The Social Dynamics of Early Bronze Age China: A Bio-Molecular Approach to the Exploration of the Regional and Interregional Interactions in Shang China

by

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Abstract

The Shang Dynasty (ca 1600 – 1046 BC) is considered one of the earliest state-societies in the world, as well as the earliest literate civilization in East Asia. The last capital of the Shang Dynasty, *Yinxu* (located in present day Anyang, Henan, China; ca. 1250–1046 BC) is therefore a crucial site for archaeologists to understand early states and the process of state formation in early Bronze Age China. In this thesis, stable isotopes of carbon, nitrogen, and sulfur of bone collagen from a total of 379 humans from *Yinxu* (n=119) and 12 roughly contemporaneous neighbouring sites (n=260) are analyzed to reconstruct past dietary as well as mobility patterns for these individuals.

This thesis consists of three projects. The first project examines the internal social dynamics of *Yinxu* by comparing the reconstructed diets of 39 individuals from *Xin'anzhuang* (XAZ), a residential neighbourhood located in *Yinxu*, with other archaeological and mortuary evidence. The second project reconstructs and compares dietary practices of sacrificial victims (n=64) with that of the local residents from XAZ, in order to address a key archaeological question that concerns the social identities of sacrificial victims found at the royal cemetery in *Yinxu*. The third project attempts to investigate the social dynamics of early Bronze Age China within a larger context. In addition to the 127 individuals examined in the first two projects, this project reconstructs and then compares the diets of local *Yinxu* inhabitants from four additional localities (n=16) with individuals (n=26) from six late Neolithic to early Bronze Age sites from the Central Plain of China. Carbon and nitrogen isotopic compositions of an additional 234 individuals from six other sites taken from published reports were also included to expand the geographic scope of this study. Results from these three studies reveal that *Yinxu* consisted of an agglomeration of people of different socio-cultural affiliations, further confirming the hypothesis that *Yinxu* was a vibrant, diverse cultural center in early Bronze Age China, where goods, ideas, technologies, and people from different cultural groups were gathered and exchanged.

Preface

This thesis is original work done by the author, C Cheung.

All samples are provided by JG Tang with permission from the Institute of Archaeology, Chinese Academy of Social Sciences (Beijing, China), and brought over to UBC by ZC Jing. These samples are prepared and analyzed in the Archaeology Isotope Laboratory at UBC by me. Subsequent quantitative analysis was conducted under the supervision of MP Richards, ZC Jing, and D Weston. Research ethics approval was not required.

Figures 5, 13, and 17 are used with permission from applicable sources.

Chapter 4 is adapted from a multi-authored manuscript that has been accepted for publication in *Archaeological and Anthropological Sciences* on 17th November 2015. Co-authors on this manuscript include ZC Jing, JG Tang, ZW Yue, and MP Richards. The title of this manuscript is "Examining Social and Cultural Differentiation in Early Bronze Age China using Stable Isotope Analysis and Mortuary Patterning of Human Remains at *Xin'anzhuang*, *Yinxu*". I am the principal author of this manuscript, MP Richards and ZC Jing gave editorial input, while JG Tang and ZW Yue provided the samples and excavation reports of the site.

Chapter 5 is a version of a multi-authored manuscript titled "Diets and Social Identity of Sacrificial Victims at the Royal Cemetery in *Yinxu*, Shang China: New Evidence from Stable Carbon, Nitrogen, and Sulfur Isotope Analysis". Co-authors on this paper include ZC Jing, JG Tang, D Weston, and MP Richards. I am the principal author of this manuscript, MP Richards, ZC Jing, D Weston gave editorial input, and JG Tang provided the samples and excavation report.

Chapter 6 is a version of a multi-authored manuscript titled: "Social Dynamics in the Early Bronze Age China: A Multi-Isotope Approach". Co-authors on this paper include

ZC Jing, JG Tang, and MP Richards. I am the principal author of this manuscript, MP Richards and ZC Jing gave editorial input, and JG Tang provided the samples and excavation reports.

Check the first pages of these chapters to see footnotes with similar information.

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This thesis is dedicated to my grandfather (*gong gong*) and the memory of my grandmother (*por por*). My grandparents have always been my heroes and inspirations in life. A distinguished scholar himself, *gong gong* is the most knowledgeable person in the (my) world. And my sweet *por por* was a war-veteran-turned-high-school-principal – the greatest female role model a little girl could ever ask for! Brilliant as they are, since the day I was born, they have dedicated their entire lives to my wellbeing and happiness. Indulging me in my every whim, they have always encouraged me to pursue my odd love for old things, and have always had the most faith in me. I owe this degree, and all success in my life, to these two people.

To my grandparents, gong gong and por por

1. Introduction

The Shang Dynasty (ca. 1600-1046 BC) is the first historical dynasty of China and the site known as *Yinxu* (present day Anyang, Henan, China, see Figure 1) is believed to be the last capital. According to historical texts, the Shang Dynasty was established by King *Cheng Tang* 成湯 around 1554 BC (Keightley 1999). During its approximately 500 year rule, the Shang moved its capital five times (Keightley 1999) and finally settled at *Yin* 殷 at around 1250 BC (Jing, et al. 2013). In 1046 BC, the Shang were overthrown by the Zhou Dynasty (Chang 1980b; Keightley 1999) and the site that hosted the last capital of Shang thus gained the name *Yinxu* 殷墟, literally, the ruins of *Yin*.

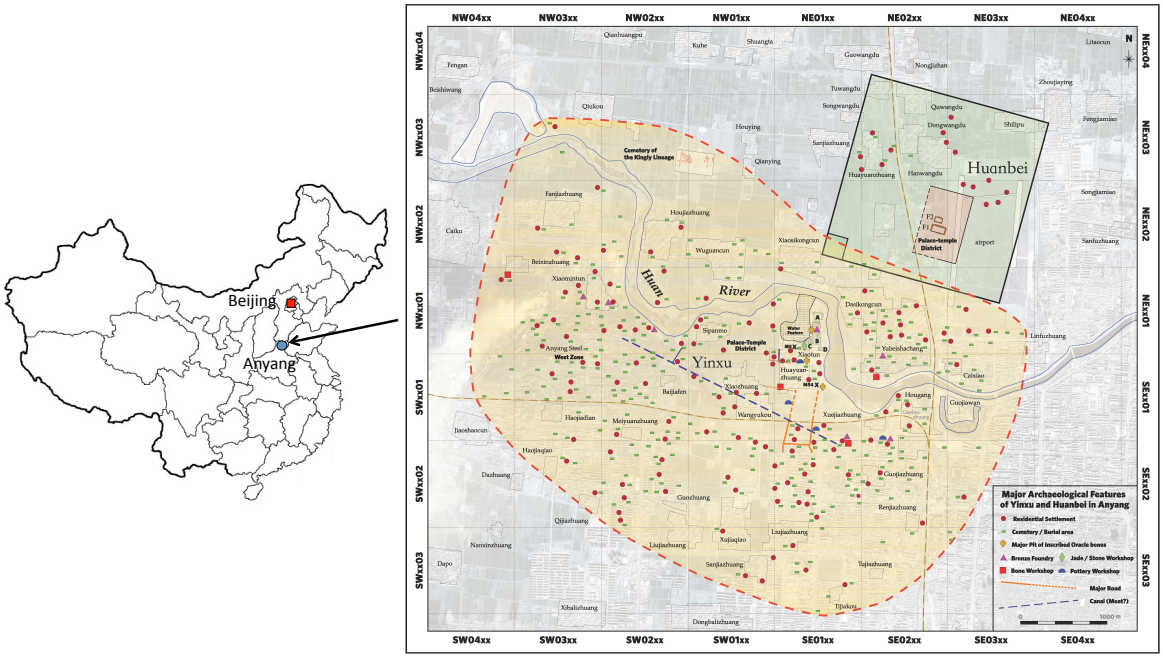

Figure 1 Map of China showing location of Anyang and the site of *Yinxu*, with reference to the location of Beijing.

This thesis will mainly focus on human remains obtained from the late Shang settlement at *Yinxu*. *Yinxu* is situated within the Anyang basin, along the banks of the Huan River 洹河, about 2 km northwest of the modern city of Anyang in Henan Province (36°07'N, 114°19'E). The current estimate for the total area of *Yinxu* is about 30 km^2 (IA CASS 1994). In the center of the site, just south of a bend at the Huan River, is the palace-temple complex at *Xiaotun* 小屯 and north of the river at *Xibeigang* 西北岡 is the royal cemetery. The rest of the ancient city was filled with small clusters of residential areas called *yi* 邑, or "neighbourhoods", their associated cemeteries, as well as various craft production workshops (see Figure 1) (Liu and Chen 2012; Tang and Jing 2009). Combining several lines of evidence, including textual evidence and mathematical modeling, the historian Huang Mingchong (2010) estimated that the population at *Yinxu* at its peak would be between 227,000 and 450,000 individuals and could be considered one of the most densely populated cities among all ancient civilizations.

1.1 Early Historiographical and Archaeological Research on *Yinxu*

"The Anyang Excavation began as an investigation of the sources of the oracle bones, but they ended by unearthing a civilization" (Bagley 1999:130). Since its discovery in 1928, archaeologists have recovered extensive remains of an ancient city with remarkable level of urban planning, including roads, public building foundations, drainage systems, and etc (Tang and Jing 2009). During the approximately 200 years of occupation (Jing, et al. 2013; Tang 2001), the Shang left a vast amount of cultural remains in the area. Thousands of artefacts made of bronze, precious stones, bone, and

ceramic have been unearthed, including the largest known bronze vessel ever found in the ancient world, *Hou Mu Wu Ding* 後母戊鼎, and over 200,000 pieces of oracle bone (Linduff 2002; Keightley 1999). All these archaeological findings, alongside the first epigraphic evidence in China, which appeared in the form of a full-fledged writing system (Bagley 2004), have given us a rare opportunity to look into one of the earliest state-societies in the world with an unprecedented level of detail.

Despite *Yinxu* being one of the longest studied sites in the world, a prominent Chinese archaeologist, K.C. Chang, once criticized the traditional approach to Shang history as being too narrow and compartmental (Chang 1980b:3). He noticed that Shang scholars tend to focus within their own individual discipline, often limited to five particular historiographic traditions of Chinese antiquity, which he referred to as the "five doors to Shang": 1) traditional historical texts, 2) bronzes (both inscriptions and typology), 3) oracle inscriptions, 4) archaeology, and 5) theoretical models (primarily Marxist theories) (Chang 1980b). In other words, the conventional view of Shang was created based on many generations of historians peeking through not one, but five different keyholes. The elitist nature of the first three "doors", or "keyholes", as well as the "traditional preoccupations with cities, elites, and other perceived trappings of 'civilizations' in archaeology" (Jing, et al. 2013:344), have inevitably constricted this view to focus on the domain of elite politics and culture. In a paper looking at bone-tool production at *Yinxu*, Campbell et al. (2011) also lamented that certain elite practices, particularly those concerning bronze production and oracle inscriptions, are clearly better understood in comparison to other areas.

Furthermore, the earliest archaeological investigation was undeniably political in nature: it was conducted to verify native traditions, and more importantly, "to feed an intense nationalism" urgently needed by a war-battered nation (Bagley 1999:132). As von Falkenhausen commented: "In general, traditional Chinese historiography is focused upon the concerns of the ruler, and it propagates the court's official interpretations of historical events. That it is Sino-centric goes without saying. Beholden to a notion of uninterrupted cultural, ethnic and historical continuity, as well as unity, it propounds a unilinear sequence of events and is prone to disregard divergent (e.g. local) traditions" (1993:840). Steered by a methodology focusing on the powerful, and interwoven with a politically driven undertone, it is no wonder that early representations of the Shang Dynasty were embellished with highly selective historical and archaeological evidence. For a long time, Shang was believed to be the only civilized power in the Central China Plain area 中原地區 of Bronze Age China and accordingly, *Yinxu* was long-regarded as the capital of an extensive and powerful empire. However, in recent years, this view has been challenged by new archaeological discoveries from other sites. It is now believed that *Yinxu* was probably one of many thriving cultural centers in Bronze Age China (Bagley 1999; Chang 1980b; Thorp 2006:214). Thus, this conventional approach of Chinese historiography has not only failed to provide a comprehensive account of Shang society, but also misrepresented the political geography of early Bronze Age China.

1.2 Bioarchaeological Approach

With many major components of early Bronze Age history having been overlooked, Shang scholars are now becoming increasingly aware of the inadequacy of

this top-heavy, Shang-centered model. As a result, over the last few decades there have been frequent calls for a more sophisticated look at Shang history, and more specifically, to bring in a correlative multi-disciplinary analysis of the archaeological and historical evidence gathered over the last century. This change in direction is further encouraged, and to a certain extent, made possible, by recent advances in scientific technologies. For example, absolute dating techniques have allowed archaeologists to place various Shang cities into the larger chronological framework of early Bronze Age China (Tang 2001). Various microscopy (e.g. SEM), spectroscopy (e.g. FTIR), and radiography (e.g. XRF) techniques have also enabled archaeologists to better understand the compositions, production processes, and provenancing of certain artefacts, especially those made of bronze (Chen, et al. 2009; He, et al. 2007; Mei, et al. 2009) and ceramic materials (Stoltman, et al. 2009; Yin, et al. 2011).

Bioarchaeology, in particular, is a new and promising area of research, which combines "methods, data, and theoretical orientations from across anthropology, a devotion to a rigorous scientific approach, and an embrace of the biocultural approach in the larger field of biological anthropology" (Zuckerman and Armelagos 2011:16). This approach has helped archaeologists to enquire into new aspects of past societies, particularly those concerning past human experiences. Different bioarchaeological techniques have been used to answer specialized questions, such as uncovering recipes of Shang period fermented beverages using residue analysis (McGovern, et al. 2004), or to address bigger questions such as reconstructing the demographic structure of the *Yinxu* population using osteological analysis (Li 1977; Yuan 2010), or to reveal the scale and nature of economic production of a bone workshop in *Yinxu* through zooarchaeological

analysis (Campbell, et al. 2011; Li, et al. 2011). Together with a new emphasis on contextualizing past human experiences within the larger political, socio-cultural, economic, and geographic context, these technological advances have allowed archaeologists to take their investigations to an entirely new level of detail and accuracy, as well as open up areas of human history previously inaccessible using conventional methods.

Despite recent success in using scientific techniques to answer archaeological questions, there is still a gap in our understanding of the dietary practices of the Shang people. Current knowledge of Shang subsistence strategy primarily relies on zooarchaeological evidence and oracle bone inscriptions (Chang 1980a; Chen 1985; Fiskesjö 2001). By failing to take into consideration the multifarious stratification and dynamism within Shang society, this approach provides only a simplistic view of what types of resources were available to the Shang people as a homogenous group. Two recent PhD theses tried to tackle this problem, and reconstructed the subsistence strategy of *Yinxu* inhabitants by analyzing stable carbon and nitrogen isotope compositions of human and animal remains recovered from two residential neighbourhoods in *Yinxu* (Si 2013; Yan 2010). Their results have not only confirmed a strongly C_4–based subsistence, but also suggested that the diets of the *Yinxu* inhabitants contained a considerable proportion of animal protein, even among the lower class commoners (Si 2013). However, due to the small sample size of humans involved (n=4), it is difficult to make any meaningful inferences about social phenomenon or organizations from these two studies.

This PhD thesis will expand on these investigations, by using multi-isotope analysis (carbon, nitrogen, and sulfur) to reconstruct the palaeodietary and palaeomobility patterns of a total of 119 individuals from *Yinxu*. In order to situate *Yinxu* within the bigger context of early Bronze Age China, the carbon (C), nitrogen (N), and sulfur (S) isotopic compositions of 260 individuals from 12 contemporaneous neighbouring sites are also analyzed. My key research question is to understand the social dynamics of the Shang capital *Yinxu* through a bioarchaeological perspective. The next chapter will give an introductory overview of the methodological approach used in this research (Chapter 2). The third chapter will go over the variety of natural resources that were available to the ancient Chinese in the relevant geographic areas (Chapter 3). The main body of this research thesis will be divided into three parts. The first part will focus on examining the internal social dynamics of *Yinxu,* by comparing the reconstructed diets of 39 local residents from one residential neighbourhood in *Yinxu* with other archaeological and mortuary evidence (Chapter 4). The second project investigates the social identities of sacrificial victims found in the royal cemetery of *Yinxu*, by comparing the reconstructed palaeodietary and palaeomobility patterns of 64 sacrificial victims with those of the local residents analyzed in Chapter 4 (Chapter 5). Finally, the last project explores the population dynamics and interregional cultural interactions between *Yinxu* and other adjacent early Bronze Age communities. In addition to the 103 individuals analyzed in Chapters 4 and 5, this study expands the analysis to include another 16 individuals from four other localities in *Yinxu*, and 26 individuals from five contemporaneous neighbouring sites. C and N measurements of an additional 234 individuals gathered from

published reports are also included, in order to expand the geographic scope of the analysis to include a wider area within the Central China Plain (Chapter 6).

The thesis explores the intricate web of interconnectivity of early Bronze Age China through a careful analysis of dietary and mobility patterns of individuals from different communities, focusing on the ancient networks surrounding the late Shang capital *Yinxu*. By situating both biomolecular and traditional archaeological data within a larger socio-political framework, this thesis presents an approach that offers a more comprehensive and finer-grained reconstruction of past social and political conditions than the traditional approaches. The results generated from this study will add to our current understanding of the social processes and dynamism of early Bronze Age China, and also complement a larger project examining the processes of urbanization and state-formations in early Bronze Age China (directed by ZC Jing).

2. Application of Stable Isotope Analysis in Archaeology

> *"Food is at least two different kinds of things at once. It is first and foremost a fundamental building block of the biological, ecological, and economic systems in which humans are involved, a driving force of life. But because it is so important in this material sense, it is also significant as a symbol: a means for communicating a highly condensed set of profound statement about ecology, biology and economy, as well as about the political cultural, and religious systems of a given society"* (Hastorf and Weismantel 2007:308).

As the age-old Chinese proverb goes, "food is a paramount necessity of the people" (民以食為天). Food is more than just a basic condition for survival, as it often carries cultural and ideological meanings that are specific to different communities. The role of food in the formation of the Chinese identity is evident. Meanings are not only ascribed to the food itself, but also to the way food is served, the context of the occasion, and the guests that are invited (Chang 1977; Nelson 2003; Underhill 2002). In fact, KC Chang went as far as to suggest that the Chinese population is split along food lines, which has further accentuated "the economic subsegmentation" of the Chinese culture" (Chang 1977:21). Therefore, the consumption of food can be seen as a physical manifestation of individual identity, which is in turn shaped by a number of factors including, but not limited to, local environments, economies, political culture, religious beliefs, as well as personal preferences (Anderson 2005; Fieldhouse 1996; Hastorf and Weismantel 2007; Twiss 2007; van der Veen 2003). Moreover, the process of digestion also endows one "with the symbolic associations of the food and reinforcing the food as a metonym of the self" (Twiss 2007:2). This latter point is particularly useful to archaeologists, as this allows for direct observations of palaeodietary practices from the

remains of an individual through bone chemistry analyses. Hence, the analysis of past foodways offers archaeologists a tangible avenue for exploring the notions of identities in past societies.

Stable carbon (C), nitrogen (N), and sulfur (S) isotope analyses of bone collagen are commonly employed in archaeology, primarily to reconstruct past dietary patterns. This technique has given archaeologists access to many different human experiences that previously could only be inferred from secondary evidence. On a technical level, stable isotope analyses provide archaeologists with a unique toolkit to quantitatively reconstruct past foodways and environment, as well as to track mobility patterns. However, on an analytical level, by using stable isotope analysis in conjunction with a bio-cultural theoretical framework, archaeologists can now gain deeper insights into the social developments and dynamics of past societies, such as changes in subsistence strategy (Hu, et al. 2008; Katzenberg, et al. 1995), social differentiation (Cheung, et al. 2012; Richards, et al. 1998), trading networks (Cox and Sealy 1997), colonialism (Schroeder, et al. 2009), and other cultural developments (Müldner and Richards 2007; Newsome, et al. 2004).

2.1 Principals of Stable Isotope Analysis

The concept of stable isotope analysis derives from the fact that the fractionation of each stable isotope can vary predictably as a response to various processes in the natural world. Generally speaking, stable isotope patterns in different chemical elements register certain characteristics of the local environment, and through different chemical reactions, such as respiration and digestion, these patterns are incorporated into the

bodies of organisms. As the isotopic makeup of an organism should be determined by the corresponding isotopic ratios of its diet, it should be possible to relate an organism to its living environment and diet through stable isotope analysis (given the isotopic signature of the diet is distinctive enough to be recognized).

2.2.1 Palaeodietary Reconstruction

The stable carbon isotope ratio ($^{13}C/^{12}C$) is primarily used to distinguish organisms exploiting different ecosystems, e.g. the marine versus terrestrial ecosystem, and plants using different photosynthetic pathways (Sealy 2005). All plants utilize one of three photosynthetic pathways, C_3, C_4, and CAM. Via different species of carboxylating enzymes, plants fix carbons in either a 3-carbon (C_3 pathway) or 4-carbon (C_4 pathway) compound during the process of photosynthesis, while each has different advantages for maximizing photosynthesis in different environments (Ehleringer, et al. 1997; Farquhar, et al. 1989; Sealy 2005). Plants that use either the C_3 or C_4 pathway are most relevant to archaeological studies, particularly in China. As the C_3 pathway discriminate strongly against ^{13}C, therefore C_3 plants tend to have more negative mean $\delta^{13}C$ values than C_4 plants. In terrestrial ecosystems the carbon isotopic compositions of C_3 plants are typically between –20 to –37‰, while those of C_4 plants are typically between –10 to –16‰ (parts permil) (Kohn 2010; O'Leary 1988; Schoeninger and DeNiro 1984). Almost all plants native to temperate regions are C_3 plants, while C_4 plants are naturally found in tropical regions. As the range in $\delta^{13}C$ values for C_3 and C_4 plants does not overlap, it is relatively straightforward to distinguish between organisms feeding exclusively on one plant source or the other. Examples of C_3 plants that played an

important role in ancient agricultural societies include rice, wheat, barley, oats and rye, while key C_4 plants include sugarcane, sorghum, maize, and millet (Sealy 2005).

Carbon isotopic compositions in the aquatic system are more complex. The range of $\delta^{13}C$ values in marine organisms is similar to that of C_4 plants, as the dissolved CO_2 in the ocean tend to be more enriched in ^{13}C compared to atmospheric CO_2, and also many marine phytoplankton perform C_4 photosynthesis (Boutton 1991; Schwarcz and Schoeninger 2011; Sealy 2005). In freshwater ecosystems, carbon isotopic compositions can be highly variable as the range of $\delta^{13}C$ values is effected by the geology of the bedrock, among other factors. For this reason, plants in freshwater ecosystems can produce $\delta^{13}C$ values that fall within the range of marine and terrestrial plants (Hecky and Hesslein 1995; Zambrano, et al. 2010). Thus, evidence from $\delta^{13}C$ analysis alone cannot reliably permit the distinction between the consumption of these resources.

Stable nitrogen isotope ratios ($^{15}N/^{14}N$) primarily reflect trophic level effects in the food chain. On average there is a 3‰ enrichment from one trophic level to another, making $\delta^{15}N$ values particularly useful for estimating an individual's animal protein intake (Hedges and Reynard 2007). As food webs in aquatic systems are generally more complex compared to those in the terrestrial systems, $\delta^{15}N$ values of aquatic organisms tend to be higher. Therefore, $\delta^{15}N$ values are often used in conjunction with $\delta^{13}C$ values to help identify and quantify the consumption of aquatic resources (Richards and Hedges 1999; Schoeninger and DeNiro 1984).

Moreover, $\delta^{15}N$ values in plants and animals are further complicated by factors such as breastfeeding (Fuller et al. 2006), long-term manuring (Bogaard, et al. 2007; Szpak, et al. 2012), growth (Trueman, et al. 2005), starvation (Fuller, et al. 2005; Hobson,

et al. 1993), certain pathological conditions (Katzenberg and Lovell 1999), and environmental circumstances such as aridity (Thompson, et al. 2005). Some of these issues can be avoided or curtailed by restricting sample selection criteria, for example by avoiding taking samples from very young children or from pathological sites on bones. However, other factors such as manuring and starvation are more difficult to address. Therefore, it is important to take other archaeological evidence into consideration when interpreting stable isotopic data.

Measurement of stable sulfur isotope ratios ($^{34}S/^{32}S$) is a relatively new technique in archaeology. It is particular useful in detecting protein intake from aquatic ecosystems (Nehlich, et al. 2010; Privat, et al. 2007; Sayle, et al. 2013), as well as identifying foreigners in a population (Richards, et al. 2001; Sayle, et al. 2013). The local S signal is affected by a combination of geological, meteorological, and topographical conditions, and it varies greatly according to local geology (Richards, et al. 2001; Zazzo, et al. 2011). In general, sulfur isotopic compositions of different geological formations can range between –20 and +30‰. Most continental minerals of igneous, volcanic, meteoric origin have $\delta^{34}S$ values around 0‰, coastal soils tend to have more enriched $\delta^{34}S$ values than inland soils, and oceanic sediments have isotopic compositions fairly consistently at +20.3‰ (Nehlich 2015; Zazzo, et al. 2011). Thus, once the local S baseline has been established, $\delta^{34}S$ values can be extremely useful for interpreting variations in $\delta^{13}C$ and $\delta^{15}N$ values. For example, several studies have shown that S isotope analysis can be used to confirm the consumption of freshwater resources in archaeological groups (Nehlich, et al. 2010; Sayle, et al. 2013). Hence, stable sulfur isotope analysis has offered archaeologists an additional means to describe past dietary composition more accurately.

Furthermore, once the local dietary practices and ecological resources have been understood, a combination of C, N, and S isotope measurements can be used in conjunction with other archaeological evidence to identify migratory activity (Fischer, et al. 2007; Zazzo, et al. 2011).

Although stable isotope analysis has been highly useful when applied to archaeological contexts, caution should be exercised. It should be noted that stable isotope signatures are highly localized and the local (and archaeological) baseline values need to be established before data can be analyzed. A good understanding of the archaeological, climatic, floral, and faunal background of the area could also help to determine what types of food were accessible to the population. Finally, it is extremely important to understand that stable isotope analysis of a single element may not be able to generate a clear understanding of past dietary practices, as discussed above. Therefore, when possible, multiple stable isotope measurements should be employed in a study.

2.2.2 Palaeomobility Pattern Reconstruction

Stable C, N, and more recently, S isotope analyses are primarily used for palaeodietary reconstruction in archaeology, while strontium (Sr), lead (Pb), and oxygen (O) isotopes analyses are more commonly used to study residential mobility. Note that $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ values are most often measured in the organic phase of bone (collagen), while $^{87}Sr/^{86}Sr$, $^{207}Pb/^{206}Pb$, $^{208}Pb/^{206}Pb$, and $\delta^{18}O$ values are usually measured in the inorganic phase of bone (apatite) or teeth (enamel). Enamel is especially useful for mobility studies, as it is not only relatively resistant to diagenetic changes in comparison to bone apatite, but it also does not remodel once it is mineralized (Bentley 2006; Hoppe,

et al. 2003). The mineralization of the enamel of human permanent teeth occurred prior to eruption, which could take place as early as 10 weeks *in utero* to 11 years of age, depending on the tooth (Anthonappa and King 2015; Reid and Dean 2006; Sahlstrand, et al. 2013). Thus, isotopic compositions of enamel should record the childhood dietary and geographic history of an individual (Budd, et al. 2000; Sealy, et al. 1995). When teeth are not available for analysis, it is still possible to detect migratory activity through stable C, N, and S isotope analysis, provided the relocation resulted in a change in dietary isotopic compositions.

By looking for changes in the isotopic compositions of different skeletal elements from the same individual, it is possible to look at migratory activity on an individual level. Bone collagen turns over slowly and for this reason, carbon and nitrogen isotope values measured in bone collagen reflect the long-term averages of diet over an individual's lifetime (Schwarcz and Schoeninger 1991; Stenhouse and Baxter 1979). However, different types of bones have differing turnover rates. This is due to the fact that turnover rate in human body tissues is highly variable, and depends on a number of factors including sex, age, and health (Hedges, et al. 2007). Generally, bone turnover is faster in growing children, especially infants, and decreases over time. Among the various types of bone, smaller bones or bones consisting mostly of trabecular bone, such as a rib turns over faster than bigger, denser bones, such as a femur (Cox and Sealy 1997; Gineyts, et al. 2000; Hedges, et al. 2007; Jay and Richards 2006; Jørkov, et al. 2009; Libby, et al. 1964; Sealy, et al. 1995). The general consensus is that rib turnover occurs at an approximately 3-5 year interval, while adult femoral collagen almost never turns over completely, as suggested by a study that by the age of 40, at least 40% of the collagen

present would have been synthesized during adolescence (Hedges, et al. 2007). While the turnover rate of other bones is not precisely known, it is safe to assume that most bones would turnover at a rate between that of a rib and a femur. The differing turnover rates in different skeletal elements have enabled archaeologists to look for evidence of migration in the form of drastically changed diets over an individual's lifetime (Cox and Sealy 1997; Jørkov, et al. 2009; Lamb, et al. 2014; Pollard, et al. 2012; Schroeder, et al. 2009).

2.3 Analytical Methods

2.3.1 Instrumental Analysis

All samples were prepared at the Archaeology Isotope Laboratory at the University of British Columbia following standard procedures for bone collagen extraction as outlined in Richards and Hedges (1999). Bones were demineralized in a 0.5M HCl solution, followed by a gelatinization step in pH3 water at 75˚C for 48 hours. Gelatinized solutions were then filtered with Ezee-filters (manufactured by Elkay Laboratory Products, UK) and then with 30kDa ultrafilters (manufactured by PALL Corporation, USA) to remove low molecular weight contaminants. The remaining solutions were lyophsized in a freeze dryer for 48 hours. All isotopic composition measurements are calibrated to international references distributed by the U.S. Geological Survey (USGS), the National Institute of Standards and Technology (NIST, earlier as the National Bureau of Standards – NBS), and the International Atomic Energy Agency (IAEA).

For carbon and nitrogen isotope measurements, samples were analyzed in duplicate with an Elementar vario MICRO cube elemental analyzer coupled to an

Isoprime™ mass spectrometer in continuous-flow mode. All reported carbon and nitrogen isotope values are averages based on duplicate analysis and are reported in 'permil' (‰). Stable carbon and nitrogen isotopes values were calibrated to Vienna Pee Dee Belemnite (VPDB) and atmospheric air (AIR) using USGS40 and USGS41, respectively (Coplen 2011). USGS40 (δ^{13}C: –26.24‰ and δ^{15}N: –4.52‰) and USGS41 (δ^{13}C: +37.76‰ and δ^{15}N: +47.57‰) are isotopically homogenous L-glutamic acids that are chemically similar to many natural biological materials, and therefore are commonly used as organic reference materials for C and N isotopic measurements (Qi, et al. 2003). Additionally, methionine (purchased from Sigma-Aldrich) and an in-house seal collagen standard were used to check measurement accuracy. The average observed δ^{13}C values for methionine and seal collagen are –28.6 ± 0.05‰ (n=61) and –13.8 ± 0.1‰ (n=58), respectively, which compare well with expected values of –28.6‰ and –13.7‰. The average observed δ^{15}N values for methionine and seal collagen are –5.0 ± 0.2% (n=61) and +17.4 ± 0.2‰ (n=58), respectively, which compare well with expected values of –5.0‰ and +17.4‰.

