the technological or invisible features of the pottery, such as paste recipe or building technique, as there are in its exterior or visible features, such as shape and decoration in the material found in the three river valleys? Is there a specific technological knowledge that is required to make this pottery? Can the investigation of shared technological knowledge help us address the connectivity of people over large distances during the Neolithic? Does technological knowledge have a social aspect which can be identified through scientific analysis?

Previous research on production technology of prehistoric pottery in northwest China has so far included diverse samples from different pottery styles to draw conclusions about prehistoric technological knowledge. This book offers the first reconstruction of the technological sequence to produce Majiayao-style pottery from raw material selection to firing techniques. The research material

[1] Personal observation in the MFEA collection and excavated pottery from the Tao River Valley in China during research stay.

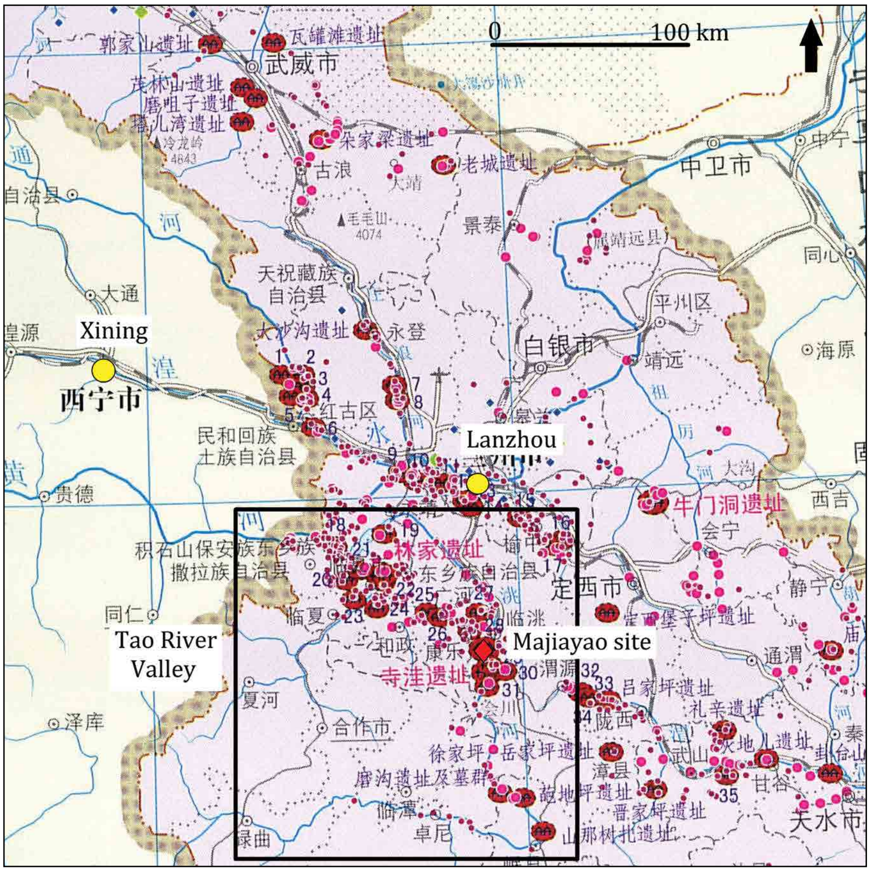

Figure 1.2. Distribution of the Neolithic sites in Gansu Province where Majiayao-style pottery was found (red and purple dots), from the Atlas of Chinese Cultural Relics: Gansu Province (Guojia Wenwuju 2011a:70-71) Full map and legend see Annex 3, Fig.A3.1; English captions by the author.

