A study of land-use across the transition to agriculture in the Northern Yinshan Mountain Region at the edge of Southern Mongolia Steppe Zone of Ulanqab, China

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A study of land-use across the transition to agriculture in the Northern Yinshan Mountain Region at the edge of Southern Mongolia Steppe Zone of Ulanqab, China

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Through an examination of subsistence, mobility, and social integration, this dissertation explores how human use of the steppe zone of the Northern Yinshan Mountain region of Ulanqab, China changed from the Early Neolithic to the Early Bronze Age. The results described herein contribute to our understanding of how people adapted to steppe environments prior to the emergence of a specialized herding economy, at a time when people in many other parts of northern China were shifting to an economy dominated by agricultural products and practices.

The analyses herein rely on data from excavated and surveyed archaeological sites in Huade County, Inner Mongolia, China, focusing on lithic assemblages and site distributions complemented by evidence such as ceramics, faunal and floral remains, and architecture. The results indicate that people in this region relied on a mixed economy of foraging and farming with the latter playing only a supplementary role in the total subsistence strategy. Though people depended heavily on wild resources throughout this period, their use of different parts of the landscape changed due in part to an increasing emphasis on animal resources during the Mid-Late Neolithic and Early Bronze Age. Though not fully sedentary, people reduced their mobility and aggregated in larger social groups from Early Neolithic period, but without pronounced development of economic specialization or social differentiation. No

dramatic increase or decrease of mobility, or significant development of social complexity can be detected in the latter Mid-Late Neolithic/Early Bronze Age.

Environmental constraints, rather than a lack of cultural preparedness or motivation, likely explain why intensive agricultural production failed to thrive in the Northern Yinshan Mountain region during the early and middle Holocene. Expanding the scale of farming is simply too risky in such a marginal environment. A mixed economy, particularly one increasingly focused on animal products however, provided a more optimal solution to the challenges of the local environment across the spectrum of Holocene climatic change.

Table of contents

List of tables

List of figures

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1.0 Introduction

1.1 Research question development

The origin and development of agriculture is a worldwide phenomenon that profoundly changed the world's ecology and the lifeways of its human inhabitants. As one of the independent centers of domestication in the world, China is key to understanding how food production emerged from an economy of hunting and gathering, and how that further developed into fully-fledged agriculture.

While research on this subject has increased dramatically in recent decades, the focus has been mainly on the patterns of agricultural origins and on the mechanisms of how and why agriculture evolved in different parts of China. Few have been devoted to a serious investigation of whether and why fully-fledged agriculture was adopted in the monsoon regions of China but was largely ignored (at least until the late Holocene) in the interior of continental Inner Asia. We do not know if the absence of fully-fledged agriculture in the regions outside the monsoon environmental zone was merely governed by environmental constraints or if it resulted, at least in part, at from human intent, calculated on the basis of the trade-offs between agricultural production and other subsistence pursuits, in specific cultural and environmental conditions.

To further explore this issue, it is of great importance for us to investigate people's subsistence strategy at the transitional zone between the areas where the fully-fledged agriculture thrived and those where no forms of farming activities, despite their levels of importance to human diets, have ever taken root. These transitional zones are often the places where the conditions or the relative attractiveness for conducting fully-fledged agriculture have reached at tipping point that requires people to make a choice between agriculture and other forms of subsistence practices. An investigation of people's subsistence choices in these areas will significantly contribute to our understandings of why fully-fledged agriculture originated and developed in some areas but not in the others.

The Southern Steppe zone at the Northern Yinshan Mountain region in Ulanqab Banner is an ideal place to make such an investigation. On one hand, this region is close to the farming communities who are engaged in fully-fledged agriculture to the south and east (like the Yangshao farming communities at the southern side of Yinshan Mountain region, and the Hongshan-Lower Xijiadian communities at West Liao River Valley 300-400 km away to the east) (Liu, et al. 2009; Zhang 2004). On the other hand, this region neighbors the Gobi-Northern Steppe zone to the north, where no prominent evidence of farming has ever been found and the transition from foraging to pastoralism indicates a divergent development of subsistence practice compared with the Monsoon region of North China (Janz, et al. 2017).

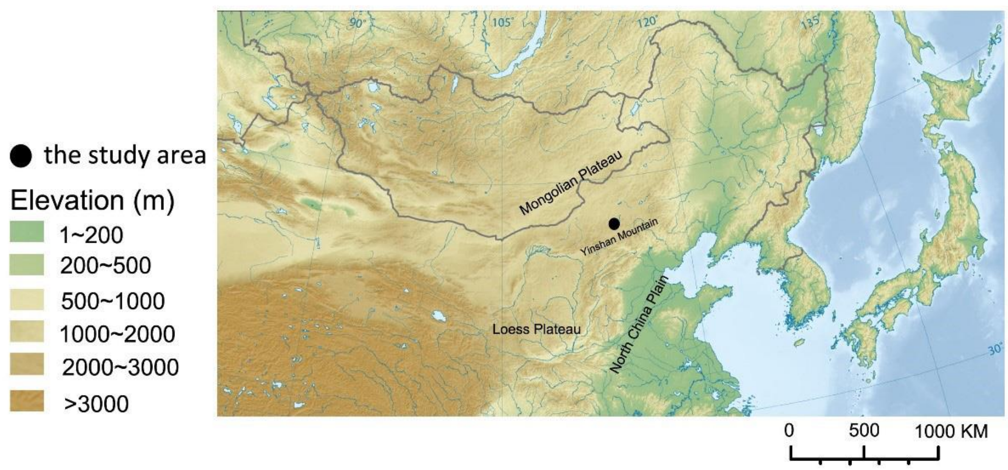

Figure 1.1 The location of the studied area

Few studies have ever focused on subsistence practice in this region. Hence, we know little about how people made a living here during the key period of the transition into agriculture in North China. We are unclear whether or not people have ever engaged in farming; and how important the farming economy was to their subsistence system (if any evidence of farming has been found). Nonetheless, the recent archaeological work of surface survey and the excavations of two Early Neolithic sites in Huade County at the southern steppe zone of the Northern Yinshan Mountain region have found abundant lithic remains which convey important information about people's daily subsistence practices. Meanwhile, the site distributions, faunal and floral remains, features of ceramics and residential architectures all provide information for learning people's subsistence practice (Bao, et al. 2016; Hu and Li 2018). Relying on a perspective of land-use, this dissertation research will focus on the analysis of lithics and synthesize it with other lines of evidence to examine: (1) What subsistence strategies have people ever applied to make use of the landscapes of resources; (2) Whether or not fully-fledged agriculture ever did develop from the pre-exist subsistence strategy; (3) Why fully-fledged agriculture developed (or did not develop) in this region.

1.2 Previous study about the origin of agriculture in China

In China, the traditional approach for the study of the agricultural origin rested mainly on archaeobotany, zooarchaeology, and bone chemistry to establish when and where the domesticated plants and animals first appeared and how they contributed to the human diet through time (Liu and Chen 2012; Wu 2014; Zhao 2011). The studies indicate that it took more than 3000 years from the earliest evidence of the exploitation of the domesticated crops to the establishment of fully-fledged agriculture in North China (Jin, et al. 2016; Ma, et al. 2016; Yang, et al. 2012). In multiple areas of North China, a mixed subsistence economy with the intensive exploitation of a broad range of wild resources combined with small-scale farming can be identified prior to the emergence of fully-fledged agriculture (Barton, et al. 2009; Liu, et al. 2015; Liu, et al. 2014; Wu 2014). It suggests that the shift from hunting and gathering to agriculture is a quite gradual process and primary farming did not gain striking advantages to the foraging economy soon after it appeared.

However, without deep understanding of the roles human behavior played during the transition to agriculture, the traditional approach failed to explain why fully-fledged agriculture appeared much later after the initial appearance of domestication, let alone the question of why it only emerged in some areas but not in the others. Zhang has pointed out that the early forms of farming were only part of the composition of the whole subsistence system. Unless we have a comprehensive understanding of how this system operated under the overall cultural contexts, we cannot further explore the reasons behind the process of agricultural origins (Zhang 2008).

Based on the perspective of cultural ecology and the synthesized study of the published materials across the monsoon climatic zone of China, Chen has emphasized that the adaptation of fully-fledged agriculture is a systemic-level subsistence transformation which requires not only the availability of domesticated plants but a whole set of mature knowledge, techniques, skills and institutional organizations concerning cultivation and the management of farming productions, which may not only take time to evolve but also require necessary conditions to evolve. Whether or not the fully-fledged agriculture can develop or even how fast it can emerge from the foraging economy really depend on the "initial conditions" of habitat, resource structure, and the cultural organization of the hunter-gatherer societies in different places (Chen 2004; Chen and Yu 2017a; Chen and Yu 2017b).

Based on information from survey and excavation of a variety of sites (including Dadiwan) throughout the western Loess Plateau and the margins of the northern deserts, Barton (2009) has proposed that people have periodically intensified the use of low-ranked seed crops and created a pattern of low-level food production under conditions of resource stress. Yet they returned to mobile hunting- and gathering once the higher-ranked wild resources had recovered. They shifted between the two kinds of subsistence practice for thousands of years until the incursive fully-fledged agriculture from the east locked made people into full-time food production (Barton 2009). Such a study implies that the initial attempt of farming would not necessarily drive people to develop intensive fully-fledged agriculture to the point of no return. Moreover, in some conditions, fully-fledged agriculture is unlikely the intentional goal people seek to develop nor the best option for people to take as their subsistence practice.

Although none of this research was focused on the steppe zone, it has enlightened us about how to conceive fully-fledged agriculture and what aspects we should pay attention in evaluating the choices and changes of subsistence practice in the Northern Yinshan Mountain region. Fully-fledged agriculture is not naturally the outcome of primary farming practice, and it requires more social and ecological conditions to generate. Moreover, the research reminds us that it is important to investigate how people were organized to make use of resources and how different factors affect people's subsistence practices as the way to understand people's choice of their subsistence strategy under specific environmental and cultural conditions.

1.3 Cultural ecology as the theoretical background to investigate the origin of agriculture

For any region, whether or not fully-fledged agriculture emerged, either from the local pre-existing foraging economy or adopted from neighboring regions, depends on the interplay between culture and environment. Neither aspect alone is adequate for inquiries into agricultural origins (Barlow 2002; MacNeish 1992). On the one hand, the existence of certain cultural elements as well as the roles they played to generate subsistence changes is constrained by environmental elements. On the other hand, the environmental factors only provide initial conditions for the changes of any cultural system. They cannot explain the diversity of the development of cultural systems under similar environmental conditions (Chen 2013; Contreras 2016; Osorio, et al. 2017). Therefore, a theoretical approach that can well integrate cultural and environmental factors is indispensable for us to explore changes in subsistence practices.

Cultural ecology is just such a theoretical approach, as it studies the cultural means people relied on to adapt to the environment. Usually, we call such cultural means an "adaptive strategy"

(Sutton and Anderson 2009). It suggests that under the principles of evolutionary mechanisms, people's selection of their subsistence strategies is both based on the constraints of local environmental factors and their own cultural systems (which include the structural patterns of techniques, socio-economic organization, ideologies, etc). The specific interplay of cultural and environmental factors formed the particular pattern of the adaptive strategy and changes in such interplay might drive the changes of adaptive strategy (Kelly 2013; Simmons 1997; Steward 1977).

Cultural ecology theory is crucial for this dissertation research mainly for the following aspects:

(1) Cultural ecology theory provides important guidance on what aspects we should look for and how we should analyze them to explore the specific patterns of subsistence strategy in the Northern Yinshan Mountain region. Previous studies of hunter-gatherer groups under the approach of cultural ecology highlight that subsistence, mobility, and social integration are three inter-related axes for the engines of human adaptive behaviors. The particular strategy people relied on to make use of the resources across the landscape was determined and reflected by the combination of these axes under the specific environmental background (Binford 1978b; Binford 1980; Kelly 2013; MacNeish 1992; Steward 1938). Therefore, finding out the appropriate analytical approaches to investigate them under the background of human-environment correlations are vital for us to understand subsistence practices in the Northern Yinshan Mountain region.

(2) Cultural ecology provides theoretical ideas for us to explore the reasons behind people's subsistence choice. Due to the complexities of the interplay between environmental constraints and cultural systems, people usually have more than one potential strategy they can use to adapt the environment under specific environmental conditions. Why they ultimately choose one of them but not the others is usually impacted by the specific principles of evolutionary mechanisms (Rindos 1984). For instance, increasing the reproductive success is an internal goal of surviving. Therefore, any subsistence strategies which involve high risks for human survival tend to be less favored than the more safe or flexible strategies with lower risks (Codding, et al. 2011;

Winterhalder 1986; Winterhalder and Goland 1997). In addition, maximizing the net acquisition rate for energy is essential for increasing reproductive fitness. Therefore, people tend to apply the subsistence strategy which can provide them with a better return rate. The relative benefits and costs of different subsistence strategies might be important considerations for people's subsistence choice (Chen 2013; Winterhalder and Kennett 2006).

Since the adoption of fully-fledged agriculture can be conceived as one of human's subsistence choices, the impacts of such principles of evolutionary mechanism can be analyzed under the specific cultural and environmental contexts to assist us in exploring why fully-fledged agriculture did or did not emerge in the Northern Yinshan Mountain region.

1.4 Human land-use: a key for exploring human's subsistence strategy across the transition to agriculture

The study of human land-use is about understanding how people manage, modify, and adapt to an environment of resources, and it seeks to identify conditions created by the interplay between the cultural system and the environmental constraints (Ebert 2001). Under the theoretical guidance of cultural ecology, land-use study is an appropriate and illuminating way for us to learn how people were culturally adapted to the Northern Yinshan Mountain region during the key period of the transition into agriculture in North China. It provides invaluable perspectives for us to answer the research questions as I proposed in section 1.1.

First, the subsistence strategy is well reflected by the particular ways of human land-use. A thorough study of land-use pattern will inform us: (1) what kinds of subsistence resource do people make use of and what is the relative importance of the contributions of kinds of resources to the whole subsistence system; (2) how are people spatially distributed to exploit or produce the food resources across the landscape, such as whether they settled down in one place and made intensive use of the surrounding area, or expanded across large territory and made extensive use of the resources in different environment zones; (3) how are people socially organized to make use the landscape of resources, such as whether they integrated in large communities or lived as small groups to procure or produce food resources or whether they are independently organized to make use the resources or bound by close ties of interdependence. The information of three perspectives respectively corresponds to subsistence, mobility, and social integration, which are three inter-related axes forming the pattern of subsistence strategy. The land-use study not only reveals the features of such aspects but also works well to examine them under the spatial background to see how they are integrated under the context of human-environment interrelationships.

Moreover, a comprehensive investigation of changes in land-use patterns can help us to evaluate whether or not fully-fledged agriculture emerged in the Northern Yinshan mountain region. Full-time agriculturists have very different land-use patterns than those of hunter-gatherers or part-time horticulturalists. Since fully-fledged agriculturalists are heavily engaged in farming work near their settlements and the increasing reliance on cultivation can provide them with adequate food resources perennially within a confined area, fully-fledged agriculturalists are usually sedentary with the persistent use of their surrounding environment at a far more intensive level than ever. They might aggregate in large social groups and tend to have more intensive forms of social integration. All such patterns can be identified by various kinds of archaeological evidence in large samples (like numerous pieces of lithics and record of site locations). Therefore, we can examine the archaeological data to see if the patterns of change of subsistence strategy through time in the Northern Yinshan Mountain region meet the expectations of the changing pattern from hunting and gathering to a fully-fledged farming economy.

In addition, the land-use pattern is also essential for us to evaluate why fully-fledged agriculture did or did not emerge in the Northern Yinshan Mountain region. What land-use study reveals is not merely a static picture of how people make use of resources across the landscape, but the dynamic pattern of how subsistence, mobility, and social integration interplay to form particular adaptive strategy (Chen and Yu 2017a; Munoz, et al. 2014). Both the potential motivations encouraging the change to a fully-fledged agricultural economy and the factors retarding this change are embedded in the particular forms of such an adaptative strategy. Therefore, a deep understanding of the land-use pattern will help us to analyze the mechanism for the changes of the subsistence strategy (Chen and Yu 2017b). Moreover, the dynamic pattern of the interplays implies that it is subjects to changes based on ever-changing cultural and environmental conditions (Chen 2004; Chen 2011; Contreras 2016). A comprehensive understanding of the land-use pattern provides a basis for us to further explore how the changes of cultural and environmental conditions impact people's land-use strategy and changed the ways of the human subsistence practice.

Due to the importance of land-use study for exploring the research questions, it is the focus of study for this dissertation and the following roadmap will indicate how this dissertation is arranged to present the analysis of the land-use study in Northern Yinshan Mountain Region.

1.5 Reader's roadmap

Chapter 2 provides the basic geographic information of the study region, illustrates the chronological scheme of the study and describes the basic features of artifacts found in the survey and excavation. Chapter 3 provides basic introductions of the two excavated sites; introduces the methods used for data collection in the field; evaluates the possible biases of in the data; lists the lines of evidence I will use, as well as the corresponding methodologies I will rely on for data analysis of the study. Chapter 4 is mainly about the analysis of the land-use pattern of the Early Neolithic period based on the excavated data. Chapter 5 is about the analysis of the land-use pattern of the Early Neolithic period from the survey data. Chapter 6 focuses on the analysis of the land-use pattern of the Mid-Late Neolithic/Early Bronze Age from the survey data. Chapter 7 compares land-use between Early Neolithic and Mid-Late Neolithic/Early Bronze Age and summarized how people's subsistence practice changed through time in the Northern Yinshan Mountain region. Chapter 8 generalizes the pattern of land-use and the subsistence strategies it reflects; explains how and why the development of land-use strategy in the Northern Yinshan Mountain region differs from the neighboring areas; illustrats how the case study of the Northern Yinshan Mountain region contributes to our understanding of the origins of agriculture in broader terms; evaluates how the methods of land-use study can be complemented with other means of study to learn human's subsistence practice; and points out future directions for improving the study.

2.0 Spatial and temporal framework of the study and the characteristics of pottery and lithic assemblages

2.1 Macro-regional environment: Farming-Pastoral ecozone of China

Between the humid monsoon region of East China where is one of the vastest agricultural zone in the world, and the arid Inner Asia desert and steppe where the pastoralism has long been relied on as the major economic basis, there is a broad region extending from Northeast to Southwest China, penetrating through the northern periphery of North China. This broad area is comprised of mountains, hills, basins, high lands and is the transitional area between the alluvial North China plain and the inland plateau. It is an ecozone between the monsoon region and the non-monsoon region. Since millet growth relied heavily on the precipitation brought by the summer monsoon, this area is also in the marginal environment for rainfed millet agriculture (Chen 2018).

In most of the historical time in China, the mixture of agro-pastoral economy dominates in this region. The proportion of agriculture increases towards the southern part of this region, while the proportion of pastoralism increases towards the northern part of the region. This transitional zone does not have a clear boundary or fixed shape. While the core area of it, like Yinshan Mountain range, remains relatively stable, the northern or southern limits of it expand or shrink according to the fluctuation of climate and the strength of political power on both sides. In general, when the climate became warmer and wetter, or the political power of farming groups to the south became strong, the bounds of the Farming-Pastoral Ecozone would expand further north, while when climate became cold and dry or the political power of nomadic groups to the north became strong, the Farming-Pastoral Ecozone would shrink from the northern part and penetrate further towards the south. It is an area of confrontation between farming groups from the south and nomadic groups from the north in most of the historical period of China (Lattimore 1962). The Great Wall built in different periods was located mostly within this region. In the pre-historic period, there are unique cultural sequences in different parts of this region which differ from both its northern and southern neighbors (Han 2015). The significant economic shift between farming and pastoralism can be identified from archaeological records, which are corresponds temporally to pronounced climate fluctuation, indicating that the economic practice in this area is sensitive to climate changes (Han 2005).

2.2 Local regional environment: survey area of Huade County

2.2.1 Current geographic settings

The survey region for my research is in the northeast part of Huade County. It locates at the northern slope of the northeast part of Yinshan Mountain (will be called the Northern Yinshan Mountain region in the following of this dissertation）, which locates in the northern margin of the belt of Farming-Pastoral Ecozone as mentioned above.

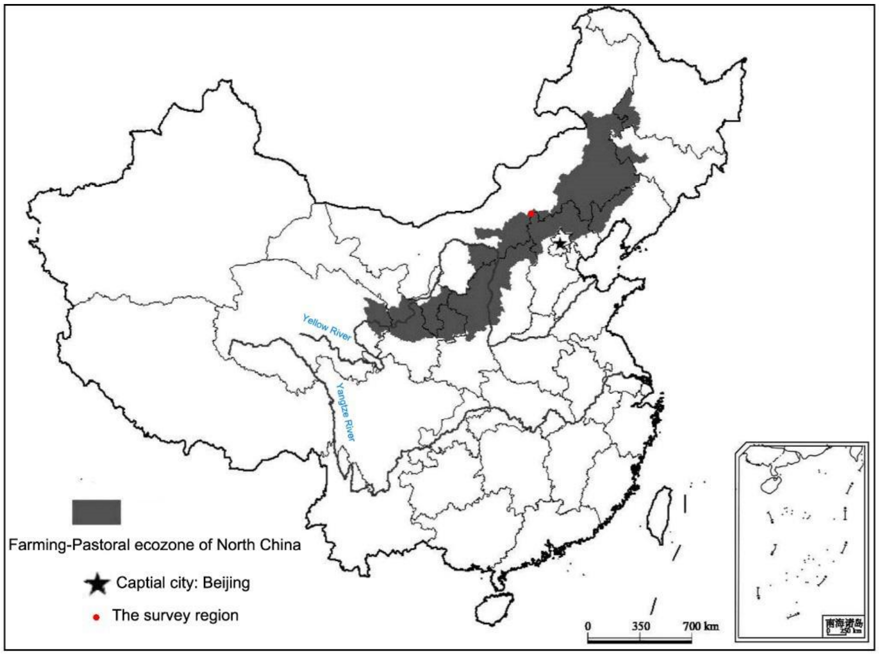

Figure 2.1 The location of the survey region in the farming-pastoral econzone

The survey area has a hilly landscape, composed of low mountains, rolling hills, basins, and river valleys. The elevation ranges from 1200 to 1700 m, and the topography is high in the south and low in the north. The landform in the south is more fragmentary and composed mainly by low mountains, hills and small mountain basin. The landform in the north is flatter, as the river valley broadens gradually from upper to lower reaches.

The annual precipitation in this area is about 330 mm and as much as 60-75% precipitation is concentrated in the summer. The average temperature in this region is 2.5 ℃ and it has four distinctive seasons with extreme seasonal variation in cold and heat (Li 2006). Due to the relatively high elevation and higher latitude in comparison with many other regions of North China, the Northern Yinshan Mountain region has a short summer and long winter. The climate in summer is warm, but not as hot as in many other places in North China. While affected by the Mongolian-Siberian high-pressure system, the climate in winter is cold and windy and the temperature is lower in comparison with most other regions located at the same latitude (Ren 1999). The vegetation is dominated by herbaceous plants. The steppe community, shrub-steppe community, meadow community are the main types of natural vegetation communities. The salinity vegetation community is sparsely distributed in low lying land (Li 2006).

2.2.2 The conditions for agriculture

This region is marginal for agricultural production mainly because of the following reasons:

(1) The precipitation is limited and unstable

Rainfed agriculture requires a sufficient amount of precipitation to support the growth of the crops. In China, the 400 mm iso-precipitation line is the dividing line between the agricultural region and pastoral region since 400 mm precipitation is a safe threshold to ensure the growth of the crops (Zhou 2000). The average annual precipitation of Huade County is 330 mm, which is slightly lower than 400mm. While it does not mean that rainfed agriculture is impossible in this region, it does indicate that conducting rainfed agriculture is risky and prone to be threatened by drought (Hu, et al. 2014; Wang and Li 1985). To make matters worse, since Huade county is located where the summer monsoon could just barely reach, the precipitation that depended on the summer monsoon is quite unstable and sensitive to the fluctuations of the strength of summer monsoon (Li, et al. 2016). While the precipitation might be higher than average 330 mm during the years when summer monsoon is strong, it will drop dramatically during the years when summer monsoon is weak. According to the county annual of Huade from 1949 to 2004, droughts have been recorded in as many as 33 years (Li 2006).

(2) The growing season is short

The growing season of Huade county is about 95-105 days. It usually starts from the end of May and ends at the beginning of September (Li 2006). It can only barely meet the minimal needs of the millet growth since 100-120 days are usually needed from the sowing to the harvest.

However, the growing season also depends heavily on the relative strength of the Winter Monsoon and Summer Monsoon. During the years when Mongolia-Siberia high-pressure weather system last longer (which means the winter monsoon dominates the weather system for a longer time of the year), the rising temperatures might be delayed or the decreasing temperature of fall could happen earlier, which will shorten the length of the growing seasons. In such a case, the crops might suffer frost disaster.

(3) Soil erosion and desertification

Wind erosion is a serious problem to influence the soil fertility and sustainability of agricultural production in Huade county of the Northern Yinshan Mountain range. Since Huade county is not far from the heartland of the Mongolian Plateau, it is heavily impacted by the Mongolia-Siberia High Pressure weather system. The wind is frequent and strong, especially in winter and spring (Zhang, et al. 2018). The soil in Huade county is more sandy in comparison with soils at the southern slope of Yinshan Mountain, which means that it is relatively loose and can be more easily blown away by strong winds (Qiu, et al. 2005). Moreover, the reclamation activity will destroy the vegetation covered on the earth. It will make the cultivated soil lack protection from surface vegetation and more vulnerable to be eroded by wind (Chi, et al. 2019). The wind erosion will blow away organics and fine-grained matters of the soil and lead to soil coarsening. As a result, the soil fertility will decrease. More seriously, it can even erode whole layer of cultivable soil and expose the underlying sands beneath the surface soils (Du, et al. 2007; Zhang and Gong 2003). Such matters make it hard to maintain the agricultural activity sustainably and will make the benefits of farming drop as time goes by after initial reclamation.

2.2.3 The general land-use pattern in history

In most of the historic period, the area of Huade county is outside the border of imperial China dynasties governed by Han people, which are rooted in intensive farming economy. The Yinshan mountain has been regarded as the divisional line between farming and pastoral sphere (Di and Wyatt 2003). While periodical farming activities have been recorded in the southern slope of Yinshan Mountain region when the climate is warmer, no historical documents have ever recorded the activity of large-scale farming activities before the end of Qing Dynasty in Huade county of Northern Yinshan Mountain region (Han 2012). The migration of farming groups into this region and the widespread reclamation of farming land happened after 1902 when the government of the Qing dynasty issued a permit for reclaiming the pastoral land in the Mongolian Plateau because of the population pressure in inland China (Li 2006). Today, the rural inhabitants of the Huade county are mainly the offspring of the migrants from inland China (mostly come from Shanxi Province). They are still engaged in agriculture and live in village life. However, due to the unsuitability of agricultural production and severe issues of soil erosion and desertification, the Chinese government in recent years have issued the policy to return the cultivated lands into forestry or grassland. Nowadays, only 19.95% of the land has been used as farming land in Huade County (Li 2006). The land-use pattern from historical period to current time suggests that traditional agricultural life has never taken deep root in Huade county in Northern Yinshan mountain. Although the farming migrants reclaimed the land here in recent history, the large-scale intensive agriculture still cannot be fully developed even with the aids of modern agricultural technology.

2.2.4 The Paleo-environment conditions

Little is known about the land-use pattern and subsistence practice in this region in prehistorical time before the emergence of pastoralism. Did people develop primary farming as a way to cope with subsistence demands or remain as foragers? If they are engaged in the farming economy, how is the role of farming played in human’s social and economic life in comparison with other means of subsistence practices? These will be the issues addressed in the following chapters. But taking account of the impact of Holocene climatic amelioration, the conditions for farming in this area was better than today's conditions during the prehistoric period characterized by warmer and wetter climate.

Although no direct paleoclimate studies have been done in Huade county, the studies of lake sediments in the surrounding regions in Inner Mongolia suggests that the Early Holocene climate amelioration, marked by the increase in humidity and temperature, started from about 10.5ka B.P. and lasted for more than 5000 years before the climatic transition into colder and drier conditions during 5500-4000 years. In spite of the discordance of the recordings of the timing of optimal climatic conditions in finer scales from different lake cores, most evidences suggest that it appeared during 8.9-6.3 ka B.P. (except for Daihai Lake in southern Yinshan Mountain, suggesting the optimal climate lasts from 7.9 ka BP to 5.1 ka BP, with a punctuated cold and dry climatic interval during 7-6 ka B.P.) (Hao, et al. 2014; Jiang, et al. 2006; Wang, et al. 2010). Increased arboreal pollen suggests that during this period, there is a shift in both the composition of tree species and the gradual expansion in the extent of woodland environments (Zhao and Yu 2012). The faunal remains of the forest species discovered from the archaeological sites in Huade region also indicates the existence of forest in Northern Yinshan Mountain[1]. Therefore, in comparison with today's environment which is dominated by steppe vegetation, the survey region in Huade county has a mosaic forest-steppe environment during the Holocene climatic optimum. According to the geographic features of the Mongolian Plateau, such patchy forests might distribute in mountainsides or nearby the rivers, which have more moisture than the other micro-environment zones (Erdős, et al. 2018; Hao, et al. 2016; Janz 2012).

The layer of blackish paleosol can be widely found in piedmont and valley margins in northern side Yinshan Mountain, which is dated between 8000-3200 BP. Such soil is sandwiched

[1] The faunal remains of Yumin and Simagou sites discovered in Huade county have not been published yet. But according to the personal communication with Dr. Lu who is in charge of the analytical work of faunal remains, there are forest speices such as the deers and boars.

between the aeolian sand depositions. While it is still relatively sandy, the higher proportions of organic and finer-grains matters indicate that it was formed under the conditions with lusher vegetation coverage and weakened aeolian activity (which means weakened winter monsoon in this area) in comparison with the period when the aeolian sand deposition formed. Such soil structure with a high content of organics and fine grains also provide good conditions for primary farming activity (Qiu, et al. 2005).

Corresponding Holocene climate amelioration with the ceramic chronology, we can see that such warmer and wetter period is simultaneous with the the Early Neolithic and early phase of Mid Neolithic period of North China. Such a time span is the crucial period of the transition from foraging to farming lifeways. The Holocene climate amelioration provided more sufficient rainfalls and extended the growing seasons of the plants, which created more favorable conditions for food production in Huade county of Northern Yinshan Mountain range in comparison with that of later on period up to now. However, compared with the core area of North China, the Northern Yinshan Mountain is closer to the limits where summer monsoon could affect. The higher latitude and elevation also make the growing season relatively shorter and the crops cultivated in this area more vulnerable to frost disaster in spite of the climate amelioration. Therefore, the survey area in Huade county of Northern Yinshan mountain region locates at the relatively marginal environment for agriculture compared with areas to the south and east of it in North China. Meanwhile, the Holocene climate amelioration heightened vegetative biomass and increased the bio-diversity, which brought favorable conditions for the exploitation of certain ranges of wild plant and animal resources as well in addition to farming (Janz 2016). The ecozone location between humid monsoon region and the arid non-monsoon region also means that the ecological conditions and food resources in this area are sensitive to the climatic oscillation (Hao, et al. 2014). Therefore, the changes in land-use pattern might be closely correlated with the climatic changes throughout the time, which will be analyzed and discussed in detail in the following chapters.

2.3 The temporal span for the study

A perspective of long-time span needs to be acquired by us to investigate the transition from foraging to farming lifeways and evaluate the impacts of food production on human's cultural, social and economic realms since the development of agriculture is a gradual process rather than the accomplishment at one stroke.

It is inevitable to use some conventional temporal terminologies to describe and discuss such process. In China, the Neolithic time has been divided into Early Neolithic (9-7 ka B.P.), Mid Neolithic (7-5 ka B.P.) and Late Neolithic (5-4 ka B.P.) mainly based on the temporal differences of material culture in a far-flung area (Liu and Chen 2012). Although these terms contain little precise indication of the social or economic changes, which were unknown when they were initially created, some significant changes in cultural, social and economic practices can be found at roughly the shifting time from one period to the other, which makes it at least useful as a descriptive scheme for talking about archaeological phenomena. The terms are also used inconsistently by different scholars. In traditional classification scheme, the Early Neolithic starts after 9 ka B.P., when the so-called "Neolithic lifeways" appeared in a variety of far-flung regions, marked by the emergence of villages, prevalence of pottery and polished stone tools and the appearance of regional cultural interaction spheres (indicated by the archaeological cultures in different regions) (Cohen 2011; Zhang 2004). However, in recent years, the archaeological evidence showing the earliest forms of pottery, ground stone and initial signs of domestication have been found at 12-9 ka B.P. (Liu and Chen 2012; Yang, et al. 2012). For one thing, such findings are rare and do not show significant social and behavioral changes. For another thing, such new elements can be conceived as the buds for the subsequent development into agricultural lifeways (Shelach-Lavi 2015). Some scholars have altered the traditional classification scheme and call the period of 12-9 ka B.P. as Early Neolithic period, and rename the previous Early, Mid, Late Neolithic periods as Mid Neolithic, Late Neolithic and Chalcolithic age (Han 2015). While other scholars still keep the old classification scheme but add the period of 12-9 ka B.P. as Initial Neolithic period (Liu and Chen 2012). For the analysis and discussion in this dissertation, I prefer to use the traditional classification scheme and regard the period of 12-9 ka B.P. as Initial Neolithic age and the period of 9-7 ka B.P. as Early Neolithic age.

In the Yellow River drainage of the heartland of North China, fully-fledged agriculture developed from low-level food production during the Early Neolithic and Mid Neolithic period (Zhao 2014). In the Early Neolithic period, two kinds of millets (foxtail and broomcorn millets), as well as pig, were on their way towards domestication and they were cultivated or raised as the supplemental food resources for the human diet. The majority of food sources were still intensive hunting, collection, and storage of a wide range of wild animals and plants (Wu 2014). Based on such a mixed economy, people began to integrate into larger groups and live in villages (Chen 2013). The abundance of cultural remains, the appearance of pit houses and storage facilities and the signs of the planned settlement layout all indicate relatively stable residence in a confined area (Liu and Chen 2012). The old view assumes that such a pattern reflects sedentism. However, recent studies note that such inhabitation was not as stable as in later periods. The de facto refuse of the pottery and stone tools which still have abundant use-life can be found in sites across different regions. Such phenomena indicate that people might temporarily leave their residences for some reasons, anticipating to return later (Li 2018). In addition, since large settlements are rare, how representative they are of general habitation patterns is still open for discussion.

In contrast to the Early Neolithic period, millet became the dominant food resource for human diets in the Mid Neolithic period. While people still practiced hunting and gathering, the contributions of the wild resources were dwarfed by the increasing importance of domesticates (Chen 2013). There was a dramatic increase in the number of the sites, indicating the booming of the population. People began to live in more stable sedentary lifeways in a larger scale of population integration, marked by the evidence of thicker cultural deposition, sufficient storage facilities, regular clearance of household garbage and enlarged settlement (Liu 2005). This is a period interpreted as the onset of fully-fledged farming communities.

The Late Neolithic and Early Bronze Age witnessed the further intensification of agriculture. The isotope studies from some sites in North China at this period indicate that the millets contribute larger proportions of the human diet (Hou 2019). The soybean was probably domesticated during this period and the wheat, barley, cattle, and sheep had been imported from the west (Liu and Chen 2012). These plants and animals have been incorporated into the original agricultural system which was dominated by millet cultivation and pig husbandry. It included more species of the domesticates in the agricultural system, which contributed to the increase of productivity and reduced the risks of agricultural production. The development of social complexity, indicated by the emergence of social hierarchy, social conflicts, political integrations, differentiation of wealth can also be observed in this time period (Liu 2005; Shelach-Lavi 2015). Such development of social complexity might be closely interrelated with the maturity of the agricultural economy.

A similar trajectory of socio-economic changes can also be detected in West Liao River valley in Northeast part of North China, despite a punctuated period of decline of agriculture and increase of mobility during Late Neolithic period after the collapse of Hongshan culture and before the arise of Lower Xiajiadian culture (Jia, et al. 2016). Therefore, the period from Early Neolithic to Early Bronze Age witnessed the development from low-level food production to fully-fledged agriculture in both Yellow river drainage and West Liao River valley.

Little is known about the social and economic developments from Early Neolithic to Early Bronze Age in the Northern Yinshan Mountain region before the studies of the excavated sites and survey results of Huade county. However, since this region experienced similar climate changes in comparison with other regions of North China; its natural environment meets the basic requirement of millet growth during the climate amelioration and it is neither far from the core areas of North China nor did natural barriers separate it from the other regions of North China. It is highly possible that if people invented or adopted food production, the subsistence transition should happen in relatively the same time period with areas in Yellow River and West Liao River valley.

Therefore, I confined the temporal span of my study from Early Neolithic to Early Bronze Age. Since my study is mainly focused on lithics as an insight to learn the patterns of land-use, it is crucial to identify the temporal differences of lithic assemblage across this long period. However, the difficulty of using lithics as chronological control is that many types of lithic tools are not sensitive to temporal changes and might remain similar forms across a long period. Therefore, it is almost impossible to subdivide the long period into tighter phases based on lithics alone. The changes of general traits of lithic assemblages, though, can be detected when significant subsistence practice and the corresponding land-use pattern change and result in the changes of technological organization and toolkit composition. Under such conditions, the lithics can be used as an enlightened means to subdivide the long period into different periods. Such division might be coarse-grained, but each divided period can well reflect a distinctive land-use pattern.

Based on the analysis of the excavated and survey material from Huade county, two kinds of lithic assemblages can be identified. Either of them can be repetitively found across the survey region. Each assemblage has spatial variations across different sites but shares some traits in common. In general, the assemblage A is mainly composed of lithics made from dark-colored igneous rock (usually in grey, blackish or dark green color) in varying scales of grain size. The sizes of stool tools and debitage vary but are larger in average compared with those of the assemblage B. A type of unique adze-like tool can be frequently found in assemblage A, which is absent in assemblage B. Except for the adze-like tool and some stone hoes, most tools of assemblage A are marginally retouched on the edges rather than being facially retouched.

The assemblage B is mainly composed of lithics made from fine-grained chert and chalcedony. The sizes of tools and debitage are on average smaller than that of assemblage A. The arrowheads, which are only occasionally found in the excavated remains but cannot be found in surveyed materials of assemblage A, could be frequently found in assemblage B. The bifacial technique is much more developed in assemblage B. The bifacial blanks, bifaces, and the bifacially retouched tools, like end scrapers, scrapers, drills, and burins can be frequently found in assemblage B. Although many tool types overlap between assemblage A and assemblage B, the specific forms of the tools are different between assemblage A and assemblage B. For instance, the sizes of end scraper in assemblage A is in general larger than those of assemblage B and there is a type of long-body end scraper which has long axis and narrow wideness. While in assemblage B, there is a kind of thumb-nail end scraper, which is extremely small and intensively retouched. As for scrapers, there is a kind of serrated scraper which can be found in assemblage A but not in assemblage B. While for the stone hoes, the ones in assemblage B are produced in more regular forms than those of assemblage A and are made from tuff instead of coarse-grained dark ingenious rock.

The assemblage A always coexisted with pottery sherds of the Early Neolithic period, whereas the assemblage B is accompanied with pottery sherds ranging from Mid Neolithic to Early Bronze Age, indicating that the differences of lithic assemblages correspond to the temporal changes. It is hard to further divide the assemblage B in accordance with cultural changes of Mid Neolithic, Late Neolithic and Early Bronze Age since the consistent features of assemblage B can be detected in spite of the sites with single Mid or Late Neolithic pottery remains, single Early Bronze Age pottery remains, or mixed pottery remains across Mid Neolithic and Early Bronze Age. In contrast, the sites with mixed remains of pottery of Early Neolithic and Late-Mid Neolithic/Early Bronze Age always reflect mixed features of assemblage A and assemblage B. Such a pattern indicate that the land-use pattern might probably remain relatively constant from Mid Neolithic to Early Bronze Age, but differs from that in Early Neolithic period.

2.4 Pottery typology and chronology

The types of pottery are subject to change throughout time, which can be used as the proxies for time control.

2.4.1 Early Neolithic pottery typology

The rich amount of pottery sherds recovered from two excavated sites gives us clear understandings of the features of pottery typology in the Early Neolithic period. The pottery in the Early Neolithic period of the study region are simple in forms, mainly composed of jar, cauldron and a kind of unique tabular-shaped pottery which is considered as serving ware[2].

The pottery in this period are low-fired, coarse-grained and usually in dark brown to gray-blackish color which is unevenly distributed on the pottery surface. The body of the pottery is thick. From the cross-section of the pottery, we can see layers of pastes, suggesting the application of the clay fillet appliqué technique for pottery making. While only the tabular-shaped pottery and a few of the jars and cauldrons are plain-faced, most of the jars and cauldron have net-impressed marks on the surface. Instead of the intentional decoration, such net-impressed marks might have resulted from the specific pottery making method. It is estimated that a net bag has been used as a mold and layers of clay have been pasted on the inner walls of the bag. Then after firing, the net bag has been burned out and left the marks on the surface of the pottery.

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[2] The studies of pottery in Early Neolithic period of the Northern Yinshan Mountain region has not yet been published. The information I recorded about the pottery are based on my personal observations of the pottery remains form the work station and the communications with Mr. Hu, Mr.Bao and Mr, Ren, who are in charge of the pottery study for the project.

Net-impressed pottery is an unique feature of the Neolithic period in this region since none of this kind of pottery has been found in contemporary archaeological cultures to the south or east of this region in North China. However, the net-impressed pottery can be found in broad regions from the central Mongolian Plateau to the west side of Baikal lake in East Siberia from about 8 ka B.P. to 6 ka B.P. (Janz, et al. 2017; McKenzie 2009). Moreover, the forms of jar and cauldron in these regions are similar to those found from the excavated materials of Huade county. They both have a long body and pointed round bottom. Such evidence indicates the probable cultural affinity between the Northern Yinshan Mountain region and the heartland of the Mongolian Plateau and the western part of East Siberia.

The exact time span of the Early Neolithic period for the study area in Huade county is hard to define accurately. The date of Yumin site ranges from 8.4-7.6 ka B.P., which is considered as a site in the earlier period of the Early Neolithic age. The dating result from Simagou site ranges from 9-7 ka B.P., but it is only based on three radiocarbon samples and the oldest one might be subject to dating biases. Based on the changes of pottery and pit houses structures, it is estimated to be slightly later than the Yumin site. The pottery in the Simagou site were probably fired in higher temperature than those in the Yumin site since the body of the pottery is harder. A major difference between Yumin and Simagou's pottery is that, while the jars and cauldrons at Yumin have pointed round bottoms, the jars and cauldrons in the Simagou site have small flat bottoms, even though the forms of the body above the bottom look similar to those of the Yumin site (as shown in Figure 2.2). The same types of pottery can also be found from the surveyed sites, but the sporadic numbers of pottery sherds from the surface collection make it hard to recover the vessel forms. In the site of LPN1 at the northern part of survey region, a kind of hard and thin-body net-impressed pottery sherd has been found. It is estimated to be fired in higher temperatures. The similar thin-body and higher fired net-impressed pottery have been found in Mongolia at about 7-6 ka B.P. Therefore, the use of net-impressed pottery might last to 7-6 ka B.P. in Northern Yinshan Mountain region.

Besides the kind of pottery assemblage which is dominated by net impressed pottery found from both excavated sites and most of the surveyed sites in Early Neolithic period, there is also a kind of unique pottery assemblage found in TDSSK and GJC sites in the southwest part of the survey area. The thick and low fired pottery sherds have been found in these two sites. They are in orange-red color and have coarse-grained sandy temper. Some of the pottery sherds have coarse-cord marks or concave bean-like decorative patterns on them (as shown from 8,9,10 of Figure 2.2). No other similar pottery has been identified from other adjacent regions. Based on the primitive features of the pottery as well as the fact that the features of lithic assemblages from these two sites are similar with those the co-occur with net-impressed pottery, the archaeologists from Inner Mongolia Institute of Archaeology and Cultural Relics and Ulanqab Museum attribute them also to the Early Neolithic, considering that they might exist during the later phase of the Early Neolithic period and are used by groups with different cultural identity compared with those who use net-impressed pottery.

In addition, the site DNYZ has yielded plenty of pottery sherds, and most of the sherds can be pieced together into a flat bottom cylinder jar of Xinglongwa culture style (as shown in 7 of Figure2.2). Such pottery resembles vessels found in the Chifeng area of southeast Inner Mongolia during the mid-late phase of Xinglongwa culture, which is estimated to be around 7 ka B.P. Such findings indicate that the archaeological culture from the east had contact with this region as early as the late phase of Early Neolithic period.

In summary, the pottery typology of the Early Neolithic period is dominated by the pottery assemblage with a prevalence of net-impressed pottery from at least 8.4 ka B.P. to 7 ka B.P. (or perhaps even being extended to 6 ka B.P.). Such pottery assemblage is also called as the Yumin culture by the archaeologists from Inner Mongolia Institute of Archaeology and Cultural Relics and Ulanqab Museum, named after the first excavated site Yumin where this pottery assemblage was first recognized. The coarse and thick orange-red pottery assemblage and the Xinglongwa pottery typology can only be found sporadically in confined areas or the individual sites of the survey area.

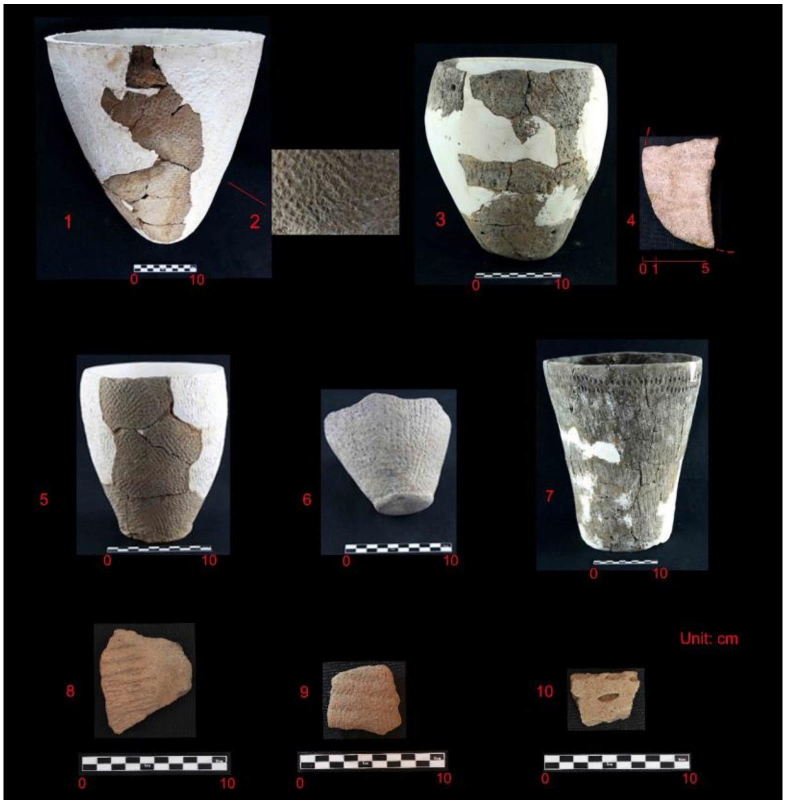

Figure 2.2 The pottery of the Early Neolithic period found from the Huade survey region

(1,3: Jar from Yumin site, 2: the details of net-impression mark of the surface of the pottery; 4: tabular-shaped pottery (incomplete); 5,6: jar from Simagou; 7: cylinder jar from DNYZ; 8,9,10: pottery sherds from TDSSK and GJC sites)

2.4.2 Mid Neolithic pottery typology

The pottery typology in Huade county of the Northern Yinshan mountain region during the Mid Neolithic period was heavily impacted by the contemporary pottery typology of the Yangshao culture from the south and that of the Hongshan culture from the east.

The sherds of the following types of pottery found in the survey region of Huade county show close affinity with Yangshao or Hongshan Pottery (Neimenggu and Beijing Daxue 2003; Wei 2003).

(1) Pure-clay red bowl

In both Yangshao and Hongshan culture, bowls made with fine-grained pure clay and fired in relatively high temperature are highly identifiable, for their unique forms, bright red or orange color and fine texture (as shown in 1 of Figure 2.3). The rims of the bowls are a little bit bend inward and the body of the bowl is curved. The body surface of some of the bowls are even polished and have glosses.

(2) Small-medium size globular jars with incised or corded pattern

The kind of pottery is sand-tempered and in dark brown or gray color. The incised or corded lines are arranged in various patterns on the surface of the pottery body. Among them, the net-like pattern (which is shown as 4,5 of Figure 2.3) can be frequently observed on the jars excavated from the mid-late phase Yangshao culture sites in trans-Daihai lake region to the southern slope of Yinshan Mountain in Mid-south Inner Mongolia.

(3) Flat-bottom cylinder jars with zigzag pattern

The flat-bottom cylinder jar with the incised zigzag pattern is a typical type of Hongshan pottery, which is prevalent in the West Liao River valley in southeast Inner Mongolia and Western Liaoning province. The zigzag patterned flat-bottom cylinder jars have also been introduced into Mid-south Inner Mongolia during its Yangshao cultural period in the late phase (approximately from 5.5 to 5 ka B.P). Therefore, the presences of the pottery sherds of zigzag-patterned flat-bottom cylinder jar (shown as 6 of Figure 2.3) found in Northern Yinshan Mountain region can either be directly introduced from the eastern Hongshan culture regions or from the south by the late-phase Yangshao culture of Mid-south Inner Mongolia which contains cultural elements of the Hongshan culture.

(4) The jar with nail-shaped incised pattern beneath the rim

This is a typical kind of pottery found in Hongshan culture (shown as 7 of Figure 2.3). Rings of nail-like incised marks are arranged neatly beneath the rim of the pottery. The presence of the sherds of this type of pottery also indicates the cultural impact from more eastern Hongshan culture regions.

Besides these types of pottery, other types of pottery with less distinctive identifiable features from Yangshao and Hongshan culture can also be detected from the sherds in the survey region based on the comparative observations of the texture, temper, thickness and the color of the sherds. Based on the detailed comparison of the features of pottery sherds from the survey region with the pottery found in adjacent regions, the archaeologists from Inner Mongolia Institute of Archaeology and Cultural Relics and Ulanqab Museum considered that the Mid Neolithic pottery remains in the survey region mostly resemble the mid and late phase Yangshao and Hongshan culture, which is ranged about 6-5 ka B.P.[3].

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[3] Based on the communication with Mr.Hu, Mr.Bao and Mr. Ren, who are in charge of the pottery study for the project.

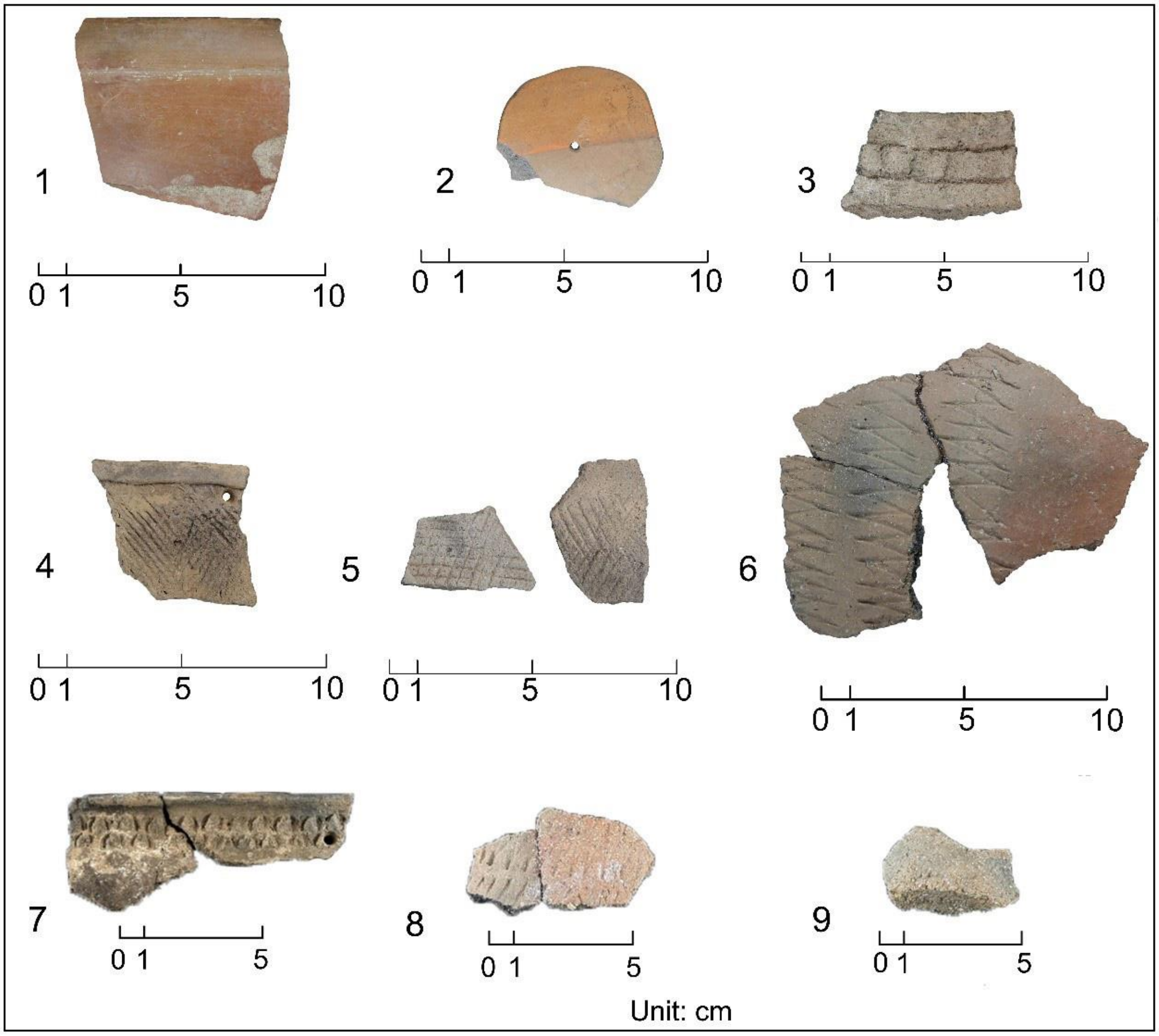

Figure 2.3 Pottery of the Mid Neolithic age found from the Huade survey region

(1: sherd of red bowl, EDW site; 2: pottery spinning wheel reformed from red bowl sherd; XH1; 3, 5: sherds from JZJ site; 4: sherd, HM site; 6: sherd with zigzag pattern, FSCX site; 7: sherd with nail-like incised pattern, YAN2; 8: sherd from KDFZB4 site; 9: sherd of the part of bottom, KDFZB4 site)

2.4.3 Late Neolithic pottery typology

The remains of the Late Neolithic period are very scarce in the survey region. The late Neolithic pottery have been found only in 10 sites and all these sites contain the cultural remains of at least one another cultural period as well. The late Neolithic pottery found in the survey area is characterized by basket-patterned grey pottery fired at relatively high temperatures. Such pottery can be found in the sites at the southern slope of Yinshan Mountain at about 4.5 ka B.P. (Han 2003). The rare cultural remains found in the survey region indicate that people might have occupied this area less during this period.

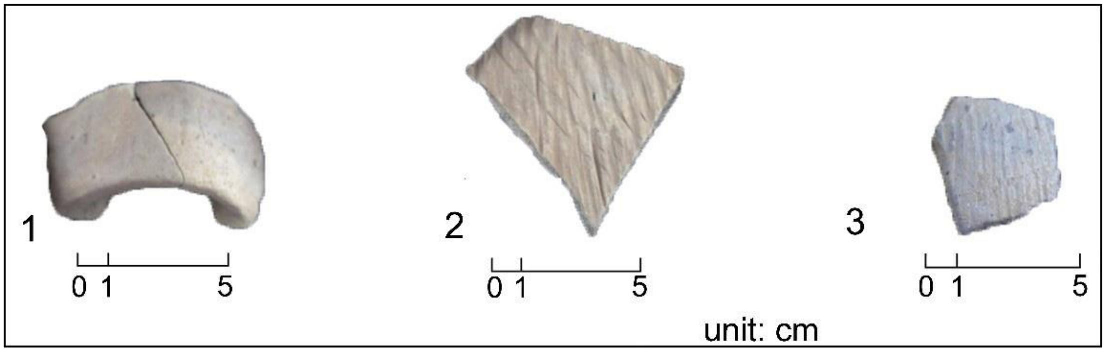

Figure 2.4 Pottery of the Mid Neolithic age found from the Huade survey region

(1,2,3: pottery sherds from GZS site)

2.4.4 Early Bronze Age pottery typology

The pottery typology in the northern part of North China during Early Bronze Age is characterized by the prevalence of tripods with hollow legs ("Li") in various forms accompanied by jars, basins, and urns. The thin-bodied, higher-fired and sand-tempered pottery is prevalent within the pottery assemblage. The cord-mark is the most popular surface treatment, followed by incised geometric designed, stamps, raised clay band, and others (Han 2003). The pottery sherds in the survey region also reflect such characteristics and show affinity with Zhukaigou culture in mid-south Inner Mongolia, reflected especially by diagnostic sherds of the following kinds of the pottery (Cui 1991).

(1) The hollow tripod ("Li") with decorative raised clay band beneath the rim (as shown in 1,3 of Figure 2.5)

(2) The hollow tripod decorated with snake-shaped raised clay band on the body close to the rim (as shown in 5 of Figure 2.5)

(3) The tripod urn made by fine-tempered clay

Besides these diagnostic wares, the pottery sherds of the bodies from less diagnostic jars, hollow tripods, and basins can also be detected. Most of such sherds are coarse-tempered, hard and thin, and show string paddled signs.

Not every single form of pottery mentioned above is exclusively found in Zhukaigou culture. For instance, the hollow tripod with decorative clay band beneath the rim or the ones with the decorative snake-like clay band can also be found in broad regions of the belt of the farming-pastoral ecozone of North China as well as in heartland of the Mongolian Plateau to the north (LU 2002). However, the general features of the remains of pottery assemblages resemble Zhukaigou culture more than the other archaeological cultures in farther areas. The dating result of Zhukaigou culture suggests that it lasts from about 4.2-3.5 ka B.P. (Neimenggu and Ordos 2000). The Bronze Age remains in the survey area of Huade county could probably be contemporary with Zhukaigou culture. However, in considerations that some types of pottery showing diagnostic features of Zhukaigou culture might last longer in other regions beyond the core area of Zhukaigou culture, especially those that not only confined in Zhukaigou culture, I conservatively extend the lower limit of Early Bronze Age to about 3 ka B.P. in the survey area.

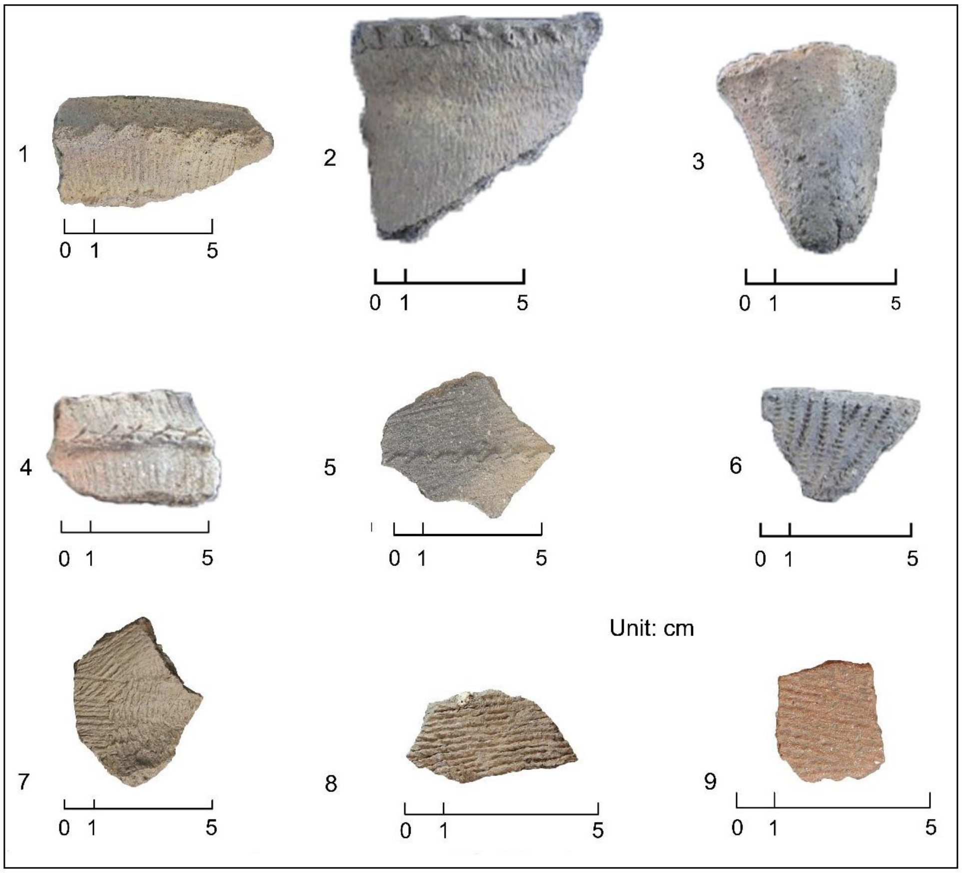

Figure 2.5 Pottery of the Early Bronze Age found from Early Bronze Age

(1: pottery sherd of the rim of the tripod, ET site 2: pottery sherd, YXX site; 3: tripod food, YAXN; 4: pottery sherd, TJN site; 5: pottery sherd, XH site; 6: pottery sherd, YAXN site; 7: pottery sherd of the lower part of tripod ware, ET site; 8: pottery sherd, JZJ site; 9: pottery sherd, JCGX2)

In summary, though more precise chronological control still calls for more systematic dating work, which is hard to be accomplish merely with survey materials, the changes in pottery typologies across time provide us with a coarse-grained chronological scheme. The divisions of Early, Mid, Late Neolithic and Early Bronze Age which are frequently used to discuss the materials from the Yellow River drainage and West Liao River in North China could also roughly fit for the discussion of the survey and excavated materials of Huade county, although the exact starting and ending time of each period might be slightly different. For instance, the Early Neolithic period in the study area of Huade county might at least start from 8.4 ka B.P. The weak evidence indicates that it might last to sometime between 7-6 ka B.P. The Mid Neolithic probably lasted from 6-5 ka B.P. Such a pattern suggests that compared with the regions in Yellow River valley and West Liao River valley, that Early Neolithic age likely lasted for longer time and the Mid Neolithic period appeared later and lasted a shorter time in this region. The Late Neolithic might last between 5-4.2 ka B.P. followed by the Early Bronze Age from 4.2-3 ka B.P.

The correspondence of changes of pottery and lithic assemblage throughout the time is summarized in the chart shown below:

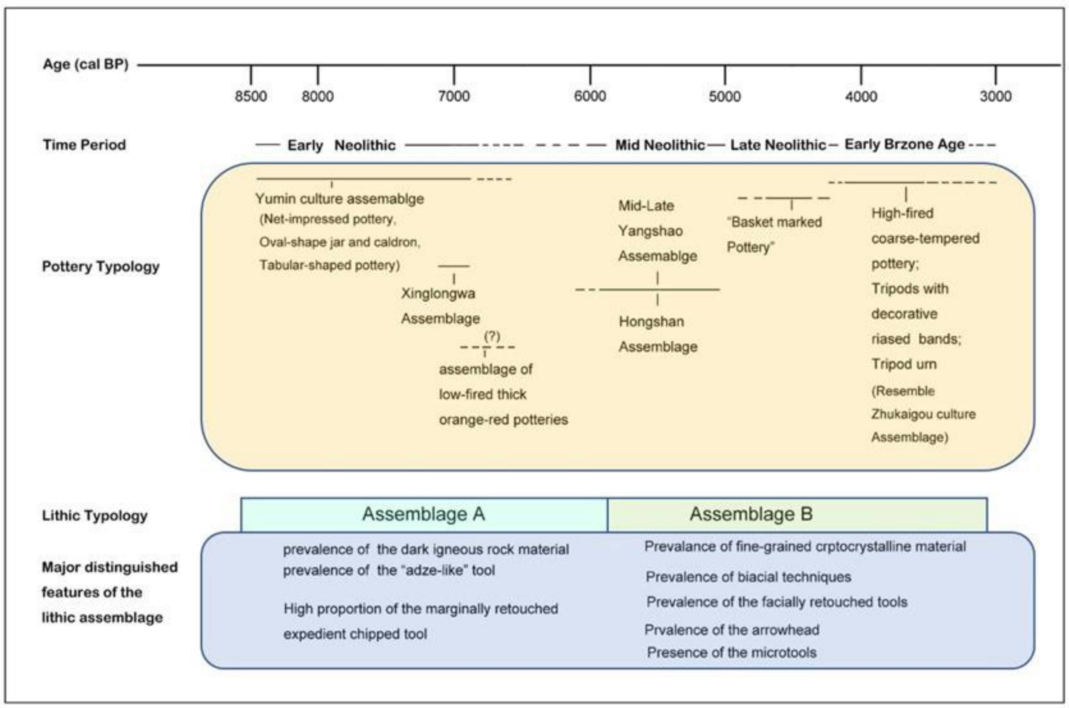

Figure 2.6 The correspondence of the changes of lithics and pottery across the time in the survey region

2.5 The features and classification of lithic artifacts

The features of lithics assemblages from either Early Neolithic or Mid-Late Neolithic/Early Bronze Age are marked by the diversity of the tool types and production techniques. The majority of the tools are produced by knapping techniques, like microblade, scraper, point, drill, burin, chopper, hammerstone, and etc. The ground stone technique is mainly used for producing grinding tools and abraders, and only occasionally used to produce woodworking tools, like axe, adze and chisel. The general features, as well as the similarity and differences of the lithic assemblage between Early Neolithic and Mid-late Neolithic/Early Bronze Age, are shown in the figures below.