For the measurement of sulfur isotopic compositions, samples were analyzed in duplicates, wherever possible, with an Elementar vario MICRO cube elemental analyzer, coupled to IsoPrime 100 mass spectrometer in continuous flow mode. Sulfur isotope values were calibrated to Vienna Canyon Diablo Troilite (VCDT) using IAEA-S-1 and NBS-127 (Coplen and Krouse 1998; Krouse and Coplen 1997). IAEA-S-1 is a silver sulfide with a homogenized δ^{34}S value of –0.30‰, and NBS-127 is a barium sulfate with a homogenized δ^{34}S value of +20.3‰ (Coplen and Krouse 1998; Halas and Szaran 2001). In addition, IAEA-S-3 (silver sulfide), NIST 1577c (bovine liver) and casein protein (purchased from Sigma-Aldrich) are used to check measurement accuracy.

The average observed $\delta^{34}S$ values for IAEA-S-3, NIST 1577c, and casein protein are –32.8‰ (n=2), +2.5‰ (n=4), and +6.0‰ (n=5), respectively, which compare well with the expected values of –32.3 ± 1.6‰, +2.3 ± 1.0‰, and +6.3 ± 0.8‰.

The quality of the collagen was assessed using collagen, carbon, nitrogen, and sulfur percentage yield (%collagen, %C, %N, and %S), wherever appropriate. C:N ratios are calculated using Equation 1. C:S ratios and N:S ratios are calculated using Equation 2 and 3, respectively.

$$\text{C:N ratio} = \frac{\%C}{\%N} \times \frac{14.007}{12.011} \tag{1}$$

$$\text{C:S ratio} = \frac{\%C}{\%S} \times \frac{32.064}{12.011} \tag{2}$$

$$\text{N:S ratio} = \frac{\%N}{\%S} \times \frac{32.064}{14.007} \tag{3}$$

Only samples that met these collagen quality criteria were included in this study. The collagen quality criteria are described in Table 1. For S measurements, 2 samples (S_UBC4974 and S_UBC2927) have C:S and N:S ratios slightly outside of the acceptable range. As the $\delta^{34}S$ values of these two samples still fall within the expected range of their group, these two measurements are included in the analysis. The sample information, carbon, nitrogen, and sulfur isotopic compositions, as well as associated elemental data of all samples used in this study are listed in Table 5, Table 10, and Table 13, each associated with its relevant project, respectively.

Table 1 Summary of the standard ranges of collagen quality criteria, as described in published literature (Ambrose 1990; DeNiro 1985; Harbeck and Grupe 2009; Nehlich and Richards 2009; van Klinken 1999).

Collagen Quality Criteria		Range
%collagen		0.5% – 22%
%C		15.3% – 47%
%N		5.5% – 17.3%
%S	Mammalian	0.15% – 0.35%
	Fish	0.40% – 0.85%
C:N		2.9 – 3.6
C:S	Mammalian	300 – 900
	Fish	125 – 225
N:S	Mammalian	100 – 300
	Fish	40 – 80

2.3.2 Statistical Analysis

Statistical analyses of the results were conducted using R (version 3.0.3). A Levene's test was used to test for homogeneity to examine equality of group variances. Differences between group means for δ^{13}C, δ^{15}N, and δ^{34}S values were determined by unpaired independent Student's *t* tests, one-way ANOVA, or one-way MANOVA, when appropriate. For ANOVA and MANOVA, when differences were detected, post-hoc comparisons are conducted using the Tukey honest significant difference (HSD) test. A 0.05 probability is considered significant.

Multivariate ellipse-based metrics are used here to illustrate the distributions of dual-isotope measurements (i.e. C and N, C and S, and N and S) as described in Jackson et al's paper (2011). The co-variance matrix (i.e. means and bivariate standard deviations) of dual-isotope measurements of each population are represented by standard ellipses using the R package SIAR (Parnell and Jackson 2013). To illustrate C, N, and S data on the same graph, the R packages Rcmdr (Fox, et al. 2015) and rgl (Adler, et al. 2015) were

used to create interactive 3-dimensional graphics. Ellipsoids represented plot concentration observed in each respective group following the conditions described in Friendly et al's paper (2013), where the expected proportion (α) of multivariate-normal observations is set as 0.5.

The Bayesian based area metrics, or SIBER (Stable Isotope Bayesian Ellipses in R), described in Jackson et al 's paper (2011) are used to evaluate the isotopic niche width of each population quantitatively, which are then used to compare the extent of intra-group dietary variability between different groups. This method compares four area metrics based on the spread of bivariate stable isotope data: TA (convex hull areas), SEA (standard ellipse areas), SEA_B (standard ellipse areas with Bayesian estimate), and SEA_C (standard ellipse areas corrected). A convex hull is the smallest convex polygon that contains a set of finite data points ($n \geq 3$) (de Berg, et al. 2000), and in this thesis only convex hulls on a two dimensional plane are considered. In ecology, the total area of the convex hull (TA) occupied by a species in terms of $\delta^{13}C$ and $\delta^{15}N$ values is often used to account for the total extent of dietary diversity within a population (Layman, et al. 2007). This approach, however, is not sensitive enough to compare two populations with unequal sample sizes. By implementing a Bayesian framework to correct for sample size biases, the SEA, SEA_B, and SEA_C area metrics allow for direct comparison of isotopic niches between populations of different sample sizes. A SEA is the area of the standard ellipse (covariance matrix) of a population, where the SEA_B is a probabilistic estimation of the SEA comprises of a set of iterative posterior draws, using a MCMC simulation (in this study, 10^4 draws were used). Finally, a SEA_C is SEA corrected for unequal sample

sizes (Jackson, et al. 2011). These area metrics are all calculated using the R package SIAR (Parnell and Jackson 2013).

To test the hypothesis regarding the mobility patterns of the sacrificial victims, circular statistics are used to quantitatively analyze the magnitude and direction of dietary changes within individuals, using the R package CircStats (Lund and Agostinelli 2012). This approach is commonly employed in ecological studies (Duyck, et al. 2011; Mauna, et al. 2011; Schmidt, et al. 2007), but most recently, it has been demonstrated that it can also be particularly illustrative in certain archaeological studies (Szpak, et al. 2014).

In order to quantify the differences in dietary compositions between the local residents and the sacrificial victims, the compositions of dietary proteins of the two populations are quantified and compared using the SIAR Bayesian mixing model with a 2-tracer (C, N), 6-source approach (Parnell, et al. 2010; Parnell and Jackson 2013). The model produces estimations of posterior probability distributions of different components of diets in credible intervals for its respective contribution to the overall diet of a population (for description of sources see Table 2). This model has the advantage of allowing the incorporation of priors (e.g. fractionation factor – see Table 3; source concentration – see Table 4) to account for uncertainty associated with any empirical and calculation errors (Galván, et al. 2012; Moore and Semmens 2008).

Table 2 Source: the carbon and nitrogen isotopic compositions of six main groups of dietary resources exploited by the *Yinxu* inhabitants. Animal data are all bone collagen measurements obtained from published reports (Si 2013; Yan 2010), plant data obtained from (Kohn 2010; O'Leary 1988; Schoeninger and DeNiro 1984).

Means	Mean δ^{13}C (‰)	sd δ^{13}C (‰)	Mean δ^{15}N (‰)	sd δ^{15}N (‰)
C4 Herbivores	–9.5	1.2	+6.5	1.4
C4 Omnivores	–7.8	1.3	+8.2	0.8
C3/C4 Mixed	–16.1	1.8	+7.3	1.1
C3 Herbivores	–19.9	2.1	+4.9	0.6
C4 Plant	–11.0	2.0	+5.0	2.0
C3 Plant	–25.0	2.0	+4.0	2.0

Table 3 Corrections: magnitude of diet-tissue trophic fractionation between each respective source to the bone collagen of consumers, values approximated from several published studies (Ambrose and Norr 1993; Jim, et al. 2004; McCutchan Jr., et al. 2003).

Sources	Mean δ^{13}C (‰)	sd δ^{13}C (‰)	Mean δ^{15}N (‰)	sd δ^{15}N (‰)
C4 Herbivores	1.0	0.3	3.3	0.26
C4 Omnivores	1.0	0.3	3.3	0.26
C3/C4 Mixed	1.0	0.3	3.3	0.26
C3 Herbivores	1.0	0.3	3.3	0.26
C4 Plant	5.0	0.3	2.2	0.30
C3 Plant	5.0	0.3	2.2	0.30

Table 4 Source concentrations: estimations of elemental concentrations (%C and %N) of each source that contribute to its respective portion in incorporated dietary proteins, values approximated from published report (Newsome, et al. 2004; Phillips and Koch 2002).

Source	Mean C (%)	sd C (%)	Mean N (%)	sd N (%)
C4 Herbivores	0.52	0.1	0.44	0.05
C4 Omnivores	0.52	0.1	0.44	0.05
C3/C4 Mixed	0.52	0.1	0.44	0.05
C3 Herbivores	0.52	0.1	0.44	0.05
C4 Plant	0.14	0.05	0.1	0.05
C3 Plant	0.14	0.05	0.1	0.05

3. Food and Natural Resources

3.1 Early Bronze Age China

Since the Neolithic period, China has been divided by an invisible "crop line". The phrase "south rice north millet" 南稻北粟 has often been used to describe the phenomenon where communities north of the Qin Mountains and Huaihe River were known to subsist on a millet-based diet, while those located south of these landmarks subsisted primarily on rice-based diet (Fuller, et al. 2009; Guo 2013). This division was shaped first and foremost by the different climatic and geographic conditions of northern and southern China, as well as a combination of contact histories and differing socio-cultural factors (Guo 2013; Talhelm, et al. 2014). Interestingly, the "crop line" division is still visible in China to this day, thus representing one of the oldest preserved dietary differences between two populations.

Broomtail millet (*Panicum miliaceum*) was first introduced to northern China during the early Neolithic period, while foxtail millet (*Setaria italica*) arrived slightly later (Barton, et al. 2009; Hu, et al. 2008; Lu, et al. 2009). Archaeological findings have suggested that the earliest appearance of millet in China can be dated to between 10,300 – 8700 years cal. BP (Lu, et al. 2009), with millet only becoming a staple crop in northern China at around 7750 – 7250 years cal. BP (Liu, et al. 2012; Penchenkina, et al. 2005). Rice (*Oryza sativa*) first appeared in the lower Yangtze River Valley around 11,000 – 9000 years cal. BP and was domesticated as early as 9000 years cal. BP (Fuller, et al. 2009; Liu, et al. 2007). Despite the fact that rice did cross the "crop line" and reached the lower Yellow River region at around 8000 years cal. BP (Liu, et al. 2007), it was not

considered a staple crop in the north. During the late Neolithic to early Bronze Age, a number of C_3 crops, such as wheat (*Triticum aestivum*) and barley (*Hordeum vulgare*), were introduced to northern China through the Hexi Corridor (Flad, et al. 2010; Liu, et al. 2014), but were not popularized in northern China until much later during the western Han Dynasty (Yang, et al. 2009).

Prior to and during the late Shang period, groups in northern China were characterized by a C_4–dominated diet, groups in southern China were characterized by a C_3–dominated diet, and some groups in the west had a mixed C_3/C_4 diet. Therefore, during the early Bronze Age, when agricultural knowledge exchanges between the south and the north were limited and the consumption of wheat in northern China was still negligible, the C_3/C_4 division between the south and north of China was unambiguously distinct. Thus, through stable isotope analysis, archaeologists are able to detect interregional interactions between the north, the south, and the west, by looking for individuals with atypical $\delta^{13}C$ values in a given group.

For the purpose of this study, the phrase "northern China" is used interchangeably with the phrase "Central China Plain", both referring to the region centered around the Yellow River Valley, and including parts of the modern day Shaanxi, Shanxi, Henan, Hebei, and Shandong provinces. The phrase "southern China" generally refers to the region south of the Qin Mountains, centered around the Yangtze River Delta.

3.2 *Yinxu*

The climate in the Anyang region during the early Bronze Age was wetter and warmer than current conditions (Chang 1980a; IA CASS 2003; Keightley 2000), and able

to support a much wider range of flora and fauna. The Shang people were members of a "warrior-farmer dynasty", who drew subsistence "mainly from food produced in settled agriculture" (Fiskesjö 2001:51-2). Derived from both inscriptional and zooarchaeological evidence, the following is a brief summary of the dietary resources available to the Shang people.

Horticulture

Inheriting the tradition of a millet-based agricultural system, the staple crop of the late Shang society was the C_4 crop millet, most likely broomtail millet 禾 and foxtail 黍 varieties. This is well attested by archaeological and historical evidence (Chang 1976; IA CASS 2003; Keightley 1999). Based on oracle texts and occasional archaeological finds, other cereals such as rice, barley, and wheat, were also cultivated and consumed by the Shang people, albeit in much smaller quantities (Chang 1977; Lee, et al. 2007; Yang and Ma 2010).

Fruit and vegetables such as pear, hawthorn, apricot, plum, peach, soybean, bottle gourd, taro, turnip, Chinese leek, and spices such as cinnamon were frequently mentioned in Zhou and later texts (Chang 1976; Xu, et al. 2010; Zhang, et al. 2007).

Animal husbandry

Animal husbandry practices were relatively mature by the late Shang period, with the traditional *liu chu* (六畜), or "the six common livestock" (i.e. cattle, horse, dog, pig, sheep, and chicken), appearing in the archaeological record of *Yinxu*. Among these domesticates, cattle (*Bos taurus*) and pig (*Sus scrofa*) were found in large quantities, and

most likely comprised the main source of protein for the Shang people (Chen 1985; Fiskesjö 2001; IA CASS 2004; Yang and Ma 2010; Zhu 2005). In fact, the recent excavation of the *Tiesanlu* 鐵三路 bone workshop revealed over 34 tons of animal bone, mostly from cattle, suggesting that the Shang must have consumed a considerable amount of meat (Campbell, et al. 2011). While birds such as chicken (*Gallus gallus*), geese (*Anser cygnoides*), and pheasant (*Phasianus colchicus*) are relatively rare in the archaeological record, they are believed to have also been domesticated by this time due to their presence in oracle bone inscriptions, as well as their representation in numerous jade, clay, and bronze figurines (Chang 1976; Chen 1985).

Zooarchaeologists have also identified a number of wild animals that would have supplemented the Shang diet, including but not limited to Père David's deer (*Elaphurus davidianus*), water deer (*Hydropotes inermis*), sika deer (*Cervus nippon*), field rat (*Myospalax psilurus*), hare (*Lepus sp.*), black bear (*Ursus thibetanus japonicus*), tapir (*Tapirus indicus*), and various aquatic resources (Chang 1980a; Chen 1985; Fiskesjö 2001; IA CASS 2003; Zhu 2005). However, it is important to note that big game hunting was mostly considered a royal sport, and thus was probably not a significant source of food for Shang commoners (Chang 1980a; Fiskesjö 2001; Keightley 2012).

3.3 Geology of the Central China Plain and its Implications for Sulfur Isotope Analysis

As mentioned in Chapter 2.2.1, the $\delta^{34}S$ value of the body tissue of an organism reflects not only its dietary patterns, but also environmental aspects such as the local geology and geography of the organism's habitat. A brief discussion of the geology of the

Central China Plain will be provided, highlighting the major geological features of the area surrounding all the sites mentioned in this study.

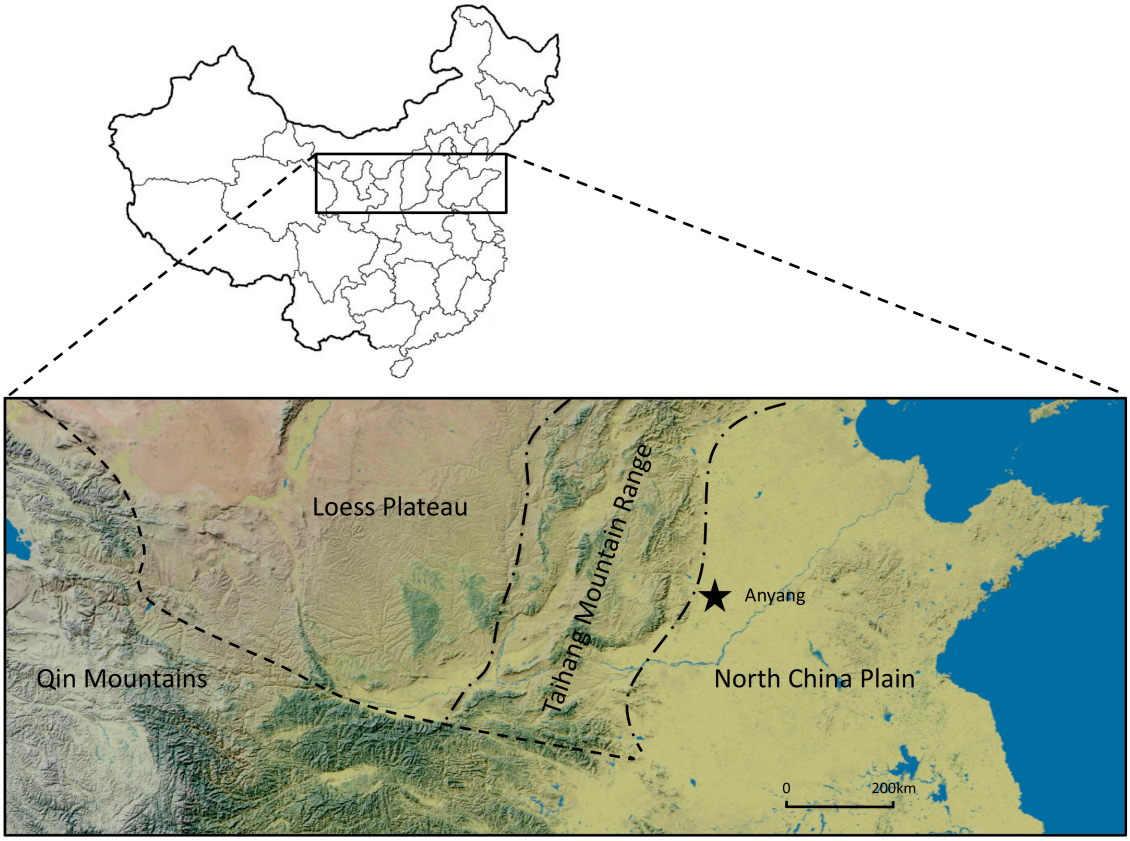

Figure 2 Major geological features of the Central China Plain.

The Central China Plain has long been regarded as the cradle of Chinese civilization. The earliest evidence of human activity in this area dates back to the early Pleistocene period, with many early cultures developing and flourishing in this region (Chang, et al. 2005). Supported by conducive climatic conditions and its strategic geographic location, over the past several thousand years the Central China Plain has become the cultural, economic, and political center of China (Zhao 1986). Many historical Chinese dynasties had established their capitals in this area, including Xian, Luoyang, Kaifeng, and Beijing.

Geologically, the Central China Plain can be divided into two parts. Separated by the Taihang Mountain Range in the center, the Loess Plateau lies to the west, while in the east is the North China Plain (see Figure 2). The Loess Plateau has a total area of approximately 430,000 km^2 (Zheng 2006). Covered by loess varying from a few meters to over 300 meters in thickness, it stretches over parts of many modern provinces, including Shanxi, Shaanxi, Ningxia, Inner Mongolia, and Gansu. The landscape is dotted with *yuan* 原 (flat highlands), *ling* 嶺 (elongated ridges), and *mao* 峁 (knolls), pierced throughout by intricate systems of *chuan* 川 (gullies). These geomorphological features are the result of the long-term accumulation of windblown Quaternary period fine sand and clay components from the Northern deserts. Blocked by the Taihang Mountain at its eastern end, loess from the Loess Plateau is distributed across the North China Plain through various river systems. For example, the Yellow River gained its name from the high volume of loess it carries and deposits along its route before emptying into the Bohai Sea (Li, et al. 2013; Ren, et al. 1985; Zheng 2006). In contrast, the geomorphology of the North China Plain is relatively flat. Chiefly composed of flat alluvial plains, the area is filled with silt carried by numerous river systems from the Loess Plateau (Zhao 1986). This region extends over five modern provinces, including Hebei, Henan, Shandong, Jiangsu, and Anhui.

Mineralogically, loess constitutes the majority of the surficial substances on the Central China Plain. Although the mineral composition of loess is highly uniform (Ren, et al. 1985), the underlying bedrock of the two regions varies greatly. The Central China Plain is part of the North China Craton and is separated into the western Ordos Basin and the eastern Ji-Lu Basin by the Central Orogenic Belt, which also includes the Taihang

Mountain Range (Yang, et al. 1986). Despite sharing a common Archaean foundation, the differing geotectonic actions and sediment distribution mechanisms differentiate the formation processes of bedrock in the two respective regions. Furthermore, during the middle Carboniferous period, the North China Plain was brought under a shallow and fluctuating sea, and only emerged by the end of the Permian period (Zhao 1986). As a result, the chemical compositions and properties of topsoil in the two regions are quite different. In the west the Loess Plateau consists mainly of calcic cambisols, while the major soil units distributed in the North China Plain are calcaric fluvisols, eutric gleysols, and solonchaks (Zhao 1986).

Finally, the climatic conditions of these two regions are also drastically different. While the North China Plain is generally characterized as having a warm-temperate continental monsoon climate, to the west of the Taihang Mountain Range, the Loess Plateau is classified as having a semiarid climate (Ren, et al. 1985; Zhao 1986). Thus, with differing geological, mineralogical, and climatic conditions on both sides of the Taihang Mountain Range, it is expected that the local baseline $\delta^{34}S$ values of sites on the North China Plain would be different from those on the Loess Plateau.

4. Social and Cultural Differentiation in Xin'anzhaung[1]

4.1 Introduction

The Shang Dynasty (16th to 11th century BC) is the first historical dynasty in China for which there is both written and archaeological evidence (Keightley 1999:232). Many considered it as the first state in China, although the exact nature of the Shang's political power is still under debate (Maisels 2010:217; Trigger 1999). During this period, multi-directional interactions with neighbouring polities intensified and ideas, as well as immigrants, moved into and out of *Yinxu*. With a particular interest in the processes of early urbanization, this study aims to look at the internal social dynamics within the Shang capital *Yinxu* during the late Shang period (c. 1250 to 1046 BC) (Jing, et al. 2013; Tang 2001), through a combination of mortuary practice and subsistence strategy analyses.

Many archaeologists have already recognized that differences in mortuary practices often reflect real differences in cultural practices, such as religious beliefs, political, social, and economic differences (Harris and Tayles 2012; Nelson 2003; O'Shea 1981; Parker-Pearson 1982; Parker-Pearson 2008). Evidence of social stratification is often preserved and reflected through differentiating burial practices (Chapman 1987; Nilsson-Struz 2010). Similarly, dietary behaviours also vary highly among different socio-cultural groups, as food choice is often determined, and limited by a number of factors including local ecology, economy, political culture, religious beliefs, as well as

[1] This chapter is adapted from a manuscript that has been accepted for publication in *Archaeological and Anthropological Sciences* on 17th November 2015: [C Cheung, ZC Jing, JG Tang, ZW Yue, and MP Richards – Examining Social and Cultural Differentiation in Early Bronze Age China using Stable Isotope Analysis and Mortuary Patterning of Human Remains at Xin'anzhuang, *Yinxu*]

personal preferences (Anderson 2005; Fieldhouse 1996; Hastorf and Weismantel 2007; Twiss 2007). On this basis the dietary and mortuary practices of 39 individuals from a residential neighbourhood, *Xin'anzhuang*, in *Yinxu* are reconstructed and compared. The results from this study will not only help to verify historical accounts of the subsistence strategy of the late Shang period, but will also provide valuable insights into the diverse socio-cultural landscape of *Yinxu*.

4.2 Internal Social Organization in *Yinxu*

The site of *Yinxu* is situated within the Anyang basin, along the banks of the Huan River 洹河, about 2 km northwest of the modern city of Anyang in Henan Province (36°07'N, 114°19'E). In the center of the site, just south of a bend in the Huan River is the palace-temple complex at *Xiaotun*. And north of the river, at *Xibeigang,* is the royal cemetery. The rest of the ancient city was filled with small clusters of residential areas called *yi* 邑, or "neighbourhoods", their associated cemeteries, as well as various craft production workshops (see Figure 3) (Liu and Chen 2012; Tang and Jing 2009).

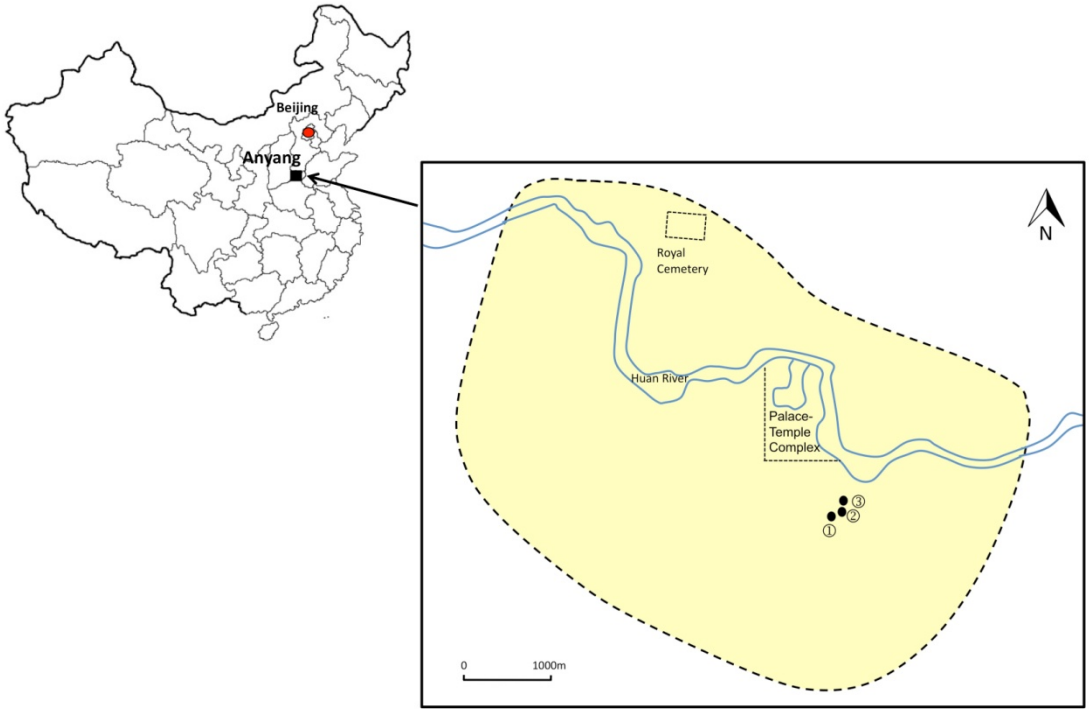

Figure 3 Location of the archaeological site *Yinxu* in Anyang, China, with reference to the location of Beijing: ①Residential cemetery of XAZ; ②*Tiesanlu* bone workshop; ③*Miaopubeidi* bronze foundry.

Both historical and inscriptional evidence suggest that the Shang was a lineage-based society. At the top of the dynastic hierarchy was the Royal Lineage, or the *Wang Zu* 王族, presumably descendants of the founding clan of Shang, the *Zi* clan 子氏. Branching out from the Royal Lineage were the Princely Lineages, the *Zi Zu* 子族, and removing further away from the political core were the Many-Princely Lineages, *Duo Zi Zu* 多子族, and other non-royal lineages, *zu* 族 (Chang 1974; Chang 1980b; Jing, et al. 2013; Keightley 1999; Zhu 2004). Control of labour was highly centralized during this period. Members of these different *zu* were referred to as "*zhong*" 眾 or "*ren*" 人 in oracle inscriptions. Under their lineage leaders, these members contributed to the dynastic economy by being involved in specialized craft production, or serving the Shang kings in

various activities, such as farming, hunting, warfare, and different construction projects (Chang 1980b; IA CASS 2003; Jing, et al. 2013; Keightley 2012; Wheatley 1971; Zhu 2004). In return, the king offered them "his spiritual and military assistance" (Keightley 1999:270).

The lineage system had determined not only the political structure and economic organization of the late Shang society, but also the spatial configuration of the city. Since many bronzes from a given cemetery often bear the same lineage insignia, it is now generally assumed that residential neighbourhoods and their associated cemeteries were organized by lineages (IA CASS 2003; Keightley 1999; Keightley 2012; Yang 1983). Although varying in terms of differential orders of wealth and closeness with the royal family, each neighbourhood could be a self-contained community itself, complete with public spaces, houses, water wells, storage pits, drainage systems, and roads (Tang and Jing 2009). Recently, archaeologists have become increasingly interested in the internal structure within each neighbourhood. Archaeological evidence, especially that from mortuary practices, has revealed intense social stratification both between and within the different neighbourhoods in *Yinxu* (Anyang Archaeological Team 1979; Anyang Archaeological Team 1994; Anyang Relics Team 1997; IA CASS 2003; Yang 1984). However, currently these investigations are mostly concentrated on analyzing burials that produced prestigious goods, particularly those made of bronze. This has unfortunately directed such research to focus on elite socio-economic activities (Campbell, et al. 2011). Furthermore, the majority of the smaller tombs in *Yinxu* have very few burial goods, thus it is generally harder to recognize people with different cultural affiliations among the lower class. As a result, very few studies have been done to look at the population

dynamics of the lesser lineages. It is hoped that by including bioarchaeological data in this analysis, more information could be drawn from the general commoners of *Yinxu*, and thus provide a fuller picture of socio-economic stratification within the neighbourhoods of *Yinxu*.

4.3 Archaeological Context

4.3.1 The Site of Xin'anzhuang

Xin'anzhuang (XAZ) is a small residential neighbourhood located about 1.2km south of *Xiaotun*, the palace-temple complex of *Yinxu* (see Figure 3). It was discovered in 1989 when a housing development project commenced on the site. Between 1989 and 1993, and again in 2007, rescue excavations were carried out by the Anyang Archaeology workstation under the directorship of the Institute of Archaeology, Chinese Academy of Social Sciences (IA CASS). As part of the site is covered by modern structures, XAZ was never fully excavated. Within the excavated area, archaeologists have found a total of 333 Shang period tombs, 90 in the east, and 243 in the west (IA CASS n.d.). The cemetery was in use from late phase 1 till the end of the *Yinxu* period (Tang 2001). Spatial analysis of the burial distribution suggested that similar to most other *Yinxu* cemeteries, burials in XAZ were formed in clusters, with each cluster possibly representing a familial unit (IA CASS 2003:303; Jing, et al. 2013; Tang 1999; Tang 2004; Yang 1983). Unfortunately at least 34% of the burials had been looted and hence the chronological sequence of many of these burials cannot be established (IA CASS n.d.).

The settlement of XAZ is located adjacent to the *Tiesanlu* 鐵三路 bone workshop (TSL) and the *Miaopubeidi* 苗蒲北地 bronze foundry (MPB) (see Figure 3), however, it

is still unclear whether XAZ was directly related to either industry. And despite its proximity to the palace-temple complex, preliminary archaeological work suggests that the inhabitants of XAZ likely belonged to a lesser lineage (IA CASS n.d.). In this study, bone samples from 59 individuals from this site have been obtained.

4.3.2 Mortuary Practices

In the cemeteries of the residential neighbourhoods, over 95% of the burials were smaller rectangular shaft tombs with a volume less than $3m^3$ (Hu 2010:169), while bigger tombs or even ramped tombs are believed to be reserved for the burials of elites (Yang and Yang 1983). Other than these formal tombs, many individuals were also found buried in refuse pits. Often buried without a coffin or any burial goods, except for the presence of a wrap, individuals buried in refuse pits were long believed to be slave burials (Keightley 1999; Yang 1984; Zhu 2004).

The typical Shang burial is in a supine, extended position, with a north by east/south by west orientation, and in a shaft pit measured between 2.0-2.4m by length, 0.8 to 1.2m by width, and between 2-3m in depth (Anyang Archaeological Team 1979; IA CASS 2003; Keightley 1999). Although supine burials constitute the majority of the burials in *Yinxu*, prone burials were not unusual. From over 830 burials in three cemetery sites in *Yinxu* (*Da'sikong cun*, *Yinxu* western and southern districts), it is estimated that approximately 25-28% of individuals were buried in a prone position, while only less than 5% were buried in a flexed position (Anyang Archaeological Team 1979; Meng 1992). Note that the majority of the prone burials in *Yinxu* were adult males, while supine

burials could be males, females or children (Anyang Archaeological Team 1994; IA CASS 2003; Meng 1992).