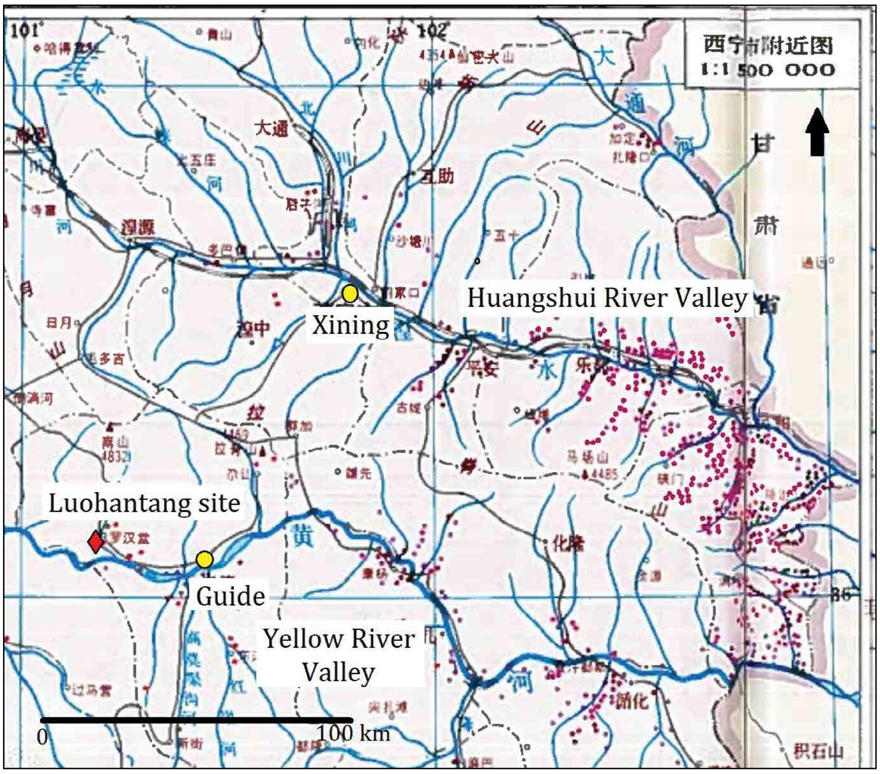

Figure 1.3. Distribution of the Neolithic sites in Qinghai Province where Majiayao-style pottery was found (red and purple dots), from the Atlas of Chinese Cultural Relics: Qinghai Province (Guojia Wenwuju 1996:15-16) Full map and legend see Annex 3, Fig. A3.2; English captions by the author.