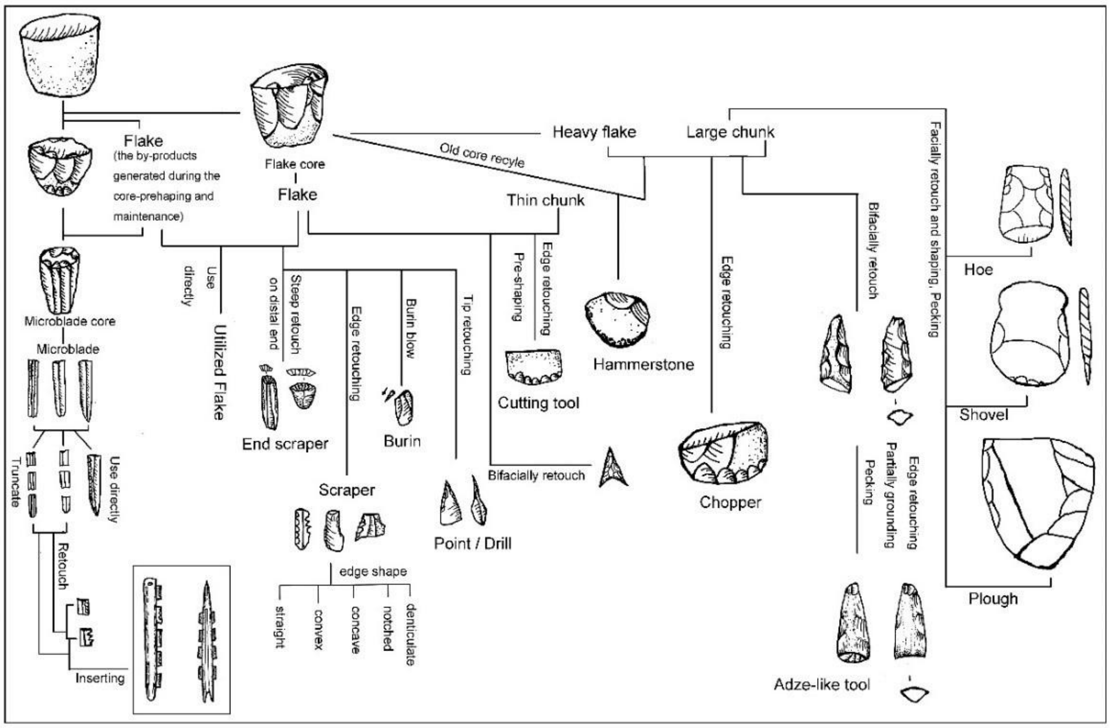

Figure 2.7 The diagram showing the correlations between reduction techniques and different types of chipped stone tools from the study area of the Huade county in Early Neolithic Period

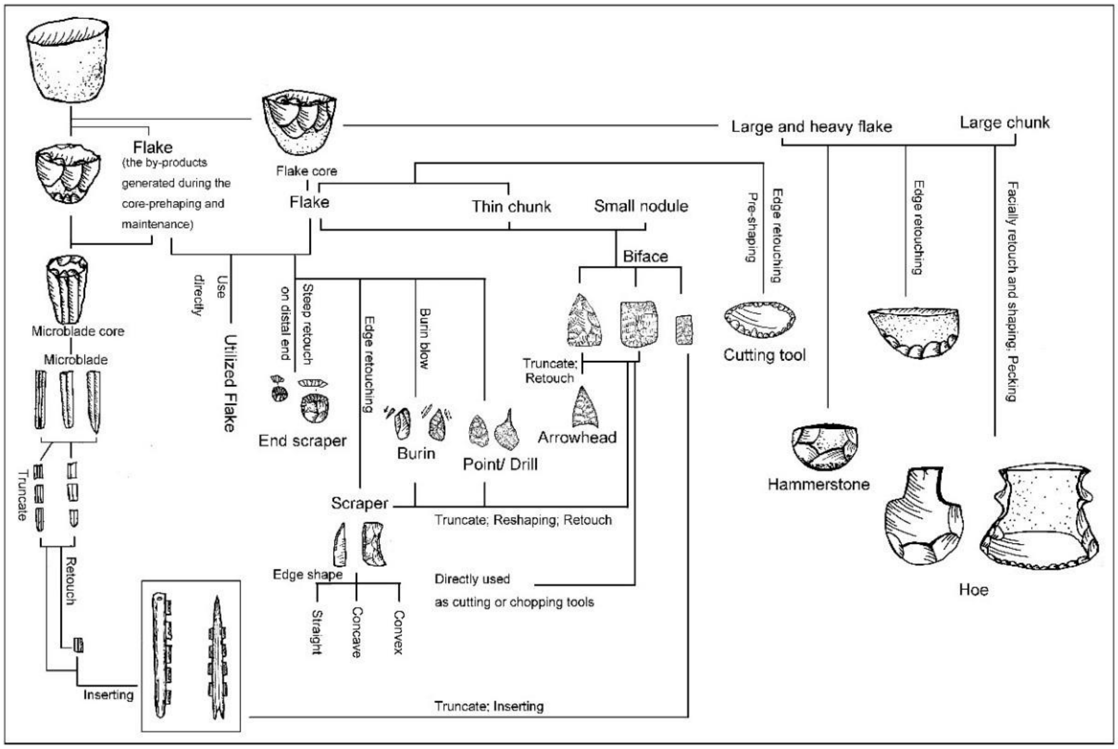

Figure 2.8 The diagram showing the correlations between reduction techniques and different types of chipped stone tools from the study area of the Huade county in the Mid-Late Neolithic/ Early Bronze Age

The tools in various kinds can be further classified into following categorizations and each category reflects specific indications of the activities and the considerations of technological organization.

(1) Microblades

The microblades are the standardized tiny pieces of blades pressed from the pre-shaped cores. The pieces of blades are usually in an elongated rectangular shape with parallel sides. The length of it is usually larger than twice the width. They are usually truncated and retouched and used as insets for composite projectile points and bone shaft knives (Chen and Ye 2019). The features of the tool design and the use-wear analysis indicate that they have been used for a variety of activities, such as hunting, butchering, and even occasionally used as plant processing (Chen, et al. 2013; Cui 2010; Wang 2016).

Microblade technology was originated before the LGM period in the Late Pleistocene and became prevalent across the broad regions of Northeast Asia in the post-LGM period (Gómez Coutouly 2018). At the onset of the Holocene climate amelioration, the microblade technology declined from the heartland of North China. However, the communities in the Mongolian Plateau and Northeast China still uses it until the Bronze Age (or even Iron Age in some places) (Lu 1998).

Microblade can be conceived as the generalized and curated tool technology. It is costly to produce since the regularity of the microblade products requires high-quality fine-grained raw materials and professional skills. Once the microblade are produced, they are portable and can either be truncated and fitted into different composite tools or left long to be hafted as individual tools. In spite of being designed to meet specific purposes, the microblades are multifunctional and can be used to meet different purposes. Therefore, microblade is comparable to the modern Swiss Army knife and well-attuned tomobile lifeways or situations with uncertainties or risks (Chen 2008; Elston and Brantingham 2002).

Since not all microblades are used as insets for composite tools and only the ones with regular shapes are inclined to be further truncated and retouched to be used as tool insets, I will only include the retouched microblades or the ones with use wear as the tools for further analysis and comparison with other toolkits. The proportions of microblade within the whole lithic assemblage can help us to evaluate the relative importance of animal resource procurement and processing activity as well as the extents of technological demands for tool flexibility and versatility, which is often indicative the degrees of mobility.

(2) Hide working tools

End scrapers

End scraper is a flake with one end blunted by steep retouch. The edge is usually convex in outline. To distinguish end scraper from scrapers and make it an independent category is justified by the fact that end scraper has been proven as a tool used for hide working (Boszhardt and McCarthy 1999). Therefore, the relative proportions of end scrapers within a whole tool assemblage might indicate the relative importance of hide working activity.

End scraper can be made from a variety of forms of blanks. In the Early Neolithic period of Huade county, the end scraper was usually made from long flakes or flakes detached during the production of microblades (like core shaping flakes or striking surface retouching flakes). While in Mid-Late Neolithic/Early Bronze Age, end scrapers are often made from smaller, round flakes and sometimes the flakes are facially retouched. Besides the steeply retouched end edge, the two lateral sides of some end scrapers are also retouched either in the steep concave edge or smooth acute edge, indicating the maximized use of edges either for hide-working or the combined functions between hide working and the others.

(3) Light-duty tools

This category includes the light-weight flake tools (or occasionally tools made by small chunks), such as scrapers, burins, points, and drills and cutting tools. They were made for light-duty activities, such as cutting, scraping, shredding, stabbing, whittling, drilling, piercing, grooving.

Scrapers

The scraper is a tool made on a flake, blade or small chunk, with continuous retouch on one or more edges to produce the working edge. As for the scrapers from the survey and excavation materials of Huade county, we can see that various edge retouching methods are applied, such as steep retouch, scaling retouch or elaborated retouch with the pressing method. Different forms of edges can also be identified, such as straight, concave-curve, convex-curve, notched and denticulate. Except for a small number of scrapers with formal shapes and intensive retouch, most of the scrapers from the survey and excavation materials are expedient tools. People cared more about the use edge rather than the regularity of the shapes. Different ways of edge retouching and different forms of the edges indicate different functional considerations. While the exact range of functions of different forms of scrapers still needs to be ensured by use-wear analysis, the educated guess based on previous research on scraper suggests that they might be used either for animal or plant resource processing, or even light-duty woodworking.

Points

The point is the tool for which an extremity was made pointed by bilateral retouching. It is considered to have been used for poking. The lateral edges could also be used for cutting or scraping.

Drills

A drill is also a pointed tool. It differs from a point because the tip of the drill is usually steeply retouched and protrudes away from the body of the tool. The cross-section of the tip is usually thick and in a triangular or diamond shape. The tool is considered to have been used for drilling or perforating

Burins

The burin is a tool with an acute angle formed by the removal of flakes roughly perpendicular to one another or from the intersection of a transverse break and a perpendicular flake. It is considered to have been used for slotting, gouging and cutting wood or bone.

Cutting tools

This type of tool is similar to a scraper but is in more regular shape. It is usually in a rectangular or crescent shape and made from thin pieces of chunks or large flakes. One or more edge is smoothly retouched in a relatively acute angle, suggesting that they are more suitable for cutting activity. The edges of a few cutting tools from the Early Neolithic Simagou site are ground. Others are made by chipping techniques.

The reason to combine point, drill, and burin with scrapers is that in Early Neolithic remains, these three kinds of tools are very rare. The number of them is too small to make any meaningful quantitative studies if they have been separately categorized. In addition, the functions of some scrapers might overlap with that of point and burin. For instance, the scrapers can also be used for grooving or slotting as burins are and the scrapers with sharp pointed edge can also be used for stabbing.

Although all these types of tools can be found in both Early Neolithic and Mid-Late Neolithic/Early Bronze Age periods, the features and proportions of them differ across different periods. There are far more points, drills, and burins in Mid-Late Neolithic/Early Bronze Age. While the burin, drill, and point in the Early Neolithic period are expedient tools with less standardized forms, quite a few of them in Mid-Late Neolithic/Early Bronze Age are made by more elaborate retouch and in more standardized forms. As for the features of scrapers, a kind of denticulate scraper can be found in Early Neolithic but not in Mid-Late Neolithic/Early Bronze Age. While a certain amount of the edges of scrapers are coarsely retouched by hammer percussion in the Early Neolithic period, the edges of scrapers are more often finely retouched by soft hammer or pressuring techniques in Mid-Late Neolithic/Early Bronze Age.

(4) Heavy-duty tools

The category includes the large and heavy chipped stone tools used for heavy activities, such as chopping, crushing, pulping, digging (except that the function of stone rings is not clear).

Choppers

Choppers are made of large, heavy chunks, nodules or flakes with one or more edges being retouched. Usually, choppers are made of more coarse-grained raw materials and are more crudely retouched. They can be used for heavy cutting and chopping activities and can be applied both for heavy works of animal butchering or plant cutting.

Pounding tools

Pounding tools are made of chunks or nodules and a pitted surface on one or more facets or margins can be detected, suggesting the signs of use for pounding or pulping. The pounding tools are in various shapes ranging from globular to strip shape. They differ from the stone hammers used for lithic production since the hammers for lithic production in excavated and survey material of Huade county are made from hard metamorphic rocks and in more regular shapes with fewer variations. The exact functions of pounding tools are still unclear. But based on tool design which emphasizes suitability for pounding, beating and pulping, they could be potentially used as tools for shredding or pulping plant resources.

Heavy point tools

This tool is made of large chunks in strip forms or nodules with one retouched pointed edge. It morphologically resembles the chipped picks which are frequently found in the Middle Paleolithic period in Central China. Such tools are very rare and are only found in the Simagou site in low quantity (only 2 pieces).

Heavy end-edge tools

Like choppers, this type of tool is made of large, heavy chunks, nodules or flakes from the coarse-grained raw materials. It might be attributed to one type of choppers. I separately list it here simply because of the uniqueness of its form since unlike most choppers which has their edge paralleled with the long axis retouched, this type of tool only has the distal short edges retouched.

Stone rings

This is a round ground stone with a round hole in the central part of the tool. The actual function is highly debated and might be differen in different areas. Suggestions regarding their possible uses include as weights on digging sticks, as hinge stones or as chunky stones identified in ethnographic records (Adams 2013). They are very rare from the survey and excavation materials. They are only found in the Yumin, Simagou and XH1 site in low quantity (1 in Yumin, 2 in Simagou, 1 in XH1)

Except for stone rings, the other tools in this category are all expedient chipped stone tools that can be easily made and fulfill different activities requiring heavy loading force.

(5) Wood-working tools

This category includes the adze-like tool, stone axes, adzes, and chisels. While tools beyond this category might also potentially used for woodworking as well, like certain types of scrapers, the tools in this category are all formalized tools that are specifically designed for woodworking. Therefore, the relative proportion of them can well reflect the relative intensity of woodworking activity.

Adze-like tools

This is a special tool type that is only found in Early Neolithic remains of the excavated and survey materials of Huade county. The tool is usually in a trapezoid or triangle shape with a larger distal end and a smaller proximal end. The distal end is usually processed into an oblique concave shape and the proximal end is thinned and retouched. The body of the tool is usually facially retouched. The ventral side of the tool usually has a slightly convex surface, while the dorsal side of it has a relatively flat surface. Some of the adze-like tools have been partially pecked and ground, especially on the ventral surface. This tool is estimated to be hafted and used to plane wood

Axes, adzes, and chisels

The assemblage of axes, adzes, and chisels is a typical woodworking toolkit that can frequently found in Neolithic cultures in many regions of North China and South China (Zhang 2004). The axe is mainly used for cutting wood. The adze is used for shaping wood by gouging and whittling. The chisel is used for gouging depressions to make grooves or holes on wood.

Except for a few axes found in the Simagou site of Early Neolithic age are the chipped ones, the other axes found from survey and excavation materials are all ground and polished. The axe is in a trapezoid shape and has a symmetrical "V" shape edge at the distal end. The form of the ground axe from the survey and excavation materials of Huade county is similar to the ones frequently found in the Neolithic Yellow River drainage area, but the size is smaller, indicating that the wood being processed in this region might be smaller and thinner than those in heartland North China.

The ground adzes and chisels found in the survey and excavation materials of Huade county also resembles the ones in the Neolithic Yellow River drainage area, but the number of them is extremely rare.

(6) Specialized hunting tools

This category includes arrowheads and stone balls. Different from microblades which can be both used as component parts for hunting weapons or be used for other functions, the arrowhead and stone ball are specifically designed for hunting activity. The relative proportions of specialized hunting tools cannot well reflect the relative intensity of hunting activity, but it can well reflect the extents of demands for specialized hunting technology.

Arrowheads

The arrowheads from the survey and excavated materials of Huade county are bifacially produced and have a symmetrical tip and thinned tail in different forms, such as concave, convex and “V” shape. There are heated debates about how to distinguish arrowheads from projectile points since they have similar forms. However, the majority of such tools found in the survey and excavated materials of Huade county are less than 3 cm long and less than 2 cm wide; such small size suggests that they are more likely arrowheads instead of projectile points.

Stone balls

The stone ball is only found in the Yumin site of the Early Neolithic period. This tool is shaped and polished in regular globular shapes with a diameter as 3.5 cm. The ethnographic materials indicate that the ball in such shape and size is usually thrown with the assistance of slings for hunting and battling.

(7) Farming tools

The farming tools from the survey and excavation materials from Huade county are composed of stone hoes, shovels, and plows, which are all related to tending the soils.

Stone hoe

Stone hoe is tabular stone tool with an oblique edge on the distal end and is hafted and used for weeding and land tilling. There are various forms and sizes of stone hoes from the survey and excavation materials of Huade county. Most of the stone hoes are chipped tools with a few exceptions that have been partially ground on the body. Some of the stone hoes have the notches on lateral sides close to the proximal end, which is suitable for hafting, while some others are in simple rectangular or trapezoid shape.

Stone shovel

This stone shovel is a tabular stone tool with a symmetrical “V” shaped curved edge. It is hafted and used for digging soil. The stone shovel is thinner than most of the thick stone hoes, and it differs from stone hoes mainly because of the ways for hafting. While the haft of the shovel is along the same axis with the long axis of the shovel body, the haft of the stone hoe is perpendicular or diagonal with the long axis of the hoe body. Digging might be related to farming activity, but might also be for creating pits or house foundations. Despite this possibility, I still include stone shovel as one kind of farming tools, since we cannot surely exclude the possibility that it is used for farming. Since the number of stone shovels is very small in comparison with stone hoes, incorporating them into farming tools will not cause bias in evaluating the relative importance of farming activity based on tool proportions, even if the stone hoe might potentially not used for farming activity.

Stone plows

Only one piece of a plow-like tool has been found in the Simagou site of the Early Neolithic period. The tool is extremely large and heavy and has a sharp convex edge at the distal end, which resembles the tool used for plowing.

(8) Grinding tools

Grinding tools are composed of stone slab/roller, stone pestle/mortar, and round hand stone. Grinding technology is characteristic of intensive, broad-spectrum resource extraction. The old view assumes that the grinding tools, like a stone slab or roller as the tools for processing farming products, such as millets (Wang 1995). However, the study of the starch analysis of the sites from Initial and Early Neolithic period of North China indicates that besides the weak evidence of millet processing, the stone slab and roller have been used to process a wide range of wild plants, such as the nuts, tubers, bulbs, and small-seeded plants. Therefore, the proportion of grinding stone tools is more suitable to indicate the relative importance of intensive plant processing (mainly for wild plants) rather than the relative importance of farming.

Stone slabs/rollers

Stone slabs and rollers are always used together as food-processing equipment. The stone slab is the netherstone, and the roller is the handheld component used on the working surface of the stone slab. There are various forms of stone slabs in different sizes. Some of the stone slabs are expediently designed, and have only a grinding surface, but no further modification, while others are strategically designed, and have been modified to regular shapes. Both saddle-shaped and relatively flat surface stone slabs can be found, indicating either different ways of use or varying levels of use intensity. Accordingly, the rollers are also made in different sizes to match different sized stone slabs. Some of the rollers have round cross-sections, which are suitable for rolling activity, while the others have ridges, which are more suitable for pulverizing activity.

Pestles and mortars

Pestles are handstones used to pulverize or to crush and grind. They are always used together with a mortar but could also be used on stone slabs (especially the ones with the concave surface).

The pestles found from excavated and survey materials of Huade county are small and light. The distal end which is used for crushing has pitted use wear. For some pestles, there is a small beveled facet at the part of the body which is adjacent to the distal end. Such a facet has polished sheen and might be used for grinding the crushed substances within the mortar.

We did not identify any stone tools which can be assured as mortars. It is probably because the mortar might be made by other materials (like wood) and was not preserved, or it might be a result of the fact that people used stone slabs together with pestles instead of relying on specially designed tools as the working surface for pestles.

Round hand stones

This is a kind of highly formalized handstone with round shape. The size of it just fits the hand. It is estimated to be held by hand and used for grinding substances on the surface of the netherstone. The round shape makes it easy to swirl and produce an extra shearing force on the processed substances.

(9) Crafting tools

This category includes the lithic tools which are used to produce other lithic tools and bone tools.

Abraders

Abraders are handstones that have one or more rough surfaces useful for removing material from the contact surface, thereby altering their texture or modifying their configuration. Two subsets of abraders can be found from the survey and excavated materials of Huade county, namely flat abraders, and grooved abraders. The flat abrader has a coarse and broad surface, which is used for producing ground stone and bone tools. The grooved abraders are smaller than the flat ones and have "U" shaped grooves located on one side of the facet possibly to straighten a shaft (Adams 2013). Since the grooves are relatively narrow, the shafts would be slender. It is highly possible that these abraders are made for the production of spear, dart, or arrow shafts.

Anvils

Anvils serve as a working surface in the production of other lithic tools. They are distinguished from the stone slabs mainly by use wear.

Stone hammers

Stone hammers are the tools used for chipping stones and producing chipped stone tools and blanks of ground stones. The stone hammers from the survey and excavated materials of Huade county vary in size and are made of hard metamorphic rock, which is not found in other types of lithic tools.

(10) Bifaces

A biface is the formalized flake with both surfaces being facially retouched. While bifacial techniques have been applied for tool production in the Early Neolithic period in Huade county, the typical forms of bifaces are only found from the remains of Mid-Late Neolithic/Early Bronze Age period of Huade county. They are shaped in oval form or rectangular form. While they might be used for cutting or chopping functions, most of them are not directly used as tools but serve as the preforms to be further worked into other forms of tools. By trimming the bifaces in different ways, they can be altered to become arrowheads, scrapers, drills, burins, or points. The small rectangular bifaces can also be truncated and used as the insets for bone hafted knives.

Besides all the tool categories listed above, the prehistoric people in Huade county also directly used flakes to work without any retouch. These are identified by the presences of utilized flakes from the survey and excavated materials. Whether or not to include them as lithic tools is debatable. While they are expediently used to accomplish certain tasks, they are not intentionally designed and retouched as tools. Moreover, the use-wear on the lithics varies from clear to vague. The light use of them might make the use-wear nearly unidentifiable. Therefore, it is hard to accurately count the numbers of utilized flakes from the survey and excavated materials. Based on these reasons, I will not include utilized flakes in tool categories and attribute them into debitage.

3.0 Methodology

This study project mainly focuses on multiscale spatial analysis of lithic remains found from both the excavated sites and survey collections to study changes in human land-use. The following methodologies detail how to make use of both survey and excavated materials to infer the patterns of land-use. The methods of excavation and survey, as well as their potential advantages and biases, will be presented below. The different roles which survey and excavated materials take for interpreting features of land-use patterns in various aspects will be discussed. The principles of how to use patterned features of lithic assemblages and lithic spatial distribution to infer behavioral patterns of land-use strategy will also be highlighted and discussed. The detailed discussion of them here will help to retain the narrative of the following chapters to follow more smoothly.

3.1 Technological organization

Technological organization is the study of the selection and integration of strategies for making, using, transporting and discarding tools and the materials needed for their manufacture and maintenance (Nelson 1991). The strategies are considered as problem-solving processes that are responsive to conditions created by the interplay between humans and their environment (Binford 1973; Shott 1986). These conditions can be quite variable in time and space and are influenced by the interaction between environmental constraints and economic and social variables. The principles of optimal foraging theory have been used to explain why certain strategies are favored over others and are adopted by people to cope with the problems (Surovell 2009b). Optimal foraging theory highlights that in the face of specific conditions, the strategies which achieve maximum return on investments of time and energy are inclined to be adopted by people (Bleed 1986; Smith 1979). The idea of technological organization is crucial for this study since it provides theoretical connections between the static lithic remains and the dynamic human behavior which is correlated with land-use strategies.

The inter-site and intra-site distributional patterns of lithics, as well as the forms of lithics, are two important lines of evidence used for inferring the behavioral information relevant to land-use. The chain of inference from the lithic remains collected from archaeological recording to the strategies that resulted from the interplay of socio-economic variables and environment constrains is listed on the graph below.

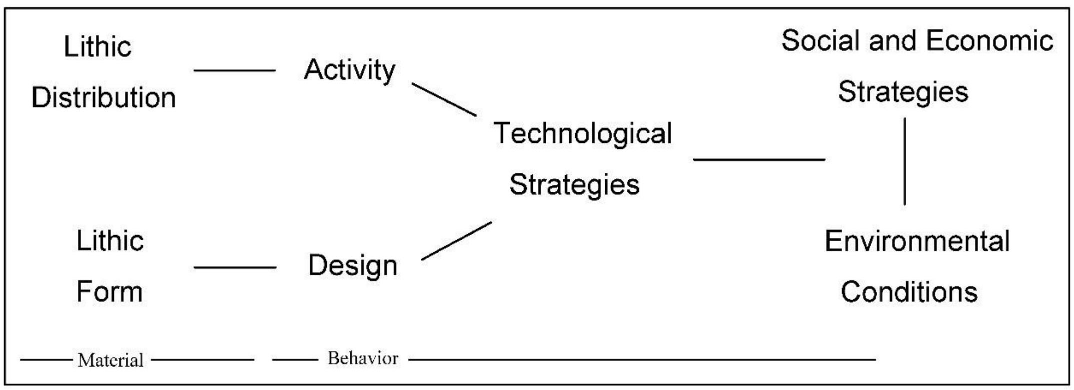

Figure 3.1 Levels of analysis in research on the technological organization

In particular for this study, the idea of the technological organization has been applied in two ways. Firstly, certain types of tools are used as proxies to indicate particular kinds of behavioral traits. The proportion and frequency of them will imply the extent of the significance of such traits embedded in human land-use strategy. The connections between the types of tools and their indications of the particular behavioral traits are based on the inferences of technological organization. For instance, microblades and bifaces are considered as proxies to indicate mobile lifeways in the study. The concrete inferences will be discussed in the following chapters. In addition, technological organization is used as a source to generate a reasonable hypothesis of the material reflection of the different potential patterns of land-use strategies. The real patterns of lithic assemblage will be compared with the hypothetical patterns to see whether the archaeological remains reflect any of the patterns of land-use strategy as we conceived or reflect any particular land-use patterns beyond our considerations.

Although the focus of the study is the distributional patterns of lithic assemblage, the particular forms of the lithics will also be analyzed and discussed, especially for those that can reflect important behavioral information of land-use. Technological organization highlights that the particular forms of the tools are designed beyond the specific task-performance requirements (Bleed 1986; Shott 1986; Torrence 1982). A range of other considerations, such as the energy costs, the expectation of the tool use life, time stress, risk management, and mobility requirements all influence tool design beyond the functional requirements (Bamforth 1986; Nelson 1991). Many of such considerations are closely correlated with the specific strategies of land-use. Therefore, the particular forms of lithic tools that reflect the design features related with the specific considerations of land-use strategy will be analyzed and discussed in the following chapters.

3.2 The analysis of the excavation data

3.2.1 The introduction of the two excavated sites and excavation methods

The two excavated sites are called Yumin and Simagou, and they are both the village-like settlement belonging to the Early Neolithic period.

The Yumin site locates at the mid-south of the survey region and it is named after the nearby Yumin village is 1.25 km southwest of the site. Yumin site is embraced on three sides by the low mountains to its east, west, and north. The south side is relatively flat and open. The terrain of the site inclines from north to south. The site is estimated to be as large as 5000m^2 and the southeast side of the site has been destroyed by a gully that formed later than the site.

Figure 3.2 The surroundings of the Yumin site

Figure 3.3 Bird's-eye view of the Yumin site after excavation

The site has been extensively excavated across 2750 m^2, and 14 oval-shaped pit houses in total have been excavated; one house has an indoor burial within it. No other kinds of features, like middens, kilns, and ditches have ever been identified besides pithouses (Bao, et al. 2016). According to statistical work of my analysis of the artifacts, 4445 pieces of lithic, 1660 pottery sherds, and numerous animal bones have been found within the site, and the majority of them have been found within the pit houses. The site was excavated by a grid of adjacent 5x5 m square units. The artifacts were collected and bagged according to the specific cultural layers and excavation units, and those found in each pit house are independently collected and bagged. All the artifacts, as well as the pit houses, were only found in layer 4, which is at the bottom of the black paleosol mentioned in chapter 2[4]. Five radiocarbon samples have been dated, and the dating result is listed in Table 3.1. Except for one sample found in the cultural layer which is dated at about 7.7 ka B.P., all the other samples are dated at about 8-8.4 ka B.P. Among them, the samples from the pit house and indoor burial are dated earlier than the samples found from the cultural layer. Since we cannot exclude the possibility that the youngest date derived from the sample of the cultural layer is a product of later human disturbance of the site it was abandoned, I tend to conservatively estimate that the time span of the Yumin site occupation is at about 8-8.4 ka B.P.

[4]Detailed information about excavation is from personal communication with Mr. Hu and Mr. Ren, who are in charge of the excavation of Yumin site.

Table 3.1 The dating result of the Yumin site[5]

Lab No.	Context	Dating material	^{14}C (yr BP)	Cal (yr BP, 95.4%)
Beta-424836	Pit house	Charcoal	7560±40	8315-8428
BA150470	Indoor burial	Human bone	7430±30	8185-8332
BA150471	Outdoor zone	Animal bone	7310±30	8030-8180
BA150472	Outdoor zone	Animal bone	7295±35	8024-8176
BA150473	Outdoor zone	Animal bone	6870±30	7627-7788

The extensive excavation work indicates that all the major part of the site has been fully excavated except the southeast corner which was destroyed by a recently formed gully, since the area where the pit houses were densely distributed has been excavated and the row of excavation squares at the northernmost, westernmost and southernmost excavation area found almost no artifacts in the cultural layer, suggesting that these reach the boundary of the settlement.

The Simagou site locates 6.5 km northeast to Yumin site and sits in the tributary valley. It locates on the slope on the east bank of the stream and is surrounded by narrow and flat valley floors and low hills and mountains. 1850 m^2 of the site has been excavated from 2017 to 2018 and 19 pit houses, in general, have been found. The houses in the Simagou site are more densely distributed than those in the Yumin site and some later constructed houses are overlaid on the houses which were built in the earlier period. The majority of the houses are rectangular except for two oval houses. One of the oval houses is overlaid by a rectangular house, indicating that rectangular pit houses might appear later than oval pit houses (Hu and Li 2018). According to the statistical work of my analysis of the artifacts, 3146 pieces of lithics, 784 pottery sherds and a large number of animal bones have been found. Like Yumin site, no other kinds of features have been identified besides pithouses, like middens, kilns, and ditches. The majority of the remains are

[5] The data is from Mr. Hu from Ulanqab Museum, who is one of the co-director for the project of Yumin/Simagou excavation and the survey in Huade County. They have not been formally published yet.

found within the pit houses. The excavation methods and artifact collection are all similar to Yumin site[6].

Figure 3.4 The surroundings of the Simagou site

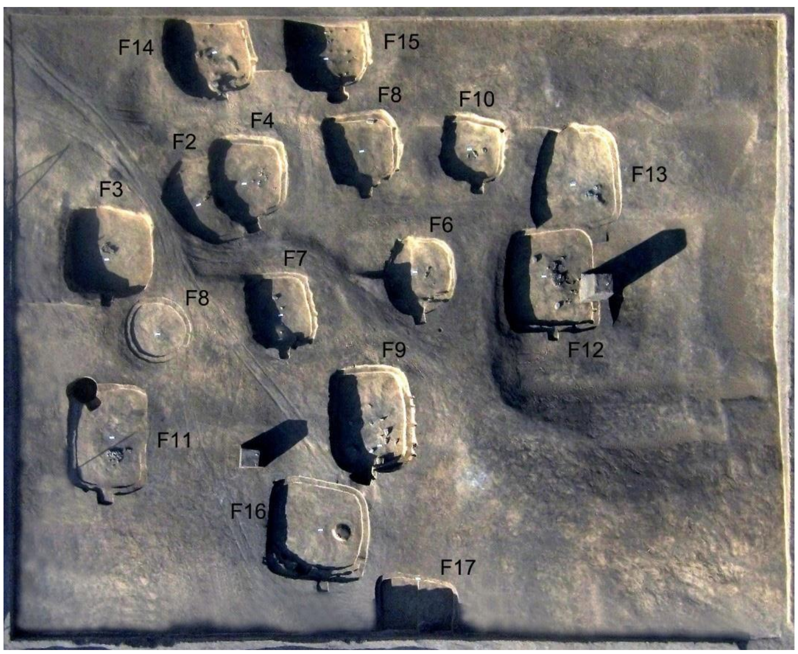

Figure 3.5 Bird's-eye view of the Simagou site after excavation

[6] Based on the personal communication with Mr. Hu and Mr. Ren, who are in charge of the excavation of the Simagou site

Dating results have not been published yet. But according to the information provided by the project director who takes charge of Simagou excavation work, the earliest radiocarbon dating sample is as old as 9 ka B.P., and the other two younger radiocarbon dating samples respectively point to 7.5 ka B.P. and 7 ka B.P.[7]. Since no other detailed information has been provided, we do not know if this reveals the realistic time span of the site occupation or whether some samples might be subject to bias. In order to learn the occupational period of the Simagou site, more dating samples need to be tested in future. But according to the similarity of material culture between Yumin and Simagou, these two sites can be conceived as contemporaneous sites in a broad time scale.

3.2.2 Analysis of the excavated data

The two excavated sites provide us sufficient lines of evidence to learn the strategy of land-use by investigating the ways of subsistence practice, mobility and social integration.

The features of subsistence practice can be learned through the analysis of the component of the lithic assemblage since different types of lithics correspond to different subsistence practices. The subsistence sources can be divided as wild animals from hunting, wild plants from gathering and crops from farming. Specialized hunting tools, like arrowhead and stone balls, are designed for hunting. In addition, truncated pieces of microblade are often used as parts for assembling composite projectile points used for hunting or bone-hafted knives mainly used for animal resource processing. Therefore, the relative proportion of the combination of specialized hunting tools and truncated microblades with use-ware or signs of retouch within the whole tool assemblage can be used to evaluate the relative contributions of hunting to subsistence practice. Grinding stones are used for pounding, grinding, and pulverizing plants into flour. As mentioned in Chapter 2, the

[7] The information was got by the personal communication with Mr. Hu from Ulanqab Museum.

main types of plants that processed are wild plants of various types, including nuts, tubers, bulbs, and small-seeded plants. Therefore, the relative proportions of grinding stones within the tool assemblage can be used to evaluate the relative importance of the intensive use of wild plant resources. Stone hoes, shovels, and plows are tools used for land tilling, which related to farming activity. Therefore, they can be conceived as farming tools and the proportion of them within the whole tool assemblage implies the relative importance of the farming activity.

The comparison of the relative importance of such different kinds of tools associated with subsistence practice can be done at either the site level or the individual household level. Comparison at the site-level can provide us a general picture of the similarities and differences of subsistence practice reflected by the two excavated settlements, whereas comparison at the household-level will help us to learn the similarities and differences of subsistence practice across different households.

Whether or not the excavated houses can be used as a reliable indicator of household activity is highly debated. Since in many sedentary villages, the garbage is periodically removed from the house floor, the middens or the garbage deposit area around the houses are the more reliable indicators for household activity than the houses themselves (Peterson, et al. 2016). However, in cases of Yumin and Simagou, no middens have been found within the sites and the majority of artifacts are concentrated within the pit houses. Therefore, each pit house can be regarded as a reliable indicator of household activity.

Rather than leaving all of their lithic tools at the site, people might take away or leave parts of the tools offsite. Therefore, the lithic tools collected within the site can be better conceived as samples instead of complete reflections of ancient human activity. Error ranges of the proportions of different tool types will be used with varying confidence levels to make the comparison quantitatively meaningful and the t-test will be used to evaluate whether the differences of the proportions of different tool types across the sites or households are significant enough to indicate real patterns or are the only result of the vagaries of the sampling.

Change in patterns of mobility will be evaluated by the remines of structures and the disposal pattern of the lithics. Traditionally, most Chinese archaeologists tend to assume the appearance of pit houses is a sign of sedentary life (Zhang 2004). However, the ethnographic record indicates that people who build permanent residential structures can still live in a mobile way and make use of two or more settlements in different areas across the different seasons of the year (Graham 1993; Steward 1938). Therefore, the evidence of pit houses alone is not sufficient to indicate the sedentism, let along to further investigate the extents of the stability of sedentism (people can, fore example, live in one location for several years and then relocate their settlement; alternatively, people live in one location for generations). Under such circumstances, the specific features of the house structure will be of great importance to learn the relative stability and intensity of the house use. Although this dissertation mainly concentrates on the lithic assemblage, the features of house structures will be briefly mentioned as an important line of evidence to strengthen the analysis.

Besides the house structure, the disposal pattern of lithics also reflects the extent of residential stability. Firstly, different modes of garbage disposal are closely associated with the duration of residence (Hardy-Smith and Edwards 2004; Li 2018). As the intensity of occupation increases (which means that people expect to live in a specific area for a longer time), people are inclined to clean their living spaces more often and the lithic debitage (like the byproducts of manufacturing and maintenance, as well as worn or broken tools) will be moved away from living floors to disposal areas (such as middens or trash heaps). By contrast, when people occupy a place only temporarily, they tend to discard their lithic waste wherever it falls (Hayden and Cannon 1983; Kent 1993). The locations of the lithics recovered from the sites were not recorded at high resolution (as one might do with sub-centimeter GPS, total station, or transit), which hindered the detailed reconstruction of disposal patterns, but separate collection of artifacts by excavated grid unit (5x5 m) and pit house at least gives us coarse-grained contextual information to study the spatial pattern of lithic distribution. If people at the Yumin or Simagou site periodically cleaned the floors of their houses, we expect to find that most of the lithic waste (like debitage generated during production, or broken tools) is distributed in the excavation grids adjacent to the houses or are concentrated within a few excavation grids (which can be identified as specific disposal areas). The lithics found within the houses should reflect only last-time production, use and discard before the abandonment of the house, since if people decided to move out of the house, there would be no need for them to clean the most recently generated lithic waste from the living floor. On the contrary, if people lack the habitus of periodically cleaning the house floors, we expect to find that lithic waste accumulated within the houses and the lithics left during the outdoor activities might be widely scattered across the excavation grids.

Admittedly, only relying on excavated sites to estimate the degrees of mobility or sedentism is limited, since we do not know if such kind of residential settlements can be frequently found in a larger region, or only occasionally appeared in specific locations accompanied large numbers of sites only showing short residential durations and less intensive site use. This kind of information is derived from survey data, which will be discussed later.

As for the investigation of social integration, the levels of population aggregation could be evaluated by site area, the number of house structures and the clusters of lithics which are identified as household activity. The regularity and intensity of social integration can be assessed by comparing inter-household differentiation in tool types associated with different activities, and the manufacturing debitage typical of different kinds of stone tool production and maintenance (Peterson 2006; Peterson and Shelach 2012). Such comparisons might reveal if individual households produce their own tools to accomplish the same kind of work, or if each household produces different kinds of tools used for different tasks. Patterned variations in the production and use of lithics across individual households will illustrate the extent of economic and social interdependence within settlements of different kinds and will, for example, reveal whether subsistence was organized on the household or community level (Shelach 2006).

3.3 The analysis of the survey data

3.3.1 Introduction of the field survey

The field survey around Yumin site was conducted from 2016 to 2018. The primary aim of the survey was to investigate the distributional patterns of prehistoric sites in the Northern Yinshan Mountain region of Huade county. A total area of 1494 km^2 has been intensively surveyed in the central and northern part of Huade county and 144 sites have been identified in total as containing either the Early Neolithic remains, Mid-Late Neolithic/Early Bronze Age remains, or both, which provide us a suitable spatial scale and sufficient data to learn the distributional pattern of the settlements, its correlation with environmental factors as well as the inter-site variations at different time period[8].

The survey has been done by carefully searching and collecting the artifacts found in the plots of the wind-erosional depressions on the surface. Since the wind is strong in this region, areas that have poor vegetation coverage, or loose soils, or face towards the prevailing wind are subject to heavy erosion by the wind. As a result, the topsoil and the buried paleosol will all be blown away and the sands at the bottom exposed. Such a heavily wind-eroded area is depressed in comparison with the surrounding terrain. Since the deposits that covered the archaeological remains have all been eroded away, the artifacts are exposed on the surface and are easy to find[9]. Unlike the artifacts found by alluvial erosion which might be moved from their original deposition

[8] The survey work has not yet been published yet. I have determined he survey area and the numbers of the sites from the maps used for survey and the documentary record of the survey provided by Inner Mongolia Institute of Archaeology and Cultural Relics and Ulanqab Museum.

[9] The information was obtained from the my personal observations in the survey work and the communications with Mr. Hu and Mr.Bao, who are in charge of the survey work.

area, the artifacts exposed by wind erosion are at the original depositional area despite small-scale relocation. Therefore, we shall not worry that the surveyed sites are displaced from their primary locations. Such depressions are found either by the satellite map or the guidance of local villagers. Once the artifacts on the surface have been spotted, the members of the survey team go through the areas around and collect all the exposed lithics and pottery until they have searched out the boundaries of the artifacts' distributional areas. Sometimes, the margins of the surface area adjacent to the depressional plots are also inspected in order to verify the boundary of the concentrated artifact distributional area.

The potential basis of such a survey method is that the sites not distributed within the depressional plots are inclined to be overlooked. For instance, the Yumin site was not found by searching in the depressional plots but was found by looking at the profile of the gully. It is very difficult to find sites by surface survey in the lands without heavy wind-erosion mainly for two reasons: (1) The areas without heavy wind-erosion might be the depositional areas where the accumulated thick deposition have deeply buried the cultural deposits and prevented artifacts from being exposed on the surface; (2) The government's policy of returning farmland to trees and grass has turned a large amount of less wind-eroded land into shrublands. The thick coverage of thorny shrubs not only makes it hard to go through but also leads to poor visibility of artifacts. Therefore, focusing on the wind-eroded depressions is a more effective way of survey to cover a fairly large survey area given the limited working season, funding, and numbers of team member. Since the wind-eroded depressions are distributed all over the survey region, it will not hinder us from comparing the relative density of site distribution across different sub-regions of the survey region. Moreover, since the wind-eroded depressions are distributed across different landforms (including river valley, maintain basin, piedmont, highland) except for the areas of steep mountain slope with little soil coverage, the depressional plots based survey won't seriously affect the distributional patterns across different landforms as well.

Since artifact collection was made quite intensively for all the surveyed sites (e.g.: the tiny debitage as well large tools were all collected), I am also confident that the study of the surveyed material can reliably reflect the patterns of lithic and pottery assemblage of the sites. The pottery found from the survey area indicate that the sites can be identified by the period: Early Neolithic, Mid Neolithic, Late Neolithic, Early Bronze Age, Warring States period, Han dynasty, Wei, Jin, Southern and Northern dynasties, Liao-Jin dynasties. Since the survey is mainly focused on pre-historic periods, the artifacts found in periods later than the Early Bronze Age have been less intensively collected. Only the pottery with clear diagnostic features have been collected and recorded for the periods after the Early Bronze Age.

When we look at the materials found from the surface collection of different sites, an impressive difference is that the numbers of the lithics vary significantly across the sites. It is highly debated if such a difference of the absolute numbers of the artifacts reflect the real patterns of ancient human behavior or is merely resulted from the specific methods of surface collection or even post-depositional process. In some cases, the number is large simply because archaeologists searched in larger areas and hence collected more artifacts. Under such circumstances, the density of artifacts, rather than the absolute number of artifacts, can more reliably reflect ancient human behaviors, such as the intensity of site use. However, the area estimation of each site is not made on rigorous and consistent standards from the survey of the Huade county. Neither was the survey conducted based on a strategic sampling method. Usually, the surface collection of the studied region is made by intensively searching for the places where pieces of lithics or pottery sherds have been found. All the artifacts on the surface have been collected despite the sizes or types until the area with relatively dense distributions of artifacts has been searched out. Therefore, the differences in the numbers of lithics are less closely associated with the certain sampling methods of the survey.

Admittedly, a few of the sites with a low number of artifacts might be a consequence of taphonomy. For instance, site BN1 has yielded only a few lithic remains. But since thick post-depositions cover the site, it is supposed that most of the artifacts are still buried under the ground. In spite of such special cases, most of the other sites are found on the depressional places caused by the erosion of the wind-force just as mentioned above. In these places, the majority of the artifacts are exposed on the ground. The variations of the numbers of them, hence make more sense to reflect the real differences of the ancient human behavior.

Since more lithics tend to be produced, used, and reused on-site if people make use of the sites more intensively (either through longer time of residency or intensified use of lithics for certain activities), the numbers of lithics can be roughly used to evaluate the relative intensity of site use. To facilitate further comparisons and analysis, I have tentatively classified the sites as three levels of use intensity based on the numbers of lithics ("less than 100 lithics", "between 100 and 500 lithics", "more than 500 lithics"). Such classifications of the sites reflects different degrees of site use intensity and can be further analyzed in association with other variables to learn the patterns of land-use.

In the following studies, the three levels of site use intensity are only used for indicating the single period occupation (either in Early Neolithic or Mid-Late Neolithic/Early Bronze Age). While it is easy to classify the single temporal component site into different levels simply based on counting the numbers of lithics, it is more difficult to know how intensively the site has been used in each period for the multiple temporal component sites since there are no clear-cut distinctions between the lithics used in Early Neolithic and Mid-Late Neolithic/Early Bronze Age. However, since people in Early Neolithic period and Mid-late Neolithic/Early Bronze period have differentiated emphasis on the use of raw materials for producing lithics, and a few specific types of tools are different between these two time periods, we can still, in general, tell whether sites with multiple temporal components were predominately used in either Early Neolithic or Mid-Late Neolithic/Early Bronze Age, or used in both periods at a similar level of intensity. By looking at the total numbers of lithics and evaluating the approximate proportions of Early Neolithic or Mid-Late Neolithic/Early Bronze Age remains within it in a coarse-grained estimation, we are still able to make an educated guess about roughly how many lithics were left during each period from the multiple temporal component sites and then assign both components to one of the three classes of relative intensity of site use.

3.3.2 Analysis of the survey data

The survey data is indispensable for studying the land-use pattern of Mid-Late Neolithic/Early Bronze Age since no sites have been excavated during this period in the study region. As for the Early Neolithic, the survey data can serve as important complementary material to combine with excavation material and provide a more comprehensive understanding of the land-use.

The advantage of survey data is that it provides us opportunities to explore the inter-site variation in terms of subsistence practice across the landscape. As for the exploration of subsistence practice, we can evaluate how each type of tool used for different subsistence practices is distributed across the sites in two ways. One way is to count the ubiquity of different tools based on the presence or absence of them across the sites with differentiated levels of site-use intensity. If we find that a certain type of tool has high ubiquity and can even be frequency found in the site with lowest levels of site-use intensity, it means that the corresponding subsistence practices are more common and played important roles in people's daily life. If the type of tool has a low ubiquity score, or can rarely be found in the site with the lowest levels of site-use intensity, it probably indicates that the corresponding subsistence practices are of only limited importance.

Another way to show the distribution is to label the sites with the presence or absence of certain types of tool in different colors and map them with the Arch GIS. This provides an intuitive view of spatial distributions of tools across the sites and enables us to explore whether they are broadly distributed across space, or only distributed in locations with specific geographic conditions.

Besides ubiquity, we can also count the proportions of the different tools across the sites which have a relatively larger sample size, and then make bullet graphs of them for the inter -site comparison. While the proportions of tools does not directly tell us the relative importance of different subsistence practices within one site (e.g.: if one site yields 1 farming tool and 10 pieces of truncated and retouched microblade, we cannot say that hunting is much more important than farming since the regeneration rate of the tools used for these two subsistence practices might be different, and different subsistence activity might require far different amounts of lithic tools even though they have been practiced at similar levels of intensity.), it still provides us a chance to make an inter-site comparison to see if any sites were more heavily engaged in certain kinds of subsistence than the others. Since comparing the bullet graphs one by one of the proportional distribution of different tools does not provide us a concise and comprehensive view of any patterned differentiation of the subsistence practices across the sites, I will also make use of principal component analysis mainly based on the proportions of different tools to see if any trends of the proportional distribution of different tools are correlated together and reveal patterned differences of the subsistence strategy among the sites.

Survey data also provides rich information for us to evaluate the patterns of mobility. As indicated by the ethnographic materials and the archaeological findings in other regions, in comparison with sedentary farming communities, the mobile foragers and the horticulturalists (or the "semi-farmers" with low reliance on the farming economy) might have different types of settlement patterns. They stayed and moved into different settlements according to different seasons and subsistence tasks. They have used them at different levels of intensity and lived there with varying extents of stability (some might be occupied yearly or even in most of the year, others might only be seasonally inhabited for short periods of time) (Binford 1980; Graham 1993; Steward 1938; Tomka 1994). Based on such findings, we can hypothesize that if the mobility is high, the majority of the settlements were inclined to be composed by the ones which show the ephemeral site occupation and might be distributed across the broad area sparsely. Nonetheless, the number of sites that shows the relatively stable residency would increase and the site distribution became denser as the mobility, in general, is decreased. Therefore, learning the compositional pattern of site types as well at their distribution is essential for us to understand the mobility pattern. The principle component analysis will be used to assist for identifying different site types. The spatial distributions will be revealed on the GIS map as a way to discern specific distributional patterns and evaluate how frequently different types of sites are distributed across the landscape.

In addition, how frequency the type of tools designed and used to fit highly mobile lifeways are distributed across the sites provide another important line of evidence for evaluating the degrees of mobility. It is expected that the if people lived on a mobile lifeways, the tools fit for mobile lifeways should be very frequently distributed across the landscape, while if mobility declined and did not play an important role for human's social and economic organizations anymore, the tools fit for mobility might be less frequently used by people and might even disappear from the tool assemblage. As for the perspective of the technological organization, the tools designed with high considerations of versatility, reflexibility, and easiness for transportation are inclined to be the ones suitable for mobile lifeways (Nelson 1991). In the case of this study, the microblade and bifaces are considered as such kind of tools. Their spatial distributions across the landscape, as well as their ubiquity, are investigated to learn the relative frequency of the use of mobility-fitted tools across the landscape.

It is difficult to use materials from survey to learn the patterns of social integration, since in comparison with the excavation data, the materials collected from the surface lack the detailed recordings of the contextual information, which hindered the further explorations of intra-site variations of lithic distribution related with behavioral information of social integration, such as the patterns of labor division and the degrees of economic inter-dependence. The site size might reflect the levels of population aggregation. Yet since the site size is not estimated in rigid rules, it can only be coarsely used as references for discussing the extents of population aggregation. In addition, the Mid-Late Neolithic and Early Bronze Age sites found in the nearby Shangdu county highly resemble the ones we found from the survey in Huade county (Fu 1992). Two of such sites found in Shangdu county have been excavated and the brief reports have been published, which provide us with important referential information to learn the extents of social integration of the Mid-Late Neolithic/Early Bronze Age sites (Ji and Wei 1995).

Besides the separate analysis of subsistence, mobility, and social integration, the survey data also provides us a chance to integrate all this information with different geographic traits to see how these three dimensions are combined with each other and interplayed with environmental conditions. Such inquiry is essential for us to understand how the particular land-use strategy was operated, changed and interacted with external conditions. Classifying the sites with different characteristics and seeing how they are spatially distributed in different kinds of environments is an important method for us to explore this issue. The methods of hypothesis tests, such as Chi-Square, two-sample t-test, nonparametric tests will be applied to see if there are any patterned differences of the correlations between specific site features and geographic locations.

3.4 Two-tiered comparison

The land-use strategy in the Early Neolithic period will be studied by the combinations of the data from the two excavation sites and the survey. Whereas the land-use strategy in the Mid-Late Neolithic period and Early Bronze Age will be learned mainly by the survey data. Both excavation and survey data have their advantages and limitations, and they are well complementary to each other.

The excavation data provided detailed record of locational and contextual information, which enables us to explore the intra-site variations of artifact assemblage on the household level. Such an analytical level provides us with a suitable scale to learn how the community was socioeconomically organized to conduct their subsistence practices. For instance, through the patterned variations of the artifact assemblage across different households, we can evaluate if different households conduct similar ranges of subsistence activities or differentially engaged in different kinds of subsistence practices. We can also investigate whether or not there are any kinds of economic cooperation above the household level. In addition, the discovery of pit-houses gives us a chance to evaluate how much effort people invested in building their houses as a way to estimate the degrees of residential stability.

While the excavation data provides us a window to see the details of the two “focal points” of the whole settlement system, the survey data provides a picture of what the whole settlement system was like through the time. Even though the survey data is too coarse-grained to learn the intra-site variations in any details of each site, the numerous sites found across the broad region provide us a solid database to compare the inter-site variations across the landscape and explore their correlations with different geographic traits. Through the evaluation of the inter-site variation, we are also able to learn how the excavated main residential settlements resemble or differ from the other surveyed sites. Admittedly, the combination of both excavation and survey data will enable us to learn the land-use pattern of Early Neolithic period in finer resolution than that in Mid/Late Neolithic/Early Bronze Age which is solely based on survey data (although the excavation material in adjacent regions might be used as referential sources). Hence, the land-use pattern of the Early Neolithic period will be presented with more detail in this dissertation. Nonetheless, such differentiated resolutions shall not seriously impede the comparison of the land-use patterns between the two periods, since the perspectives I choose for comparisons between these two periods are all the comparable behavioral information extracted either from the combined excavation and survey dataset of Early Neolithic period or the survey dataset of Mid-Late Neolithic/Early Bronze Age.

4.0 The land-use analysis based on the excavation data in the Early Neolithic period

4.1 The comparison of lithic assemblage between the Yumin and Simagou site

Abundant remains of lithics have been found in both Yumin and Simagou sites (4445 pieces are found in the Yumin site and 3146 pieces are found in the Simagou site), including a wide range of the tools used for different purposes and debitage generated during the different production sequences.

From Figure 4.1 and 4.2, we can see that both sites have similar ranges of tool types. Nonetheless, the proportional distributions of some types of the tools are different across the two sites.

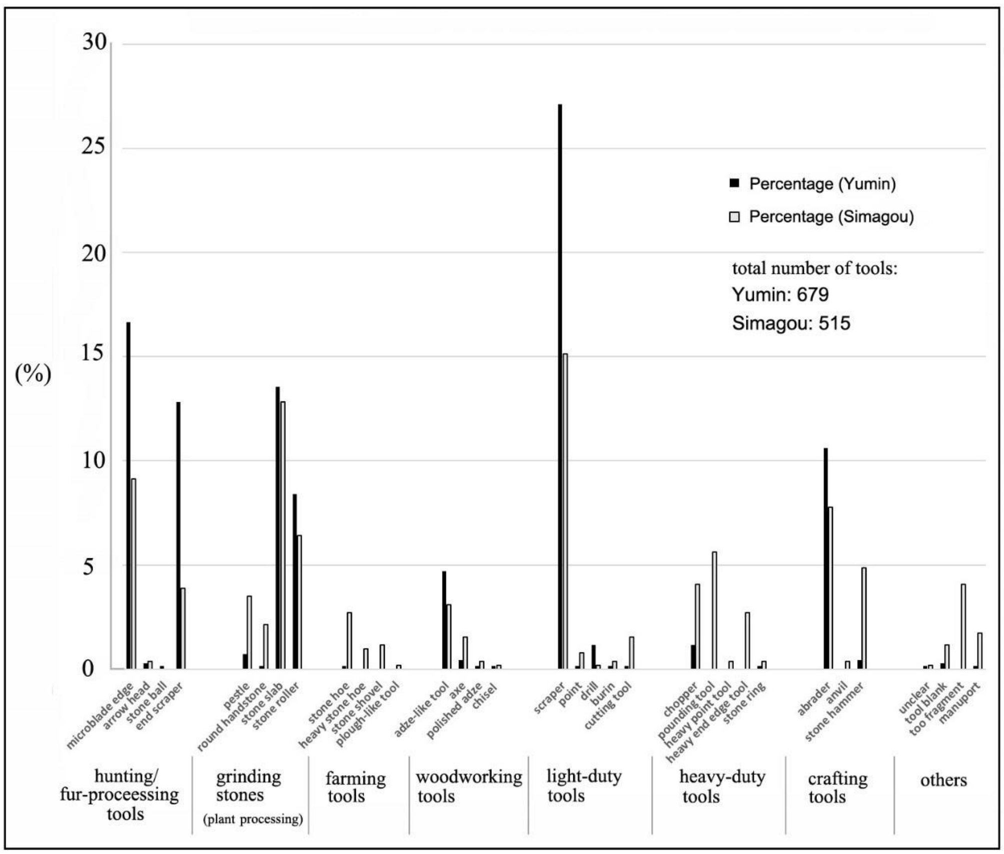

Figure 4.1 The proportional distribution of lithic tools in the Yumin and Simagou site

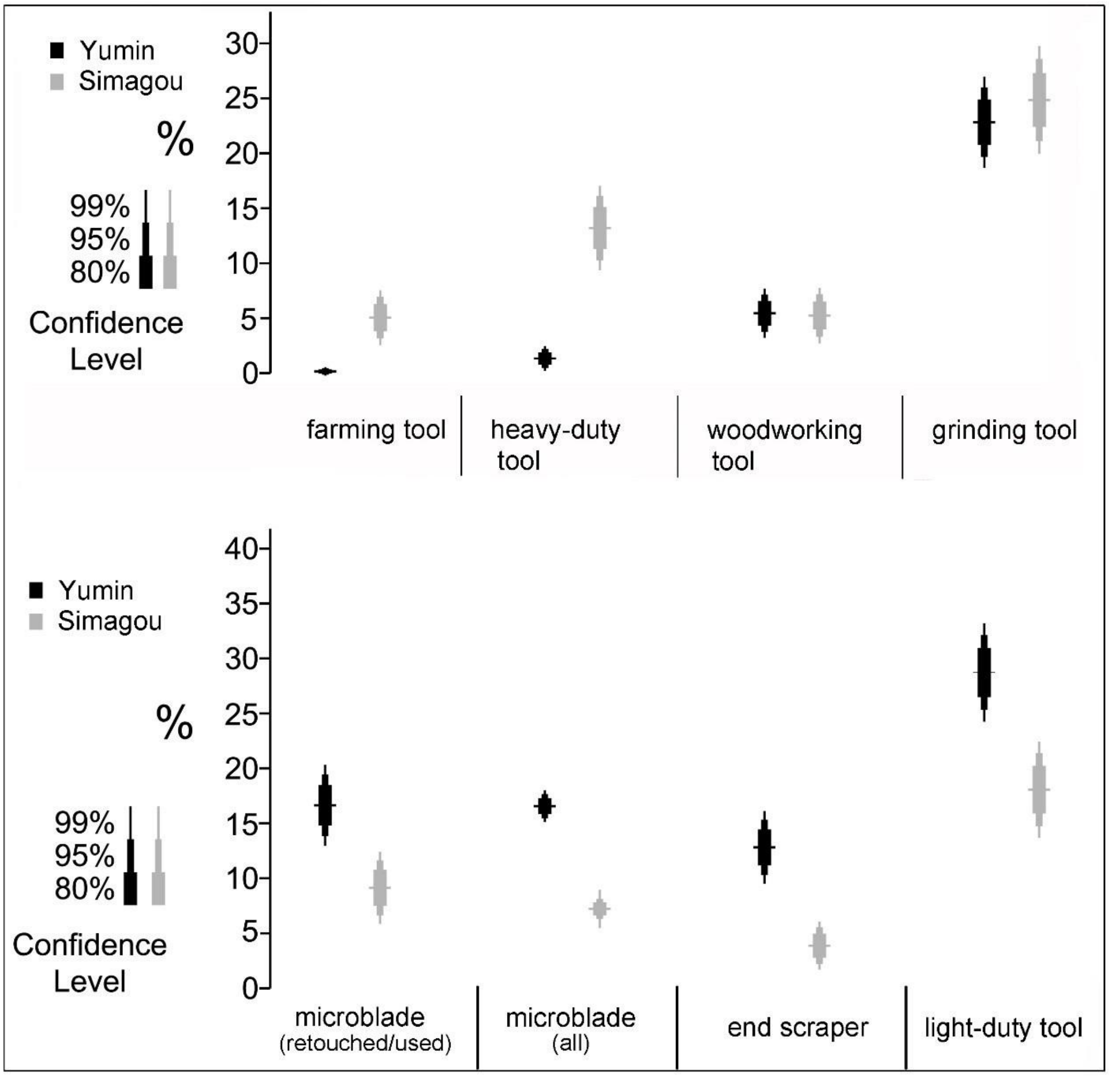

Figure 4.2 The bullet graph showing the comparisons of the proportional distribution of tool types associated with different subsistence activity

(Microblade(all) includes both the pieces of microblade with and without retouch and use. Since the ones without retouch and use signs are more likely by-products generated during microblade production instead of the inserted tools, the denominator of this proportion is the total number of lithic remains rather than the total number of tools which is used as the denominator for calculating the proportions of other tool types)

The light-duty tools which are mainly composed of scrapers comprise a large proportion in both the Yumin and Simagou sites. Except for a few scrapers and cutting tools which have formalized shapes, most of them are expediently designed and used for a wide range of activities like scraping, cutting, whittling, stabbing, etc. Such light-duty lithic tools are made from various forms of blanks like small chunks of stone, flakes intentionally detached from flake cores, or by-product flakes or shatter generated during the shaping, maintaining and retouching processes of microblade core reduction sequences. They are usually in irregular forms and only the edges used for working are intentionally retouched in various ways. Such features indicate that people mainly relied on expedient technology to deal with daily light-duty work. Without sufficient micro-usewear studies, it is hard for us to correlate each light-duty tool with a specific function. Moreover, many such tools might be used in multiple ways for different activities. Therefore, it is difficult to directly associate them with specific activities and rely on their proportional distributions to evaluate the relative importance of these activities. However, according to the features of tool design and previous studies of these types of tools, it is estimated that the works they undertake might range from skinning, the butchery of animals, slicing or shredding the fibers of plant resources, to grooving bone shafts or whittling and shaping wood pieces.

As for the tools which are more unequivocally used for certain subsistence practices, such as the those listed on the left three columns of Figure 4.1, we can see that for both of the two sites, the tools used for hunting, animal resource processing (such as hide working) and intensive processing of plant resources take dominating proportion, while the tools used for farming activity only take a very small proportion. Assuming that the proportions of tools positively correlate with the relative importance of the corresponding subsistence practice, we can infer that in the Early Neolithic period of the study area, people's subsistence economy was still mainly based on the procurement of wild resources from hunting and gathering. The farming activity, at most served as an auxiliary to a subsistence system based on hunting and gathering.

To investigate the proportions of different tool types at higher resolution, we can find some interesting differences between the Yumin and Simagou sites. For instance, even though the farming tools only take a limited percentage in tool assemblage in both the Yumin and Simagou sites, the relative proportion of the farming tools in Simagou is much higher than that of Yumin site, and this difference of the proportions of farming tools is significant as shown in Figure 4.2. While only one piece of stone hoe has been found in the Yumin site, there are more diversified types of farming tools in the Simagou site. This difference indicates that people in Simagou site were more engaged in farming activities

As for microblades and end scrapers, the proportions in Yumin site are higher than those in the Simagou site, and this proportional difference is also significant as reflected by the bullet graphs in Figure 4.2. Not only truncated microblades with marks of retouch or use wear has higher proportions, but the proportion of the overall number of microblade (including untruncated pieces and truncated microblades without any signs of retouch or use wear) in Yumin site is higher than in Simagou site, indicating that microblades were more intensively produced and used in Yumin site. Such evidence implies that people in Yumin site are more engaged in hunting and animal resource processing.

Both Yumin and Simagou have similar proportions of grinding stones, but with different patterns of the composition of different types of grinding stones. While stone slabs and rollers take higher proportion of the grinding stone in Yumin site, Simagou site has more pestles and round hand stones (as shown in Table 4.1). In other words, the composition of grinding stone in Simagou is more diverse than at Yumin (as indicated by Table 4.1 and Figure 4.3). Since different types of grinding tools might be used either to process different ranges of plant resources or process the same kinds of plant resource in different ways, this difference of grinding stone composition suggests that people in Simagou process wider ranges of plant resources or engaged with more diversified methods for plant resource processing.

Table 4.1 The composition of grinding stone tools in the Yumin and Simagou site

	Yumin	Simagou
Stone slab/Roller	149	99
Pestle	5	18
Round handstone	1	11
Simpson's index of Diversity (1-L)	0.075	0.378

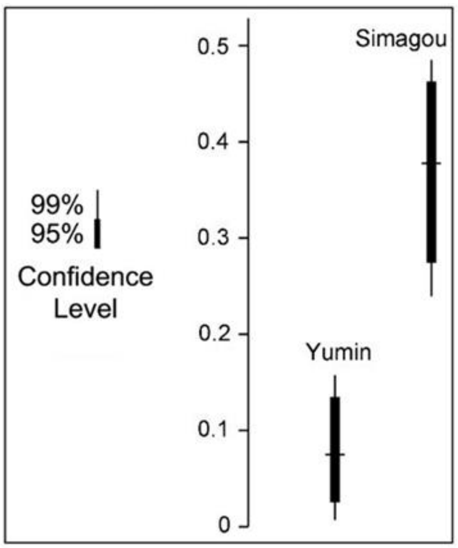

Figure 4.3 The comparison of the diversity index of grinding stone tools between the Yumin and Simagou sites

Another significant difference of the tool proportions between these two sites is that there is a higher proportion of heavy-duty tools in the Simagou site than in the Yumin site. Like most of light-duty tools, the heavy-duty tools are expediently designed and produced. Their forms are irregular with little modification from the original blanks. Only the working edges are crudely retouched. In contrast to light-duty tools, they are large and heavy and are used for work requiring heavy loads. The specific subsistence indications of such heavy tools are not clear. It is hypothesized that hammer-like pounding tools were probably used for pounding and shredding plant matter, such as roots. If this is true, at least part of the heavy-duty tools might be used as expedient tools for plant processing.

The differences in the composition of tool assemblage between the Yumin and Simagou sites also influenced the raw material choices for tool production, which is reflected by the different proportions of various types of raw materials in lithic assemblage, as reflected in Figure 4.4 and Table 4.2.