The presence of a coffin, or *guan* 棺, is common, and so is the presence of a *yaokeng* 腰坑, or "waist pit" (see Figure 4). A *yaokeng* is a unique Shang burial practice, where a small pit is often dug beneath the coffin, usually with a dimension of 70 x 30-40cm (Tang 1999). As the position of these pits was usually located close to the waist of the deceased, it is also referred to as a "waist pit" (Keightley 1999:267). In the neighbourhood cemeteries, a *yaokeng* often contained the remains of a dog, and in larger tombs the *yaokeng* sometimes contained the remains of another human.

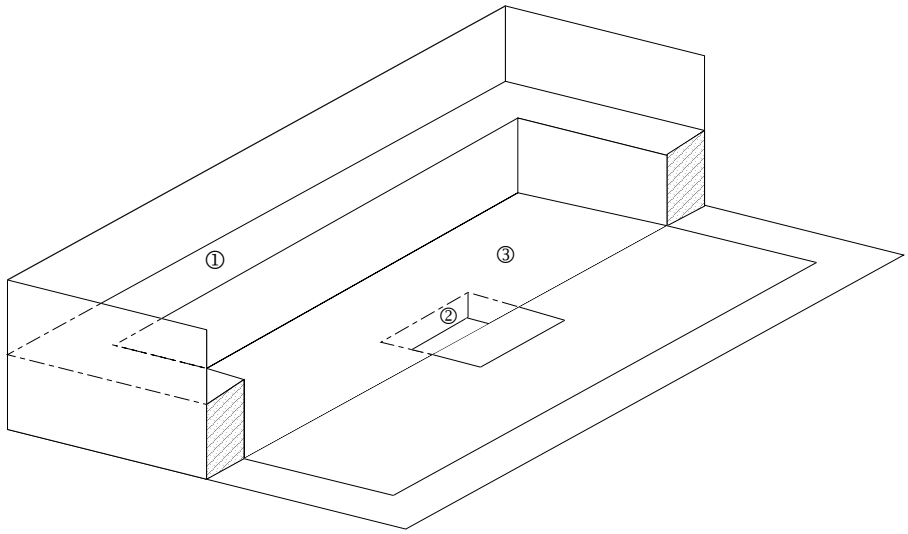

Figure 4 Cutout of a typical Shang style rectangular shaft tomb showing the features of *yaokeng* and *ercengtai*: ① *ercengtai*; ② *yaokeng*; ③ floor of the tomb.

Additionally, more affluent commoners could afford a *guo* 椁, and sometimes even an *ercengtai* 二層臺 (see Figure 4). A *guo* is an additional wooden chamber outside of the *guan* (Tang 1999), and *ercengtai* are the ledges, or in some translations, secondary

terraces on the sides of the tomb, where grave goods and sacrificial human or animals were placed (Keightley 1999:267). Only bigger tombs are furnished with such features.

In terms of grave goods, the most basic "set" of Shang grave goods consists of at least one or more pottery vessel(s). Figure 5 depicts the seven types of pottery vessels mentioned in this study. The combination of pottery types varies from period to period, with a single *dou* 豆 or *li* 鬲 being more prominent in the earliest phase, to a set of drinking vessels *gu* 觚 and *jue* 爵 becoming the standard set of burial goods during the later phases (Han 1997; IA CASS 1994; Tang 1999; Thorp 1985). Many types of shells, such as those of shells of various whelks and river clams, as well as money cowries (*Monetaria moneta*) were also commonly seen among burial goods in *Yinxu*. It is believed that the cowries in particular, were imported from the southern coast, and were used as money in the area during the late Shang period (IA CASS 1994:402-3). Prestigious items such as bronze or jade were rare, and it is estimated that only 10% of the population could afford any prestigious items among their burial goods (Yang 1983). Although the practice of offering human and/or animal companion-in-death was a common mortuary practice during the Shang period (Bagley 1999; Keightley 1999; Tang 1999), human sacrificial victims only occurred in medium to large tombs, and rarely in smaller tombs (Yang 1984; Zhu 2004). Animal remains, however, were prevalent among all ranks of burials. Dogs were often found in the *yaokeng* or *ercengtai* of a tomb. And in certain cases, remains of cattle, dog, pig, sheep, and chicken, often represented by a body part, could be seen in the tomb (IA CASS 2003).

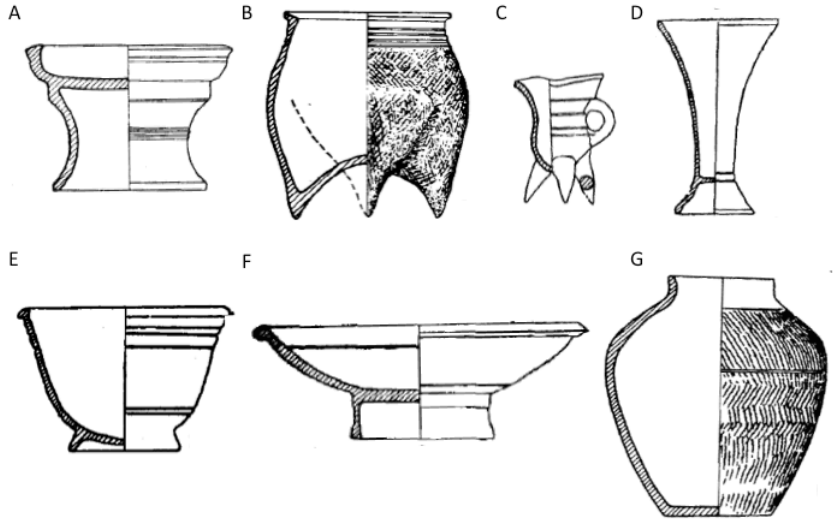

Figure 5 Examples of pottery vessels mentioned in this study: A) *dou* 豆(YH358:208F); B) *li* 鬲(YH190:350D); C) *jue* 爵(YW437:5); D) *gu* 觚(YW437:4); E) *gui* 簋(T290⑥:6); F) *pan* 盘(GT106③:644); G) *guan* 罐(64F1:5). Drawings adapted from AAT 1979:65, 67 and IA CASS 1994:200, 203, 218, 220 with permission from publisher.

Generally speaking, we expect individuals of a higher socio-economic status to be interred in tombs that were more energy-intensive to create. This refers not only to the architectural aspects of the tombs, such as the size and shape of the tomb, the presence of *yaokeng* and/or *ercengtai*, but also in terms of the quality and quantity of grave goods present. And we predict that these differences in socio-economic status will also contribute to differences among these individuals' dietary practices.

4.4 Results

The sample information, elemental compositions, and averaged measurements of stable carbon and nitrogen values of each sample are given in Table 5. Only 39 samples yielded well-preserved collagen for stable carbon and nitrogen isotope analysis. The 20 samples that did not meet the collagen quality criteria were excluded from this study

Table 5 Summary of sample information, elemental compositions, and bone collagen stable carbon and nitrogen isotopic compositions of all XAZ local residents analyzed in this study.

Sample ID	Sample No	Sex	Age	Phase	Burial Position	Orientation	Tomb Size/Type	Tomb attributes	% collagen	%C	%N	C:N ratio	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)
387	M10	F?	20+	3	Prone	NS –E	S	0	2.8	43.3	14.5	3.5	–8.5	+9.6
388	M30	F	25-34	1	Supine	NS	?	Y+G	13.8	44.4	15.7	3.3	–8.3	+10.2
389	M35	M	25-34	2	?	NS-E	L	G	11.1	42.1	14.2	3.4	–9.3	+9.8
390	M46	F?	35-44	4	Supine	WE- N	L	G	3.9	38	12.6	3.5	–10.7	+10.8
391	M48	F	35-44	2	Supine	WE-N	L	G	4.4	37.5	12.3	3.6	–9.7	+10.5
392	M49	F	35-44	4	Supine	NS-E	S	G	4.7	31.1	10.5	3.5	–9.7	+9.5
393	M54	M	35-44	4	Prone	EW-S	?	Y+G	11.2	42.3	14.5	3.4	–9.1	+10.5
394	M100	F	25-34	2	Supine	NS-E	L	G	10.3	41.3	14.1	3.4	–9.8	+9.0
395	M108	M	35-44	4	?	NS-E	?	Y+G	6.4	40.9	13.8	3.4	–9.8	+11.4
397	M168	F	35-44	3	Supine	NS-E	S	Y+G	3.9	41.2	13.3	3.6	–9.8	+10.1
398	M170	?	20+	3	Supine	NS-E	S	G	1	38.2	12.2	3.6	–10.3	+9.4
399	M198	M?	25-34	1	Prone	NS-E	?	Y+G	3.1	33.6	10.8	3.6	–9.8	+10.6
400	M233	M	35-44	1	Prone	EW-S	L	Y+G+G	10.8	44.3	15.5	3.3	–8.4	+10.2
401	H102	F?	15-24	?	?	?	Refuse pit		1.8	38.1	13	3.4	–9.0	+8.4
402	H201	F	25-34	?	?	?	Refuse pit		5.6	42	14.5	3.4	–8.7	+9.1
729	M9	?	35-44	2	Supine	NS-E	S	G	2.4	42.7	14.9	3.3	–9.2	+9.5
733	M55	F?	45+	4	Supine	WE-N	?	0	4	34.6	11.6	3.5	–9.1	+10.7
734	M81	?	8-14	2	Supine	NS	S	G	12.7	44.7	16.2	3.2	–7.4	+10.3
735	M91	?	8-14	2	Prone	EW-S	L	G	2.2	36.1	12	3.5	–9.4	+10.9
736	M107	?	8-14	2	Prone	EW-S	?	0	11.2	43.5	15.5	3.3	–8.8	+9.6
739	M120	F?	35-44	4	Supine	NS-E	L	Y+G	0.6	26.8	9.3	3.4	–9.3	+9.4
741	M125	F	15-24	4	Prone	EW-S	S	0	4.9	42.9	15.1	3.3	–8.7	9.8
742	M131	F	25-34	2	Supine	EW-S	S	Y+G	2.1	39.3	13.1	3.5	–8.9	+10.0
746	M137	F	15-24	2	Supine	NS	L	G	3.1	34.6	11.8	3.4	–8.3	+9.8
747	M139	M	35-44	2	?	NS-W	L	Y+G+G	5	41	14.1	3.4	–7.8	+10.8

Sample ID	Sample No	Sex	Age	Phase	Burial Position	Orientation	Tomb Size/Type	Tomb attributes	% collagen	%C	%N	C:N ratio	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)
749	M156	?	35-44	4	?	NS-E	?	0	5	43.3	14.9	3.4	–8.8	+8.6
751	M181	M	25-34	2	Prone	EW-S	?	Y+G	4.6	40.2	13.7	3.4	–8.3	+11.1
753	M184	F?	15-24	2	Supine	NS-E	?	0	6.8	44.3	15.8	3.3	–8.7	+9.9
754	M188	F	35-44	2	Supine	EW-S	S	0	4.9	41.4	14.3	3.4	–9.3	+9.8
755	M193	M	25-34	3	Prone	SN- W	L	G	2.6	36.7	12.3	3.5	–8.6	+10.3
757	M210	F	15-24	2	Supine	NS-E	?	Y	3.5	45.6	16.1	3.3	–8.5	+9.7
758	M216	?	20+	2	Prone	SN-W	S	0	3.1	39.5	13.4	3.4	–9.0	+9.7
759	M228	M	35-44	2	Prone	NS-E	L	Y+G	8.2	42.9	15.3	3.3	–7.5	+11.3
761	M237	M?	35-44	2	Prone	NS-W	S	Y	3.8	43.5	15.1	3.4	–8.6	+10.3
762	M238	?	25-34	3	Supine	EW-S	S	0	6.5	39.6	13.9	3.3	–8.0	+10.4
763	M239	F	15-24	2	Supine	EW-S	S	0	4.6	37.9	13.4	3.3	–8.4	+9.9
1835	M165	F	22+	?	Supine	NS-E	L	Y+G	8	38.7	13.2	3.4	–9.3	+8.9
1837	M241	F	32+	4	Supine	NS-E	L	Y+G	8.7	38.8	13.3	3.4	–8.6	+9.3
1839	M352	M	35+	3	Prone	NS-E	?	0	10.6	39	13.5	3.4	–10.1	+9.7

δ^{13}C values of all individuals ranged from –10.7 to –7.4 ‰, and δ^{15}N values ranged from +8.6 to +11.4‰ (Table 5). Figure 6 plots all the δ^{13}C and δ^{15}N values of the XAZ residents with local fauna; all individuals displayed stable carbon and nitrogen values typical of a population subsisting heavily on a C_4-based terrestrial diet.

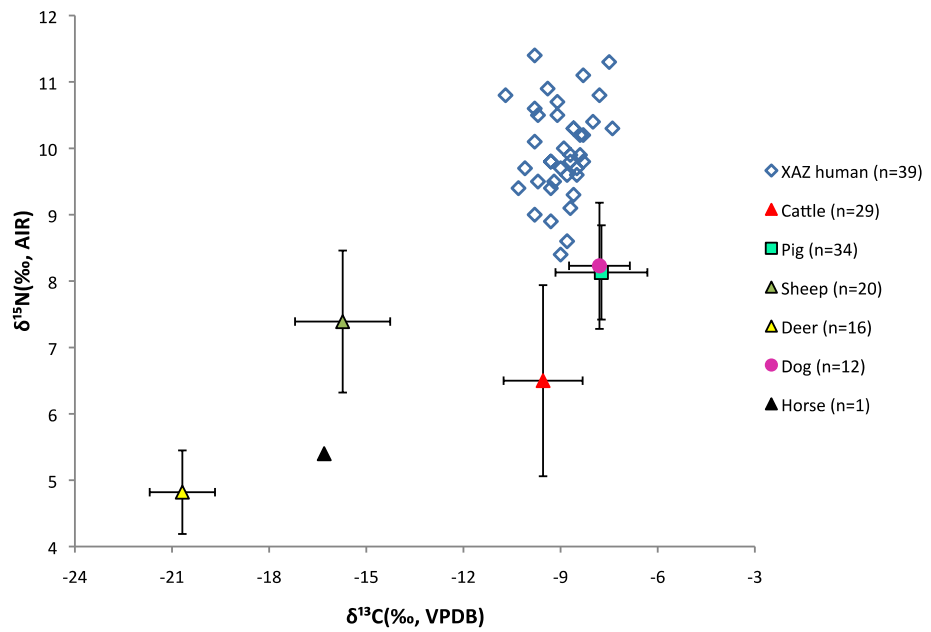

Figure 6 Bone collagen δ^{13}C and δ^{15}N values of all XAZ residents plot with local fauna data from published reports (Si 2013; Yan 2010).

<u>Phase</u>

A one-way ANOVA test suggested that there is no obvious pattern in the δ^{13}C ($F(3,33)=1.69$, $p=0.1881$) and δ^{15}N ($F(3,33)=0.48$, $p=0.6984$) values among the individuals of different phases, indicating that these isotopic variations do not display any temporal trend.

Burial types

Individuals buried in refuse pits have significantly lower δ^{15}N values than those buried in rectangular shaft pits (Figure 7A). As there are only two samples from refuse pit burials, however, the sample size is too small to establish the statistical significance of this difference.

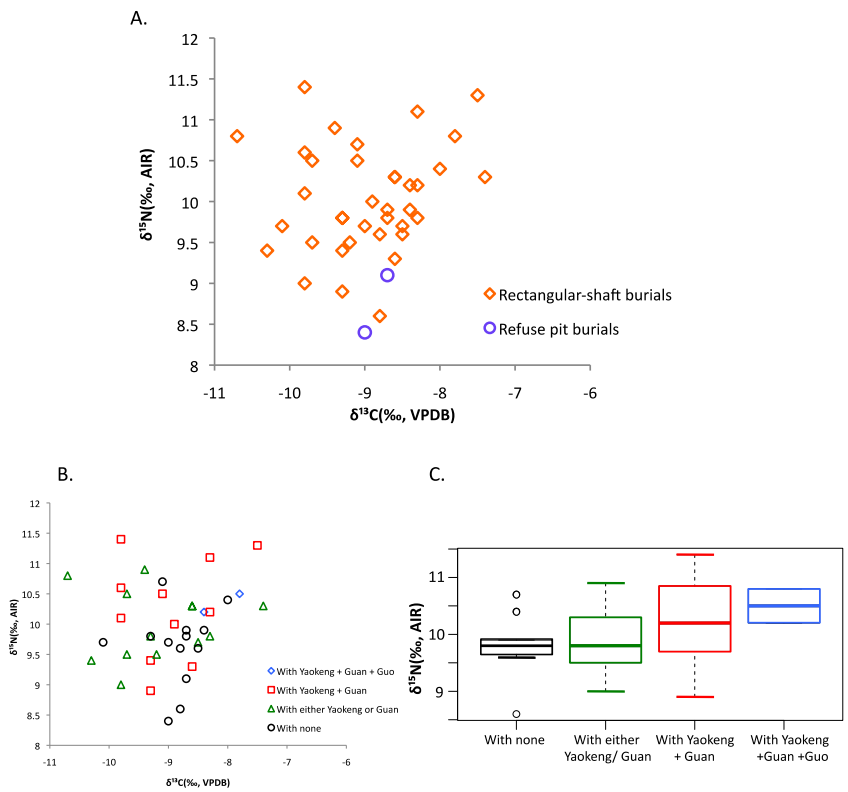

Figure 7 Bone collagen δ^{13}C and δ^{15}N values of humans plotted by A: different burial types; B: tomb architectural attributes; and C: tomb architectural attributes only by δ^{15}N values.

Presence of burial containers and other architectural attributes of the tomb

In terms of tomb size, the tombs are divided into two categories: a) larger tombs with a volume of at least 3m^3 (depth of at least 1.5m); and b) smaller tombs with a volume of less than 3m^3. The δ^{13}C and δ^{15}N values of individuals buried in different tomb sizes were compared. Although individuals with the highest δ^{15}N values were mostly

buried in larger tombs, a t-test suggested that there is no statistically significant difference between the mean δ^{15}N values of the two groups ($t(24)=0.8871$, $p=0.3838$, $\text{mean}_{\text{large-tombs}}$ = +10.1‰ and $\text{mean}_{\text{small-tombs}}$ = +9.9‰). Similarly, the presence of various tomb attributes such as *guan*/*guo* or *yaokeng* appear to have little statistically significant correlation with dietary patterns (Figure 7B and 5C), as confirmed by an one way ANOVA test ($F(3,33)=1.319$, $p=0.285$).

Only one individual in this sample set had an *ercengtai* in the tomb chamber, and unfortunately this individual's collagen was too degraded for carbon and nitrogen isotope analysis.

Burial Orientations

Burial orientation is divided into six categories (see Table 6): north by east/south by west (NS-E), north by west/south by east (NS-W), cardinal north south (NS), south by west/north by east (SN-W), east by south/ west by north (EW-S), and west by north/east by south (WE-N).

Table 6 Means and standard deviations of δ^{13}C and δ^{15}N values of individuals buried in different orientations.

Orientation	N=	δ^{13}C (‰, VPDB)	δ^{15}N (‰, AIR)
EW-S (95°-110°)	10	–8.7±0.5	+10.2±0.5
NS (0°)	3	–8.0±0.5	+10.1±0.3
NS-E (2°-16°)	17	–9.2±0.7	+9.7±0.8
NS-W (355°)	2	–8.2±0.6	+10.6±0.4
SN-W (195°-200°)	2	–8.8±0.3	+10.0±0.4
WE-N (275°-285°)	3	–9.8±0.8	+10.7±0.2

One-way ANOVA tests suggest that there is little difference between the mean δ^{15}N values of individuals buried in different orientations (F(5,31)=1.816, p=0.139). However, the differences between the mean δ^{13}C values are significant (F(5,31)=4.009, p=0.0064). A Tukey HSD test revealed that the differences are most prominent between those buried in a WE-N direction and a NS (p=0.015) direction, and between those buried in NS-E and NS (p=0.0423) directions (Figure 8).

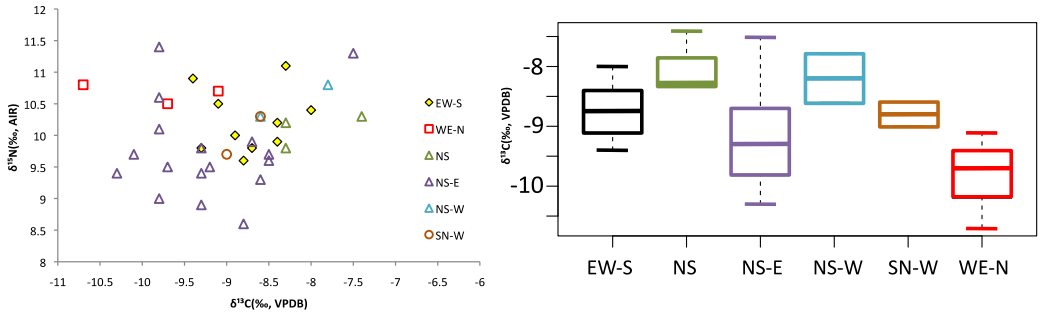

Figure 8 Bone collagen δ^{13}C and δ^{15}N values of human plotted by burial orientation.

Grave Goods

Detailed descriptions of the grave goods found with individuals analyzed in this study are summarized in Table 7.

Individuals buried with at least four items (multiple shells count as one item) had higher δ^{15}N values than those who had three or fewer items (t(37)=-2.958, p=0.005, $\text{mean}_{3\text{-items}}$= +9.7‰ and $\text{mean}_{4\text{-items}}$= +10.4‰; Figure 9A). Those buried with prestigious goods (bronze and jade) had significantly higher δ^{15}N values (t(37)=-4.126, p=<0.001, $\text{mean}_{\text{no-prestigious-items}}$= +9.8‰ and $\text{mean}_{\text{pretigious-items}}$= +10.9‰; Figure 9B). Individuals buried with cowries also had higher δ^{15}N values than those buried with river shells and those without any shell (F(2,36)=6.067, p=0.0053; Figure 9C). The difference is most

remarkable between those buried with cowries and those with no shell at all (TukeyHSD: p=0.0036, $\text{mean}_{\text{no-shell}}$ = +9.6‰ and $\text{mean}_{\text{cowries}}$= +10.5‰). In addition, those buried with a dog (all in *yaokeng*) had higher δ^{15}N values than those without (t(37)=-2.883, p=0.006, $\text{mean}_{\text{without-dog}}$= 9.8‰ and $\text{mean}_{\text{with-dog}}$= +10.7‰; Figure 9D).

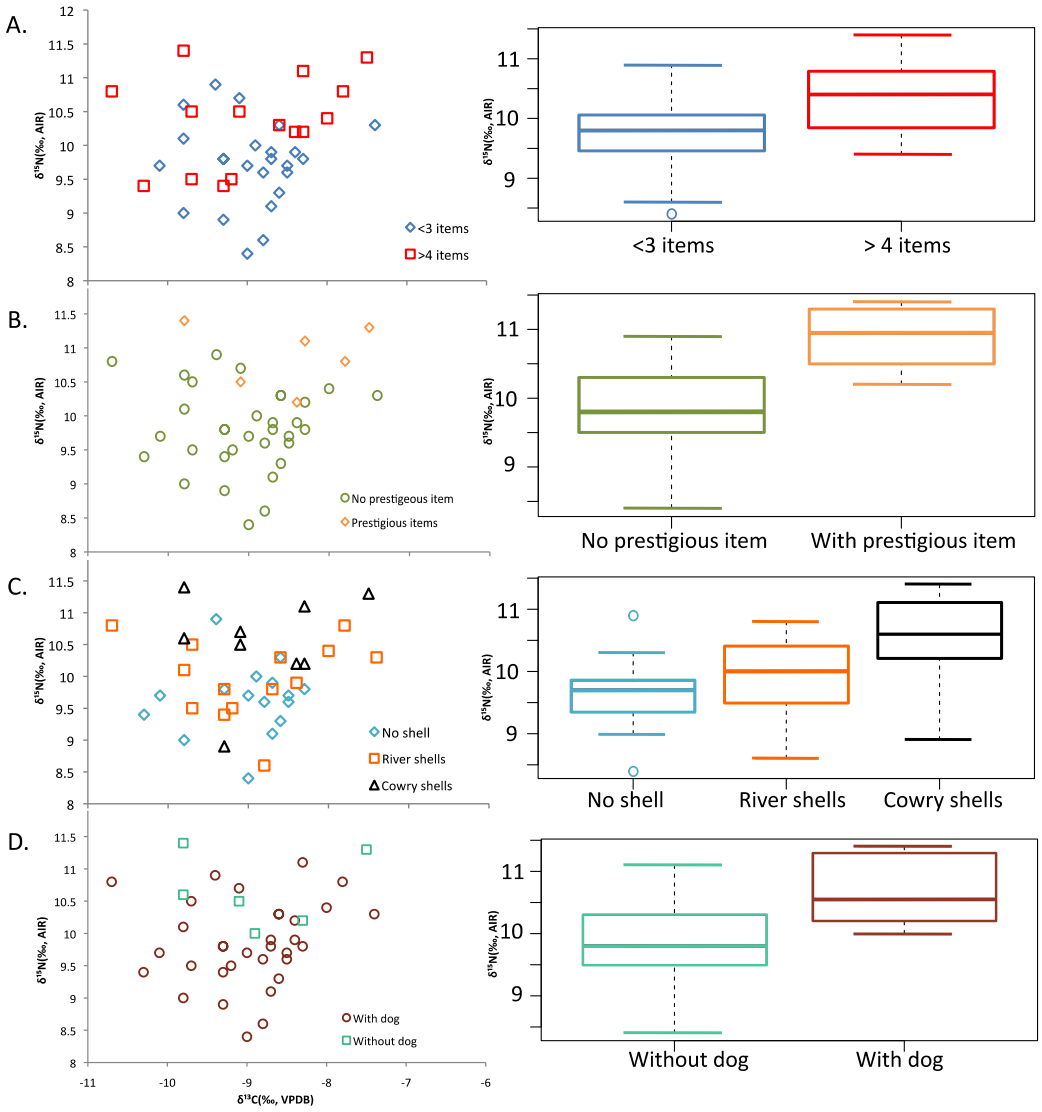

Figure 9 Bone collagen δ^{13}C and δ^{15}N values of humans plotted by burial goods.

In terms of the combination of vessel types, individuals who were buried with a *jue* and a *gu* had a higher mean δ^{15}N value than those without (t(37)=-3.535, p=0.0011, $\text{mean}_{\text{without-gu/jue}}$= +9.9‰ and $\text{mean}_{\text{with-gu/jue}}$= +10.4‰; Figure 10A), while individuals who were buried with a *pan* and a *guan* had significantly depleted δ^{13}C values (t(37)=-2.758, p=0.0089, $\text{mean}_{\text{with-pan/guan}}$= –9.9‰ and $\text{mean}_{\text{without-pan/guan}}$ = –8.9‰; Figure 10B) than the rest of the group.

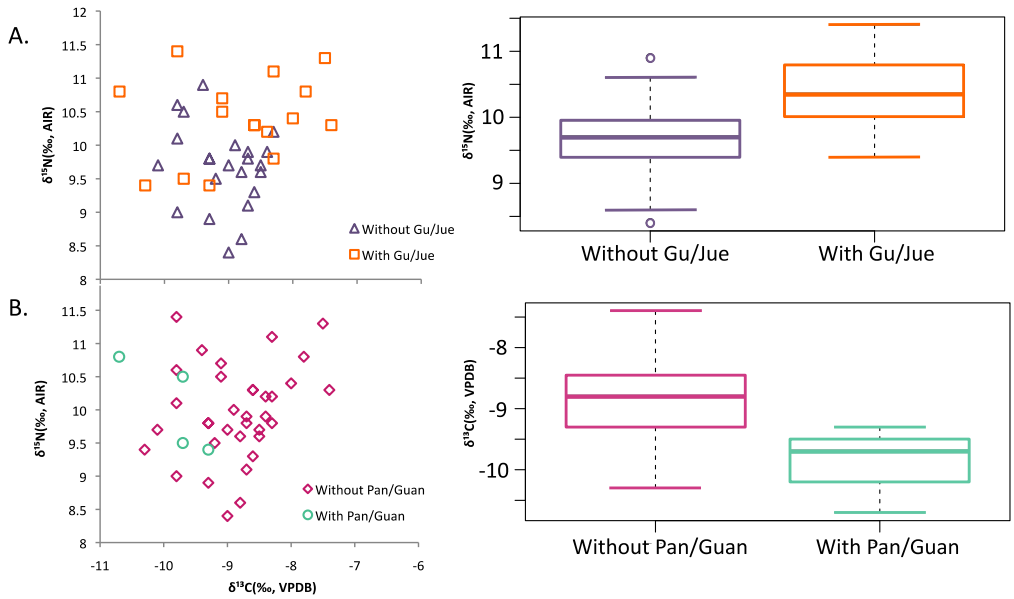

Figure 10 Bone collagen δ^{13}C and δ^{15}N values of humans plotted with different combinations of vessels.

Table 7 Detail descriptions of grave good distribution among the XAZ residents analyzed in this study.

Samples with asterisk* are burials that had been disturbed.

S_UBC no	Sample No	Pottery							Money Cowry	Shell	Bronze	Jade	Bone tool	Dog/ animal bone
		Dou	Li	Jue	Gu	Gui	Pan	Guan						
		豆	鬲	爵	觚	簋	盤	罐	貨貝	海貝	銅	玉	骨器	狗／獸骨
387	M10	✓												
388*	M30		✓			✓				✓				✓
389	M35					✓			✓					
390	M46			✓	✓		✓	✓	✓					
391	M48	✓				✓	✓		✓					
392	M49			✓	✓	✓	✓	✓	✓					
393*	M54		✓	✓	✓					✓	✓			✓
394	M100				✓	✓								
395*	M108		✓	✓	✓					✓	✓			✓
397	M168				✓				✓					
398	M170	✓		✓	✓	✓								
399*	M198		✓							✓				✓
400	M233	✓	✓	✓	✓	✓				✓	✓		✓	✓
401	H102													
402	H201													
729	M9	✓				✓			✓					
733*	M55			✓	✓					✓				
734	M81			✓	✓				✓					
735	M91	✓				✓								
736*	M107		✓											
739	M120			✓	✓		✓	✓	✓					

S_UBC no	Sample No	Pottery							Money Cowry	Shell	Bronze	Jade	Bone tool	Dog/ animal bone
		Dou	Li	Jue	Gu	Gui	Pan	Guan						
		豆	鬲	爵	觚	簋	盤	罐	貨貝	海貝	銅	玉	骨器	狗／獸骨
741	M125					✓			✓					
742	M131				✓									✓
746	M137	✓		✓	✓									
747	M139			✓	✓				✓			✓	✓	
749	M156				✓				✓					
751*	M181		✓	✓	✓					✓	✓			
753*	M184		✓											
754	M188	✓												
755	M193	✓		✓	✓				✓					
757*	M210		✓											
758	M216	✓												
759	M228			✓	✓	✓					✓			✓
761	M237		✓	✓	✓									
762	M238		✓	✓	✓				✓					
763	M239		✓						✓					
1835	M165		✓							✓				
1837	M241	✓				✓								
1839	M352													

Burial position

Individuals buried in a prone position had a slightly higher mean $\delta^{15}N$ value than those buried in a supine position (Figure 11). The difference is statistically significant as deemed by a t-test ($t(31)=2.1447$, $p=0.0399$; $mean_{prone}$ = +10.3‰ and $mean_{supine}$= +9.9‰). As mentioned in Section 3.2, the majority of prone burials are male, therefore to a certain extent, burial position appears to be related to sex, and we will discuss these two aspects together in the next section.