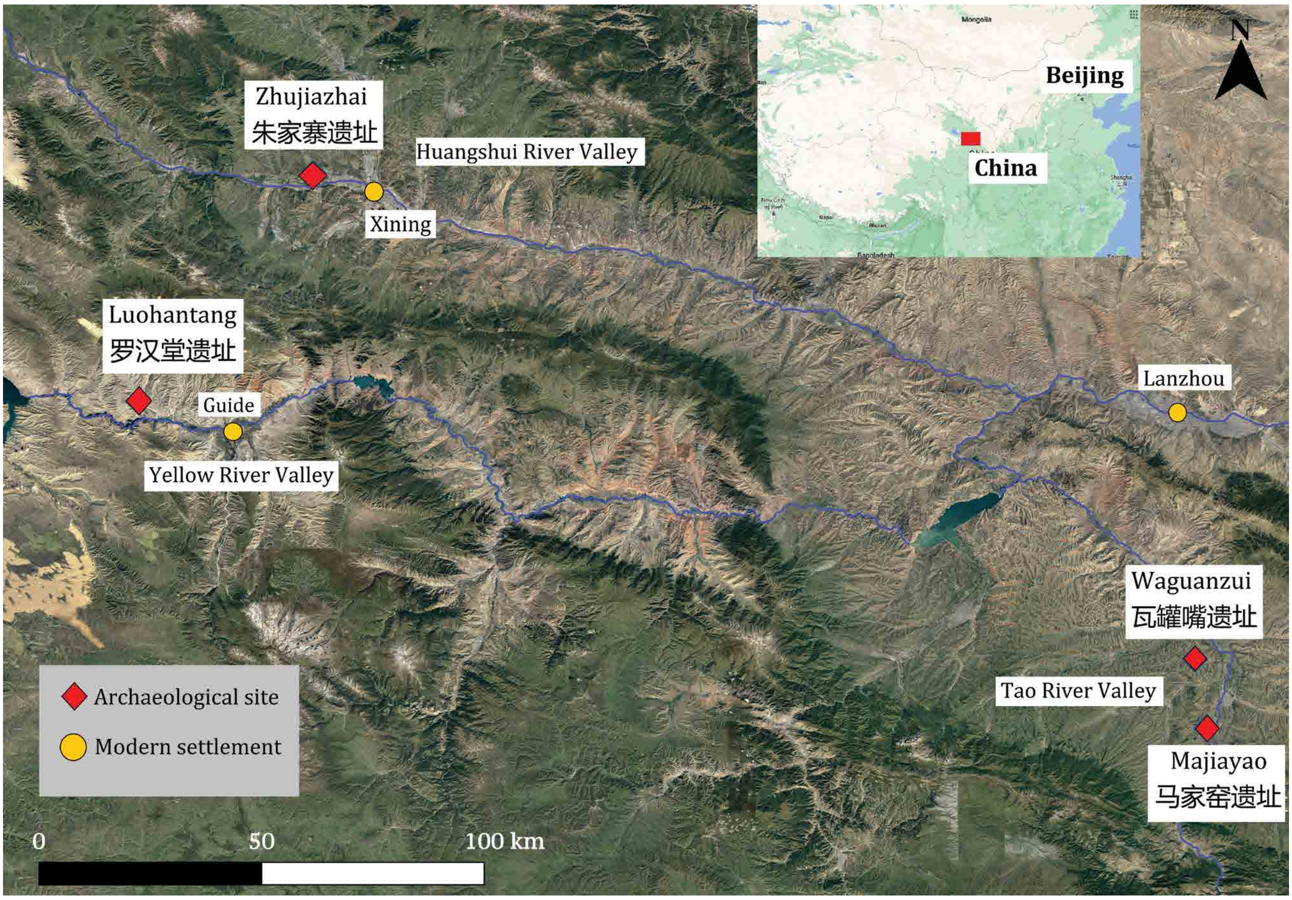

Figure 1.4. Study area: Tao River Valley, Huangshui River Valley and the Yellow River Valley (the upper reaches).

consists of pottery samples found at distances as large as 250 km from each other, providing the opportunity to investigate how prehistoric potters engaged with their local environment in different parts of the study area. Did they have extensive geographical and geological knowledge in order to select specific materials required to produce pottery in Majiayao-style, or did they work with materials available in close proximity without apparent preference? The information and data gathered from investigating these questions allows for a discussion on the connectivity between potters in the three river valleys and extend it further to the consumers of Majiayao-style pottery.

1.2. Previous studies on Majiayao-style pottery technology

The first technological studies of Majiayao-style pottery were mainly conducted by macroscopic examination (Palmgren 1934; Wu 1938; Bylin-Athin 1946; Sommarström 1956). These studies identified and discussed primary and secondary building techniques, such as coiling and paddling, and the application of decoration. They provided the first characterisation of clay pastes. Although the content of these works is mostly descriptive and does not engage in extensive discussions of social structure or similar topics about life in prehistory, they provide a solid basis for the present study of technological knowledge.

The studies applying methods of chemistry and geology to study prehistoric pottery technology in modern northwest China mostly grouped Majiayao-style with pottery samples from later or earlier prehistoric pottery styles. Besides macroscopic examination, the newly included analytical techniques were X-ray-radiography, petrographic and chemical analysis, X-ray diffraction and scanning electron microscope (Vandiver 1988; Ma and Li 1991; Ma 2000). The results of these analyses provided new insights into the composition of pigments and the firing temperature (Ma and Li 1991; Ma 2000).