As shown in Table 4.2, the distribution of various kinds of raw materials in different tool types reflects that in general, people have similar raw material exploitation strategy between the Yumin and Simagou sites. They favor fine-grained igneous rock and cryptocrystalline stones (like chert, calcedony, agate) as the raw materials for processing end scrapers, microblades, and light-duty tools, and use coarse-grained igneous rock and sandstones to produce grinding tools and farming tools. As for the woodworking and heavy-duty tools, they use the raw materials of various grain sizes, ranging from relatively fine-grained igneous rock and cryptocrystalline to medium-grained quartzite and coarse-grained igneous rock. However, a slight difference of the proportional distributions of different raw materials indicates that people in the Simagou site tends to rely more on fine-grained cryptocrystalline rather than fine-grained igneous rock to produce end scrapers and microblades (as shown in Figure 4.4). Therefore, as reflected in the raw material distribution in debitage, we can see the significant reduction of the proportions of fine-grained igneous rock in the Simagou site, since the process of microblade production usually generates a large amount of debitage and less reliance on fine-grained igneous rocks to produce microblades will lead to a dramatic decrease of debitage of the fine-grained igneous rocks. The higher proportions of coarse-grained igneous rocks, however, results from the more intensive production of farming-tools and heavy-duty tools, since there are higher proportions of these tools in the Simagou site than in Yumin site.

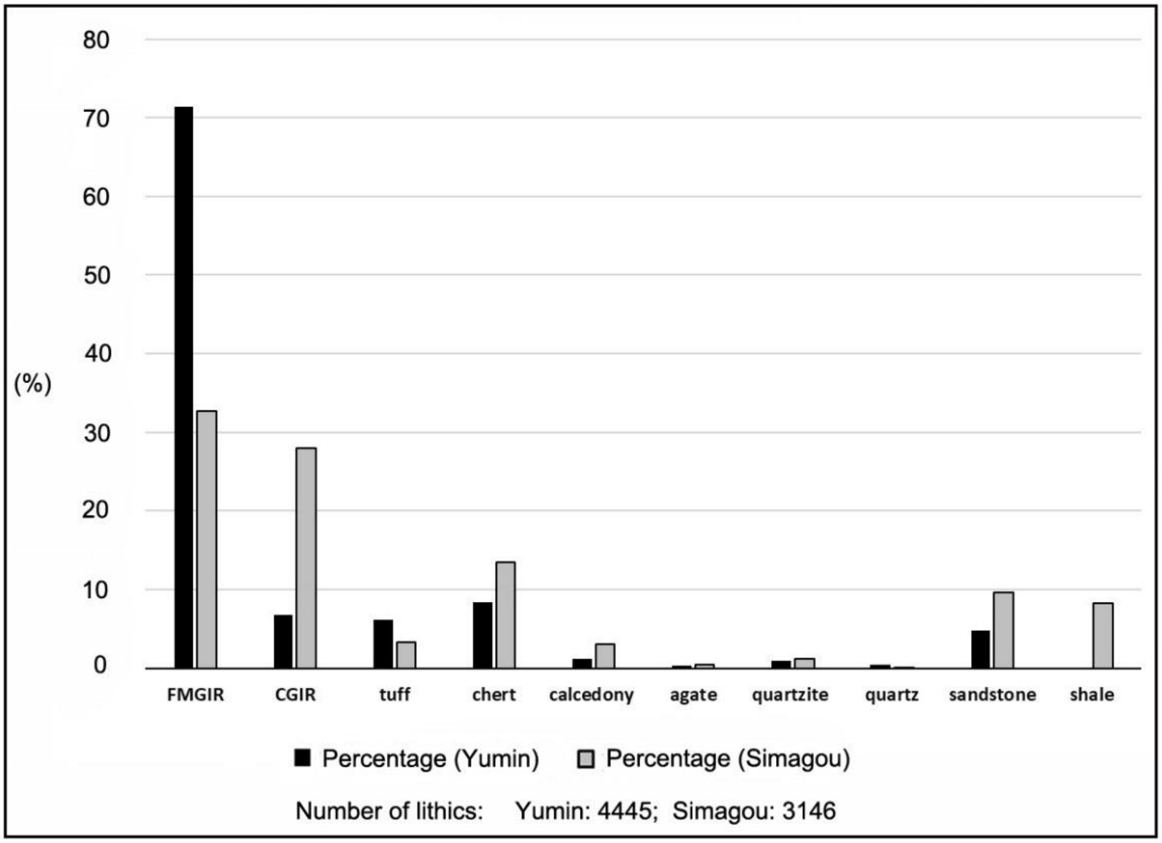

Figure 4.4 The proportional distribution of different raw materials of the lithic assemblage of the Yumin and Simagou site

(FMGIR: fine-medium grained igneous rock; CGIR: coarse grained igneous rock)

Table 4.2 The proportional distribution of raw materials across different categories of lithics of the Yumin and Simagou site

lithic type	site	N	percentage of different raw materials in each tool type (%)						
			FMGIR	CGIR	tuff	CS	Q-Q	S-S	total
microblade core	Yumin	120	69	0	15	16	0	0	100
	Simagou	73	49	0	11	40	0	0	100
flake core	Yumin	61	87	2	2	5	5	0	100
	Simagou	30	67	10	13	10	3	0	100
microblade insets	Yumin	113	32	0	13	55	0	0	100
	Simagou	47	15	0	4	81	0	0	100
microblade debris	Yumin	623	76	0	12	12	0	0	100
	Simagou	186	22	0	11	67	0	0	100
end scraper	Yumin	87	47	0	7	45	1	0	100
	Simagou	20	20	0	15	65	0	0	100
light-duty tool	Yumin	195	65	3	7	22	3	0	100
	Simagou	93	59	16	1	20	2	1	100
heavy-duty tool	Yumin	9	67	22	0	0	11	0	100
	Simagou	71	4	77	0	0	3	15	100
hunting tool	Yumin	3	0	33	0	67	0	0	100
	Simagou	2	0	0	0	100	0	0	100
farming tool	Yumin	1	0	100	0	0	0	0	100
	Simagou	26	0	96	0	0	0	4	100
woodworking tool	Yumin	37	73	8	14	5	0	0	100
	Simagou	27	59	19	11	4	4	4	100
grinding tool	Yumin	155	0	23	3	0	0	74	100
	Simagou	128	7	14	0	0	1	78	100
crafting tool	Yumin	75	4	13	3	0	3	77	100
	Simagou	67	13	0	0	0	37	49	100
tool (others)	Yumin	2	100	0	0	0	0	0	100
	Simagou	36	11	75	3	0	6	6	100
debitage	Yumin	2962	78	8	5	6	1	1	100
	Simagou	2417	35	31	3	13	0	18	100

(FMGIR: fine-medium grained igneous rock; CGIR: coarse-grained igneous rock; CS: cryptocrystalline; Q-Q: quartzite, quartz; S-S: sandstone, shale)

4.2 The forms and designs of the lithic tools

Some specific morphological features of tools reflect the ideas of tool design, which is closely related to certain subsistence practices and degrees of mobility/sedentism.

The lithic tool assemblages in the Yumin and Simagou site have remarkably high diversity in terms of the tool types and the techniques of tool production. While some types of tools resemble the ones we frequently found in the Upper Paleolithic sites in North China, like microblade, end scrapers, scrapers, burins, drills, points, choppers and so on, some types of tools resemble the ones which are prevalent in Mid-Late Neolithic period of North China, like polished axes and adzes. In addition, some specific types of tools show the unique features of this period and are not common both in the earlier and later periods.

One typical kind of such tools which are specific for this period are the ones related to farming activity. The tools are designed in different shapes with a wide range of variations in terms of the sizes and weights, indicating that they might be used for different purposes (as shown in Figure 4.5 and 4.6). Experimental study of farming tools found in the prehistoric sites of southeast Inner Mongolia (Chen, et al. 2014), the heavy and large hoes might be used to reclaim the land and loosen the soil. The light and small stone hoes might be used for tilling and weeding. The stone shovels and long-body stone hoes might be used for digging. The plough-like tool might be used for furrowing.

All such tools are chipped stone and are made with varying levels of elaboration. Some of them are well-shaped and have notches on both sides of their upper lateral margin or have thinning retouch on their proximal end. Such designs make them more feasible for hafting. In contrast, the others are more expediently processed with less effort paid for formalized shaping. People took full advantage of the original tabular form of blank they chose and made limited retouch of the working edges.

The features of farming tools indicate the stages of the development of primary farming. On one hand, people at this period have already begun to design and use the tools in different forms according to different needs of land tending, suggesting that intensive efforts have been made for the earthwork of cultivation. On the other hand, in comparison with the ground stone hoes and shovels used in the Mid-Late Neolithic period in the far-flung regions of North China, the farming tools found at Yumin and Simagou are less standardized in forms. Since the grounding technique has not been used for the manufacture of farming tools, the bodies of many of the tools are less symmetrical and have uneven surfaces with different thickness. Such features of design limited the efficiency and use life of the tools since the uneven surfaces of the tool body might make the tool suffer from loading forces to varying extents in different parts of the body and would therefore be easy to break. It seems that people care more about the purposes of the tools rather than the extended efforts to increase the overall reliability of the tools. Since the degree of investment in tool manufacture is closely correlated with expectations of the intensity of tool use (Bettinger, et al. 2006), the fact that many of the farming tools are produced without extended investment for shaping and retouching reflects that people in this period in the study region did not use the farming tools as intensively as in the subsequent period in most regions of North China. Moreover, a wide range of variation in the forms of the farming tools also indicates the lack of formality and stability of farming tool design. It seems that people at this time are still at the exploring and experimenting stages for farming tool making as an attempt to fit different purposes of land tending. Furthermore, no formalized reaping tools have been found in the Yumin and Simagou sites as well as the other surveyed sites of the Early Neolithic period in this area, such as the perforated ground stone knife frequently found in far-flung regions of North China from Mid Neolithic to Bronze Age (Di 2016). This probably suggests that since the yields from farming were low, there were no urgent needs for people to make large investments in making formalized reaping tools. All this evidence indicates that farming was still at its primary stage of development and people did not as intensively engage in food production as full-time farmers in later periods in many regions of North China.

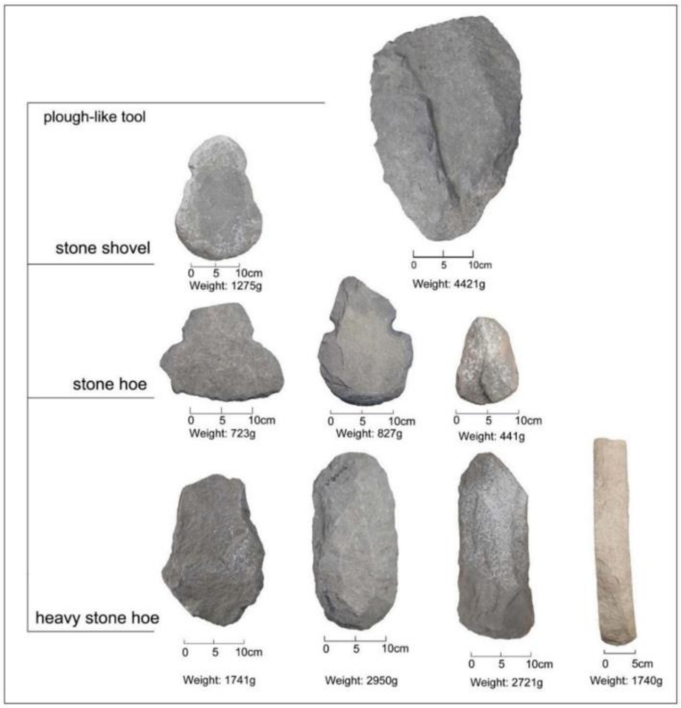

Figure 4.5 The farming tools in the Simagou site

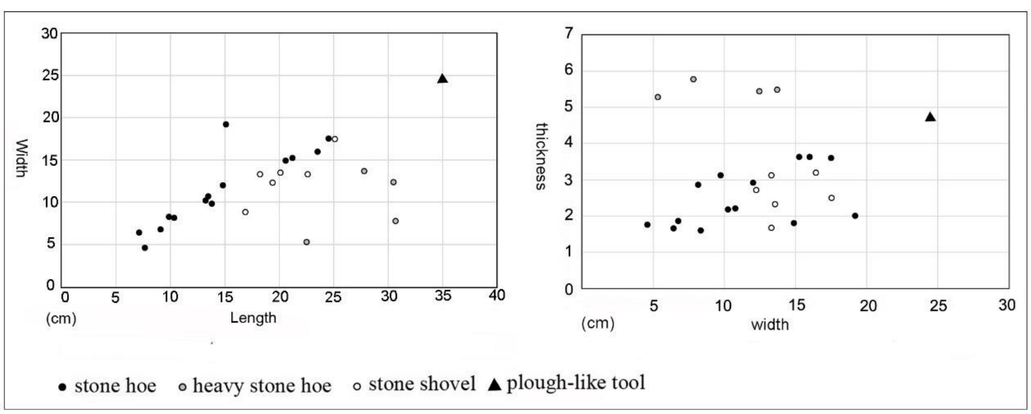

Figure 4.6 The size of farming tools in the Simagou site

Another type of tool that is typical for this period is the adze-like tool. As mentioned in chapter 2, the adze-like tool might be used as a plane for shaping wood. Such tools appeared sporadically during the late Upper Paleolithic of North China and disappeared after the Early Neolithic. They can be found in both the survey and excavation sites of the Early Neolithic period in the study region. Like the farming tools, the adze-like tools are also processed to varying degrees. While some adze-like tools are regularly shaped by dexterous bifacial techniques and are partially ground on the ventral face and lateral sides, some others are more casually made by taking advantage of the original form of the blank and with the limited effort of unifacial or bifacial retouch. Such features of the design are correlated with the intensity of demands for wood processing. The formalized design in terms of the edge shape and the overall tool form suggest that people have attempted to design and use the new type of more formalized tool instead of the expedient tools to cope with the increasing demands of woodworking. However, the varying degrees of sophistication in terms of shaping and retouching suggests that in some cases, people still strive to minimize the efforts of tool production to meet the basic utility needs rather than extending the investments to increase the reliability of them. Such a tool design strategy differs from that of the polished axe, adze, and chisel we found in the Yumin and Simagou sites, which are more regularly shaped and ground on the whole body. Much more amount of investments has to be paid beyond the basic functional considerations for the production of the polished axe, adze, and chisel. Such extended investments benefit to increase the length of the use life. Therefore, only in conditions when people need to intensively and repetitively use the tools for a long time, the techniques used for increasing investment to improve the regularities of the tools will be deserved and widely accepted. In the Yumin and Simagou sites, only a very low number of the woodworking tools have been processed by such a technique. Hence, we can infer that even though the demands of woodworking activity increase, it has not reached at a point that required the widespread adoption of highly regular ground stone tools.

The demands of woodworking might be correlated with the levels of residential stability and the sophistication (or the prevalence) of composite tool techniques since the processed wood (like wood poles) are needed for house construction and the haft of composite tools are usually made of wood. The woodworking toolkit found in Yumin and Simagou show the transitional features between earlier and later periods (shown in Figure 4.7), implying that the level of residential stability and the sophistication (or the prevalence) of the composite tool techniques might also fit in between the highly mobile and fully sedentary lifeways which have differentiated demands of dwelling constructions and composite tool production.

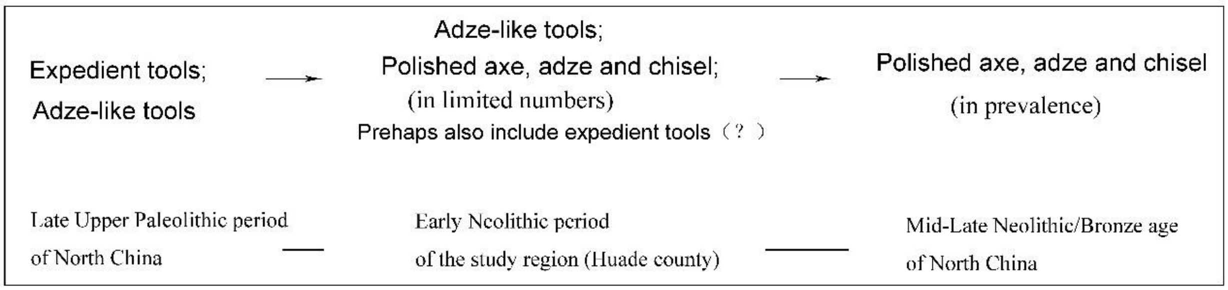

Figure 4.7 The development of woodworking tool composition from late upper Paleolithic to the Early Bronze Age

The varying investment in production from relative expediency to formalization can also be detected from the stone slabs, indicating that people have different expectations for the intensity and use life for the use of stone slabs. The more expedient stone slab only has a grinding surface and has no further modifications of the whole tool shape. The curated-designed stone slab is usually well-shaped in a regular rectangular shape with extra efforts to shape the tool through grinding. In both the Yumin and Simagou sites, the stone slabs are found in various sizes and weights. The forms of the stone slabs are also various and are mainly reflected by the differentiated ratios of length to width. Usually, the formally designed stone slabs are used more intensively than the expedient ones. The working surface of stone slabs also has different features. While some stone slabs have polished glosses on the working surface, some others have pitted scars on it. The variations of the forms, use wear and the use intensity of the stone slabs indicate that they have been used to process a wide range of plants in varying degrees of intensity, rather than specifically focusing on one or a few kinds of plants.

4.3 The distributional patterns of lithics inside and outside the pit houses

For both the Yumin and Simagou sites, the majority of lithic artifacts are found within the pit houses. In Yumin site, 77.4% of lithics are found in pit houses. In Simagou site,83.5% of them are found in pit houses. All the other remaining lithics are scattered on the ground of the cultural layer in both of the sites.

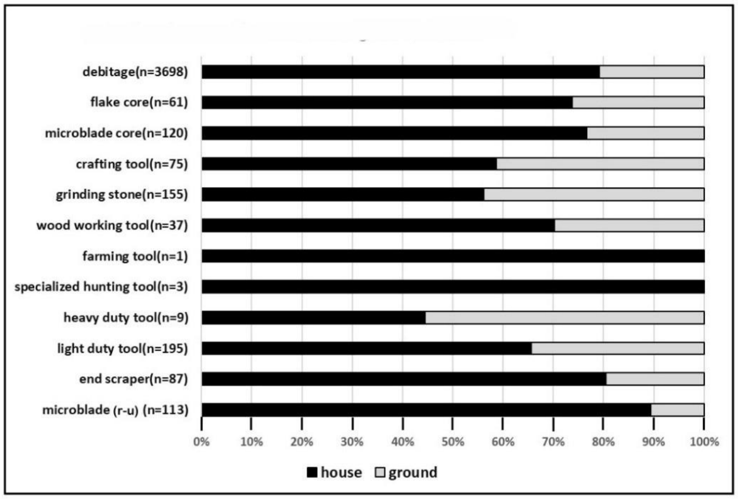

Figure 4.8 The comparison of the proportional distribution of lithic categories between house and ground in the Yumin site

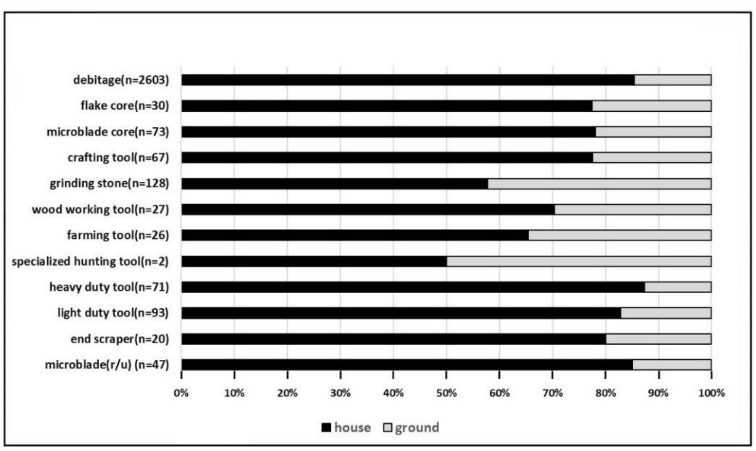

Figure 4.9 The comparison of the proportional distribution of lithic categories between house and ground in the Simagou site

The distributional patterns of different types of lithic remains found inside and outside the houses between Yumin and Simagou are shown as the graphs above. The pattern implies that the activities of lithic production are conducted mainly in different houses rather than in outdoor areas since most of the debitage and cores are found in the pit houses.

For many kinds of the tools used for different activities, higher proportions of them are found in the pit houses, especially microblades and end scrapers. This indicates that the production, maintenance, discard, and perhaps the use of these tools was mainly in the houses. In comparison with many other toolkits, a larger proportion of grinding stones have been found outside the pit houses. In both the Simagou and Yumin sites, we found the phenomenon that the stone slab and rollers are laid out neatly on the ground outside of the houses in postion for use. Such in-situ disposal indicates that at least parts of the activity of plant resource processing happened outdoors.

The lithic remains found in the houses were unlikely generated in a short time period, like a one-off event of lithic production or disposal. Instead, it is more likely that they were accumulated in a relatively long time span along with the occupational period of the house since the lithics are found at the different heights of the indoor depositions of the pit houses. The excavators of the Yumin and Simagou sites consider that the house floor has been built up higher and higher as the occupation of the houses went on (as shown from phase 1 to phase 2 in fig 4.9), since the evidence shows that ground hearth has been blocked up and got significantly thickened as the time of use lasted. According to the memories of the excavators, during the process of excavation[10], when they identified the sphere of the pit house deposition (indicated by differences of color and texture of the deposition from the surrounding soils) and dug downwards, they could soon find the hearth deposition within the house, and such deposition could be continuously found in the same location as they dug down and reached the bottom of the pit house. The hearth

[10] Based on personal communication with Mr. Hu from Ulanqab Museum and Mr.Ren from Inner Mongolia Institute of Archaeology and Cultural Relics, who are in charge of the excavation of both Yumin and Simagou sites.

deposition could be as thick as 70 cm in some well-preserved houses. They can find lithic artifacts distributed around or in the hearth from the top of the hearth deposition all the way down to the bottom of the house floor, suggesting that the artifacts found in the pit houses were deposited in a gradual process along with the use of the houses. It seems that there was a lack of intensive house floor cleaning at this time since broken tools and debitage generated in different stages of production and maintenance can be found in the houses, even including large pieces of flake and chunk debris. Moreover, no midden features were found in both Yumin and Simagou sites. Lithics found outside the houses are more numerous near the houses than farther away. The scattered patterns of their distribution around the pit houses suggest that instead of being intentionally moved out of the houses and dumped, they were more likely to be the artifacts initially deposited in the houses but then were exposed because of the erosions of the upper deposition of the house structure.

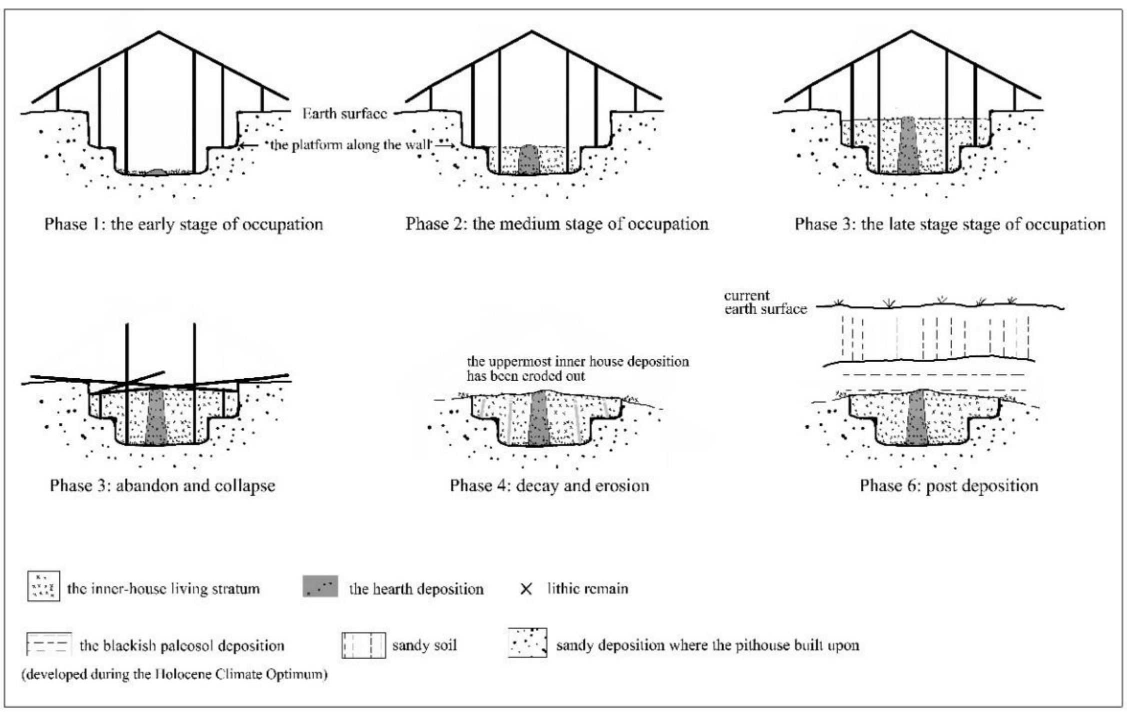

Figure 4.10 The estimated model showing the process of the construction, use, abandon and post-deposition of the house in the Yumin and Simagou sites

Such a pattern of lithic distribution reflects a specific refuse disposal pattern, which is correlated with the degrees of mobility and sedentism (Hardy-Smith and Edwards 2004). Ethnoarchaeological studies have shown that discard behavior corresponds with residential strategies influenced by the length of the duration of occupation (Hayden and Cannon 1983). People are inclined to clean their dwelling and working areas more regularly as they stay in a location for a longer time since the accumulated garbage produced through time might impede people's normal activities. So people tend to relocate the refuse to secondary dumps (Graham 1993; Hayden and Cannon 1983). However, if people live in a location shortly, they tend to discard garbage where it falls and exert limited efforts for cleaning the dwelling and working areas (Binford 1978a; Binford 1978b; Kent 1993).

Since the houses are used as working and resting places, they are not good places for refusing dumps. Therefore, the majority of the accumulated lithic artifacts found in the houses of the Yumin and Simagou sites are more likely to be the primary refuse (like broken and worn-out tools) discarded in their location of use, or the by-product debris generated during the tool manufacturing process and left in the places where the tool production activity occurred. A few of the tools found in the pit houses are still useable, indicating that they were not refuse, but were cached for anticipated use in the future. Not only are the majority of the lithic artifacts found in the pit houses, but faunal remains are also mostly found within the houses, which further strengthens the inference that people did not regularly relocate the refuse to secondary dumps. In contrast with houses, the midden is a more ideal structure to hold secondary refuse. However, no middens have been identified in Yumin or Simagou sites.

Such a pattern of refuse disposal suggests that people in this period had not yet tailored their household refuse disposal practices to the long-term requirement of stable sedentary living. Therefore, even though pit house structures indicate that people invested more in their dwelling construction, suggesting the decline of mobility and the attempt for more stable residence, they were still not living in a fully-fledged stabilized sedentary lifeway at this period.

Such a pattern of lithic disposal also suggests that each well-preserved house can be potentially used as a meaningful unit to examine the inter-household differentiations since the lithic artifacts left in the houses can well reflect the daily activity of the corresponding households. This will be further explored below.

4.4 The inter-household differentiations of the lithic assemblage

By examining how various types of lithics are distributed across different houses, we can see how commonly each subsistence activity was practiced by the households within the community and compare the differences and similarities of daily activities across different households.

The pit houses in Yumin and Simagou are preserved in varying extents of completeness. While some pit-houses are well-preserved and rich amounts of lithic remains can be found from the top to the bottom of the inner house depositions, some others are heavily eroded by various kinds of post-depositional forces (like a later gully, or heavy wind). Usually, the poorly-preserved houses have fewer lithics than the well-preserved houses since the majority of the lithics have lost due to the erosional forces. Therefore, in comparison with well-preserved pit houses, they cannot reliably reflect the activities of the household which are involved with the use of lithics. Therefore, in the following discussions, I will mainly rely on the well-preserved houses as the analytical units to explore inter-household differentiation. In the Yumin site, pit houses F1, F2, F3, F4, F5, F6, and F13 are well-preserved (half of F1 has been eroded by the gully, but the other half of it is well-preserved). In the Simagou site, the well-preserved houses include F3, F4, F5, F7, F9, F10, F13, F14, and F15.

While the assemblage of toolkits can well reflect the information on different activities related to subsistence practices, the assemblage of debitage conveys information on tool production and maintenance. Therefore, I will separately discuss the distributional patterns of the toolkits and debitage to fully understand inter-household differentiations.

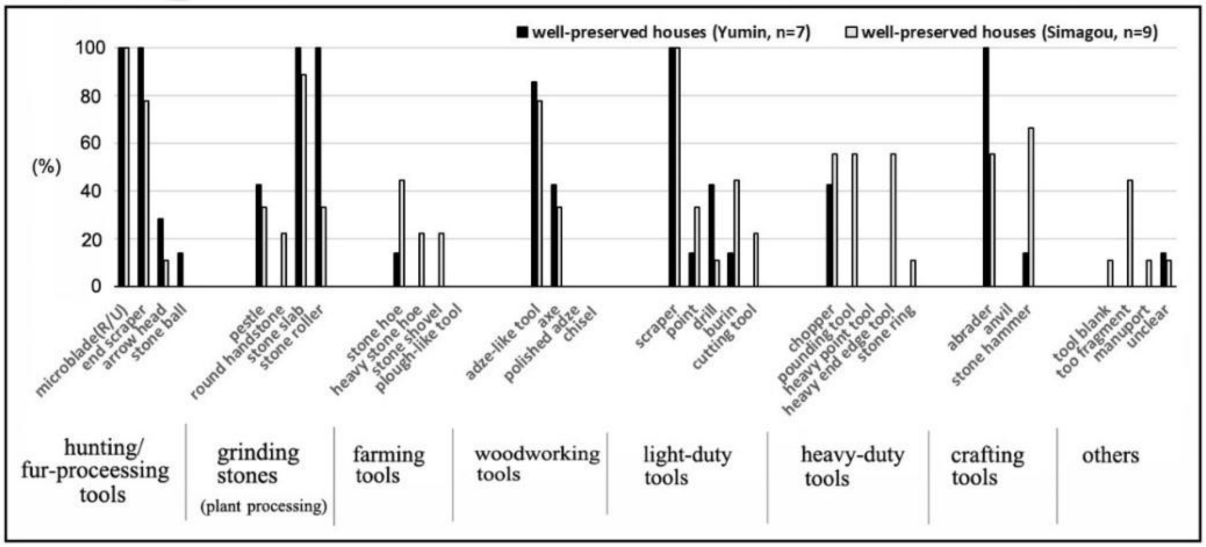

Figure 4.11 The ubiquity of tool types found in the pit-houses of the Yumin and Simagou sites

According to the ubiquity of the tools in different houses of the Yumin and Simagou sites (as shown in Figure 4.11), the most widely distributed tools are microblades, end scrapers, scrapers, stone slabs, and rollers (particularly in Yumin site), and abraders (particularly in Yumin site). These tools cover the functional range of hunting, animal and plant resource processing, and the production of ground stone and bone tools. They can be found in all well-preserved Yumin houses and most of the well-preserved Simagou houses (except for abraders which are found in less than half of the well-preserved houses in Simagou site). Such a distributional pattern suggests that hunting and gathering were frequently engaged by different houses. In addition, adze-like tools are commonly found in a majority of the well-preserved houses in both Yumin and Simagou, implying that the shaping of wood is also an activity widely engaged by the majority of the households.

On the contrary, farming tools are only found in a smaller number of houses. In the Yumin site, only one house had farming tool. In the Simagou site, 6 out of 9 well-preserved houses had farming tools but no single farming tool type is found in all these houses. This suggests that in comparison with the subsistence activities of hunting and gathering, farming was less frequently practiced and might be engaged in by a smaller number of the households.

Among the toolkits used for each activity, we can see varying distributions. For example, in terms of hunting weapons, it seems that generalized microblades which can be used either as hunting tools or for other purposes is more prevalently used by different households than the specialized-designed hunting weapons, like arrowheads and stone balls which are only found in a few pit houses.

For the grinding tools, stone slabs and rollers are more widely distributed than pestles and round handstones. As for the light-duty tools, the scrapers with different forms of edges are far more commonly than drills, points, burins and cutting tools. This difference indicates that while people designed a range of different tools for each broad activity, they clearly favored certain kinds of tools over the others. The favored tool types were more broadly adopted by households, while the other less popular types are used only in limited numbers of households. This differentiated distributional pattern implies that while each well-preserved house was equipped with a set of toolkits used for a similar range of activities in broad terms, different houses might have slightly different habits of the tool use for subsistence practices.

4.4.1 The proportional distribution of different tools across the houses

The degrees of differences in household activity can be evaluated by how much lithic assemblages differ from house to house. For both of the two tables listed below, the proportions of different tools in each house are derived by dividing the number of tools of each type by the total number of tools from that house. The proportion of debitage, however, is the number of pieces of debitage in each house divided by the number of all lithics from that house. The debitage counted in these two table includes not only flakes, chunks, and shatter produced during lithic reduction, but also cores used for producing lithic tools.

Since the lithic remains are an incomplete record of human activities, they should be thought of as samples reflecting human activity. Therefore, bullet graphs are made to illustrate the proportions of different tool types in tables 4.3 and 4.4 with error ranges for different confidence levels for the well-preserved houses of both the Yumin and Simagou sitesand compared by adding the error range of different confidence levels to the proportion of certain tool types from the well-preserved houses of both the Yumin and Simagou sites (as shown in Figure 4.12 and 4.13).

Table 4.3 The information on lithics distribution across the houses in the the Yumin site

Houses	All lithics	Lithic tool	Microblade (R-U) (%)	End scraper (%)	Light-duty tool (%)	Heavy-duty tool (%)	Hunting tool (specialized) (%)	Woodworking tool (%)	Farming tool (%)	Grinding stone (%)	Crafting tool (%)	Debitage proportion (%)
F1	**184**	**38**	**21.1**	**7.9**	**23.7**	**0.0**	**0.0**	**7.9**	**0.0**	**36.8**	**10.5**	**79.3**
F2	**184**	**32**	**28.1**	**9.4**	**43.8**	**0.0**	**0.0**	**0.0**	**0.0**	**21.9**	**6.3**	**82.6**
F3	**822**	**110**	**20.9**	**20.9**	**53.6**	**0.9**	**1.8**	**3.6**	**0.0**	**14.5**	**4.5**	**86.6**
F4	**270**	**41**	**7.3**	**2.4**	**51.2**	**2.4**	**0.0**	**4.9**	**2.4**	**17.1**	**12.2**	**84.8**
F5	**650**	**65**	**26.2**	**12.3**	**35.4**	**0.0**	**0.0**	**9.2**	**0.0**	**18.5**	**10.8**	**90.0**
F6	**724**	**81**	**32.1**	**14.8**	**34.6**	**0.0**	**2.5**	**3.7**	**0.0**	**16.0**	**11.1**	**88.8**
F7	23	3	66.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	87.0
F8	31	7	28.6	0.0	14.3	0.0	0.0	14.3	0.0	14.3	28.6	77.4
F9	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F10	102	10	10.0	20.0	80.0	0.0	0.0	0.0	0.0	0.0	10.0	90.2
F11	25	2	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	50.0	92.0
F12	60	16	12.5	25.0	56.3	0.0	0.0	6.3	0.0	18.8	6.3	73.3
F13	**335**	**53**	**15.1**	**26.4**	**47.2**	**1.9**	**0.0**	**7.5**	**0.0**	**18.9**	**9.4**	**84.2**
F14	11	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	75.0	25.0	63.6

(The bold font marks the well-preserved house)

Table 4.4 The information on lithics distribution across the houses in the Simagou site

Houses	All lithics	Lithic tool	microblade (R-U) (%)	End scraper (%)	Light-duty tool (%)	Heavy-duty tool (%)	Hunting tool (Specialized) (%)	Woodworking tool (%)	Farming tool (%)	Grinding tool (%)	Crafting tool (%)	Debitage proportion (%)
F2	262	15	26.7	0.0	0.0	13.3	0.0	6.7	6.7	20.0	13.3	94.3
F3	**291**	**19**	**15.8**	**0.0**	**36.8**	**10.5**	**0.0**	**5.3**	**10.5**	**15.8**	**10.5**	**93.5**
F4	**326**	**27**	**11.1**	**11.1**	**18.5**	**3.7**	**0.0**	**11.1**	**3.7**	**33.3**	**0.0**	**91.7**
F5	**228**	**16**	**12.5**	**12.5**	**18.8**	**12.5**	**0.0**	**0.0**	**12.5**	**6.3**	**12.5**	**93.0**
F6	205	40	7.5	5.0	12.5	25.0	0.0	0.0	7.5	17.5	20.0	80.5
F7	**89**	**8**	**25.0**	**25.0**	**12.5**	**12.5**	**0.0**	**12.5**	**0.0**	**0.0**	**12.5**	**91.0**
F8	36	5	40.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	40.0	86.1
F9	**871**	**55**	**9.1**	**1.8**	**49.1**	**14.5**	**1.8**	**1.8**	**5.5**	**9.1**	**5.5**	**93.7**
F10	**239**	**26**	**23.1**	**7.7**	**26.9**	**0.0**	**0.0**	**7.7**	**0.0**	**19.2**	**7.7**	**89.1**
F11	47	16	0.0	0.0	0.0	12.5	0.0	6.3	0.0	62.5	6.3	66.0
F12	344	22	13.6	0.0	18.2	9.1	0.0	18.2	0.0	22.7	18.2	93.6
F13	**255**	**12**	**8.3**	**8.3**	**16.7**	**16.7**	**0.0**	**8.3**	**0.0**	**8.3**	**33.3**	**95.3**
F14	**678**	**63**	**6.3**	**0.0**	**27.0**	**20.6**	**0.0**	**3.2**	**1.6**	**23.8**	**7.9**	**90.7**
F15	**560**	**42**	**2.4**	**7.1**	**16.7**	**38.1**	**0.0**	**2.4**	**2.4**	**11.9**	**21.4**	**92.5**
F16	62	3	0.0	0.0	0.0	33.3	0.0	0.0	0.0	66.7	0.0	95.2
F17	56	7	14.3	0.0	0.0	0.0	0.0	14.3	0.0	28.6	42.9	87.5

(The bold font marks the well-preserved house)

Based on the information provided by Table 4.3, 4.4, and the Figure 4.12 and 4.13, we do find differences between the lithic assemblage of different houses for both the Yumin and Simagou sites, yet such differences are not dramatic enough for us to conclude that the houses are highly differentiated from each other in terms of lithic production and economic activities. For instance, Tables 4.3 and 4.4 indicate that there is a high-level overlap of the range of the tool types among most of the well-preserved houses, suggesting that each household might be engaged in a similar range of activities. The moderate difference of their proportional distribution in each household suggests the differentiated emphasis on different activities across the household in subtle degrees, which is discussed below.

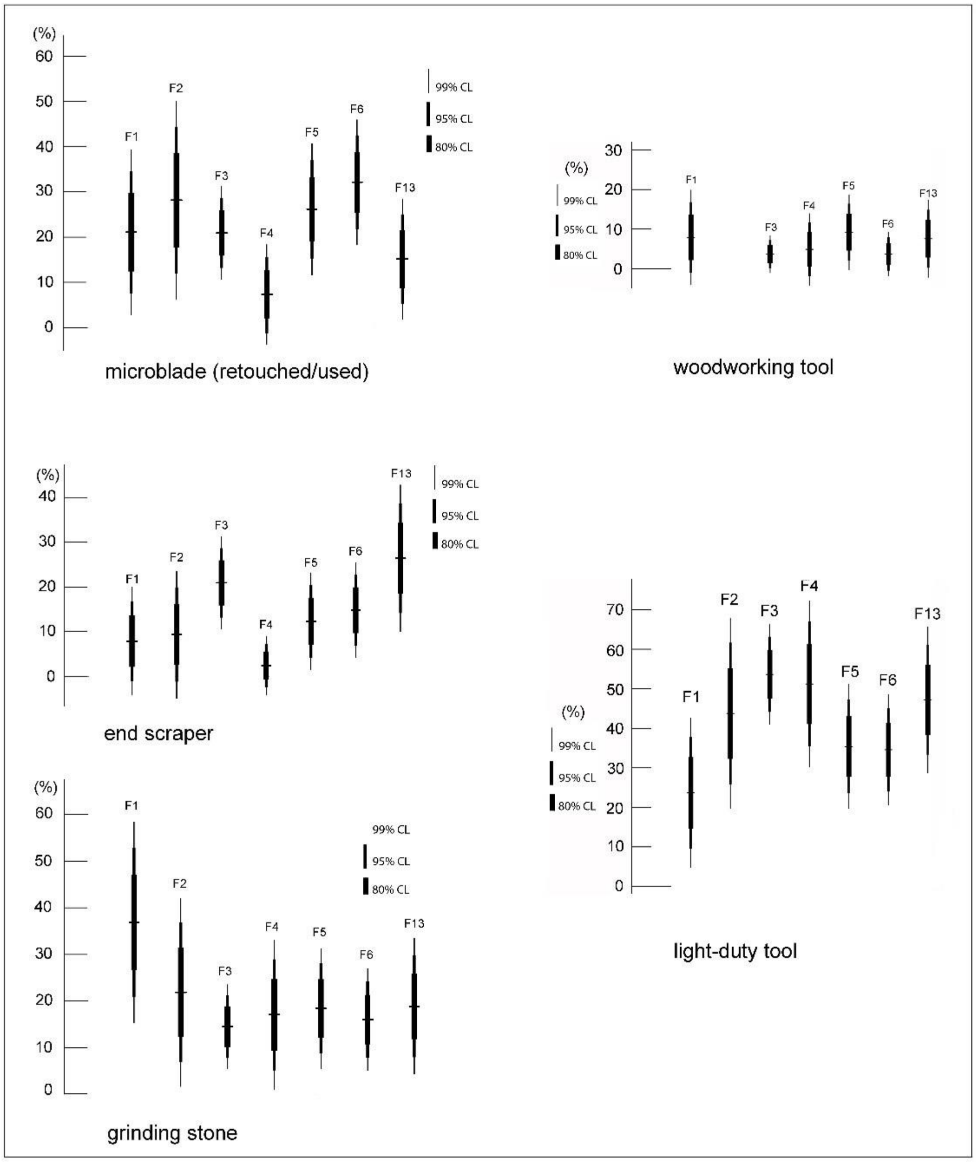

Figure 4.12 The bullet graph showing the proportional distribution of tool types correlated with different subsistence activity across the well-preserved houses of the Yumin site

To investigate the Yumin site first based on the information provided by Figure 4.12, we can see that houses F4 and F13 have significantly lower proportions of retouched or used microblades, but the other houses have similar proportions of them (not significant even at 80% confidence level). Yet differing from F4, F13 has much more debitage correlated with microblade production. Therefore, the lower proportion of retouched and used microblades in F13 might be caused by the fact that people in F13 have taken away large portions of the retouched or used microblade and reused them in other places. While the lower proportion of both retouched and used microblades and microblade cores in F4 might reflect that this household is less intensively involved in the production and use of the microblade.

For the end scrapers, house F4 has significantly lower proportions of them in comparison with other houses (at 99% confidence level). F3 and F13 have the highest proportions of end scrapers. F1, F2, F5, and F6 have similar proportion of end scrapers and these proportions are lower than those of F3 and F13 (The difference is significant at confidence levels ranging from 80% to 99% depending on the comparison being made.). Such difference of proportions is correlated with the levels of intensity of hide-working activity.

The proportion of grinding tools forms a continuum of minor differences among the houses except for F1 which has a significantly higher proportion of them (at a confidence level ranging from 95% to 99% depending on the comparison being made). Such a pattern of proportional distribution indicates that different houses are engaged in the same levels of intensity for activities like intensive processing of plant resources, except for household F1, which might be more intensively involved in such activity. Moreover, a detailed investigation of the tool forms indicates that the specific composition of the grinding tools is also highly repetitive among different houses. Each house has a set of grinding slabs and rollers in varying sizes and different forms. The distribution of the maximum diameters of the stone roller among the houses indicates that each well-preserved house has both relatively smaller and larger stone rollers, which might be used for different purposes. However, since the sample size is too small, we do not have much confidence to compare the proportion of different stone roller sizes across the houses to investigate whether or not each household has a preference for using different sized rollers to process food resources.

Table 4.5 The distribution of stone rollers in different size across the houses of the Yumin site

D of the stone roller intersection	F1		F2		F3		F4		F5		F6		F13	
	N	P (%)	N	P (%)	N	P (%)	N	P (%)	N	P (%)	N	P (%)	N	P (%)
2-3 (cm)	1	16.7	0	0	0	0.0	0	0	0	0	0	0.0	0	0.0
3-4 (cm)	3	50.0	1	50	1	16.7	0	0	0	0	1	14.3	2	66.7
4-5 (cm)	2	33.3	0	0	4	66.7	2	50	3	75	1	14.3	0	0.0
5-6 (cm)	0	0.0	1	50	0	0.0	1	25	0	0	4	57.1	1	33.3
6-7 (cm)	0	0.0	0	0	1	16.7	1	25	1	25	0	0.0	0	0.0
7-8 (cm)	0	0.0	0	0	0	0.0	0	0	0	0	1	14.3	0	0.0

(D=diameter)

According to the forms of the cross-section, the stone rollers can be divided into three types, suggesting different functions. The ones with round intersection face might be mainly used for rolling; the ones with edged intersection face might be used for rubbing. The ones with the intersection forms between these two types might be combinedly used for both rolling and rubbing (Adams 2013). Table 4.6 shows that at least two types of such stone rollers can be found in the well-preserved household. Since the different designs and forms of the grinding stone suggest different ways of use for processing different kinds of plant resources, the diversity of the grinding stone forms observed in each house implies that every house takes charge to process the various kinds of the collected or cultivated plant resources in relative independence. However, given the small sample size, we do not have much confidence to compare the proportions of rollers with different intersection faces across the pit houses to evaluate whether or not each household has differentiated preferences for using the stone rollers with different intersection faces to process the food resources.

Table 4.6 The distribution of stone rollers used in different functions across the houses of the Yumin site

Estimated function	F1		F2		F3		F4		F5		F6		F13	
	N	**P (%)**	**N**	**P (%)**	**N**	**P (%)**	**N**	**P (%)**	**N**	**P (%)**	**N**	**P (%)**	**N**	**P (%)**
Rolling	1	16.7	1	50	0	0.0	1	25	0	0	2	28.6	1	33.3
Rubbing	1	16.7	0	0	1	16.7	1	25	3	60	2	28.6	1	33.3
R-R	4	66.7	1	50	3	50.0	2	50	1	20	3	42.9	1	33.3
Unclear	0	0.0	0	0	2	33.3	0	0	1	20	0	0.0	0	0.0

R-R: the combined function of rolling and rubbing

The proportion of the woodworking tools also forms a continuum of minor differences, except that F2 is devoid of such tools. Since the proportion of woodworking tools is relatively small in all of the houses, such absence might be the result of the small sample size and does not necessarily mean that people living in F2 did not produce woodworking tools. More likely, it indicates that woodworking tools only take a very small proportion within the tool assemblage. Based on the statistic estimation, F2 might have less than 10% woodworking tools within the tool assemblage at 96.6% confidence level.

The light-duty tools are the most commonly used tools across the households since besides F1 which shows lower proportion of light-duty tools (the difference is significant with other houses at confidence levels ranging from 95% to 99% depending on the comparison being made), the lowest value of the error range even at 99% confidence level of their proportions across the houses were above 15%. F3 seems to have a slightly higher proportion of light-duty tools than the other houses except for F4 (at confidence levels ranging from 80% to 99% depending on the comparison being made). F4 has a similar proportion of light-duty tools compared with F3 but is subject to a much wider error range. Since based on current studies, we cannot unequivocally correspond light-duty tools to any specific subsistence activities, the indications of such differences of proportional distribution across the houses still require for further functional studies of the lithics attributed as light-duty tools.

Based on the analysis above, we can see that each household undertakes a wide range of daily activities but they have differentiated emphasis on different activities. Considering that the only farming tool in Yumin site has been found in F4 and F4 has lower proportions of microblade and end scrapers, it seems that this household is engaged in farming activity and less intensively involved in the activities of hunting and fur processing. On the contrary, specialized hunting weapons are only found in F3 and F6. In addition, F3 has a higher proportion of end scraper and F6 has a slightly higher proportion of microblade. Hence, it is probably that the household F3 and F6 are more involved in hunting and animal resource processing activities. F5 might also get intensive involved in such activities. Even though the proportions of microblade and end scrapers of this house are not prominently higher, F5 has a large number of microblade core and the debitage analysis indicate that this household is perhaps intensively involved in microblade reduction activity. The inference made from lithic evidence agrees well with the evidence of fauna remains, since a larger number of animal bones have been found in F3, F5, and F6.

The household F1 is considered special because a piece of a ground stone tablet was found in it. More than sixty drilled round pits have been arranged regularly on this artifact. It seems that this stoneware has special symbolic meanings and might be used for ritual activity. The only indoor burial is also found in this house. Such evidence suggests that the household F1 might undertake a special ritual or even religious function. However, in terms of the daily economic activity, it has nothing special in comparison with the other households, except for the lower proportion of light-duty tools and a higher proportion of grinding tools which probably indicates more intensive involvement in plant resource processing.

Since the well-preserved houses in the Simagou site have fewer tools, it is more difficult to compare the inter-house differentiations of the Simagou site in fine resolution based on bullet graphs, for the smaller sample size usually generate the larger error range of the proportion of each tool type. Moreover, in spite of the well-preserved condition, the house F7 has too few tools to make a sensible comparison with other houses. There, it is excluded from the inter-house comparison of lithics debitage.

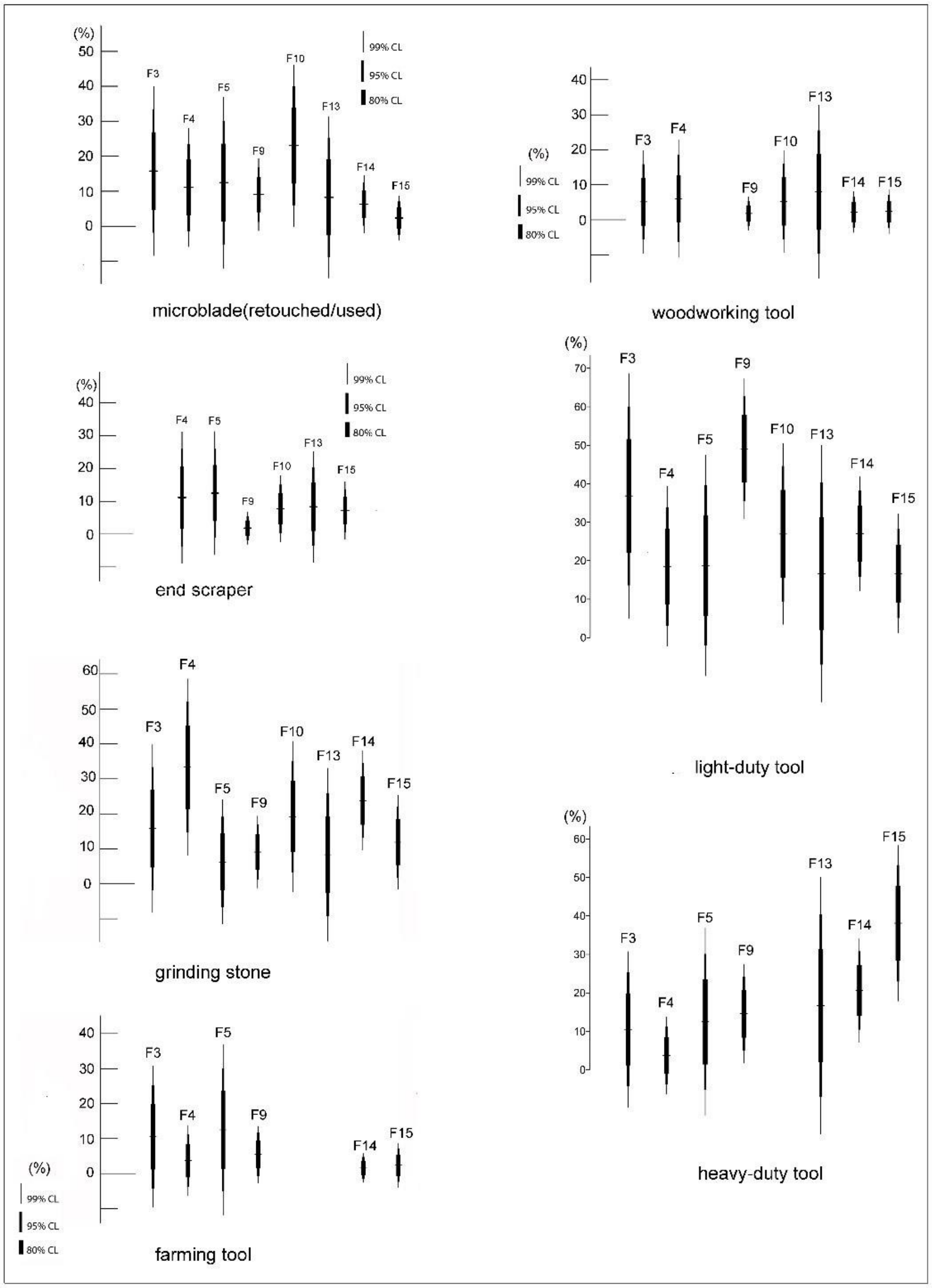

Figure 4.13 The bullet graph showing the proportional distribution of tool types correlated with different subsistence activity across the well-preserved houses of the Simagou site

As shown in Fig 4.13, we can say that only at a low significance level, there are no pronounced inter-household differentiations in the Simagou site. Probably, the minor or moderate differences across the households might exist, but it cannot be reliably detected due to the limitations of the sample size.

Not every well-preserved house found all types of the lithics in the Simagou site. At first glimpse, it might indicate that not every household is in charge of every important subsistence activities by itself and a certain level of economic interdependence might involve. However, since the sample sizes are relatively small, the absence of certain tool types within some houses is not meaningful. As the result shown in Table 4.7, while we have relatively high confidence level to say that the absence of certain type of the tool in the samples from any particular house suggests that such tool-type only take less than 15% of the tool assemblage, we do not have high confidence level to say that they take even less than 5% of the tool assemblage except for the end scraper in F14. Therefore, limited by the sample size, we cannot simply conclude the absence of certain types of tools in any particular household even if they are not found from the samples of lithics of the household.

Table 4.7 The confidence level for concluding the low proportional distribution of the tools which are absent from the sample

Tool type absent from the house	House	Total number of lithic tools	The confidence level for the low proportion concluded by the absence from a sample (%)		
			5.0%	10%	15%
End scraper	F3	19	62.3	85	95.4
	F14	63	95.4	99.8	>99.9
Farming tool	F10	26	73.6	93.5	98.5
	F13	12	46.0	71.8	85.8
Woodworking tool	F5	16	56.0	81.5	92.6
Heavy-duty tool	F10	26	73.6	93.5	98.5

4.4.2 The analysis of debitage across the houses of the Yumin and Simagou site

The issue we particularly want to know from debitage analysis is the degrees of relative independence of lithic production for each household, like whether each household produce their own tools, or if there are certain levels of specialization of lithic production among the households.

It is hypothesized that if each household takes charge to produce their own lithic tools, we expect to see that the debitage take a high proportion in each of the houses and the debitage should be highly varied, composed of the ones generated at the different stages of lithic reduction sequences. While if the households engaged in lithic production in varying extents, we expect to see that a large amount of debitage generated at different reduction sequences can be only found in a limited number of houses which are specified on lithic production and the rest of the houses can only find limited number of debitage confined in certain specific reduction stages, like retouching, remodifying or maintenance.

From the distributional pattern of lithic debitage, as shown in Figure 4.14 and 4.15, we can see that they all take the majority of the proportion of lithic assemblage in each of the well-preserved houses in both the Yumin and Simagou sites, suggesting that each household is intensively engaged in lithic production to a roughly similar extent.

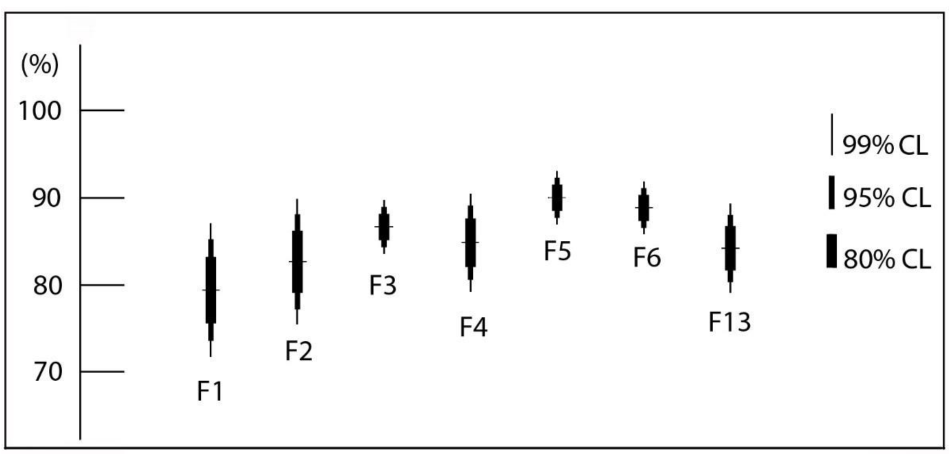

Figure 4.14 The proportion of debitage in each well-preserved house of the Yumin site

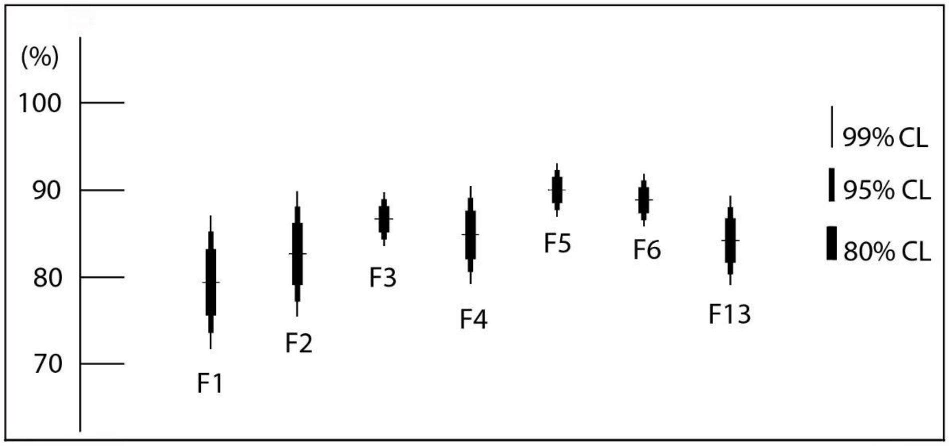

Figure 4.15 The proportion of debitage in each well-preserved house of the Simagou site

To further evaluate if each house is composed of lithic debitage from different reduction sequences and how the debitage assemblage of different houses differs from each other, we need to do more detailed quantitative analysis. Since the number of the debitage is overwhelming and the time and energy in laboratory analysis is limited, I selected 100 pieces of debitage by random sampling from the houses of F2, F3, F4, F5, F6, F13 of Yumin and F9 from Simagou and made quantitative analysis of them to learn the detailed features of lithic production. The sample size 100 is large enough for us to control the error range to less than 15% on 95% confidence level for the comparisons of proportional differences of the specific index of debitage features (like the proportions of debitage made with different raw materials, the proportions of non-cortex to cortex covered cores). The samples from the six well-preserved houses of the Yumin site enable us to evaluate the intra-site differentiations of lithic production among the houses of the Yumin. Incorporating a sample from one typically well-preserved house of Simagou enables us to compare the differences in lithic production between the Yumin and Simagou sites.

The sizes of debitage can reflect the relative stages of lithic production since with the continuously exhausting of lithic cores or tool blanks, the debitage generated in later stages tend to be smaller than the ones generated earlier. However, the sizes of debitage are also influenced by the sizes of the blanks selected for lithic production. Therefore, the variations of the sizes often reflect the combination of both reduction stages and sizes of raw materials used for blanks of tool production.

The maximum diameter and weight can be used as the index for evaluating the sizes of the debitage. As seen from the Table 4.8 and 4.9 below, the debitage of each household are distributed in a wide range of different sizes. Except for some extremely tiny and thin pieces of debitage (like the ones lighter than 0.1g) which can be unequivocally attributed as the fine-tuned retouch flakes, we are not quite sure if the debitage generated in different sizes (especially for the size range of 2-4 cm) are the finely retouched ones removed from the larger blank or the ones generated at primary or secondary reduction sequences of the smaller blank.

In such a case, the number of dorsal scars can be cross-tabulated with the ranges of maximum diameter as a way to evaluate the relative reduction sequence of the debitage and the intensity of lithic production. Since the scars on the dorsal face of the flakes or chunks are left by previous reduction behaviors, the debitage generated in later phases usually contain more dorsal scars than the ones generated at earlier stages of reduction. By inspecting the distribution of the numbers of dorsal scars of the debitage in different ranges of maximum diameter (as shown in Table 4.10), we can find that the debitage with varying grades of dorsal scar numbers are distributed in each size category. Such a pattern suggests that for each household, the reduction sequence from the beginning to end has been widely applied to process raw materials in different sizes.

The medians and means of the maximum diameter and weight can further serve as indexes to measure the central tendency of the distribution of debitage sizes. As shown from the Table 4.8 and 4.9, the median values are relatively low in viewing the whole distributional ranges of maximum diameter and weight. They are also smaller than the mean (such difference is obvious especially in case of the weight). It implies that while a few of very large or heavy debitage generated at the primary stage skew up the distributions of the means, the majority of the debitage falls within the range of medium to small ones which are more likely to be generated at the secondary stage of reduction. Such a distributional pattern fits in with the material implications of the strategy of independent lithic production from beginning to end since the later stage of lithic reduction sequence usually requires fine-tuned modifications and tends to generate many more pieces of debitage than in earlier stage of reduction.

Table 4.8 The basic statistical information of the maximum diameter of the debitage samples from different houses of the Yumin and Simagou site

House	Median	Mean	SD	ER (95% CL)	Range	P% (<2 cm)	P% (2-4 cm)	P% (>4cm)
YMF2	21.4	26.2	16.4	3.3	71.7	45	40	15
YMF3	27.9	29.8	13.3	2.6	64.8	27	52	21
YMF4	29.5	33.8	15.4	3.1	76.9	12	61	27
YMF5	23.2	25	10.8	2.1	84.1	33	61	6
YMF6	22.4	25.2	12.3	2.4	89.5	35	59	6
YMF13	21.5	25.5	11.8	2.3	54.9	40	49	11
SMGF9	36.5	53.2	85.9	17	780.3	13	46	41

Table 4.9 The basic statistical information of the weight of the debitage samples from different houses of the Yumin and Simagou site

House	Median	Mean	SD	ER (95% CL)	Range	P% (<0.1g)	P% (0.1-1g)	P% (1-10g)	P% (>10 g)
YMF2	1	8.5	27.7	5.7	189.5	20	31	38	11
YMF3	2.8	6.2	10.4	2.1	75.1	11	17	57	17
YMF4	3.2	11.1	21	4.2	152.9	2	13	61	24
YMF5	1.2	2.3	4.6	0.9	42.3	4	38	55	3
YMF6	1.5	5.457	18.3	3.6	168.2	5	34	53	8
YMF13	1.15	4	8.9	1.8	63.8	11	36	45	8
SMGF9	5.4	28.7	89.9	17.8	794.7	0	14	47	39

Table 4.10 The cross-tabulation of the ranges of the maximum diameter and the numbers of the dorsal scars of the debitage

House Number	Max Diameter of the debitage	Number of dorsal scar		
		0-3	4-6	>6
YM-F2	0-2 cm	21	16	7
	2-4 cm	15	14	10
	>4 cm	7	5	2
YM-F3	0-2 cm	15	11	1
	2-4 cm	21	26	5
	>4 cm	12	7	2
YM-F4	0-2 cm	7	5	0
	2-4 cm	12	30	19
	>4 cm	8	8	11
YM-F5	0-2 cm	11	17	6
	2-4 cm	10	33	17
	>4 cm	2	3	1
YM-F6	0-2 cm	15	15	6
	2-4 cm	17	27	14
	>4 cm	1	4	1
YM-F13	0-2 cm	15	23	2
	2-4 cm	20	22	7
	>4 cm	4	5	2
SMG-F9	0-2 cm	9	3	1
	2-4 cm	32	13	1
	>4 cm	23	15	3

The range of reduction stages and the relative intensity of lithic reduction can also be measured by the amount of cortical surface remaining on debitage. The debitage generated at the primary reduction stage tends to contain a large proportion of cortex on the surface. As the reduction process continues, more and more portions of the cortex will be removed out from the cores or blanks. According to this pattern, the debitage sampled from each house are classed into three categories. 0% suggests that there is no cortex on the dorsal side and 0-50% suggest that the cortex takes less than 50% of the dorsal surface. The debitage belonging to these two categories were probably produced at the secondary part of the reduction sequence. 50-100% suggest that the cortex has taken over 50% of the dorsal surface and the ones belonging to this category imply that they are generated at the primary stage of the reduction. The proportion of the debitage belonging to each category from each house is illustrated as the bullet graph for comparison (as shown in Figure 4.16). From it, we can see that the debitage in each house is distributed across all three categories and the majority of them have none or less than 50% of the cortex. Such a pattern quite likely indicates the independent production of the lithics by each household since they have debitage left at difference stages of lithic reduction sequence and the ones generated by fine retouching or reshaping at the later part of reduction sequence are more than the ones produced by primary detaching and shaping, which fits the normal rules of the individualized lithic production.