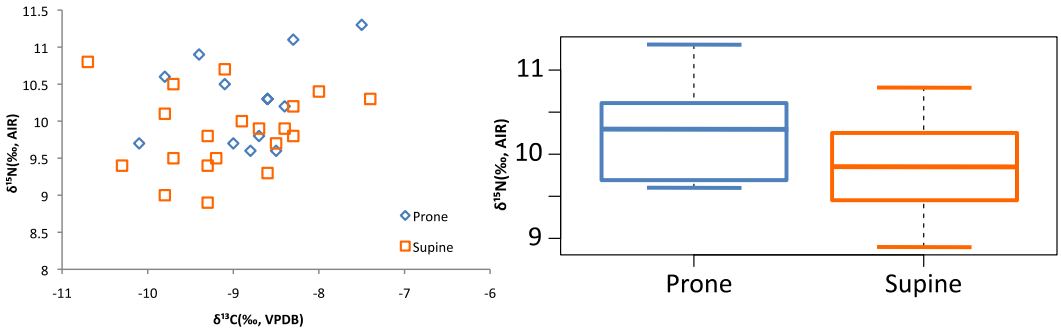

Figure 11 Bone collagen $\delta^{13}C$ and $\delta^{15}N$ values of human plotted by burial position.

Sex

Males appear to have a higher mean $\delta^{15}N$ value than females (Figure 12). The difference is still significant after the two females buried in refuse pits are removed, as confirmed by a t-test ($t(27)=-3.493$, $p=0.0016$, $mean_{females}$= +9.8‰ and $mean_{males}$= +10.6‰).

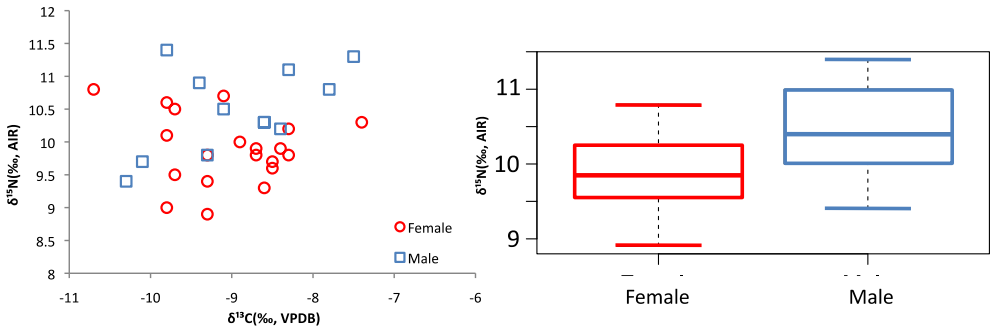

Figure 12 Bone collagen δ^{13}C and δ^{15}N values of humans plotted by sex (excluding individuals from refuse pits).

4.5. Discussion

The range of δ^{13}C values from both human and domesticates from *Yinxu* indicates that millet was not only a staple crop for humans, but secondary products of millet were likely also fed to domesticates as fodder. This is supported by carbon and nitrogen isotope studies done on multiple Neolithic groups in northern China, where a simultaneous shift from a reliance on C_3– to C_4– based resources was observed in both the humans and their associated domesticates (Barton, et al. 2009; Chen, et al. 2014). This practice had likely persisted through the Shang period (Lee, et al. 2007). Meanwhile, the mean δ^{15}N value of the humans is 3.5‰ higher than that of cattle and 1.8‰ higher than that of pigs, and is in agreement with zooarchaeological evidence that the *Yinxu* locals consumed a considerable amount of animal protein in their diet (Campbell, et al. 2011; Li, et al. 2011). Note that a higher δ^{15}N value only suggests a diet with a higher proportion animal protein, not necessarily a higher quality diet. In most archaeological contexts, especially in early societies, it is generally assumed that a diet higher in animal protein is indicative of a higher socio-economic status (Schmitt and Lupo 2008; van der

Veen 2003). In this study, we aim to test this hypothesis by examining the stable isotope data of these 39 individuals in conjunction with other mortuary evidence.

Burial types

While it is generally agreed that the smaller rectangular shaft tombs contained the burials of lower class commoners, the identity of those buried in refuse pits is less well understood. Recent excavation revealed more of these burials, and in several cases the buried individuals had their arms or legs cut off (Yang 2002:73; Yang 1983:933), further affirming the hypothesis that these were likely burials for non-local labourers, criminals, or those with little importance in society (Tang 2004; Yang 1983). Results from this study reveal that when compared to those buried in shaft tombs, individuals buried in refuse pits likely had a significantly smaller amount of animal protein in their diet (Figure 7A), thus agreeing with early analyses and suggesting that individuals buried in refuse pits belonged to the lowest social strata in society. However, as mentioned in the previous section, our sample size is too small (only two samples) to yield a meaningful or reliable conclusion. More analyses of refuse pit burials are needed to confirm or refute such a hypothesis.

Presence of burial containers and other architectural attributes of the tombs

As mentioned in Section 3.2, larger tombs and burials with more elaborate features (i.e. the presence of *guan*, *yaokeng*, and *guo*) often reflect higher energy expenditure, and are generally regarded as tombs of slightly more affluent individuals. Contrary to this assumption, there is no statistically significant correlation between these

features and the dietary patterns of the deceased in XAZ. In an overview of mortuary practices in *Yinxu*, Hu Jinzhu (2010) believed that in late Shang society, a strict hierarchical regulation regarding mortuary practices was already well established, where what one was allowed to be buried in and with was strictly dictated by one's social standing. Since in most higher status burials, including that of *Fuhao* 婦好, a royal consort of the Shang king *Wuding* 武丁 (IA CASS 1980; Linduff 2002), both *guan* and *guo* were present, it is now generally accepted that the presence of both *guan* and *guo* in a tomb is indicative of a higher social status for the deceased (Anyang Archaeological Team 1979:41; Hu 2010:160). In this study, even though individuals buried in both *guan* and *guo* have mean δ^{15}N values (+10.5‰) higher than those buried without a *guo* ($\text{mean}_{guan + yaokeng}$: +10.3‰, $\text{mean}_{guan / yaokeng}$: +10.0‰, and $\text{mean}_{\text{none}}$: +9.9‰; see Figure 7C), the differences are not statistically different. Thus, in terms of the consumption of animal protein, there is little evidence that individuals buried with more elaborate tomb features had significantly higher proportions of animal protein in their diet.

Orientation

Cardinality has significant cosmological importance in the Shang world (Fiskesjö 2001; Keightley 2000:82), and accordingly the Shang buried their dead in very specific orientations. The majority of the major architectural features, including the royal tombs and the sacrificial pits in the royal cemetery, were oriented in a NS-E direction (Keightley 1999:263; Yang 1983), as were the orientations of other Shang cities and Shang-style burials in other sites (Keightley 2000; Pankenier 2013; Tang 2001). However, it has been observed that the burial orientation of medium-small tombs in the residential

neighbourhoods of *Yinxu* were more varied, possibly reflecting the multi-origin nature of these non-royal lineage-groups (Anyang Archaeological Team 1994; Anyang Relics Team 1997; Han 1997). This is definitely the case at XAZ – while the majority of the burials were in a NS-E orientation, in total, burials were found in roughly six different orientations (Table 6).

The differences seen in dietary patterns between individuals of different burial orientations are only registered in their $\delta^{13}C$ values, not their $\delta^{15}N$ values. In particular, individuals buried in a WE-N direction had more negative $\delta^{13}C$ values (Figure 8), suggesting that although their diets were still largely C_4 based, these individuals would have supplemented their diet with a slightly larger proportion of either wild game (deer/freshwater fish), sheep (instead of cattle and pig), or C_3 crops, than individuals buried in other orientations. Nevertheless, the $\delta^{13}C$ and $\delta^{15}N$ values of individuals buried in different orientations appeared to form tight clusters. This close correlation between dietary patterns and burial orientations suggests a high level of heterogeneity in terms of the socio-cultural organization among the XAZ population.

Burial goods

Analysis of grave goods is one of the most common techniques used by archaeologists to determine the social status of the deceased in past societies (Parker-Pearson 2008; Robb, et al. 2001). Under most circumstances, higher status burials are often represented by richer burial assemblages and more elaborate tomb features. This isotope study has shown that various tomb architectural features (not including tomb types) have little correlation with dietary patterns among the XAZ residents. The

correlation between dietary patterns and the types of grave goods, however, painted a different picture. Isotopic data from this study has revealed that individuals who were buried with energy intensive burial goods, characterized by the total number of burial goods present (Figure 9A), the presence of labour-intensive products (Figure 9B), the presence of exotic items (Figure 9C), and the presence of animal sacrifices (Figure 9D), generally consumed more animal protein as evidenced by higher $\delta^{15}N$ values. This observation has permitted us to hypothesize that in late Shang society, the consumption of large quantities of animal protein is associated with greater economic power. This brings into question as to why tomb size and various other burial features, such as *guan*, *guo*, and *yaokeng*, did not also reveal a similar correlation, as these features are also supposed to reflect the social status of the deceased. One explanation is that while XAZ is not a residential neighbourhood for a high status lineage, as evidenced by the lack of ramped tombs and human sacrifices in the cemetery (IA CASS n.d.), it is possible that the degree of social stratification is less intense within this neighbourhood. Thus, at least in XAZ, it may be possible that while various tomb attributes still reflected some level of social stratification (as shown in Figure 7C), the quality and quantity of burial goods are more sensitive indicators of the deceased's socio-economic standing (Figure 9).

Furthermore, individuals who were buried with a set of drinking vessels, *gu* and *jue*, also appeared to have higher mean $\delta^{15}N$ values than those without (Figure 10A). It is generally believed that these vessels had more than just utilitarian value, but were also considered as *li qi* 禮器, or ceremonial items, that carried certain ritual significance (Thorp 1985). Therefore, even though Tang Jigeng (1999) suggested that the most basic ritual vessel set for the lower ranks consisted of a *gu* and a *jue* made of pottery,

individuals who could at least afford these items appeared to be of a stronger economic standing than those who could not. Individuals buried with the serving vessels *pan* and *guan*, however, exhibited marginal differences in their stable carbon isotope compositions, suggesting a slightly different dietary composition when compared to the rest of the population (Figure 10B). Several studies have pointed out that *pan* and *guan* only began to feature heavily among burial goods during the later phases (IA CASS 1994:32-7). And in this study, three out of four individuals with this particular set of serving vessels belonged to Phase 4. Thus, it is possible that this observation has revealed a shift in dietary patterns on a temporal scale, where foodstuffs relatively depleted in ^{13}C became increasingly important among the XAZ residents towards the end of the *Yinxu* period. However, as little pattern can be observed in the patterning of $\delta^{13}C$ and $\delta^{15}N$ values in terms of phases, this could also suggest that individuals buried with a *pan* and *guan* belonged to a specific socio-cultural group that had slightly different dietary preferences.

Burial positions and sex

The majority of prone burials are males, yet the reasoning behind the connection between sex and burial positions in *Yinxu* is not very well understood. Earlier scholars such as Zhao Guangxian and Guo Baojun argued that individuals buried in a prone position were likely slaves, following the observation that almost all of the decapitated sacrificial victims found in the royal cemetery area were buried in a prone position (Zhao 1956). Another hypothesis is based on the assumption that males were more likely to be involved in various conflicts and/or used in sacrificial rituals than females, therefore

burial positions could be reflecting manner of death, where individuals buried in a supine position could be those who died of natural causes, while those buried in a prone position were killed by violence (*xiong si* 凶死) (Hu 2010:154-5). Recently, more thorough excavations of the residential cemeteries have revealed that many individuals buried in a prone position have at least similar, if not richer, grave goods than those buried in other positions. Thus, more and more scholars have begun to advocate that prone burials should not be considered as a "deviant" burial practice, and instead as one that carried certain political or religious significance (Hu 2010; Ma and Zhou 1956). For example Meng Xianwu argued that individuals who were buried in a prone position in residential cemeteries were not slaves, instead, they were likely affiliated with the Shang court through various military, political, or religious posts (1992:53). In terms of archaeological evidence, several excavation reports have documented that many individuals who were buried in a prone position were also buried with bronze weapons and other prestigious goods (Anyang Archaeological Team 1979; Hu 2010; Ma and Zhou 1956; Meng 1992). And as shown in Figure 11, the relatively higher δ^{15}N values of individuals buried in a prone position suggest that these individuals had consumed more animal protein than those buried in a supine position. Thus, assuming that slaves had lower amounts of animal protein in their diets and would have relatively lower δ^{15}N values, isotope data from this study indicate that the people in these prone position burials were not slaves. Thus, both archaeological and stable isotope evidence agree well with Meng's hypothesis (1992) that at least in residential cemeteries, burial positions likely reflected the occupational identity of the deceased, where prone burials likely belonged to

individuals who were in a position of higher economic status than those buried in other positions.

Moreover, isotope data also suggested that males consumed more animal protein in their diets than females in XAZ. Traditionally historians paid very little attention to the lives of women in Chinese antiquity, and it is largely assumed that Shang women played similar inferior roles as had other females in the later periods. Recently more scholars have devoted their interests to bringing the lives of Shang women into the light (Linduff 2002; Nelson 2002). By studying the only unspoiled royal tomb in *Yinxu*, the tomb of *Fuhao*, as well as looking at oracle inscriptions, it is now believed that even though the Shang was a patrilineal society, women could still hold high offices and even military posts, which in later historical periods were positions held only by men. In spite of this, studies of mortuary practices in late Shang China revealed that on average, the tomb sizes of males in *Yinxu* were slightly larger than those of the females, and that males tended to receive more burial goods than females, suggesting that during the Shang period, males may have had a higher social position than females (Tang 2004; Underhill 2002). Stable isotope evidence from this study revealed a similar picture, where the $\delta^{15}N$ values of males were on average 0.7‰ higher than those of females (Figure 12), suggesting that males in XAZ consumed slightly more animal protein than the females. It should be noted however, that among the 39 individuals used in this study, eight out of 11 males were buried in a prone position. Therefore, it is not clear whether the difference in $\delta^{15}N$ values is related to burial positions, sex, or perhaps both. Another interesting observation is that in this study, even though the majority of the prone burials are males, two out of 13 individuals who were buried in a prone position had been identified as females. Just

like other prone-buried males, these females had similar access to high status burial goods and a high animal protein diet. Assuming the morphological markers present on the remains accurately reflected sex, the new data generated from this study would verify oracle inscriptions that in the late Shang period, gender dichotomy was less absolute than previously thought. While prone burials were more frequently associated with males, the underlying reason for prone burial, whether it be occupational or behavioural (e.g. manner of death), was also applicable to females.

4.6. Conclusion and Future Studies

This paper presented dietary reconstructions from the bone collagen stable isotopic compositions of 39 inhabitants from the residential neighbourhood XAZ, in *Yinxu*. The study has shown that the comparison of dietary patterns and mortuary practices can help to reveal both vertical and horizontal social stratification within XAZ, and thus provide a glimpse into the diverse socio-cultural differentiations among the population of *Yinxu*. Results from this study suggested that individuals buried with higher energy-intensive burial goods, and to a lesser extent, buried in tombs with more elaborate architectural features, are associated with a higher intake of animal protein and that prone burials, and by extension, males, are often associated with richer grave goods as well as a diet higher in animal protein. On the other hand, individuals buried with differing combinations of grave goods, or those buried in differing orientations appeared to have different dietary practices.

The analysis of this study, however, is limited by the small sample size and poor chronological contexts of some of the samples. Despite promising findings from this

preliminary study, many questions concerning the nature and formations of differing socio-cultural groups in *Yinxu* are left unanswered. For example, many lines of archaeological evidence have suggested that the number of burials, and hence population, began to increase during Phase 2, peaked during Phase 3, and continued throughout Phase 4 (Han 1997). This expansion in population was probably due to a sudden influx of migrants entering *Yinxu*, as evidenced by the sudden increase in variations of burial rites and foreign artifact types (Bagley 1999; IA CASS 1980; Stoltman, et al. 2009; Thorp 1985). With only 39 samples, however, it is difficult to establish a solid chronological understanding of this process. It is hoped that more samples can be acquired from the site to allow further investigation. Nonetheless, this study has brought novel insight to the understanding of the population dynamics of late Shang society, and as a result, offers a valuable reference point for the larger discussion of state-formation and urbanization processes in early Bronze Age China.

5. Diets and Social Identity of Sacrificial Victims at the Royal Cemetery[2]

5.1 Introduction

The killing of human and animal victims during ritualistic ceremonies was a prevalent practice in many ancient societies, including but not limited to ancient Greece, Early Dynastic Mesopotamia, the Inca of Peru, and the Aztec Culture (Carrasco 1999; Dickson 2006; Hughes 1991; Klaus, et al. 2010; Pizzato 2005; Swenson 2003). Despite the fact that the explicit motivations for most of these rituals were to please or pacify various deities/ancestors, their substantive outcome allowed the ruling elites to instill fear into the spectators, which ultimately helped "to discourage outside attacks and internal revolt" (Gibbons 2012:834). In any case, there is little doubt that mass ritual killing was more than part of a religious ceremony, it also stood as an important piece of political theatre which helped to consolidate the ruler's power (Bagley 1999; Campbell 2007; Nelson 2002; Pizzato 2005; Swenson 2003) as well as create a sense of group identity amongst members of society (Burkert, et al. 1987; Fiskesjö 2001; Keightley 2004). This is particularly important in early state societies, "where stratification and social differences are already well developed but where the system is not yet institutionalized or very stable, […] the ruler needs a strong mechanism of legitimation to maintain his power base" (Shelach 1996:19-20). In the case of the Shang Dynasty, the "strong mechanism"

[2] This chapter is adapted from an unpublished manuscript: C Cheung, ZC Jing, JG Tang, D Weston, and MP Richards: Diets and Social Identity of Sacrificial Victims at the Royal Cemetery in *Yinxu*, Shang China: New Evidence from Stable Carbon, Nitrogen, and Sulfur Isotope Analysis.

employed was the sheer volume of lives involved and the extreme violence associated with the (presumably public) ritual mass killings.

At *Yinxu*, a capital of China's earliest state society, the Shang Dynasty (16th to 11th century BC), sacrificial pits are prevalent across the entire site. Sacrificial pits in residential areas are usually smaller in scale, featuring mostly animal offerings. Human sacrifices were relatively uncommon in residential areas (Yang 1983). One early survey of eight cemeteries located in the western district of *Yinxu* 殷墟西區 revealed that under 2% (18/939) of the tombs contained human sacrificial victims, with numbers usually limited to one to three victims per tomb, and occasionally up to 12 (Anyang Archaeological Team 1979). Sacrificial activities that involved higher numbers of human victims, up to several hundred at a time, were found only in the royal cemetery or the palace-temple complex (Bagley 1999; IA CASS 1994). This has not only substantiated the inference for a wide wealth and status gap between the rulers and the ruled, but also further supports the proposition that mass sacrificial rituals were indeed state-run performances and political acts (Maisels 2010). It is estimated that during the approximately 200 years of occupation at *Yinxu* (c.1250 – 1046BC), more than 13,000 humans (Allan 1991; Nelson 2002; Thorp 2005), and many more animals were sacrificed.

In order to better understand the practice and role of sacrificial rituals in early state societies such as the Shang Dynasty, the diet and social identity of 64 sacrificial victims from *Yinxu* were analyzed using stable carbon, nitrogen, and sulfur isotope analysis. To further elucidate the migratory patterns of these sacrificial victims, individuals from one residential funerary context (*Xin'anzhuang*) were also analyzed for their sulfur isotopic compositions and compared to the sacrificial victims. Although *Yinxu*

is currently known as the longest-studied archaeological site in China (discovered in 1928 and still undergoing excavation), so far relatively few studies concerning the site have involved the use of biomolecular techniques. By integrating isotopic analysis with the rich contextual information provided by the almost century-long excavations, it is hoped that this study will provide novel insights and a more in-depth understanding of the social and political dynamics of the period.

5.2 Human Sacrifice during the Shang Dynasty

One key aspect that contributes to *Yinxu*'s significance is that it is also the site where the first evidence for writing in China surfaced in the form of oracle inscriptions (Bagley 1999). These texts, by and large, were records of divinations[3], reflecting the king's various concerns, ranging from personal matters such as an unsettling toothache (Keightley 2012:209[272C]), to state issues such as crop failures (Keightley 2012:137[127B]; 145[153B]; 153[174B]). However, a considerable number of these inscriptions were dedicated to documenting the king's ritual activities (Bagley 2004; Keightley 2012). For example, in one instance 30 *Qiang* captives and 30 cattle were offered to *Tang* (an ancestor) for his assistance to the Shang king (Keightley 2012:67[40]). On another occasion, 10 *Qiang* captives were offered to *qi* (an unspecified deity) for his assistance (Keightley 2012:67[41A]). These inscriptions thus provided the first textual accounts of sacrificial ceremonies in early Bronze Age China, and

[3] In a few instances, inscriptions on imported materials appeared to be inventorial in nature, for example, the note "X sent in [a certain number of] plastrons" was found inscribed on a piece of turtle plastron (Bagley 2004:214).

particularly, and have given us a unique glimpse into the different methods of killing sacrificial victims during this time (Figure 13).

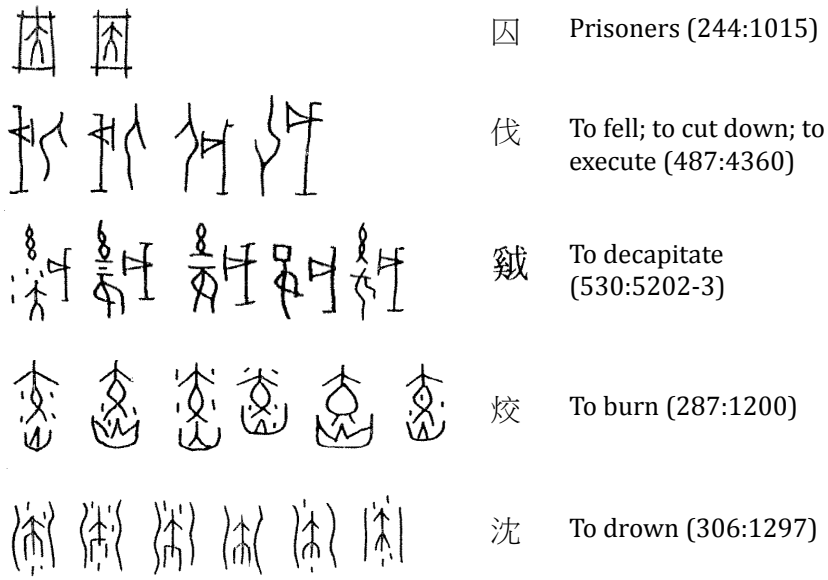

Figure 13 Examples of oracle inscriptions concerning the different methods of killing sacrificial victims. All inscriptions are taken from Matsumaru & Takashima's oracle index (1994), first number indicates page number and the second indicates the code of the set of inscriptions. Reproduced with permission from authors.

Moreover, the archaeological record has corroborated the historicity of many of these accounts. Extensive excavation of the site since 1928 has revealed an intricate internal structure of the city, which consisted of numerous lineage-based residential neighbourhoods and workshops, encasing a palace-temple complex (present day *Xiaotun* 小屯) in the center (see Figure 1). Across the river to the north is the royal cemetery (present day *Xibeigan* 西北岡), where royal burials as well as thousands of sacrificial pits containing both human and animal victims were found (IA CASS 1994; Liu and Chen 2012). This study will focus on the human sacrificial victims found in the royal cemetery.

5.2.1 Types and Origins of Human Sacrifice

In Shang China, there were two main types of human sacrifice: *rensheng* 人牲 and *renxun* 人殉. *Rensheng* literally means "human offerings", and these victims were often buried in large groups, mutilated, and with little to no grave goods. *Renxun* can be loosely translated as "human companions", who were often buried with elaborate grave goods, individual coffins, and even their own *rensheng* (Huang 2004). Sometimes it is difficult to differentiate between the two types of human sacrifice. However, for the individuals involved in this study, all but one (M260-23YK) were most likely killed as human offerings (i.e. decapitated in mass burial with no grave goods).

While it is generally agreed that *renxun* were mostly family members or servants (Huang 2004; Yang and Yang 1977; Yang 1988), the origins and identities of *rensheng* are largely unknown. Even though some scholars argue that local retainers[4] were also used (Wang 2007; Yang 1988; Zhu 2004), oracle bone inscriptions seem to suggest that an overwhelming number of these victims were war captives (Bagley 1999; Shelach 1996; Yang and Yang 1977; Yao 1979). According to oracle bone inscriptions, *rensheng* sacrificed in various ceremonies included captives obtained from at least 13 enemy groups, such as *Dai* 大, *Gen* 亘, *Er* 而, *Yin* 印 (Yao 1979), but particularly from a group called the *Qiang* 羌 (Chang 1980b; Huang 2004; Shelach 1996; Tang and Tang 2014; Wang 2007). References to *Qiang* captives dominated the majority of oracle bone inscriptions regarding human sacrifices (at least 7426 out of the documented total 13,052)

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[4] Many scholars consider the "forced labourers" of the Shang period to be slaves, or *nuli* 奴隸 in Chinese (IA CASS 1994; Yang 2002; Yang and Yang 1977). However, in recent years a few scholars argued that the notion of property and individual rights would not have existed until much later in Chinese history (He 2013; Keightley 2012; Yates 2001), therefore instead of using the term "slaves", in this study this class of individuals are referred to as "retainers".

(Huang 2004:77; Shelach 1996:13), and the largest groups of human sacrifices were always consisted of *Qiang* captives (Tang and Tang 2014).

While the non-Shang origins of the majority of these sacrificial victims have been accepted by most scholars, very little direct archaeological evidence supports this hypothesis. Furthermore, Shang scholars are still debating whether the word "*Qiang*" referred to a specific state/culture, or used as a generic term to describe all enemies from the west of *Yinxu* (Sun and Lin 2010). As most of these sacrificial victims were buried without accompanying grave goods, the only archaeological evidence available to the archaeologists is the skeletal remains. So far little systematic osteological work has been done on these remains, thus advocates of the non-local origins hypothesis have relied heavily on an early craniometric study of decapitated skulls recovered from the sacrificial pits in the royal cemetery, which revealed that these skulls represent a heterogeneous group (Li 1977). However, a recent osteological study examining the population compositions of several residential neighbourhoods in *Yinxu* also reported similar observations (Yuan 2010). This consistent finding of heterogeneity among both sacrificial and local samples suggests that both conventional archaeology and craniometric studies are insufficient to prove that a) many sacrificial victims were non-locals; and b) the term "*Qiang*" referred to a specific group (i.e. that many sacrificial victims shared a common origin).

5.2.2 Social Identities of Human Sacrifice

Another question regarding the social identities of the sacrificial victims is concerned with their involvement in productive labour prior to their executions (Wang

2007; Yang 1988; Yates 2001:300) or not (Keightley 2012; Shelach 1996; Yao 1979). The first view is founded on a materialistic model that takes the socio-economic and political context of the Shang period into consideration. Many studies looking at the practices of large-scale human sacrificial rituals from other archaeological cultures have suggested that in early state societies, sacrificial rituals involving human victims often intensified during times of political instability (Gibbons 2012). In *Yinxu*, epigraphic evidence implies that most sacrificial activities occurred during the earlier phases, when the ruling group was trying to establish its authority at the then new capital (Bagley 1999; Huang 2004; IA CASS 1994; IA CASS 2003; Maisels 2010). Without a strong political grip and substantial economic capacity, it would have been dangerous to employ a large, hostile, and foreign group of young men as forced labourers (Huang 2004; Keightley 2012; Yang 1983). In this way, "sacrifice was the only way of using the many prisoners captured during the wars of the Shang" (Shelach 1996:16). However, as political circumstances stabilized, the need to demonstrate state power by means of theatrical sacrificial performances subsided (Gibbons 2012). The intensification of craft production during the later *Yinxu* period would have also caused a rapid increase in the demand for labourers, thus enabling the Shang state to integrate a large number of external labour forces into the population (Huang 2004:116; Keightley 2012; Yao 1979). This claim is further supported by oracle bone inscriptions. Although infrequent in occurrence, several oracle bone inscriptions documented the enslavement of the *Qiang* people, where they were involved in various forms of productive labour such as opening up fields and participating in hunts (Chang 1980b:230; Keightley 2012:68[44][45][46A][46B],162[192A]).

Scholars who have argued against this view contend that large-scale human sacrificial rituals were considered a socio-political investment (Green 1998; Groot 2008), especially to those who believed in the efficacy of such rituals. For example, it has been observed that in many other archaeological cultures, such as the Dahomey Kingdom of West Africa and many Romano-British sites, sacrificial ceremonies were carried out despite the apparent economic loss (Groot 2008:108-9; Shelach 1996:17). Some archaeologists argue that in the Shang rulers' eyes, war captives, particularly the *Qiang*, were not seen as potential labour forces, but were used as "sacrificial 'currency'" (Green 1998:171) to exchange for negotiating power with the supernatural forces. As "sacrificial currency", the greatest value of these war captives was their (sculpted) identity as "the archaic kings' sacrificable Other" (Fiskesjö 2001:149). By materializing the threat of invading enemies into a more tangible form as war captives, the violence involved in sacrificing these captives thus helped to reinforce the Shang kings' power (both within and outside of the Shang dominion) as well as to strengthen solidarity among Shang subjects (Fiskesjö 2001; Shelach 1996). Gideon Shelach, a prominent Chinese archaeologist, has argued that participation in productive labour would have likely rendered the status of these captives from ferocious foes of the state to mere slaves and that the stripping of their paradigmatic "otherness" would have greatly depreciated their "sacrificial currency" (1996:18). Furthermore, according to oracle bone inscriptions it is apparent that the Shang kings preferred using the *Qiang* captives in sacrificial rituals over captives from any other states (Tang and Tang 2014). If that was the case, then the labeling of the *Qiang* captives definitely carried some special, even exclusive, meaning that gave them a different status than ordinary slaves. Unfortunately, other than oracle

bone inscriptions, there is very little archaeological evidence available to support either view.

5.2.3 Archaeological Background

The royal cemetery is located about 2.5 km northwest of the palace-temple complex at *Xibeigang* 西北岡 (see Figure 1), and occupies an area of roughly 11 ha (IA CASS 1994). Excavation of the royal cemetery began in 1934 and it has been continuously excavated up to the present day. The cemetery can be divided into an eastern and a western wing (Figure 14). In the western wing there are a total of eight ramped royal tombs and one unfinished large tomb. In the western wing a further five ramped royal tombs have been discovered, together with an area that is probably a royal sacrificial ground where the Shang kings offered sacrifices, including humans, to their ancestors during their religious ceremonies (Hu 2010; IA CASS 1994).