Ma and Li investigated the technological choice in raw material. Using X-ray diffraction and running analyses of physical properties such as hardness, water absorption, porosity and firing temperature, they analysed the chemical composition of 25 Neolithic and Bronze Age painted pottery samples and six Malan loess[2] samples (Ma and Li 1991: Tables 1 and 2). Based on a chemical sample distribution map produced in their study, most of the samples of various types are concentrated in one area (Ma and Li 1991:263, Fig. 1). Ma and Li concluded that the prehistoric potters deliberately chose a particular type of raw material. Furthermore, by using a high temperature

[2] Malan loess 马兰土 is the youngest layer of loess on the Chinese Loess Plateau (Fan and Du 1999:34; Liu 1988:15; Derbyshire et al. 2000:48-49).

dilatometer they were able to determine the average firing temperature: 900° C to 1050° C (Ma and Li 1991:268). According to the researchers, the firing structures would have been the down- or updraft kilns fired in oxidising atmosphere, since most of the pottery appears to be red in body colour (Ma and Li 1991:268). It is not clear whether Ma and Li came to this conclusion because they had only sampled painted sherds, which would have been predominantly fired in an oxidising atmosphere as this book argues.

By using X-ray diffraction and X-ray fluorescence, Ma (2000) put an emphasis on pigment analysis, identifying magnetite and hematite as pigments on Majiayao-style pottery besides the already known manganese and iron oxides (Ma 2000:58). In sum, Ma came to similar conclusions as Ma and Li (1991) in terms of kiln structure, firing temperature and raw material for paste and paint. In terms of clay, Ma's analysis of the CaO content on the fine fabrics from Dadiwan showed different amounts for each sample(2000:46-47); therefore, Ma suggested that the clay might have been purified. However, as the experimental firing of the geological samples conducted in the present study shows, local clays can naturally have different CaO content (see Chapter 4).

Studies by Ma and Li (1991; Ma 2000) reconstruct pottery technology in the study area by combining data obtained from samples from different periods which are dated hundreds of years apart. It is possible that the pottery technology did not undergo significant changes throughout the Neolithic and Bronze Age. There are studies on prehistoric pottery from other places in the world that show long consistency in pottery technology (e. g. D'Ercole et al. 2017). However, Bronze Age pottery styles in the study area show changes in visible technological choices such as in vessel shape, surface treatment and painted motifs. Studies such as by Ma and Li (1991), analysing samples from different pottery styles and periods, provide various data on elemental composition, firing temperature and surface treatment. However, it is difficult to address technological questions that focus on one type or period using such studies as a basis. Although the overall sample size might be sufficient, the number of samples of a certain pottery type might be low. This approach contrasts with the typological studies in Chinese archaeology which tend to further separate the vessels into different sub-types, while scientific research does not differentiate and instead aims to reconstruct the technological sequence for the entire prehistoric period of Northwest China.

There are several subsequent scientific studies on a small number of samples (max. 10 samples) using X-ray diffraction, 3D-X-ray fluorescence, SEM-EDX, Raman spectroscopy, petrography and P-ED-XRF (Ma et al. 2000; Chen et al. 2000; Zhong et al. 2013; Yan et al. 2013; Yi et al. 2016a-b; Li and Yu 2018; Hein and Stilborg 2019, 2021). These are pilot studies which provide preliminary scientific data and experiment with new methods. They touch on the issues of technology such as clay paste or paint composition or firing temperature, but the small sample size does not allow for a detailed investigation of specific archaeological issues.