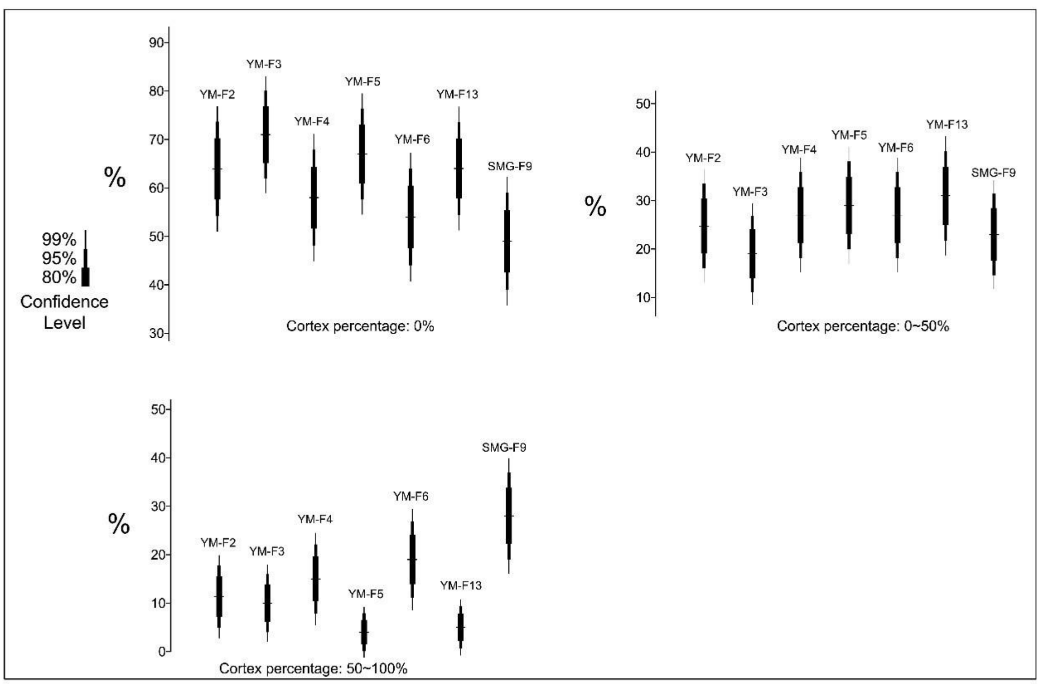

Figure 4.16 The proportional distribution of the debitage sample of varying levels of cortex percentage in different houses of the Yumin and Simagou sites

As analyzed above, several lines of evidence point that each household is engaged in lithic production from the initial shaping of raw materials to the finely retouch of the tool blanks. The differences of the debitage assemblage across the households of the Yumin and Simagou sites also reflect the differentiated emphasis of tool making pertinent to the subsistence practices, which is well in accordance with the pattern revealed by the distribution of lithic tools across different households.

For instance, one significant difference is that the debitage in house F9 of Simagou site is composed of a higher proportion of coarse-grained igneous rock than in other houses (as shown in Figure 4.17). Such difference might have resulted from the fact that the house F9 of the Simagou is more intensively engaged in the production of heavy-duty and farming tools which are often made by coarse-grained raw materials. These two types of tools compose 20% of the whole tool assemblage in Simagou house F9, which is higher than those in all the Yumin houses.

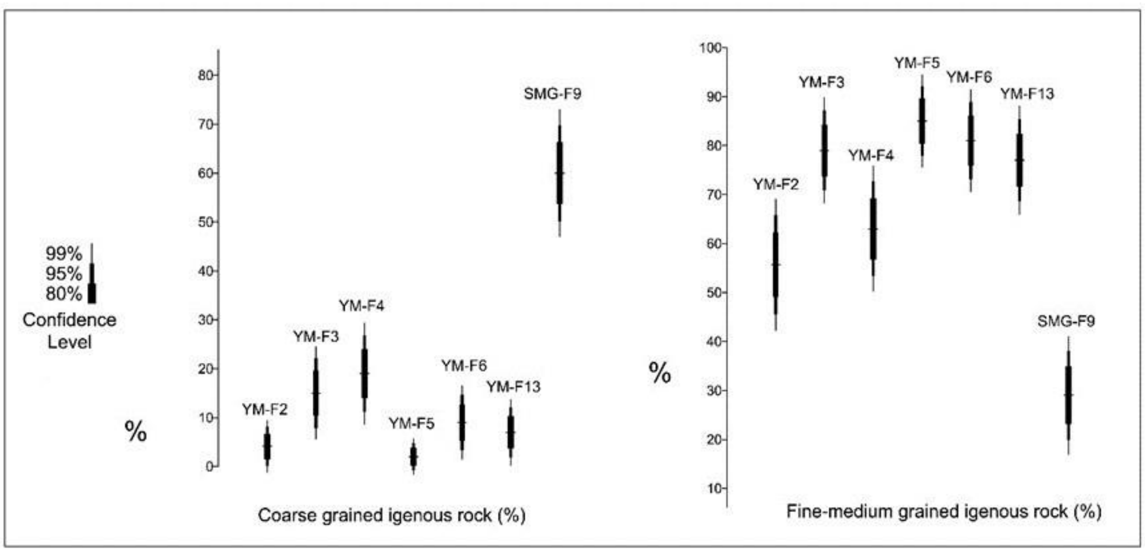

Figure 4.17 The proportional distribution of the raw materials of the debitage sample from different houses of the Yumin and Simagou site

In addition, the households of the Yumin site in general, have more intensive lithic reduction behaviors than the ones in Simagou site (as represented by F9) since the general debitage sizes are smaller (as shown in Table 4.8 and 4.9) in the Yumin houses and they have higher proportion of the debitage with none or less than 50% cortex remains than those in SMG-F9 (as shown in Figure 4.17, the significance level is based on the cases being compared). Such difference might have resulted from the fact that the households in Yumin are more intensively engaged in microblade production, since numerous medium to small-sized debitage with little cortex remains can be generated during the process of microblade production, like core-preshaping, platform retouching, and the detaching surface rejuvenation.

4.5 Other lines of evidence which shows the features of land-use in the Early Neolithic period

Besides lithic remains, the excavated materials in other aspects also provide important information about the subsistence practice, degrees of sedentism/mobility and levels of social integration. In the following part, I will briefly introduce faunal and floral remains, pottery, house structure, and site size, since all such information can well complement with lithic remains to deepen our comprehensive understandings of people's lifeways and land-use strategy in Early Neolithic period of this region.

A large number of faunal remains have been found from the Yumin and Simagou site and the animal bones found in both of the sites are composed by wild animal species. While a highly diversified animal species in various sizes have been found in the Yumin and Simagou site, the medium to large-sized animals takes a large percentage of the faunal remain, including horse/donkey, cattle, boar, and different kinds of deer. The faunal remains include the animals living in different eco-habitats, suggesting that people in Yumin and Simagou site have fully exploited a range of animals from different micro-environment zones around the settlement[11]. The excavators said that the Yumin site have found more faunal remains than the Simagou site[12]. However, without the statistical numbers of the faunal remains, it is hard to normalize them into ratios and proportions for comparison right now. If the future comparison work shows that Yumin site does have left more amount of faunal remains, it can serve as another line of evidence to indicate that people in Yumin are more engaged in hunting activity.

The flotation work in Yumin did not find any domesticated millets, but the work in Simagou has found one and a half pieces of the foxtail millet. The number is too few to estimate whether or not it is the domesticated one. Yet the most recent study of the starch grain from the grinding stones suggests that both foxtail and broomcorn millets in the domesticated forms have been exploited in the Yumin and Simagou site. In addition to the millets, tuber starches were also detected, such as the lily bulb and snake gourd root[13].

The basic features of pottery in this period have been introduced in chapter 2. A major difference of the pottery form between the Yumin and Simagou is that the jar and cauldron of Yumin site have an oval-shaped bottom, while the ones in the Simagou site have a small flat bottom. It seems that people in the Yumin site have more intensive use of pottery than people in the Simagou site. While the ratio of pottery sherds to lithic remains is 0.37 in the Yumin site (1660/4445), it is only 0.25 in the Simagou site (784/3146). Such difference might result from the

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[11] The information of faunal remains is got by the personal observation from the work station and the communication with Dr. Lu, who is in charge of the study of faunal remains for the project.

[12] From the personal communication with Mr.Ren from Inner Mongolia Institute of Archaeology and Cultural Relics, who is in charge of the excavation of both Yumin and Simagou site

[13] The floatation result was come from the unpublished report from Mr. Hu, the co-director of the project for Huade survey and excavation. Dr. Sun Yonggang from Chifeng College provided this result. The result of starch grain analysis was derived from He Yanhui and Chen Ran from Stanford University.

fact that these two sites are occupied perhaps at different time period with different emphasis on subsistence activity and therefore are requested in varying extents for the pottery use (Sturm, et al. 2016). The feature of pottery assemblage is a good indicator to evaluate the levels of sedentism. Since pottery are fragile and not easy to carry with, people only pay greater investment to make them when they have more stable residency in the confined area. The high investment of pottery making and the intensive expectations of pottery use usually lead to the specializations of pottery forms, the sophistication of pottery design and the more advanced firing techniques (Shelach-Lavi and Tu 2017). As for both the Yumin and Simagou sites, the pottery can be categorized into only a few numbers of types according to the form and design. They are relatively simple with no extended efforts on shaping and decorating. The uneven colors on the surface and the porous sherd sections with high contains of charcoal and organic matters indicate that the pottery are low-fired at open space rather than being fired at the well-controlled kilns. The limited efforts invested for pottery making suggest that people in the Yumin and Simagou still not lived on a stable sedentary lifeway.

Like pottery, the extents of investment for the residential architectures also well indicate the levels of sedentism. The existence of post holes indicates that there are wood-frame structures to support the pit house of the Yumin and Simagou sites. In many of the houses, we can find the earth platform which is elevated above from the living surface along the inner walls of the houses. Such earth platform, as inferred by the excavators, might be used to strengthen the houses to avoid for the collapse of the houses since the soils in this region used for house construction are sandy and loose. The signs of postholes were also found in some of such platforms, indicating that it might also serve as the flat to support the poles. No particular treatment has been identified from the house floors. The hearths are usually found in the middle of the houses. Yet unlike the pit hearths or the stone-lined houses which can be frequently found in the Neolithic Yellow river valley or west Liao river valley of North China (Zhongguo 2010), no special treatment has been made for the hearths in Yumin and Simagou sites. They are slightly higher than the house floors and are mainly identified by the concentrated distribution of ashes. Therefore, it is estimated that people repetitively set fires on the ground at the confined area of the houses and as time went by, the layers of ashes are accumulated and formed the so-called heaths (as shown in Figure 4.9). The features of the pit houses, on one hand, suggest that compared with the more temporary forms of dwelling structures, people have paid more investment into the constructions of their dwelling places, which indicates that people expect to use them in a longer period of time. But one the other hand, there was no fine treatment of the living floors and the heaths. Combining such evidence with the refuse disposal patterns as analyzed above, the pit houses in the Yumin and Simagou sites were unlikedly used as intensively and durably as those used by the fully sedentary groups.

Since both Yumin and Simagou are residential settlements, the site size of them is closely correlated with the numbers of the houses. It is estimated that the excavation area of the Yumin site has recovered the most part of the settlement as indicated in chapter 3. Even though the southeast corner of the site has been destroyed by the gulley, it is estimated that no more than 5 houses could be likely distributed at the destroyed part based on the considerations of the area of the destroyed part and the intervals of the house distributions. Therefore, it is highly possible that no more than 20 houses have been built within the settlement. Assuming that they are simultaneously built and each of them is lived by a nuclear family with 4-6 people, only more or less than 100 people have lived in this settlement. Surely, such population size is larger than many of the small-scale mobile hunter-gatherer groups, but it is still smaller than the population size of fully-fledged farming communities of Neolithic China. Simagou site seems to have a similar group size with that of Yumin site. Even though the whole settlement has not been thoroughly excavated, yet based on the information of surface collection, the core part of the site has been already excavated and there are only limited areas left unexcavated. Hence, this settlement has probably about 20 or slightly more than 20 houses. The house intervals in the Simagou site are smaller than the Yumin site, and there is a phenomenon that the later on built house is overlaid on part of the earlier built house, suggesting that people are confined to build their dwelling structures within the circumscribed area. No unequivocal explanation has been made to explain this phenomenon. Both the need to increase the inter-household interaction or the increasing request to strengthen social order can potentially be considered as the reasons for it, which still needs further investigations by more lines of evidence.

4.6 Discussion and conclusion

Subsistence, seasonality, and mobility

Multiple lines of evidence indicate that both the Yumin and Simagou communities relied heavily on hunting and gathering as their subsistence base. Whereas farming had already been incorporated into subsistence practices, it was still in its infancy and served as a secondary complement to hunting and gathering. The products from farming made only a minor contribution to the diet.

Some interesting differences can be detected between Yumin and Simagou, suggesting that people in the Yumin site were more intensively engaged in hunting and animal resource processing while people at Simagou made greater investments in farming. Combined with site locations, such different emphasis on subsistence activity might be correlated with different seasonal use of the sites, which is estimated as the model of Figure 4.18 shows.

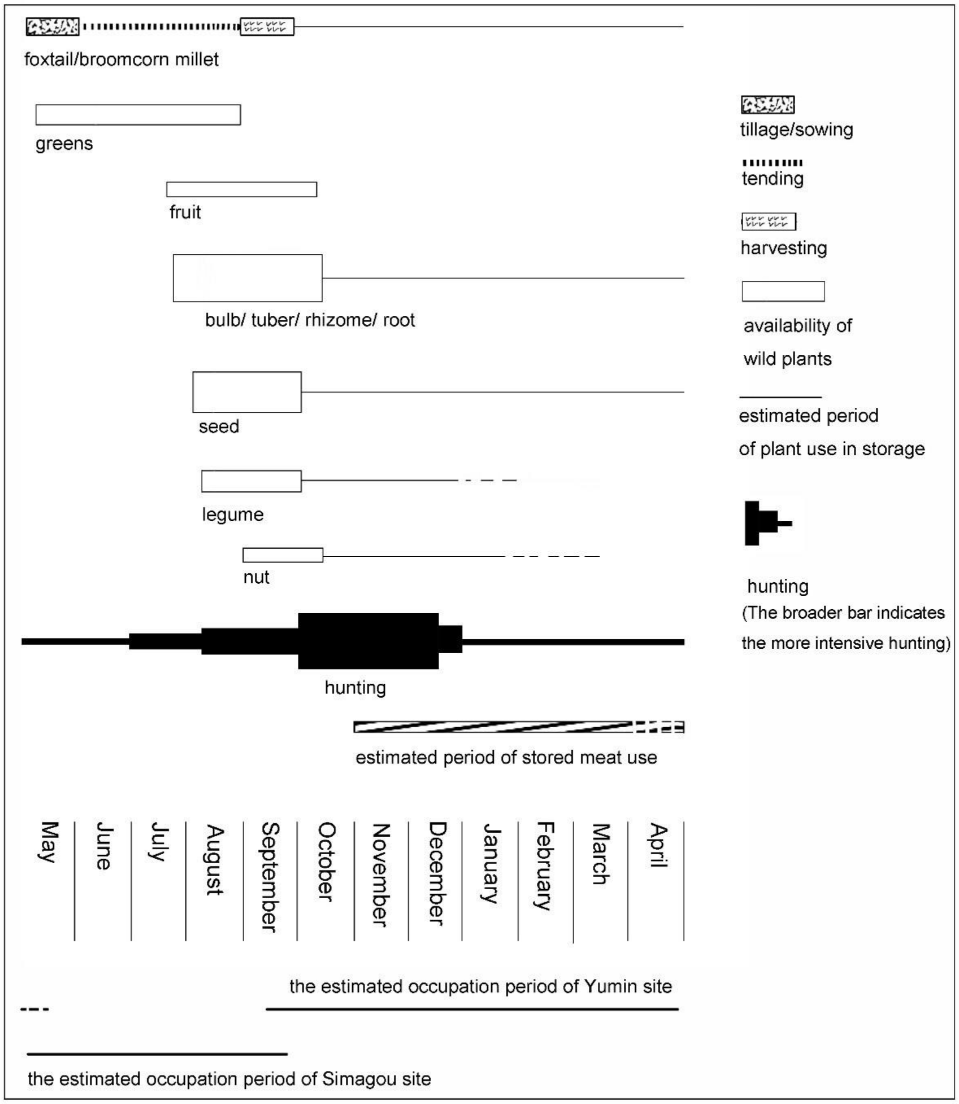

Figure 4.18 The estimated model showing the seasonality of resource exploration and site occupation (The model was made by taking the references of the "Flora Inner Mongolia"(Ma 1985) and "Fauna Inner Mongolia" (Xurigan 2016))

As indicated by Figure 4.18, resource distribution in the Mongolian Plateau is highly seasonal. Even though hunting could be a year-round subsistence activity, the high season for hunting in the Mongolian Plateau is from late fall to early winter (Song 2001). This is a period when some species of medium to large-sized herbivores aggregate in larger herds. Animals during this season are usually fatter than in the rest of the year. Therefore, this period is ideal for people to hunt fatty animals in large quantities. The upcoming colder weather also provides good conditions for storage and people can keep a large amount of the hunted prey without drying them to prevent from spoilage. Meanwhile, this season also provides good visibility for hunters to search for preys and enhances the success rate of hunting since the trees have faded and the grass has withered; a thin covering of snow makes it easier for hunters to track the footprints of the animals. This period and the upcoming mid-winter are also the high time of hide working as well. Since the majority of furred animals were hunted during this period and the intensive work of hide processing is required to be done right after the acquisition of these hunted animals (Song 2001).

Intensive hunting combined with massive storage of certain kinds of plant resources could enable people to aggregate and settle down in one place to spend the long and cold winter. Farming could not be conducted during this period due to the frozen land and cold weather. However, people could till the land and sow the seeds before they transfer to other settlements when the weather got increasingly warmer and reap the products when they come back again; or a few households might still live in this site and engage in the farming activity when the majority of the community members left for the other settlements.

The features of Yumin site well meet the expectations of the material implications of the settlement dwelled during this colder period of the year (from late fall to the early or late spring of the next year), since there are high proportions of end scrapers and microblade remains which pertinent to hunting and fur-processing activity; the farming tools are very rare, but there is a moderate number of grinding stones which were used to process the stored plant resources (like seeds, nuts, tubers, bulbs). Furthermore, the Yumin site is located at a southeast-facing mountain cove with closed landforms surrounded by low mountains to the north, east, and west. This location provided good conditions to block off the winter winds and helped people to reduce the sufferings from cold and windy weather.

In comparison, relatively open surroundings and a northwest facing direction made Simagou a terrible place to be during the cold period of the year, since it suffers more heavily from the cold and windy climate brought by the northwest oriented winter monsoon. However, it could still be an ideal place for dwelling during the warmer period of the year when sheltering away from the winter wind is no longer a big consideration for site locational choice. The proximity to the small river, diversified landscapes, and thick soil depositions between mountains and river bottom provide the Simagou site with convenience of living and good conditions for foraging and farming. The lower proportions of microblades and end scrapers suggest that this site was probably not used during the high hunting and fur-processing season. However, the more diversified toolkits used for plant resource processing composed of diversified grinding stones and some heavy-duty tools, like pounding tools, probably indicate either people exploiting a wider range of plant resources or applying more methods for plant processing (Sun 2017). Such a more complicated engagement with plant resource processing more likely appeared during the warmer period of the year, like summer and early fall, the high time for plant food collection (Song 2001). Furthermore, the warmer period of the year is also the season for farming activity. According to the observation of millet cultivation in the southern Mongolian Plateau, the sowing season is usually in May and the reaping season is in September (Li 2006). Therefore, the north-west facing site locations, relative higher proportions of farming tools, more diversified tools involved with plant resource processing and lower proportions of end-scrapers and microblade remains suggest that Simagou site was more likely inhabited and used during the warmer seasons of the year (from late spring or early summer to the early fall).

Admittedly, the hypothesis of such seasonality of site use is mainly based on site location, lithic assemblage and the seasonal resource distribution pattern of the Mongolian Plateau. More direct evidence of seasonality, like the faunal and floral remains, are still needed to be studied in depth to further test this hypothesis.

The possibility of seasonal use, nonetheless, corresponds well with the levels of residential stability indicated by the two sites. The pit-house construction, pottery making and the refuse pattern of the lithics all indicate that even though people have paid substantial investment for their settlement constructions and have higher expectations of residential stability at least on some localities of their territory, they have not yet evolved the habits to adapt to stable sedentism or made intensive enough investments in house construction required by more stabilized sedentary lifeways.

Social integration

Both the Yumin and Simagou sites are on a tiny village scale, which is larger than the camp sites found from the late Upper Paleolithic period of North China. The enlarged settlement suggests that people have begun to aggregate into larger social communities. However, such an aggregational scale is small, compared either with the fully-fledged agricultural communities that appeared in the Mid Neolithic period or the few contemporaneous low-level food producers' communities that were in the more affluent environments in North China (Chen 2013).

According to the analysis of the intra-site distributions of the lithics, the community was composed of a group of households with high levels of economic independence. Each household produces its own set of lithic tools that met the basic demands of subsistence practices by itself. Economic specialization was weakly developed within the community. Such a structure suggests that the community was flexibly organized with no complicated interconnections and mutual reliance among the social members. Equipped with tools and corresponding skills to cope with different subsistence needs, the individual households existed as the basic production units and were free to aggregate or disperse according to the changes and fluctuations of resources across the year.

5.0 The land-use analysis of Early Neolithic period based on the survey data

To fully understand the land-use pattern of the Early Neolithic period, we need to know what roles did the Yumin and Simagou sites play in the whole settlement system and whether or not there are other types of sites showing different focuses of activities than the two excavated sites. Such an exploration requires us to look beyond the two excavated sites and investigate the features of multiple sites on a broader regional scale.

Limited by time, financial budget, and preservation conditions, it is unrealistic to excavate all the sites near Yumin and Simagou. Moreover, due to the various post-depositional disturbances of the sites after their abandonment (such as the wind or stream erosions, furrowing, etc.), some of the sites are badly preserved and most of the artifacts are exposed on the ground. In such conditions, the surface collections of the surveyed sites provide us the most efficient ways to learn about the settlement system.

5.1 The comparison of the survey and excavation data

A comparison of the materials from surface collection and excavation at the same site is of great importance for the two-tiered exploration of land-use. The excavated and survey data subject to the influence of different sets of taphonomic processes and are derived by different sampling methods. Therefore it is highly possible that what the excavated data reflect differs from what the survey data reflect even from the same site. A comparison of the excavated and surveyed data from the same site will help us evaluate how different or similar the information is reflected from excavation and survey data for the same site. If they reflect quite different patterns, we should be cautious for the further comparison of the excavated and surveyed data for subsequent research and need to figure out which one can better reflect the real pattern of the ancient human behavior. If they both reflect roughly the similar pattern in spite of different taphonomic and sampling issues, we can be more confident with the patterns they reflect for further research and hold the opinion that the excavation data and survey data are comparable. Then what we learned from the excavation data can further serve as the references to investigate the survey data. For instance, as discussed in chapters 3 and 4, the two excavated sites are residential settlements. Hypothetically, if the information revealed from the survey data of these two sites highly resembles that indicated by the excavation data, we may consider them as mutually comparable. Extending from the logic, any surveyed sites which show the similar pattern to the surveyed data of these two sites can be conceived as the residential settlements while the ones which distinctively differ from these two sites will be considered as other types of the settlements.

The Simagou site was found within the tributary valley. During the survey of 2017, four spots of the concentrated lithic scatter were identified along the river valley and were recorded as four localities. The Simagou loc.3 (abbreviated as SMG3) was later on got excavated and is called as the Simagou site. Therefore, the surface collections of SMG3 and the excavated data of Simagou sites can help us compare the similarities and differences of lithic assemblages found from survey and excavation at the same locality.

The Yumin site is deeply buried under the later depositions and was found by Mr.Ren from Inner Mongolia Institution of Archaeology and Cultural Relics, who was walking through the gully (the one which developed later than the site and eroded out the southeast part of the site) and found the exposures of the lithics and human bones in the profile of the gully. Therefore, there are no surface collections from the Yumin site. However, 500 meters to the southeast of Yumin site is another site called BN2, which has nearly the same site size and landscape settings as the Yumin site. Since the surface of the site is heavily eroded, numerous pieces of lithics have been found on the surface and have been collected. In addition, a pit house deposition with ashes of the hearth has been found in the profile of the gully in BN2 during the review survey of 2019 summer. The gully developed later than the time the site was used and interrupted the site on the northern side. The findings of pit house deposition suggest that the site was stably inhbitated like the Yumin site. Due to the findings of abundant lithic remains in various types, the discoveries of the signs of dwelling structures, as well as the similarities of site size and landscape settings between this site and the Yumin site, it is likely that this site is similar to the Yumin site in terms of site functions and the nature of occupation. Therefore, though they were not collected in the exact same locality, the comparison between the surface collected data of BN2 and the excavated data of Yumin can still help us compare the similarities and differences of lithic assemblages found from survey and excavation for a site with specific similar functions.

Table 5.1 The comparison of the proportional distribution of different types of lithics between the excavated and surveyed sites

	Tool (%)	Microblade (%)	Microblade(R-U) (%)	End scraper (%)	Light-duty tool (%)	Grinding stone (%)	Heavy-duty tool (%)	Woodworking tool (%)	Farming tool (%)	Crafting tool (%)
Simagou (Excavation)	16.0	7.2	9.1	3.9	18.1	24.9	13.2	5.2	5.0	13.0
SMG3 (Survey)	15.5	9.7	4.1	6.8	12.3	11.0	12.3	1.4	13.7	12.3
Yumin (Excavation)	15.3	16.6	16.6	12.8	28.7	22.8	1.3	5.4	0.1	11.0
BN 2 (Survey)	10.7	14.2	21.4	11.6	38.7	7.5	1.7	2.9	1.2	5.8

(Note: the proportion of tools and microblade remains are calculated by dividing the total number of the tools or microblade remains by the total number of lithics in each site (including the debris). The denominators of other lithic tool types are the total number of lithic tools of each site.)

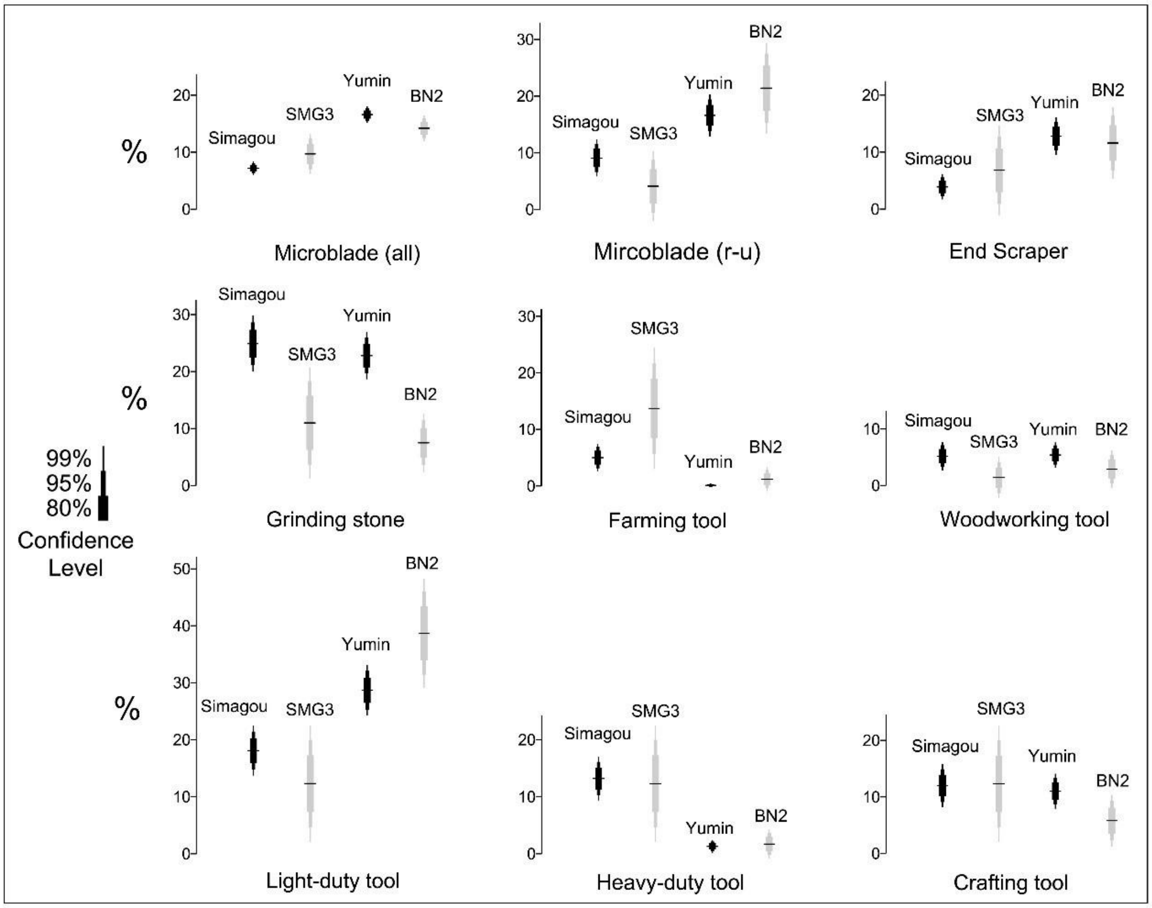

Figure 5.1 The comparison of the proportional distribution of different types of lithics between excavated and survey sites

(Note: Microblade (all) includes all the identifiable pieces of microblade; Microblade (r-u) only includes the pieces of microblade which only have signs of use or retouch. The proportion of Microbalde (all) is derived by using the total number of microblade to divide the total number of lithics; while the denominators of the others are only the total number of lithic tools (which means the debitage are not included))

From the comparison of the lithic assemblages between excavated and surveyed data as shown in Table 5.1 above, we did not see rigorous consistency of the proportions of different toolkits between the excavated and surveyed data of the same sites or the two adjacent sites. The two paired cases of comparison show that the surface collection tends to overrepresent the proportions of farming tools but underrepresent the proportions of grinding stones and woodworking tools in comparison with the excavated data. The proportion of end scrapers, heavy-duty tools, and microblade (all) are relatively closer between surveyed and excavated recording (as shown in Figure 5.1, although the difference is significant for the proportion of microblade (all) and wood woodworking tools, the strength is low). The proportion of the light-duty tools and the proportion of the microblade (retouched or used) might be either overrepresented or underrepresented by the surveyed data in comparison with excavated data according to different cases. While the proportion of crafting tools is similar between surveyed and excavated data of Simagou, it is significantly underrepresented by surveyed data of BN2 in comparison with the excavated data of Yumin.

Despite such differences, the comparison of the surveyed data between the SMG3 and BN2 site reflect similar patterns of proportional differences of tool assemblage as implied by the comparison of excavated data of Simagou and Yumin. For instance, even though the surface collections have overrepresented the proportion of farming tools in comparison with the excavated data, SMG3 still shows significantly higher proportions of the farming tools than BN2. Moreover, the proportion of heavy-duty tools is significantly higher in SMG3 than in BN2, while the proportions of microblade remains are significantly lower in SMG3 than in BN2. Such aggrement of the patterned differences revealed by both surface-collected and excavated data suggest that the inconsistency of the proportional differences of the lithic assemblage between surveyed and excavated data has not been large enough to obliterate the patterned inter-site variations observed from the survey data.

The comparison between surface collected and excavated data reminds us that the proportional distributions of different toolkits from survey data cannot well represent that from the excavations of the same spot or the site with the same features. Therefore, the excavated Yumin and Simagou sites cannot be used directly to compare with other surveyed sites in terms of the proportional differences of the different toolkits. However, the surveyed data alone can also reflect patterned differences of the lithic assemblages across the sites, just like those reflected by the excavated data. Therefore, the surveyed data can still be reliably used to evaluate the variations of the sites across the studied area to learn the land-use pattern.

5.2 Inter-site variations of the survey data

5.2.1 Site types: the conceptional frame to inspect inter-site variations

Site types are important analytical concepts for the study of land-use strategies by mobile hunter-gatherers. This set of concepts firstly derived from the ethnographic observations of the foraging groups since they are engaged with different ranges of activities in different places and occupied in these places with varying extents of intensity and durations. Based on such behavioral variations, these sites can be attributed to several types, and each type might correspond to a different role the site played in the whole settlement system (Binford 1978a; Binford 1980; Nelson 1991).

Archaeologists have tried to identify the material implications of these site types based on the associations of the artifact classes and labeled these sites as different names under different studies. But in general, they can be summarized as three categories: (1) Base camp or residential base: refers to the site where the members of groups aggregate and occupy as the home base for over one or more seasons. (2) Field camp: refers to the site served as temporary home bases for task groups operating far from the base camp. (3) Task site or locations: refers to the sites used by task groups to procure or process certain kinds of resources. They can be further divided as quarry site, butchering site, hunting spot, cache, and etc based on the resolution of material remains (Bettinger, et al. 1994; Binford 1980; Ebert 2001; Janz 2012).

Applying the approach of site types is desirable to investigate the land-use pattern of the Early Neolithic period in the survey region since people living in the Northern Yinshan Mountain range area at this time were still not fully sedentary groups. Besides, based on the inter variations of the surveyed sites, it is fairly unlikely that they all belong to the same type of sites.

However, the detailed division of the site types and the application of it for studying land-use patterns are often subject to harsh critiques. Since the land-use strategies are mixed and differentially emphasized in many ways, the sites with different natures of use are not always neatly corresponded with specific patterns of artifact association. Moreover, the characteristics of particular site types in one region will not necessarily apply to any other region (Nelson 1991). The palimpsest effect and post-depositional disturbance would further add complexities for the analysis of the artifact assemblage and make it not always correspond well to certain behaviors of site use (Schiffer 1987; Schiffer 1972).

A simple and coarse-grained categorization of the site types might help us to avoid or reduce the impacts of such problems. Since distinguishing residential and task sites should be easier than recognizing more detailed types of site function. I will mainly attribute the sites found from the survey into these two categories. The residential site encompasses the ones used more like base camps as well as those used like field camps. I will call them main residential site and the temporary residential sites as two sub-categories for distinction. The detailed discussion of them is presented as the following.

5.2.2 Samples and attributes used for evaluating the inter-site variations

Sixty-nine sites found from the survey contain the Early Neolithic remains. Among these sites, 28 of them only contain the Early Neolithic remains, including the excavated Yumin and Simagou sites. While for the rest of the sites, the Early Neolithic remains are commingled with the Middle Neolithic or Early Bronze Age remains.

I have selected 15 sites for further analysis. Except for SHSK (which is a commingled site, but it is dominated by Early Neolithic remains and the artifacts found during Mid-Late

Neolithic/Early Bronze Age are very rare), all the other ones are single component Early Neolithic sites. The reason why the other 13 single component Early Neolithic sites are not selected is either because the artifacts of some of these sites are not stored in the work station for the laboratory analysis or because they have too few pieces of lithics (less than 45 pieces) for the meaningful comparison. Moreover, the Yumin site only has excavated materials but no recordings of the surveyed materials. Since as mentioned above, the excavated materials and the survey materials at the same spot reflect different proportional values of the same kind of tools, the two excavated sites will not be included to make a direct comparison with other surveyed sites. Instead, the surface collection of SMG3, which locate at the same place with the excavation area of the Simagou site, is included as the representation of the excavated Simagou site. It should be emphasized here that the SMG3 mentioned in the following discussions actually refers to the same site of Simagou as mentioned in Chapter 4. Using the name of SMG3 instead of Simagou is just to emphasize that the analysis of this site comes from the survey material instead of the excavated material. The BN2, as mentioned earlier in this chapter, resembles the excavated Yumin site and hence can be used to represent the excavated Yumin site for comparison.

A quantitative evaluation of the artifact composition is of great importance for us to identify the site types and evaluate the inter-site variations. The proportional differences of various types of artifacts, diversity of lithic raw materials and tools, and the quantities of pottery and lithics (as long as the quantity is not subjected to the sampling issues) are all important variables to reflect the features of artifact composition. The information of such variables for each site is listed in Table 5.2 below. As for the variables shown in Table 5.2, the proportions of different tool types in each site are measured by using the number of the specific type of the tool in that site divided by the total number of tools in the site; the proportion of microblade cores is measured by using the number of microblade cores in that site divided by the combination of microblade cores and total number of tools in the site; the proportion of tool blank is measured by using the number of tool blanks in that site to divide total number of the tools in it; the ratio of pottery is measured by using the number of pottery sherds in that site to divide the total number of lithic tools in the site; the diversity of raw materials and lithic tools are all measured by Simpson’s D index (1-L). A higher value of the index indicates higher diversity. One thing to emphasize here is that the relative importance of microblade tools was evaluated by the proportion of microblade cores instead of by the retouched or used microblades because (1) some small pieces of microblades were hard to identify on surface during the survey; (2) people were inclined to take away the microblades which are still available for use but leave the exhausted microblade cores as refuse on the surface in the more temporarily occupied sites. Therefore, microblade cores could more reliably reflect the ubiquity and intensity of the use of micoblade techniques.

Table 5.2 provides us with the basic raw data to evaluate the inter-site differentiations. What we should pay attention here is that some sites which have very few lithics and tool types, like DJGDB1 and DJGDB2, actually got similar diversity index score of the tools with the sites comprised by more types of tools and a far larger number of lithics (like SMG3 and BN2). Such a result might be caused by the fact that the few types of tools in these sites are more evenly distributed in numbers. Therefore, they got similar or even slightly higher diversity index scores than the sites with a broad range of tool types, but different types of tools take varying levels of proportion in the assemblage. Hence, despite such similarity in terms of the diversity score of tool types, they reflect quite different patterns of lithic composition. The varying levels of discrepancy across the sites as shown in Table 5.2 probably imply the existence of different types of sites used for different purposes, which will be analyzed below.

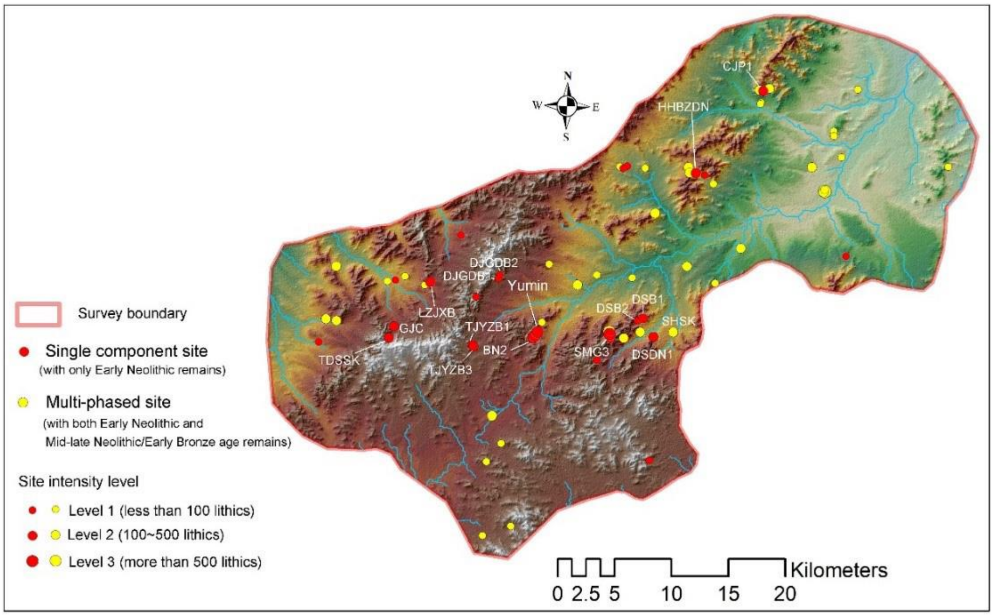

Figure 5.2 The map showing the locations of the 15 selected Early Neolithic sites and Yumin site

Table 5.2 The proportional distribution of different tool types across 15 selected Early Neolithic site

Name	Pottery sherds (N)	Lithics (all) (N)	Lithic tools (N)	Light-duty tool (%)	End scraper (%)	Wood-working tool (%)	Heavy-duty tool (%)	Grinding stone (%)	Crafting tool (%)	Farming tool (%)	Micro blade (r-u) (%)	Micro-blade core (%)	Tool blank[1] (%)	Others or unidentified (%)	Ratio of Pottery to lithics	Diversity of tool types	Diversity of raw materials
BN2	20	1614	185	36	11	3	2	7	5	1	26	24	0	9	0.11	0.84	0.6
CJP1	5	182	60	37	3	27	2	7	5	5	5	29	2	9	0.08	0.82	0.74
SMG3	2	472	73	12	7	1	29	11	12	14	4	8	3	10	0.03	0.92	0.76
SHSK	2	332	121	54	2	10	7	8	6	0	2	1	5	10	0.02	0.8	0.53
HHBZDN	2	274	68	40	13	13	0	9	9	1	7	7	0	8	0.03	0.85	0.82
LZJXB	3	309	68	51	1	21	1	12	3	0	6	6	7	5	0.04	0.72	0.27
GJC	3	313	113	45	2	30	4	3	2	1	0	3	31	13	0.03	0.79	0.26
TDSSK	15	383	90	18	10	18	4	10	8	1	9	19	12	22	0.17	0.9	0.7
TJYZB1	2	109	19	53	11	11	0	11	5	0	4	14	0	5	0.11	0.89	0.46
TJYZB3	0	171	22	55	0	18	0	5	5	0	16	15	14	1	0	0.79	0.37
DSB1	0	132	19	32	0	32	16	11	0	11	0	24	16	0	0	0.91	0.71
DSB2	0	77	10	60	0	0	10	10	0	20	0	0	10	0	0	0.71	0.58
DSDN1	0	118	41	34	12	29	5	10	0	0	0	11	15	10	0	0.87	0.56
DJGDB1	1	58	5	0	0	20	0	20	20	0	0	17	20	40	0.2	0.83	0.32
DJGDB2	0	95	4	0	0	0	50	0	0	0	0	0	25	50	0	0.8	0.04

5.2.3 The identification of the residential sites

As analyzed in Chapter 4, Yumin and Simagou are two residential sites probably used in different seasons of the year. The survey dataset can further assist us to learn how many other sites from the survey resemble Yumin and Simagou. The relative proportions of such more stably inhabited residential settlements in the survey area provide us invaluable information to learn the patterns of land-use and the degrees of mobility. If people were more sedentary (or "semi-sedentary" in rigorous terms of definition) to make use of the environments with the routine trans-seasonal shift of the base settlement, we expect to see the majority of the survey sites are similar with the Yumin or Simagou site. Nonetheless, if people are organized in more mobile ways and make use of the different localities across the landscape with varying levels of intensity, we expect to see that only a few of the sites resemble the Yumin and Simagou sites , and most of the other sites probably show the more ephemeral occupation or, the more task-specific use of the certain localities.

Due to the nature of relatively long-time occupation with intensified site use, the main residential settlement tends to contain large quantities of lithics relevant to people's daily activities. Also, there should be a fairly large number of tools used for a wide range of activities (Binford 1980; Hitchcock 1982; Thomas 1971). However, the more temporary dwelled sites also tend to generate a large number of lithics (both in terms of the total lithic remains or the lithic tools) if they are used repetitively for a long time span or used for certain kinds of activity which involve massive lithic production or use (Binford 1983). Therefore, the proportional distributions of different tool types and the diversity index of tool and raw material types (as listed in Table 5.2) must be used to distinguish such multiple possibilities (Cascalheira and Bicho 2018; Tremayne 2015). The bullet graphs of 13 out of the 15 sites mentioned above in 5.2.2 have been made to compare the proportional distributions of different kinds of tools across different sites (DJGDB1 and DJGDB2 are excluded from the comparison, since the numbers of the lithic tools of these two sites are too small and therefore the error ranges are too large to make any meaningful comparison). The error ranges made according to different confidence levels will assist us to evaluate how confident we can be for the differences of the proportional distributions we observed.

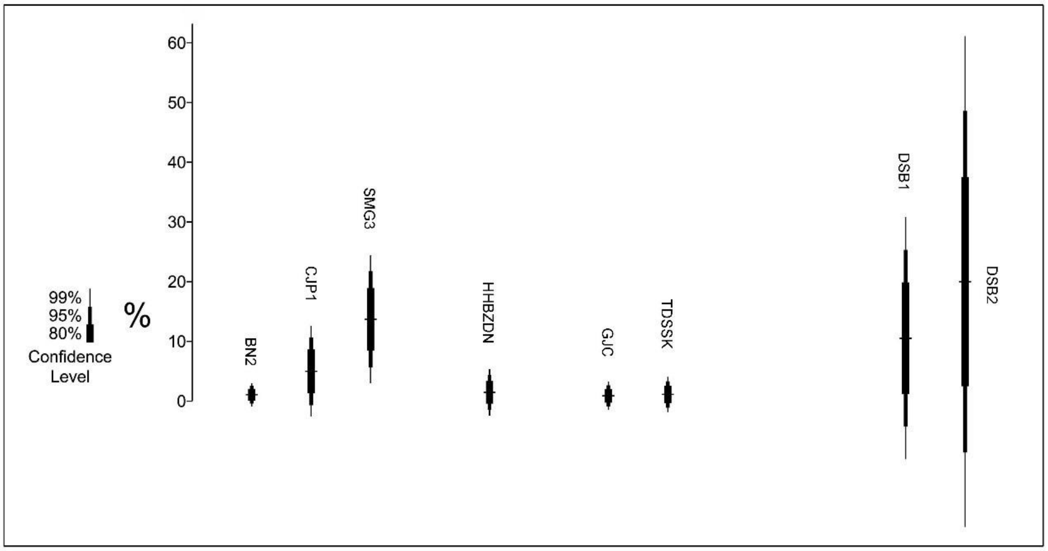

Figure 5.3 The bullet graph showing the proportional differences of the farming tools across the sites

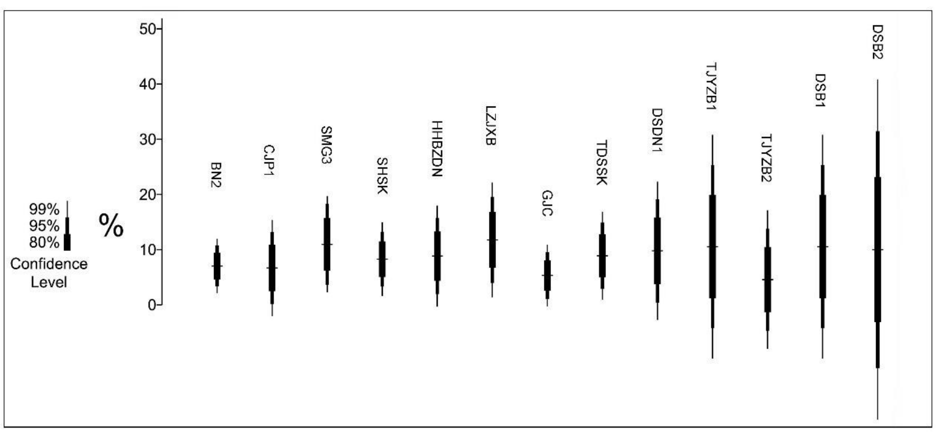

Figure 5.4 The bullet graph showing the proportional differences of the grinding stone tools across the sites

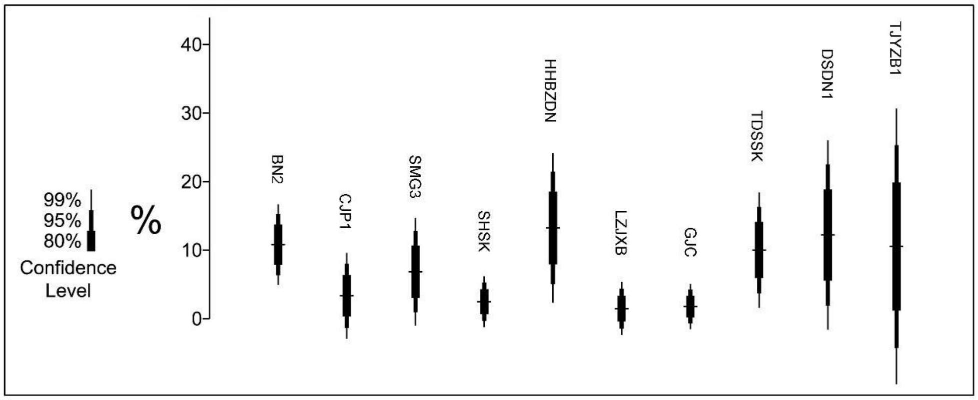

Figure 5.5 The bullet graph showing the proportional differences of the end scrapers across the sites

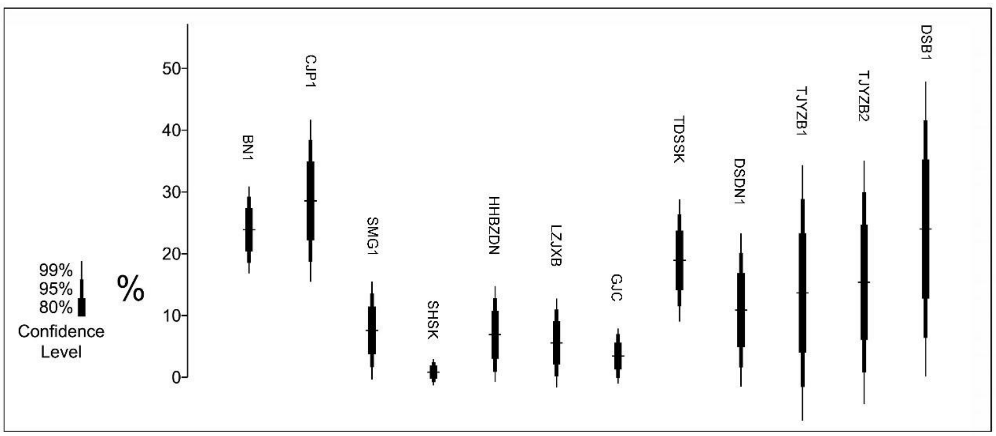

Figure 5.6 The bullet graph showing the proportional differences of the microblade cores across the sites

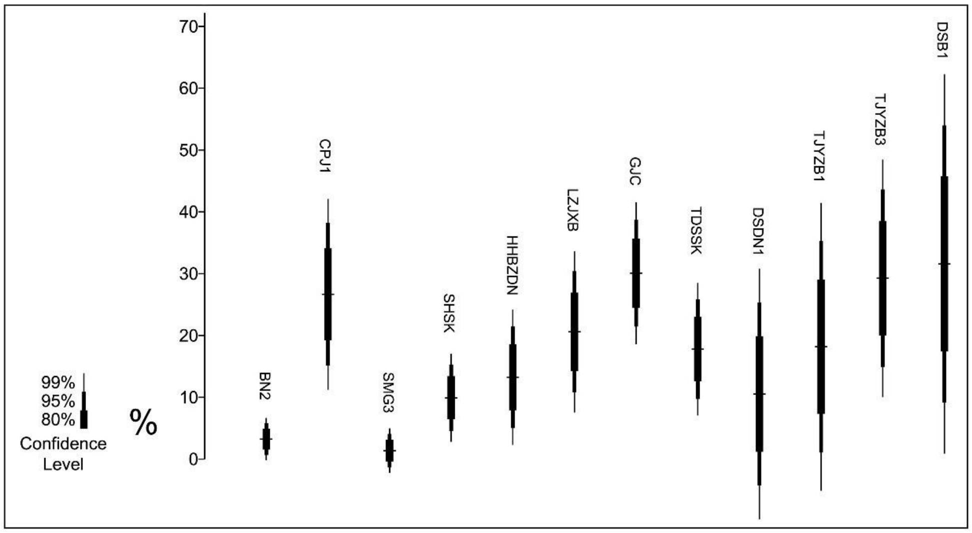

Figure 5.7 The bullet graph showing the proportional differences of the woodworking tools across the sites

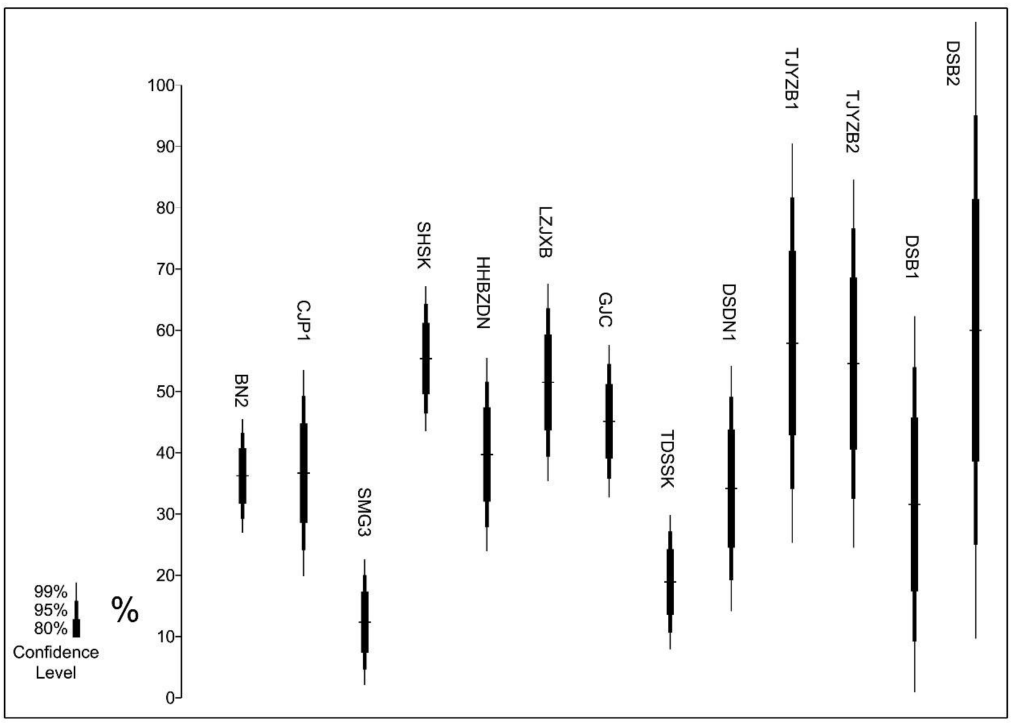

Figure 5.8 The bullet graph showing the proportional differences of the light-duty tools across the sites

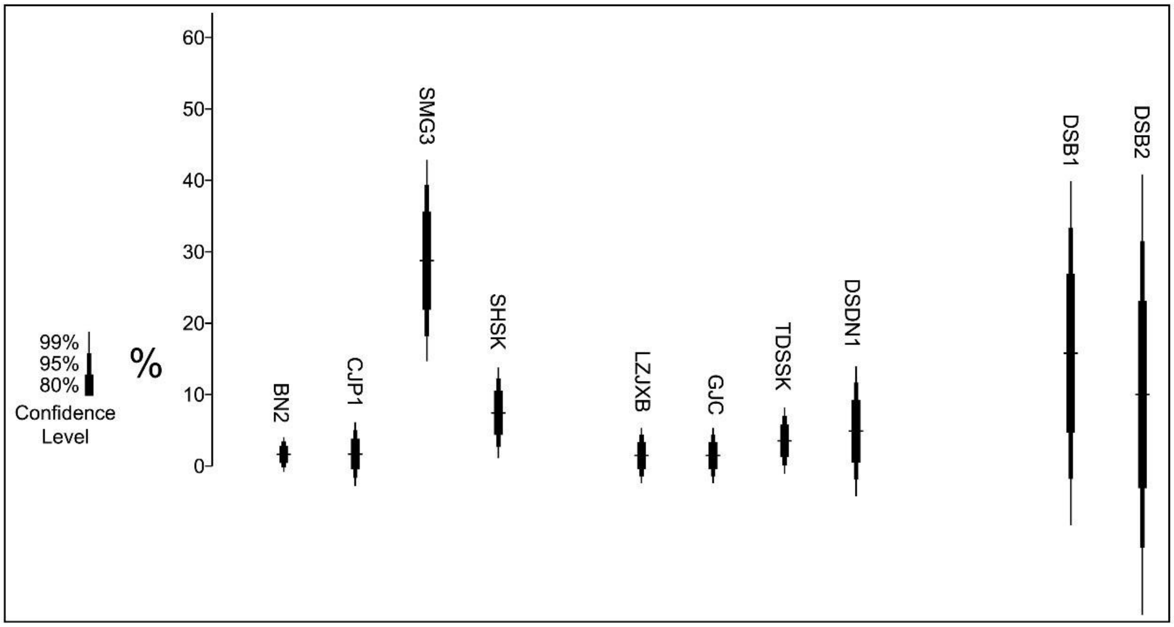

Figure 5.9 The bullet graph showing the proportional differences of the heavy-duty tools across the sites

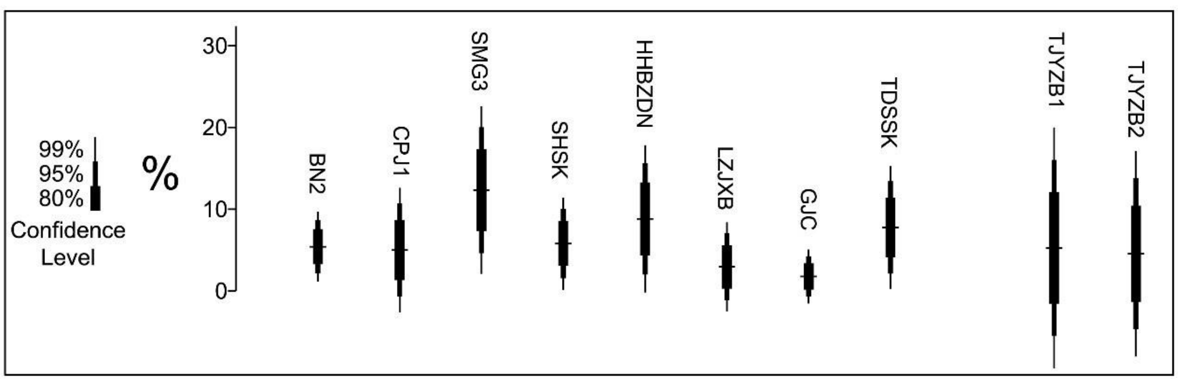

Figure 5.10 The bullet graph showing the proportional differences of the crafting tools across the sites

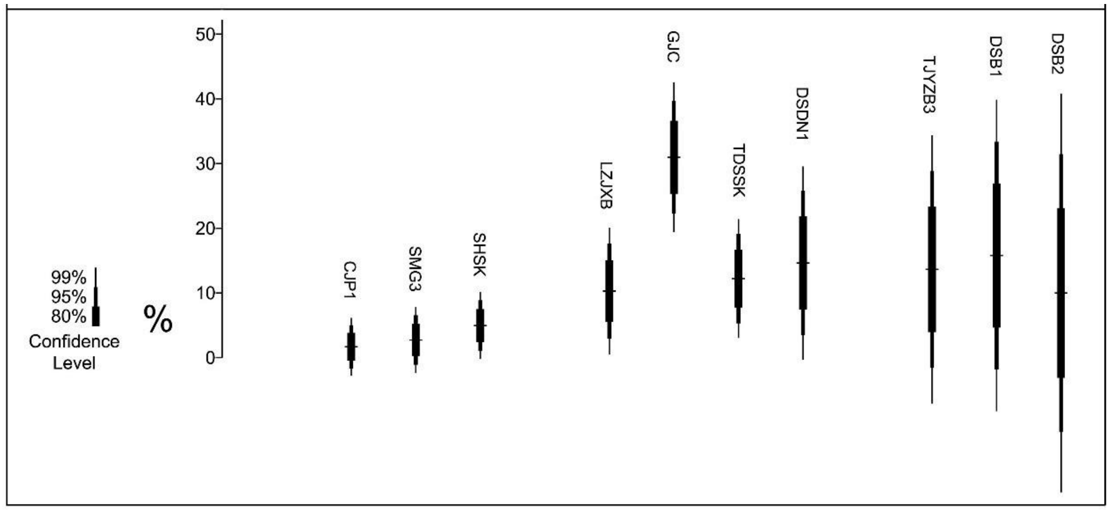

Figure 5.11 The bullet graph showing the proportional differences of the tool blanks across the sites

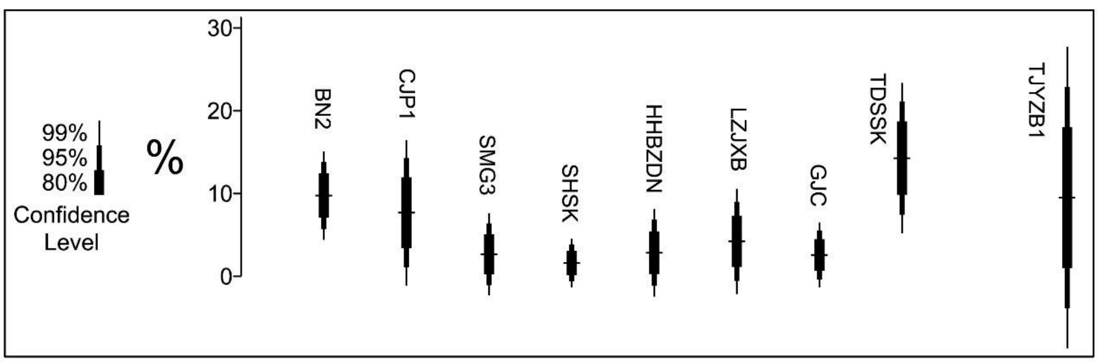

Figure 5.12 The bullet graph showing the proportional differences of the pottery across the sites

(The proportion of pottery is derived by: N of pottery sherds/ (N of pottery sherds+ N of lithic tools))

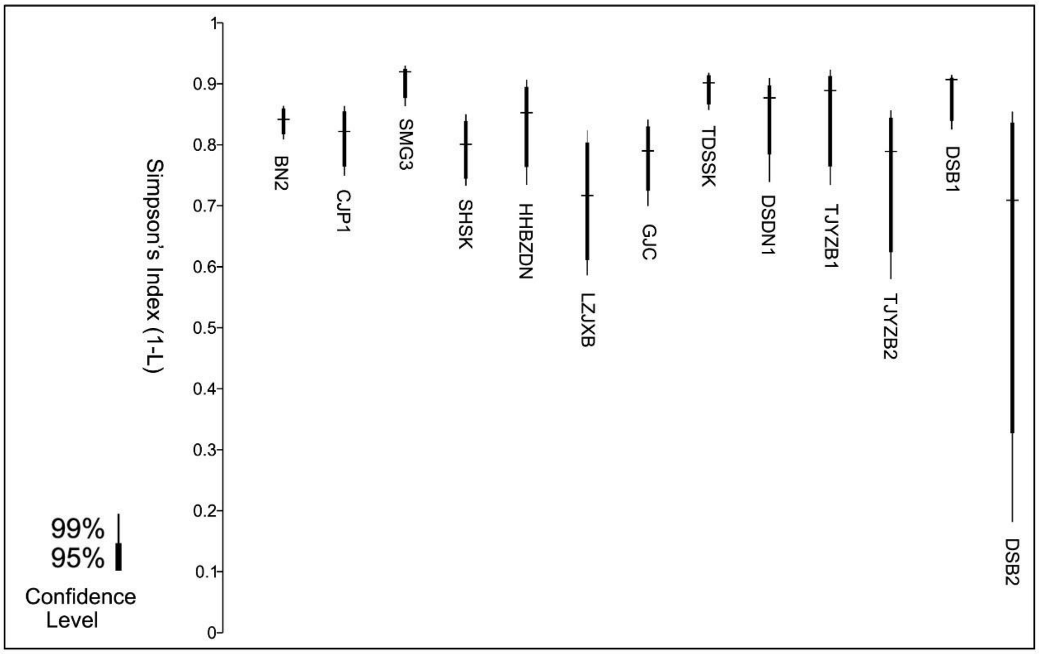

Figure 5.13 The bullet graph showing the diversity of the lithic tools

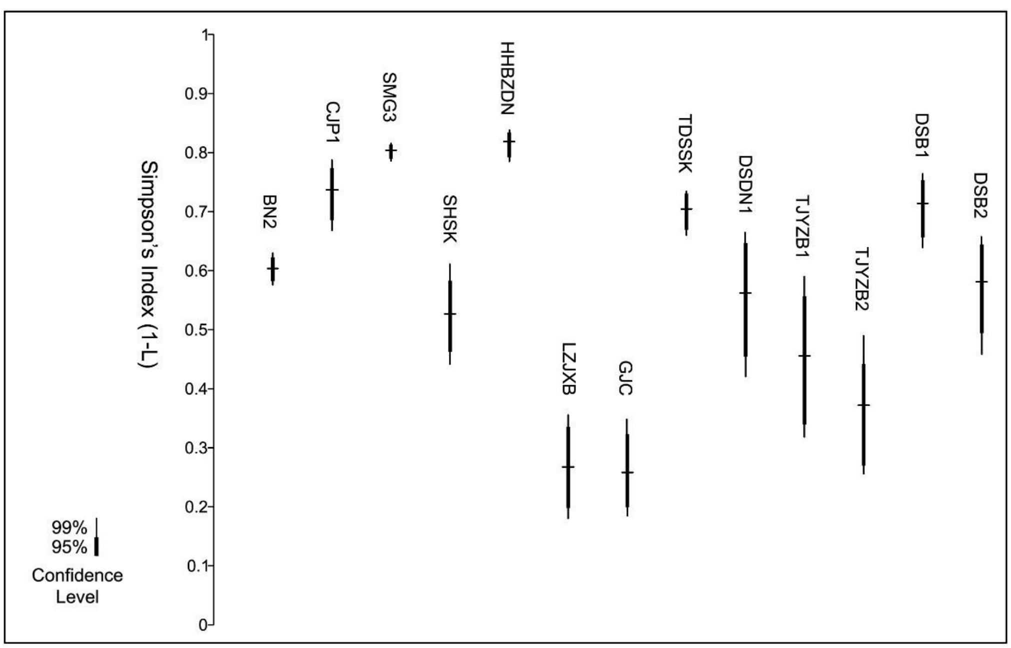

Figure 5.14 The bullet graph showing the diversity of the raw materials of the lithics

From the observation of these bullet graphs from Figure 3 to Figure 5.14, we do find that for some types of tools, they take more or less the similar portions of the tool composition across different sites. Whereas other types of tools take different proportions in different sites, probably revealing important information about the variations of site functions. Moreover, the diversity index of raw materials and tool types also show variations across the sites, which appears to suggest the different site natures and uses. However, since there are too many variables, it is difficult for us to find a more concise view of the overall pattern of inter-site variations based on the one by one comparison of such a blizzard of bullet graphs. Therefore, a principal component analysis is designed based on the same set of variables as a way to reveal a more comprehensive and intuitive pattern of inter-site variations. In order to reduce the impact of random noise, only the 8 sites with more than 45 pieces of lithic tools have been selected since it can control the error range within 15% based on 95% confidence level. The bullet graphs made above can further help us to evaluate how confident we can be for the result of the principal component analysis.