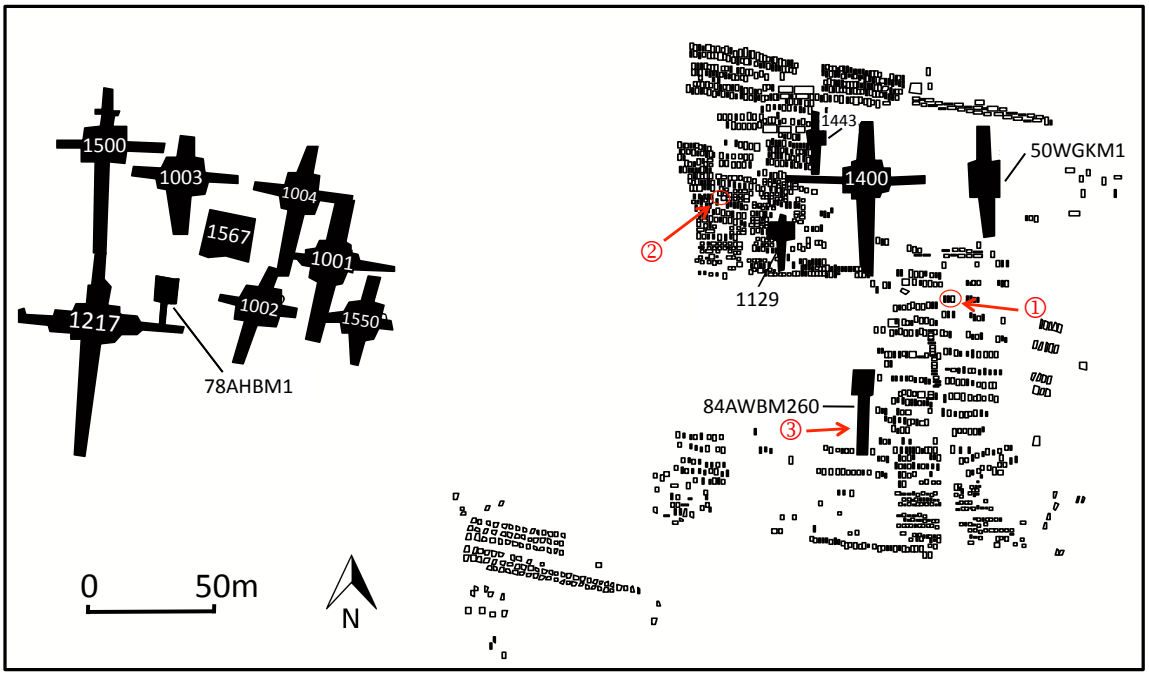

Figure 14 Map of the royal cemetery showing the locations of the royal tombs and the royal sacrificial ground. Solid black enclosures are royal tombs and open rectangles are sacrificial pits. Red markers show the locations of the three sets of samples analyzed in this study: ①–2013AWBT1M1-M3; ②–2013AWBT3M9-M10; ③–84AWBM260

In the royal cemetery, human sacrificial victims were found both within and outside of the royal tombs. As all royal tombs were looted, the original spatial positioning of many of the sacrificial victims and their accompanying grave goods has been disturbed. This has made it difficult to identify the victims as *rensheng* or *renxun*. The majority of the sacrificial victims were found in the royal sacrificial ground located in the eastern wing of the royal cemetery (Figure 14). In this area archaeologists have discovered over 2500 sacrificial pits containing the remains of humans, animals, and chariots, as well as various objects such as ritual items and weaponry (Anyang Work Team n.d.; IA CASS 1994). Of these 2500 sacrificial pits, over 1300 have been excavated, among which about 900 contained exclusively human sacrifices, numbering at

least 3460 individuals (IA CASS 1994). While individuals buried with grave goods and un-mutilated were considered possible *renxun*, pits containing strictly *rensheng* can be roughly divided into four categories: 1) "skull pits" – only cranial elements are present; 2) "headless pits" – only containing post-cranial[5] skeletal elements; 3) "mutilated pits" – full skeletons may be present but the bodies had been mutilated in various ways; and 4) complete skeleton pit (IA CASS 1994). A majority of these pits contained skeletal elements from multiple individuals, mostly in groups of 10, but ranging from 1-39 individuals (IA CASS 1994; IA CASS 2003). Spatial and stratigraphic analyses suggested that these pits were formed in clusters over a period of 200 years, where each cluster likely represented a single ceremonial activity (Anyang Excavation Team 1977; IA CASS 1994; Yang 1983). The biggest cluster consisted of 47 sacrificial pits and at least 339 human victims, but on average each ceremonial activity likely involved at least 50 human victims (Bagley 1999). Osteological analysis revealed that most of the individuals found in sacrificial pits, especially those having been mutilated, were young adult males aged between 15-35 years. Female and juvenile sacrificial victims were relatively uncommon, and were only found in pits dated to the later *Yinxu* period (Anyang Excavation Team 1977; Han and Pan 1977; Huang 2004; Linduff 2002; Yang 1988).

5.3 Sample Selection

In this study, bone samples were obtained from 68 individuals derived from three sets of sacrificial pits in the royal cemetery (Figure 14). The first set of sacrificial pits consisted of a total of 30 sacrificial victims from three individual "headless pits" –

[5] Due to the angle of decapitation, in a few cases part of the mandible was found with the skeleton.

2013AWBT1M1-M3. The second set consisted of 15 sacrificial victims from two "skull pits" – 2013AWBT3M9-M10. These two sets of sacrificial pits belonged to two distinct clusters, and are therefore likely non-contemporaneous. The third set consisted of 23 sacrificial victims from the royal tomb M260. The carbon and nitrogen isotopic compositions of these individuals were compared with those of the 39 local residents from the residential neighbourhood *Xin'anzhuqng* (XAZ – see Chapter 4). In addition to carbon and nitrogen isotope analyses, 15 samples from 2013AWBT1M1-M3 were analyzed for sulfur isotopic compositions.

The first group of sacrificial victims (2013AWBT1M1-M3, hereafter M1-M3) was found about 80m northeast of the royal tomb M260 (Figure 15). A total of thirty individuals were found among three sacrificial pits (M1, M2, and M3), where each pit contained 10 decapitated individuals. The pits were aligned in the same direction (north by east/south by west) and had similar dimensions (approx. 2 x 0.9 x 1.9m). The sacrificial victims were all buried in a prone position and stacked in layers, with individuals in each layer oriented in opposite directions. Only post-cranial skeletal elements were present for a majority of the victims, except for M1-10, M3-8, and M3-10, where parts of the mandible remained. Osteological analysis revealed that the victims all died between 15 and 50 years of age, with a majority of them being in the late adolescence to young adult age categories (15-35 years) (Wolin n.d.). Of the 15 individuals who could be sexed, all were male (Wolin n.d.). For each individual in this group, samples from two bone elements with differing turnover rates were obtained: one from either of the ulna, fibula, radius, or tibia (referred to as "smaller bones") and one from femur (see Table 10 for more detail).

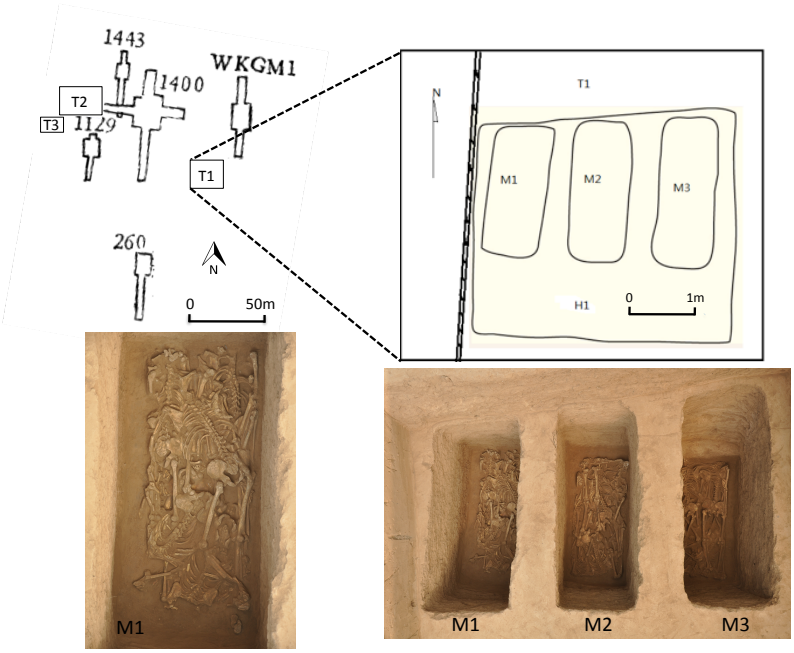

Figure 15 Map and photos of 2013AWBT1M1-M3 (headless pits).

The second group of sacrificial victims (2013AWBT3M9-M10, hereafter M9-M10) was located northwest of the royal tomb M1129 (Figure 16). Remains of at least nine and six individuals were found in the two sacrificial pits, M9 and M10, respectively. This set of sacrificial pits had dimensions of approximately 0.8 x 0.8 x 1.9m, and only cranial elements were found. Osteological analysis revealed similar demographic patterns in this group of victims, where most of the individuals could be identified as late adolescent to young adult males (Wolin n.d.). Due to the lack of diversity of skeletal elements, from this group only one sample was obtained from each individual (see Table 10).

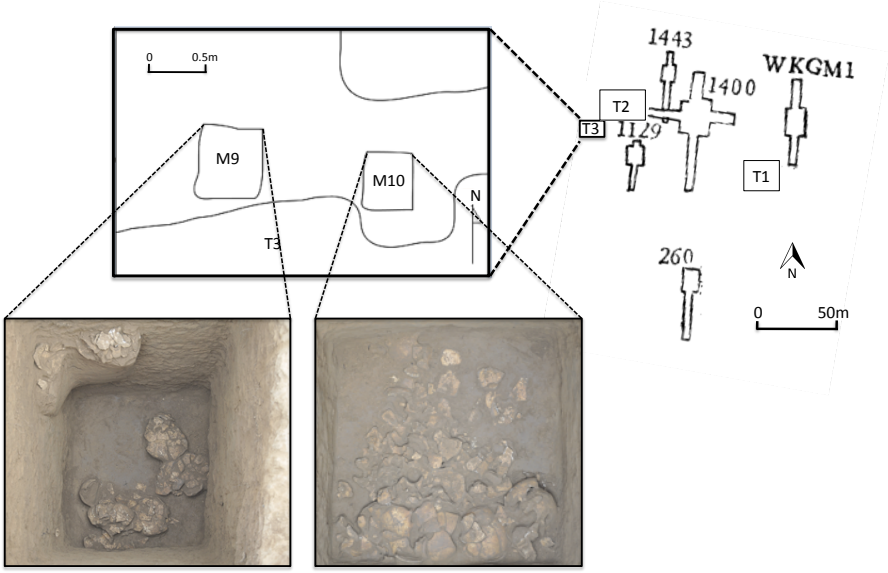

Figure 16 Map and photos of 2013AWBT3M9-M10 (skull pits).

The third group of sacrificial victims came from the royal tomb M260 (Figure 17). Discovered in 1959 and excavated in 1984, 84AWBM260 (hereafter M260) was widely believed to be the tomb of King *Wu Ding*'s spouse, *Fu Jing* 婦姘 (IA CASS 1987; Linduff 2002). The tomb was oriented 5° to the North and had one entrance ramp to the south of the tomb chamber. The biggest and heaviest bronze artifact ever discovered in China, the square tetrapod *Hou Mu Wu Ding* 後母戊鼎[6], was allegedly looted from this tomb in 1939. As with most other royal tombs, the contents of M260 were heavily disturbed, however, archaeologists were able to estimate that there were at least 38 human sacrificial victims in this tomb (IA CASS 1987; IA CASS 1994). Samples from 22 skulls found on the southern ramp of the tomb, and one individual from the waist pit

[6] This tetrapod has been variously referred to as *Si Mu Wu Ding* 司母戊鼎 and *Hou Mu Wu Ding* 後母戊鼎 due to disagreements regarding the interpretation of inscriptions found on the vessel (Cao 2011). For the purpose of this paper we will refer to this vessel as the *Hou Mu Wu Ding*.

(*yaokeng* 腰坑, see Figure 17) were also obtained. The individual buried in the waist pit (M260-23YK) may represent a possible *renxun*. Unfortunately, the 22 skulls have not been analyzed osteologiocally, however, the excavation report did note that M260-23YK was likely an adult male (IA CASS 1987). Although this individual was decapitated, his skull and body were placed in anatomical position on top of a dog, a smashed jade dagger-axe 戈, and three cowry shells (IA CASS 1987).

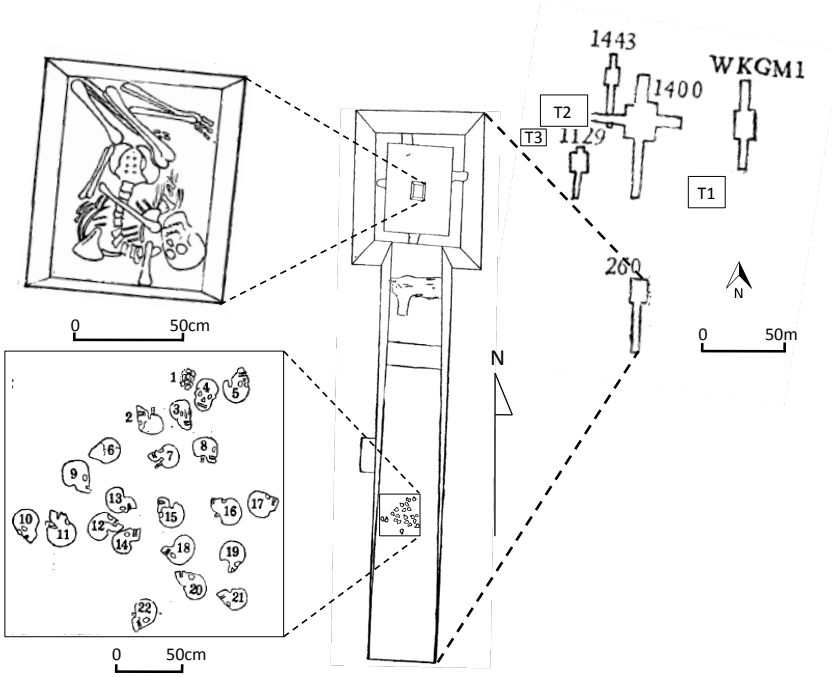

Figure 17 Map and sketches of 84AWBM260, modified from IA CASS excavation report (1987) with permission.

5.4 Results

Animal remains retrieved from the royal cemetery often include species that were not commonly raised or hunted for their meat, such as elephants, horses, and monkeys (Bagley 1999; Fiskesjö 2001), therefore it is believed that the zooarchaeological assemblage found in this context does not represent the typical sources of dietary protein

for the ordinary *Yinxu* inhabitants. Data from previously published reports were used to establish the C and N isotopic baseline of the local *Yinxu* fauna instead (Si 2013; Yan 2010). Furthermore, published $\delta^{13}C$ and $\delta^{15}N$ values from an additional 39 local inhabitants from the *Yinxu* residential neighbourhood XAZ were included in this study to serve as a representation of the typical lower class subsistence pattern seen in *Yinxu* (Chapter 4 – see Table 5). The $\delta^{13}C$ and $\delta^{15}N$ values of all sacrificial victims, local residents, and local fauna are plotted in Figure 18.

With regard to the local sulphur baseline in Anyang, rats (*Rattus rattus*, *Rattus norvegicus*, and *Mus musculus*) are considered to be excellent proxies for human diets in archaeology, mostly due to their commensal relationship with humans (Atahan, et al. 2011; Guiry and Gaulton 2015; Meehan 1984). In addition to sharing the same pool of dietary resources with local residents, rats are also a non-migratory species, making them a good indicator of the local geological sulfur measurements. Therefore, to provide a general estimation of local $\delta^{34}S$ values, $\delta^{34}S$ values were derived from three rats from the sacrificial pit AGBD-T1110H91 and eight local residents from XAZ. The summary statistics of the $\delta^{13}C$ and $\delta^{15}N$, and $\delta^{34}S$ values of all animals and humans mentioned in this study are presented in Table 8 and Table 9, respectively.

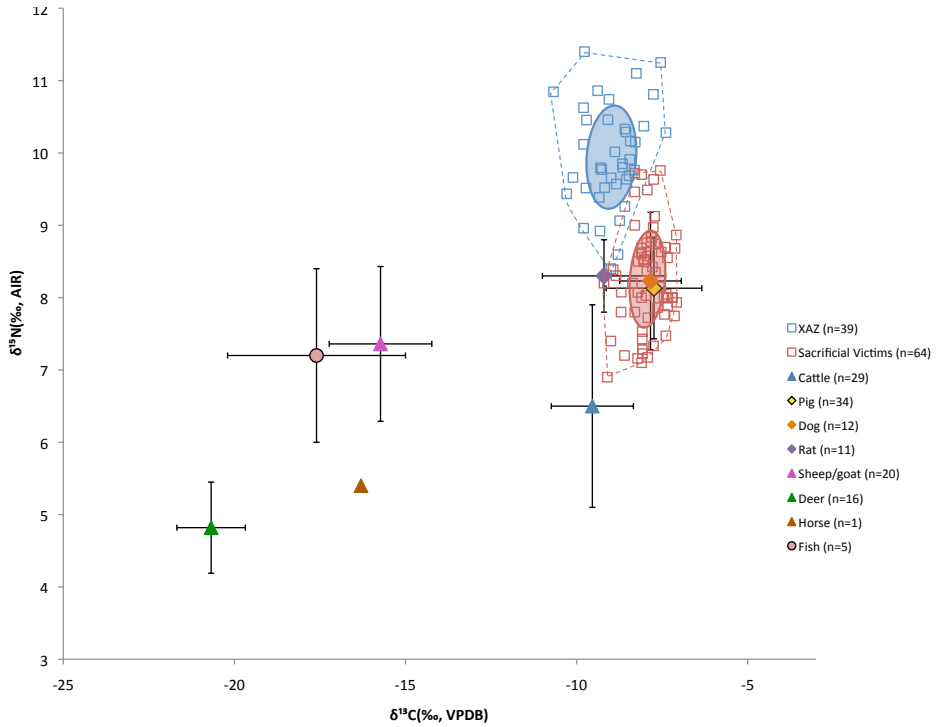

Figure 18 Bone collagen $\delta^{13}C$ and $\delta^{15}N$ values of all sacrificial victims, local residents, and local fauna. Shaded ellipses represent the bivariate SDs of each respective group. Dotted polygons are the convex hull areas.

Table 8 Means and standard deviations of the stable carbon and nitrogen isotopic compositions of all humans and fauna in this study. Faunal data were obtained from published reports (Si 2013; Yan 2010) and local residents data obtained from *Xin'anzhuang* (Chapter 4).

Species	N=?	$\delta^{13}C$ ± SD (‰, VPDB)	$\delta^{15}N$ ± SD (‰, AIR)
Cattle	29	–9.5±1.2	+6.5±1.4
Sheep/Goat	20	–15.7±1.5	+7.4±1.1
Pig	34	–7.7±1.4	+8.1±0.7
Dog	12	–7.8±0.9	+8.2±1.0
Horse	1	–16.3	+5.4
Deer	16	–20.7±1.0	+4.8±0.6
Fish	5	–17.6±2.6	+7.2±1.2
Rat	11	–9.2±1.8	+8.3±0.5
Human (XAZ)	38	–9.0±0.7	+10.0±0.7
Human (all sacrificial victims*)	64	–7.9±0.5	+8.2±0.7
M1-M3 ("Smaller bones")	20	–8.9±0.5	+7.9±0.5
M1-M3 (Femur)	29	–7.8±0.4	+8.2±0.7
M9-M10	13	–8.4±0.5	+8.0±0.8
M260	22	–7.9±0.5	+8.3±0.8

[*] Compared to the "smaller bones", the stable isotopic compositions of femora better represent the lifetime averages of diets of these individuals, rather than dietary practices of their last few years of life. Thus, the femur measurements from M1-M3 are used to represent the M1-M3 data in this summary. See Section 2.2.2 for detailed discussion.

Table 9 Means and standard deviations of the stable sulfur isotopic compositions of all human and fauna in this study.

Species	N=?	δ^{34}S ± SD (‰, VCDT)
Local fauna (rat)	3	+6.3±0.5
Local human (XAZ)	8	+6.7±1.1
Sacrificial victims		
M1-M3 ("Smaller bones")	8	+6.1±0.5
M1-M3 (Femur)	7	+4.9±0.8

Bone preservation was generally good, with approximately 86% (84/98) of the samples from 68 individuals yielding well-preserved collagen. All the results of the accepted C, N, and S measurements, elemental compositions, and sample information are listed in Table 10. Figure 19 plots the bone collagen δ^{13}C and δ^{15}N values of all sacrificial victims against the local residents (XAZ), and Figure 20 plots the δ^{34}S values of all sacrificial victims against the local fauna and local residents.

Table 10 Summary of sample information, elemental compositions, and bone collagen carbon, nitrogen and sulfur isotopic compositions of all samples analyzed in this study.

Context	Sample ID	Sample Name	Species	Element	Sex	Age	% collagen	%C	%N	%S	C:N ratio	C:S ratio	N:S ratio	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	$\delta^{34}S$ (‰)
2013AWBT1	2914	M1-1	Human	R. Radius	M	35-45	1.6%	39.9	13.2	0.2	3.5	507.7	144.0	–8.8	+7.9	+6.6
	4960			L. Femur			15.1%	39.9	14.3	0.2	3.3	533.1	163.8	–7.4	+8.0	+5.5
	2915	M1-2	Human	Tibia	M	20-35	5.1%	35.4	11.6	0.2	3.6	497.9	139.8	–8.9	+8.2	+5.8
	4961			L. Femur			5.1%	36.8	12.5	0.2	3.4	447.0	130.1	–7.9	+9.3	+4.6
	2916	M1-3	Human	L. Humerus	M	20-30	/	/	/		/			/	/	
	4962			L. Femur			9.6%	39.3	13.3		3.5			–7.1	+7.8	
	2917	M1-4	Human	R. Fibula	?	20-35	/	/	/		/			/	/	
	4963			L. Femur			3.5%	36.7	12.5		3.4			–8.9	+8.6	
	2918	M1-5	Human	R. Fibula	M	20-35	3.0%	41.5	14.4	0.2	3.4	462.0	137.4	–8.1	+7.8	+6.0
	4964			L. Femur			6.1%	34.9	12.0	0.2	3.4	490.8	144.7	–8.0	+7.7	+4.7
	2919	M1-6	Human	R. Fibula	M	15-25	/	/	/		/			/	/	
	4965			L. Femur			8.1%	37.6	13.0		3.4			–8.1	+7.5	
	2920	M1-7	Human	L. Fibula	?M	25-35	3.1%	39.2	12.9		3.6			–8.8	+7.9	
	4966			L. Femur			5.6%	35.3	12.1	0.3	3.4	362.8	106.6	–7.1	+7.9	+4.8
	2921	M1-8	Human	R. Fibula	?	15-20	3.9%	32.4	10.9	0.2	3.5	393.5	113.5	–8.2	+8.1	+7.3
	4967			L. Femur			5.2%	38.8	13.0	0.2	3.5	493.4	143.7	–7.6	+8.4	+6.3
	2922	M1-9	Human	L. Ulna	?	18-25	/	/	/		/			/	/	
	4968			L. Femur			9.0%	38.3	13.2		3.4			–7.4	+8.7	
	2923	M1-10	Human	L. Fibula	?	19-30	3.2%	39.0	12.8	0.2	3.6	453.1	127.5	–9.4	+8.1	+5.7
	4969			L. Femur			8.4%	38.9	13.5		3.4			–7.3	+7.9	
	2924	M2-1	Human	R. Fibula	?M	15-30	1.7%	38.3	13.0		3.4			–8.2	+7.5	
	4970			L. Femur			6.0%	33.4	11.3		3.5			–7.8	+7.8	
	2925	M2-2	Human	R. Radius	?M	15-25	1.0%	38.1	12.9		3.5			–8.6	+7.6	
	4971			L. Femur			5.4%	38.9	13.5		3.4			–7.6	+7.6	
	2926	M2-3	Human	L. Fibula	?	15-25	2.3%	33.3	11.8		3.5			–8.7	+6.6	
	4972			R. Femur			7.4%	32.4	10.9	0.2	3.5	432.9	124.8	–8.1	+7.3	+3.6
	2927	M2-4	Human	L. Radius	?	>18	3.6%	23.3	7.8	0.2	3.5	311.3	89.3	–9.4	+7.8	+5.9
	4973			L. Femur			11.0%	35.2	12.0		3.4			–8.0	+8.5	

Context	Sample ID	Sample Name	Species	Element	Sex	Age	% collagen	%C	%N	%S	C:N ratio	C:S ratio	N:S ratio	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	$\delta^{34}S$ (‰)
	2928	M2-5	Human	R. Fibula	?	14-22	5.2%	40.0	13.3	0.2	3.5	534.4	152.3	–8.3	+8.0	+5.8
	4974			L. Femur			11.7%	27.8	9.5	0.3	3.4	265.3	77.7	–8.3	+9.7	+4.5
	2929	M2-6	Human	R. Fibula	?	15-20	3.7%	32.9	10.7		3.6			–9.5	+9.0	
	4975			L. Femur			15.9%	40.6	13.9		3.4			–8.1	+8.6	
	2930	M2-7	Human	R. Fibula	M	35-45	3.4%	29.0	9.6		3.5			–9.9	+8.6	
	4976			L. Femur			4.4%	40.4	13.3		3.5			–7.6	+8.6	
	2931	M2-8	Human	L. Fibula	?M	17-25	2.0%	41.9	14.2	0.2	3.4	599.3	171.2	–8.9	+7.9	+5.9
	4977			L. Femur			9.9%	37.7	12.9		3.4			–7.7	+8.7	
	2932	M2-9	Human	R. Fibula	?	20-35	4.8%	33.6	11.3		3.5			–8.6	+7.2	
	4978			L. Femur			7.7%	39.7	13.9		3.3			–7.6	+8.5	
	2933	M2-10	Human	R. Radius	?M	30-50	/	/	/		/			/	/	
	4979			L. Femur			7.4%	35.7	12.3		3.4			–7.8	+8.3	
	2934	M3-1	Human	L. Radius	?M	20-30	/	/	/		/			/	/	
	4980			L. Femur			3.1%	39.6	13.1		3.5			–8.1	+7.1	
	2935	M3-2	Human	R. Radius	M	40-50	3.8%	29.6	9.9		3.5			–9.0	+8.2	
	4981			R. Femur			3.1%	32.3	10.7		3.5			–8.1	+8.7	
	2936	M3-3	Human	L. Radius	?	15-20	2.2%	22.0	7.3		3.5			–9.5	+8.0	
	4982			R. Femur			4.5%	33.4	11.8		3.3			–7.8	+9.6	
	2937	M3-4	Human	L. Fibula	?M	18-25	/	/	/		/			/	/	
	4983			L. Femur			6.1%	35.8	12.3		3.4			–8.0	+7.1	
	2938	M3-5	Human	L. Ulna	M	30-40	/	/	/		/			/	/	
	4984			L. Femur			6.0%	41.7	14.3		3.4			–7.6	+8.6	
	2939	M3-6	Human	L. Fibula	M	30-40	/	/	/		/			/	/	
	4985			L. Femur			4.6%	30.1	9.9		3.6			–7.8	+8.2	
	2940	M3-7	Human	R. Radius	M	20-35	4.3%	27.5	9.2		3.5			–9.2	+8.1	
	4986			L. Femur			4.5%	40.4	13.4		3.5			–7.9	+8.3	
	2941	M3-8	Human	R. Radius	?M	19-30	3.3%	30.3	10.1		3.5			–8.5	+8.2	
	4987			L. Femur			/	/	/		/			/	/	
	2942	M3-9	Human	L. Radius	?M	20-40	/	/	/		/			/	/	
	4988			L. Femur			4.5%	33.8	11.5		3.4			–8.0	+8.0	

Context	Sample ID	Sample Name	Species	Element	Sex	Age	% collagen	%C	%N	%S	C:N ratio	C:S ratio	N:S ratio	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	$\delta^{34}S$ (‰)
	2943	M3-10	Human	R. Ulna	M	35-50	2.5%	26.0	8.6		3.5			–8.9	+8.3	
	4989			R. Femur			8.0%	36.7	13.0		3.3			–7.1	+8.0	
2013AWBT3	2944	M9-1	Human	Cranium	?	15-25	5.3%	27.8	9.4		3.5			–8.6	+7.2	
	5258	M9-2	Human	Cranium	?M	>15	2.9%	31.2	10.3		3.5			–9.0	+7.4	
	2946	M9-3	Human	Cranium	?M	15-25	3.2%	27.0	9.1		3.5			–8.7	+7.8	
	5260	M9-4	Human	Cranium	M	15-25	1.9%	39.8	13.8		3.4			–8.1	+8.0	
	5261	M9-5	Human	Cranium	M	15-26	2.5%	35.8	12.5		3.4			–9.2	+8.2	
	5262	M9-6	Human	Cranium	M	>15	2.4%	40.1	13.7		3.4			–8.3	+7.8	
	5264	M9-8	Human	Cranium	?M	LA-YA	3.9%	40.0	14.0		3.3			–7.2	+8.0	
	2952	M9-9	Human	Cranium	?	?	4.6%	30.7	10.4		3.5			–8.2	+8.5	
	3249	M10-2C	Human	Cranium	?	LA-YA	3.4%	27.3	9.5		3.4			–9.1	+6.9	
	2955	M10-3	Human	Cranium	M	A	6.9%	35.7	12.1		3.5			–8.1	+7.1	
	5269	M10-4	Human	Cranium	?M	?	3.4%	40.6	13.7		3.5			–8.1	+8.6	
	5270	M10-5	Human	Cranium	?M	?	2.8%	41.1	14.2		3.4			–8.1	+9.7	
	5272	M10-6A	Human	Cranium	?	15-25	2.8%	39.2	13.4		3.4			–8.3	+9.0	
84AWBM260	5294	1	Human	Cranium			3.0%	35.6	12.2		3.4			–7.4	+8.7	
	5295	2	Human	Cranium			1.9%	37.5	12.7		3.4			–8.1	+7.3	
	5296	3	Human	Cranium			2.8%	39.4	13.3		3.5			–8.0	+8.5	
	5297	4	Human	Cranium			4.5%	40.4	13.9		3.4			–7.1	+8.7	
	5298	5	Human	Cranium			5.3%	40.1	14.2		3.3			–7.2	+7.9	
	5299	6	Human	Cranium			2.8%	37.5	12.8		3.4			–7.8	+8.7	
	5300	7	Human	Cranium			3.4%	38.5	13.5		3.3			–7.5	+7.9	
	5301	8	Human	Cranium			3.4%	41.3	14.4		3.4			–7.7	+7.4	
	5302	9	Human	Cranium			4.0%	40.2	14.1		3.3			–7.7	+7.8	
	5303	10	Human	Cranium			3.1%	40.6	14.2		3.3			–7.5	+9.9	
	5304	11	Human	Cranium			3.1%	39.4	13.3		3.4			–8.3	+8.7	
	5305	12	Human	Cranium			4.0%	39.7	13.8		3.3			–8.0	+8.9	
	5306	13	Human	Cranium			2.2%	38.4	13.0		3.4			–8.7	+8.2	
	5307	14	Human	Cranium			3.1%	38.2	12.9		3.5			–8.2	+8.0	
	5308	15	Human	Cranium			3.1%	38.7	13.3		3.4			–8.0	+10.0	

Context	Sample ID	Sample Name	Species	Element	Sex	Age	% collagen	%C	%N	%S	C:N ratio	C:S ratio	N:S ratio	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	$\delta^{34}S$ (‰)
	5309	16	Human	Cranium			4.4%	42.2	14.8		3.3			–7.5	+7.8	
	5310	17	Human	Cranium			3.3%	39.7	13.7		3.4			–7.4	+7.9	
	5311	19	Human	Cranium			1.8%	38.9	13.2		3.4			–8.0	+6.9	
	5312	20	Human	Cranium			2.7%	76.7	12.7		7.0			–8.2	+7.5	
	5313	21	Human	Cranium			1.9%	34.8	11.5		3.5			–9.1	+8.5	
	5314	22	Human	Cranium			2.1%	40.0	13.4		3.5			–8.4	+8.3	
	5315	YK	Human	Cranium	M	?	2.3%	40.9	14.4		3.3			–8.3	+9.4	
07AXA	388	M30	Human		F	25-29	13.8%	44.4	15.7	0.2	3.3	565.0	171.2	–8.3	+10.2	+9.1
	389	M35	Human		M	30-35	11.1%	42.1	14.2	0.2	3.5	535.7	154.9	–9.3	+9.8	+6.8
	393	M54	Human		M	30-38	11.2%	42.3	14.5	0.2	3.4	513.8	151.0	–9.1	+10.5	+6.2
	400	M233	Human		M	35-39	10.8%	44.2	15.5	0.2	3.3	492.1	147.9	–8.4	+10.2	+6.3
	402	H201	Human		F	25-30	5.6%	42.0	14.5	0.3	3.4	431.6	127.7	–8.7	+9.1	+7.0
	734	M81	Human		?	?	12.7%	44.7	16.2	0.2	3.2	597.2	185.5	–7.4	+10.3	+5.9
	747	M139	Human		M	30-40	5.0%	41.0	14.1	0.2	3.4	521.7	153.8	–7.8	+10.8	+5.8
AGBDT1110	4427	H91	Rat	R. Mandible			6.9%	42.1	13.7		3.6			–9.9	+9.0	
	4454	H91	Rat	L. Femur			8.4%	40.7	13.9	0.2	3.4	494.7	144.9	–8.8	+7.6	+6.5
	4456	H91	Rat	L. Tibia			6.7%	41.2	14.2		3.4			–7.7	+8.3	
	4459	H91	Rat	R. Mandible			7.4%	39.2	13.2		3.5			–8.4	+8.5	
	4460	H91	Rat	L. Femur			6.5%	43.1	14.4	0.2	3.5	479.3	136.9	–7.4	+7.7	+5.7
	4461	H91	Rat	L. Femur			8.4%				3.5			–11.1	+8.6	
	4463	H91	Rat	L. Mandible			5.9%				3.6			–9.1	+8.4	
	4465	H91	Rat	L. Mandible			5.4%				3.6			–12.2	+8.8	
	4466	H91	Rat	L. Humerus			4.8%				3.4			–7.0	+7.8	
	4467	H91	Rat	L. Humerus			6.8%				3.5			–11.6	+8.5	
	4470	H91	Rat	L. Humerus			6.8%	42.6	14.5	0.2	3.4	517.3	151.4	–7.8	+8.4	+6.6
	4415	H91	Fish	Vertebra			4.2%	40.0	13.6		3.4			–6.4	+8.4	
	4419	H91	Fish	Mandible			3.0%	40.3	13.1		3.6			–21.7	+5.8	
	4428	H91	Fish	Vertebrae			6.2%	40.5	13.8		3.4			–14.9	+6.4	
	4434	H91	Fish	Vertebrae			7.1%	42.1	14.1		3.5			–16.8	+6.9	
	4439	H91	Fish	Vertebra			6.0%	41.6	14.0		3.5			–18.0	+8.3	

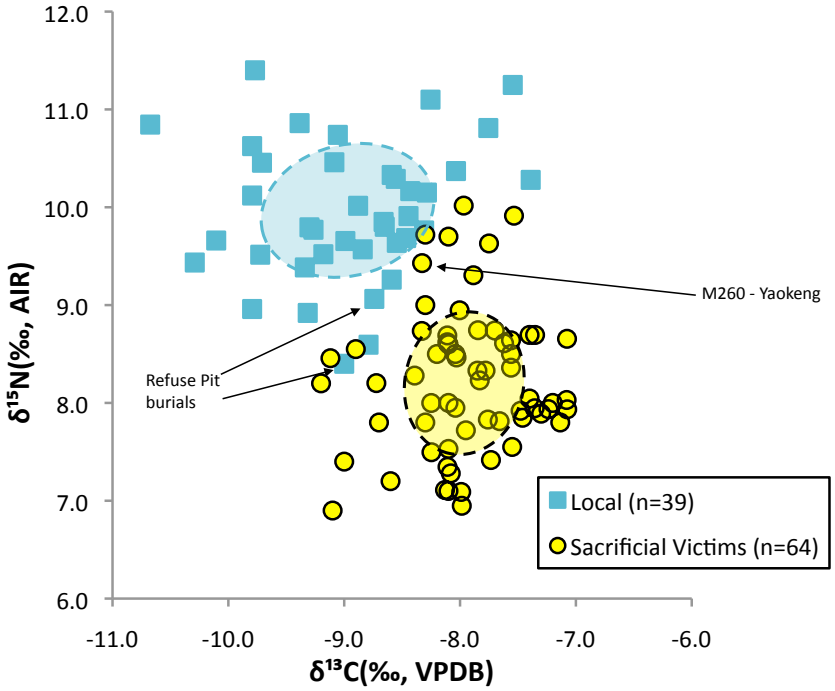

Figure 19 Plot showing differences in $\delta^{13}C$ and $\delta^{15}N$ values between the XAZ residents and all sacrificial victims examined in this study (M1-M3 Femur, M9-M10, and M260). Shaded ellipses represent the bivariate SDs of the respective group.