Combining and working with research data from the previous scientific research of Majiayao-style pottery technology presented above can be challenging, since these studies analyse samples from different pottery styles instead of focusing on one. The sample size and the geographical scope vary so that conclusions drawn from these analyses either concern a very specific site or address the pottery production in prehistoric northwest China in general. Therefore, the insights gained from these studies do not reach beyond the technological characteristics of the pottery and only graze the topic of the role of technology in the prehistoric society. So far, there was no attempt to reconstruct the entire technological sequence to produce Majiayao-style pottery and consider it from the perspective of shared knowledge. Furthermore, despite the people who used Majiayao-style pottery being considered to belong to the same prehistoric community in Chinese archaeology, research on the technology of Majiayao style combining analysis of pottery excavated in Gansu and pottery excavated in Qinghai is scarce.[3]

The first large-scale study addressing the production of Majiayao-style pottery from several sites in Qinghai and Gansu was conducted by Hung (2011). She was a critic of the culture-historical approach in Chinese archaeology arguing that this approach is a simplistic view of the communities during the Majiayao period (Hung 2011:211). Her study focused on the connections in settlement patterns, pottery production and mortuary practices between Majiayao period sites in Gansu, northeast Qinghai (including sites in the Tao, Huangshui and Yellow River Valleys) and northwest Sichuan provinces, covering a geographical area of more than 1000 km north-east and 500 km east-west. By analysing 687 pottery samples[4] of Majiayao-style pottery from thirty-three archaeological sites using laser ablation inductively coupled plasma atomic emission spectroscopy (LA-ICP-AES) and principal component analysis, she investigated issues of regional pottery production, inter-regional pottery exchange and social hierarchy (Hung 2011:30).

Through comparison of chemical data, Hung was able to draw conclusions about inter-regional exchange and provenience of pottery (Hung 2011:70). She argued that painted Majiayao pottery was produced for inter-regional exchange between elites and unpainted coarse pottery was produced locally (Hung 2011:70, 107, 232). However, only in a few cases did Hung specify that unpainted pottery was decorated with cord-impression and appliqué, which

[3] It needs to be pointed out though, that the published research on pottery analysis by archaeologists working in Qinghai appears to be difficult to access outside of Qinghai. Some serials and edited volumes are published by museum staff such as by the Liuwan Museum of Painted Pottery, e. g. the pilot study on pigments by Li and Yu (2018) and sold in museum shops (pers. observation during a research trip in 2019).

[4] 473 painted and 214 unpainted pottery samples.

is in accordance with Majiayao-style. The question would then be: if only painted pottery of this style was subject to inter-regional exchange, why was the unpainted pottery of the same style produced locally in remote places which imported the painted pottery? Assuming Hung's claim that painted pottery was a symbol of elite, why would potters in different locations across a large area produce coarse pottery and decorate it in similar ways when only painted pots were socially significant for displaying wealth? Although Hung included 214 unpainted coarse pottery samples in her principal component analysis, there was no sufficient consideration of it in her study. She grouped her sampled material according to its calcium carbonate (CaO) and magnesium oxide (MgO) contents and compared it to the data from geological and archaeological pottery studies which did not correspond to her study area and had an insufficient sample number for a detailed comparison: the geochemical data from the study of Quaternary loess and Tertiary clay from Gansu by Chen et al. (2001) and the chemical studies of prehistoric pottery, totalling less than 20 samples of Majiayao-style pottery by Zhou et al. (1964), Ma (2000), and Sundius (1961). Based on these studies Hung (2011:70) concluded that the sediments in the Gansu and Qinghai area have a high calcium carbonate content and so do the painted Majiayao-style sherds in contrast to the prehistoric pottery from other regions in northwest China. Through principal component analysis, Hung (2011:70) determined that Majiayao-style painted pottery from Gansu has a higher content of CaO and MgO than unpainted pottery from Sichuan which she assumed was produced locally and did not further investigate its production (Hung 2011:71; 232, 285 fig. 2.19). She suggested that the painted pottery from Sichuan with high CaO and MgO content was imported from Gansu and the imported pottery would have been made from Tertiary red clay (Hung 2011:71; 127). Hung treated the different sample groups as equivalent to separate production groups in the Gansu and Qinghai area, implying that each production group used chemically different raw material but painted the vessels in similar designs for inter-regional exchange (Hung 2011:70-71, 107, 127).