Table 5.3 Component loading for the analysis of the artifact compositional features of the 8 selected Early Neolithic sites

	Factors					
	1	2	3	4	5	6
Crafting tool (%)	**0.934**	-0.222	-0.073	-0.143	0.049	0.209
Diversity of tool types (%)	**0.900**	0.099	0.337	-0.229	0.015	0.029
Light-duty tool (%)	**-0.851**	-0.073	-0.456	-0.106	-0.200	-0.016
Diversity of Lithic Raw materials (%)	**0.849**	0.261	-0.116	-0.096	-0.305	0.294
Wood-working tool (%)	**-0.808**	0.223	0.394	0.199	-0.043	0.499
Farming tool (%)	**0.697**	-0.491	0.330	0.297	-0.235	-0.004
End scraper (%)	**0.664**	0.459	-0.158	-0.501	0.093	0.002
Heavy-duty tool (%)	**0.630**	-0.686	0.294	0.125	0.009	-0.163
Tool blank (%)	-0.577	-0.138	**0.721**	-0.231	0.269	0.043
Ratio of Pottery to lithics	0.286	**0.816**	0.238	0.176	0.357	-0.139
Microblade core (%)	0.309	**0.770**	0.137	0.425	-0.299	-0.136
Grinding tool (%)	0.483	-0.183	-0.520	0.421	0.500	0.184

Table 5.4 Eigenvalues for Principal Components extracted from the data of the 8 selected Early Neolithic sites

Factor	Eigenvalue	Percent of total variance explained
1	5.696	47.47%
2	2.411	20.13%
3	1.582	13.18%
4	0.931	7.754%
5	0.740	6.169 %
6	0.474	3.954 %

The variables and their factor loadings are listed in Table 5.3 above. From it, we can see that a couple of variables highly correlate with each other. For instance, eight variables have very high loadings on Factor 1, namely: the proportion of crafting tool, the diversity index of tool types, the diversity index of lithic raw material, the proportion of farming tools, the proportion of light-duty tools, and the proportion of woodworking tools. Two factors have high loadings on Factor 2, namely the ratio of pottery sherds to lithic tools and the proportion of microblade cores. One factor has a high loading on Factor 3, which is the proportion of tool blanks.

Factor 1 probably conveys the information about the functions of the site and can help us distinguish between the sites used as main residential settlements and used as a more temporary settlement mainly because it has both high loadings of the diversity of tool types and diversity of lithic raw materials. The main residential settlement tends to have more diversified lithic tools since a broader range of daily activities were inclined to be held in the main residential settlement than the other temporarily used sites and therefore required people to produce and use different sets of tools for meeting the demands of various activities (Binford 1980). Correspondingly, the lithic raw materials also likely had the higher diversity since the production of different types of tools sometimes prefer different kinds of raw materials. Meanwhile, the lithics made of different raw materials sources tend to aggregate in the main residential settlement since people might bring in the lithics (either as tools or blanks) they produced or collected from the temporary sites in different locations, where have access to different raw material sources.

Factor 1 shows the high correlation between these two variables. In addition, these two variables are positively correlated with the proportions of crafting tools, farming tools, heavy-duty tools, and end scrapers, but negatively correlated with the proportion of light-duty tools and woodworking tools, which may further suggest that the main residential settlement can be distinguished from the more temporary used sites based on the differences of the tool composition.

The Factor 2 likely conveys the information of seasonality of the site use, since it shows the highly positive correlation of the ratios of pottery to lithics and the proportion of microblade. People were likely engaged in a more intensive level of hunting and cooking activities during the cold seasons of the year. As discussed in Chapter 4,the most intensive hunting activities happened from the late fall to early winter and the pottery got its greatest utility during the winter times when people need to fully extract the nutrients from the food resources (such as extracting essential lipids from animal bones) to make up the deficiencies of fresh plant resources.

Factor 3 reflects the features of lithic production since the proportion of tool blanks has a high loading on it. The high proportions of tool blanks reveal the emphasis on the primary stage of lithic production for certain kinds of tool types. From Table 5.3, we can see that the variable of the tool blank proportion does not have high loadings on either Factor 1 or Factor 2, suggesting that such behavior of lithic production is not strongly correlated with certain site types or the seasonal use of the site.

As shown in Table 5.5 above, these three factors have higher eigenvalues than the other factors. Taken together, they can explain 80.8% of the variations in the dataset, indicating that they convey much of the meaning to be found in these results. Based on the scores of these three factors for each site, the scatter plots can be made as the following to provide us a concise and intuitive way to see the relative proximity of the sites according to different site functions. However, since the variables used for the principal component analysis are either proportions or diversity index, which are all subject to varying extents of error ranges according to the sample size of the site, it is necessary for us to look at the result of the principal component analysis with the lists of bullet graphs together to evaluate on what extents do the random noises affect the analysis result and how confident we can draw conclusions from the multi-variable analysis. The detailed analysis is presented as the followings.

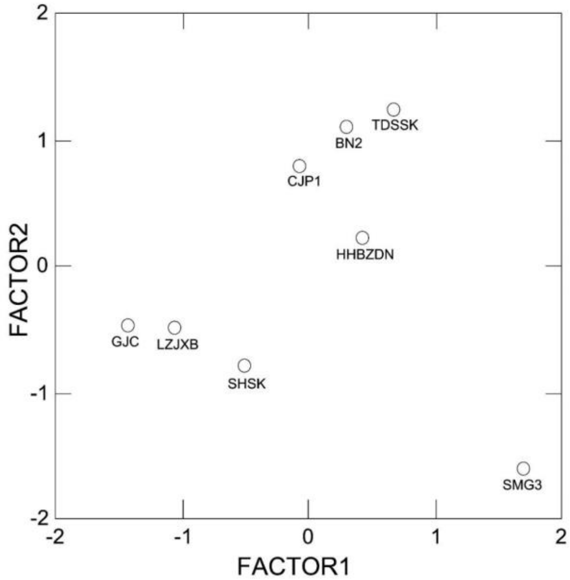

Figure 5.15 Scatter plot showing the factor scores of the 8 selected Early Neolithic sites on factor 1 and factor 2

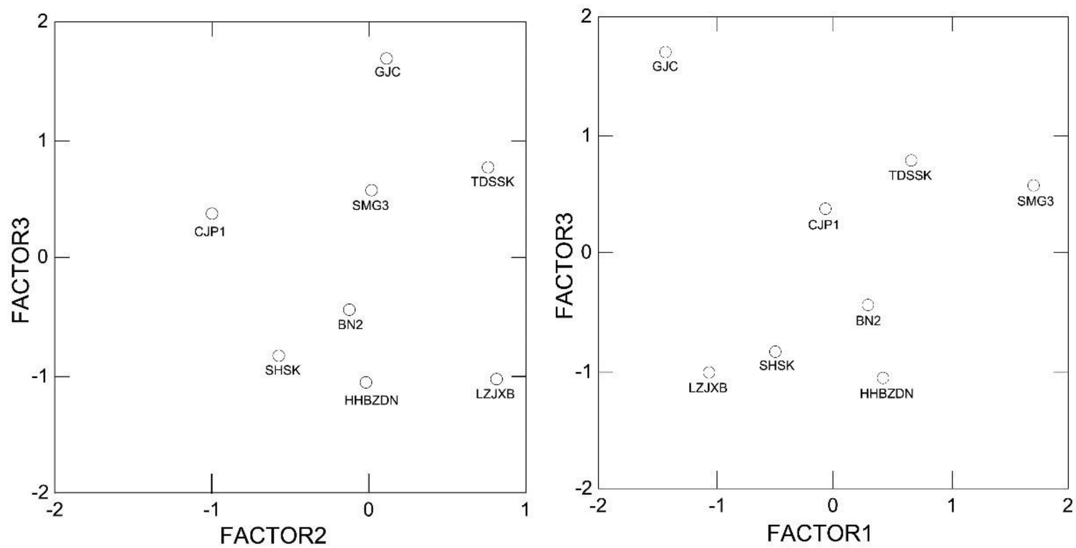

Figure 5.16 Scatter plot showing the factor scores of the 8 selected Early Neolithic sites on factor 1 and fact 3 (on the left) as well as factor 2 and factor 3 (on the right)

As seen in Figure 5.15, the ones located at the right side of the plot and have higher scores of Factor 1 are probably the sites used as the main residential settlements. Admittedly, from the comparative observation of the bullet graphs and the scatter plots derived from the principal component analysis, the random noises have probably exaggerated the differences of these site on the plot since not all the differences of variables which have high loadings on factor 1 are significantly different across the sites. The diversity of raw materials does show significant higher score across the sites located on the left part (like the SMG3, TDSSK, HHBZDN, BN2, CJP1) than the ones located on right part (like the GJC, LZJXB, SHSK), suggesting that the sites attributed as the main residential settlement have more diversified raw materials of the lithics. However, for the diversity of tool types, though the sites located on the right side of the figure in general have higher diversity score than the ones on the left side, yet taking consideration of the error ranges, not every case of the left ones show significant difference with the right ones. For instance, while the SMG3 and TDSSK show significantly higher diversity index than the sites located on the left site of the Figure 5.15, the CJP1 and HHBZDN do not. Similar issues also exist on the proportional differences of the tool types which have high loading scores on factor 1, except for light-duty tools. As for the proportion of light-duty tools (dominated by scrapers), most of the sites located on right side of the figure do show significantly lower proportions than those located on the left side of the figure, which makes sense that as the main residential settlements usually have more types of other tools to fulfill different purposes, the relative proportion of light-duty tools tend to be lower.

Even though there is random noise, the scatterplot based on the principal component analysis is still able to provide a relatively reliable and concise way to show the differences of the main residential settlements and the more temporary inhabited and used sites. What we should be aware though is that the differences between these two kinds of sites might not be as clear-cut as shown in Figure 5.15. While the most typical main residential settlements, like the SMG 3 and TDSSK might be easily distinguished from the most typical temporarily used sites like the LZJXB and GJC due to significant differences on multiple variables which have high loading on factor 1, the other sites cannot be easily distinguished apart since whereas they differ from each other according to some variables, they are similar in other aspects (as indicated by the charts of bullet graphs from Figure 3 to Figure 14.

To further observe the Figure 5.15 in detail, we can see that the sites BN2, CJP1, TDSSK, and HHBZDN are clustered at the upper right part of the scatterplot, reflecting that they share similar features in terms of both site functions and the seasonality of site use. However, an inspection of bullet graphs revealed that while BN2, CJP1 and TDSSK have significantly higher proportion of microblade cores and pottery than most of the other sites (at a confidence level ranging from 80% to 99% depending on the comparison being made), HHBZDN does not show significantly higher proportions of them taking considerations of the error range. Therefore, the proximity of the HHBZDN to the BN2, CJP1, and TDSSK might be caused by random noises.

Since the BN2 resembles the Yumin site as discussed above, the other two sites (namely the CJP1 and TDSSK) might also resemble the Yumin and were probably used by Early Neolithic communities during the colder seasons of the year. Such inference is further supported by the information of site locations. The surrounding terrains of the site CJP1 are highly similar to that of the BN2 and Yumin. It also sited at the gentle slope of the mountain cove, enclosed by low mountains at the north, west, and east side and facing towards the southside with more opening spaces. Such a location provides a nice shelter for people to protect from cold weather and strong wind. The TDSSK locate at the more open landscapes than the BN2 and CJP1. However, it also faces the southeast side, suggesting that sheltering from the cold and windy weather might be an important consideration for the locational choice of the site.

The SMG 3 has been sorted far away from the other sites estimated as the main residential settlements in the scatterplot, suggesting that the main residential settlement used during the warmer seasons of the year might be very rare. Admittedly, an observation of the bunch of bullet graphs gives us the impression that the tool composition of SMG 3 differs from the other sites in many aspects (like the significantly higher proportion of heavy-duty tools and farming tools, and the significantly lower proportion of light-duty tools). However, the random noises from the samplings as mentioned during the analysis of factor 1 also contribute to pulling apart of SMG 3 from the other sites in greater distances to some extent.

One site which is particularly similar to the SMG 3 is the adjacent SMG1. Since this site is commingled with Mid-Late Neolithic/Early Bronze Age remains, it was not incorporated into the principal component analysis. However, it has similar geographic settings with the SMG 3 and the farming tools and heavy-duty tools also take higher proportions within the tool assemblage. Moreover, the pottery sherds of the Early Neolithic period were very rare, but the lithic remains are quite rich. Therefore, it was probably also used as a main residential settlement inhabited during the warmer period of the year. In addition, excluding the impacts of random noise and observing from the bunch of the bullet graphs, HHBZDN might also share more similarities with the SMG3 rather than the BN2, CJP1, and TDSSK.

The GJC, LZJXB, and SHSK are clustered at the lower right part of the scatterplot and were probably used as the temporary settlements during the warmer period of the year. As mentioned in the discussion above, they have a slightly lower diversity of the tools and significantly lower diversity of the raw materials. The light-duty tools take a higher proportion in the tool assemblage, which is mainly composed of the expediently crafted scrapers made by local igneous rocks. These features have mainly separated them far away from the SMG 3 on the dimension of Factor 1. The relative higher proportions of expediently made scrapers suggest that other types of tools that are designed and used particularly for fulfilling different spheres of activities are less frequent in these sites. The dominance of the local igneous rocks in raw material assemblages indicate the fewer extents of the convergences of lithics made from different localities. Such features make these sites more resemble the temporary dwelled settlement used by shorter durations and perhaps lower levels of population aggregation. Yet like the SMG 3, these sites also show the low ratio of pottery to lithic tools and low proportions of the microblade core, indicating the less intensive use of pottery and the limited involvement in the production of hunting tools. It probably suggests that these sites are used during the warmer seasons of the year since the pottery cooking was less intensively applied during the warmer seasons, and the time from summer to early fall is the high time for wild plant collections instead of the large-scale hunting.

From the scatterplot of Figure 5.16, we can see that GJC is separated far away from the other sites. Such a distributional pattern is caused by the significantly higher proportion of the tool blanks found in the GJC site (which is supported by the bullet graph Figure 5.11). The blanks in the GJC site were mainly used as the preforms to produce woodworking tools. None of the other sites have ever found such a high proportion of tool blanks. This difference suggests that the GJC site has special functions for massively producing the blanks of woodworking tools.

It is hard for us to make an accurate estimation of how much proportion did the residential sites take within all the surveyed sites. On one hand, a large number of Early Neolithic sites overlap with cultural remains of Mid-Late Neolithic/Early Bronze Age. Such mixture composition makes it hard to separate the lithics used exclusively in the Early Neolithic period from the ones used in later time for further analysis. On another hand, many single component sites used exclusively during the Early Neolithic period have too few numbers of tools to make a convincing analysis of the proportional distributions of tool types. Therefore, only very limited cases have been used to learn site types.

However, the general sense from the observation of survey data still reminds me that the main residential settlements are not common and probably are not a take large percentage of all the 69 sites which contains Early Neolithic remains since except for a few sites like the SMG1, MLG3, and XH5 which shows the abundant lithic remains and diversified tools, most of the mixture site either shows the predominance of Mid-Late Neolithic remains or the predominance of Early Neolithic remains but in less affluence both in terms of total lithic remains and tool types. Such a pattern indicates that probably only a very limited number of sites from the mixture remains might serve as the main residential settlement during the Early Neolithic period. Moreover, the single Early Neolithic component sites excluded from the principal component analysis are unlikely to be used as main residential settlements, since the scarcity of tools in these sites do not meet the expectation that the main residential settlements would leave a fairly large number of tools used for a broad range of activities.

In comparison with the main residential settlement, there are more temporary settlements found from the survey data. Except for GJC, LZJXB, and SHSK, many of the sites with more than 100 pieces of lithics being found were probably served as temporary settlements, since even though the numbers of lithic tools are low, there are still multiple types of tools, suggesting that people are engaged in a variety of activities rather than focusing on the particular activity in these sites. There is a gradient of temporary settlement from the intensively occupied ones with longer durations of residency or repeated use to the ones used far less intensively and occupied by a shorter period. Moreover, some temporary sites might undertake certain specific functions. For instance, the GJC site was more involved in producing woodworking tools. The SHSK site has a significantly higher number of serrated scrapers than many other sites, implying that some specific cutting or sawing activities have been more intensively conducted in this site rather than in the other sites.

5.2.4 The task sites

The task sites are the ones occupied by a shorter period and are probably focused on a narrower range of activities in comparison with residential sites (Bettinger 1999; Binford 1980; Janz 2016). We can even identify the specific activities the site undertakes from a few of the sites, such as DJGDB2. It locates at the mountainous cave where the layers of igneous rock exposed. Such fine-medium sized igneous rock with suitable hardness and fragility are suitable to be used for processing a wide range of chipped stone tools. The site is predominately composed of the debris of such material and has very few tools. The lithic pieces made by other raw materials are also extremely rare. Such a pattern indicates that this site might probably be used as a quarry site, especially focused on making chipped stone tools based on local raw material sources.

Very few sites found from the survey resemble DJGDB2. For the sites with less than 100 pieces of lithics being found, some of them are mainly composed of debitage with extremely rare lithic tools; some others might contain slightly more tools, and these tools are usually from different categories used for fulfilling different activities. There are no sites found from the survey which have a relatively large number of lithics but only have a narrow range of tool types used for fulfilling specific tasks. There are also no sites from the survey data that show the predominance of lithic tools rather than debris. Such a pattern indicates that no intensively used task-specific sites have ever been found within the survey zone. In addition, the task sites also undertook the work of lithic production or maintenance, and none of them only rely on the use of the tools people brought from other localities. The scarcity of tools might be resulted by the fact that people have brought away most of the lithic tools while they left from the site. Whereas the discovery of the multiple kinds of the tools might indicate that more than one kind of activity has been conducted on the site.

Admittedly, since the task sites were used more ephemerally by people and generate only very limited amounts of artifacts, there are high chances that some of them were overlooked by archaeologists during the survey, and some might even leave little material traces for archaeologists to identify. For instance, the residential settlement used during the cold season, like the Yumin site, has lots of animal bones from the species inhabited in different ecozones. However, none of the specific hunting sites have been identified from the survey data. It reminds us that the actual number of task sites might be more than what we could identify from the survey.

Table 5.5 The correlation between site types and the intensity levels of site use

Intensity level of site use	Number of lithics	Associated site types
3	>500	Main residential site
2	100-500	Main residential site; Temporary residential site
1	<100	Temporary residential site; Task site

As discussed in Chapter 3, the extents of site use intensity are tentatively classified into three levels based on the number of lithics found from the site. The correlations between different types of sites and different levels of site use intensity are listed in the table above. Since the sites from each site type have been used by a gradient range of intensity, we cannot find the rigorous one-to-one association between each site type and the level of site use intensity. While the most intensively used sites were likely to be served as the main residential site, the sites occupied with lower level of intensity (like the one where over 100 but less than 500 lithics have been found) can either be used as main residential settlement or used as temporary settlement depending on the variations of their artifact compositions. The site used with the least level of intensity (the ones where less than 100 lithics have been found) are more likely to be used as task sites, but some ephemerally occupied temporary residential sites might also belong to this level of site use intensity.

5.3 Variations of the subsistence practice across the sites

While the variations of the subsistence practice have been mentioned as the discussions in chapter 5.2 above, a more intuitive analysis for evaluating the variations of subsistence practice across the sites could be done by mapping the sites in various kinds (like the ones with different types or in different intensity of use) with the information of the presence and absence of different tool types which are indicative for specific subsistence practices and counting the ubiquity of these tool types across such sites.

Such analysis can supplement the analysis and discussions made above and help us to better understand the subsistence strategies applied by the ancient communities of the studied region on a concrete spatial background across the landscapes.

Just like the study of the excavated sites, the microblade and end scrapers are used as the index suggesting the practice of hunting and animal resource processing. The grinding tools are used for implying the activity of the intensive process of plant resources. The farming tools (mostly composed by stone hoes in terms of the surveyed sites) are indicative of land-tilling, which is associated with the primary farming activity. For all of these toolkits, only the farming tools can be distinguished as either belong to Early Neolithic period or to Mid-Late Neolithic/Early Bronze Age period, since the farming tools in Mid-Late Neolithic/Early Bronze Age are made by tuff instead of the coarse-grained igneous rock and have more formalized shape than those in Early Neolithic period. Therefore, to explore the spatial distribution, two figures of the maps show the presence or absence of farming tools across the sites have been used. One of them includes all of the sites containing Early Neolithic remains, and another one only includes the sites with a single component of Early Neolithic remains. As for the investigation of the spatial distribution of microblade, end scraper and grinding tools, only the sites with single component of Early Neolithic remains have been selected, since we cannot unambiguously attribute these types of tools to certain time period for the sites commingled with both Early Neolithic and Mid-Late Neolithic/Early Bronze Age remains. The presence or absence of these types of toolkits across the sites is spatially shown below. Besides, the presence or absence of different toolkits mentioned above and their ubiquities are also cross-tabulated with the classes of the sites distinguished by the numbers of lithics (shown in Table 5.6). For both tables and maps, the site BN1 is excluded from the analysis since as discussed above, the post-depositional issue made the small sample found from this site cannot reflect the real patterns of human activities on it.

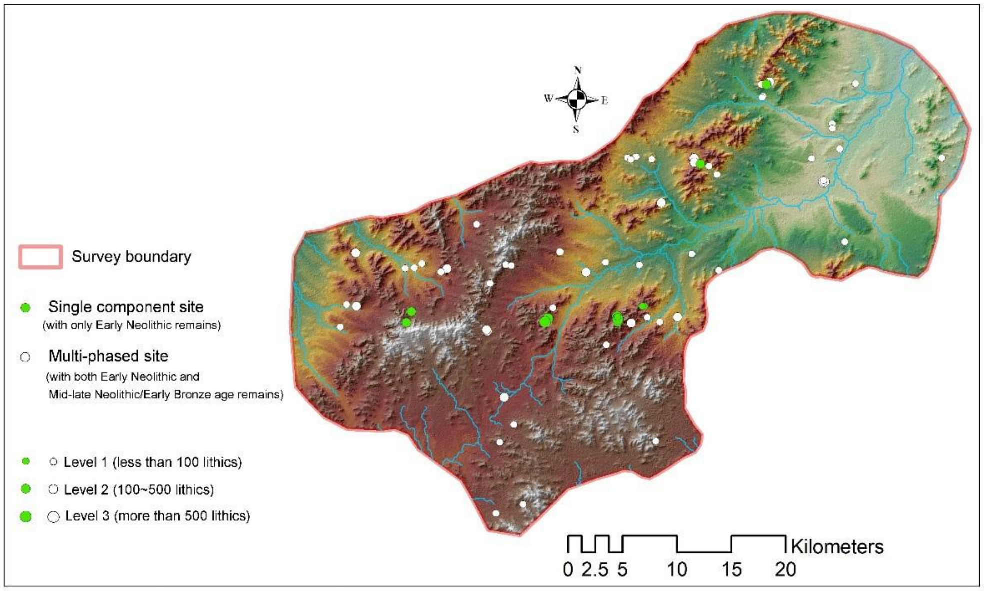

Figure 5.17 The distribution of the Early Neolithic sites with the presence of farming tools (All of the sites which contain Early Neolithic remains are included)

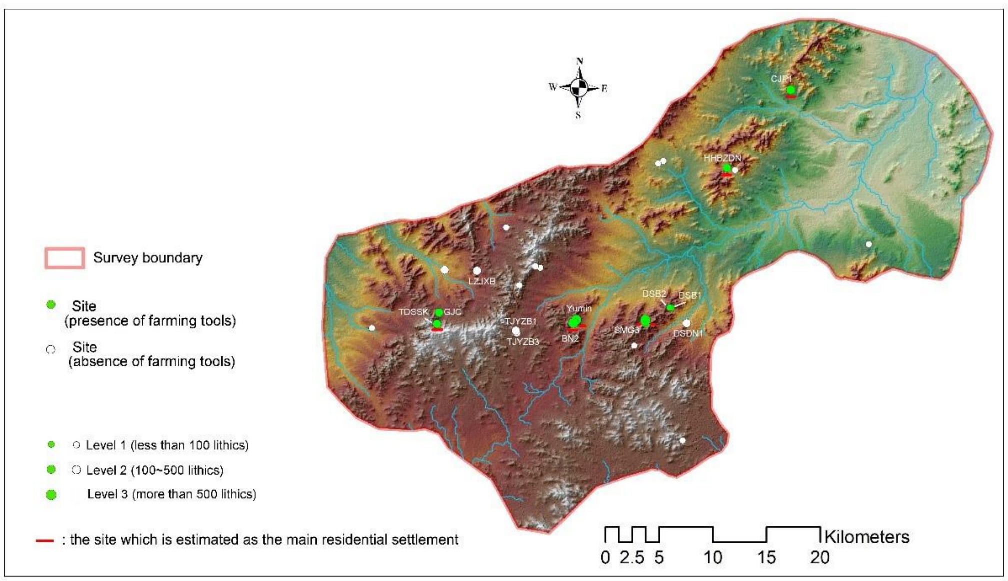

Figure 5.18 The distribution of the Early Neolithic sites with the presence of farming tools (Only include the sites with the single component of Early Neolithic remains)

(Yumin site, as well as the sites with their proportional distribution of farming tools being analyzed as the following, are marked as write font)

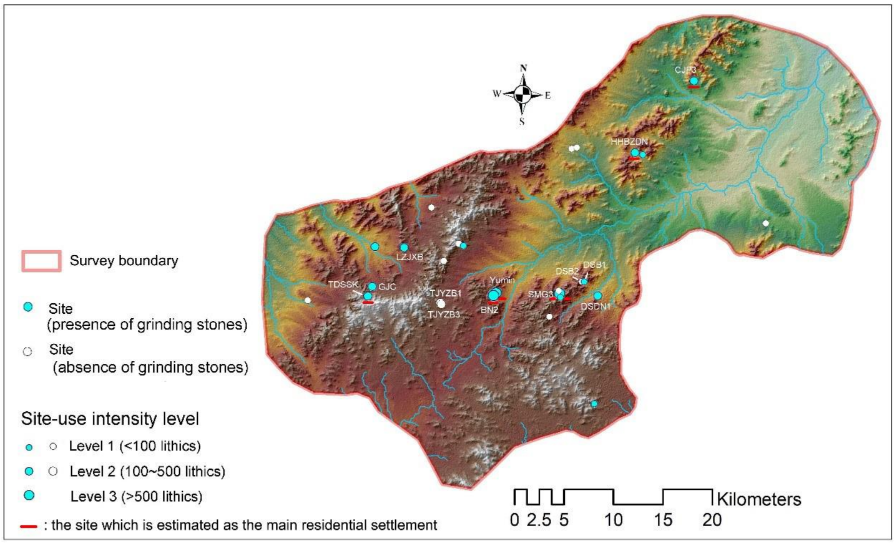

Figure 5.19 The distribution of the Early Neolithic sites with the presence of grinding tools (Only include the sites with the single component of Early Neolithic remains)

(Yumin site, as well as the sites with their proportional distribution of grinding stone tools being analyzed as the following, are marked as write font)

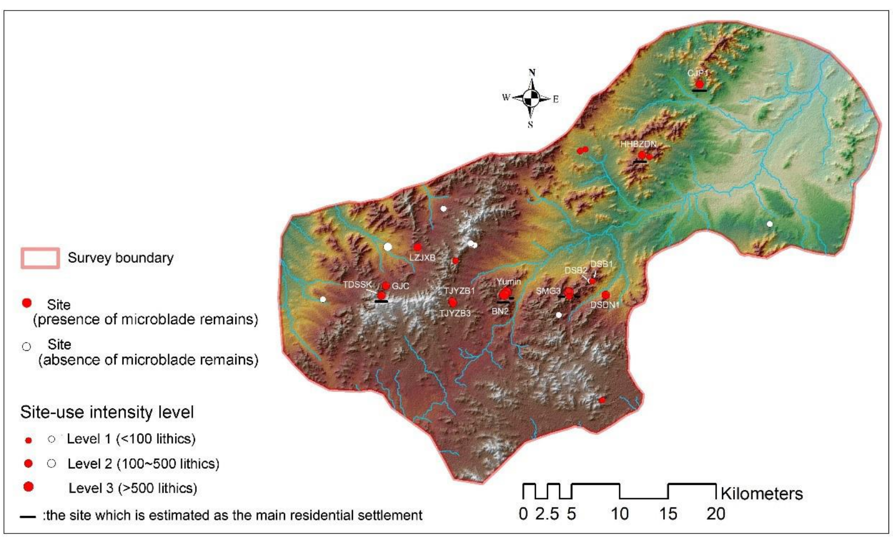

Figure 5.20 The distribution of the Early Neolithic sites with the presence of microblade remains (Only include the sites with single component of Early Neolithic remains)

(Yumin site, as well as the sites with their proportional distribution of microblade cores being analyzed as the following, are marked as write font)

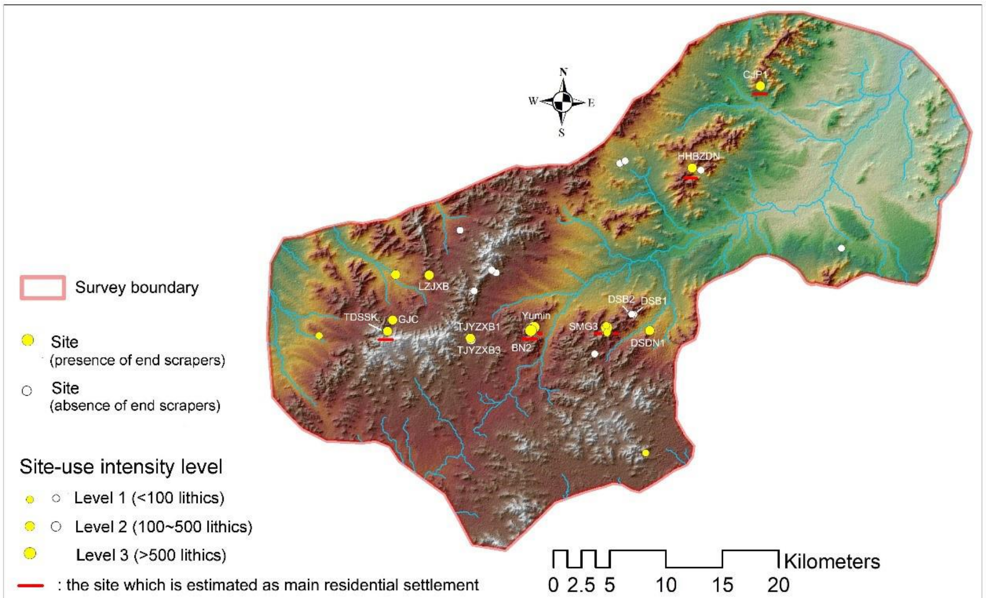

Figure 5.21 The distribution of the Early Neolithic sites with the presence of end scrapers (Only include the sites with the single component of Early Neolithic remains)

(Yumin site, as well as the sites with their proportional distribution of end scrapers being analyzed as the following, are marked as write font)

Table 5.6 The ubiquity of different tools across the Early Neolithic sites with varying levels of use intensity

Site-use intensity level	The site with farming tools		The Site without farming tools	
	Number	Ubiquity（%）	Number	Ubiquity（%）
Level 3 (>500 lithics)	4	100	0	0
Level 2 (100-500 lithics)	3	37.5	5	62.5
Level 1 (<100 lithics)	4	26.7	11	73.3
	The site with grinding tools		The site without grinding tools	
	Number	Ubiquity（%）	Number	Ubiquity（%）
Level 3 (>500 lithics)	4	100	0	0
Level 2 (100-500 lithics)	6	75	2	25
Level 1 (<100 lithics)	5	33.3	10	66.7
	The site with microblade remains		The site without microblade remains	
	Number	Ubiquity（%）	Number	Ubiquity（%）
Level 3 (>500 lithics)	4	100	0	0
Level 2 (100-500 lithics)	7	87.5	1	12.5
Level 1 (<100 lithics)	9	60	6	40
	The site with end scrapers		The site without end scrapers	
	Number	Ubiquity	Number	Ubiquity
Level 3 (>500 lithics)	4	100	0	0
Level 2 (100-500 lithics)	7	87.5	1	12.5
Level 1 (<100 lithics)	3	20	12	80

Based on the maps and table shown as Figure 5.17-51.21 and Table 5.6, we can see that the most ubiquitously distributed tool is microblade, followed by grinding tools and end scrapers. The farming tools are the least ubiquitously distributed tools across the sites. Interestingly, most of the sites with the presence of farming tools are the sites with the single component of Early Neolithic remains and located close to the maintains. The majority of them are the main residential settlements and a few of them are temporary residential or task sites that are located close to the main residential settlement (as shown in Figure 5.17 and 5.18). It is noteworthy that the two less intensively used sites close to the SMG3, namely the DSB1 and DSB2, have similar proportion of farming tools compared with SMG3 and higher proportions of farming tools than some other main residential settlement, such as the BN2, HHBZDN, TDSSK (as shown in Figure 5.3; though at 80% confidence level due to the small sample size of tools). Such difference might indicate that the intensity of farming is not tightly associated with the intensity of settlement occupation but is more likely correlated with the seasonal variations of subsistence activities since the proximity to SMG3 and the lack of pottery in these two sites make DSB1 and DSB2 more likely to be the sites used during warmer period of year, just like the SMG3.

Compared with farming tools, the grinding stones are more frequently found across the sites, especially in the more intensively used sites (the sites with more than 100 pieces of lithics being found). It implies that the intensive processing and exploitation of plant resources have been more commonly adopted as a means of subsistence practice than farming.

Like the grinding stones, the end scrapers are also more frequently found across the sites with a higher intensity of site-use (as shown in Figure 5.21), suggesting that fur-processing is also a relative common subsistence practice happened across the different places in the survey region.

The microblade remains are more frequently distributed in comparison with the three types of tools mentioned above. As shown in Table 5.6, even at the site with less than 100 pieces of lithic remains, more than half of them have found microblade remains, suggesting that microblade production is a quite prevalent technique applied by people at different backgrounds of site-use, either in the more intensively occupied sites or the temporary or task sites. Since the truncated microblades are mainly used as insets for assembling hunting weapons and animal resource processing tools, the ubiquitous microblade remains reflect the importance of hunting activity for human subsistence at this period.

To sum up, the analysis of subsistence variations across the surveyed sites indicates that the intensive hunting and gathering based subsistence could be constantly found across different sites, and the farming activity only confined in specific spots of the survey region. For many of the sites being studied, different tool types associated with different subsistence practices often coexisted and the proportional differences of these tool types across the sites are only in minor to moderate levels (as shown in bullet graphs from Figure 5.3 to Figure 5.14 in section 5.2). It suggests that despite the varying levels of emphasis on different subsistence activities caused by seasonal variations as discussed in section 5.2 above, there is no strong differentiation of subsistence practices across the sites either in terms of the spatial distributions or the levels of intensity of site use (especially between level 3 and level 2).

5.4 Correlations between sites and environmental settings

5.4.1 Paleoenvironment and resource distributions of the survey region

The survey area of the Huade county locates at the northern slope of the stretching branch of Yinshan Mountain range. Even though the altitude difference here is not great, the landscape is quite rugged and complicated in this area. The river valleys and intermontane basins in varying sizes are dissected by low mountains and hills with different heights, degrees of steepness, and patterns of alignment. Such landscapes created heterogeneous micro-environment zones located at different landforms, which provide different sets of benefits and limitations for people to get necessary living resources.

The paleoclimate during the Early Neolithic period is quite different from nowadays in the survey region. Today, this region is identified as the steppe zone. Except for the anthropogenically planted woods and shrubs, the natural vegetation is dominated by the steppe species (Wu, et al. 2015). However, as discussed in Chapter 2, impacted by the increases of humidity and temperature during the Holocene climate optimum, the forest zones in East Asia Continent have been expanded northward into the southeast part of the Mongolian Plateau (Zhao and Yu 2012). The paleoclimate proxies studied in the nearby area of the survey region show an increase in *Picea* (spruce), *Pinus* (pine), and *Quercus* (oak) and the decrease of steppe vegetation (Jiang, et al. 2006; Wang, et al. 2010). It is estimated that the survey area has mosaic forest-steppe vegetation during the Early Holocene climate optimum.

According to the observations of the vegetation distributions in the current mosaic forest-steppe in the Mongolian Plateau, the forests might be patchily distributed along the mountainside and river valleys during the Early Neolithic period in the survey region. The mixed forests with both coniferous and deciduous trees might be mainly distributed in the mountainous region, while certain types of deciduous trees, like willows, might be distributed as gallery forests along the river where the water table is relatively high (Erdős, et al. 2018). The increased humidity also led to the expansions of the water bodies in the low-lying terrains of the Mongolian Plateau. Therefore, the swamps, meadows and small lakes might also exist in certain locations of the valley floors during the Early Neolithic period.

Based on the findings of floral and faunal remains from the two excavated sites, the information of paleoenvironments, and the references of the modern distributions of the main plant and animal species in the Mongolian Plateau, we can tentatively reconstruct the patterns of seasonal resource availability according to different ecozones, which is summarized in the Table 5.7 listed below.

Table 5.7 The possible seasonal distribution of raw material and edible resource at the survey region during the Early Neolithic period (after (Huai and Pei 2000; Janz 2012; Ma 1985; Xurigan 2016))

Season	Wetlands	Plain	Foothills/Mountains
Year round	Roe deer Père David deer Wood Reed Clay Fuel (dry reeds and woods)	Cattle Horse Donkey Gazelle Stone Fuel (dung)	Boar Red deer Sika deer Wood Fuel (dry wood and shrubs) Stone Wind-shelter
Spring	Horses Waterfowl Fish Eggs Greens	Marmot Allium greens	Ibex herds Young greens
Summer	Shellfish Waterfowl Reptiles Eggs Green legumes Chenopodiaceae seeds Barely seeds Herbs	Cattle herd Marmots/rodents Green legumes Allium greens/bulbs C. ammannii C. thesioides Chenopodiaceae seeds	Ibex Hare Green legumes Allium greens Rheum Berries/fruit Herbs C. ammannii C. thesioides
Fall	Bear Shellfish Fish Waterfowl Eggs Allium bulbs Tubers/Roots Crusgalli seeds	Horse herds Cattle herds Gazelle herds Donkey herds Allium bulbs Hare Legume C. ammannii Snakegourd root Chenopodiaceae seeds	Ibex Nuts (acorn/pine) Fruit Lilly bulbs Allium bulbs C. ammannii Snakegourd root
Winter	Fuel (dry reeds, bushes)	Donkey herds Horse herds Gazelle herds Hare	Bear Ibex herds Argali herds Fur mammals Hare

Based on this table, although certain types of the resource might occur across different ecozones, the general resource distributional patterns across the three ecozones are pronouncedly different, which provides different foraging opportunities and living conditions for human beings. The plain area is the main habitat for the medium-large sized herbivore. In certain seasons, the different species of herbivores might aggregate in large herds, providing good opportunities for massive hunting. The wetland area provides a range of edible wetland plants as well as riverine animal species like fish, shellfish, and migratory birds. The mountainous region provides diversified types of edible plant resources and certain types of animals living in the forest margin areas, like deer and boar. By learning people's choice of site locations, we can evaluate how people take opportunities of the resource distributions in different ecozones to procure food resources and meet the living demands.

5.4.2 The geographic landforms and the site locational choices

5.4.2.1 The relative occupational intensity in different landforms

Exploring how the sites are distributed across different landforms can provide us a holistic picture to evaluate people's land-use strategy and patterns of interaction between humans and the environment.

According to the result of the survey, the sites from both Early Neolithic and Mid-Late Neolithic/Early Bronze Age are mainly distributed in four different landforms, namely major river valley, tributary valley, piedmont, and mountain cove.

Different locations provide different conveniences for people to get access to the three different ecozones as discussed above. The major river valley locates in the middle part of the survey zone and has the broadest plain area in the survey zone. The large portions of waterbody were also distributed in the major river valley. The places along the river might have oxbow lakes, marshes, swamps, meadows, and galley forests, whereas the places farther away from the river might have a broad range of open steppe land. Therefore, the sites in major river valley can provide convenient locations for people to get access to both wetland and plain resources.

The tributary valleys are narrower and smaller than the main valley. The riverine and wetland resources were probably distributed in smaller patches than those in the major valley. It has a flat and open ground along the river and is surrounded by the undulating mountains and hills. The sites located within it often have a closer distance to the mountainous area than those located in the major river valley. Therefore, the location of this landform provides people with access to multiple resource patches distributed in different ecozones.

The piedmont area is the transitional zone between mountains and valley floor. It can be conceived as the outskirt of the major or tributary valley. In comparison with the heartland of the valleys, it is closer to the mountains but farther away from the large water bodies. Therefore, such location provides people more convenience to exploit the mountainous resources as well as the resources at the open and gently rolling terrains adjacent to the mountains. Except for the diversity of natural resources, some particular parts of the sloping landforms also have relatively thick soil depositions and are less likely to be threatened by floods, which provides good conditions for primary farming in early times.

The mountain cove is the small plot of the flat area which is surrounded by the mountains. It provides even more convenient locations for people to make use of the mountainous resources, but more importantly, the relatively closed and undulating terrain provides ideal shelters for people to protect from the sufferings of cold and windy weather during the winter. Some of the cove areas also have the exposure of certain kinds of rocks, which can be potentially used as raw materials for people to produce lithic tools.

Based on Table 5.8 and Figure 5.22 as shown below, it seems that people more densely occupied in the tributary valley and piedmont. While these two landforms only take 38% of the total area of survey region, as many as 45 sites which contain Early Neolithic remains have been found, taking 65.2% of the total number of the sites containing Early Neolithic remains. As shown from Table 5.9, the one-sample Chi-Square implies that the differences in the occupation density between tributary valley/piedmont and other landforms are highly significant. From Figure 5.22, we can see that both more intensively or less intensively used sites can be found in these two landforms. The sites with more than 100 lithics (which are probably served as main residential sites or temporary residential sites) take respectively 35% and 50% of the total sites ever being found in these two landforms. The tributary valley has two most intensively used sites, namely the SMG3 and SMG1, which is estimated as main residential sites occupied during the warmer period of the year. Although no site with more than 500 lithics has been found in the piedmont area, some of the sites which have between 100 to 500 pieces of lithics found here might also be served as the main residential settlement, like the HHBZDN, TDSS, according to the analysis of inter-site variation made above. A fair amount of least intensively used sites (with less than 100 lithics) further implies that besides the intensively occupied sites, some ephemerally occupied task sites or temporary residential sites are also located in these two landforms, suggesting that they have been exploited in diversified ways by Early Neolithic communities.

The mountainous area found the least number of the sites. However, it has the highest proportion of the sites used by the most intensive level. These sites are estimated as the main residential settlement used during the cold seasons. Besides, a site showing far less intensive use has been found as well and is estimated as a quarrying site. Therefore, even though the large ranges of the mountains are unoccupied or occupied with very low-intensity levels, some specific spots of the mountainous area, like mountain coves, are extremely intensively occupied by people due to their geomorphological benefits for people to protect against the harsh weathers in the cold season.

The major valley seems to be used less intensively in comparison with tributary valley and piedmont zones. While the area of major river valley takes up 32.7% of the total area of survey region, only 15 sites have been found, which takes 21.7% of all the sites containing Early Neolithic remains. Even though one site of them shows the highest levels of site use intensity, the sites with the least intensity of site use (the ones with less than 100 lithics) take as high as 60% of all sites. Moreover, all the sites located in the major valley are the mixed sites with both Early Neolithic and Mid-Late Neolithic/Early Bronze Age remains, suggesting that the sites used in the major valley were re-occupied by people living in a later period.

Table 5.8 The number of sites distributed across different landforms

	major valley	tributary valley	piedmont	mountains(1)	total
area(km^2)	488	210	366	430	1494
area(%)	32.7	14.0	24.5	28.8	100
sites (N)	15	23	22	9	69
sites (%)	21.7	33.3	31.9	13.1	100

(1): include both the mountains and the small coves within the mountains

Table 5.9 Observed and expected numbers of sites across the different landscapes for the Chi-Square Test

	Area Surveyed	No. of sites	
		Exp.	Obs.
Major valley	32.7%	22.6	15
Tributary valley	14%	9.7	23
Piedmont	24.5%	16.9	22
Mountains	28.8%	19.9	9

(X^2=29.2, p<0.001)

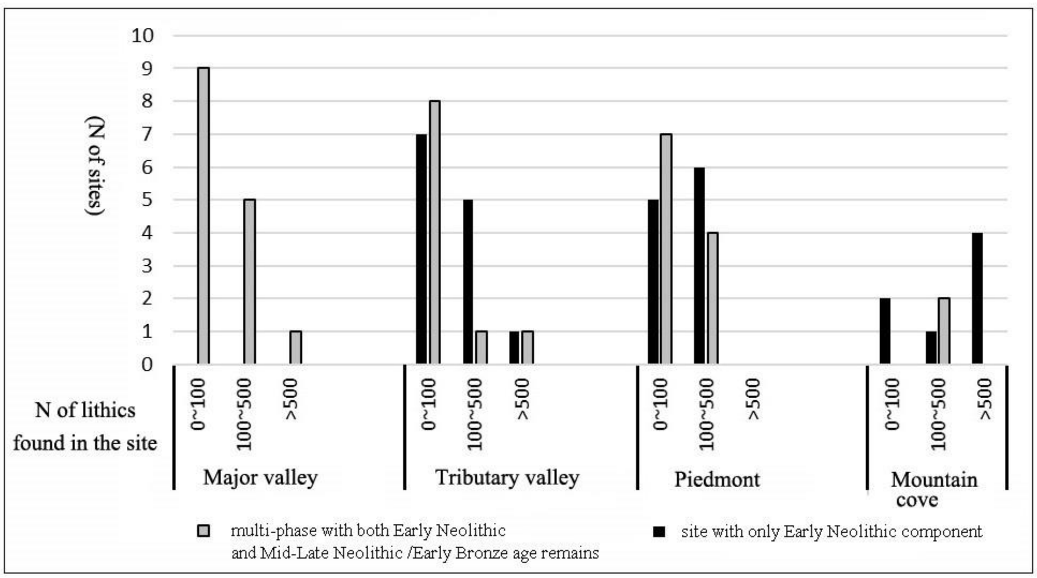

Figure 5.22 The distribution of sites with different levels of site use intensity across different landforms

5.4.2.2 The proximity to the mountainous area

The analysis of the correlation between geographic landforms and site locations reminds us that people might have more intensive use of the convergence zones between maintains and plains rather than the zones between plains and wetlands. The proxy of the site's proximity to the mountainous area can be applied in spatial analysis to further test this inference under finer-grained resolution.

The proportion of mountainous areas within the 1 km radius catchment zone of the site can be used as an appropriate proxy to evaluate the relative proximity of each site to the mountainous area. The 1 km radius catchment zone can well reflect the immediate surrounding environment of each site. The closer to the mountains, the higher proportions of the mountainous area could take within the 1 km radius catchment zone.

From Figure 5.23, we can see a wide range of the proportional distributions of the mountainous area across the sites. While the chart of all sites containing Early Neolithic remains reveal that the majority of them are located at the flat and open places, the chart of the sites with only single Early Neolithic cultural remains reveals that the sites which have more flat areas within the catchment zone have roughly the similar number with the ones which have more mountainous areas within the catchment zones. As shown in Table 5.9, the Chi-Square analysis suggests that there is a significant difference in terms of the proportions of sites distributed close to the mountainous areas between single Early Neolithic component sites and the multi-phase component site which contains Early Neolithic remains (p=0.002).

In addition, the most intensively used sites of the Early Neolithic period are located close to or even within the mountainous area except for XH5. For instance, the mountainous area takes 79.2% of the 1 km radius catchment zone of the Yumin site and takes 62.6% of that in the Simagou site. Other sites that have similar even higher proportions of the mountainous area within the 1 km radius catchment zone, like SMG1, BN1 and BN2, are all estimated as the residential settlement with relative stable residency. In comparison, XH5 is an exceptional case. It located at the major river valley of the survey region with open landscapes. Nearly 2000 lithics have been found from this site, showing the mixture of Early Neolithic and Mid-late Neolithic/Early Bronze Age remains. Based on the features of lithics and pottery, the Early Neolithic and Mid-late Neolithic remain might take similar proportions of the whole artifact assemblage, indicating the intensive site use of the both periods. The less intensively used sites, though, have more variable distributions across the landscape.

As shown in Table 5.11, the Chi-Square analysis shows that the relative proximity to the mountainous area is significantly different among the sites with varying levels of intensity of use (p=0.024). For those more intensively used sites which are mainly served as main residential or temporary residential settlement, there are higher proportions of them located close to the mountainous area than those of least intensively used sites. Such a pattern reflects that people have made full use of the resources provided in different ecozones but have more intensive use of the areas where are relatively closer to the mountainous area.

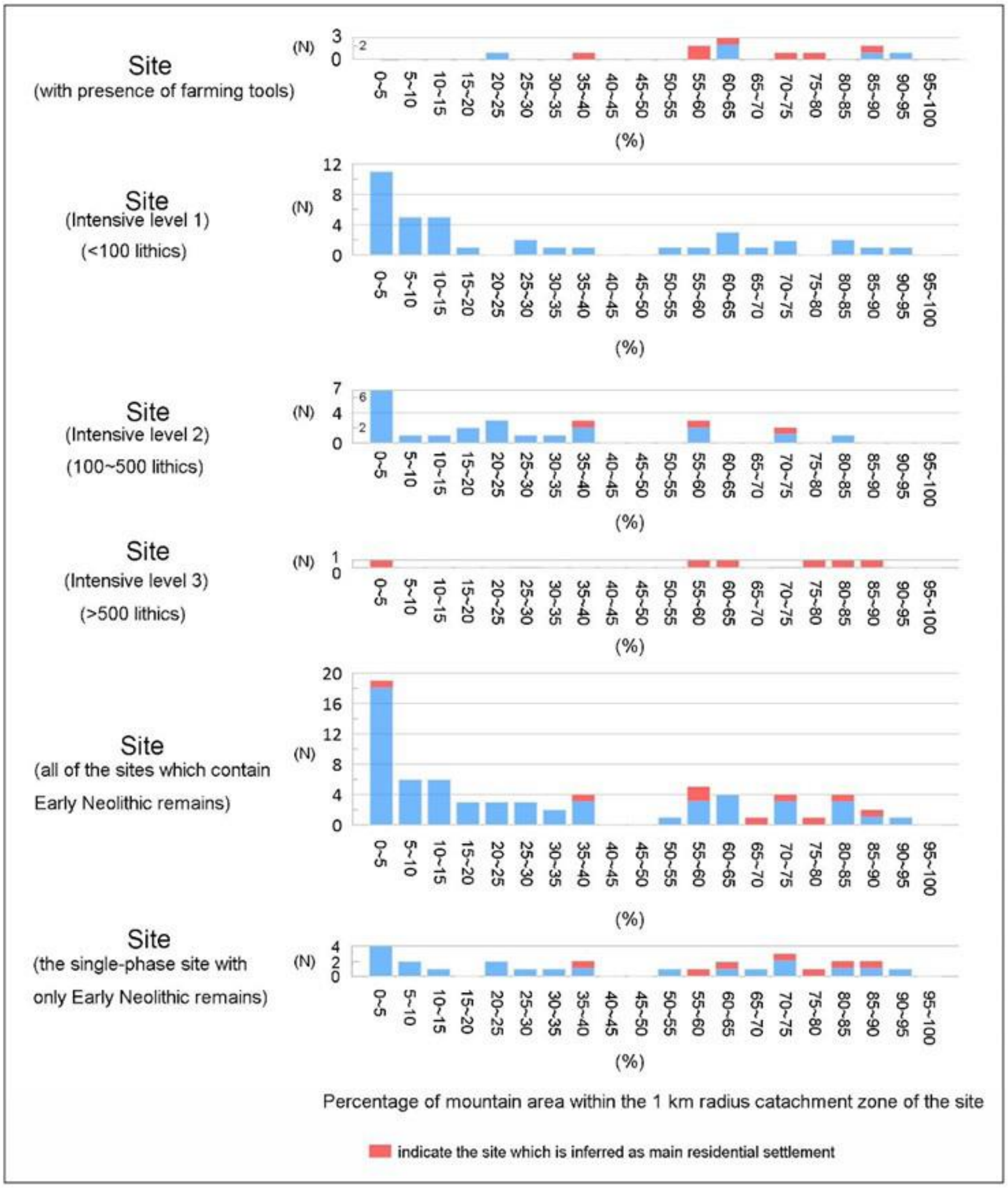

Figure 5.23 The Early Neolithic sites with different proportions of the mountainous area within the 1km radius catchment zone

Table 5.10 The actual and expected number of single Early Neolithic component sites and the multi-phased sites which contains Early Neolithic remains across the locations with different proximity to the mountainous area

Site feature		Mountain area within 1 km radius site catchment zone (0-45%)	Mountain area Within 1 km radius site catchment zone (45-100%)
Site with only Early Neolithic component	Counts	13	15
	Expected counts	18.7	9.3
Multi-phase site with both Early Neolithic and Mid-Late Neolithic/Early Bronze Age remains	Counts	33	8
	Expected counts	27.3	13.7

X^2=8.685; p=0.003

Table 5.11 The actual and expected numbers of sites with differentiated levels of site-use intensity across the locations with different proximity to the mountainous area

Site-use intensity level		Mountain area within 1 km radius site catchment zone (0-45%)	Mountain area Within 1 km radius site catchment zone (45-100%)
Level 3 (>500 lithics)	Counts	1	5
	Expected counts	4	2
Level 2 (100-500 lithics)	counts	19	6
	Expected counts	16.7	8.3
Level 1 (<100 lithics)	Counts	26	12
	Expected counts	25.3	12.7

X^2=7.783; p=0.02

Several reasons might explain such a preference for the choice of settlement locations. For one thing, people can fully exploit the resources in the mountainous areas by setting their settlement close to the mountains. Moreover, the transitional area between mountains and plains converges the resources from both ecozones, providing diversified species and rich resource volumes. Such geographic benefits can provide a more solid resource basis to support the more durably occupied settlements. In addition, certain places within or close to the mountainous area can protect people from suffering cold and windy weather and therefore might be treated as the ideal place to build settlements used during cold seasons. Furthermore, some specific places of the transitional area between mountains and plains have thick soil depositions and less prone to the threats of floods or salinization as compared with the flat areas located closer to the rivers. Therefore, it provides a more favorable condition for farming, which could be served as an additional subsistence practice to support the more durable residential sites besides hunting and gathering.

5.4.2.3 The altitude differences around the sites

Not only the closeness to the mountainous matters for people's choices of site locations and impacts the intensity of site use, the relative height of the mountains and hills could also be another important factor to influence people's site choice and convey the information about the particular land-use preferences. In the mountainous area, the forests, shrubland, and steppe are estimated to be vertically distributed in different heights of the mountains during the Early Holocene climate optimum. Therefore, the higher mountains with greater altitude difference to the adjacent valley floor tend to have more pronounced vertical distributions of different resource patches. The low hills, terraces, and tablelands have minor altitude differences with the surrounding low-lying terrains and therefore, the resources in these places are distributed more homogeneously or in more horizontal differences (like the differentiated distances to large water bodies will cause the different resource distributions across the flat land). In this case, the range of altitude difference within the 1 km radius catchment zone of each site is calculated and such data is cross-tabulated with the intensity levels of different sites to investigate the preference of people's site choices and resource exploitation strategies.

From Figure 5.24, we can see that the range of altitude differences at the surroundings of the sites is closely related to the intensity of site use. For the sites used with the least levels of intensity, there is a higher proportion of them distributed in regions with minor altitude differences nearby. While the majority of more intensive used sites (like the sites labeled with intensity level 2) likely located at the juncture between the flat valley floor and the moderate to higher mountains. As for the most intensively used sites, all the ones except for XH5 are sited in areas with relatively pronounced altitude differences. As shown in Table 5.12, the Chi-Square analysis shows that the range of the altitude difference at the surrounding area is significantly different among the sites with varying levels of intensity of use (p=0.026). Such difference informs that people were more inclined to set down their sites with higher expectations of use intensity to the areas where have a convenient location for the vertical exploitation of the resources distributed at different heights.

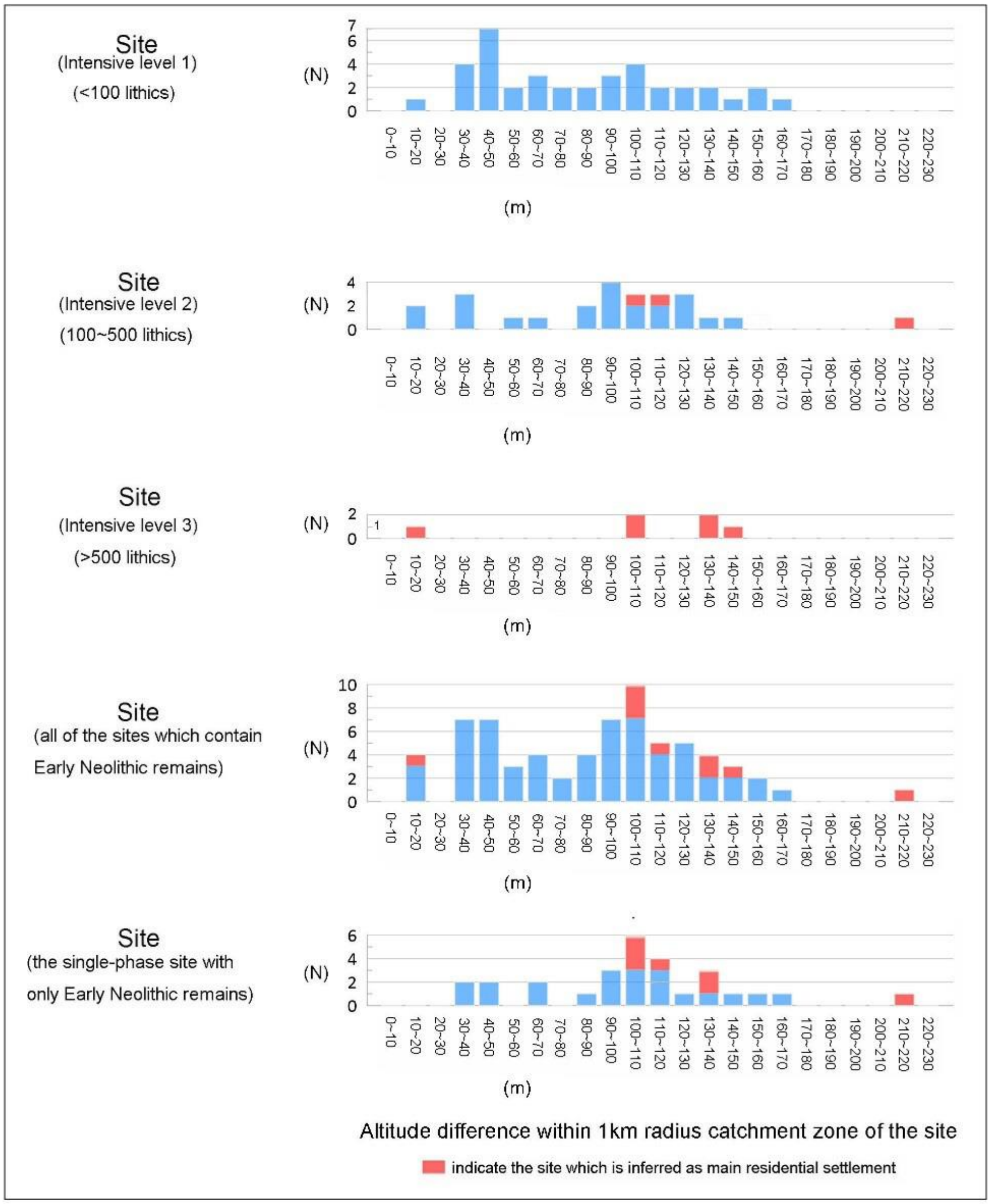

Figure 5.24 The distribution of the Early Neolithic sites with different ranges of the altitude difference within the 1km radius catchment zone

Table 5.12 The actual and expected numbers of sites with differentiated levels of site-use intensity across the locations with different ranges of altitude differences within the 1 km site catchment zone

Site-use intensity level		Altitude difference within 1 km radius site catchment zone (less than 70m)	Altitude difference Within 1 km radius site catchment zone (more than 70m)
Level 3 (>500 lithics)	counts	1	5
	Expected counts	2.5	3.5
Level 2 (100-500 lithics)	counts	7	18
	Expected counts	10.5	14.4
Level 1 (<100 lithics)	counts	21	17
	Expected counts	16	22

X^2=6.335; p=0.042

5.4.2.4 The aspects of the sites

The distributional pattern of the aspects of sites implies the seasonal use strategy of the sites. Since the winter in the survey region is brutally cold and windy even in Holocene climate optimum, people need to locate their cold-season used sites in more winter-sheltered and relatively warmer places. The south-facing slopes are the ideal places for setting the sites used in cold seasons since it can help people protect the cold wind directed from the northwest. Although the sites at the south-facing slopes can also be used during the warmer seasons of the year, it is unlikely that people would settle down their cold season used sites at the north-facing slopes, since people were inclined to be more severely suffered from the bad weathers in such location during the cold and windy times. Therefore, the north-facing sites might more likely to be used exclusively during the warmer seasons of the year, like the period from late spring to the early fall.

Among 69 sites which contain Early Neolithic remains, 15 of them are located at the north-facing slopes. Even though it only takes about 22% of the total number of sites, the relatively intensively used sites take a considerable proportion of them (the sites with intensity levels 2 and

3 take 53% of all these 15 sites). Such a pattern suggests that besides SMG, there are also other intensively used sites only occupied seasonally by people in the Early Neolithic period.

5.4.2.5 Site distributional pattern

One remarkable feature of the site distribution during the Early Neolithic period is that many of the sites are distributed closely with each other as compact clusters in certain places of the survey area. According to the recall of archaeologists who have participated in the survey work as well as my field experience during the survey work in 2017, whenever a spot with densely distributed artifacts have been found, we will search the areas around it to find the boundaries of the artifact distribution. The artifacts at first got increasingly sparser as we move farther from the core area of the dense artifact distribution. However, they suddenly got densely distributed again along a certain direction as the distance from the previous densely distributed zone continuously increases. Then we realized the existence of another dense distribution zone of artifacts. Usually, several such densely distributed spots can be found within the same landforms and each of them is not far away from each other. The archaeologists from the Inner Mongolia Institute of Archaeology and Ulanqab Museum gave them the same name but still treat them as different sites and distinguish them with the numbers of the locality as a way to show their physical proximity. Admittedly, since the survey is not based on a rigorous systematic way, the surroundings of the known site might be more intensively surveyed than the other parts of the region and are inclined to be labeled with more numbers of localities. It does not necessarily mean that the clustered distribution of artifacts did not exist but reminds us that there are certain degrees of biases of the data caused by the survey method.

Both the area around the SMG and Yumin show such a clustered pattern of distribution (as shown in fig 5.24). Before the excavation of the SMG site, four localities that show the densely distributed artifacts have been found within 500m distance along the valley floor. They are separately labeled as locality 1 to 4 of SMG. Each marker in Figure 5.25 was pointed to the most densely distributed spot of the artifacts for each locality. There are no clear-cut boundaries of these localities. They are mainly separated from each other by the gaps with rare artifact distribution sited between them. As for the surroundings of the Yumin site, two other sites, namely BN1 and BN2, are located at two adjacent mountain coves near the one where the Yumin site locates in. The airline distance between them is within 400 m. Since the mountain ridges separated them, their boundaries are clearer than those of the SMG locality group.

Figure 5.25 The map showing the clustered distributions of sites in the area around the Yumin and Simagou sites

(The group of sites around Yumin: on the left; The group of sites around Simagou: on the right)

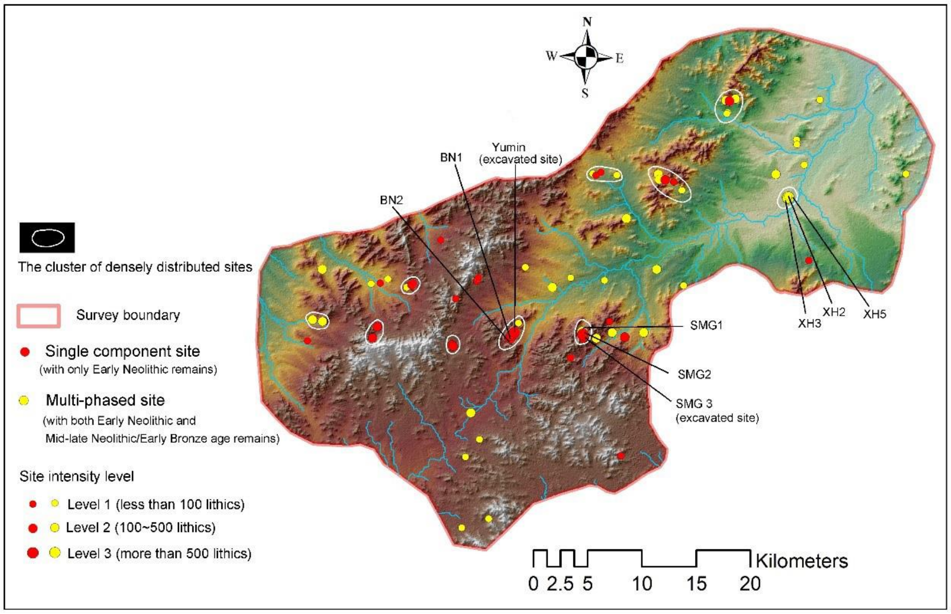

Figure 5.26 The map showing the clustered distributions of the Early Neolithic sites

Besides these two groups of sites, several other clusters of sites can be identified from the map in Fig 5.26. Although such clustered distribution has been found in different landforms, they are more concentratedly located at the transitional zones between valley and mountains. In contrast to such clustered distribution, we can also see that some sites are more dispersedly distributed and relative far away from the neighboring sites. Such a pattern of site distribution suggests that people have made use of different areas within the survey region with varying extents of intensity. They especially favored some places than the others and have made repetitive use of them in a long period and therefore left clusters of sites in certain confined areas.

Moreover, we can also see that some clusters are dominated by the sites with single component Early Neolithic remains, while the others are either dominated by multiple-cultural component sites which include the Early Neolithic remains or mixed by both single Early Neolithic component sites and multi-cultural component sites. For instance, five localities have been identified in the group of XH sites. While two of them are exclusively used during the Mid-Late Neolithic/Early Bronze Age, three of them are used by both Early Neolithic and Mid-Late

Neolithic/Early Bronze Age. Such a pattern indicates that while some places might be especially favored by Early Neolithic communities for exploitation, some other places are favored by both the Early Neolithic and Mid-Late Neolithic/Early Bronze Age communities.