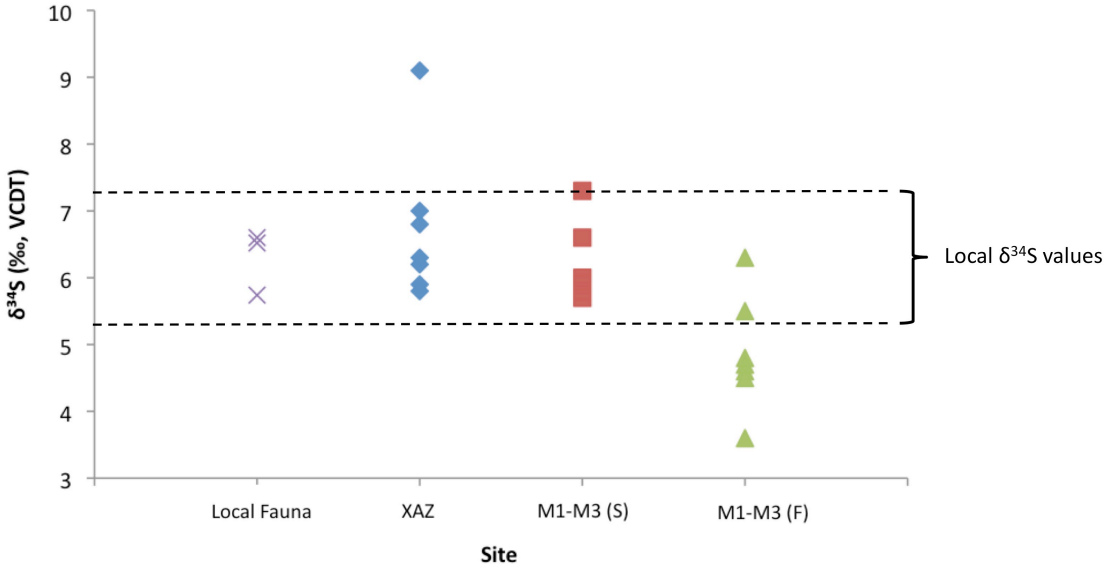

Figure 20 Plot comparing the $\delta^{34}S$ values (‰) of *Yinxu* local fauna, local residents, and M1-M3 sacrificial victims. M1-M3 (S) corresponds to the "smaller bones" measurements of the M1-M3 group M1-M3 (F) corresponds to the femoral measurements of the M1-M3 group. Dotted line illustrates the estimated range of local $\delta^{34}S$ baseline values in *Yinxu*.

Inter-site comparisons

In Figure 19 the $\delta^{13}C$ and $\delta^{15}N$ values of all the sacrificial victims are compared with those of the 39 local residents of XAZ. For the individuals from M1-M3, measurements from femora are used to represent the group. As mentioned in Section 2.2.2, femoral bone has a slower turnover rate than other smaller skeletal elements, therefore the carbon and nitrogen isotopic compositions of femur and "smaller bones" should represent the averages of long-term and short-term dietary patterns of an individual, respectively. Hence, in cases where individuals moved long distances during their lifetimes, femoral isotopic compositions would be more reflective of earlier dietary practices for these individuals, whereas "smaller bones" would reflect the diets later in life. Figure 19 demonstrates that the C and N isotopic compositions of these sacrificial victims were significantly different than those of the local residents of XAZ. Unpaired independent-samples *t* tests confirmed that there were significant differences in the $\delta^{13}C$ values ($t(101)=-8.236$, $p=<0.001$) as well as the $\delta^{15}N$ values ($t(101)=11.894$, $p=<0.001$) between the two groups.

The $\delta^{34}S$ values of the two populations demonstrated a similar trend. As shown in Figure 20, the femoral $\delta^{34}S$ values of the sacrificial victims from M1-M3 clearly deviate from the $\delta^{34}S$ values of the local fauna and residents. Unpaired independent-samples *t* tests confirmed that the $\delta^{34}S$ values of the local residents (XAZ) are significantly higher than those of the sacrificial victims (represented by M1-M3 femur values) ($t(12)=3.4995$, $p=<0.01$).

Intra-site comparisons

The bone collagen $\delta^{13}C$ and $\delta^{15}N$ values were compared among the four groups of sacrificial victims (Figure 21). The groups had statistically different mean $\delta^{13}C$ values, as determined by one-way ANOVA ($F(3,80)=24.42$, $p=<0.001$). A Tukey HSD post-hoc test further confirms that the mean $\delta^{13}C$ value of "smaller bones" from M1-M3 is significantly different than those of the other three groups (see Table 11). The differences between the means of M9-M10 and M1-M3 femur $\delta^{13}C$ values, and that between M9-M10 and M260 are also statistically significant, despite the small magnitude of the differences (0.6‰ and 0.5‰ respectively). There is no difference observed between the mean $\delta^{13}C$ values of M260 and M1-M3 femora. In terms of $\delta^{15}N$ values, there is no significant difference observed among the three groups, as determined by one-way ANOVA ($F(3,80)=1.326$, $p=0.272$).

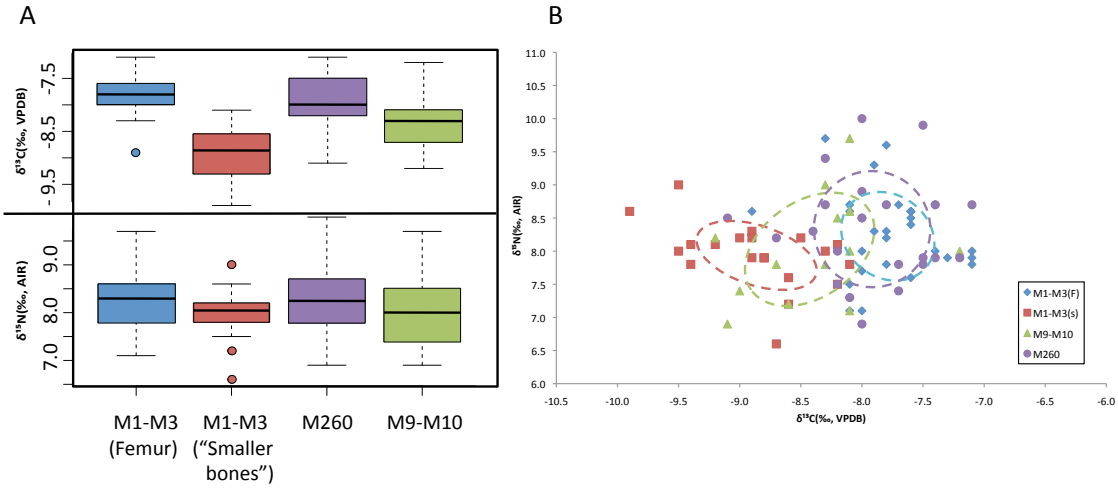

Figure 21 Differences in dietary patterns between the three groups of sacrificial victims: (A) Box plots compare the distributions of $\delta^{13}C$ and $\delta^{15}N$ values in these three groups, respectively. (B) Scatter plot showing differences in $\delta^{13}C$ and $\delta^{15}N$ values between these three groups, dotted ellipses represent the bivariate SDs of the respective group.

Table 11 Descriptive table of Tukey HSD post-hoc test, testing the differences in $\delta^{13}C$ values between the different groups of sacrificial victims. Diff: difference in means; lwr: lower boundary; upr; upper boundary; P adj: P values.

	Diff	lwr	upr	P adj
M1-M3(s) vs. M1-M3(f)	–1.08	–1.44	–0.73	<0.001
M260 vs. M1-M3(f)	–0.13	–0.48	0.22	0.77
M9-M10 vs. M1-M3(f)	–0.60	–1.01	–0.19	<0.01
M260 vs. M1-M3(s)	0.96	0.58	1.34	<0.001
M9-M10 vs. M1-M3(s)	0.49	0.05	0.92	<0.05
M9-M10 vs. M260	–0.47	–0.90	–0.04	<0.05

Intra-skeletal comparisons

For samples from M1-M3, the C and N measurements of the "smaller bones" were compared with those of the "femora". Figure 22 shows that the femur measurements were more enriched in both ^{13}C and ^{15}N.

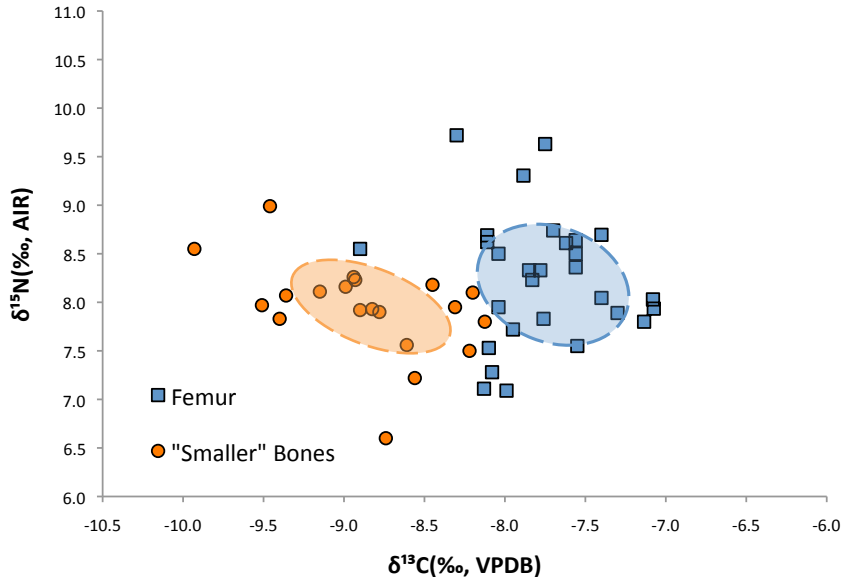

Figure 22 Plot showing the $\delta^{13}C$ and $\delta^{15}N$ values of the femora and "smaller bones" of individuals from M1-M3. Shaded ellipses represent the bivariate SDs of the respective group.

Similar effects have been observed with the sulfur measurements. As shown in Figure 20, the $\delta^{34}S$ values of the "smaller bones" from M1-M3 were more similar to those of the XAZ residents than to those from the femora from M1-M3. This is confirmed by a one-way ANOVA test comparing the three groups ($F(2,19)=8.621$, $p=<0.01$). A post-hoc Tukey HSD test further identifies that the differences in mean $\delta^{34}S$ values are most significant between the femora and "smaller bones" from M1-M3 ($p=0.03$), and between the femora of M1-M3 and the local residents ($p=<0.01$).

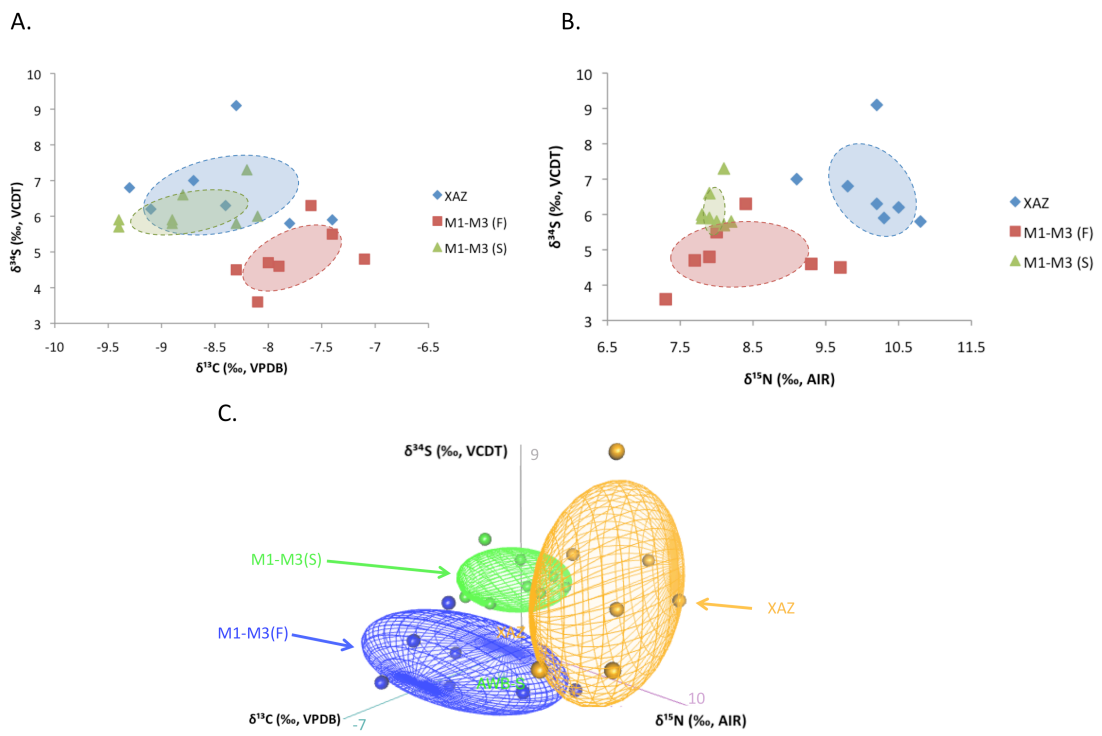

Figure 23 Plots comparing the $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ values between femora and "smaller bones" of individuals from M1-M3 and XAZ residents: A) bone collagen $\delta^{13}C$ and $\delta^{34}S$ values of the three groups; B) bone collagen $\delta^{15}N$ and $\delta^{34}S$ values of the three groups; C) bone collagen $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ values of the three groups. In A) and B), shaded ellipses represent the bivariate SDs of the respective group. In C) shaded ellipsoids represent concentrations of points in each group.

Furthermore, Figure 23 demonstrates that depending on whether $\delta^{34}S$ values are compared with $\delta^{13}C$ values (Figure 23A) or $\delta^{5}N$ values (Figure 23B), "smaller bones" from M1-M3 vary from appearing to be more similar with the XAZ residents, to more similar with femora from M1-M3, respectively. However, Figure 23C clearly demonstrates that when all three isotopes were considered together, the three groups formed distinct clustering. This observation was confirmed by a one-way MANOVA test ($F(2,19)=11.947$, Pillai's Trace = 1.3314, $p=<0.001$). Further ANOVA tests confirmed that the differences were significant across all C ($F(2,19)=6.1595$, $p=<0.01$), N ($F(2,19)=28.164$, $p=<0.01$), and S ($F(2,19)=8.621$, $p=<0.01$) measurements.

In order to better understand the intra-individual isotopic variation, the "smaller bones" and "femur" C and N measurements from each individual were paired, and the magnitude and direction of changes in diet from earlier to later in life were presented in a circular diagram (Figure 24). Due to the poorer preservation of the "smaller bones", only 19 individuals had measurements from two bone elements. On average these 19 individuals had a –1.4‰ shift in $\delta^{13}C$ values and –0.3‰ shift in $\delta^{15}N$ values, with an average magnitude of 1.4‰ (the orange arrow).

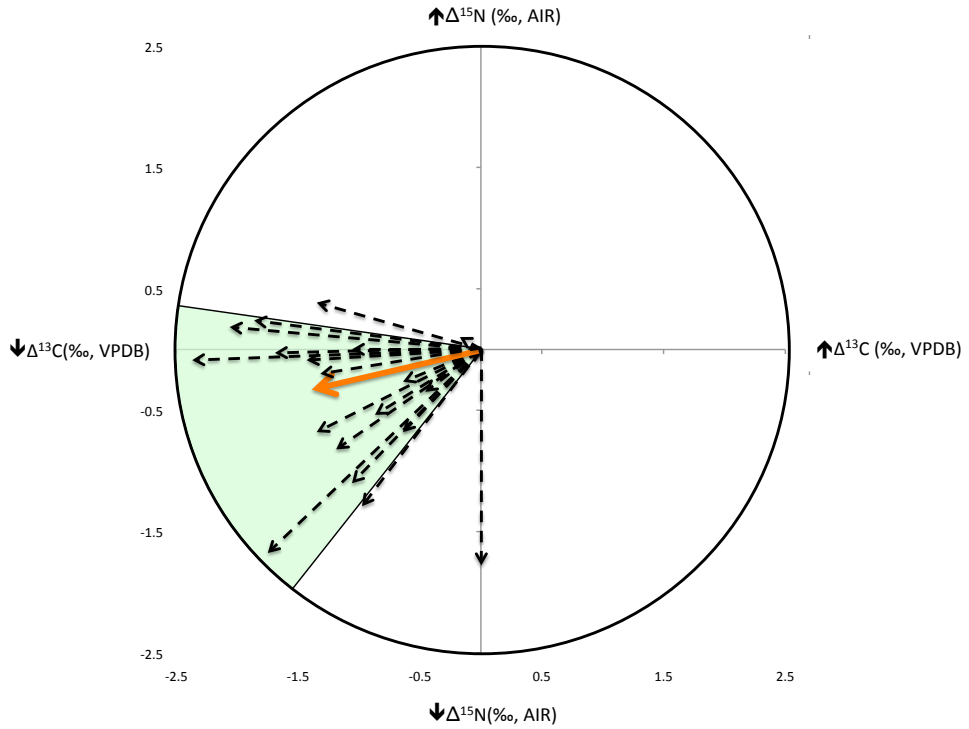

Figure 24 Circular diagram showing the directions and magnitudes of dietary changes among the group of sacrificial victims from M1-M3. The shift is expressed by the vector (*x*, *y*), where *x* represents the net shift in $\delta^{13}C$ values over time ($\Delta^{13}C = \delta^{13}C_{\text{"smaller bones"}} - \delta^{13}C_{\text{femur}}$) and *y* represents the net shift in $\delta^{15}N$ values over time ($\Delta^{15}N = \delta^{1}N_{\text{"smaller bones"}} - \delta^{15}N_{\text{femur}}$). Each dotted arrow corresponds to a single individual, the length of the arrow represents the magnitude of change, while the angle of the line represents the angle of change. The shaded area expresses the angular SD of change, and the orange arrow represents the mean magnitude and direction of change among all samples.

Unfortunately, only five individuals from M1-M3 were measured for all three isotopes in both a femur and "smaller bone". As shown in Table 12, the shifts in $\delta^{34}S$ values among these five individuals were not only uniform in direction (all positive gain), but also highly consistent in magnitude.

Table 12 Summary information for the five sacrificial victims with all carbon, nitrogen, and sulfur isotope measurements from both a femur and "smaller bone" and the magnitude of dietary shift between the two elements expressed in isotopic measurements (‰).

	Femur			"Smaller bone"			Shift from femur to "smaller bone"		
Sample names	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	$\delta^{34}S$ (‰)	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	$\delta^{34}S$ (‰)	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	$\delta^{34}S$ (‰)
M1-1	–7.4	+8.0	+5.5	–8.8	+7.9	+6.6	–1.4	–0.1	+1.1
M1-2	–7.9	+9.3	+4.6	–8.9	+8.2	+5.8	–1.0	–1.1	+1.2
M1-5	–8.0	+7.7	+4.7	–8.1	+7.8	+6.0	–0.1	+0.1	+1.3
M1-8	–7.6	+8.4	+6.3	–8.2	+8.1	+7.3	–0.6	–0.3	+1.0
M2-5	–8.3	+9.7	+4.5	–8.3	+8.0	+5.8	0.0	–1.7	+1.3

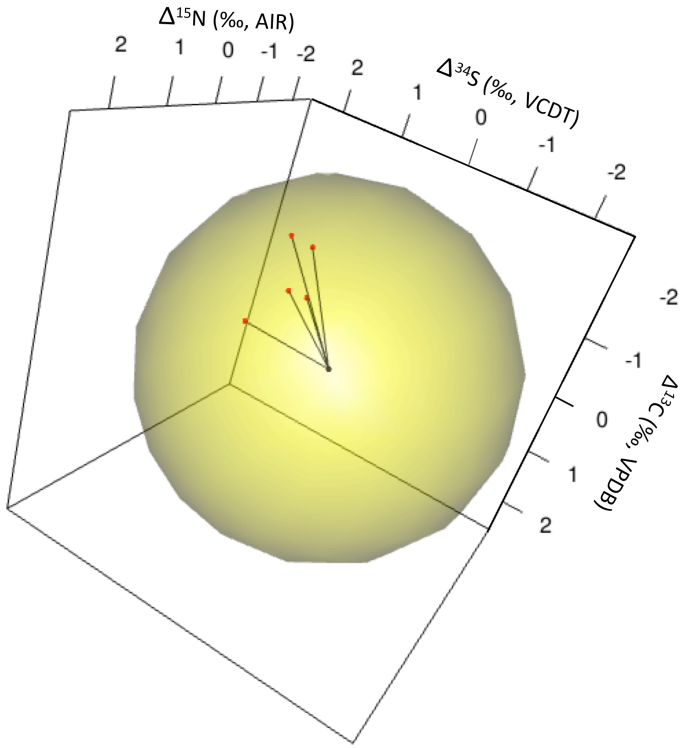

Figure 25 3D plot showing the directions and magnitudes of net dietary changes in terms of carbon, nitrogen, and sulfur isotopic compositions among five individuals from M1-M3.

Quantifying dietary compositions

A dual isotope (C, N), Bayesian isotope mixing model, SIAR, was applied to quantify the proportions of different protein sources in each population's diet. While the exact origin of the sacrificial victims is still unknown to us, it would be meaningless to

interpret their $\delta^{13}C$ and $\delta^{15}N$ values without an idea of the local baseline values or a prior knowledge of any cultural-specific dietary preferences. However, carbon and nitrogen isotope compositions of the "smaller bones" from the sacrificial victims from M1-M3 (herein M1-M3[s]) should represent the average diet consumed by these sacrificial victims while they were living in *Yinxu*. As a result, the dietary composition of the sacrificial victims when they were living in *Yinxu* (M1-M3 [s]) was reconstructed and compared with those of the local population. Assuming the source data accurately represent the isotopic values of dietary subsistence for both populations, the mixing model suggests that as much as 50-60% of the dietary protein for the local population came from terrestrial animal proteins, compared to less than 20% for the sacrificial victims (Figure 26).

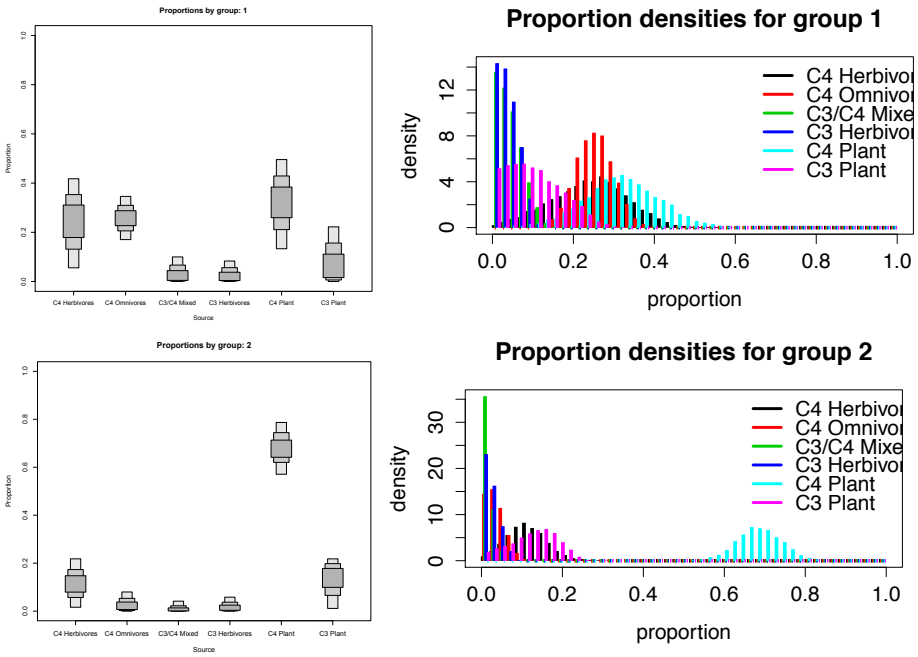

Figure 26 Variation in estimated contribution of different dietary protein in the diets of two populations: Group 1 refers to XAZ residents; Group 2 refers to sacrificial victims M1-M3 (s). Estimated posterior distributions of all six sources for each respective group are shown as box plots (on the left) and density histograms (on the right).

5.5 Discussion

Inter-site comparisons

The $\delta^{13}C$ and $\delta^{15}N$ values of all the sacrificial victims range from –7.1 to –9.5‰ and +6.6 to +10.0‰, respectively. This suggests that the group relied heavily on C_4 crops (e.g. millets) and their derived by-products, which is consistent with historical records as well as archaeological evidence from many contemporary sites in the region (Barton, et al. 2009; Chang 1976; Hou, et al. 2013; IA CASS 2003; Keightley 1999; Li 1977; Liu, et al. 2012; Liu, et al. 2014). The carbon and nitrogen stable isotope data show that the sacrificial victims had diets that were enriched in ^{13}C and depleted in ^{15}N in comparison to the diets of the local residents from XAZ. Even though both groups appeared to be subsisting on a largely C_4-based diet, the XAZ group had $\delta^{13}C$ values that were on average 1.1‰ lower than those of the sacrificial victims, suggesting that the XAZ group might have further supplemented their diets with small amounts of C_3 crops (e.g. wheat, rice) or wild animals (e.g. fish, deer). This inference is supported by both archaeological evidence as well as oracle inscriptions (Chang 1977; Chen 1985; Fiskesjö 2001; IA CASS 2003; Yang and Ma 2010; Zhu 2005).

On the other hand, the $\delta^{15}N$ values of these sacrificial victims are on average 1.9‰ lower than those of the XAZ residents, suggesting that they had more restricted access to animal protein. The potential *renxun*, M260-YK appeared to have a higher $\delta^{15}N$ value when compared to the majority of the other sacrificial victims ($\delta^{15}N_{M260\text{-}YK}$value = +9.4‰; average $\delta^{15}N_{sacrificial\_victims}$ value = +8.2±0.7‰; average $\delta^{15}N_{M260}$ value = +8.3±0.8‰; see Figure 19 and Table 8). However, with only one sample, it is difficult to determine whether this observation would hold true for all other *renxun*.

Additionally, the mean $\delta^{15}N$ value of the sacrificial victims is even lower than that of the two refuse pit burials in XAZ (Figure 19). This observation indicates that these sacrificial victims were eating a poorer diet than those buried in the refuse pits, implying that they likely belonged to the lowest socio-economic class in Shang society. This is supported by our mixing model, which suggests that on average, the XAZ residents had access to 30 to 40% more animal protein than the sacrificial victims. Although the application of a Bayesian mixing model to reconstruct the dietary compositions of organisms with complicated feeding habits, such as humans, can be problematic, this exercise has nonetheless presented a means by which the differences between the dietary compositions of two populations can be quantified. Furthermore, the proportion of consumed C_4 herbivores (cattle) compared to C_4 omnivores (pigs) agrees well with zooarchaeological evidence from a nearby bone workshop (Campbell, et al. 2011), thus suggesting that this estimation is reasonable. Unfortunately, as there are no available sulfur measurements from fauna, it is not possible to conduct a dietary reconstruction using a three-isotope mixing model. In fact, the number of samples in this project with S measurements is far too few for truly representative dietary modeling. It is hoped that in the future more samples, both human and faunal, can be analyzed for their sulfur isotopes, which would significantly enhance the resolution of this study.