Relying on CaO and MgO as determining elements to identify and differentiate raw materials origins might be misleading. First, the data provided by Chen et al. (2001) on the CaO and MgO content from Gansu is limited to the Xifeng area 西峰区 in south-eastern Gansu and may not apply to the entire Gansu and Qinghai area. Second, geochemical data from Sichuan for comparison is not provided in Hung's study; however, the sediments in Sichuan show high variation in CaO and MgO content (Du et al. 2013:1834). Therefore, the data obtained from pottery alone might not necessarily point to the Tertiary clays in Gansu and could also be characteristic of raw material available in Sichuan.

Hung's study did not include geological samples which could have put the data gathered from archaeological material into another perspective. For example, through local geological sampling, one would be able to link different chemical composition of pottery with different clay beds in the same location. Without geological sampling, this specificity would otherwise be difficult to infer from large scale geological maps. Furthermore, in Hung's interpretation of data, post-depositional alterations in pottery paste were not considered. Results of chemical analysis suggested analcime content in the pottery paste (Hung 2011:184), which she interpreted as tempering material, though noting that it was an unusual choice of temper. Studies on post-depositional alteration of ceramics (Schwedt et al. 2006:238; Zacharias et al. 2007) have shown that analcime is also a product of a chemical reaction which happens due to weathering underground. Analcime content being a product of underground weathering might explain its presence in Hung's analysis of pottery deposited in graves.

The wide distribution of Majiayao-style pottery highlighted in Hung's study provides further incentive to investigate technological transfer beyond the shared painted designs. Hung's approach to investigate pottery making within one archaeological period and in a geographically large study area is innovative for prehistoric archaeology in northwest China. Regardless of the production place and the export extent, Hung has shown that the fine painted pottery from distant areas is chemically similar. This chemical overlap may be a result of either similar properties of chosen raw material or it may be due to a general similar sediment composition from northeast Qinghai to northwest Sichuan. Ma and Li (1991) interpreted the overlap in chemical composition of pottery samples from different sites in Gansu as potters' knowledge of which clay to choose. Chemistry as the main method analysis of archaeological pottery has proven to produce data that includes elements formed during firing and underground deposition (Freestone 2001; Cultrone et al. 2001; Pollard and Heron 2008:116, 127-129; Schwedt et al. 2006:238; Maritan 2020). This means that this data does not reflect the actual chemical composition of the raw material, and that the comparison between pottery samples from distinct places might be inaccurate. A combination of chemical study with other analytical methods such as firing experiments or petrographic studies could add a different perspective to the discussion of pottery provenance.

One of the few published scientific studies on Majiayao-style pottery from the Huangshui River Valley was conducted by Cui et al. (2015). They analysed 28 Majiayao-style pottery sherds from the Huangshui River Valley using X-ray fluorescence measurement as a part of their study on prehistoric pottery exchange during different periods between sites in Gansu and Qinghai. Altogether, they analysed 118 samples dating to the Neolithic and Bronze Age. The results of the trace element analysis showed that all Majiayao sherds, except one, form one cluster meaning that they were made from similar clay (Cui et al. 2015:66-67); calcium was excluded from the trace element analysis because of contamination risks. Cui et al. (2015:66) additionally collected five red clay and five loess samples in the area about 100 km south from the Huangshui Valley and compared their composition to the pottery clay. Despite the large distance between the locations of pottery and clay sample collection, Cui et al. (2015:67-68) found that the chemical composition of pottery corresponds to the composition of red clay more than it does to loess. This observation is in agreement with the studies by Ma and Li (1991)[5] who also suggested that loess was unlikely used for pottery making and is further supported by the experimental study in the present project.