5.5 Summary

The analysis of the survey data can well complement and extend the information we learned from the excavation materials to provide a more comprehensive picture of the land-use strategy in the Early Neolithic period. Several important conclusions about the land-use pattern we learnt from survey data are listed below.

(1) People did not live in a fully sedentary way during the Early Neolithic period in the survey region. Mobility was still retained as an important dimension for organizing socio-economic activities. However, the mobility significantly declined in terms of both the frequencies of movement and the distance of movement in comparison with the typical highly mobile hunter-gatherers.

According to the survey data, there is a wide range division of sites in terms of use intensity. Among them, only a limited number of the sites resemble the Yumin and Simagou sites. Those which dissimilar with the Yumin and Simagou usually show a shorter period of occupation and less intensive use. They were probably used as temporary residential sites dwelled by a short period of time or used as task sites to fulfill specific activities. Different sites might be occupied in different seasons of the year. While some main residential sites identified from the survey data might be inhabited by people during the colder period of the year, the main residential settlement of the SMG3, SMG1, as well as several temporary residential settlements might probably be used during the warmer seasons.

Despite the seasonal shift among different settlements with varying degrees of residential stability, people have made repetitive use of certain places of the survey area and left densely distributed remains. Such a pattern probably implies that the sphere of the mobility was somehow circumscribed and people have become tethered to certain places where there are relatively abundant resources or nice winter shelters. They recurrently exploited these places year after year rather than frequently relocating their settlements in a broad range of land and making only extensive use of any certain spots. Moreover, the sites used in different seasons can all be found within the 1494 km^2 survey region, which indicates that the Early Neolithic community in the studied area probably not make long-distance movement for the seasonal use of the environment, since otherwise, only the sites used in the specific season can be found and those used in different seasons might be out of the sphere of the survey region. Furthermore, in comparison with the base camps used in the earlier period which undertake similar roles as the main residential settlement within the whole settlement system, the main residential settlements used in the Early Neolithic period in the studied region show more stable forms of residency. They have not only rich remains of artifacts and high diversity of tools and lithic materials, but also have the relative permanent dwelling structure, like pit house.

(2) Farming activity was already incorporated into subsistence system but did not likely serve as the major means of subsistence. People still heavily relied on intensive hunting and gathering to acquire their food.

The tools related to farming activities have been found only in a limited number of sites. They are either distributed in all the main residential sites as identified from the survey or occasionally found in the more temporary occupied sites which are close to the main residential settlement. Such a pattern indicates that farming activity was usually conducted when people were aggregated in the main residential settlement or occupied the temporary residential or task sites, which were located close to the main residential settlement. However, farming was unlikely the kind of activity that people heavily depended on or intensively engaged in since the absence of the farming tools in many sites indicates that people did not need farming everywhere they settled down. Moreover, besides the Simagou site (shown as the SMG3 in the survey data) and two adjacent less-intensively occupied sites (DSB1, DSB2) which shows a moderate-low proportion of farming tools, the other sites only have extremely low proportions of farming tools within the whole tool assemblages. Admittedly, due to the issues of preservation, refuse disposal patterns, or the availability of farming tools made of alternative materials other than lithics (like wood and bone instead), some much later Neolithic or Bronze Age sites in some parts of North China also contain a very small amount of identifiable farming tools. However, the few remaining farming tools are usually finely made and well-shaped, implying that they are designed for long-term intensive and effective use. In comparison, the farming tools found either from excavation or survey sites from the Early Neolithic of Northern Yinshan Mountain region are crude and simple, suggesting a more expedient design for shorter-term and less intensive use.

In comparison with farming, the intensive collection and processing of the wild plant resources seems contributed more to human's subsistence economy since the grinding stones can be much more frequently found in different sites than farming tools. They are more common in the more intensively used sites.

The microblade remains are even more frequently found across different sites. Even for the least intensively used sites, more than 60% of them have found lithics remains relevant to the microblade industry. It implies that hunting is the most frequently practiced subsistence strategy. The difference of the proportions of microblade remains across the different sites is more significant than that of grinding tools and is probably associated with the seasonal differences of the hunting intensity.

(3) People made full use of resources from different environmental zones but made particularly intensive use of the transitional zones between plain and mountainous regions.

The sites have been broadly distributed across different landforms and located in the places with differentiated proximities to the mountainous area and varying ranges of altitude differences in the surrounding areas. Such a distributional pattern indicates that instead of focusing on specific ecozone for exploitation, people made comprehensive use of the resources from different ecozones.

Among different landscapes, people especially favored the transitional zone between mountains and plains and settled most of their main residential settlements as well as a large number of temporary settlements and task sites in this region. It indicates that people had taken full advantages of the benefits of the ecozones with convenient access to both steppe and forest resources distributed at the different elevations. They made intensive exploitation of a broader range of edible resources with diversified sets of toolkits. Such land-use strategy enabled them to obtain their food supplies within a relatively circumscribed region and provided a subsistence base for them to settle down in more stable forms of residence in specific lcations at certain seasons.

6.0 The analysis of land-use in Mid-Late Neolithic/Early Bronze Age based on the survey data

In total, 116 sites have been identified as containing the cultural remains of Mid-Late Neolithic and Early Bronze Age. Among them, 106 sites yielded Mid-Late Neolithic and Early Bronze Age pottery, and 10 sites yielded only lithics but no pottery sherds. These last are tentatively attributed to the Mid-Late Neolithic and Early Bronze Age because the features of lithic assemblages of these sites resemble the ones found with diagnostic pottery sherds of Mid-Late Neolithic/Early Bronze Age.

Among the 116 sites, 41 are commingled with Early Neolithic remains, and the rest contain only Mid-Late Neolithic/ Early Bronze Age remains. Although none of these sites have been excavated, a fairly large number of the surveyed sites and the abundant lithics remain found at them reveal important features about the correlation between sites and environments, lithic technological organization, and the inter-site variation in lithics, which provide us with rich information to investigate the patterns of land-used during this period.

6.1 Technological organization

6.1.1 Features of technological organization in general

The features of the lithic assemblage from the surveyed sites reflect thriving development of chipped lithic tools and limited reliance on ground stone tools. Although chipped stone tools comprise the largest proportion of the tool assemblage in both Early Neolithic and Mid-late Neolithic/Early Bronze Age in the survey region, a higher proportion of the chipped stone tools in

Mid-late Neolithic/Early Bronze Age are more elaborately made with more intensive reduction and retouch processes and are usually shaped into more regular forms of various kinds.

This tendency of lithic technological development is quite different from that in many other regions of North China, especially the core regions like the Yellow River drainage, where reliance on ground stone tools increases and chipped stone declines (Zhang 2004). This difference further indicates that the prehistoric communities in the studied area adopted different land-use strategies in comparison with contemporaneous communities in the core regions of North China. By exploring the design and use of tools based on specific features of tool forms and chipping techniques, I suggest that a degree of mobility was retained in land-use strategy, and there was an increasing reliance on animal resources during this period.

6.1.2 The prevalence of the bifaces

A biface is a flake or core blank that has been reduced on both faces from two parallel but opposing axes through percussion and is shaped into a specific form. While no typical forms of bifaces have been identified in Early Neolithic remains, 35 out of 75 sites with the single component of Mid-Late Neolithic and Early Bronze Age remains have yielded either well-shaped bifaces or blanks of bifaces. The byproducts and end-products of bifaces (such as tools modified from the bifaces) are found in even more sites.

Previous studies of bifaces imply that they can either be used as cores, as long use-life tools, or as by-products of the shaping process, such as components to fit a preexisting haft (Kelly 1988). Since the bifaces found in the surveyed area are relatively small, it is unlikely that they were used mainly as cores during the Mid-Late Neolithic/Early Bronze Age. Instead, they are more likely to be used as preforms of tools since, based on the analysis of by-products and end-products of bifaces from the survey, bifaces can be further modified into arrowheads, points, drills, burins, and scrapers by various ways of truncating and reshaping, and the small trimmed rectangular pieces of bifaces can be directly used as insets to fit bone-hafted knives (as shown in Figure 6.2). In addition, since bifaces already have retouched edges before they have been further modified into other tool types, it is also possible that they were directly used as tools in some cases, but this idea still needs to be tested by use-wear analysis.

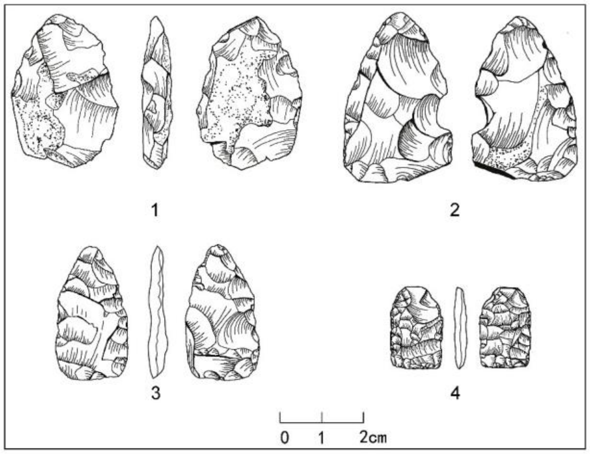

Figure 6.1 The bifaces found at Mid-Late Neolithic/Early Bronze Age sites in the survey region

(1: biface blank, NHDN site; 2: biface, JCGX1 site; 3: biface, NHDN site; 4: rectangular biface blade,YAN2 site)

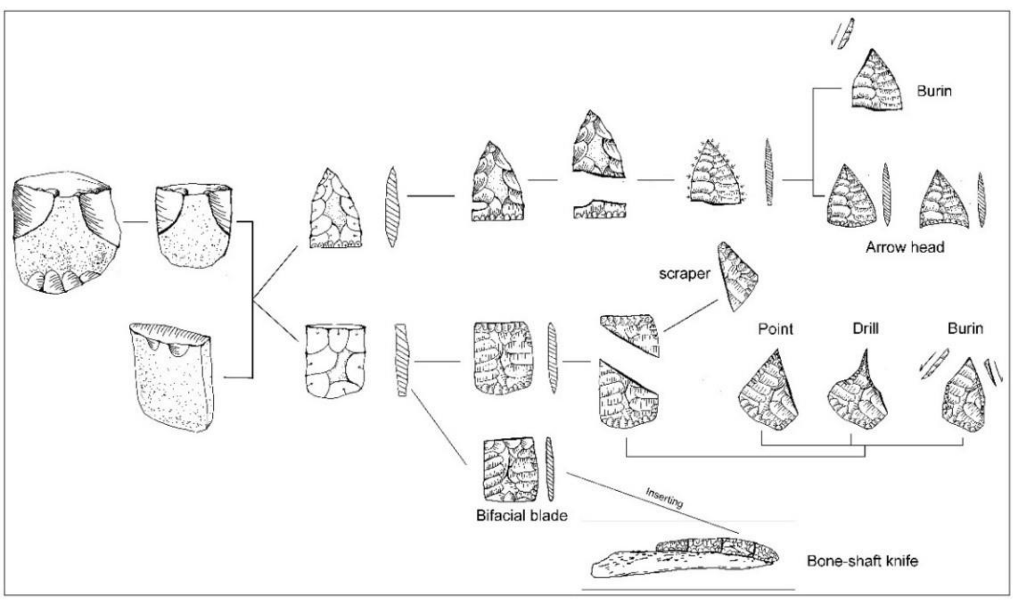

Figure 6.2 The diagram showing the reduction sequences of biface technique reflected from the Mid-Late Neolithic/Early Bronze Age sites in the survey region

The prevalence of bifaces in this period shows significant organizational changes in lithic technology in comparison with the Early Neolithic period. Unlike expedient tools which can be easily made and discarded, the relatively high energy investment in biface making suggests that bifaces were not discarded quickly. Certain tasks that cannot be done with expediently chipped stone tools might be accomplished with the bifaces to outweigh the high energy investment in their manufacture (Bamforth 1986; Binford 1979).

One advantage of the biface in the studied area is that it can be flexibly reformed into various kinds of tools used for different functions. Such an advantage is badly needed under conditions when people need to prepare for a variety of tasks requiring stone tools but cannot well anticipate how many tasks, or the relative proportions of different tasks (Torrence 1982).

Another advantage is that travelling with bifaces as tool blanks can save transportation cost during the travel. Since the facial retouch on both sides has removed redundant parts of the lithics, bifaces are usually thinner than other tool blanks, which are not facially retouched (such as chunks, flakes, and nodules). Bifaces maximize the total amount of stone cutting edge while minimizing the amount and the weight of the stones carried (Kelly 1988).

These two advantages can solve the problems of spatial and temporal differences between the locations of raw material and the locations of stone tool use (Kelly 1988). Ethnoarchaeological studies indicate that hunter-gatherers who make longer logistical forays are more prone to meet such situations since there are more occasions for the urgent need of tool use which cannot be well anticipated in advance during the long foray, and such needs might not always happen in places where the suitable raw materials are readily available (Murdoch 1892; Torrence 1982). Therefore, hunter-gatherers who make longer forays often carry a substantial amount of gear to cope with such challenges (Binford 1978b). Based on their suitability for transportation and flexibility for converting into multiple tool types for dealing with different activities, bifaces are ideal for carrying on long forays (Odell 1998; Surovell 2009a). Therefore, the prevalence of the biface technique might imply increasing need for people to make suitable lithics for long-distance forays during this period.

6.1.3 The prevalence of facial retouch technique

Tool retouch can be classified as the marginal retouch and facial retouch. Marginal retouch only focuses on retouching the edges of the tools while facial retouch refers to the invasive retouch from the edge to the inner part of the body of lithic blanks (Andrefsky 2005). While the bifaces are the typical facially retouched tools, facial retouch can be applied for making a much broader range of types of tools besides bifaces.

As for the facially retouched tools found in the surveys, we can see that while some of them are modified from bifaces, others were directly shaped by facial retouches from the original pieces of the manuports. Whereas facial retouch in the Early Neolithic period was mostly used for making medium-to-large tools (like adze-like tools, stone hoes) and was only occasionally used to make like-duty tools (like scrapers), facial retouch was widely applied for making a range of small tools during Mid-Late Neolithic/Early Bronze Age, like end scrapers, scrapers, burins, drills and points.

Facial retouch can significantly change the forms of the tool blanks. It requires more investments during the tool making process, which is usually accompanied by more intensive reductional sequences (Kelly 1988). Moreover, since facial retouch can only be successfully applied to homogenous materials with suitable hardness and fragility, it has more stringent requirements for the quality of the raw materials. Therefore, facially retouched tools are more costly than marginally retouched tools in terms of the energy invested for raw material selection and tool production.

However, in comparison with marginal retouch, facial retouch can modify the forms of tools as needed and make them convenient to use. Moreover, facial retouch can potentially extend the use-life of certain tools. A well facially retouched tool usually has a similar microtopography along all its edges. When the tool edge breaks or becomes dull, it can be resharpened easily and persistently used for a longer period (Kelly 1988). Such features increased the reliability of tool use and make tools suitable for intensive use under the situations when there is time pressure for carrying out certain activities efficiently, or it is inconvenient to produce replacement tools at any time (either when suitable raw materials were not at hand or time pressure requires people to focus on working persistently rather than being interrupted by lithic production) (Bleed 1986). Therefore, the more frequent application of facial retouch techniques reflects higher demand for reliability during Mid-Late Neolithic and Early Bronze Age in the studied area.

6.1.4 The prevalence of arrowhead

The arrowheads from the excavation and survey materials of Huade county are elaborately retouched small points in symmetrical form with intentionally retouched tails. The tails of the arrowheads are thinned by trimming in various ways, like concave, convex, or flat (as shown in the Figure 6.3). In the Early Neolithic period, such arrowheads are only occasionally found at the excavated Yumin and Simagou site. None of them have been found at the surveyed sites, which have only a single component of Early Neolithic remains. In comparison, 37 out of 116 surveyed sites have yielded the remains of arrowheads from the sites with a single component of Mid-late Neolithic/Early Bronze Age remains.

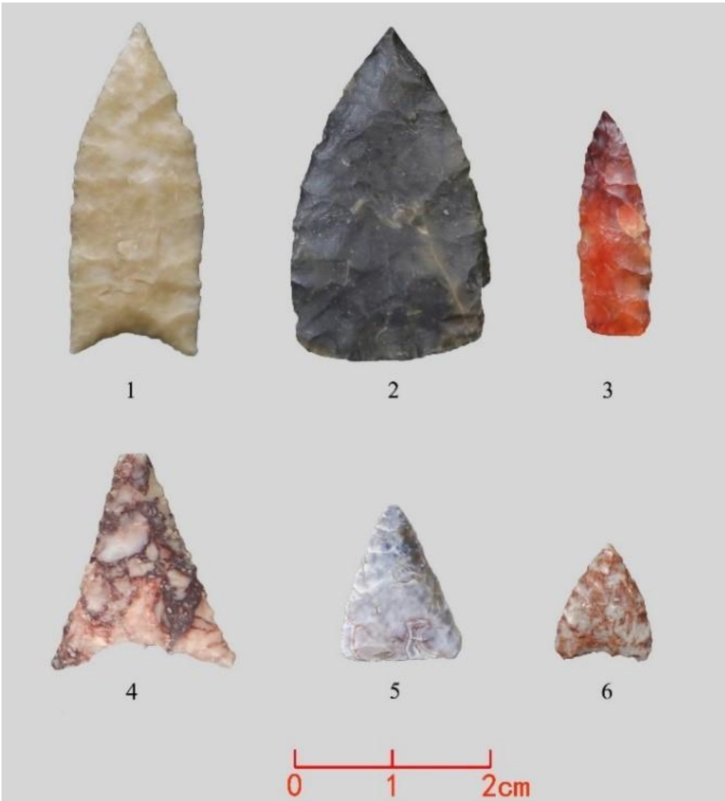

Figure 6.3 The arrowheads found from the Mid-Late Neolithic/Early Bronze Age sites

(1: EDW site; 2: JZJ site; 3: JZJ site; 4:FSCX site; 5: ZJYZXB site; 6: ETC site)

The increasing prevalence of arrowheads suggests intensified tool investment for hunting activities. Unlike microblades which can be inserted into different forms of hafts and used either as hunting weapons or for other purposes, arrowheads are specifically designed to be used as hunting weapons. Microblade-inserted projectiles are usually large and hence are more suitable for hunting medium-to-large animals. In comparison, the arrowhead can be produced in various sizes and used for hunting animals of different sizes. If we assume that the sizes of arrowheads are correlated with the animals people hunt, the arrowheads found at the Huade surveyed sites might be designed to hunt for medium-to-small animals since most of the 47 complete arrowheads are small. A couple of them are even less than 15 mm in both length and width (as shown in Figure 6.4). Whether or not such extremely small arrowheads were specifically designed for hunting small animals remains open for discussion.

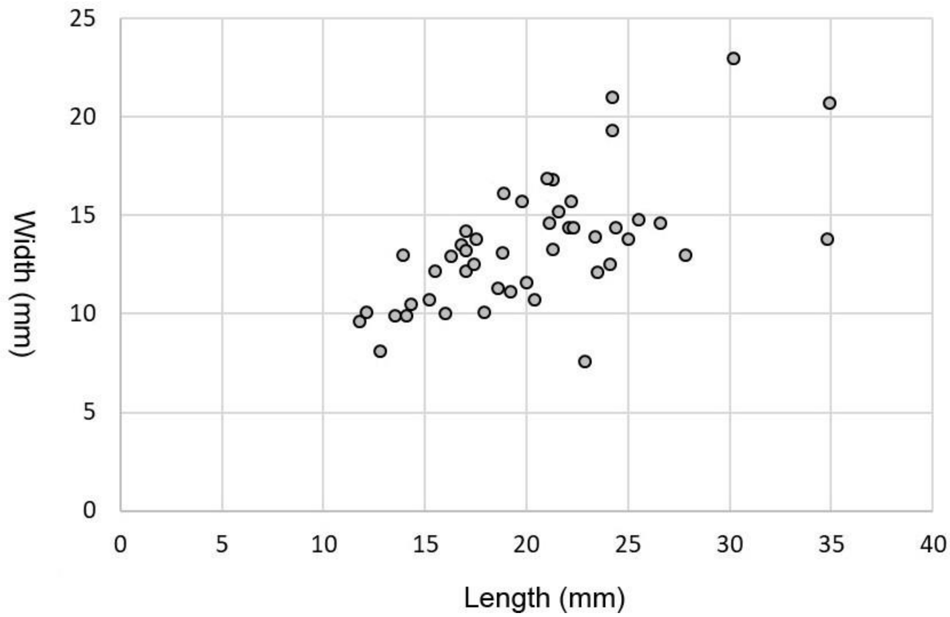

Figure 6.4 The size of the complete arrowhead found from the Mid-Late Neolithic/Early Bronze Age sites

The bow and arrow is a complex technology for hunting activity. It involves a high investments in tool manufacture but is highly efficient for hunting since it can increase the success rate and makes it possible to hunt animals that are hard to capture by other means of hunting (Bettinger 2013). Therefore, the prevalence of arrowheads reflects intensification of hunting in the Mid-Late Neolithic/Early Bronze Age. The coexistence of arrowheads and microbaldse implies varied methods and strategies for hunting.

6.1.5 The miniaturization of the chipped lithic tools

In general, the chipped stone tools from the Mid-Late Neolithic/Early Bronze Age are smaller than those from the Early Neolithic. The lithic remains from four Mid-Late Neolithic/Early Bronze Age sites have been measured and used to make comparisons with lithic remains of the excavated Yumin and Simagou sites. From Tables 6.1 and 6.2 , we can see that the differences in the sizes of end scrapers and light-duty tools (including scrapers, points, drills, burins) between Early Neolithic and Mid-Late Neolithic/Early Bronze Age are significant.

Table 6.1 The comparison of the maximum diameter of end scrapers between Early Neolithic and Mid-Late Neolithic/Early Bronze Age sites

Site	Number	Median	Mean	LO(95%CL)	UP(95%CL)	P%(<2cm)	P%(2-4cm)	P%(>4cm)
Yumin	86	22	24.6	22.4	26.9	37.2	55.8	7.0
Simagou	19	18.5	21.8	17.2	26.5	57.9	36.8	5.3
JCGX1	14	16.45	16.7	13.9	19.5	78.6	21.4	0.0
JHDN	6	14.3	15	10.1	19.8	83.3	16.7	0.0
FDCSX	32	15.7	16.3	14.7	17.8	81.3	18.8	0.0
HDLGDN	32	13.95	15.1	13.1	17	84.4	15.6	0.0

Table 6.2 The comparison of the maximum diameter of the light-duty tools between Early Neolithic and Mid-Late Neolithic/Early Bronze Age sites

Site	Number	Median	Mean	LO(95%CL)	UP(95%CL)	P%(<2cm)	P%(2-4cm)	P%(>4cm)
Yumin	193	35	38.3	36.1	40.6	7.3	54.9	37.8
Simagou	82	39.55	43.7	37.9	49.5	19.5	31.7	48.8
JCGX1	50	19.95	20.8	18.2	23.5	50.0	48.0	2.0
JHDN	8	19.85	21.4	18	24.7	62.5	37.5	0.0
FDCSX	85	23.8	26.2	24.3	28.2	22.4	67.1	10.6
HDLGDN	24	21.75	21.7	19.5	23.9	25	75	0

Whether such difference resulted from intentional tool design or caused by the use of different raw materials is still open to be discussed. Admittedly, blanks of high-quality cryptocrystalline stone used to make tools are usually smaller than those of locally available igneous rocks. Since people in the Mid-Late Neolithic/Early Bronze Age relied more heavily on high-quality cryptocrystalline stone, the tools tend to have smaller sizes in general.

However, some extremely small tools with a maximum diameter as small as about 1 cm are far below the size limit of the tools which can be made even from small blanks of high-quality cryptocrystalline stone. Moreover, tool size differences sometimes impact the ways people use them. Some very tiny tools, like those less than 2 cm in maximum diameter, cannot be conveniently used by hand and are more likely to be used by hafting (Keeley 1982). Unless people have such requirements to make tiny tools used for hafting, they are unlikely to shift their focus on the use of small cryptocrystalline blanks for tool production. Therefore, people's intentional considerations of tool design at least account partly for the miniaturization of stone tools in Mid-Late Neolithic/Early Bronze Age.

The appearance of extremely small tools might correlate with increasing demand for hafting of chipped stone tools. This inference still needs to be tested by use-wear analysis to see if signs of hafting are found on the lithic tools. Since hafting is another way to improve the working efficiencies of the tools (Keeley 1982), we can further infer the increasing demand for improving the reliability of tool use during Mid-Late Neolithic/Early Bronze Age.

6.1.6 The reduced size of grinding stones

In comparison with chipped stone tools, the grinding stones are rare, and most of them are fragmentary from the survey collections of Mid-Late Neolithic/Early Bronze Age remains. The observations of the fragmentary pieces of stone slabs leave us the impression that the stone slabs seem to be smaller than those found in the Early Neolithic remains. Among them, a stone slab from JZJ is relatively well preserved (as shown in Figure 6.5). It is 14.7 cm in width and about 24 cm in length, which is about the same size as the smaller versions of the stone slab found at the Yumin and Simagou sites and is smaller than the larger ones found in Early Neolithic remains. Both sides of the slab have obvious depressions, and the thinnest part of the body is less than 1 cm, showing that it was used quite intensively. This design and use of grinding stones might also speak to a certain degree of mobility, for the smaller grinding slabs were easier to transport from site to site in comparison with large and heavy grinding stones which are often described as "site furniture" due to their unsuitability for transporting. Moreover, the maximized use of the few grinding slabs repetitively rather than producing more grinding slabs to use can also save the costs of transportation.

Figure 6.5 The grinding slab found from the JZJ site

6.1.7 The changes in raw materials

As mentioned in 5.1.5, one significant difference of raw material use between Early Neolithic and Mid-Late Neolithic/Early Bronze Age is that people in later periods relied mostly on high-quality cryptocrystalline materials, such as chert and chalcedony to produce small chipped stone tools. While such materials are also used for making similar types of tool in the Early Neolithic period, they occur in small proportions in comparison with the most frequently used dark-colored igneous rocks.

Since both fine-grained igneous rocks and cryptocrystalline stone are workable for producing similar ranges of lithic tools, the changes in raw material use implies that instead of being passively confined by the availability of raw materials for tool making, people can adjust their raw material exploitation strategies according to the changing needs of lithic technological organization.

The advantage of igneous rocks is that they are more abundant in the survey region, and the manuport or blanks of them are usually bigger than the ones of cryptocrystalline stones. However, except for a few of the most fine-grained igneous rocks, the majority of the less fine-grained igneous rocks are difficult to retouch facially into well-controlled forms compared with the cryptocrystalline stones. Due to the structures of these rocks, fracture is more difficult to control during the chipping process, resulting in more wasted attempts, less form control and less sharpness. Therefore, the increasing demand for the production of small and highly curated tools made people become more reliant on the use of cryptocrystalline.

The cryptocrystalline used for tool making comes from various sources. Based on the survey, we can see that one type of white chert can be frequently found on the ground in parts of the survey area in forms of highly weathered small chunks. Other types of cryptocrystalline, like jaspers, chalcedony and agate cannot be easily found within the survey area. While the exact provenance of them still needed to be learned by surveys to investigate the distribution of raw material sources, the focus of cryptocrystalline for tool production implies that people have relied more on raw materials transported from other areas rather than focusing on the use of locally available raw materials.

6.1.8 Summary: the implications of changing technological organization

The features of lithic assemblages in the Mid-Late Neolithic/ Early Bronze Age of the studied area indicate that people had specific considerations for increasing the flexibility, reliability, and suitability for transportation of chipped stone tools. Such concerns closely tie with a continued importance of mobility in economic and social activities. Rather than fully settling down in specific places, people were made even long-distance forays in specific situations and were equipped with toolkits for solving various challenges caused during movement.

The features of lithics, as well as the corresponding lifeways they indicate, also reflect increasing exploitation of the animal resources at a more intensive level. The prevalence of arrowheads indicates more investment in hunting techniques. While the other types of chipped stone tools (although their functions still need to be investigated by use-wear analysis) have forms and sizes that suggest that the majority of them were more likely used for animal resource processing, such as butchering, hide-working, and grooving on bones or antlers. Moreover, the presumed long logistical forays might be conducted for hunting purposes, since frequent hunting would reduce the abundance of animals in the areas surrounding the settlement and require people to expand the search for prey (Jerozolimski and Peres 2003). The time pressure of moving during the move might also be correlated with hunting activity. Since game is often agile moving targets compared with static plant resources, successful hunting requires people to have quicker reactions and efficient ways for resource procurement once the opportunity appeared.

6.2 Inter-site variations of the survey data

6.2.1 The features of the main residential settlement

Among all 116 surveyed sites with the single cultural component of Mid-Late Neolithic/Early Bronze Age remains, six sites are distinguished from the others by much more abundant lithic remains (>500 pieces of lithics). Except for JHDN which has only a few pottery sherds, less diversified tool assemblages, and was overwhelmingly dominated by locally available white cherts as lithic raw materials, all the other five sites (Namely EDW, HDLGDN, FDCXS, JCGX, JZJ) have highly diversified tool assemblages and sources of raw materials as well as a large number of pottery sherds (though because of the tremendous number of lithics, their ratios of pottery sherds to lithic tools well distinguished from some of the other sites where fewer remains were found). Such features indicate that they might have served as the main residential settlements during this period because people made more intensive use of them and probably occupied these places for a long time. Except for the single-phased sites mentioned above, some multi-phase sites also had large amounts of lithics and pottery in high diversity belonging to Mid-Late Neolithic/Early Bronze Age, like sites XH5, LPB1, MLGABS3. They might probably also be used as the main residential settlements during the Mid-Late Neolithic/Early Bronze Age.

Since the sites have been heavily destroyed by post-depositional forces (mainly wind erosion), the layers of cultural deposition have been eroded out, and only scatters of lithic and pottery remains were found on the ground of the eroded surface. Therefore, we are unable to explore the internal structures of these sites in any detail. However, during the review survey of 2019 summer, we identified several stone circles in the EDW site (as shown in Figure 6.6). Unlike the naturally weathered rocks in situ on the ground, these large stones were more likely to be transported by people from other places and were careful placed in a concentration of circles in the site. Some of them can be clearly identified as laid in circles while the others were piled as clusters without distinct shapes due to post-depositional disturbance. More than ten such clusters of stones can be identified in the EDW sites and their distribution highly overlapped with the area where the artifacts were most densely distributed. Such stone circles were probably related to dwelling structures since we can find the deposition of hearth remains among the three relatively less-disturbed circles. The ash and the red sintered soils were concentrated in an oval shape and exposed on the ground. The test excavation of one of them indicates that the thickest part of the deposition is about 10 cm. It is estimated that the upper part of the hearth has been already eroded out. Numerous small lithic flakes (i.e. “debitage”) and tiny pieces of pottery sherds have been found around the hearth deposition, indicating that cooking and lithic retouch once occurred around the hearth.

Figure 6.6 The view of the EDW site

(The black circle marks the concentrated distributional zone of the stone circles)

Besides the EDW site, a hearth deposition was found in the JZJ site in the form of a concentration of ash, charcoal, and red sintered soils. The test excavation indicates that it was as thick as about 20 cm. The hard crust of the sintered soil and the thick deposition suggest that instead of being used temporarily, it was used for a relatively long period. Yet unfortunately, since the site is badly preserved, only one heath has been found, and most of the artifacts were exposed on the sandy ground which seems the eroded surface (indicating that the main cultural layer has already been eroded away).

No specific structures have been reported from the other three sites seem main residential settlements. However, since these sites have not been covered by the more detailed review survey of 2019 and the remaining traces of the kinds of structures mentioned above were extremely difficult to find due to the heavy post-depositional disturbance, it is highly possible that remaining dwelling structures still existed but needs the more careful survey to find.

The excavation of the Langwogou 2 site in Shangdu county in the 1990s further provides us important information about the features of main residential settlements in the survey region, since it is highly comparable with contemporaneous sites found in the survey area. Shangdu county is adjacent to Huade county and is also located on the northern slopes of North Yinshan Mountain. It has a similar environment to the survey region (Fu 1992). The artifacts of Mid-Late Neolithic/Early Bronze Age found in both Shangdu county and our survey region also share similar features. Located at about 56 km southwest of the southern boundary of our survey region, Langwogou2 was interpreted as a site occupied during the Mid Neolithic period based on identification of the pottery sherds. Like the main residential settlement identified from the survey region, Langwogou2 also found a large amount of lithics of various types. Although the site was badly preserved, the test excavation still found remaining traces of three houses. Each of them has a hardened living floor and a stone-lined hearth, suggesting that a certain amount of effort was invested in constructing the dwelling structures (Ji and Wei 1995).

Piecing together all this fragmentary evidence, we can see that people still constructed the relatively permanent dwelling structures in their main residential settlements during Mid-Late Neolithic/Early Bronze Age. They might inhabit these sties more permanently and conducted a wide range of activities within them.

6.2.2 Site types

Evaluating how the other sites are different from or similar to the main residential settlements is crucial to developing a comprehensive understanding of land-use strategy during the Mid-Late Neolithic/Early Bronze Age. Like the analysis made in chapter 5, inter-site variation can be evaluated by the composition of artifact assemblages across different sites. To make more reliable estimations of the proportion of different types of lithics, I excluded the mixed sites from the research except for KJYZX, which is dominated by Mid-Late Neolithic/Early Bronze Age remains, and the Early Neolithic remains are very rare. On the one hand, the evaluation of the lithic assemblage requires a fairly large number of lithics from the site in order to reduce the error range of the estimates of proportions; on the other hand, a comprehensive understanding of inter-site variation requires us to include as many sites as possible for analysis. As a trade-off solution, I have included 19 sites for analysis since they all have more than 45 pieces of lithic in total (making the error range smaller than 15% at the 95% confidence level) and more than 15 tools within the lithic assemblage (making the error range smaller than 25% at 95% confidence level and smaller than 17% at the 80% confidence level). The distribution of these selected sites is shown in Figure 6.7 and the basic information on their artifact assemblages is listed in Table 6.3. A principal component analysis of artifact assemblage composition has been done to further explore inter-site variations (the results are shown in Table 6.4, 6.5 and Figure 6.8, 6.9).

As for the variables used for evaluating the artifact assemblages, the proportions of different tool types are measured by dividing the number of the specific tool type in each site by dividing the total number of tools in that site; the proportion of microblade cores in each site is the number of microblade cores in each site divided by the sum of microblade core and the total number of tools in that site; the proportion of tuff in each site is the total number of the lithics made of tuff in each site divided by the total number of lithics in that site (including both tools and debitage); the ratio of pottery in each site is the number of pottery sherds divided by the total number of lithic tools in that site; the ratio of lithic tools in each site is the number of lithic tools divided by the total number of debitage fragments in that site; the diversity of raw materials and lithic tools are all measured by Simpson's D index (1-L). A higher value of the index indicates higher diversity.

Facial retouch is not an independent tool category, but refers to the total number of tools across different types which were facially retouched during the lithic production process. The proportion of facially retouched tools can be used to evaluate the fineness of chipped stone making. The relative importance of microblade tools was evaluated by the proportion of microblade core instead of retouched or used microblades because (1): some small pieces of microblades were hard to identify on surface during the survey; (2) people were inclined to take away the microblades which are still available for use but leave the exhausted microblades as refuse on surface in the sites occupied more temporarily. Therefore, micoblade cores could more reliably reflect the ubiquity and intensity of the use of micoblade techniques.

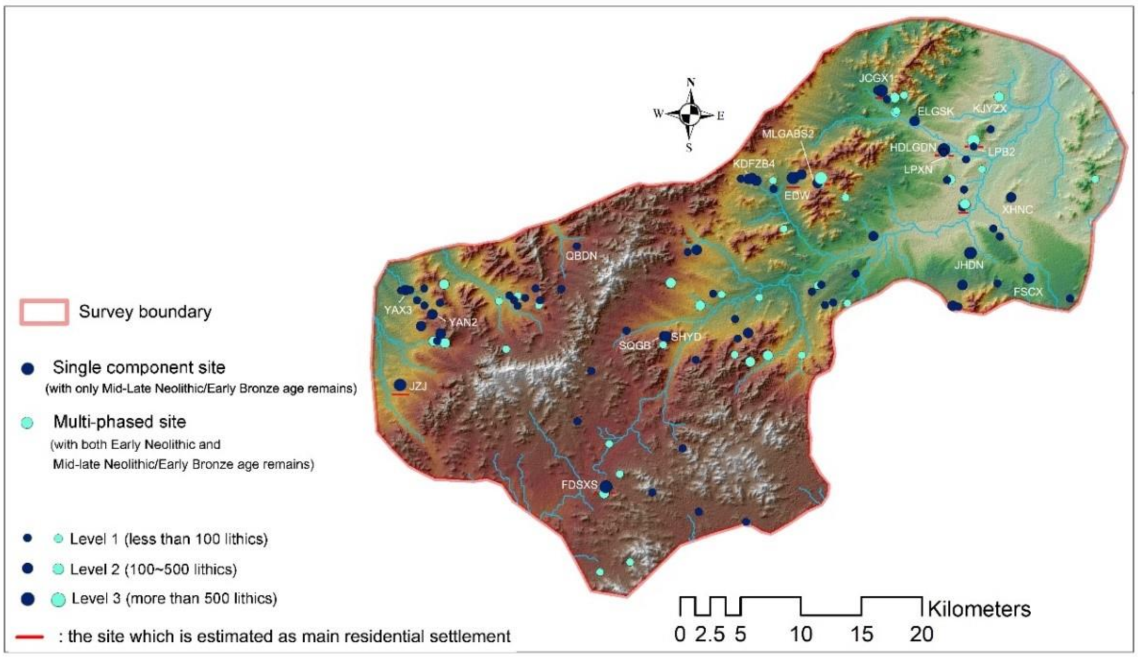

Figure 6.7 The map showing the locations of the 19 selected Mid-Late Neolithic/Early Bronze Age site

Table 6.3 The spreadsheet showing the features of artifact compositions across the 19 selected sites of Mid-Late Neolithic/Early Bronze Age

Name	N of pottery sherds	N of lithics	N of lithic tools	Tool / Debitage	End scraper (%)	Scraper (%)	Point (%)	Drill (%)	Burin (%)	Cutting tool (%)	Arrowhead (%)	Microblade (r-u) (%)	Microblade core (%)	Heavy duty tool (%)	Grinding tool (%)	Farming tool (%)	Crafting tool (%0	Biface blank (%)	Bifaces (%)	Others (%)	Facially retouched tool (%)	Diversity of raw material (%)	Diversity of lithic tools (%0
ELGSK	25	187	25	0.15	20	20	4	0	0	0	12	8	4	4	0	0	0	0	32	0	52.9	0.75	0.9
JCGX1	46	1710	140	0.09	10.7	18.6	4.3	4.3	8.6	0.7	14.3	0	3	0	0.7	0	0	20.7	17.1	0	72.8	0.51	0.92
FDCXS	331	1495	176	0.13	19.3	43.8	4	3.4	2.8	0	8.5	4	3	0.6	1.1	0	0.6	5.1	6.8	0	30.5	0.65	0.83
FSCX	208	220	20	0.1	10	5	10	0	10	0	10	10	13	5	0	5	15	0	20	0	57.9	0.63	0.93
SQGB	22	193	25	0.15	28	16	0	0	8	4	20	0	19	0	0	0	0	16	8	0	46.2	0.66	0.88
HDLGDN	181	1635	116	0.08	30.2	20.7	0	3.4	0	1.7	10.3	4.3	4	1.7	0.9	0.9	0.9	21.6	3.4	0	65.6	0.82	0.92
JHDN	14	1591	98	0.07	6.1	7.1	0	1	2	0	5.1	4.1	6	0	1	0	0	60.2	12.2	1	63.2	0.69	0.9
LPXN	68	88	22	0.33	18.2	27.3	0	4.5	0	0	4.5	13.6	0	0	0	0	9.1	9.1	13.6	0	52.9	0.15	0.74
EDW	88	2063	166	0.09	13.9	21.7	3	2.4	2.4	3	4.2	3.6	4	1.2	0.6	0	1.2	27.1	15.7	0	58.6	0.79	0.9
XHNC	33	164	19	0.13	5.3	78.9	0	0	0	0	0	0	4	0	0	10.5	5.3	0	0	0	8	0.54	0.92
KDFZB4	34	143	21	0.17	33.3	14.3	0	4.8	0	0	9.5	9.5	14	0	0	0	0	4.8	23.8	0	57.9	0.5	0.69
MLGABS2	27	353	17	0.05	47.1	11.8	0	0	0	0	23.5	11.8	19	0	0	0	0	0	5.9	0	11.8	0.66	0.88
QBDN	29	72	17	0.31	17.6	17.6	0	0	0	0	23.5	0	0	0	0	0	0	5.9	35.3	0	78.6	0.73	0.85
YAX3	87	274	48	0.21	33.3	39.6	2.1	0	4.2	0	4.2	14.6	2	0	0	0	0	0	0	2.1	56.3	0.46	0.86
YAN2	42	324	26	0.09	26.9	19.2	7.7	3.8	7.7	0	0	7.7	7	0	7.7	0	11.5	0	3.8	3.8	50	0.1	0.94
SHYD	23	318	49	0.18	26.5	28.6	6.1	2	6.1	4.1	6.1	18.4	2	0	0	0	2	0	0	0	49	0.7	0.9
JZJ	93	566	59	0.12	20.3	28.8	3.4	5.1	1.7	0	16.9	0	0	0	3.4	0	6.8	1.7	11.9	0	47.5	0.58	0.9
LPB2	16	45	13	0.41	0	7.7	0	0	0	15.4	0	0	0	0	0	53.8	7.7	7.7	7.7	0	7.7	0.46	0.67
KJYZX	2	153	22	0.17	0	0	0	0	0	4.5	0	0	0	4.5	0	31.8	13.6	27.3	0	18.2	0	0.73	0.85

Table 6.4 Component loading for the analysis of the artifact compositional features of the 19 selected Mid-Late Neolithic/Early Bronze Age sites

	Factors					
	1	2	3	4	5	6
Farming tool (%)	**-0.923**	0.107	0.159	0.094	-0.021	-0.212
Raw material: tuff (%)	**-0.885**	-0.040	-0.059	-0.328	0.072	0.047
Facially retouched tool (%)	**0.825**	-0.182	0.080	0.273	-0.221	0.141
Diversity of tools (%)	**0.796**	0.225	0.326	0.056	0.016	-0.308
cutting tool (stone knife) (%)	**-0.759**	0.012	0.110	0.218	-0.123	-0.485
End scraper (%)	**0.668**	-0.295	-0.155	-0.351	0.004	-0.439
Arrowhead (%)	**0.564**	-0.550	0.261	0.015	0.041	-0.196
Ratio of lithic tool to debitage	**-0.561**	-0.273	0.336	-0.047	-0.663	-0.080
Point (%)	0.379	**0.759**	0.278	-0.139	0.012	0.008
Crafting tool (%)	-0.362	**0.722**	0.377	-0.137	-0.057	0.016
Grinding tool (%)	0.278	**0.676**	-0.407	0.017	-0.268	-0.123
Burin (%)	0.394	**0.605**	0.127	0.022	0.035	-0.195
Diversity of raw material	0.048	-0.508	**0.620**	-0.169	0.145	-0.244
Ratio of pottery to lithics	-0.037	0.139	**0.666**	-0.348	-0.465	0.324
Heavy duty tool (%)	-0.065	0.317	**0.627**	0.215	0.550	0.144
Bifaces (%)	0.324	-0.300	**0.509**	0.261	-0.260	0.405
Biface blanks (%)	-0.112	-0.039	-0.297	**0.824**	0.213	0.230
Scraper (%)	-0.067	-0.107	-0.427	**-0.661**	-0.024	0.320
Microblade core (%)	0.233	-0.023	0.020	**-0.642**	0.405	0.108
Drill (%)	0.403	0.216	-0.257	0.011	-0.531	0.010

Table 6.5 Eigenvalues for Principal Components extracted from the data of the 19 selected Mid-Late Neolithic/Early Bronze Age sites

Factor	Eigenvalue	Percent of total variance explained
1	5.696	27.3%
2	2.411	15.05%
3	1.582	12.89%
4	0.931	10.99%
5	0.740	8.02%
6	0.474	6.03%

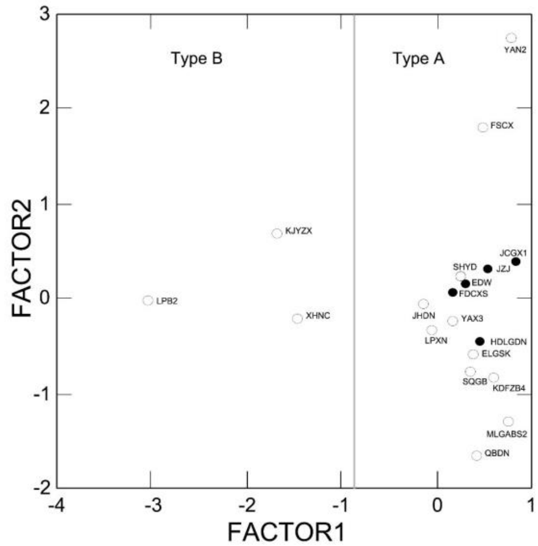

Figure 6.8 The factor score plot of the 19 selected Mid-Late Neolithic/Early Bronze Age sites (showing Factor 1 and Factor 2)

(The black dots indicate the main residential settlements as identified and discussed in section 6.2.1; the hollow dots indicate the other kinds of sites)

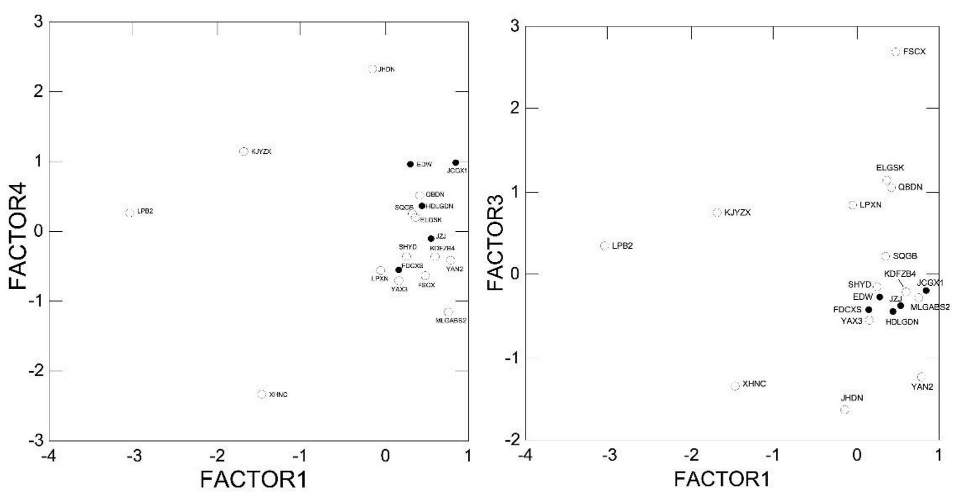

Figure 6.9 The factor score plot of the 19 selected Mid-Late Neolithic/Early Bronze Age sites (on the left: showing Factor 1 and Factor 3; on the right: showing Factor 1 and Factor 4)

(The black dots indicate the main residential settlements as identified and discussed in section 6.2.1; the hollow dots indicate the other kinds of sites)

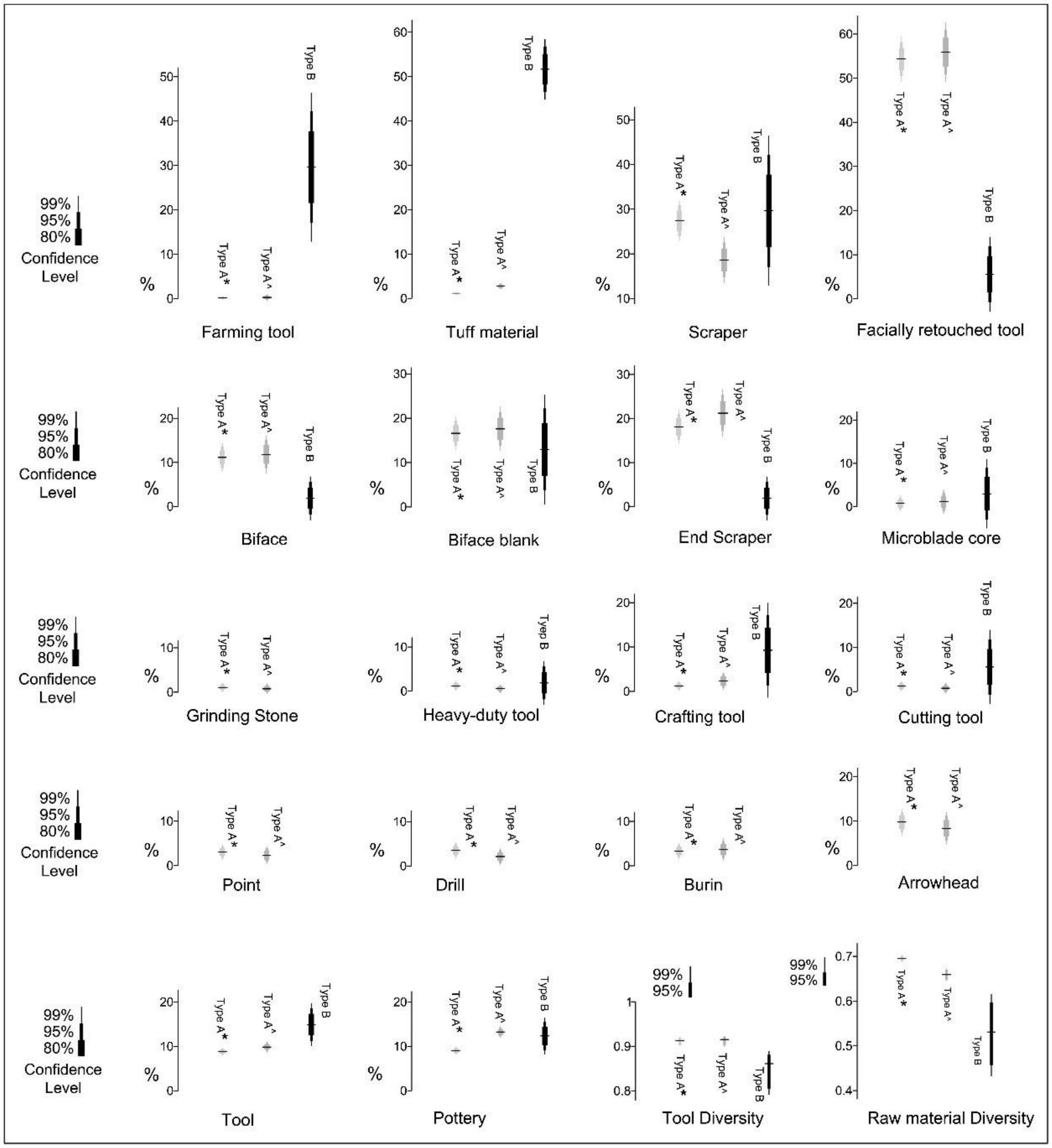

Figure 6.10 The group of bullet graphs showing the proportional differences of various kinds of lithic remains and the diversity of lithic tools and the raw materials of the lithics across site type A and site type B (The proportion of tool is measured by using the number of lithic tools to divide the total number of lithic tools and debitage; the proportion of pottery is measured by using the number of pottery to divide the combinational number of pottery and lithic tools)

From the analysis, we can see that factor 1 strikingly separates the sites into two types (shown as site type A and site type B marked on Fig 6.8). The sites located on the left part of the plot in figure (type B, with scores on 1 <0.1) all have a higher proportion of farming tools and cutting tools. Tuff, which is the raw material used for making farming tools (such as stone hoes), also is a high proportion of the total lithic assemblage in these sites. The tiny curated tools made by facial retouch as well as the tools correlated with animal resource procurement and processing (like arrowheads for hunting and end scrapers for hide processing) only have very low proportions or are even absent from these sites. Such a pattern of lithic composition implies that these sites have a particular emphasis on farming over other activities.

Artifacts are not abundant in these sites. Except for KJYZX which has more than 100 lithics, the other two sites have fewer than 100 lithics. The diversity of tool types from the thee sites is also lower than those identified as site type A. Such features indicate that they are unlikely to be settlements used intensively by people with more stable occupation. Rather, they were probably used temporarily in a certain period of the year for farming activities. Hence, we can identify them as a particular farming residence. The site XYX, which is excluded from the principal component analysis due to the small sample size (with only 29 lithics in total and 4 pieces of lithic tool), perhaps is also such kind of site since tuff has a higher proportion in the total lithic assemblage, and farming tools have a high proportion in the tool assemblage.

By contrast to site type B which is identified as a farming residence, only a very limited number of sites of type A contain farming tools, and they have much lower proportions in the tool assemblage. The majority of lithics were made of various sources of fine-grained cryptocrystalline stones instead of tuff. The tiny curated tools made by facial retouch can be more commonly found across type A sites, and they usually have higher proportions in the tool assemblage. Since facial retouch requires intensive flaking and generates more debitage, many of the sites of type A have lower ratios of tool to debitage than those of type B. In addition, type A sites also have more diversified lithic tools as well as higher proportion of the tools used for procuring and processing animal resources than “type B” sites. Such a pattern indicates that type A sites have a very differentiated emphasis in subsistence practices as well as the nature of residency compared with type B sites.

All of the main residential settlements analyzed in chapter 6.2.2 fall within t site type A. Meanwhile, type A also contains the sites which have less abundant lithic or pottery remains and hence are inferred as less intensively used sites. Variation within type A sites can be evaluated by factor 2, factor 3, and factor 4. Four variables have relatively high loadings on factor 2, namely the proportion of points, the proportion of crafting tools, the proportion of grinding stones, and the proportion of burins. The sites which have higher scores on factor 2 (which are shown on upper part of the Figure 6.8) tend to have higher proportions of these tools than the ones with lower scores on factor 2 (except for FSCX, which is absent of grinding stones but has a high score on factor 2 since the other three types of tools all have higher proportions in this site).

Four variables have relative high loadings on factor 3, namely diversity of raw material, the ratio of pottery to lithic tools, the proportion of heavy-duty tools, and the proportion of bifaces. They positively correlate with each other, and the sites with higher scores on factor 3 tend to have more diverse raw material, a higher ratio of pottery to lithic tools as well as a higher proportion of heavy-duty tools.

Factor 4 also has three high loading variables, namely the proportion of biface blanks, the proportion of scrapers and the proportion of microblade cores. However, the latter two variables are inversely correlated with the first variable. As reflected in the plot, the sites with a higher proportion of tool blanks are located more upwards while the sites with higher proportions of scrapers and microblade cores are located closer to the bottom of the plot.

However, taking considerations of the error ranges (especially for the sites with fewer tools), the proportional differences of most of the variables listed above are not significantly different from site to site. The high loading scores of certain sets of variables for Factor 2, 3, or 4 might be heavily influenced by random noise.

To evaluate the confidence levels of the differences of the site type A and site type B detected from the principal component analysis as well as to further explore on what extents do the main residential settlements differ from the other more temporarily used or inhabited type A sites, three bullet graphs for each variable are made and listed in Figure 6.10. One is derived by pooling together all the artifacts from type B sites (which is labeled as type B in the bullet graphs in Figure 6.10). One is got by pooling together the artifacts of all the identified main residential sites as discussed in section 6.2.1 (which is labeled as type A* in the bullet graphs in Figure 6.10). And the other one is got by pooling together all the artifacts of the other type A sites except for the main residential settlements as identified in section 6.2.1 (which is labeled as type A^ in the bullet graphs in Figure 6.10).

Based on what shown in Figure 10, we can see that proportional differences of the variables that mainly account for distinguishing site type A and site type B are highly significant across type B and type A*/A^. Therefore, we have high confidence to conclude that the two site types we identified from the principle component analysis reflect the real pattern of the site variations rather than the impacts of random noises.

However, for most of the variables, type A* and A^ show quite similar proportions without any significant differences. The only exceptions are: for type A* sites, the proportion of pottery and the proportion of scraper are significantly lower than those of the type A^. The lower proportion of pottery is mainly because that the type A* sites have a far larger number of lithics (including both tools and debitage) and therefore make the percentage of pottery sherds within the total amount of the pottery and lithics smaller. Such a similarity of the proportional distributions of different variables suggests that in spite that the main residential settlements have substantially more lithic remains than the other non-main residential type A sites, the features of their tool compositions do not differ much from other non- main residential type A sites.

Besides the sampled sites used for the principal component analysis, most of the sites with the single component Mid-Late Neolithic/Early Bronze Age remains more resemble site type A rather than type B (except for XYX mentioned above) according to the general features of artifact assemblage. However, since they have a fewer lithics both in terms of debris and tools, their occupations might be even more ephemeral.

6.3 Variations of the subsistence practice across the sites

By mapping out the sites with the presence and absence of different tool types which are indicative of specific subsistence practices, we can see that the sites with farming tools are concentrated in the northern part of the survey region. Except for ELGXB which is close to the mountainous area, the other sites with farming tools are all located within the flat river valley farther from the mountains. The farming tools are only present in a very limited number of sites. Only ten out of 116 sites that contain Mid-Late Neolithic/Early Bronze Age remains have farming tools (as shown in Figure 6.10). If we confined our focus to the sites with only single component of Mid-Late Neolithic/Early Bronze Age remains, then only 5 out of 75 sites have farming tools (as shown in Figure 6.12). Moreover, farming tools do not always appear in the main residential settlement since only one main residential settlement (HDLGN) has a piece of stone hoe that is associated with farming activities. The other sites with farming tools are either the special farming residences or the residential settlements with was less intensive or durable occupation than the main residential settlements. From Figure 6.10 (as shown in section 6.2.2 above), we can see that the proportion of farming tools from the main residential settlements is extremely low. It is significantly lower than that of the type B site.

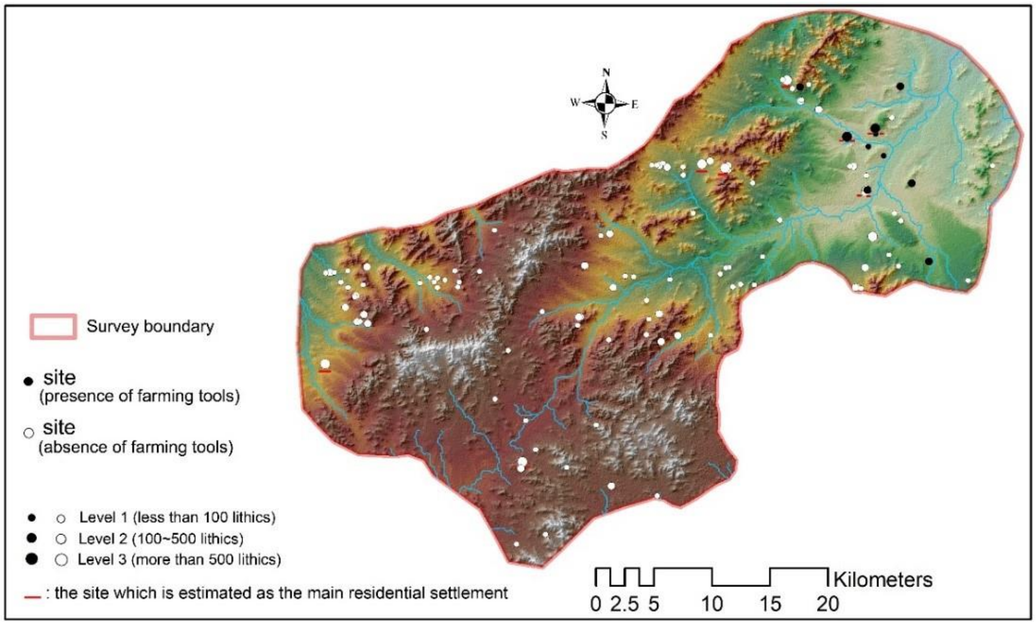

Figure 6.11 The distribution of the Mid-Late Neolithic/Early Bronze Age sites with the presence of farming tools (All of the sites which contain Mid-Late Neolithic/Early Bronze Age remains are included)

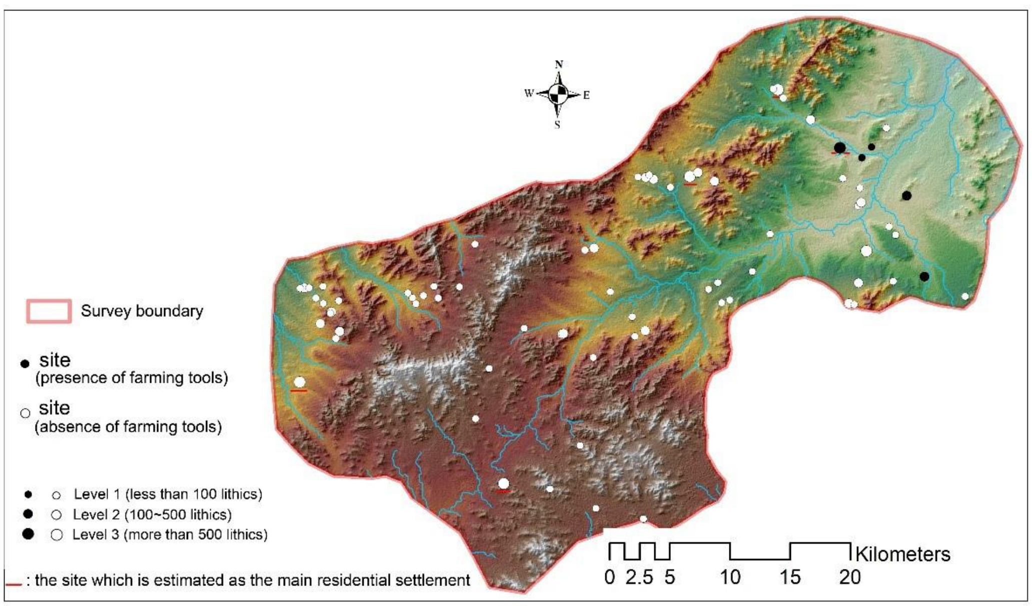

Figure 6.12 The distribution of the Mid-Late Neolithic/Early Bronze Age sites with the presence of farming tools (Only include the sites with the single component of Mid-Late Neolithic/Early Bronze Age remains)

In comparison with farming tools, the other tool types which have specific indications for certain subsistence activities, like grinding stone tools, end scrapers, microblade remains, arrowheads, are more scattered across the sites located in different parts of the region (as shown from Figure 6.13 to 6.17 and Table 6.6). The most ubiquitous type of lithics mentioned above are microblades, which can be found in 43 out of 75 sites which contain the single component of Mid-Late Neolithic/Early Bronze Age remains and are present in most of the sites which have more than 100 pieces of lithics (as shown in Figure 6.13). The next most ubiquitous type of lithic is end scrapers. The ubiquity of end scraper is only slightly less than that of microblade remains across sites with intensity level 2 and intensity level 1 (as shown in Figure 6.14 and Table 6.6). The arrowhead (as shown in Figure 6.15) was less ubiquitously distributed across the sites in comparison with microblades and end scrapers. However, since arrowheads were more likely to be refuse on the hunting spots instead of the sites, the popularity of arrowheads in this period may have been a little underestimated if we merely observe the presence and absence of them across the sites. All of these types of lithics mainly correlate with the activities of animal resource procurement and processing. The frequent distributions of these types highlight the importance of such activity in subsistence strategy.