Intra-site comparisons

There are small but significant differences in the dietary patterns between the three sets of sacrificial victims. The low $\delta^{15}N$ values suggest that all these victims had little input of animal protein in their diet. The $\delta^{13}C$ values suggest all groups of victims

from M260 and M1-M3 (femora) had diets that were isotopically homogenous. Even though current evidence is insufficient to support the claim that these individuals had a common origin, the overall homogeneity in isotopic compositions of these three sets of sacrificial victims suggests that this might be the case.

Intra-skeletal comparisons

The intra-skeletal analysis of the sacrificial victims from M1-M3 suggests that these individuals had shifted to a diet with lower $\delta^{13}C$ and $\delta^{15}N$ values, and higher $\delta^{34}S$ values, later in life (Figure 23 and Figure 24). One possible explanation is that the group moved to *Yinxu* from a place where the diet was more enriched in both ^{13}C and ^{15}N, and depleted in ^{34}S, than the local diet available to them in *Yinxu*. As the magnitude and direction of dietary change among these individuals are fairly consistent, it is likely that these individuals moved to *Yinxu* as a group. Furthermore, the $\delta^{13}C$ and $\delta^{34}S$ values of these sacrificial victims were trending towards those of the XAZ residents (see Table 8 and Table 9). This indicates that these individuals had lived in *Yinxu* for at least a few years – long enough for the new diet to start showing in their "smaller bones".

Overall Significance

The results from this study have significant implications for understanding the roles and origins of sacrificial victims in the Shang Dynasty. First, the isotopic data have verified the historicity of oracle bone inscriptions, which state that many of the sacrificial victims from the royal cemetery were non-locals. Second, the overall isotopic homogeneity of these three sets of sacrificial victims further substantiates the claim that a

particular group of individuals was preferred as sacrificial victims by the Shang kings. Finally, the intra-individual comparisons suggest that some sacrificial victims, at least those from M1-M3, were kept in *Yinxu* for several years before being sacrificed. This time frame is much longer than the previously estimate from oracle bone inscriptions, where war captives were thought to be killed within eight days (Yao 1979:389). With this new information, the hypothesis proposing that sacrificial victims were involved in economic production prior to their executions would be more likely, as it would be highly uneconomical to keep and support a large number of late adolescent/young adult males in captivity for years without involving them in economic production. Furthermore, the early Shang scholar Yang Sheng Nan reported that on more than one occasion, Shang nobles and vassals had to ask for the king's permission to offer *Qiang* captives to the king for sacrifice, and only after consulting an oracle the king would demand a specific date for the delivery of such captives (Yang 1988:139). Yang thus argued that war captives were offered for sacrifice upon request, not upon availability. This implies that even though war captives offered to the king may have been executed relatively promptly, prior to being "received" by the king, Shang nobles or vassals could have kept the war captives in their household as slaves for a period of time, before turning them over to the king at the right time (Yang 1988:139-140).

Having only analyzed a small fraction of the human sacrificial victims from the royal cemetery (possibly < 1%), at this time it is difficult to determine if all sacrificial victims habitually laboured for a few years before being killed in various ceremonies. The current methods used to date the royal tombs and sacrificial pits in the royal cemetery are limited to stratigraphic analysis and artifact typology based on the burial

goods occasionally missed by looters. With M260, the inscriptions on the bronze tetrapod *Hou Mu Wu Ding* have allowed the dating of the tomb to roughly phase 2 (Hu 2010). However, it is much harder to date the sacrificial pits, as few burial goods were found associated with these pits. Consequently, the two sets of sacrificial pits involved in this study cannot be situated within the overall temporal framework of the royal cemetery. Thus, it is impossible to determine if the sacrificial victims of the earlier period were killed sooner after capture than those of the later period.

Although this study could benefit from more contextual data, this limitation should not stop us from analyzing and interpreting the stable isotopic data generated to date. With sound statistical techniques and an awareness of present analytical limitations, data generated from this study can still provide a solid quantitative assessment of dietary differences between the local residents and the sacrificial victims. And by confirming the hypothesis that many sacrificial victims in *Yinxu* were foreign, and likely participated in productive labour, this study has provided a unique glimpse into the relationship between sacrificial rituals and the political-economic processes of the late Shang society.

5.6 Conclusion and Future Studies

In this study, the carbon, nitrogen, and sulfur isotopic variations among and between groups of sacrificial victims from *Yinxu* were examined, and evidence of migration in these individuals was identified. Thus, this study has provided the first direct evidence of non-locals being sacrificed in *Yinxu*. In addition, this study has also demonstrated that even though most contemporaneous groups in the Central China Plain were subsisting on a largely C_4-based diet (Barton, et al. 2009; Hou, et al. 2013), there are

still subtle but significant local variations among these different groups, sufficient to detect migrational activities through intra-skeletal C, N, and S isotopic analysis. This is particularly important for investigating the origins of sacrificial victims in *Yinxu*, as many of these victims were buried headless, making tooth enamel unavailable for isotope analyses (e.g. strontium). Nevertheless, this study has provided a strong methodological framework for future analyses on this topic.

To conclude, this study has provided valuable insight into the life histories and social identities of 64 sacrificial victims in *Yinxu* and has illuminated novel details on the political and economic organization of the late Shang state. However, as only three groups of sacrificial victims have been included in this study, the analytical data generated is not adequate to confirm the hypothesis regarding the *Qiang*-origin of most sacrificial victims in *Yinxu*, or to answer questions concerning the schematics of early Bronze Age sacrificial rituals. This evidence also does not lead us to reject any of these interesting theories. These questions should be addressed by future research projects, by expanding the number and range of sample collection, improving the chronological resolutions of these sacrificial pits, as well as building a better osteological database of both the sacrificial victims and local populations.

6. Social Dynamics in Early Bronze Age China[7]

6.1 Introduction

Yinxu has long been the center of attention for scholars who are interested in understanding the nature and processes of state formation in Early Bronze Age China (Campbell 2009; Chang 1980b; Keightley 1983; Liu and Chen 2012; Trigger 2003; Yates 1994). Traditionally, historical texts led us to believe that the Shang was the only civilized power in the Central China Plain 中原地區 in Bronze Age China (Bagley 1999; Campbell 2009; Chang 1980b; Wheatley 1971). Accordingly, *Yinxu* was long-regarded as the capital of an extensive and powerful empire. However, this uncomplicated view is now being criticized as being too "Anyang-centered" (Thorp 2006:214). After all, the only surviving written records from this period, inscriptions on oracle bones and bronze vessels, were composed or commissioned by the ruling house. As such, these inscriptions were likely affected, or even motivated by various political agendas (Allan 1991; Bagley 1999; Bagley 2004; Fiskesjö 2001). Also, more and more complex archaeological sites contemporary with, and distinct from the Shang culture have been discovered in the last few decades, e.g. *Sanxingdui* 三星堆 in the west and *Wucheng* 吳城 in the south. The rich collections of stylistically distinct artifacts found in these sites indicate sophisticated social organization as well as a high level of technological knowledge comparable with the Shang culture (Bagley 1999; Chang 1980; Liu and Chen 2012; Maisels 2010; Thorp 1985; Thorp 2005b). Thus, instead of assuming that the Shang had maintained absolute

[7] This chapter is adapted from an unpublished manuscript: [C Cheung, ZC Jing, JG Tang, and MP Richards: Social Dynamics in Early Bronze Age China: A Multi-Isotope Approach].

political and military supremacy over its neighbouring polities, a more realistic interpretation is that of a "multiple-centers view", where the Shang's relationship with its neighbours was a two-way exchange system where goods, natural resources, labour, and knowledge travelled both into and out of *Yinxu* (Bagley 1999; Keightley 1983; Thorp 1985; Thorp 2006).

This study will build upon the earlier chapters on the social dynamics in *Yinxu* (Chapter 4) and the social identity of sacrificial victims (Chapter 5), by using a multi-isotope approach (C, N, and S) to explore the social dynamics of the Shang Dynasty within a larger context. In this study the C, N, and S isotopic ratios from 16 individuals from three other contexts in *Yinxu*, and 26 individuals from six late Neolithic to early Bronze Age sites across the Central China Plain (Figure 27:①–⑦) are measured. In addition, C and N measurements of a total of 234 individuals from an additional six contemporaneous sites in the Hexi Corridor from published reports (Liu, et al. 2014; Ma, et al. 2013) are included to widen the geographical scope of this analysis (Figure 27: ⑧–⑬). By including sites outside of *Yinxu*, this study will first investigate into the possible origins of sacrificial victims in *Yinxu*, and second, explore the cultural contacts and exchanges between *Yinxu* and other communities beyond the acquisition of sacrificial victims, and involving a broader range of cultural groups. Finally, this study aims to test whether sulfur isotope analysis can be used alongside with carbon and nitrogen isotope analyses to examine the mobility patterns in the Central Plain of China.

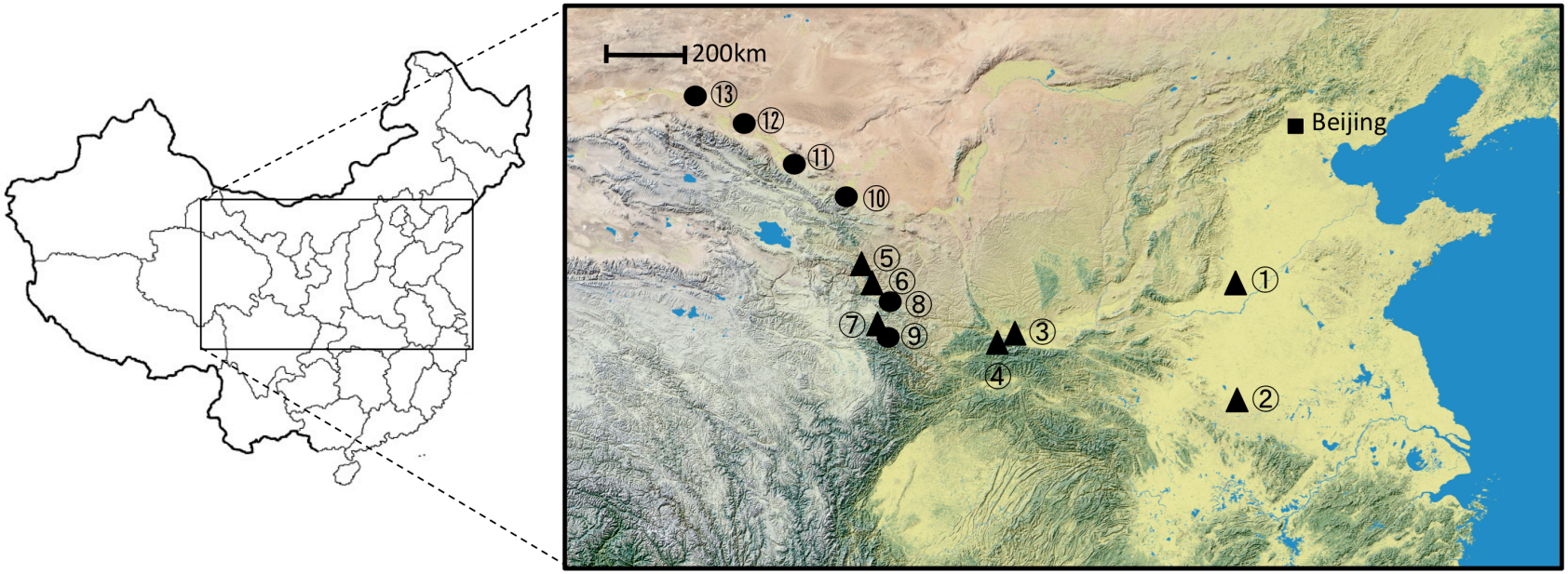

Figure 27 Locations of all sites mentioned in this study: ①*Yinxu*; ②Runlou; ③Zhouyuan; ④Shigushan; ⑤Xiahaishi; ⑥Lianhuatai; ⑦Zhanqi; ⑧Qijiaping; ⑨Mogou; ⑩Mozuizi; ⑪Wuba; ⑫Ganguya; ⑬Huoshaogou. ▲corresponds to sites with carbon, nitrogen and sulfur measurements, ●corresponds to sites with only carbon and nitrogen measurements.

6.2 Political Geography of Early Bronze Age China

Most of our current knowledge about the neighbours of the Shang comes from oracle bone inscriptions, along with a few inventory records inscribed on imported goods (Bagley 1999; Jung 1989; Thorp 2006). Over 500 place names (Keightley 1983; Wheatley 1971), and 158 names of *fang guo* 方國, or polities, have been mentioned in Shang oracle and bronze inscriptions (Sun and Lin 2010:239). Divination topics on oracle bones discussing Shang's neighbours varied greatly, from asking for services from certain groups, praying for an ally's safekeeping, to wishing harm to enemy groups (Keightley 1983). These suggest that relationships between Shang and its neighbouring polities were not stable, but fluctuating "according to shifting political, economic and military interests" (Maisels 2010:225). Though the actual number of polities that the Shang had ties with is difficult to establish and verify, the written sources have nonetheless illustrated the busyness of diplomatic traffic surrounding the late Shang capital.

Archaeologically, an ever-growing body of both direct and indirect evidence also suggests that during the late Shang period, *Yinxu* had frequent and substantial interactions with its neighbouring groups, and even hosted a highly diverse population. For example, an early craniometric study of 319 decapitated sacrificial victims found at the royal cemetery at Xibeigang 西北岡 revealed a highly heterogeneous group, thus suggesting that the *Yinxu* population consisted of people from multiple groups (Li 1977). The hypothesis that most sacrificial victims found in the royal cemetery had non-Shang origins has been recently confirmed by stable isotope evidence (see Chapter 5). The sudden appearance of fully developed horse-drawn chariots at *Yinxu* also suggests that

the Shang must have a close relationship with their northern neighbours, as chariotry originated from the Eurasia Steppe, and it is a technological complex that required "special skills and resources for its construction, use, and maintenance" (Bagley 1999:207). Furthermore, analysis of the form, style, and composition of artifacts found in *Yinxu* revealed that the trading network in early Bronze Age China was extensive, both in terms of volume of traded resources and geography. Assorted natural resources and goods were imported from various regions, and similarly, Shang-style artifacts were abundant in many other sites (Bagley 1999; Stoltman, et al. 2009; Thorp 1985). For example, cowry shells (*Monetaria moneta*) used as currency, were brought in from as far away as the South China Sea (IA CASS 1994:403) and other imports include nephrites from Xinjiang, salt from Shandong, and weaponry and bronze mirrors from the Northern zone (Hwang 2010; Keightley 1983; Liu and Chen 2012; Thorp 2006). More recently, Campbell et al. (2011) examined the production scale of a bone workshop at *Tiesanlu* 鐵三路 in *Yinxu*. They estimated that the scale of production in just this site alone had already exceeded the need for local and elite consumption by approximately 300%, suggesting goods produced here were traded with groups outside of *Yinxu*. These examples all suggest that during the Shang Dynasty, *Yinxu* was part of, if not the center of, an active exchange network where natural resources, labour, and knowledge travelled in both directions (Thorp 2006).

6.2.1 Sources of Human Sacrificial Victims

One of the key questions concerning the interregional relations between the Shang and its neighbours is the origins of the vast number of sacrificial victims found in *Yinxu*.

Results presented in Chapter 5 have confirmed the hypothesis that many of these sacrificial victims had likely came from a single source outside of *Yinxu*, but their exact origins are still uncertain. While most Shang scholars have come to the consensus that the majority of these sacrificed individuals belonged to the group *Qiang*, Shang's greatest military adversary in the Central China Plain area, there are still debates on the definition of the term *Qiang*. According to historical texts, the *Qiang* were one of the eight polities, *mushi baguo* 牧誓八國, who followed and assisted the Zhou to revolt against the Shang Dynasty in 1046 BC (Zhou 2012). However, the exact nature of the political organization of these "polities" is not well understood. Currently there are two main schools of thought: 1) the word *Qiang* refers to a specific enemy state in the west; 2) it is a general directional description and refers to all enemy states in the west (Sun and Lin 2010).

Geographically, it is generally believed that the domain of the *Qiang* group(s) lay somewhere between the modern border of Gansu and Shaanxi Provinces (Chen and Shang 1990). Numerous scholars have tried to connect the *Qiang* group(s) with particular archaeological cultures in that region (Shelach 1996). Many advocated that the archaeological culture *Siwa* 寺窪文化, in Gansu Province, was related to the *Qiang* (Hsia 1949; Wu 1961; Yang 2013). Other candidates include the *Siba* 四壩文化 and *Xindian* cultures 辛店文化 in Gansu and Qinghai Provinces (Jiang 2011; Wang 2003; Zhang 2012). Using evidence from stable isotope analysis, this study aims to answer some of the yet unsettled questions concerning the origins of sacrificial victims in *Yinxu*, as well as exploring the interregional interactions between *Yinxu* and other early Bronze Age communities.

6.3. Archaeological Background

All the sites included in this study were occupied during the late Neolithic or early Bronze Age. Samples from a total of 57 individuals were obtained from across six sites. All individuals are adult, with the exception of one individual from *Lianhuatai* (S_UBC2994), who was an early adolescence (10-14 yrs).

6.3.1 *Yinxu* 殷墟 (ALN, AXN, AXS, HD)

The site of *Yinxu* is situated approximately 2 km northwest of modern day Anyang, in Henan Province (see Figure 27 - ①). A total of 22 human bone specimens from four localities were obtained.

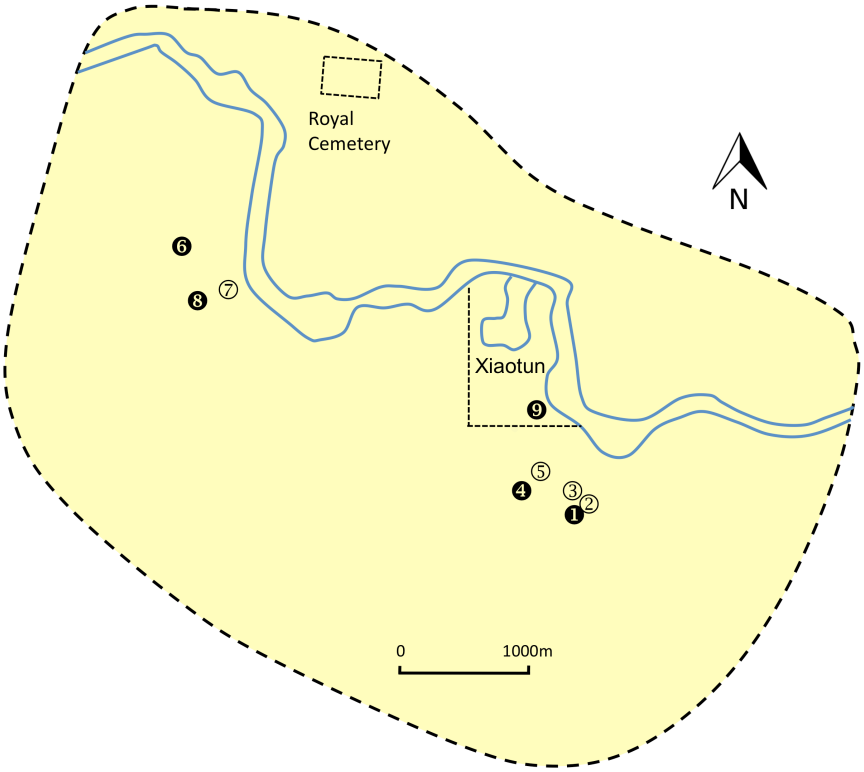

Figure 28 Map of Yinxu showing the locations of neighbourhoods and workshops mentioned in this project. Darkened symbols represent cemetery sites, open circles represent workshops: ❶XAZ; ②Tiesanlu bone workshop; ③Miaopubeidi bronze foundry; ❹ALN; ⑤Ceramic workshop; ❻AXN; ⑦Xiaomintun bronze foundry; ❽AXS; ❾ HD.

Liu'jiazhuang North (ALN)

The site of ALN is located in the modern village of *Liu'jiazhuang* 劉家莊, approximately 1 km south of *Xiaotun*, the royal palace-temple area of *Yinxu* (see Figure 28 - ❹). Archaeologists believe that the residential area, as well as the burial grounds found on this site, were associated with the large ceramic workshop (Figure 28 - ⑤) found at the center of the site (He, et al. 2012; Yue, et al. 2012). A bone sample from one individual has been obtained from this site.

Xiao'mintun North and South (AXN, AXS)

Xiao'mintun 孝民屯 is a site located about 2.5 km west of *Xiaotun*, and takes its name from a modern village located near the center of the site. The northern part of the site (AXN; see Figure 28 - ❻) consists mainly of residential sites, a burial ground, and over 400 refuse pits. The archaeological remains in the southern part of the site (AXS; see Figure 28 - ❽) are more densely packed, and over 100 residential sites, six burial grounds, over 700 refuse and sacrificial pits, as well as a large bronze foundry have been found (see Figure 28 - ⑦) (Wang and He 2007; Yin, et al. 2007; Yue 2006). The lack of a ramped tomb and few prestigious grave goods (e.g. bronze or jade items) suggests the site was likely occupied by lower class commoners (Yin, et al. 2007). Bone samples from two individuals from AXN and 17 individuals from AXS were obtained.

Hua'yuangzhuang East (HD)

The site of *Hua'yuanzhuang* (HD) is located directly south of *Xiaotun* (see Figure 28 - ❾), and was likely used as a ritual and burial ground for the royal household. Since 1987, archaeologists have discovered several remarkable finds on the site, including H3,

a pit that contained 1583 pieces of oracle bones (Liu and Cao 1999) and M54, one of the three unlooted higher status tombs in *Yinxu* (Liu 2009b).

The tomb M60 in HD is one of the earliest Shang period burials in *Yinxu*. It is unusual in many aspects, particularly with regards to the way the grave goods were presented: destroyed and placed in a layer underneath the coffin. Many of these grave goods were considered prestigious items, including one piece of oracle bone, at least nine bronze vessels, and numerous jade items (for a more detailed discussion of the burials of M60, please refer to Tang (2010)). The tomb shaft was oriented 90˚, with two individuals buried inside. The individual on the northern side was a female aged 35-40 and buried in a prone extended position, while the individual on the southern side was a female approximately 16 years of age and buried in a supine extended position. Both individuals were buried in coffins (IA CASS 2007:232-250). Bone samples from both individuals were obtained.

6.3.2 *Runlou* 閏樓 (ZZR)

The archaeological site of *Runlou* is a late Shang site located about 40km southeast of the modern city of Zhumadian, in Henan Province (See Figure 27 - ②). Excavated in 2008-2009, archaeologists have uncovered at least 160 Shang period tombs, from which more than 400 pieces of bronze, jade, and white ceramic items were uncovered (Jing Zhichun, personal communication). Bone samples from eight individuals were collected from this site.

6.3.3 *Zhouyuan* 周原 (QZ, QF, and QS)

The archaeological site of *Zhouyuan* is believed to be the pre-dynastic fiefdom of the clan *Ji shi* 姬氏, the founders of the Zhou Dynasty, as well as the site of the first capital of the Zhou Dynasty (Shaughnessy 1999; Shelach-Lavi 2015:273). It is located at the base of the Qishan mountain 岐山, about 100 km west of the modern day city of Xian in Shaanxi Province (see Figure 27 - ③). A total of seven human bone specimens from three localities in *Zhouyuan* were obtained: *Zhujiaxiang* 祝家巷 (QF, n=3), *Songjia* 宋家 (QS, n=2), and *Zhougongmiao* 周公廟 (QZ, n =2).

6.3.4 *Shigushan* 石鼓山 (BSGS)

The archaeological site of *Shigushan* is located close to the modern day village of *Shizuitou* 石嘴頭村 in Baoji City, Shaanxi Province (see Figure 27- ④). Discovered in June 2012, the site is still being excavated. To date, archaeologists have discovered a cemetery site consisting of 13 tombs, preliminarily dated from the predynastic Zhou to the early Western Zhou period (Liu, et al. 2013). An analysis of the tomb features and grave goods from one particular tomb, M3, suggests that this cemetery likely belonged to a group that is culturally distinct from both the Shang and the Zhou groups (Zhang 2014). Some scholars have suggested that the cemetery possibly belonged to the family *Hu shi* 户氏, a sub-lineage of the *Qiang* group (Wang, et al. 2013). A bone sample from one individual from this site was obtained.

6.3.5 *Xiahaishi* 下海石 (LHX)

The archaeological site of *Xiahaishi* (LHX) is located roughly halfway between the modern cities of Lanzhou and Xining, in the western part of Gansu Province (see Figure 27 - ⑤). The site was discovered in 1923 by the Swedish archaeologist J. G. Andersson, and is considered part of the *Machang* culture 馬廠文化 (Zhao, et al. 2008). ^{14}C dates produced from nearby sites suggest that LHX can be dated to around 3870-3750 BP (Zhao, et al. 2008:164). Bone samples from four individuals from this site were obtained.

6.3.6 *Lianhuatai* 蓮花台 (LL)

The archaeological site of *Lianhuatai* is located in modern day Linxia county 臨夏縣, south of the *Liujiaxia* Reservoir 劉家峽水庫 in Gansu Province (See Figure 27 - ⑥). Discovered in 1956 during an archaeological survey, this site is considered part of the *Xindian* Culture 辛店文化. In 1984, a rescue excavation in *Lianchengcun* 蓮城村 was conducted prior to housing construction, and a total of 18 tombs were discovered (Pu and Nan 1988). ^{14}C dates obtained from two charcoal samples from a contemporaneous site suggest that the site was likely occupied between 3520-3030 BP (Pu and Nan 1988:19), and an uncalibrated and unnormalized date obtained from a human bone from LL suggested the site was occupied at least until 2800 BP (Zhao, et al. 2008:168). Bone samples from six individuals from this site were obtained.

6.3.7 *Zhanqi* 占旗 (MWZ)

The archaeological site of *Zhanqi* is a *Siwa* Culture 寺窪文化 site located 500m east of the *Zhanqi* village in modern day Min County, Gansu Province (See Figure 27-⑦). During a rescue excavation conducted prior to a dam construction, archaeologists discovered a total of 66 tombs, two residential sites, 10 refuse pits as well as two sacrificial pits (Ma, et al. 2012). A ^{14}C date obtained from a human sample falls between 1100 and 950 cal. BC (Liu, et al. 2014), which is consistent with the chronological range of the *Siwa* Culture (3300-2500 BP) (Jiang 2011). A total of nine human samples from this site were obtained. Published data from an additional 34 individuals from the site were also included in the analysis (Liu, et al. 2014).

6.4 Results

The results of C, N, and S isotopic analyses of the 42 samples analyzed in this study, as well as all the contextual information, are listed in Table 13. Out of the 57 samples acquired, only 42 samples yielded collagen well-preserved enough for stable isotope analysis. All the C and N measurements of individuals analyzed in this study, together with the 39 local residents from XAZ (Chapter 4), and 64 sacrificial victims from AWB (Chapter 5), are plotted together in Figure 29. The sulfur isotopic compositions of individuals from all sites analyzed (including those from Chapter 5) are plotted in Figure 30.

Table 13 Summary of sample information, elemental compositions, and the bone collagen carbon, nitrogen, and sulfur isotopic compositions for all samples analyzed in this study.

Sample ID	Site	Sample No	% wt	%C	%N	% S	C:N	C:S	N:S	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	$\delta^{34}S$ (‰)
3323	ALN	11ALNM381	15.5	39.3	14.1		3.3			–9.0	+11.4	
3321	AXN	03AXNM140	15.4	42.5	14.9		3.3			–8.0	+10.1	
3322	AXN	03AXNM186	6.6	35.5	12.0		3.4			–8.8	+9.3	
3350	AXS	03AXSM360	13.2	41.8	14.2		3.4			–9.1	+10.5	
3351	AXS	03AXSM385	15.2	40.7	14.3		3.3			–8.0	+7.7	
3352	AXS	03AXSM386	17.3	40.7	14.4		3.3			–8.2	+10.1	
3354	AXS	03AXSM556	4.9	37.7	12.9	0.3	3.4	403.0	120.0	–7.8	+10.9	+8.8
3355	AXS	03AXSM662	11.0	40.2	14.2		3.3			–10.5	+9.2	
3356	AXS	03AXSM667	17.2	41.2	14.4	0.2	3.3	477.7	145.6	–14.6	+10.5	+3.5
3358	AXS	03AXSM761	7.5	40.7	14.0		3.4			–8.2	+9.9	
3360	AXS	03AXSM769	7.1	33.6	11.1		3.5			–9.3	+10.1	
3361	AXS	03AXSM877	6.4	37.5	12.6		3.5			–8.9	+9.8	
3363	AXS	03AXSM922	7.6	28.5	9.2		3.6			–8.4	+10.4	
3366	AXS	03AXSM976	5.7	39.8	13.4		3.5			–9.0	+7.7	
5292	HD	01HDM60 (S)	1.8	38.0	13.0		3.4			–8.2	+9.7	
5293	HD	01HDM60 (N)	3.7	42.8	14.7		3.4			–7.8	+9.4	
2958	QZ	04QZM18	13.2	39.7	14.0	0.2	3.3	504.9	155.7	–8.6	+9.5	+5.1
2959	QZ	04QZTZM2	10.0	38.2	13.4	0.2	3.3	509.5	156.6	–9.2	+10.3	+3.2
2964	QF	06QFIIIA2M2	3.9	32.0	11.4		3.3			–10.5	+8.5	
2965	QF	07QFIIIA1TG1 H63	3.9	32.4	10.9		3.5			–16.0	+9.4	
2966	QF	07QFIIIA1TG4 H22(12)	3.9	32.7	11.1		3.4			–11.5	+10.5	
2986	QS	08QSM2	13.4	39.0	14.2		3.2			–12.1	+11.5	
2987	QS	08QSM9	9.8	40.8	14.5	0.2	3.3	518.7	160.6	–11.8	+11.9	+6.7
2988	BSGS	13BSGSM10	4.3	34.4	11.7		3.4			–9.8	+9.4	
2960	LHX	05LHXM9	9.4	38.3	14.0	0.2	3.2	464.6	148.5	–7.2	+9.6	+4.1
2961	LHX	05LHXM17	12.2	40.1	14.9	0.2	3.1	486.2	157.7	–7.5	+8.8	+4.1
2962	LHX	05LHXM20	9.4	39.0	14.6	0.2	3.1	452.7	147.8	–7.3	+9.2	+3.6
2963	LHX	05LHXM25	11.5	42.6	14.6	0.2	3.4	493.9	148.4	–7.5	+10.1	+4.3
2989	LL	84LLM4	5.3	33.9	11.4		3.5			–10.3	+8.3	
2990	LL	84LLM5	6.8	32.8	11.3		3.4			–10.2	+8.2	
2991	LL	84LLM2/M6	12.4	40.5	14.6		3.2			–9.4	+8.5	
2992	LL	84LLM7	13.0	40.2	14.5		3.2			–10.1	+8.7	
2993	LL	84LLM8	14.8	40.3	14.8	0.2	3.2	537.8	172.7	–9.7	+8.9	+5.3
2994	LL	84LLM10-1(?)	9.4	39.1	13.9		3.3			–10.0	+8.6	
2975	MWZ	08MWZM1	8.1	39.5	14.1	0.2	3.3	439.3	136.5	–17.1	+9.6	+4.8
2976	MWZ	08MWZM24	16.3	39.5	14.0		3.3			–14.5	+9.4	
2977	MWZ	08MWZM25	13.0	40.3	13.4	0.2	3.5	537.4	155.9	–14.8	+11.4	+4.6
2979	MWZ	08MWZM49	12.1	39.6	14.4	0.2	3.2	459.7	145.6	–16.3	+9.9	+3.0
2980	MWZ	08MWZM53	10.8	39.2	14.1	0.2	3.2	523.3	164.2	–16.8	+11.0	+4.0
2981	MWZ	08MWZM65	10.0	39.7	14.3	0.2	3.2	505.2	159.0	–16.0	+10.9	+5.1
2982	MWZ	08MWZTG4M 24	11.3	40.3	14.3	0.2	3.3	488.7	151.5	–15.5	+9.5	+4.5
2983	MWZ	08MWZTG4M 25	13.1	39.5	14.1	0.2	3.3	502.0	156.2	–15.9	+11.2	+4.6

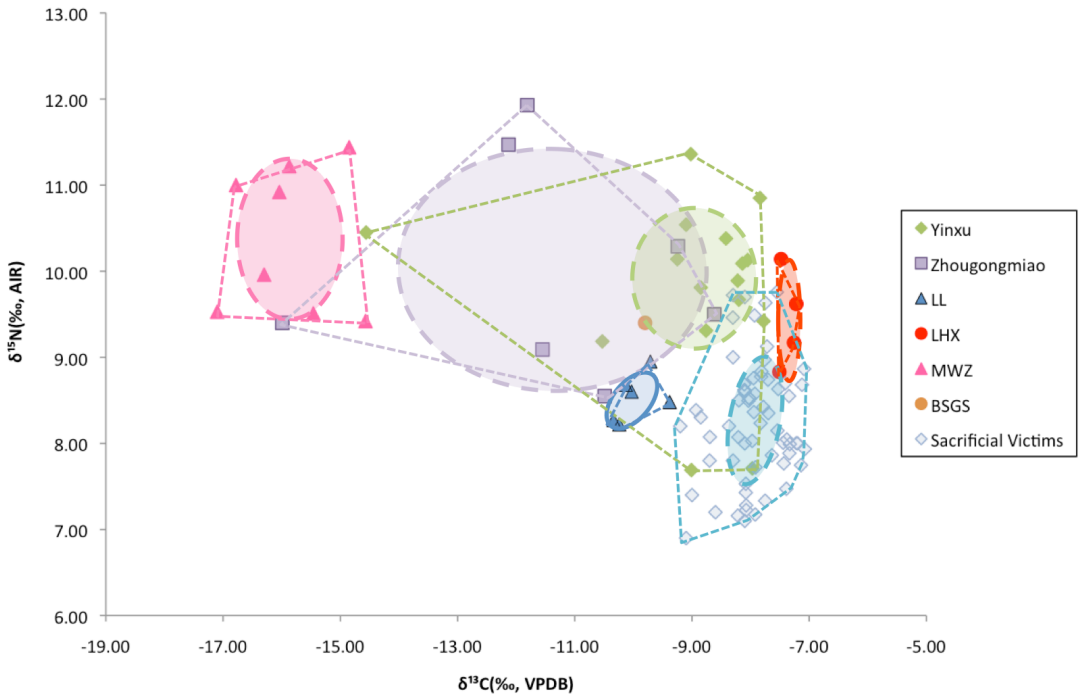

Figure 29 Bone collagen $\delta^{13}C$ and $\delta^{15}N$ values of humans analyzed in this study plotted by sites. Shaded ellipses represent the bivariate SDs of each group. Dotted polygons are the convex hull areas that encompass all individuals within each group.