It is important to point out that loess and red clay deposits on the Chinese Loess Plateau have varying calcium carbonate contents; calcium carbonate appears to be one of the most abundant elements in these sediments and yet it is frequently used in provenance identification, or at least in investigations into whether Tertiary or Quaternary deposits were used for clay extraction (cf. discussion in Ma et al. 2020). The calcium content in prehistoric pottery has proven to vary as well, and so far, this issue has mainly been analysed through chemistry and trace element analysis. Comparative studies with geological samples from the same area as pottery yielded rather general results where both sample types were grouped in broadly consistent clusters (e. g. Hong et al. 2011; Ma et al. 2020). The firing experiment in this book has shown that the calcium content in the red clay samples collected within a radius of 1 km can vary significantly. To continue using mainly chemistry to investigate raw material selection in prehistory on the Chinese Loess Plateau would not contribute to progress on this issue, as such studies seem to be detached from the practical technological process where the physical properties of clay and its reaction to firing play a major role in selection. Further, the possible post-firing or post-depositional alteration or formation of new carbonate components was often not taken into account in the previous chemical studies on prehistoric pottery. Such a miscalculation led Hung (2011) to interpret analcime, which possibly formed due to underground weathering, as tempering material used in production. Chemical data on the environment of the burial context of the pottery analysed by Hung (2011) is required to approach this issue.

The present study suggests that to investigate the role of calcium in raw material provenance, it would be beneficial to include experimental pottery making from geological samples with further chemical comparative studies of geological clays and prehistoric pottery. Experimental firing has proven to be an effective method of preliminary assessment of calcium content in clay which would have potentially affected the technological choices in prehistory due to the degree of visible lime spalling after firing. The comparison between the experimentally fired samples and prehistoric pottery would need to happen under the consideration of the factor of post-depositional contamination, which would have potentially contributed to a higher calcium content in the sample. Such a comparison would allow one to address follow-up questions such as whether the purification of clay was possible to reduce the calcium content raised by Ma (2000:46-47). To my knowledge there were no previous firing experiments on clay from the study area to specifically observe its post-firing behaviour.

Petrography as one of the main analytical techniques for investigating pottery making was applied by Womack (2017; et al. 2019). He analysed 273 thin sections of sherds from three sites in the Tao River Valley (Dibaping 地巴坪遗址, Dayatou 大崖头遗址 and Siwashan 寺洼山遗址) to assess the diversity in paste mixing of both styles and to identify indicators of change or continuity in Neolithic and Bronze Age technologies within his study area. Womack (2017:79) considered the variation in paste recipes as indicators of different local production groups. He proposed a hypothesis that a production group would use similar paste recipes to produce a specific type of vessel; different pastes identified in a single vessel type would indicate different production groups making pottery in the same shape (Womack 2017:90). In the results of his study, Womack identified diversity in coarse fabrics and less diversity in fine fabrics. He associated the varying coarse pastes with being made by different production groups and the similar fine fabrics by one single production group (Womack 2017:214). His connection of paste diversity to the existence of multiple production groups led him to the conclusion that there was a higher demand in coarse pottery and that multiple producers were engaged in production and potentially exported pottery to other sites (Womack 2017:214-215). Nevertheless, the coarse fabrics identified by Womack are similar in composition with constant feldspar and quartz inclusions, and vary only slightly in other predominant inclusions, as he himself explained (Womack 2017:137). Womack constructed his argument around the differences in amounts of matrix, silt, and sand in the fabrics, which vary in fabrics. However, there could be several reasons, including wedging or kneading, for the different distribution of particles and homogeneity in the fabric. A thin section is but a snapshot of a vessel fabric and may not show the average amount of all its components within. Therefore, an overly detailed assessment of fabric components might be counterproductive for studying clay recipes. A general description of textures and types of large inclusions could be more helpful in this case and for addressing provenance, especially in comparison with geological samples.