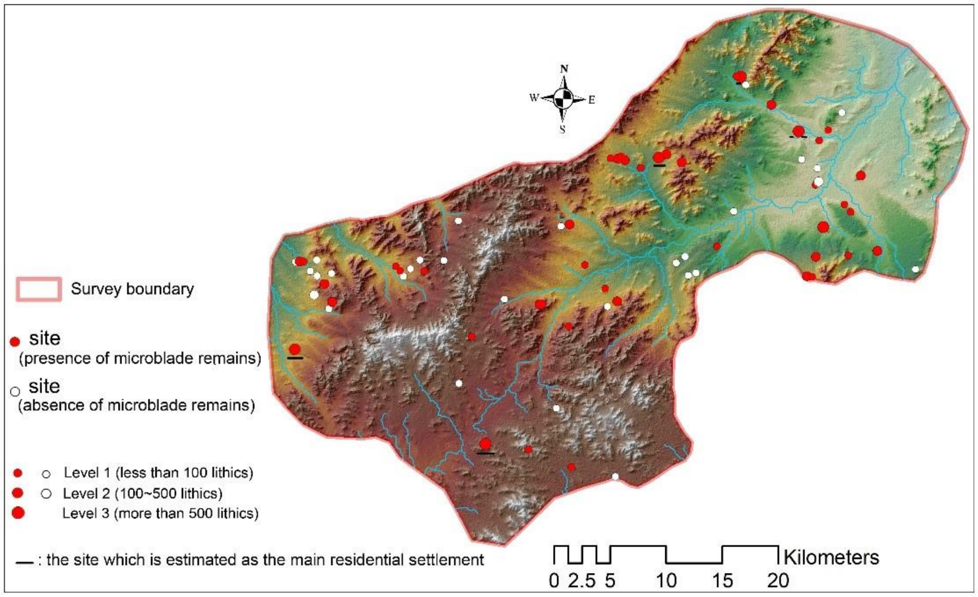

Figure 6.13 The distribution of the Mid-Late Neolithic/Early Bronze Age sites with the presence of microblade remains (Only include the sites with the single component of Mid-Late Neolithic/Early Bronze Age remains)

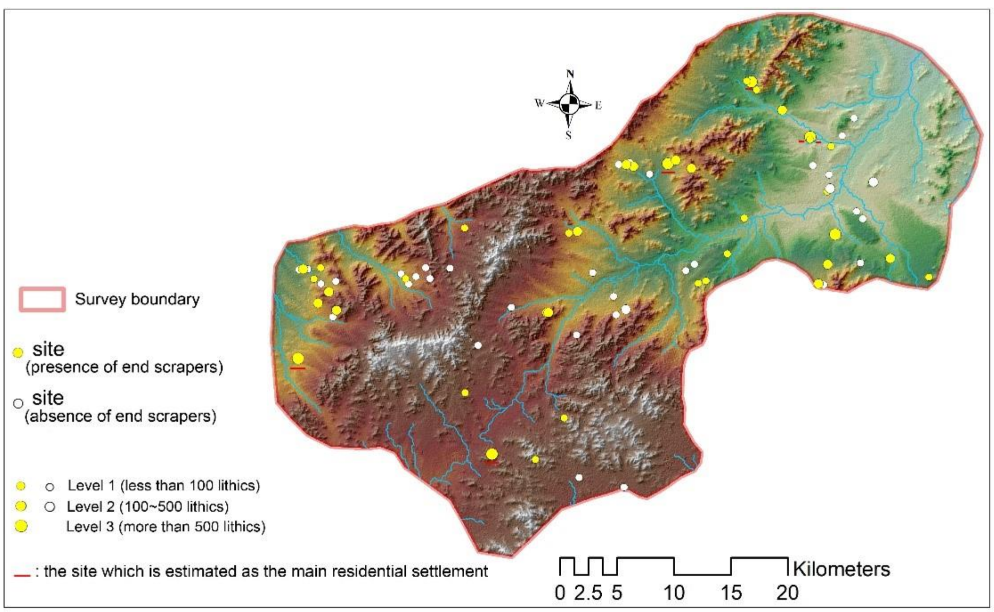

Figure 6.14 The distribution of the Mid-Late Neolithic/Early Bronze Age sites with the presence of end scrapers (Only include the sites with the single component of Mid-Late Neolithic/Early Bronze Age remains)

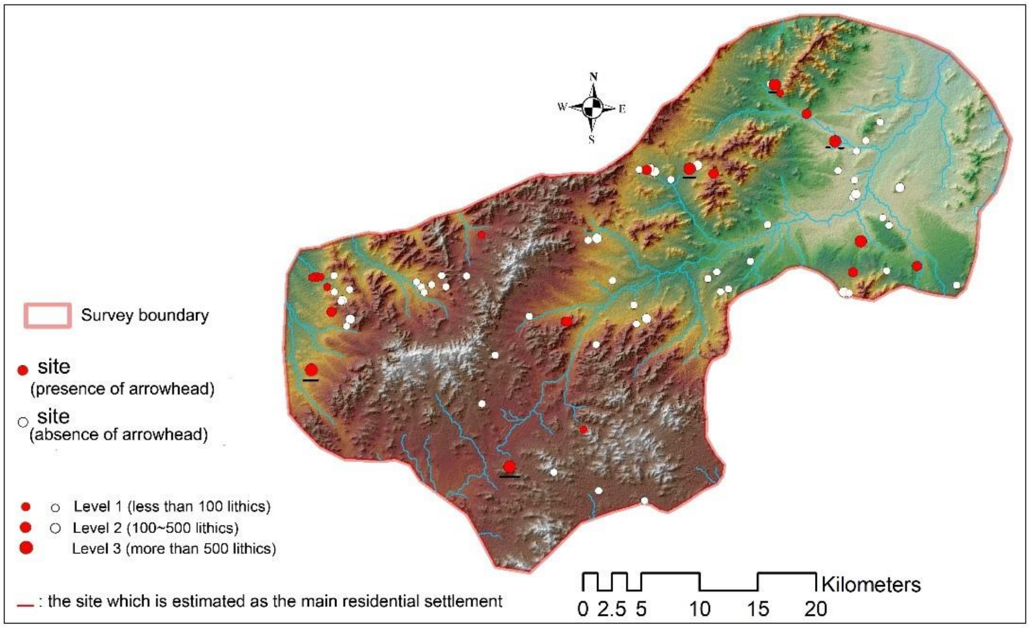

Figure 6.15 The distribution of the Mid-Late Neolithic/Early Bronze Agesites with the presence of arrowhead (Only include the sites with the single component of Mid-Late Neolithic/Early Bronze Age remains)

The grinding stone tools (as shown in Figure 6.16) are less ubiquitous than the microblade and end scrapers. However, they are much more widely distributed across the sites located in different places compared with farming tools, suggesting that the intensive exploitation of plant resources is a more common subsistence practice and is less confined by geographic conditions in comparison with farming activity. However, as shown in Figure 6.10, the proportion of grinding stone tools of type A and type A* are extremely low, suggesting that the intensive plant processing was unlikely to be the subsistence activities that people are heavily engaged in.

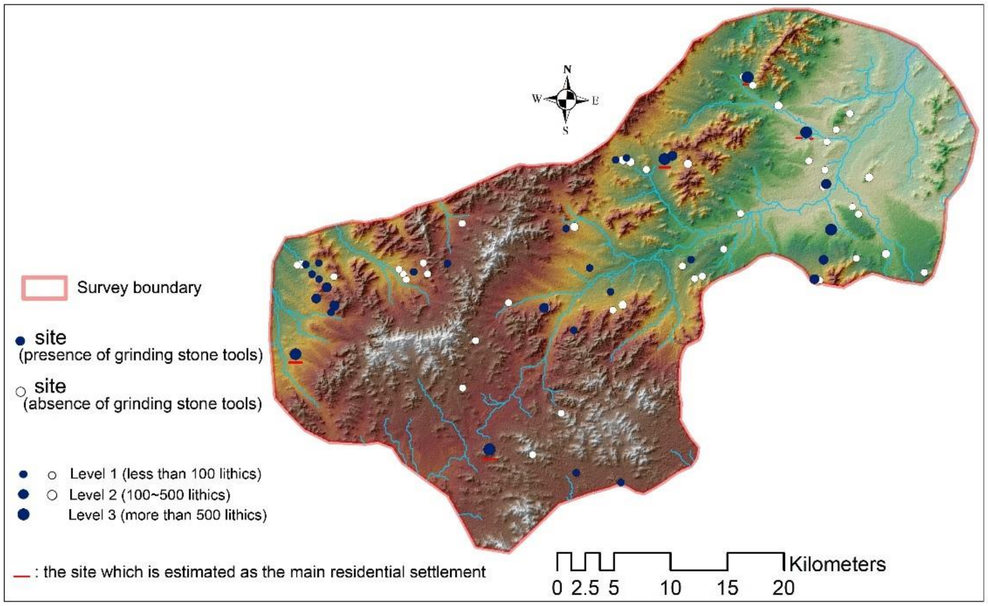

Figure 6.16 The distribution of the Mid-Late Neolithic/Early Bronze Age sites with the presence of grinding stone tools (Only include the sites with the single component of Mid-Late Neolithic/Early Bronze Age remains)

The bifaces are not straightforwardly correlated with any of the specific subsistence activities, but reflect important information about technical organization which highlights the particular tool design considerations of suitability for mobility. As shown from the map of Figure 6.17, bifaces are widely distributed across the different parts of the survey region, suggesting that it they were frequently used in a wide range of areas rather than concentrated in specific places. As shown in Table 6.6, they are much more frequently distributed in the more intensively used sites (the ones with more than 100 pieces of lithics) than the sites with a lower level of use intensity (the ones with fewer than 100 lithics). A further investigation of the proportions of bifaces (the complete ones) and biface blanks suggests that the sites with a higher proportion of biface blanks are not always the ones with a high proportion of bifaces in completed forms as well (as shown in Figure 6.18 and 6.19). For instance, JHDN has a significantly higher proportion of biface blanks than the other sites, but the proportion of bifaces in JHDN is smaller than several of the other sites. Moreover, in comparison with the relatively constant proportional distributions of bifaces across sites, the proportional distribution of biface blanks across sites is more uneven. Meanwhile, they are found in fewer sites than the completed forms of bifaces. In addition, although some sites have not yielded any bifaces or biface blanks, they did have the tools made from bifaces, such as arrowheads. Such a pattern suggests that people produced and used the bifaces in different stages across difference places in varying levels of intensity. This distributional pattern further implies that biface is likely a kind of lithic technology used in a mobile condition, since movement will cause the people to bring the tool blanks they made in one place to the other places for use. Therefore, the tools produced and used in different stages tend to be found in different places rather within one site.

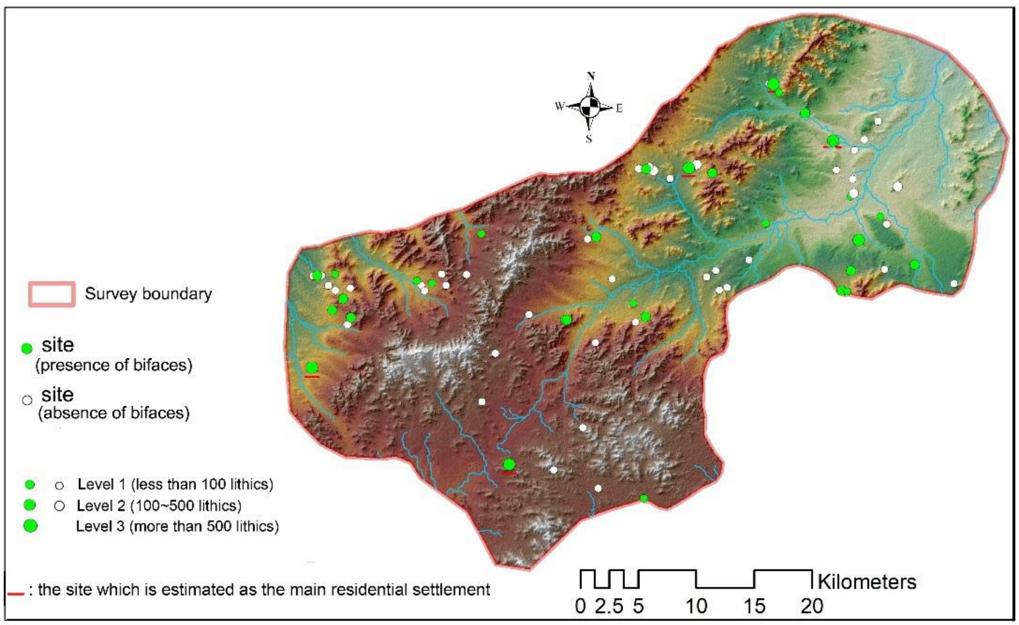

Figure 6.17 The distribution of the Mid-Late Neolithic/Early Bronze Age sites with the presence of bifaces (Include both biface blanks and bifaces; Only include the sites with the single component of Mid-Late Neolithic/Early Bronze Age remains)

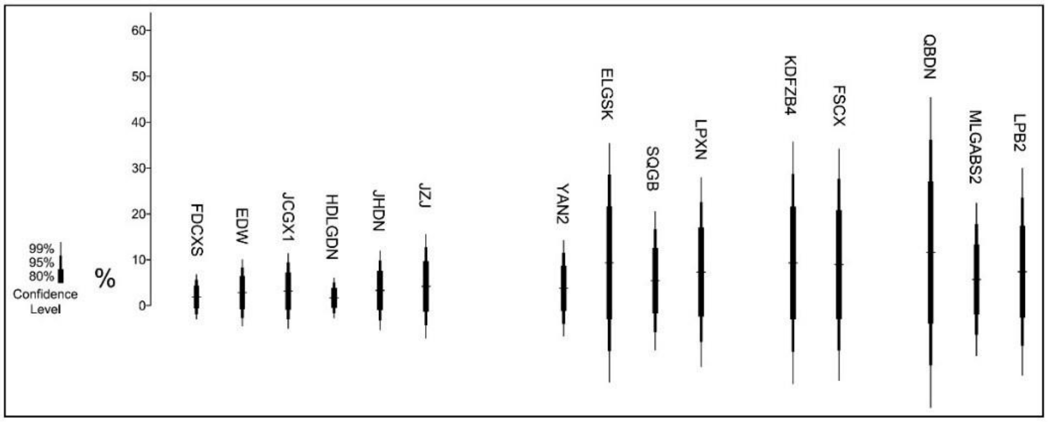

Figure 6.18 The bullet graph showing the proportional differences of the bifaces (in complete forms) across the sites of Mid-Late Neolithic/Early Bronze Age.

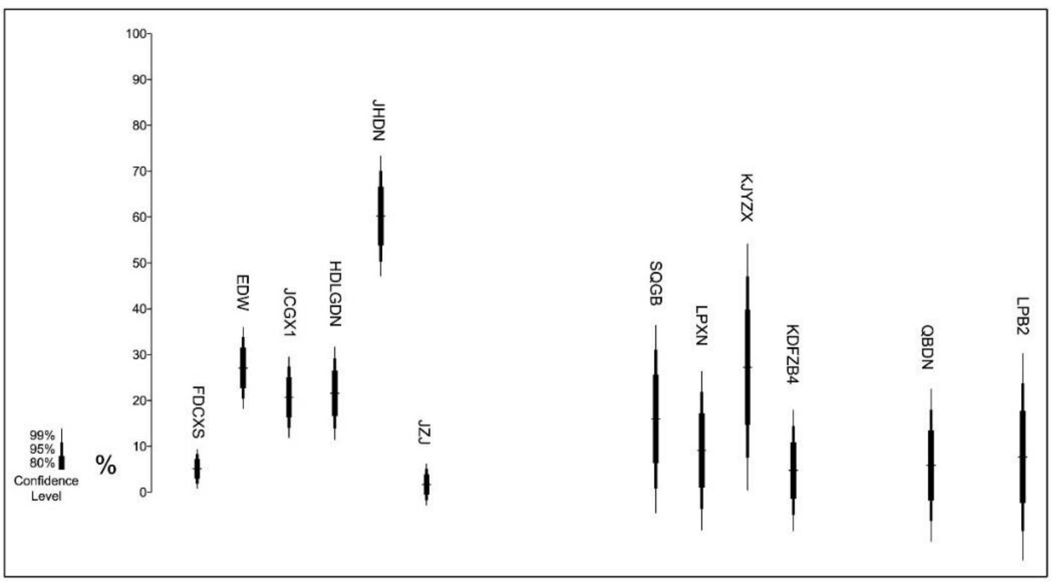

Figure 6.19 The bullet graph showing the proportional differences of the biface blank across the sites of Mid-Late Neolithic/Early Bronze Age.

Table 6.6 The ubiquity of different tools across the Mid-Late Neolithic/Early Bronze Age sites with varying levels of use intensity

Site-use intensity level	The site with farming tools		The site without farming tools	
	Number	Ubiquity（%）	Number	Ubiquity（%）
Level 3 (>500 lithics)	1	16.7	5	83.3
Level 2 (100-500 lithics)	3	15	17	85
Level 1 (<100 lithics)	1	2	48	98
	The site with grinding tools		The site without grinding tools	
	Number	Ubiquity（%）	Number	Ubiquity（%）
Level 3 (>500 lithics)	6	100	0	0
Level 2 (100-500 lithics)	10	50	10	50
Level 1 (<100 lithics)	13	26.5	36	73.5
	The site with end scrapers		The site without end scrapers	
	Number	Ubiquity（%）	Number	Ubiquity（%）
Level 3 (>500 lithics)	6	100	0	0
Level 2 (100-500 lithics)	15	75	5	25
Level 1 (<100 lithics)	18	36.7	31	63.3
	The site with microblade remains		The site without microblade remains	
	Number	Ubiquity	Number	Ubiquity
Level 3 (>500 lithics)	6	100	0	0
Level 2 (100-500 lithics)	17	85	3	0
Level 1 (<100 lithics)	20	40.8	29	59.2
	The site with arrowhead		The site without arrowhead	
	Number	Ubiquity（%）	Number	Ubiquity（%）
Level 3 (>500 lithics)	6	100	0	0
Level 2 (100-500 lithics)	9	45	11	55
Level 1 (<100 lithics)	7	14.3	42	85.7
	The site with bifaces		The site without bifaces	
	Number	Ubiquity（%）	Number	Ubiquity（%）
Level 3 (>500 lithics)	6	100	0	0
Level 2 (100-500 lithics)	14	70	6	30
Level 1 (<100 lithics)	12	24.5	37	75.5

6.4 Correlations between sites and environmental settings

6.4.1 The geographic landforms and the site locational choices

By attributing each site's location into one of the four categories of the landforms (as shown in Table 6.7), we can see that the most intensively occupied areas are the tributary valleys and major valleys. The sites found in either of these two landforms are 77.6% of the total sites. As shown in Table 6.8, the one-sample Chi-Square test also indicates that the differences of the occupation density between major/tributary river valleys and the others are highly significant.

While tributary valleys have the largest number of sites and the highest site density, the major valleys have the highest proportions of the most intensively used sites, the majority of which are identified as main residential settlements (as shown in Figure 6.20). The piedmont was less intensively occupied by people in comparison with river valleys. Though the sites with different levels of use intensity can all be found in the piedmont region, it has both fewer sites as well as lower site density. The mountain cove is the least intensively occupied landform since only two sites have been found. None of them has the highest site-use intensity level, and both of them are commingled with Early Neolithic remains.

The lower site density in piedmont and mountain cove implies that people might locate most of their sites further away from the mountainous area. This idea will be analyzed further in the following two sub-sections.

Table 6.7 The number of the Mid-Late Neolithic/Early Bronze Age sites distributed across different landforms

	major valley	tributary valley	piedmont	mountains	total
area (km^2)	488	210	366	430	1494
area (%)	32.7	14.0	24.5	28.8	100
sites (N)	37	53	24	2	116
sites(%)	31.9	45.7	20.7	1.7	100

Table 6.8 Observed and expected numbers of the sites across the different landscapes for Chi-Square Test

	Area Surveyed	No. of sites	
		Exp.	Obs.
Major valley	32.7%	37.9	37
Tributary valley	14%	16.2	53
Piedmont	24.5%	28.4	24
Mountains	28.8%	33.4	2

(X^2=113.82, $p<0.001$)

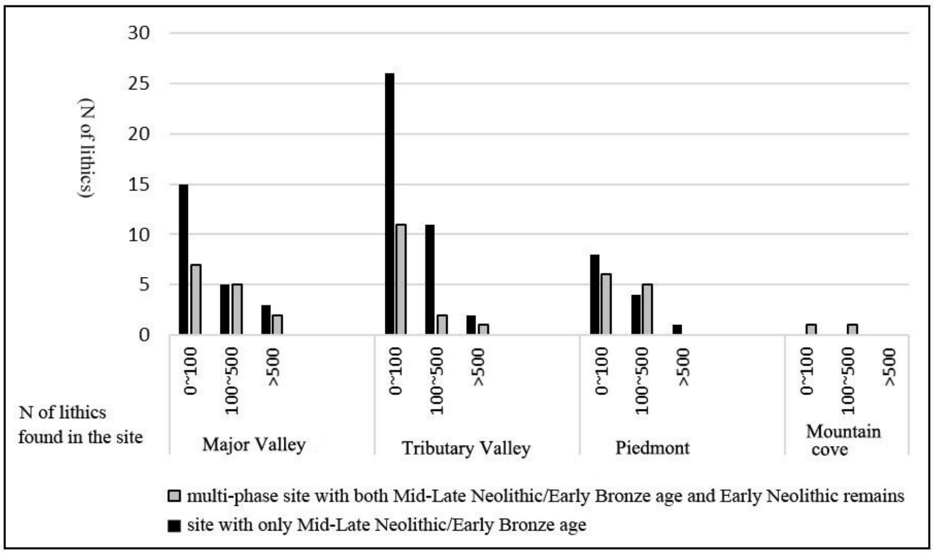

Figure 6.20 The distribution of the Mid-Late Neolithic/Early Bronze Age sites with different levels of site-use intensity across different landforms

6.4.2 The proximity to the mountainous area

By calculating the proportions of the mountainous area within a 1km radius catchment zone of each of the sites and illustrating them with a bar graph of the proportion of mountainous area, we can see that most of the sites have catchments less than half of which are the mountainous. Site with less than 5% mountainous area within their 1km radius catchment zone are strikingly abundant (as shown in Figure 6.21). This implies that the majority of sites in this period are located at a certain distance away from the mountainous area rather than located right next to the mountains.

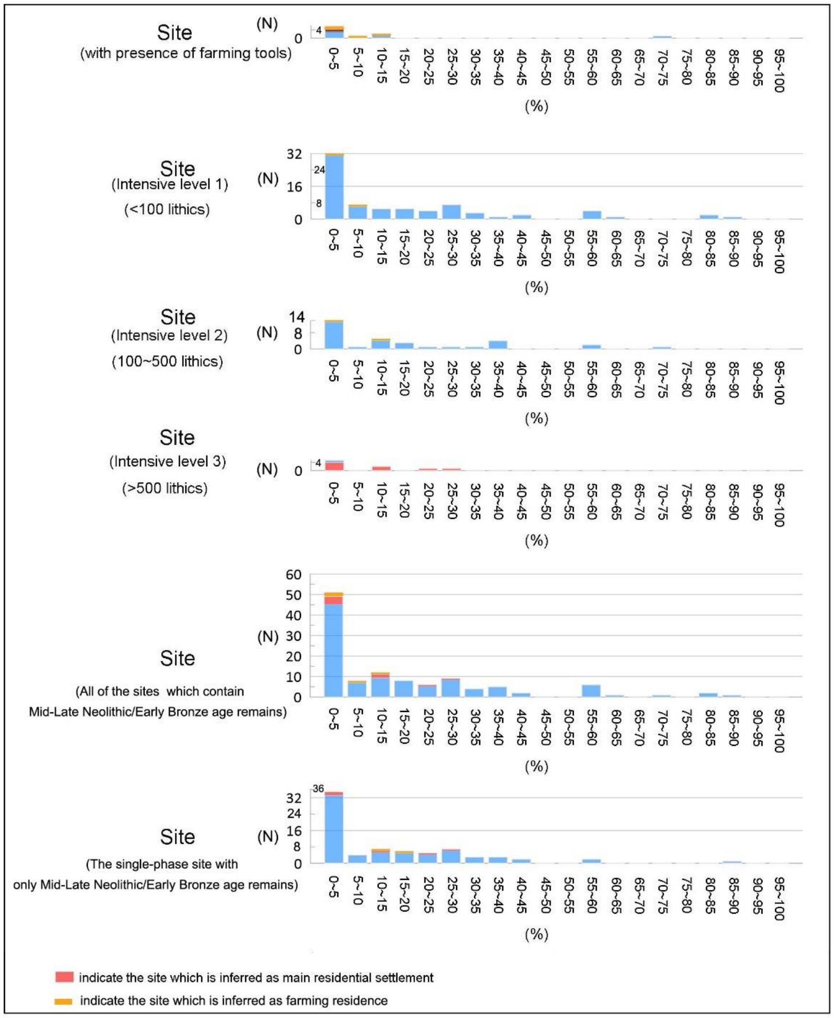

Figure 6.21 The distribution of the Mid-Late Neolithic/Early Bronze Age sites with different proportions of the mountainous area within the 1km radius km catchment zone

Moreover, this distribution can be identified for all different kinds of sites, including the site with single component Mid-Late Neolithic/Early Bronze sites with mixed remains of both Mid-Late Neolithic/Early Bronze and Early Neolithic artifacts, and sites with farming tools or sites with varying levels of site-use intensity. As shown from Table 6.9, the Chi-Square analysis further indicates that there is no significant difference in the relative proximity to the mountainous areas across the sites with different levels of use intensity (p=0.577), suggesting that people do not have particular preferences of locational choices for certain kinds of the sites in terms of the proximity to the mountainous area.

Table 6.9 The actual and expected number of the Mid-Late Neolithic/Early Bronze Age sites across the locations with different proximity to the mountainous area

Site-use intensity level		Mountain area within 1 km radius site catchment zone (0-45%)	Mountain area Within 1 km radius site catchment zone (45-100%)
Level 3 (>500 lithics)	counts	9	0
	Expected counts	8.1	0.9
Level 2 (100-500 lithics)	counts	30	3
	Expected counts	29.9	3.1
Level 1 (<100 lithics)	counts	66	8
	Expected counts	67	7

X^2=1.101; p=0.577

6.4.3 The altitude differences around the sites

As shown in Figure 6.22, although we can see a wide range distribution of altitude difference within the 1km radius catchment zone across the sites, the majority of the sites have less than 100m altitude difference nearby. As compared with other sites, there is a higher proportion of sites with medium-ranged intensity levels of use (intensity level 2, -100-lithics being found) that have relatively larger altitude differences within their 1km radius catchment zone. The Chi-Square analysis suggests that we have about 88% confidence that sites with medium-ranged intensity levels of use have more altitude differences within their 1 km catchment zones (as shown in Table 6.10).

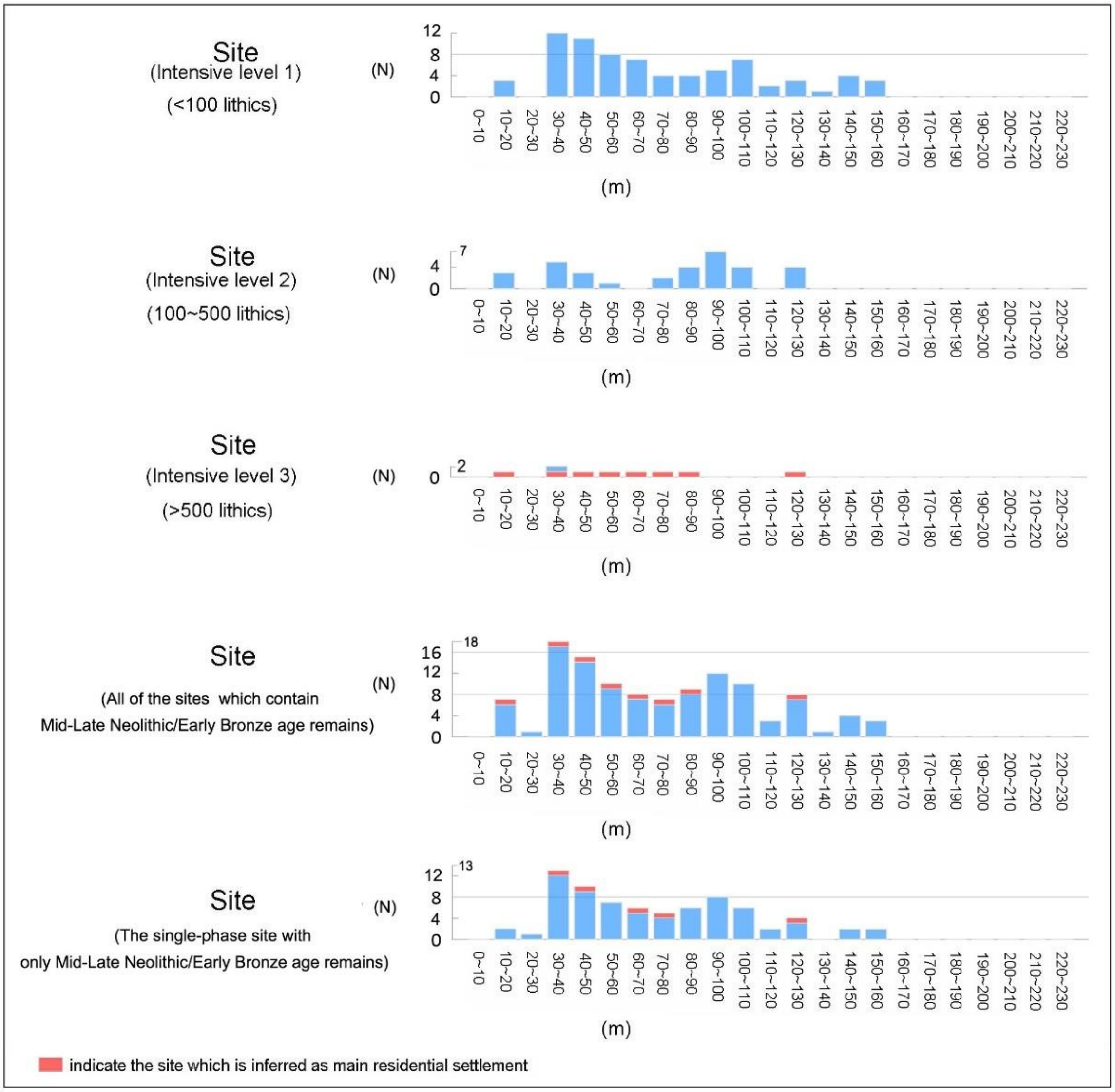

Figure 6.22 The distribution of the Mid-Late Neolithic/Early Bronze Age sites with different ranges of the altitude difference within the 1km radius km catchment zone

Table 6.10 The actual and expected numbers of the Mid-Late Neolithic/Early Bronze Age sites with differentiated levels of site-use intensity across the locations with different ranges of altitude differences within the 1 km site catchment zone

Site-use intensity level		Altitude difference within 1 km radius site catchment zone (less than 70m)	Altitude difference Within 1 km radius site catchment zone (more than 70m)
Level 3 (>500 lithics)	Counts	6	3
	Expected counts	4.6	4.4
Level 2 (100-500 lithics)	Counts	12	21
	Expected counts	16.8	16.2
Level 1 (<100 lithics)	Counts	41	33
	Expected counts	37.6	36.4

X^2=4.286; p=0.117

Such a distributional pattern fits the evaluations of the proximity to the mountainous area across different sites as discussed above. These two lines of evidence together suggest that people have tended to locate their sites in the relatively open landscapes within the valley floor rather than at the junction between mountains and plains. It also implies that people might less rely on the exploitation of the vertically distributed resource patches but focus more on the exploitation of either the more homogenous resource patches or the patches with diversified resources distributed horizontally across the landscape (like the relative proximity to rivers might provide the places with different sets of animal and plant resources). Such shifting emphasis on land-use will be further discussed in the next chapter.

6.4.4 The aspects of the sites

The north-facing sites are 36.2% of the total sites, with Mid-Late Neolithic/Early Bronze remains. Such substantial amounts of north-facing sites probably indicate seasonal occupation of the sites. While the south-facing sites might be used either in the warmer or colder period of the year or even year roundly, the north-facing sites were probably used during the warmer period of the year.

Table 6.11 reveals that both north-facing and south-facing sites are composed of the ones with varying levels of use intensity. As shown in Table 6.12, the Chi-Square analysis further indicates that there are no significant differences in the proportional distributions of the sites with varying levels of use intensity between north-facing sites and south-facing sites ($p=0.942$).

It worth noting that among the north-facing sites, three of them are the most intensively used sites which are estimated as main residential settlements. Such findings suggest that at least some of the main residential settlements were probably not occupied perennially but might only be seasonally inhabited during Mid-Late Neolithic/Early Bronze Age.

Table 6.11 The distribution of the Mid-Late Neolithic/Early Bronze Age sites with varying levels of site-use intensity across different aspects

	Intensity3 (>500 lithics)		Intensity2 (100-500 lithics)		Intensity1 (<100 lithics)		Total	
	N	P (%)	N	P (%)	N	P (%)	N	P (%)
North-facing slope	3	7.1	11	26.2	28	66.7	42	100
South-facing slope	6	8.1	21	28.4	47	63.5	74	100

Table 6.12 The actual and expected numbers of the Mid-Late Neolithic/Early Bronze Age sites with differentiated levels of site-use intensity across the different aspects

Site-use intensity level		North-facing sites	South-facing sites
Level 3 (>500 lithics)	counts	3	6
	Expected counts	3.3	5.7
Level 2 (100-500 lithics)	counts	11	21
	Expected counts	11.6	20.4
Level 1 (<100 lithics)	counts	28	47
	Expected counts	27.2	47.8

6.4.5 Site distributional pattern

As shown in the map in Figure 6.23, some of the sites which contain Mid-Late Neolithic/Early Bronze remains are concentrated in clusters in specific parts of the survey region (as marked by the white circles on the map). In some such areas, the sites are mixture of single-component sites with multi-phase sites which also contain Early Neolithic remains. Whereas the other clustered areas are dominated by single-component sites with only Mid-Late Neolithic/Early Bronze Age remains. This suggests that people in this period continued to make intensive use of some areas that were intensively used by Early Neolithic communities (clusters A and B in Figure 6.23), and also exploited other areas more intensively level than they had been in the earlier period.

Some of the clustered areas consisted mainly of sites with less intensive use (clusters C and D in Figure 6.23), which suggests frequent visits but without permanently inhabited sites. Short occupation at these sites might have been to make use of resources nearby at a certain season of the year. Repeatedly visits left concentrations of sites. Nonetheless, in some other site concentrations, we can see both the most intensively used sites as well as sites used at a less intensive level, suggesting that people not only used these areas for shorter periods, but also settled in more permanently inhabited sites at certain locations in these areas.

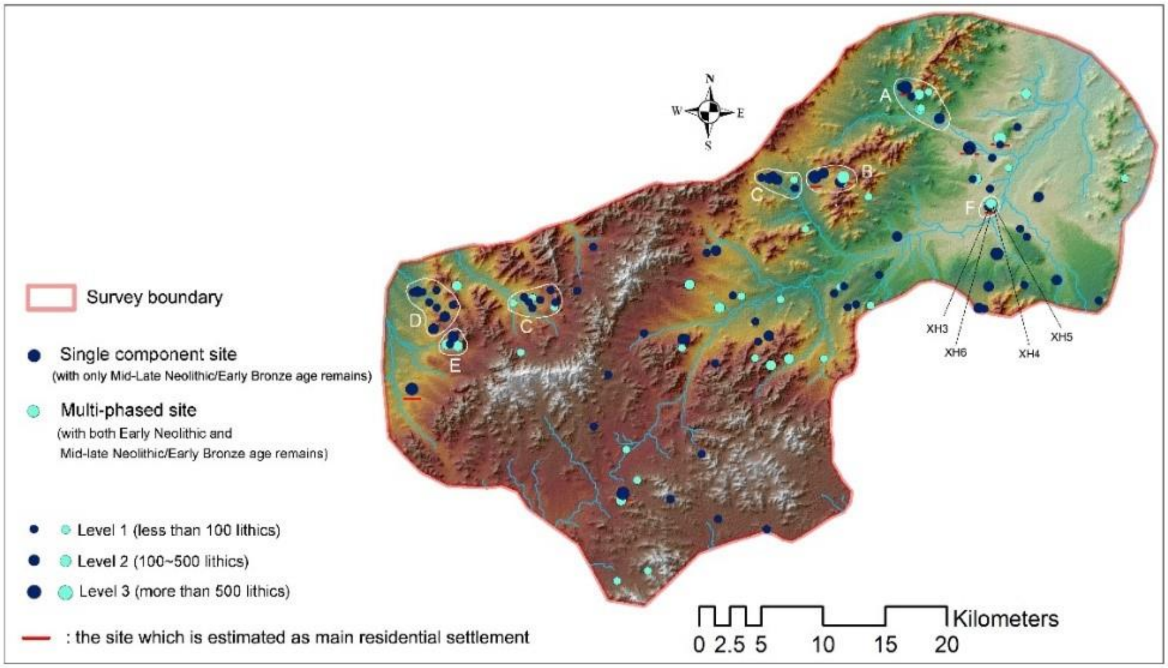

Figure 6.23 The map showing the clustered distributions of the Mid-Late Neolithic/Early Bronze Age sites

6.5 Conclusion

Synthesizing all the evidence presented above, the main features of land-use strategy during Mid-Late Neolithic/Early Bronze Age are summarized as below.

(1) Mobility still played an important role in socio-economic activities. Whereas people lived more permanently at some settlements, they might also have pursued logistic forays and make made temporary use of other localities.

Exploring the degrees of mobility/or sedentism during this period requires us to have a more comprehensive understanding of the implications from multiple lines of evidence since they reflect and emphasize different dimensions of mobility. While the technical organization from lithic remains highlights that lithic tools were specifically designed to meet the needs of mobile lifeways, the inter-site variations and the spatial distribution of the sites suggest a more complicated pattern of mobility. On one hand, it suggests that the degrees of mobility was restricted since people invested more in the construction of permanent dwelling structures in the main residential settlements; left abundant artifact remains in them; and made repetitive use of certain areas within the survey region at a fairly intensive level. One the other hand however, mobility still played an important role. A large number of sites from the survey have only a very limited number of lithics and pottery (or even no pottery), suggesting that people might use them more ephemerally. Such sites far outnumber the sites interpreted as main residential settlements. In addition, the circulation of bifaces in different reduction stages across different sites suggests the impact of mobility on artifact distribution.

Combining all this evidence together, it is more likely that people settled down in the main residential settlements with longer periods of occupation and organized foraging groups to make logistical forays from the main residential sites or sent out members of the communities to do specific activities at certain seasons of the year, such as farming activities. According to the aspects of site locations, some of the main residential settlements might be used only seasonally. However, the seasonality cannot be unequivocally seen in the lithics, and the inference of seasonal use of main residential settlements still needs to be investigated with more lines of evidence in future research.

(2) Farming did not play an important role in the subsistence system. Nonetheless, people intensified the use of animal resources.

From the survey region, we cannot observe any increasing importance of farming to subsistence in this period, even though this is widely detected in many other regions of North China. Farming tools occur in only limited numbers of sites located in the northern part of the survey region. Only one of the main residential settlements yielded farming tools, and they comprise an extremely low proportion in the whole tool assemblage. The existence of farming residences further implies that farming was organized in different ways compared to the earlier period. Instead of farming around the main residential settlements, people might dispatch task groups to farm on a short-term basis in certain seasons at particular locations.

In comparison with the limited discovery of farming tools, tools used for hunting and animal resource processing are much more abundant across sites in different parts of the survey area. Moreover, by contrast to the ones used in the Early Neolithic period, these tools were more curated, made into formal shapes and distributed in the whole tool assemblage with higher diversity.

Since domesticated cattle, sheep, and goat were introduced into North China during Late Neolithic and Early Bronze Age, and the migrating Yangshao farmers have brought domesticated pigs into this southern steppe region during Mid Neolithic period, it is possible that certain levels of pastoralism might have developed in the survey region during this period. However, there is no direct evidence of pastoralism in the material remains from the survey. Therefore, we can neither confirm the existence of pastoralism nor discuss how important a possible pastoral economy plays a role in human subsistence. We can say, however, is that, despite the possible existence of pastoralism, hunting was still an important subsistence practice, since the prevalence of arrowheads suggests the further development of hunting tools as well as intensified hunting activities with particular focus on small-medium animals. Furthermore, tool design in this period is well suited to hunting on long-distance forays since the tools were more reliable and are suitable for transporting long-distances and working under high time pressure.

(3) People made full exploitation of resources from different environmental zones but particularly intensive use of the plain area within the river valleys

The sites broadly distributed across different landforms. However, except for a few located close to the mountains, people have set the majority of their main residential settlements, temporarily or short-use residential sites and task-specific sites on the flat or gently rolling valley floors with open surroundings nearby.

Such a pattern of site locations implies that people emphasized the exploitation of resources from plain and wetland zones. The increasingly intensive use of the river valleys might be correlated with changes in subsistence practices from Early Neolithic to Mid-Late Neolithic/Early Bronze Age, which will be further discussed in the following chapter.

7.0 The comparison of land-use pattern between Early Neolithic and Mid-Late Neolithic/Early Bronze Age

A comparison of land-use patterns between Early Neolithic and Mid-Late Neolithic/Early Bronze Age based on the archaeological remains of the survey area is crucial for understanding the changes in land-use pattern through time in Northern Yinshan Mountain region. The mobility patterns, subsistence practices, social integration, and correlation between site distributions and environment are all important perspectives to provide a comprehensive understanding of changes in land-use patterns between these two periods, as discussed below.

7.1 The comparison of mobility pattern

It is hard to determine if the mobility of Mid-Late Neolithic/Early Bronze Age increased or decreased from the Early Neolithic period. Nonetheless, based on multiple lines of evidence, we can infer that people in Mid-Late Neolithic/Early Bronze Age neither returned to highly mobile lifeways nor became fully sedentary groups.

Both the Early Neolithic and Mid-Late Neolithic/Early Bronze Age sites are composed of a few main residential settlements combined with a large number of more temporarily used settlements or task sites. People built permanent dwelling structures in the main residential settlement in both periods. A tremendous amount of artifacts in high diversity can be found within these sites, indicating that people already had relatively stable inhabitants in certain places. However, the number of such sites is far fewer than the temporary settlements or task-specific sites which show shorter-period occupations.

Also, in both periods, we can see clustered distributions of sites in certain areas either dominated by main residential settlements, or temporary settlements/task sites, or a mixture of both. Such a settlement pattern differs from both highly mobile or fully sedentary communities. It suggests that though people have not been able to settle down stably and make persistent use of one site for a long time, they have been tethered somehow to the specific places and repeatedly visited and used them intensively for a long period.

All such evidence indicates that for both Early Neolithic and Mid-Late Neolithic/Early Bronze Age, people were in the middle of the spectrum from highly mobile to fully sedentary lifeways. However, it is worth mentioning that the technological organization of the lithic assemblage implies that the toolkits in Mid-Late Neolithic/Early Bronze Age were more suitably designed to fit mobile lifeways. This suggests that even in general the whole community did not live in highly mobile lifeways, certain members of the communities might still periodically conduct logistical forays even at longer distance or higher frequency than that occurred during the Early Neolithic period.

7.2 The comparison of the subsistence practice

Farming existed in both the Early Neolithic and Mid-Late Neolithic/Early Bronze Age period, but was organized and integrated into the whole subsistence system in different ways. In the Early Neolithic period, farming tools were usually found in the main residential settlement or the surrounding temporary settlements and task sites. Whereas in Mid-Late Neolithic/Early Bronze Age, only very limited numbers of the main residential or temporary settlements have yielded farming tools, and the majority of farming tools, as well as debitage generated during farming tool production, were found in specific farm residences. In addition, during the Early Neolithic period, the sites with farming tools can be found in the north, mid, and south of the survey region, and they were usually found in the rolling lands close to the maintains. Nonetheless, in Mid-Late Neolithic/Early Bronze Age, sites with farming tools were all located on the relatively flat land in the valley in the northern part of the survey region where the elevation is lower in general. The elevations of the sites with farming tools are listed in Table 7.1. The t-test reveals that the 150.4 m differences in mean elevation between the Early Neolithic and Mid-Late Neolithic/Early Bronze Age sites with farming tools is extremely significant ($t=-9.54$; $p<0.001$).

Table 7.1 The elevation of the sites with the presence of farming tools

Early Neolithic period											
KJYZX	LPCN	XH4	XYX	HDLGDN	LPB2	XHNC	LPB1	FSCX	ELGXB		
1264	1273	1275	1277	1290	1303	1318	1320	1321	1401		
Mid-Late Neolithic period/Early Bronze Age											
CJP1	HHBZDN	DSB1	SMG1	SMG2	DSB2	SMG3	SMG4	GJC	BN2	YM	TDSSK
1390	1409	1443	1444	1445	1455	1456	1456	1472	1480	1487	1518

(unit: meter)

This pattern indicates that in contrast to the Early Neolithic communities, people in Mid-Late Neolithic/Early Bronze Age concentrated their farming in the lower and flatter part of the northern survey area where there were slightly warmer weather conditions. This shift might be an adaptative response to climate change, which will be discussed later in section 7.5. Moreover, instead of incorporating food production near the main residential settlements, the Mid-Late Neolithic/Early Bronze Age communities might dispatch their members to conduct farming activities in specific farming residences at certain seasons.

Except for such differences, we cannot identify any sharp increase in the importance of farming to the human subsistence system from Early Neolithic to Mid-Late Neolithic/Early Bronze Age. For one thing, only very limited numbers of sites have yielded farming tools during Mid-Late Neolithic/Early Bronze Age. The ubiquity of farming tools is even lower than that of the Early Neolithic period. For another thing, most of the main residential sites are devoid of farming tools, and they usually are some distance away from the farming residences. This suggests that farming is probably not the key considerations in choosing the locations of residential settlements. In order to deal the distance from the main residential locations and suitable land for farming, people set up special farming residences in places more suitable for farming and might occupy these places temporarily during the farming season. This pattern is fairly unlikely to happen in communities with heavy reliance on farming since the heavy labor requirements of farming and the massive processing and storage of the agricultural products require people to locate their main residential settlement as close as possible to land suitable for farming.

Wild resources are important for the communities of both Early Neolithic and Mid-Late Neolithic/Early Bronze Age. Tools used for the intensive processing of plant resources, such as grinding stones, as well as those used for animal resource procurement and processing, like end scrapers, microblades, and the arrowheads (in particular refer during the Mid-Late Neolithic/Early Bronze Age) are more frequently found across the sites than farming tools. Moreover, the settlement pattern which shows a few main residential settlements combined with large numbers of temporary settlements and task sites also tallies with the subsistence practice based on heavy reliance on wild resources. Since in contrast to fully-fledged agriculture, the acquisition of wild resources requires people to move around within a territory rather than staying in any specific spots for a long time. Therefore, such a subsistence basis can only support a very limited number of main residential settlement with relatively stable residence (either located in the zones with abundant wild resources or relying on the massive storage of food brought by people from different localities) and leave all the other sites more briefly occupied.

A further investigation indicates that though people in both periods heavily relied on wild resources, people seem to have decreased their reliance on plant resources and increased the intensity of the procurement of animal resources in Mid-Late Neolithic/Early Bronze Age. The ubiquity of grinding stones in the Mid-Late Neolithic/Early Bronze Age is lower than in Early Neolithic period. Moreover, as shown in Figure 7.1, the proportions of grinding stone tools are lower in the majority of Mid-Late Neolithic/Early Bronze Age sites than in Early Neolithic sites (specifically focusing on the sites which have more than 15 total tools). By contrast, the prevalence of arrowheads during Mid-Late Neolithic/Early Bronze Age indicates that people made more technical investments into the production of hunting weapons. The co-existence of arrowheads and microblade techniques also suggest that people applied diversified ways for hunting. Without the aid of micro use-wear analysis, it is hard to estimate the specific functions of chipped light-duty tools. However, based on the morphologies and designs, most of them found in Mid-Late Neolithic/Early Bronze sites were probably used for animal resource processing and many of them were more finely made than the ones of Early Neolithic periods. A more advanced micro use-wear study is needed to make a comparison of light-duty tools between these two periods to see if the light-duty tools in Mid-Late Neolithic/Early Bronze Age were more focused on the processing of animal resources.

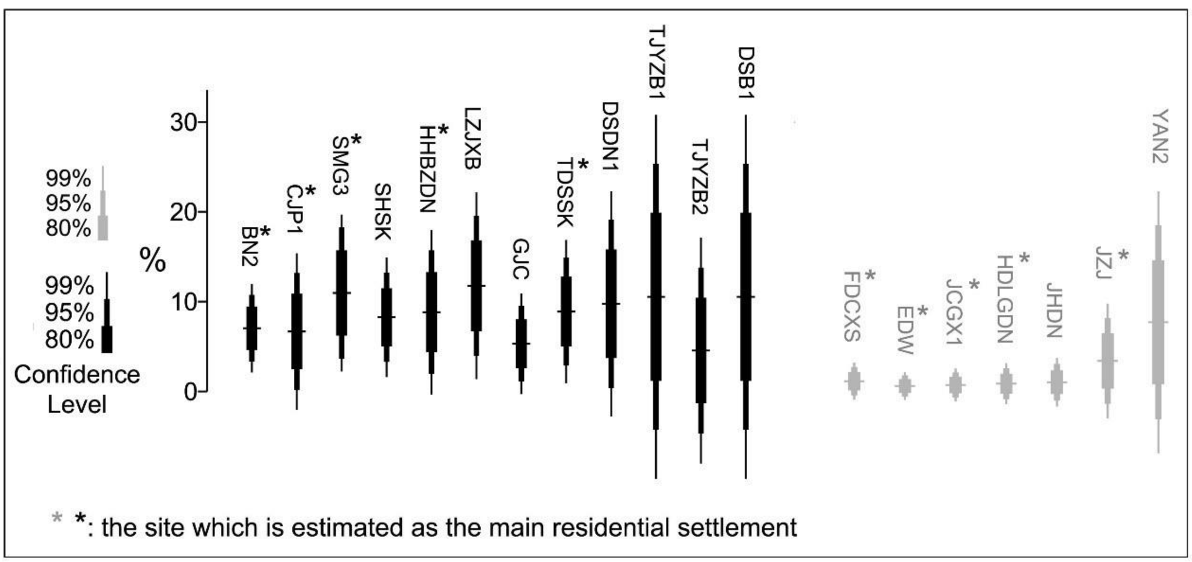

Figure 7.1 The bullet graphs showing the comparison of the proportion of grinding stone tools of the sites (with more than 15 pieces of lithic tools) between the Early Neolithic and Mid-Late Neolithic/Early Bronze Age

(The bullet graphs in black colors refers to the Early Neolithic sites; the bullet graphs in gray colors refers to the Mid-Late Neolithic/Early Bronze Age sites)

All the faunal remains found in Yumin and Simagou sites of the Early Neolithic period are wild animals except for dogs. Therefore, pastoralism was unlikely to be a subsistence practice during the Early Neolithic period. Though fully domesticated pigs appeared in the Mid Neolithic period and the domesticated cattle, goats, and sheep were introduced by the Late Neolithic period in adjacent regions, no faunal remains or any direct material expressions of pastoralism have been found from the survey. Hence, the survey data alone cannot either substantiate or exclude the existence of pastoralism in the studied area of the Mid-Late Neolithic/Early Bronze Age. It cannot further provide any information about the relative importance of possible pastoralism in the whole subsistence system. However, the prevalence of arrowheads as hunting tools, as well as biface techniques fitting in the conditions of high time pressure and mobility which probably associated with hunting activity highlight that wild game was still an important meat resource for human subsistence.

7.3 The comparison of the levels of social integration

The extensive excavations of Yumin and Simagou sites reveal that people in the Early Neolithic period of North Yinshan mountain are in the middle of the spectrum from an extremely low level of social integration to highly sophisticated social integration (in terms of population nucleation, economic interdependence, social differentiation). For one thing, the scale of settlements is larger than those found before 8.5 ka B.P. in the northern part of North China (Shelach-Lavi 2015). The aggregated pit-house distributions make Yumin and Simagou like two tiny village-type settlements, indicating a certain level of population nucleation. Nonetheless, these sites are still smaller than the typical full-agriculturalists' communities found in the Mid Neolithic period in the heartland of China, like Banpo or Jiangzhai (Peterson and Shelach 2010), suggesting that the scale of population nucleation was smaller than that of the fully-fledged agriculturalists.

No materials have shown any pronounced tendency toward intensification of social interactions, such as the development of social hierarchy or complex economic specializations. The comparisons of artifact assemblage across the houses indicate that there are only minor degrees of inter-house differentiation. Each household might independently undertake a range of activities including tool production and various subsistence practices. Except for one drilled stone tablet found in House F1 which might convey specific symbolic meanings, all the other artifacts recovered from the sites are practical utensils.

We know little about details of social integration of the Mid-Late Neolithic/Early Bronze Age period since there are no extensive excavations of any Mid-Late Neolithic/Early Bronze Age sites. Since the site area was not estimated in accurate and consistent ways, it is difficult to directly use the site areas as a proxy to evaluate community size. However, the review survey conducted in 2019 summer has made a re-estimation of the area where the clusters of stone piles were concentrated in the EDW site. As mentioned in chapter 6, each cluster of the stone piles is interpreted as the remnant of a house structure, the concentrated distribution of the stone piles can help us evaluate the scale of the EDW residential settlement. This area is about 4800 m^2. It is only slightly larger than the Yumin and Simagou sites and is still smaller than most of the settlements of full-agriculturalists in the contemporaneous heartland of North China, which are usually larger than 1 ha (Peterson and Shelach 2010).

Since neither excavations nor intensive survey collections have been conducted for the sites of Mid-Late Neolithic/Early Bronze Age, it is impossible to investigate inter-household differentiation as a way to explore the issues such as economic specializations or social differentiation. However, according to what we found from the survey, all the artifacts are quotidian utensils and no prestige goods have ever been found.

All these lines of evidence indicate that there was probably neither pronounced development of social differentiation nor the enlargement of community size from Early Neolithic to Mid-Late Neolithic/Early Bronze Age.

7.4 Difference of site distribution across the landscape

The people in both Early Neolithic and Mid-Late Neolithic/Bronze Age of the survey area settled in a variety of different landforms. However, Early Neolithic communities more focused on the use of land in the transitional zone between the mountains and the plains, whereas the Mid-Late Neolithic/Early Bronze Age communities paid more attention to the use of the plain area relatively farther away from the mountainous area. From Figure 7.2, we can see that in general, the Early Neolithic sites are located closer to the mountains since a large number of the sites have relatively higher proportions of mountain areas surrounding them. Such a pattern is even more clear if we omit the multi-component sites and only leave the single-component sites of both periods for comparison, which further suggests that as time went by, people were more inclined to settle farther away from the mountains. The Chi-Square analysis (as shown in Table 7.2 and 7.3) reveals that the differences in proximity to the mountainous area is significant between Early Neolithic and Mid-Late Neolithic/Early Bronze Age sites ($p< 0.001$ for both the comparison of the total number of multi-component with both Early Neolithic and Mid-Late Neolithic/Early Bronze Age and the comparison of single-phase sites).

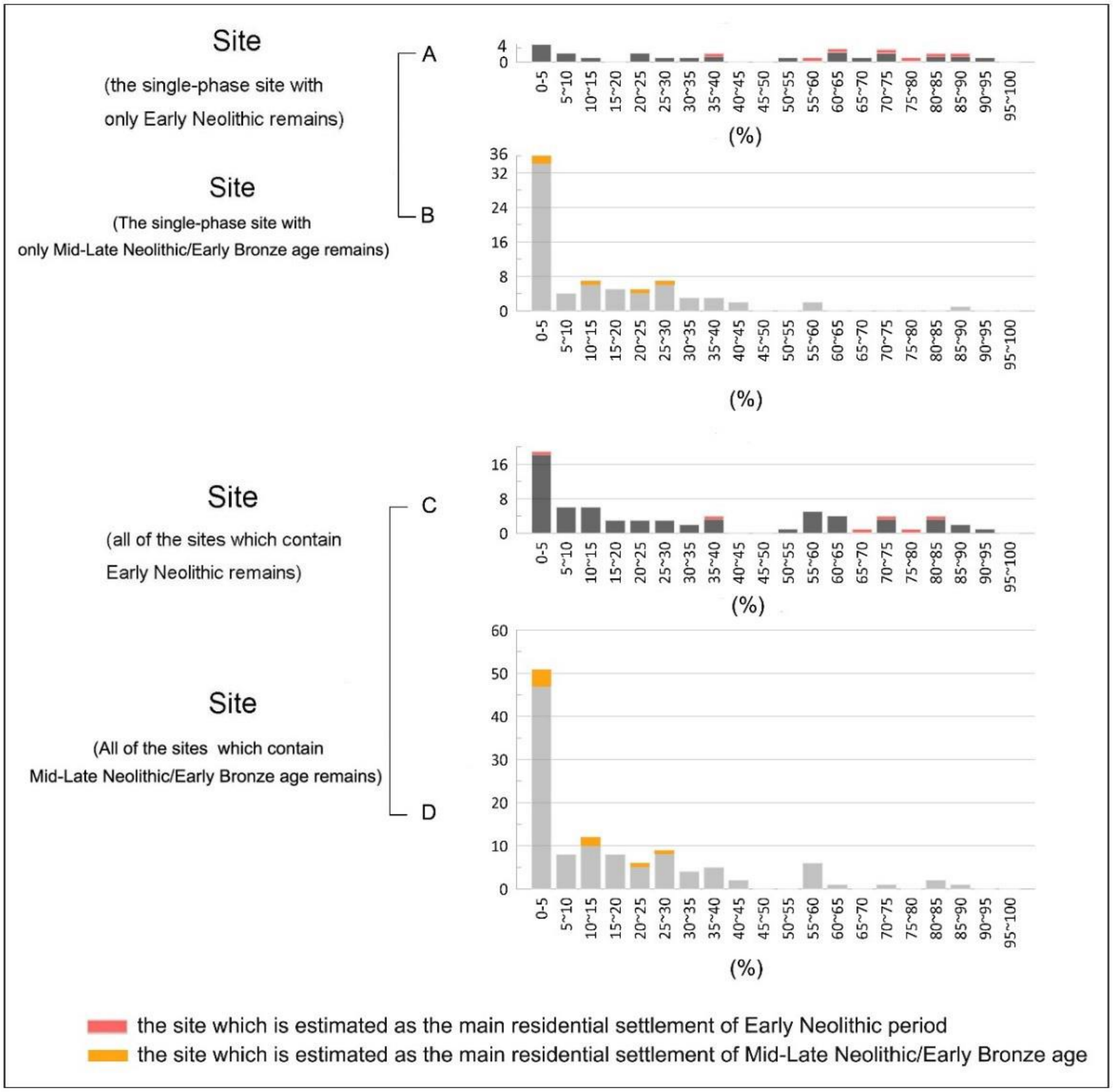

Figure 7.2 The bar graph showing the comparison of the distribution of the sites with different proportions of the mountainous area within the 1km radius catchment zone between the Early Neolithic and Mid-Late Neolithic/Early Bronze Age period

Table 7.2 The comparison of the actual and expected numbers of the sites with different proximity to the mountainous area between Early Neolithic and Mid-Late Neolithic/Early Bronze Age period (All the sites which include either Early Neolithic or Mid-Late Neolithic/Early Bronze Age remains are included)

Period (all sites are included)		Mountain area within 1 km radius site catchment zone (0-45%)	Mountain area Within 1 km radius site catchment zone (45-100%)
Early Neolithic	Counts	46	23
	Expected counts	56.3	12.7
Mid-Late Neolithic/ Early Bronze Age	Counts	105	11
	Expected counts	94.7	21.3

X^2=16.407; p<0.001

Table 7.3 The comparison of the actual and expected numbers of the sites with different proximity to the mountainous area between the Early Neolithic and Mid-Late Neolithic/Early Bronze Age period (Only the single component of either Early Neolithic or Mid-Late Neolithic/Early Bronze Age remains are included)

Period (only include single-component sites)		Mountain area within 1 km radius site catchment zone (0-45%)	Mountain area Within 1 km radius site catchment zone (45-100%)
Early Neolithic	Counts	15	13
	Expected counts	4.9	23.1
Mid-Late Neolithic/ Early Bronze Age	Counts	3	72
	Expected counts	13.1	21.3

X^2=34.740; p<0.001

As indicated by Figure 7.2, compared with temporary settlements and task-specific sites, the distribution of main residential settlements in each period is more restrict to specific landforms. For instance, except for XH5, all the main residential settlements of the Early Neolithic period were located close to the mountains. By contrast, the residential settlements of Mid-Late Neolithic/Early Bronze Age were located on relatively flatter landforms. Such a pattern further highlights the shifting focus of land-use from the intersections of the mountains and plains to the open lands farther away from the mountains.

As a result of this distribution, the elevations of the Mid-Late Neolithic/Early Bronze Age sites are in general lower than those of Early Neolithic sites, and this difference is significant based on Kruskal-Wallis test ($p<0.01$). Moreover, the surrounding areas of the Mid-Late Neolithic/Early Bronze Age sites have more minor altitude differences in comparison with those of Early Neolithic sites (as shown in Figure 7.3). The Chi-Square analysis (as shown in Table 7.2 and 7.3) reveals that the difference in altitude variation across the 1 km radius site catchment zone is significant between Early Neolithic and Mid-Late Neolithic/Early Bronze Age sites (the p-value is less than 0.053 for the comparison of the multi-component sites; the p-value is 0.004 for the single-phase sites of either Early Neolithic or Mid-Late Neolithic/Early Bronze Age).

The difference has considerable significance looked at either way (as shown in Table 7.4 and 7.5). This difference suggests that while people in Early Neolithic period took advantage of the locations in the transitional zone between mountain and plain in order to exploit the resources distributed at different heights, people in Mid-Late Neolithic/Early Bronze Age were more focused on the use of either more homogenous resource patches or the multiple resources distributed horizontally across different ecozones on the flat landscapes.

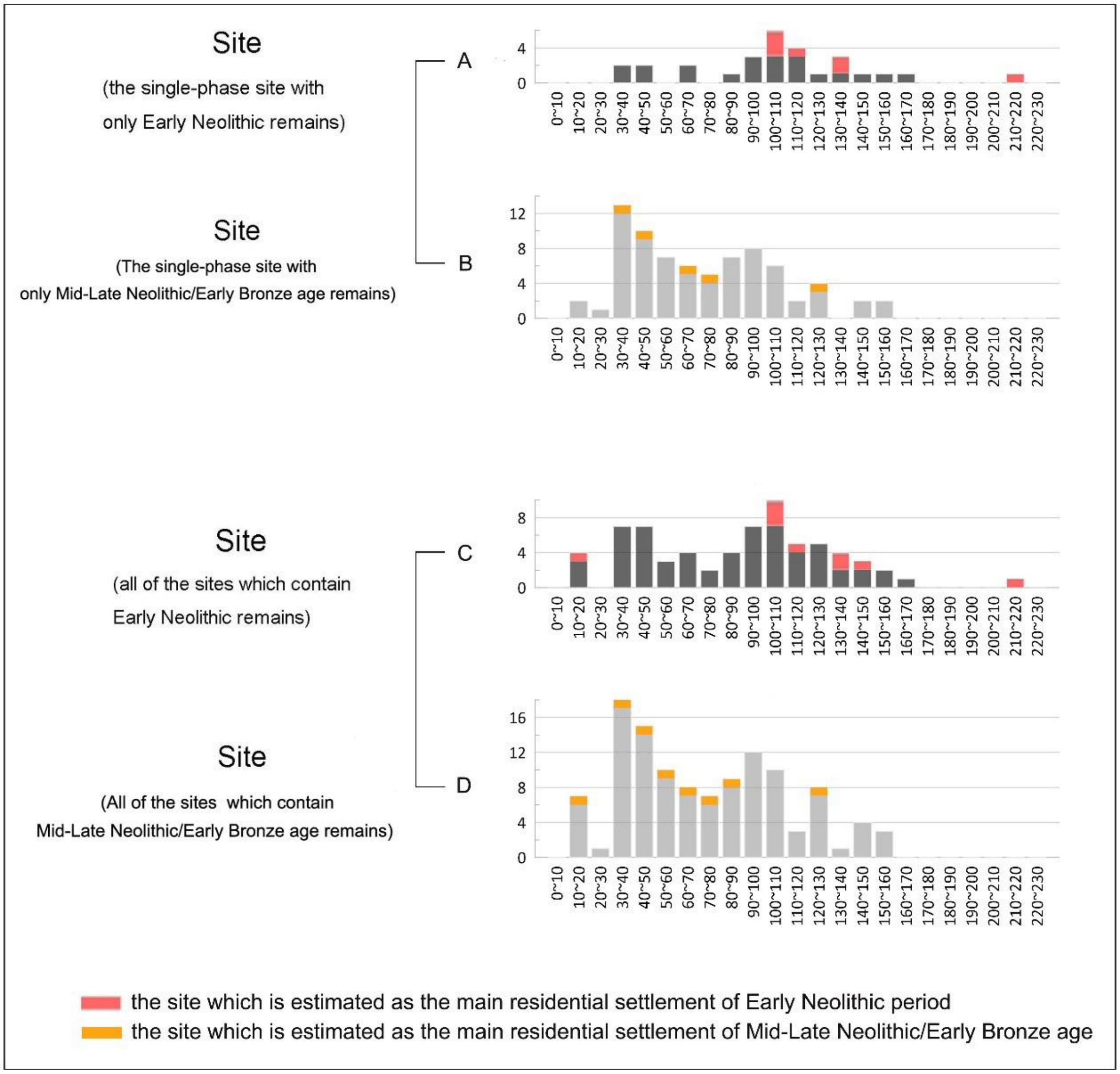

Figure 7.3 The bar graph showing the comparison of the distribution of the sites with different ranges of altitude difference within the 1km radius km catchment zone between the Early Neolithic and Mid-Late Neolithic/Early Bronze Age period

Table 7.4 The comparison of the actual and expected numbers of the sites with different ranges of altitude difference at the surrounding areas between the Early Neolithic and Mid-Late Neolithic/Early Bronze Age period (All the sites which include either Early Neolithic or Mid-Late Neolithic/Early Bronze Age remains are included)

Period (all sites are included)		Altitude difference within 1 km radius site catchment zone (less than 70m)	Altitude difference Within 1 km radius site catchment zone (more than 70m)
Early Neolithic	counts	25	44
	Expected counts	31.3	37.7
Mid-Late Neolithic/ Early Bronze Age	counts	59	57
	Expected counts	52.7	63.3

X^2=3.736; p=0.053

Table 7.5 The comparison of the actual and expected numbers of the sites with different ranges of altitude difference at the surrounding areas between Early Neolithic and Mid-Late Neolithic/Early Bronze Age period (Only the single component of either Early Neolithic or Mid-Late Neolithic/Early Bronze Age remains are included)

Period (only include Single component sites)		Altitude difference within 1 km radius site catchment zone (less than 70m)	Altitude difference Within 1 km radius site catchment zone (more than 70m)
Early Neolithic	counts	6	22
	Expected counts	12.5	15.5
Mid-Late Neolithic/ Early Bronze Age	counts	40	35
	Expected counts	33.5	41.5

X^2=8.397; p=0.004

As discussed in chapter 5, the different landforms provide different foraging opportunities and living conditions for the prehistoric communities. The plain area (mainly in the major and tributary valleys) comprises the steppe, meadow, and wetland along the river. It provides good opportunities for massive hunting of herbivore species and the collection of seeds, tubers, roots, bulbs, and rhizomes. Moreover, the rivers, lakes, and wetlands also provide aquatic resources (like fish, shellfish) as well as migratory birds in specific seasons. However, since there are no large water bodies in the survey region, the contributions of such riverine and wetland resources to the human diet should be not overestimated.

During the warmest and wettest period of the Holocene climatic amelioration, the mountainous area might be covered by patches of forest, which provide a variety of forest animals, nuts, fruit, and other edible plant resources.

The benefits of the location at the intersection between mountains and plains is that it can provide people with easy access to both the mountainous and plain resource zones whereas the location in the heartland of the plain provides people more convenient access to the resources provided by steppe, meadow, and wetland as discussed above. Therefore, the shifting focus of the land-use from the intersectional region of mountains and plains to the plain area indicate that people have changed their land-use strategy from the diversified acquisition of both mountain and plain resources in Early Neolithic period to increasing reliance on plain resources in Mid-Late Neolithic/Early Bronze Age.

7.5 Environmental factors which affect the changes of land-use strategy

The shift of land-use strategy discussed above might result from people's modifications of their adaptive strategies in coping with the climate changes. The lake cores from Anguli-nuur and Bayanchagan lake provide good references to evaluate the environmental changes of the survey region since they are both located on the northern slope of Yinshan mountain and have similar environmental settings with survey region. Anguli-nuur Lake is 66 km south of the survey region, whereas Bayanchagan Lake is 70 km southeast of the survey region. The combination of pollen, mineral magnetism, particle size, TOC, C/N of Anguli-nuur Lake reveals that the wettest and warmest conditions occurred during 8.9-7.4 ka B.P. The climate became less wet and warm during 7.4-6.9 ka B.P. and further deteriorated after 6.9 ka B.P. (Wang, et al. 2010). As for the core from the Bayanchagan Lake, individual pollen taxa (PT-MAT) and the PET affinity scores (PET-MAT) were used for quantitative climatic reconstruction from pollen and algal data. This indicates that the wettest climate occurred between 10.5 and 6.5 ka B.P. (Jiang, et al. 2006). In spite of showing different durations of the most optimal climate period of the Holocene, they all overlap with the Early Neolithic period of the survey region. Accordingly, the period when the climate became colder and drier corresponded with the Mid-Late Neolithic period/Early Bronze Age.