Womack's study of raw materials included collecting geological clay and rock samples within a radius of 2 km in his study area. Although he concluded, based on comparison with archaeological ceramics, that the sampled clay was likely used by prehistoric potters (Womack 2017:138, 208), he compared pottery fabrics to the fabrics of unfired geological samples which could complicate the interpretation of paste preparation. Unfired clay samples contain organic material and other impurities which combust or alter during firing but can still be detectable in the thin section of a raw sample.

[5] The unsuitability of loess for pottery making due to its low plasticity is also mentioned in the study by Zhou et al. (1964:17) which mainly focused on prehistoric pottery from Shaanxi, Henan and Shandong provinces.

Prior to firing, the pottery clay likely underwent some processing such as crushing, purification by sedimentation or levigation, which separates coarse grains and large pieces of unwanted material (e. g. small sticks, grass etc.) from the clay material, and wedging to homogenise the paste. All these steps contribute to the change of the groundmass texture which would end up looking different from the groundmass of the unprocessed and unfired raw material. Details of Womack's research results will be further discussed in the interpretation of petrographic data regarding the issues of tempering and clay mixing in Chapter 4 of this book.

A potential existence of multiple production groups as proposed by Womack (2017) could be an indicator for potter networks which could then provide a basis for long-distance technological knowledge exchange. In a subsequent petrographic investigation of clay recipes within the same study area, Womack et al. (2019a:11, 13) concluded that the paste preparation did not change in the transition from Majiayao style to Qijia style (4100-3600 cal yr BP), contrasting with the change in vessel shape and decoration. Womack et. al (2019a:13-14) demonstrated that the knowledge of pottery technology was shared between generations within a small geographical area (25 km radius), despite changes in visual features of the vessels over hundreds of years.

This book uses Hung's study (2011) as a basis for covering a large study area to investigate connectivity in prehistory through Majiayao-style pottery distribution, and it follows Womack (2017) in applying petrography together with studies of geological material to reconstruct the chaîne opératoire to produce Majiayao-style pottery for the first time and investigate social connectivity through technology.

1.3. Structure of this book

This book begins with the setup of theoretical framework which serves as a guideline for approaching the questions about technological knowledge. It introduces the main concepts of chaîne opératoire and technological choices used in this book to interpret the data gathered through scientific analysis. The chapter on theory discusses the main purpose of this study: approaching prehistoric life through technological knowledge. The idea behind this is that technology and technological knowledge are part of social life and social knowledge outside craft production. This book focuses on the search for this link between technology and social connectivity in Neolithic northwest China.

After having discussed the theoretical concepts and defined the main terminology, the book is divided in two main parts. Part I discusses the entire production process from the procurement of raw materials to firing. Part II first discusses the interplay of visible stylistic features of Majiayao-style pottery and the invisible technological features only known to the potters who made it and presents the final argument for the existence of a specific technological sequence to produce Majiayao-style pottery. The second section of Part II discusses the insights gained through the technological study and considers the extent to which technological knowledge is intertwined with social knowledge shared between community members outside of craft production. This book ends with a final conclusion and outlines the prospects for future research and avenues for scientific investigation.

This book provides supplement material with primary analysis data and images of all sampled archaeological and geological materials. Annex 1 is the list of complete vessels analysed macroscopically and information about their provenance. Annexes 2 and 3 provide detailed macroscopic description of complete vessels and sherds. Annex 2 is a summary of macroscopic characteristics of Majiayao-style pottery including construction technique and decoration illustrated with example images of vessel parts. Catalogues 1 and 2 contain detailed petrographic description about grouped pottery and geological samples. The table at the beginning of the Catalogue 1 and 2 with petrographic groups includes detailed information about shape types and size measurements of inclusions and voids, as well as percentage estimations of inclusion frequencies. Catalogues 3 and 4 provide information and macroscopic and microscopic levels about individual pottery and geological samples.