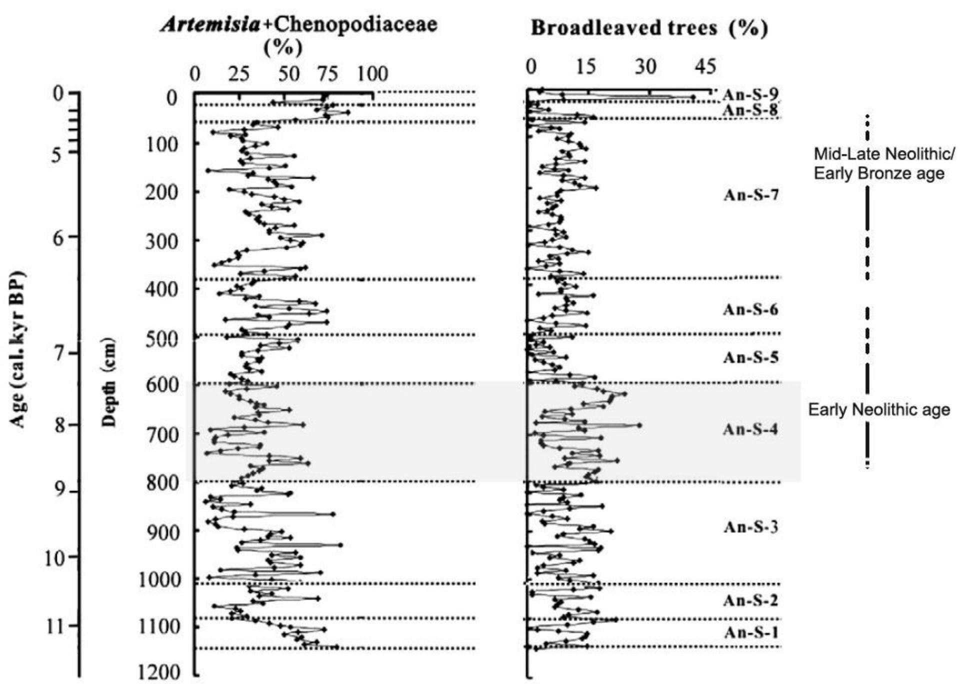

Figure 7.4 The pollen record of the Anguli-nuur lake core which shows the proportions of "artemisia+chenopodiaceae" and broadleaved trees

(The gray belt marks the warmest and wettest period of the Holocene climate optimum ; The chart is revised from (Wang, et al. 2010))

The tendency of the change into drier and colder climate would lead to the shrinkage of the forest areas. As shown in Figure 7.4 of Anguli-nuur Lake, we can see that the percentages of the pollen of broadleaved trees dropped after 7.4 ka B.P. while the percentage of artemisia and chenopodiaceae increased after 7 ka B.P. The pollen record from Bayanchagan Lake also indicates that although the region was dominated by steppe vegetation throughout the Holocene, forest patches were relatively common during the period of 9.2 to 6.7 ka B.P. Such circumstances might also occur in the survey region. The shrinkage of forest zones after the peak of Holocene climatic optimum could lead to the decreasing affluence of the potential edible resources provided from the forests. As a result, the location close to the mountains close less appealing for settlement, since it was no longer the intersection zone between patches of forest and steppe. The increasing reliance on resources provided from steppe, meadow and wetland might have attracted people to build more of their settlements at the heartland of the plain area.

The possible existence of pastoralism (though it cannot be substantiated by the artifacts from the survey data) might be another factor that attracted people to locate their settlements at plain area since it has vast lands covered with steppe vegetation which could potentially serve as good pasture lands.

Since the Northern Yinshan Mountain region is located at in the marginal area for farming, climate change into drier and colder conditions would also pose harsher circumstances of the development of farming. An evaluation of the individual pollen taxa (PT-MAT) from the Bayanchagan Lake (as shown in Figure 7.5) further suggest that the annual precipitation dropped below 400 mm after 7 ka B.P., and the growing degrees days above 5°C is closer to today's standard during 6.5-3 ka B.P. (Jiang, et al. 2006). As discussed in chapter 2, the iso-precipitation line of 400 mm is the dividing line between the agricultural region and pastoral region in China since 400 mm precipitation is a safe threshold for the growth of the crops. The decline of annual precipitation to less 400 mm means that it became risker to practice rain-fed agriculture in the Northern Yinshan Mountain region. The decrease of the growing degree days above 5°C was also not in favor of the growth of millets since millets are thermophilic crops. Since the Northern Yinshan Mountain region is located in a very marginal area where farming could be practiced, it is more sensitive to even subtle climate changes. While the environmental changes into drier and colder conditions after the climax of the Holocene climate optimum did not pose a great threat to the development of agriculture in many core areas of North China, it did make the Northern Yinshan Mountain a riskier area for farming.

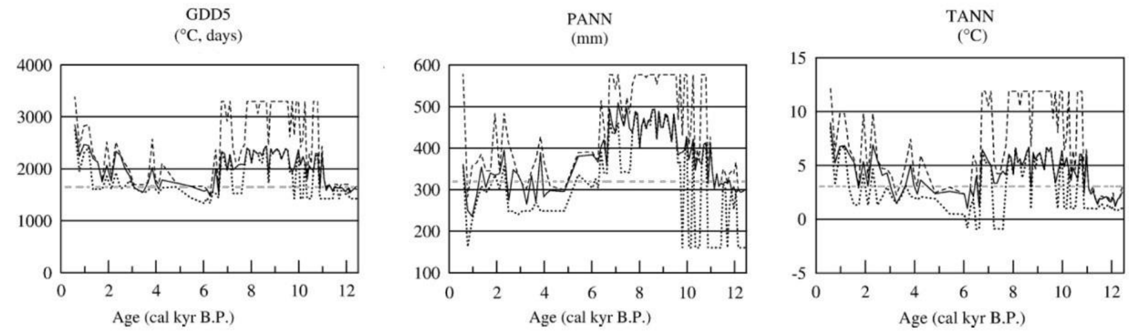

Figure 7.5 Climate parameters reconstructed from pollen data of Bayanchagan lake using PT-MAT (GDD5: growing degrees day above 5 °C; PANN: annual precipitation; TANN: mean annual temperature; Each reconstructed curve shows the mean estimates (solid lines), the lower limit of estimates (dotted lines), the upper limit of estimate (dashed lines); dashed horizontal gray line: present-day climate) (revised from (Jiang, et al. 2006))

Such an impact might explain why the sites with farming tools during Mid-Late Neolithic/Early Bronze Age, in general, have lower elevations compared with those of Early Neolithic period and why the mid and south part of the survey region (which was relatively higher elevation) is devoid of any sites with farming tools in Mid-Late Neolithic/Early Bronze Age. Concentrating farming in the places with lower elevations could better reduce the risks of farming since these places are slightly warmer than the areas with higher elevations. Although the archaeological evidence suggests that farming could still be practiced in the Northern Yinshan Mountain region despite the environmental change, the drier and colder climate did create unfavorable conditions for expanding the scale of farming in Northern Yinshan Mountain region.

A comparison of land-use pattern between the Early Neolithic and Mid-Late Neolithic suggests that instead of overcoming the challenges of the unfavorable environment to intensify farming, people retained a mixed subsistence pattern but shifted their focus more towards the animal resources. I suppose this choice was made because there were alternative subsistence practices, which were either compatible with the existing land-use patterns and could fit well in the local environment to reduce the subsistence risks. The specific discussion of this will be expanded in the next chapter.

8.0 Discussion and conclusion

8.1 A brief conclusion of the dissertation results

The primary goals of this dissertation are: (1) To identify how people used the resources in the steppe zone of the Northern Yinshan Mountain region of Ulanqab, China from the Early Neolithic to the Early Bronze Age; (2) To learn whether or not fully-fledged agriculture emerged during the Neolithic or Early Bronze Age and to evaluate the underlying mechanisms that either facilitate or resist the development of fully-fledged agriculture in the region.

Three research questions have been proposed in the first chapter of this dissertation to structure the research, namely: (1) What subsistence strategies have people employed to make use of resources in the landscape? (2) Did fully-fledged agriculture develop from a pre-existing subsistence strategy? (3) If fully-fledged agriculture did emerge in the region, why did it? If it did not emerge, why did it not?

A comprehensive study based on multiple lines of evidence from both the excavated and surveyed sites provides answers to these questions. It reveals that people employed a mixed subsistence strategy through time from Early Neolithic to Early Bronze Age. Although the changes in site distribution across different landforms suggest that people preferred different environmental zones for resource extraction from Early Neolithic to Mid-Late Neolithic/Early Bronze Age, this mixed subsistence strategy continued to focus on the broad-spectrum extraction of wild plant and animal resources with only limited incorporation of farming as the supplementary subsistence.

Whether or not people raised domesticated animals during Mid-Late Neolithic/Early Bronze Age still requires further study, but the land-use pattern indicates that there is no dramatic increase in plant cultivation at this time. Therefore, fully-fledged agriculture seems not to have emerged in this region even though people had already practiced small-scale farming since the Early Neolithic period.

The presence of low-level farming activity through time, proximity to fully-fledged agricultural communities since the Middle Neolithic period, and the relatively intensive use of resources across the landscape with restricted mobility all suggest that the reason why fully-fledged agriculture did not evolve here is not because of a lack of cultural preparedness or motivation. Instead, it was more likely a consequence of the environmental limits along with the possibility of other more suitable subsistence strategies. Under the increasingly cold and arid climate, farming in this marginal resource zone became increasingly risky and unreliable; as a result, the expansion of agricultural production was constrained. In comparison, a mixed subsistence economy that relied increasingly on animal resources might thrive, first because of the availability of herbivorous herds of wild animals, and perhaps ultimately because introduced domestic animals (namely sheep, goats, cattle, and potentially horses) could convert the largely inedible biomass of the steppe zone to something edible for humans.

The following sections 8.2, 8.3, and 8.4 will extend discussion of the answers to each of the three research questions.

8.2 The changes in subsistence strategy reflected by the patterns of land-use from Early Neolithic to Mid-Late Neolithic/Early Bronze Age

During the Early Neolithic, people relied on a subsistence strategy focused on intensive hunting and gathering with small-scale farming as a supplementary practice. People exploited various different landforms for a living but focused especially on the transitional zones between mountain and plain. People still lived in a mobile lifeway with a seasonal shift of settlements to acquire resources. Most of the sites from the survey probably only reflect temporary dwellings and uses. However, mobility declined at the onset of Neolithic period since people had more stable inhabitations in a few of the main residential settlements evidenced by greater investment in site construction and more intensive site use. Moreover, the site distribution in some parts of the survey region is quite dense, suggesting that people have been attracted and tethered to certain locales rather than wandering around in the vast territories. Meanwhile, people began to aggregate into larger groups than ever in the main residential settlement but without complicated forms of social integration. Each household living in the main residential settlement produce their own set of the toolkits used for meeting different subsistence purposes, suggesting a relatively high level of economic independence and a weak development of economic specialization.

In the Mid-Late Neolithic period/Early Bronze Age, people still employed a mixed subsistence strategy that relied heavily on the acquisition of wild resources. Farming was only included as an auxiliary source of food and was conducted only in the restricted parts of the survey region. Pastoralism was also possibly incorporated into the subsistence system, but without direct evidence, we do not know how important it was in the subsistence economy overall. People also made use of a variety of landforms, but they put more focus on the use of flat areas in the river valleys. Mobility still played an important role in organizing people's land-use strategy since the majority of the sites only show temporary use or habitation; certain types of lithic tools were specially designed for the demands of mobility. Yet like as was indicated by Early Neolithic remains, mobility was also circumscribed during this period since people had more stable residence in their main residential settlements as well as making the repeated use of certain places in the survey region. No signs of much change in social integration, such as the increase in community size or social differentiation can be found in the archaeological evidence.

The comparison of land-use patterns between Early Neolithic and Mid-Late Neolithic/Early Bronze Age revealed both similarities and differences of subsistence strategies in these two periods. The similarities are mainly reflected in the fact that (1) People extracted and processed wild plant and animal resources at a fairly intensive level within restricted environments;

(2) People were socially organized at similar levels of integration to practice subsistence strategy. In spite of such similarities, there were still some prominent changes of land-use pattern from Early Neolithic to Mid-Late Neolithic/ Early Bronze Age, including (1) The shifting focus of the land-use from the transitional area between mountains and plains to the core area of the plains in the valley; (2) The constriction of farming to the northern flat valley area of the survey region and the emergence of specific farming residences in Mid-Late Neolithic/Early Bronze Age. (3) The changes of lithic technical organization which highlight the fitness for mobility of certain types of tools and the intensification of the hunting and processing of animal resources in Mid-Late Neolithic/Early Bronze Age. Such changes suggest that people had pronouncedly adjusted their subsistence strategies for wild food resource acquisition and the practice of farming. It was highly possible that despite the continuity of the mixed subsistence economy based on the broad-spectrum resource extraction, people have increased the intensity of animal resource acquisition in Mid-Late Neolithic/Early Bronze Age.

8.3 Divergent pathways of the development of subsistence practice: Sticking to the mixed economy with modifications or stepping into the fully-fledged agriculture

The conclusion that fully-fledged agriculture did not emerge in the Northern Yinshan Mountain region during the Mid-Late Neolithic/Early Bronze Age is mainly derived from the following evidence: (1) The farming tools are simple and far less ubiquitously distributed across the landscape compared with the tools used for extracting and processing wild food resources; (2) The settlement pattern identified in Mid-Late Neolithic/Early Bronze Age in this region is fairly unlike that left by the fully-fledged agricultural communities. Since fully-fledged agriculture can greatly increase the food productivity of a restricted area, it will lead to fully sedentary lifeways, stimulate population increase, and facilitate social aggregation. Therefore, if fully-fledged agriculture emerged, we would expect to see that the settlement pattern was mainly composed of sedentary nucleated villages and reflected dramatic population increase. Nonetheless, none of the suggested features can be identified from the settlement pattern of Mid-Late Neolithic/Early Bronze Age in the studied area.

Rather than a dramatic increase in reliance on farming, the most pronounced change in the farming economy is that people modified their ways of practicing farming. In the Early Neolithic period, farming tools were often found in the main residential settlements which are located close to the mountainous zones. Whereas in the Mid-Late Neolithic/Early Bronze Age, people did their farming in specific places concentrated in relatively flat areas in the northern portion of the survey area. The majority of the main residential settlements, in comparison, were devoid of farming tools. Such changes suggest that unlike their Early Neolithic predecessors who conducted small-scale farming around the main residential settlements, people in the Mid-Late Neolithic/Early Bronze Age might have sent task groups to conduct farming in specific places a few times each year.

The long-term trajectory of subsistence change from Early Neolithic to Early Bronze Age in the Northern Yinshan Mountain region differs from that observed in many other regions of the core area of North China, like Yellow River Drainage and West Liao River valley. The comparison shows that in the Early Neolithic period, people adopted a similar pattern of subsistence across these regions. They all rely on a pattern of mixed subsistence which centered on the intensive exploitation of wild resources but also included small-scale farming as supplementary subsistence resource (Barton, et al. 2009; Crawford, et al. 2016; Ma, et al. 2016; Wu 2014). Mobility decreased and there was a tendency of using the land and resources of restricted areas in an increasingly intensive ways than before (Chen and Yu 2017a; Li 2018). People even aggregated at larger social scale at least seasonally in some restricted areas. Such a pattern indicates that despite living in a more arid and colder environment, people in the Northern Yinshan Mountain region adopted similar coping strategies to those employed by the communities living in more humid and mild environments. They both took advatnage of the Holocene climatic optimum to experiment with farming and increase the intensity of resource exploration in restricted areas (Chen 2013).

However, the subsequent development of subsistence strategies in the Northern Yinshan Mountain Region diverged from regions like Yellow River drainages and West Liao River valley in Mid-Late Neolithic/Early Bronze Age. The further development of the toolkits for farming, the soaring population and the flourishing of nucleated sedentary villages suggest that fully-fledged agriculture was involved and became the major economic practice of the people in the latter two regions (Chen 2011; Zhao 2017). In contrast, people in the Northern Yinshan Mountain region at this period still followed a mixed subsistence strategy. They only conducted a limited scale of farming in the specific locales and shifted their focus more to the use of animal resources. Such a divergent development of subsistence practice implies that people made different choices to adapt to the changing cultural and environmental conditions after the peak of the Holocene climatic optimum.

8.4 Why not agriculture? -An exploration of the possible reasons why fully-fledged agriculture did not evolve in Northern Yinshan Mountain region

The development of fully-fledged agriculture requires both external and internal factors. External factors include environmental conditions and cultural contact, whereas the internal conditions mainly refer to cultural preparedness and social-economic motivation. Whether to further intensify farming, keep the original subsistence practices, or shift into other alternative strategies can be conceived as the choice people made based on the interplays of the internal and external factors under specific circumstances (Barlow 2002).

What the land-use study tells us is that people in the Northern Yinshan Mountain region did not lack any motivations nor cultural preparedness for the development of fully-fledged agriculture. Firstly, though not playing the dominant role in human subsistence, farming existed throughout the time from Early Neolithic to Mid-Late Neolithic period, indicating that the techniques, skills, and knowledge of farming already existed and might even have increased as time went by.

In addition, although mobility still retained in people's lifeways, it was circumscribed and people began to repeatedly use certain places of the survey region and even settled down in specific locales with more stable residence. Such reduced mobility increased the resource pressures in restricted area and required people to have more efficient means of resource exploitation in those areas (Kelly 1992). The appearance of tools for the intensification of food resource exploitation, such as grinding stones, has is seen in multiple sites across the landscape of the survey region from Early Neolithic period, implying the need for food resource intensification. Since farming is an effective intensification technique for getting food resources, intensifying farming would potentially be an appealing solution to increase the food supply in a restricted area if external factors do not pose strong constraints.

Moreover, since the Early Neolithic period, people had already aggregated at least seasonally in larger group sizes than before. Such scale of aggregation makes it possible to have certain levels of social cooperation for farming, which is necessary for supporting intensified agriculture in a more marginal and risky environment (Cleland 1976).

Besides the internal conditions as indicated by the land-use study, the Northern Yinshan Mountain region is adjacent to areas where the fully-fledged agriculture emerged from the Mid Neolithic period. For instance, the survey region is less than 200 km north of the regions of the south slope of the Yinshan Mountain range where the Yangshao agricultural communities lived (Neimenggu and Beijing Daxue 2003). It is also about 300-400 km west of the core area of Hongshan-Lower Xiaojiadian culture in West Liao River valley where the fully-fledged agriculture served as the main subsistence basis for the society (Chen 2011). Such evidence suggests that the communities of Northern Yinshan Mountain could easily be in contact with the neighboring fully agricultural societies and get the advanced knowledge and skills for farming based on cultural communication.

Then, why did fully-fledged agriculture still not develop in the Northern Yinshan Mountain region in spite of having all these important prerequisites? I suppose it is mainly a result of environmental constraint and the availability of other alternate subsistence people could rely upon. As discussed in Chapter 7, the changes to drier and colder climate created unfavorable climate conditions for farming. The magnitude of the change probably made the annual precipitation and growing season fall just below the safety threshold for the growth of millets (Fang 1999). As a place located at the margin of the summer monsoon region and with strongly fluctuating climate from year to year, such a climatic change inevitably increased the risks for farming. Admittedly, the climate was still not harsh enough to make the farming economy totally impossible in this region. As long as people did not over-rely on farming, small-scale farming could serve as part of the diversification strategy to buffer against the risks. In good years, the harvests of the crops provided extra food, which could be further stored for future use. While in bad years, there were still other wild food resources to rely on, and the failure of the harvest wouldn't cause disastrous results. However, if people increased the scale of farming in this region, the failure of harvests in bad years would cause disastrous results and lead to a serious survival crisis. People could still exert extra effort to reduce the risks of increasing reliance on agriculture, such as building irritation canals to ameliorate the local environment, or breeding drought or cold-resistant species for cultivation. Such efforts would inevitably increase the cost of farming, though, and reduce the overall return rate of farming in terms of costs and benefits.

As long as the return rate of intensified farming was lower than the other possible subsistence practices, people would be unlikely to further intensify farming (Barlow 2002). This would probably be the case in Northern Yinshan Mountain region. In contrast to the harsh environment for agriculture, the Northern Yinshan Mountain region boasts an abundance of herbivore animal species (Xurigan 2016). Compared with the boreal forest region, the temperate grassland environment has more aggregated herds of animals (Kelly 1983), which create favorable conditions for massive hunting. Moreover, it has large open spaces with steppe and meadow vegetation, which could potentially serve as good pasture land (Zheng 1989). Therefore, increasing reliance on the use of animal resources could be a less risky and more profitable subsistence practice in coping with increasing demands for food resource acquisitions within a restricted area. Given the facts that domesticated animals had already appeared in adjacent regions and that the popularity of the finely made chipped arrowheads in Mid-Late Neolithic/Early Bronze Age reflects a more advanced development of the hunting weapons, it is highly possible that increasing reliance on animal resources was achieved by the combination of animal husbandry and more intensified hunting of wild resources. Before the introduction of horses to the steppe environment, the scale of the domesticated herding people could practice was limited (Wang 2008). Therefore, a highly mixed subsistence combining intensive hunting, heading, wild plant gathering, and a small-scale farming could enable people to make more efficient use of the local environment and reduce subsistence risks.

Hence, the potential tendency for the development into fully-fledged agriculture was interrupted in the Northern Yinshan Mountain region and people employed a different subsistence strategy compared with that adopted in the heartland of North China since Mid Neolithic period. Rather than being fully engaged in agricultural production, people modified their mixed subsistence strategy during Mid-Late Neolithic/Early Bronze Age by focusing more on the use of the landforms with more convenient access to animal resources, developing a set of tools more suitable for logistic forays, and changing the location of their farming fields into the least risky environment.

8.5 Farming in the marginal environment

Any form of agriculture, irrespective of the crops it depends upon, can only exist in certain areas where the environmental conditions meet the demands for the growth of the crops. However, it is extremely difficult to draw the clear-cut boundaries of such areas since between the core area with suitable environmental conditions for cultivation and the area where the cultivation of crops is totally impossible there exists a broad transitional zone where the environmental conditions are not so friendly and reliable for farming, but people could still make efforts to practice cultivation even at higher level of risks under specific conditions like population pressures, social competitions, or the lack of other alternative means of subsistence to cope with adaptive challenges (Graham 1993; Indrisano 2006; Varian 1999). Such zones can be defined as the marginal area for agriculture. Given the nature of the environment in the Northern Yinshan Mountain region, it can be seen as an extreme marginal area of millet-based farming.

A review from archaeological evidence suggests that while people have developed fully-fledged agriculture in some of such environments, people did not in the other marginal environments (Chen 2013; Graham 1993). Moreover, people might even shift between fully-fledged agriculture and other forms of subsistence in the same marginal environment throughout time (Chen 2011; Han 2005). Explaining such discrepancies of subsistence choice in marginal environments is of great significance for us to understand where the threshold lies of human subsistence choice of whether or not to practice a fully agricultural economy under specific social and economic circumstances.

As one of the prevalent theoretical explanations of the origin of agriculture, the stress model has been applied to explain why people would intensify farming in marginal environments. It highlights that these marginal areas are more prone to various kinds of subsistence stresses than areas of abundance and hence provide more stimulus pushing people to expand the scale of farming (Binford 1983; Childe, et al. 1940; Cohen 1977). However, the land-use study of Northern Yinshan

Mountain reminds us that in spite of the existence of such motivations, the marginal environment can also pose harsh constraint conditions for the persistent development of farming. Moreover, besides the choices of agriculture, there might be alternative choices for people to rely on in coping with the resource stresses. Therefore, we can see that though people in Northern Yinshan Mountainregion incorporated the farming in quite an early period as a way to cope with subsistence stresses, they did not further develop it to more intensive levels and rely increasingly on farming as time went by.

This study suggests that the specific pattern of the land-use strategy, the relative return rate of agriculture, and the feasibility of the alternative subsistence practices are all important considerations for people to make their subsistence choice. An exploration of the interaction of these three factors is crucial for us to understand why fully-fledged agriculture could emerge in some marginal environments but not in the others.

In the case of the Northern Yinshan Mountain region, the land-use pattern provides the potential stimulus for the further development of fully-fledged agriculture but it is also compatible with more extensive forms of subsistence. In such cases, developing fully-fledged agriculture is either too risky or requires too much investment to get a limited return. By contrast, increasing reliance on animal resources can well take advantages of local resources and reduce subsistence risks. Therefore, people ultimately selected a mixed subsistence economy with an increasing focus on animal resources as the coping strategy to deal with environmental changes.

In terms of specific concerns for promoting our understanding of the issues of the agricultural origin in North China, this case study in the Northern Yinshan Mountain region has contributed in the following ways.

(1) It highlighted that the initial attempt for the development of millet farming appeared almost simultaneously in multiple areas across broad region of China. It was not only confined to the core areas of North China with suitable climatic and soil conditions for millet cultivation but even appeared in extreme marginal environments with challenging conditions for millet cultivation,

and fully-fledged agriculture did not develop even during the subsequent periods. Northern Yinshan Mountain has never come into the view of archaeologists who seek to study the origin of millet agriculture in China. However, this research shows that millet farming, although it did not ultimately develop into a major subsistence practice, was long incorporated as a supplementary subsistence practice in the southern steppe zone for people to adapt to the local environment prior to the rise of a specialized herding economy.

(2) The dissertation pointed out that the region where attempts to practice farming is broader than the region where fully-fledged agriculture ultimately emerged. It suggests that the whole process of millet agricultural origin in China was not likely the diffusion of an "agricultural package" from a core origin center to other regions (Chang 1963). Instead, it was more likely that people dispersed across a quite vast area (including both North China and its peripheral regions) experimented with incipient farming as an innovative subsistence practice to adapt to changing environment, but only those who lived in core areas of North China further intensified farming and developed a form of fully-fledged agricultural economy eventually.

(3) The research suggests that once incipient farming emerged, it would either be gradually intensified and become the major subsistence practice, or it would be long incorporated as a supplementary subsistence strategy and might even subsequently be replaced by alternative subsistence practices. Such different trajectories of development were not passively determined by environmental constraints but involved people's active choice in face of the interplay between culture and environment under specific conditions. Comparing these different trajectories would provide us a more comprehensive understanding of the conditions why fully-fledged agriculture only developed in certain areas but not others. It will further provide insights to evaluate different roles farming practice played in different societies. Hence, for future research on the origin of millet agriculture in China, this dissertation calls for the expansion of the focus from the core areas where fully-fledged agriculture ultimately emerged to the marginal areas which saw the initial attempt for conducting farming but never witnessed the establishment of fully-fledged agriculture.

8.6 Reconstructing the subsistence strategy from the land-use pattern

This study has shown how we can make a comprehensive study of land-use to learn the changes of people's subsistence strategy either into fully-fledged agriculture or into other directions. Faunal and floral remain and bone chemistry analytical results have long been used as the primary evidence for reconstructing subsistence strategy since they directly reflect what kinds of food resources have been used. However, due to taphonomic issues, we cannot always find large quantities of animal bones and macro/micro plant remains in every site, such as ones which were heavily disturbed by post-depositional factors. Moreover, the high cost of bone chemistry makes it only possible to test on a limited number of bones from a small sample. These issues limit our ability to make quantitative studies on a regional settlement scale to evaluate subsistence practices. By contrast, land-use study provides an approach for us to integrate various lines of evidence ranging from site distribution to the features, assemblages, spatial distribution of lithics and pottery to learn how people strategically used resources. Much such evidence can be easily collected from most sites in large quantities. Hence, this provides a more solid base for quantitative studies on the regional settlement scale. Although this land-use approach cannot directly provide information on what specific species of animal and plant resources people have used, it is quite good at revealing the technological and organizational means people have employed to exploit resources. Therefore, such approaches can be combined with faunal, floral, and bone chemistry evidence to generate a more holistic and detailed view of subsistence practices in the past.

Moreover, this study also shows that a comprehensive understanding of land-use is essential for us to evaluate the patterns of the interplay between cultural system and environment constraints which generate changes of subsistence practices. The pre-existing land-use pattern constrains the choices people make for their subsistence strategy. The relative benefits and costs of any subsistence strategies in comparison with farming were also impacted by the specific land-use pattern people have adopted. Therefore, we cannot simply explore the impacts of the relative return rate of agriculture and the availability of other potential subsistence means on people's choice of subsistence strategy without any consideration of the background of land-use.

The specific patterns of land-use, the relative return rate of agriculture, and the feasibility of other subsistence strategies differ from case to case across the different areas. Such different conditions might have impacted people to make different choices of subsistence practices as to whether to develop fully-fledged agriculture or adopt other means of subsistence. The perspectives and the methods used in this dissertation can be potentially extended into the studies of the origin of agriculture in other regions. With more accumulated case studies in future, we can hopefully make trans-regional comparisons to learn how people made choices of whether to develop fully-fledged agriculture or rely on other subsistence strategies under specific cultural and environmental conditions as a way to better understand the mechanisms of the process of agricultural origins.

8.7 Future directions for research

Based on multiple lines of evidence from the combination of survey and excavation data, this dissertation has delineated a framework of land-use pattern from Early Neolithic to Mid-Late Neolithic/Early Bronze Age in Northern Yinshan Mountain region. However, constrained by the availability of current data as well as the limited work ever done for data analysis, some aspects of the land-use pattern were only discussed at a very coarse-grained resolution or were merely supported by weaker evidence than the others.

For instance, social integration was less thoroughly discussed in the dissertation, especially on the aspects of how social integration played a role in the whole land-use strategy by the interplays with subsistence and mobility and how it differed in Mid-Late Neolithic/Early Bronze Age compared with that in Early Neolithic Age. This is mainly the consequence of the fact that we only have rich evidence of social integration from comparisons of inter-household differentiation for the two excavated Early Neolithic sites. If there are chances to do fieldwork in future, the site-based intensive survey on certain selected surveyed sites can be potentially used as a way to learn about social integration. For instance, Peterson has developed the method of the intensive surface collection, applied it in the study of the Fushanzhuang site of Hongshan culture, and made insightful observations on the degrees and the patterns of social differentiation across households (Drennan, et al. 2017; Peterson 2006; Peterson, et al. 2017). Some of the sites found in Huade survey have similar preservation conditions with those of Fushanzhaung. Peterson's research approach can well be introduced to guide our fieldwork of intensive survey. It highlights that from the clustered distribution of artifacts, we can hopefully identify the household units on the surface remains. By separately collecting them based on well-designed sampling methods, we can make comparisons of the differentiation of the artifacts from the clustered distributions as a way to learn inter-household differentiation. In addition, the site-based intensive survey can assist us to have a better estimation of the site area (or at least of the area where the artifacts within the certain period are concentrated). Such information can be used as a reference to evaluate the scales of social integration. Based on such information, we can hopefully investigate questions like how do patterns of social integration change through the time, and whether or not people were periodically aggregated or dispersed in different social scales across the landscape.

Besides the exploration of social integration, there is also a gap in our knowledge about subsistence pattern. Based on the changes in lithic assemblages, this dissertation estimated that people placed more emphasis on the exploitation of animal resources from Early Neolithic to Mid-Late Neolithic/Early Bronze Age. However, we know little about the magnitude of such change or the relative importance of plant resources in comparison to animal resources in both the Early Neolithic and Mid-Late Neolithic periods. Moreover, we do not know mcuh about the particular ways people made use of different resources. Did they have any specialized focuses on a few types of animal and plant resource? Or did they place more or less equal emphasis on a broad range of animal and plant species as their food resource.

The faunal and floral resources can surely provide us direct evidence about the range of species people have exploited and the relative importance of each species contributing to human subsistence. Multi-disciplinary research has already been initiated to examine the faunal and floral remains found from the two excavated sites. It takes time for the results to come out. However, due to the post-depositional conditions, most of the surveyed sites have no faunal and floral remains left. In this situation, investigating the tool functions and comparing the relative proportions of the tools used for different subsistence practices will be an invaluable approach to learn the subsistence patterns. In this dissertation, only the lithics with relatively clear functional indications of subsistence practices or unique roles in terms of technological organization have been emphasized. A large portion of tools were omitted from use in evaluating subsistence patterns either on intra- or inter-site level, such as the tools identified as light-duty or heavy-duty tools since little is known about their specific functions without use-wear analysis. The use-wear analysis can help us to at least reveal the functional indications of parts of such tools and enable us to incorporate more lithics as the indexes to evaluate the relative importance of plant and animal resource exploitation across time. For instance, the functions of the scrapers are hard to tell merely by morphological observations. Yet the micro-use ware study of lithic tools in the Longwangchan site of late Upper Paleolithic period has successfully distinguished the scrapers as used for processing animal resources and those used for processing plant resources (Wang 2017). Similar research could also be conducted for the materials found from excavation and survey in Huade County to provide us with a better understanding of the functions for more kinds of tools.

The aspects of mobility have been discussed by several lines of evidence in the dissertation. However, due to the limitations of the survey and excavation methods and recording, the evidence cannot be fully analyzed in the dissertation, which reduced their contribution to convincing inference. For instance, the particular refuse pattern of the pit-houses in two early Neolithic sites has been mentioned to suggest that people did not likely lived in a fully-sedentary lifeway. However, without detailed recordings of the intra-site spatial distribution of artifacts, the refuse pattern cannot be well shown in objective and informative graphs, maps, or even photos. Instead, it is only be presented as narrative descriptions based on excavators' memory. Moreover, the survey information shows that people have repeatedly used certain places at an intensive level but probably did not live in these places in stable sedentary ways. Such a pattern reveals an important transitional status from mobile to sedentary lifeways. However, without the appropriate recordings of such information, we cannot express it in clear, intuitive, and convincing ways

Such limitations constrain our ability to further explore this line of evidence in depth to learn more about the details of human mobility. An improved way of excavation and survey might solve these problems. For instance, we can pay more attention in future excavations to detailed recording of the spatial distributions of artifacts found in different archaeological contexts. The case study of the Wadi Hammeh 27 provides invaluable reference for us to do this kind of work. The different tools, debitage, faunal remains, and other materials from different layers of the pit houses of this site were collected by continuously distributed 1x1 meter grid units. In this way, the detailed distributional pattern of the artifacts left in the pit houses through time can be revealed by their differential densities across these grids. Such distributional patterns can be further examined and compared with each other to analyze specific refuse behaviors (Hardy-Smith and Edwards 2004). As for the survey work, the systematic survey with more rigorous rules of sampling strategy could be applied and the artifacts can be collected and recorded based on collection units rather than sites. In this way, we can avoid the subjectivity of the site delimitation and more reliably recover the human activities reflected by clusters of artifacts scattered on landscape (Drennan, et al. 2015; Drennan, et al. 2003). Williams's systematic work in Zhangwu county provides a good reference for how to conduct this kind of work. Without using the preconceived concept of site, he examined the distributional pattern of the pottery sherds and lithic remains which were systematically collected under the specific sampling principles across the landscape to evaluate the population distributional pattern and scales of social aggregation (Williams 2014).

Combining with the evidence of mobility and subsistence, this dissertation has proposed the seasonal pattern of land-use. However, it still needs more evidence to evaluate. Compared with lithic assemblages and site locations, some aspects of faunal and floral remains can provide more direct evidence for seasonal use, like the presence or absence of certain kind of species which was only available in certain seasons, the killing profiles of prey and other lines of evidence. Synthesizing the evidence from different perspectives will provide us a more convincing basis to explore the seasonal transhumant pattern existed or not and how the seasonal pattern was scheduled and changed through time. Flannery's research on human subsistence during the Archaic period in the Valley of Oaxaca provides an exemplary case study of seasonality (Flannery 1968). It indicates that it is essential for us to understand the local resource structures and correlate multiple lines of evidence together with the features of local resource structure to understand how people scheduled their subsistence practices through different seasons (Flannery 1968; Flannery 1986).

Last but not least, more intensive dating is badly needed to provide a more precise chronological framework for future research. Currently, the chronological model for the region is still mainly based on the established ceramic typologies. It only provides us a very coarse-grained estimation of the time range for each period and limits our capability to do a fine-scaled comparison of the changes of land-use in the Northern Yinshan Mountain region with any climatic proxies at high temporal resolution or with any other regions with better chronological framework. A fine-resolution chronological framework can not only provide us with a better basis to make such comparisons, but could also reveal more detailed information on land-use. For instance, Barton made an intensive dating based on multiple samples systematically collected from the stratigraphic profile of the Dadiwan site and revealed that people might have periodically abandoned and re-used the sites rather than living there persistently (Barton 2009). A similar research approach can also be applied for examining the nature of residence reflected by the Yumin and Simagou sites.

Hopefully, by synthesizing all these lines of information together from multi-disciplinary studies under a finely controlled chronological framework, we can get a more comprehensive picture of the land-use pattern at higher resolution. Such a better understanding of the land-use pattern will provide us with a more solid basis to understand the role human behavior played under specific cultural and environmental conditions to drive changes in people's subsistence practices.

Bibliography

Adams, Jenny L.

2013 Ground Stone Analysis: A Technological Approach (Second Edition). Salt Lake City: The University of Utah Press.

Andrefsky, William Jr.

2005 Lithics: Macroscopic Approaches to Analysis. New York: Cambridge University Press.

Bamforth, Douglas B.

1986 Technological Efficiency and Tool Curation. American Antiquity 51(1):38-50.

Bao, Qingchuan., Xiaonong. Hu, and Gouming. Yue

2016 A 8ka B.P. Village Site Has Been Found in Huade County, Inner Mongolia (in Chinese). http://www.kaogu.cn/cn/xccz/20160603/54180.html.

Barlow, K. Renee

2002 Predicting Maize Agriculture among the Fremont: An Economic Comparison of Farming and Foraging in the American Southwest. American Antiquity 67(1):65-88.

Barton, Loukas W.

2009 Early Food Production in China's Western Loess Plateau, Department of Anthropology, University of California, Davis.

Barton, Loukas W., et al.

2009 Agricultural Origins and the Isotopic Identity of Domestication in Northern China. Proceedings of the National Academy of Sciences of the United States of America 106(14):5523-5528.

Bettinger, Robert.L.

1999 From Traveler to Processor: Regional Trajectories of Hunter-Gatherer Sedentism in the Inyo-Mono Region, California. *In* Settlement Pattern Studies in the Americas: Fifty Years since Viru. B.R. Billman and G.M. Feinman, eds. Pp.39-55. Washington,D.C.: Smithsonian Institution Press.

2013 Effects of the Bow on Social Organization in Western North America. Evolutionary Anthropology: Issues, News, and Reviews 22(3):118-123.

Bettinger, Robert L., David B. Madsen, and Robert G. Elston
1994 Prehistoric Settlement Categories and Settlement Systems in the Alashan Desert of Inner Mongolia, PRC. Journal of Anthropological Archaeology 13(1):74-101.

Bettinger, Robert L., Bruce Winterhalder, and Richard McElreath
2006 A Simple Model of Technological Intensification. Journal of Archaeological Science 33(4):538-545.

Binford, Lewis.R.
1973 Interassemblage Variability- the Mousterian and the "Functional" Argument. *In* The Explanation of Culture Change. C. Renfrew, ed. Pp.227-254. London: Duckworth Press.

1978a Dimensional Analysis of Behavior and Site Structure: Learning from an Eskimo Hunting Stand. American Antiquity 43(3):330-361.

1978b Nunamiut Ethnoarchaeology. New York: Academic Press.

1979 Organization and Formation Processes: Looking at Curated Technologies. Journal of Anthropological Research 35(3):255-273.

1980 Willow Smoke and Dogs' Tails: Hunter-Gatherer Settlement Systems and Archaeological Site Formation. American Antiquity 45(1):4-20.

1983 In Pursuit of the Past : Decoding the Archaeological Record. London: Thames and Hudson.

Bleed, Peter
1986 The Optimal Design of Hunting Weapons: Maintainability or Reliability. American Antiquity 51(4):737-747.

Boszhardt, Robert F., and Joelle McCarthy
1999 Oneota End Scrapers and Experiments in Hide Dressing: Aa Analysis from the La Crosse Locality. Midcontinental Journal of Archaeology 24(2):177-199.

Cascalheira, João, and Nuno Bicho

2018 Testing the Impact of Environmental Change on Hunter-gatherer Settlement Organization during the Upper Paleolithic in Western Iberia. Journal of Quaternary Science 33(3):323-334.

Chang, K. C.

1963 The Archaeology of Ancient China. New Haven: Yale University Press.

Chen, Hong, et al.

2013 Cultural Adaptations to the Late Pleistocene: Regional Variability of Human Behavior in Southern Shanxi Province, Central-northern China. Quaternary International 295:253-261.

Chen, Minghui

2013 A Study of the Cutlure and Society of Peiligang Period (in Chinese), Fudan University.

Chen, Quangong

2018 A Re-discussion of "Huhuanyong Line" and Farming-Pastoral Ecozone of China (in Chinese). Pratacultural Science (03):669-676.

Chen, Shengqian

2004 Adaptive Changes of Prehistoric Hunter -Gatherers during the Pleistocene -Holocene Transition in China, Southern Methodist University.

2008 The Origin of Microblade Technique- A Theoretical and Ecological Perspective (in Chinese). A Collection of Studies on Archaeology:244-264.

2011 The Adaptative Changes of the Prehistoric Cultures in the Zones along Yanshan Mountains and the Great Wall (in Chinese). Kaogu Xuebao (01):1-22.

2013 The Prehistoric Modernization- An Ecological-based Exploration of the Process of Origin of Agriculture in China (in Chinese). Beijing: Kexue Chubanshe.

Chen, Shengqian, and Canyang Ye

2019 Theoretical Retrospection on the Origin of Microblade Technology (in Chinese). Acta Anthropologica Sinica 38(04):751-766.

Chen, Shengqian, and Pei-Lin Yu

2017a Early "Neolithics" of China: Variation and Evolutionary Implications. Journal of Anthropological Research 73(2):149-180.

2017b Intensified Foraging and the Roots of Farming in China. Journal of Anthropological Research 73(3):381-412.

Chen, Shengqian., et al.

2014 Explaining the Function of Stone Hoes Unearthed at the Dashanqian Site, Kalaqin, Inner Mongolia (in Chinese). Acta Anthropologica Sinica 33(04):522-533.

Chi, Wenfeng, et al.

2019 Impacts of Anthropogenic Land Use/Cover Changes on Soil Wind Erosion in China. Science of the Total Environment 668:204-215.

Childe, V. Gordon, et al.

1940 Man Makes Himself. Science and Society 4(4):461-466.

Cleland, Charles E.

1976 The Focal-Diffuse Model: An Evoluntionary Perspective on the Prehistorical Cultural Adaptions of the Eastern United States. Midcontinental Journal of Archaeology 1(1):59-76.

Codding, Brian F., Rebecca Bliege Bird, and Douglas W. Bird

2011 Provisioning Offspring and Others: Risk-Energy Trade-offs and Gender Differences in Hunter-Gatherer Foraging Strategies. Proceedings. Biological sciences 278(1717):2502-2509.

Cohen, David Joel

2011 The Beginnings of Agriculture in China: A Multiregional View. Current Anthropology 52(S4): S273-S293.

Cohen, Mark N.

1977 The Food Crisis in Prehistory: Overpopulation and the Origin of Agriculture. New Haven: Yale University Press.

Contreras, D. A.

2016 Correlation is not Enough: Building Better Arguments in the Archaeology of Human-Enviornment Interactions. *In* The Archaeology of Human-Environment Interactions: Strategies for Investigating Anthropogenic Landscapes, Dynamic Environments, and Climate Change in the Human Past. D.A. Contreras, ed. Pp. 19-40. New York: Routledge.

Crawford, Gary W., et al.

2016 People and Plant Interaction at the Houli Culture Yuezhuang Site in Shandong Province, China. The Holocene 26(10):1594-1604.

Cui, Tianxing

2010 The Study of Donghulin Site’s Lithic Assemblage——The Lithic Industry and Human Behavioral in the Process of Paleolithic to Neolithic Age (in Chinese), Peking University.

Cui, Xuan

1991An Analysis of Pottery of Zhukaigou Site (in Chinese). Kaogu (04):361-371.

Di, Cosmo., and Don Juan. Wyatt

2003 Political Frontiers, Ethnic Boundaries, and Human Geographies in Chinese History. New York: RoutledgeCurzon.

Di, Nan

2016The Experimental Study of the Excavated Stone Knife from the Xinjie Site, Shaanxi Province (in Chinese). Xibu Kaogu (02):263-280.

Drennan, Robert D., C. Adam. Berrey, and Christian E. Peterson

2015 Regional Settlement Demography in Archaeology. New York: Eliot Werner Publications.

Drennan, Robert D., et al.

2017 Hongshan Households and Communities in Neolithic Northeastern China. Journal of Anthropological Archaeology 47:50-71.

Drennan, Robert D., et al.

2003 Method for Archaeological Settlement Study. *In* Regional Archaeology in Eastern Inner Mongolia: A Methodological Exploration. I.C.A.R.P. Chifeng, ed. Pp. 122-151. Beijing: Kexue Chubanshe.

Du, Pengfei., et al.

2007 Study on the Effects of Wind Erosion in Different Land Use Types on the Topsoil Organic Matters in North Foot of the Yinshan Mountain in Spring (in Chinese). Journal of Arid Land Resources and Environment (12):89-92.

Ebert, James I.

2001 Distributional Archaeology. Salt Lake City: University of Utah Press.

Elston, R. G., and P. Jeffrey. Brantingham

2002 Microlithic Technology in Northern Asia: A Risk-Minimizing Strategy of the Late Paleolithic and Early Holocene. *In* Thinking Small: Global Perspectives on Microlithization. R.G. Elston and S.L. Kuhn, eds. Pp. 103-116. Arlington, Virginia: Archaeological Papers of the American Anthropological Association.

Erdős, László, et al.

2018 The Edge of Two Worlds: A New Review and Synthesis on Eurasian Forest-Steppes. Applied Vegetation Science 21(3):345-362.

Fang, Xiuqi

1999 Viewing the Decline of Primary Agriculture and the Formation of Agro-Pastoral Transitional Zone in North China via the Perspective of Agricultural Climate Conditions (in Chinese). Journal of Natural Resources (3):21-27.

Flannery, Kent V.

1968 Archaeological Systems Theory and Early Mesoamerica. *In* Anthropological Archeology in the Americas. B.J. Meggers, ed. Pp. 67-87. Washington: Anthropological Society of Washington.

1986 Guilá Naquitz : Archaic Foraging and Early Agriculture in Oaxaca, Mexico. Orlando: Academic Press.

Fu, Zhanjun

1992 The Survey of the Neolithic Sites in Shangdu County, Inner Mongolia (in Chinese). Kaogu (12):1082-1091.

Gómez Coutouly, Yan Axel

2018 The Emergence of Pressure Knapping Microblade Technology in Northeast Asia. Radiocarbon 60(3):821-855.

Graham, Martha

1993 Settlement Organization and Residential Variability among the Raramuri. *In* Abandoment of Settlements and Regions: Ethnoarchaeological and Archaeological Approaches. C.M. Cameron and S.A. Tomka, eds. Pp. 25-42. New York: Cambridge University Press.

Han, Jianye

2003 A Study of Neolithic Culture in North China (in Chinese). Beijing: Wenwu Chubanshe.

2015 Early China: The Making of the Chinese Cultural Sphere (in Chinese). Shanghai: Shanghai Guji Chubanshe.

Han, Maoli

2005 The Formation of the Farming-Pastoral Ecozone of North China and the Changes of the Climate (in Chinese). Kaogu (10):57-67.

2012 Historical Agricultural Geography of China (in Chinese). Beijing: Beijing Daxue Chubanshe.

Hao, Qian, Hongyan Liu, and Xu Liu

2016 Pollen-detected Altitudinal Migration of Forests during the Holocene in the Mountainous Forest–Steppe Ecotone in Northern China. Palaeogeography, Palaeoclimatology, Palaeoecology 446:70-77.

Hao, Qian, et al.

2014 Varied Responses of Forest at its Distribution Margin to Holocene Monsoon Development in Northern China. Palaeogeography, Palaeoclimatology, Palaeoecology 409:239-248.

Hardy-Smith, Tania, and Phillip C. Edwards

2004 The Garbage Crisis in Prehistory: Artefact Discard Patterns at the Early Natufian Site of Wadi Hammeh 27 and the Origins of Household Refuse Disposal Strategies. Journal of Anthropological Archaeology 23(3):253-289.

Hayden, Brian, and Aubrey Cannon

1983 Where the Garbage Goes: Refuse Disposal in the Maya Highlands. Journal of Anthropological Archaeology 2(2):117-163.

Hitchcock, R.K.

1982 The Ethnoarchaeology of Sedentism: Mobility Strategies and Site Structure among Foraging and Food Producing Groups in the Eastern Kalahari Desert, Botswana, Department of Anthropology, University of New Mexico.

Hou, Liangliang.

2019 Alternative Indicators of Reconstructing the Ancestors Livelihood and Industry Economy from the Perspective of Stable Isotope (in Chinese). Nanfang Wenwu 02:165-183.

Hu, Qi., Xuebiao Pan, and Changxiu Shao

2014 The Distribution of Precipitation during Crop Growth Season and the Monthly Drought Characteristics in Inner Mongolia (in Chinese). Journal of Arid Land Resources and Environment (10):61-67.

Hu, Xiaonong., and Enrui Li

2018 The Simagou Site in Huade County- Another Important Discovery of Yumin Culture (in Chinese): http://kaogu.cssn.cn/zwb/kgyd/kgsb/201812/t20181227_4801672.shtml.

Huai, Khasbagan Hu-Yin, and Sheng-Ji Pei

2000 Wild Plants in the Diet of Arhorchin Mongol Herdsmen in Inner Mongolia. Economic Botany 54(4):528-536.

Indrisano, Gregory G.

2006 Subsistence, Environmental Fluctuation and Social Change: A Case Study in South Central Inner Mongolia, Department of Anthropology, University of Pittsburgh.

Janz, Lisa.

2012Chronology of Post-Glacial Settlement in the Gobi Desert and the Neolithization of Arid Mongolia and Chinaa, Department of Anthropology, University of Arizona.

2016 Fragmented Landscapes and Economies of Abundance: The Broad-Spectrum Revolution in Arid East Asia. Current Anthropology 57(5):537-564.

Janz, Lisa, D. Odsuren, and D. Bukhchuluun

2017 Transitions in Palaeoecology and Technology: Hunter-Gatherers and Early Herders in the Gobi Desert. Journal of World Prehistory 30(1):1-80.

Jerozolimski, Adriano, and Carlos A. Peres

2003 Bringing Home the Biggest Bacon: A Cross-Site Analysis of the Structure of Hunter-Kill Profiles in Neotropical forests. Biological Conservation 111(3):415-425.

Ji, Ping., and Jian Wei

1995 The Survey and Test Excavation of the Two Neolithic Sites of Shangdu County, Inner Mongolia (in Chinese). Beifang Wenwu (02):4-20.

Jia, Xin, et al.

2016 The Transition of Human Subsistence Strategies in Relation to Climate Change during the Bronze Age in the West Liao River Basin, Northeast China. The Holocene 26(5):781-789.

Jiang, Wenying, et al.

2006 Reconstruction of Climate and Vegetation Changes of Lake Bayanchagan (Inner Mongolia): Holocene Variability of the East Asian Monsoon. Quaternary Research 65(3):411-420.

Jin, GuiYun, et al.

2016 Archaeobotanical Records of Middle and Late Neolithic Agriculture from Shandong Province, East China, and a Major Change in Regional Subsistence during the Dawenkou Culture. The Holocene 26(10):1605-1615.

Keeley, Lawrence H.

1982 Hafting and Retooling: Effects on the Archaeological Record. American Antiquity 47(4):798-809.

Kelly, Robert L.

1983 Hunter-Gatherer Mobility Strategies. Journal of Anthropological Research 39(3):277-306.

1988 The Three Sides of a Biface. American Antiquity 53(4):717-734.

1992 Mobility/Sedentism: Concepts, Archaeological Measures, and Effects. Annual Review of Anthropology 21:43-66.

2013 The Lifeways of Hunter-Gatherers : The Foraging Spectrum. New York: Cambridge University Press.

Kent, S.

1993 Models of Abandonment and Material Culture Frequencies. *In* Abandonment of Settlements and Regions: Ethnoarchaeological and Archaeological Approaches. C.M. Cameron and S.A. Tomka, eds. Pp. 54-73. Cambridge: Cambridge University Press.

Lattimore, Owen

1962 Inner Asian Frontiers of China. Boston: Beacon Press.

Li, Binsen.

2018 The Abandonment Process Research of Early Neolithic Sites in Northern China (in Chinese), Jilin University.

Li, Pengfei.

2006 The Annals of Huade County (in Chinese). Hailar: Neimenggu Wenhua Chubanshe.

Li, Yan., et al.

2016 The Dominant Modes of Summer Precipitation over Inner Mongolia and Its Typical Circulation Characterisitics (Bilingual: Chinese/English). Chinese Journal of Atmospheric Sciences (04):756-776.

Liu, Li, et al.

2015 Plant Domestication, Cultivation, and Foraging by the First Farmers in Early Neolithic Northeast China: Evidence from Microbotanical Remains. The Holocene 25(12):1965-1978.

Liu, Li, et al.

2014 A Broad-spectrum Subsistence Economy in Neolithic Inner Mongolia, China: Evidence from Grinding Stones. The Holocene 24(6):726-742.

Liu, Li.

2005 The Chinese Neolithic: Trajectories to Early States. New York: Cambridge University Press.

Liu, li., and Xingcan. Chen

2012 The Archaeology of China: From the Late Paleolithic to the Early Bronze Age. New York: Cambridge University Press.

Liu, Xinyi, Harriet V Hunt, and Martin K Jones

2009 River Valleys and Foothills: Changing Archaeological Perceptions of North China's Earliest Farms. Antiquity 83(319):82-95.

Lu, Liedan.

1998 The Microblade Tradition in China: Regional Chronologies and Significance in the Transition to Neolithic. Asian Perspectives 37(01):84-112.

LU, Zhirong.

2002 A Study of the Relevant Questions of Zhukaigou Culture (in Chinese). Huaxia Kaogu (02):33-42.

Ma, Yuquan.

1985 Flora Inner Mongolia (in Chinese). Hohhot: Neimenggu Renmin Chubanshe.

Ma, ZhiKun, et al.

2016 Early Millet Use in West Liaohe Area during Early-Middle Holocene. Science China Earth Sciences 59(8):1554-1561.

MacNeish, Richard S.

1992 The Origins of Agriculture and Settled Life. Norman: University of Oklahoma Press.

McKenzie, Hugh G.

2009 Review of Early Hunter-Gatherer Pottery in Eastern Siberia. *In* Ceramics Before Farming: The Dispersal of Pottery Among Prehistoric Eurasian Hunter-Gatherers. P. Jordan and M. Zvelebil, eds. Pp: 167-208. Walnut Creek, CA: Left Coast Press.

Munoz, Samuel E., et al.

2014 Defining the Spatial Patterns of Historical Land Use Associated with the Indigenous Societies of Eastern North America. Journal of Biogeography 41(12):2195-2210.

Murdoch, J.

1892 Ethnological Results of the Point Barrow Expedition. *In* Ninth Annual Report of the Bureau of American Ethnology. J.W. Powell, ed. Washingtong D.C.: Government Printing Office.

Neimenggu, Institute of Cultural Relics and Archaeology., and Peking Universty Chinese Archaeoogy Research Center.

2003 Daihai Archaeaology III: The Symposium of the Excavation Report of the Sites of Yangshao Culture (in Chinese). Beijing: Kexue Chubanshe.

Neimenggu, Institute of Cultural Relics and Archaeology., and Ordos Museum.

2000 Zhukaigou: The Excavation Report of an Early Bronze Age Site (in Chinese). Beijing: Wenwu Chubanshe.

Nelson, Margaret C.

1991 The Study of Technological Organization. Archaeological Method and Theory 3:57-100.

Odell, George H.

1998 Investigating Correlates of Sedentism and Domestication in Prehistoric North America. American Antiquity 63(4):553-571.

Osorio, Daniela, et al.

2017 Hunter-Gatherer Mobility Strategies in the High Andes of Northern Chile during the Late Pleistocene-Early Holocene Transition (ca. 11,500–9500 CAL B.P.). Journal of Field Archaeology 42(3):228-240.

Peterson, Christian E.

2006 "Crafting" Hongshan Communities? - Household archaeology in the Chifeng Region of Eastern Inner Mongolia, PRC, Department of Anthropology, University of Pittsburgh.

Peterson, Christian E., Robert D. Drennan, and Kate L. Bartel

2016 Comparative Analysis of Neolithic Household Artifact Assemblage Data from Northern China. Journal of Anthropological Research 72(2):200-225.

Peterson, Christian E., and G. Shelach

2010 The Evolution of Early Yangshao Period Village Organization in the Middle Reaches of Northern China's Yellow River Valley. *In* Becoming Villagers: Comparing Early Village Societies M.S. Bandy and J.R. Fox, eds. Pp. 246-275. Tucson: The University of Arizona Press.

Peterson, Christian E., and Gideon Shelach

2012 Jiangzhai: Social and Economic Organization of a Middle Neolithic Chinese Village. Journal of Anthropological Archaeology 31(3):265-301.

Peterson, Christian E., et al.

2017 Upper Daling Region Hongshan Household and Community Dataset. University of Pitssburgh, Comparative Archaeology Database, ed.

Qiu, Weili., et al.

2005 Aeolian Sand Activities at Fengning, Heibei Province during Holocene and Their Influence on Ancient Culture (in Chinese). Quaternary Science 06:76-78.

Ren, Meie

1999 The Compendium of Chinese National Geography (in Chinese). Beijing: Shangwu Yinshuguan.

Rindos, David

1984 The Origins of Agriculture: An Evolutionary Perspective. New York: Academic Press.

Schiffer, M. B.

1987 Formation Processes of the Archaeological Record. Albuquerque: University of New Mexico Press.

Schiffer, Michael

1972 Archaeological Context and Systemic Context. American Antiquity 37.

Shelach-Lavi, Gideon, and Dongdong Tu

2017 Food, Pots and Socio-Economic Transformation: The Beginning and Intensification of Pottery Production in North China. Archaeological Research in Asia 12:1-10.

Shelach-Lavi, Gideon.

2015 The Archaeology of Early China: From Prehistory to Han Dynasty. New York: Cambridge University Press.

Shott, Michael

1986 Technological Organization and Settlement Mobility: An Ethnographic Examination. Journal of Anthropological Research 42(1):15-51.

Simmons, I.G.

1997 Humanity and Environment: A Cultural Ecology. London: Longman.

Smith, Eric Alden
1979 Human Adaptation and Energetic Efficiency. Human Ecology 7(1):53-74.

Song, Zhaolin
2001 The Last Hunters (in Chinese). Jinan: Shandong Huabao Chubanshe.

Steward, Julian H.
1938 Basin-Plateau Aboriginal Sociopolitical Groups. Washington D.C.: Smithsonian Institution

1977 Evolution and Ecology: Essays on Social Transformation. Champaign: University of Illinois Press.

Sturm, Camilla, Julia K. Clark, and Loukas Barton
2016 The Logic of Ceramic Technology in Marginal Environments: Implications for Mobile Life. American Antiquity 81(4):645-663.

Sun, Qianqian
2017 A Study of Prehistoric Grinding Tools in Liaoxi (in Chinese), Jilin University.

Surovell, Todd A.
2009a Bifaces, and So On: Modeling the Design of Tools and Toolkits *In* Behavioral Ecology of Lithic Technology: Cases from Paleoindian Archaeology. T.A. Surovell, ed. Pp. 142-176. Tucson: The University of Arizona Press.

2009b Toward a Behavioral Ecology of Lithic Technology. *In* Toward a Behavioral Ecology of Lithic Technology: Cases from Paleoindian Archaeology. T.A. Surovell, ed. Pp. 1-22. Tuscon: University of Arizona Press.

Sutton, M.Q., and E.N. Anderson
2009 Introduction to Cultural Ecology. Walnut Creek: Rowman Altamire.

Thomas, D. H.
1971 Prehistoric Subsistence-Settlement Patterns of the Reese River Valley, Central Nevada, Department of Anthropology, University of California, Davis.

Tomka, Steve Alajos

1994 Quinua and Camelids on the Bolivian Altiplano: An Ethnoarchaeological Approach to Agro-Pastoral Subsistence Production with an Emphasis on Agro-Pastoral Transhumance, Department of Anthropology, The University of Texas at Austin.

Torrence, Robin

1982 Time Budgeting and Hunter-Gatherer Technology. *In* Hunter-Gatherer Economy in Prehistory: A European Perspective. Pp: 11-22. G. Bailey, ed. New York: Cambridge University Press.

Tremayne, Andrew Hale

2015 The Origin and Development of Maritime Foraging Systems in Northern Alaska, Department of Anthropology, University of California, Davis.

Varian, Mark D.

1999 Sedentism and Mobility in a Social Landscape: Mesa Verde and Beyond. Tuscon: The University of Arizona Press.

Wang, Hongya, et al.

2010 Holocene Environmental Changes as Recorded by Mineral Magnetism of Sediments from Anguli-nuur Lake, Southeastern Inner Mongolia Plateau, China. Palaeogeography, Palaeoclimatology, Palaeoecology 285(1):30-49.

Wang, Jun

2016 The Research of Lithic Function and Human Behavior in Huiheshuiba Site, Inner Mongolia: Result of the Use-Wear Analysis (in Chinese), College of Humanity, Zhejiang University.

Wang, Mingke

2008 The Nomad's Choice: The First Encounter between Northern Nomads and Imperial China (in Chinese). Guilin: Guangxi Normal University Press.

Wang, Shili., and Shikui Li

1985 Analysis of Agricultural Climatic Characteristics in the Arid and Semi-arid Areas in Northern China (in Chinese). Arid Land Geography(03):28-38.

Wang, Xiaoqing.

2017 The Microwear Observation of the Stone Tools Unearthed at Locale No.1 of Longwangchan Site in Yichuan City, Shaanxi (in Chinese). Kaogu(11):100-111.

Wang, Xingguang.

1995 The Tools and Agricultural Origin in China (in Chinese). Nongye Kaogu (01):176-179.

Wei, Jian

2003 Miaozigou and Dabagou: The Excavation Report of a Neolithic Settlement (in Chinese). Beijing: Zhongguo Dabaikequanshu Chubanshe.

Williams, James Thomas

2014 Staple Econmies and Social Integration in Northeast China: Regional Organization in Zhangwu, Liaoning, China, Department of Anthropology, University of Pittsburgh.

Winterhalder, Bruce

1986 Diet Choice, Risk, and Food Sharing in a Stochastic Environment. Journal of Anthropological Archaeology 5(4):369-392.

Winterhalder, Bruce., and C. Goland

1997 An Evolutionary Ecology Perspective on Diet Choice, Risk, and Plant Domestication. *In* People, Plants, and Landscapes: Studies in Paleoethnobotany. K.J. Gremillion, ed. Pp. 123-160. Tuscaloosa: University of Alabama Press.

Winterhalder, Bruce., and D. J. Kennett

2006 Behavioral Ecology and the Transition from Hunting and Gathering to Agriculture. *In* Behavioral Ecology and the Transition to Agriculture. B. Winterhalder and D.J. Kennett, eds. Pp. 1-21. Berkely: University of Berkely Press.

Wu, Jianguo, et al.

2015 Historical landscape dynamics of Inner Mongolia: Patterns, Drivers, and Impacts. Landscape Ecology 30(9):1579-1598.

Wu, Wenwan

2014 Research on the Subsistence of Peiligang Period in North China (in Chinese), The School of History and Culture, Shandong University.

Xurigan

2016 Fauna Inner Mongolia (in Chinese). Hohhot: Neimenggu Daxue Chubanshe.

Yang, Xiaoyan, et al.

2012 Early Millet Use in northern China. Proceedings of the National Academy of Sciences of the United States of America 109(10):3726-3730.

Zhang, Chi.

2008 The Study of Agricultural Origin in China (in Chinese). *In* A Century Review of Chinese Archaeology: the Volumn of Neolithic Archaeology. Beijing: Kexue Chubanshe.

Zhang, Haiyan, et al.

2018 Response of Wind Erosion Dynamics to Climate Change and Human Activity in Inner Mongolia, China during 1990 to 2015. Science of The Total Environment 639:1038-1050.

Zhang, Xuelei., and Zitong Gong

2003 Human-induced Soil Degradation in China (in Chinese). Ecological Environment (03):317-321.

Zhang, Zhiheng

2004 The Neolithic Archaeology of China (in Chinese). Nanjing: Nanjing Daxue Chubanshe.

Zhao, Yan, and Zicheng Yu

2012 Vegetation Response to Holocene Climate Change in East Asian Monsoon-Margin Region. Earth-Science Reviews 113(1):1-10.

Zhao, Zhijun

2011 New Archaeobotanic Data for the Study of the Origins of Agriculture in China. Current Anthropology 52(S4):S295-S306.

2014 The rocess of Origin of Agriculture in China: Archaeological Evidence from Flotation Results (in Chinese). Quanternary Sciences (01):73-84.

2017 The Development of Agricultural Production and the Establishment of Farming Society in Yangshao Culture Period - A Case Study Based on the Analysis of the Floation Result of the Yuhuazhai Site (in Chinese). Jianghan Kaogu (06):98-108.

Zheng, Shugang

1989 The Distributional Pattern and Main Features of the Steppe across the Area of Yinshan Mountain (in Chinese). Inner Mongolia Prataculture (04):11-15.

Zhongguo, Shekeyuan Kaogu Yanjiu Suo
2010 Chinese Archaeology: The Volume of Neolithic Age (in Chinese). Beijing: Zhongguo shehui kexue chubanshe.

Zhou, Lisan.
2000 Chinese Geography of Agriculture (in Chinese). Beijing: Kexue Chubanshe.