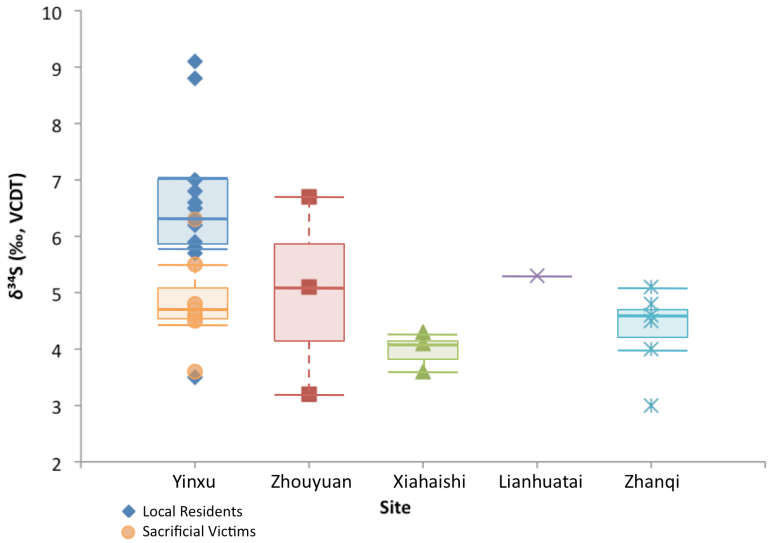

Figure 30 Sulfur isotope compositions of humans from all sites. Overlaying box plots show the medians and lower and upper quartiles with 1.5 IQR of the data spread for each site.

6.4.1 Intra-site Comparison

Yinxu

Figure 31 compares the bone collagen $\delta^{13}C$ and $\delta^{15}N$ values of all local residents from *Yinxu*. As shown in this figure, except for one individual (03AXS_M667) who had unusually depleted $\delta^{13}C$ values, the *Yinxu* population appeared to be isotopically homogenous. This was confirmed by a one-way MANOVA test, where differences in $\delta^{13}C$ and $\delta^{15}N$ values between neighbourhoods were not considered significant ($F(4,50)=0.9907$, Pillai's Trace = 0.1469, $p=0.448$, see Table 14).

Table 14 Means and standard deviations for the stable carbon and nitrogen isotopic compositions of all *Yinxu* residents.

Locality	N=?	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)
XAZ	39	–9.0 ± 0.7	+10.0 ± 0.7
AXS	12	–9.3 ±1.9	+9.7 ± 1.1
AXN	2	–8.4	+9.7
ALN	1	–9.0	+11.4
HD	2	–8.0	+9.5

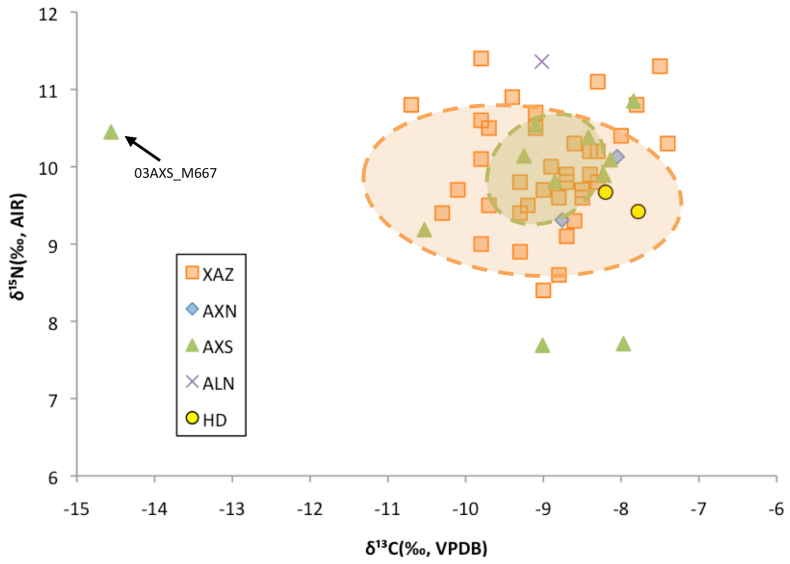

Figure 31 Bone collagen $\delta^{13}C$ and $\delta^{15}N$ values of local Yinxu residents plotted by neighbourhoods.

Furthermore, consistent with the result in Chapter 4, the mean $\delta^{15}N$ value of males in these four localities was more positive than that of the females (mean $\delta^{15}N_{males}$ = +10.440‰; mean $\delta^{15}N_{females}$ = +9.314‰). Although the difference is not statistically significant with these 12 individuals (p=0.079), when combined with the other 30 data points from XAZ, the difference is deemed statistically significant ($t(42)$=-3.285, p=<0.01, see Figure 32).

Table 15 Sex of individuals from the four localities (ALN, AXN, AXS, and HD) in *Yinxu*.

S_UBC No	Site	Sample No	Sex
3323	ALN	11ALNM381	M
3321	AXN	03AXNM140	F
3322	AXN	03AXNM186	?
3350	AXS	03AXSM360	F
3351	AXS	03AXSM385	F
3352	AXS	03AXSM386	F
3354	AXS	03AXSM556	?
3355	AXS	03AXSM662	F
3356	AXS	03AXSM667	M
3358	AXS	03AXSM761	F
3360	AXS	03AXSM769	M
3361	AXS	03AXSM877	M
3363	AXS	03AXSM922	M
3366	AXS	03AXSM976	F
5292	HD	01HDM60 (S)	?
5293	HD	01HDM60 (N)	?

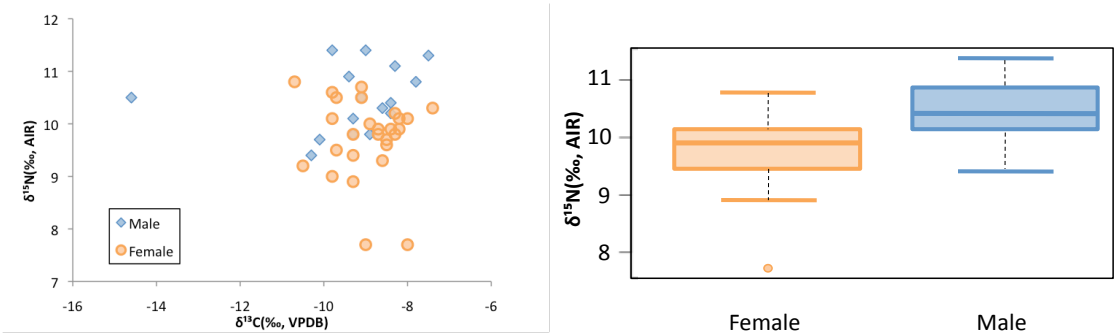

Figure 32 Bone collagen $\delta^{13}C$ and $\delta^{15}N$ values of all individuals from Yinxu (XAZ, ALN, AXN, AXS, HD) plotted by sex.

Two individuals in this group (03AXS_M556 and 03AXS_M667) were analyzed for sulfur isotopes. The results will be discussed in the next section.

Zhouyuan

Figure 33 compares the bone collagen $\delta^{13}C$ and $\delta^{15}N$ values of all individuals from *Zhouyuan*. In this site, the individuals from each locality appear to cluster together. However, with such small sample sizes, it is difficult to determine whether the clustering is random or real. Three individuals in this group (04QZ_M18, 04QZ_TZM2, and 08QS_M9) were analyzed for sulfur isotopes. The results will be discussed in the next section.

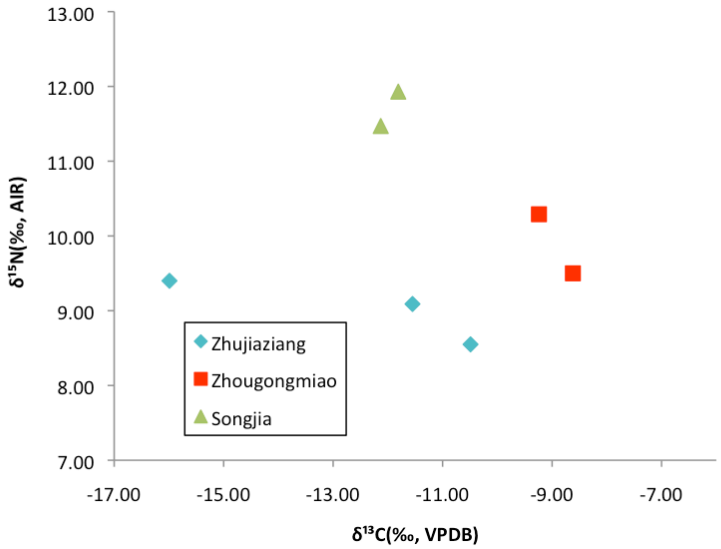

Figure 33 Bone collagen $\delta^{13}C$ and $\delta^{15}N$ values of humans from *Zhouyuan* plotted by locality.

Intra-site variability

Intra-site variability was evaluated by comparing the total area of data spread for each site expressed in convex hulls and standard ellipses, as shown in Figure 29. The

SEA, SEA_B, and SEA_C of the six sites (as there is only one sample from *Shigushan*, the site is excluded in this analysis) are shown in Figure 34 and Table 16 (see Chapter 2.3.1 for a detailed description of the statistical methods).

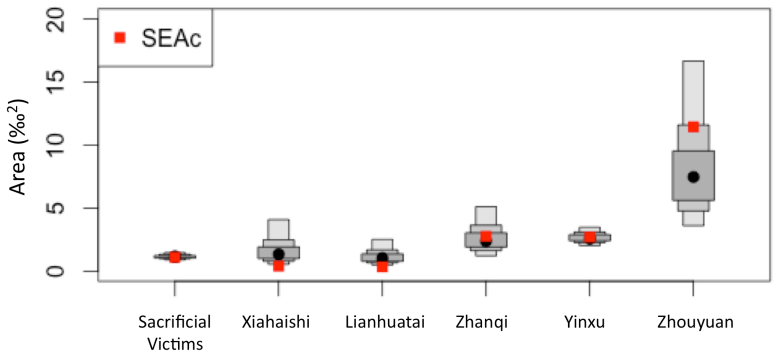

Figure 34 Density plot depicting areas (SEA_B) of the standard ellipse of each respective site, expressed in resultant uncertainty. Shaded boxes represent the 50%, 75%, and 95% credible intervals from dark to light grey. Red dots represent SEA_C: standard ellipse area corrected for sample size.

Table 16 Summary of the area metrics of the six groups: SEA – standard ellipse areas; SEA_C – standard ellipse areas corrected for sample size; TA – total area of convex hull.

Site	SEA	SEA_C	TA	N =
Sacrificial victims	1.083	1.100	4.451	64
Xiahaishi	0.265	0.398	0.228	4
Lianhuatai	0.273	0.341	0.352	6
Zhanqi	2.363	2.756	3.900	8
Yinxu	2.650	2.699	15.709	55
Zhouyuan	9.535	11.442	13.028	7

As shown in Table 16, the sites with the largest SEA_B and SEA_C are *Zhanqi*, *Yinxu*, and *Zhouyuan*. This suggested that the intra-site variability at these three sites is significantly greater than the other sites.

6.4.2 C, N, and S Measurements

Preliminary sulfur isotope analysis revealed significant differences between the $\delta^{34}S$ values of individuals from *Yinxu* and those from the west (Figure 30). The *Yinxu*

group had higher δ^{34}S values (mean = +6.6±1.7‰; n=9) than individuals from other sites from the west of the Taihang Mountains (mean = +4.5±0.9‰; n=14), and this is supported by a t-test (t(22)=4.074, p=<0.001). Figure 35 compares all the groups in terms of δ^{13}C, δ^{15}N, and δ^{34}S values.

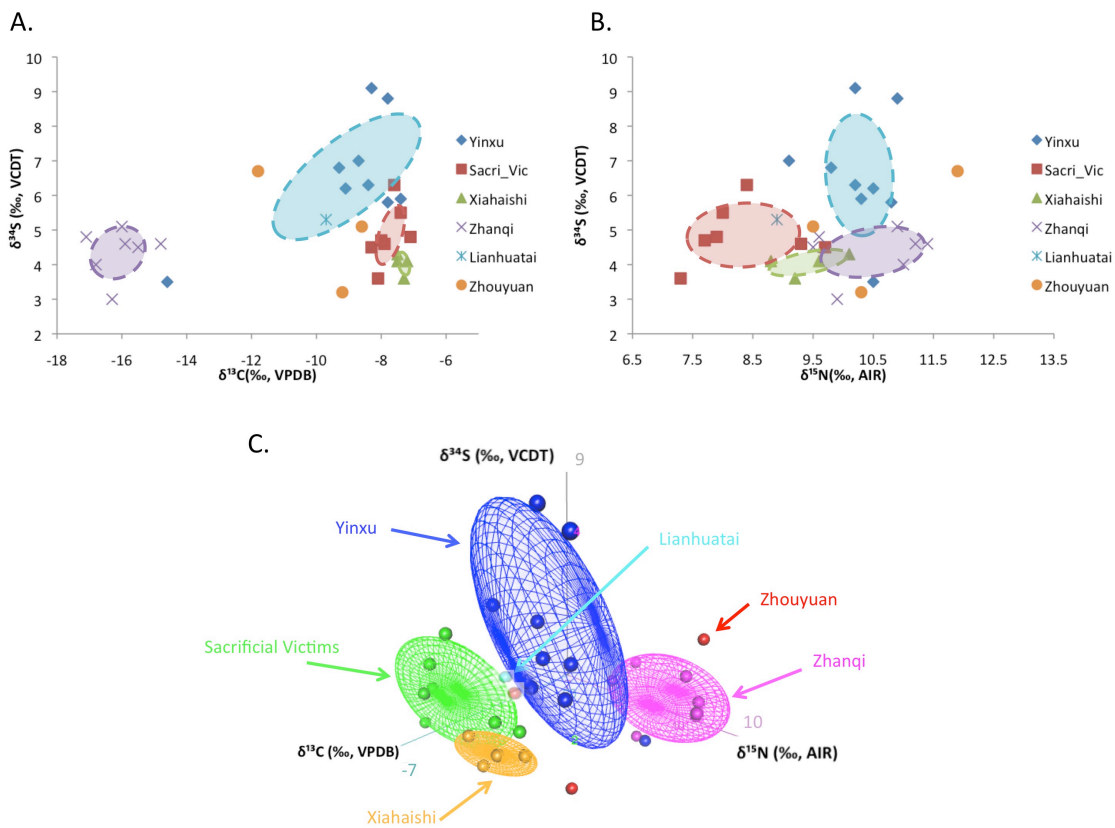

Figure 35 Plot comparing the δ^{13}C, δ^{15}N, and δ^{34}S values between different groups: A) shows the bone collagen δ^{13}C and δ^{34}S values of the six groups; B) shows the bone collagen δ^{15}N and δ^{34}S values of the six groups; and C) shows the bone collagen δ^{13}C, δ^{15}N, and δ^{34}S values of the six groups. In A) and B), shaded ellipses represent the bivariate SDs of the group. In C) the shaded ellipsoids represent the concentrations of points in each group.

As shown in Figure 35C, the differences in the means of the δ^{13}C, δ^{15}N, and δ^{34}S values are significant across all groups, as confirmed by a one-way MANOVA test (F(5,25)=7.0248, Pillai's Trace = 1.7526, p=<0.001). Follow up ANOVA tests further

confirm that the differences are significant across all C ($F(5,25)=33.693$, $p=<0.001$), N ($F(5,25)=7.9746$, $p=<0.001$), and S ($F(5,25)=4.032$, $p=<0.01$) measurements. The Tukey HSD post-hoc tests revealed that in terms of δ^{13}C values, the strongest differences occurred between the *Zhanqi* group and the rest of the population ($p=<0.001$). And in terms of δ^{15}N values, the sacrificial victims are significantly different from the *Yinxu* and the *Zhanqi* populations ($p=<0.001$), as well as the Zhouyuan group ($p=<0.01$). Finally in terms of δ^{34}S values, the *Yinxu* group is the most distinct from the *Xiahaishi* and *Zhanqi* groups ($p=<0.05$).

6.4.3 Population Dynamics at the Larger Context

In order to expand the geographic scope of this study, published C and N measurements of 234 individuals from seven sites in Gansu Province were also included in this analysis (Liu, et al. 2014; Ma, et al. 2013). The summary statistics of the C and N measurements, as well as the contextual information for all sites mentioned in this study are listed in Table 17.

Table 17 Means and standard deviations of the carbon and nitrogen isotopic compositions of individuals from sites mentioned in this study.

Province		Site	Culture	Date	N	δ^{13}C (‰)	δ^{15}N (‰)
Henan	①	*Yinxu* local residents (AXA, AXN, AXS, ALN, HD)	Late Shang	c. 1250-1046 BC	55	–9.0 ± 1.1	+9.9 ± 0.8
		Yinxu sacrificial victims (AWB)[a]	Late Shang	c. 1250-1046 BC	64	–7.9 ± 0.5	+8.2 ± 0.7
	②	*Runlou* (ZZR)	Late Shang	13th to 10th century BC	0	/	/
Shaanxi	③	*Zhouyuan* (QZ, QF, QS)	Predynastic to early Western Zhou	12th – 10th century BC	7	–11.4 ± 2.4	+10.0 ± 1.3
.	④	*Shigushan* (BSGS)	Predynastic to early Western Zhou	12th – 10th century BC	1	–9.8	+9.4
Gansu	⑤	*Xiahaishi* (LHX)	Machang Culture	c. 1920-c. 1800 BC	4	–7.4 ± 0.1	+9.4 ± 0.6
	⑥	*Lianhuatai* (LL)	Xindian Culture	c. 1470-c. 1080 BC	6	–10.0 ± 0.4	+8.5 ± 0.3
	⑦	*Zhanqi*[b] (MWZ)	Siwa Culture	1100-950 BC[d]	42	–16.0 ± 1.5	+9.4 ± 1.9
	⑧	*Qijiaping*[e]	Qijia Culture	1515-1264 BC[d]	42	–8.9 ± 1.1	+9.8 ± 0.9
	⑨	*Mogou*[c]	Qijia – Siwa Culture	1750-1100 BC[d]	36	–13.9 ± 1.6	+10.2 ± 1.2
	⑩	*Mozuizi*[c]	Machang Culture	2350-2000 BC[d]	13	–7.1 ± 0.4	+8.3 ± 0.4
	⑪	*Wuba*[c]	Banshan – Machang Culture	2450-1950 BC[d]	53	–7.3 ± 0.5	+9.1 ± 1.1
	⑫	*Ganguyai*[c]	Siba Culture	1350-950 BC[d]	29	–15.3 ± 1.5	+11.6 ± 0.9
	⑬	*Huoshaogou*[c]	Siba Culture	1900-1300 BC[d]	27	–12.4 ± 1.4	+12.2 ± 1.0

[a] For individuals from AWBM1-M3, the femur measurements are used to represent the group.
[b] Part of the data come from published report Liu et al 2014.
[c] Data from published report Liu et al 2014.
[d] Direct carbon dates obtained from samples.
[e] Data from published report Ma et al in 2013.

Figure 36 presents the bone collagen δ^{13}C and δ^{15}N values of all 379 samples from 13 sites discussed in this study. Only samples from *Yinxu* and the sacrificial victims are represented by individual points, samples from all other sites are represented by means and standard deviations.

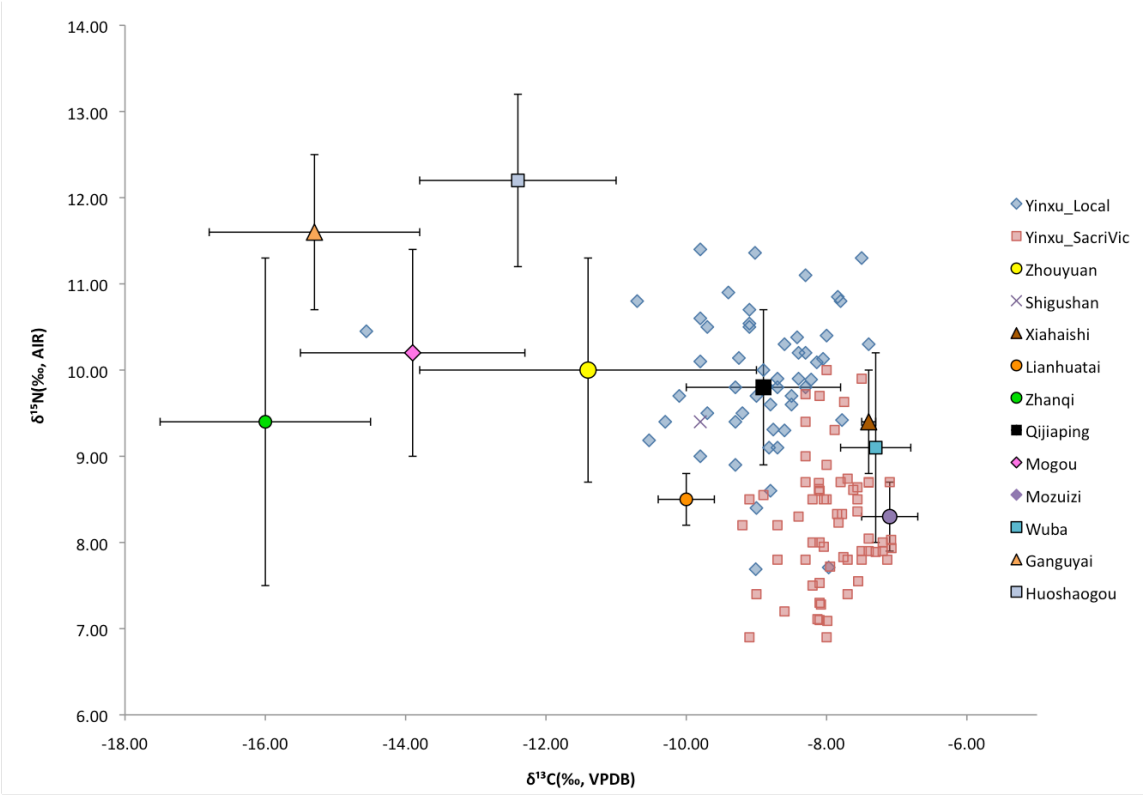

Figure 36 Bone collagen δ^{13}C and δ^{15}N values of all humans plotted by site.

As shown in Figure 36, the diets of humans from the Central China Plain varied immensely by site, both in terms of δ^{13}C and δ^{15}N values. The δ^{13}C values of all humans ranged from –17.5 to –6.8‰. Although it is evident that C_4 resources were consumed across all sites, the proportion of C_4 resources in diets range from almost exclusively C_4–based in some sites, such as *Mogou*, *Wuba*, and *Xiahaishi*, to very minor in other, such as *Zhanqi* and *Ganguyai*. The δ^{15}N values of all humans range from +6.9 to +13.2‰. Individuals with the lowest δ^{15}N values were the sacrificial victims from *Yinxu*, as well as individuals from *Mozuizi*. Individuals with the most elevated δ^{15}N values came from *Ganguya* and *Huoshaogou*.

6.5 Discussion

6.5.1 Social Dynamics within Sites

Sex as a factor in dietary differences in *Yinxu*

Although there were only 12 additional sexed individuals from *Yinxu* (ALN, AXS, AXN, and HD), the fact that a similar pattern in $\delta^{15}N$ values between males (n=17) and females (n=27) is observed across five localities (plus XAZ from Chapter 4) in *Yinxu* suggests that males likely had greater access to animal protein in Shang society (mean $\delta^{15}N_{males}$ = +10.5‰) than women (mean $\delta^{15}N_{females}$ = +9.7‰). Unfortunately, there is no associated information on the mortuary patterns (e.g. burial positions, accompanying grave goods, etc) for the majority of these new data. Further analysis would be appropriate when more evidence is available.

Intra-site variability

There were no observable differences in the $\delta^{13}C$ and $\delta^{15}N$ values between individuals from different localities within *Yinxu* (Figure 31). The opposite is observed in *Zhouyuan*, however, where individuals from each locality have distinctive $\delta^{13}C$ and $\delta^{15}N$ values (Figure 33). The current data may suggest that *Zhouyuan* was organized differently than *Yinxu*, where culturally different groups were segregated not only by dietary practices, but also by spatial arrangements. Yet with only seven samples from the site, the data is inconclusive. Nevertheless, this observation is interesting and warrants future studies to investigate further.

Among all six groups analyzed, *Yinxu*, *Zhouyuan*, and *Zhanqi* displayed the largest in-group variability (Table 16). It should be noted that both *Zhouyuan* and *Yinxu*

were regarded as important cultural centers in early Bronze Age China (Liu and Chen 2012; Shelach-Lavi 2015). Therefore, the large intra-site variability is expected. *Zhanqi* also exhibited fairly high intra-site variability, especially when compared to the other two groups, *Xiahaishi* and *Lianhuatai*. Thus, *Zhanqi* could be another cultural center in the western Central China Plain, further substantiating the multi-centers view advocated by many Shang scholars (Bagley 1999; Keightley 1983; Thorp 1985; Thorp 2006).

As sample sizes from the two groups *Xiahaishi* and *Lianhuatai* were too small for meaningful statistical comparison, it is possible that the area metrics were not sufficiently sensitive for these two sites. Small sample sizes tend to underestimate in-group variability, even though SEA_C was corrected for bias in sample sizes. Due to the lack of data points from these two sites, it is possible that the bias correction still did not account for all the lost variability. More samples need to be obtained from these sites to allow for a more comprehensive analysis.

The group of sacrificial victims, despite its relatively larger sample size, exhibited an exceptionally tight range in the spread of both $\delta^{13}C$ and $\delta^{15}N$ values. As discussed in Chapter 5, at least 30 of these sacrificial victims (M1-M3) likely moved to *Yinxu* as a group. Therefore, it is possible that the tight cluster $\delta^{13}C$ and $\delta^{15}N$ values reflects an isotopically homogenous diet at their origin. Another explanation is that the low intra-group variability was a result of their similar treatment in *Yinxu*, where the isotopic compositions of these victims slowly converged from being fed with the same type of food. Or it could be a combination of both explanations. Nonetheless, the area metrics used in this study provide a means to quantitatively compare intra-site variability between several sites. This has not only confirmed the hypothesis that *Zhouyuan* and *Yinxu* were

important cultural centers in early Bronze Age China, but also highlighted the unusual dietary homogeneity of sacrificial victims in comparison with individuals from these diverse cultural centers (see Table 16).

6.5.2 Placing *Yinxu* in the Larger Context of the Central China Plain

The outlier 03AXS_M667 in *Yinxu* (Figure 36) could represent a recent migrant to the city. This individual has a $\delta^{13}C$ value (-14.6‰) closely resembling those from the two *Siwa* groups, *Zhanqi* and *Mogou (*mean $\delta^{13}C_{Zhanqi}$ value = -16.0±1.5‰; mean $\delta^{13}C_{Mogou}$ value = -13.9±1.6‰*)*. And when S measurements are also considered (Figure 35), it is more certain that 03AXS_M667 had come from west of the Taihang Mountains. In fact, his C, N, and S measurements fit securely within the ellipsoid of the *Zhanqi* group (Figure 35C), and thus it is highly possible that he was an immigrant from *Zhanqi*. During a recent excavation, archaeologists unearthed a large number of bronze weapons at *Zhanqi*, among which a bronze *ge*(s) 戈 (dagger-axe) found at the site were very similar to those found in *Yinxu* (Yang 2013). While it is not always possible to use artefactual evidence to confirm direct interactions between two groups, bone collagen stable isotopic evidence allows the direct identification of foreigners among a group of local residents. Hence, even though individual 03AXS_M667 was only a singular example of a possible *Siwa* immigrant in *Yinxu*, his presence has further confirmed the cultural exchanges between Shang and its western neighbours.

Furthermore, as mentioned in Chapter 6.2.1, many Shang scholars consider that the *Siwa* Culture in Gansu Province was closely related to the *Qiang* people mentioned in the Shang oracle inscriptions. However, results from this project suggest otherwise.

Being one of the major type-sites of the *Siwa* Culture, *Zhanqi* was considered one of the possible origins of the sacrificial victims in *Yinxu*. While $\delta^{34}S$ values of the sacrificial victims (+4.9±0.8‰) were consistent with information derived from oracle inscriptions and implied a western origin (see Figure 30), the C isotopic evidence strongly suggests that *Zhanqi* was not the source of sacrificial victims in *Yinxu*. As shown in Figure 35, with regards to all C, N, and S measurements, the sacrificial victims from *Yinxu* clearly do not cluster with the *Zhanqi* group. Instead, C and N measurements suggest that the sacrificial victims are more closely related to the *Wuba*, *Mozuizi*, and *Xiahaishi* groups, which all belonged to the *Machang* Culture.

6.5.3 More Thoughts on the Cultural Implications of Changing Dietary Practices

Other than answering the specific questions asked in this study, these results have revealed one interesting surprise. The differing $\delta^{13}C$ values of the various cultural groups has also shed some light onto the cultural utilization of C_3 and C_4 crops across the Central Chain Plain area, as well as the cultural implications. As mentioned in Chapter 3, during the Neolithic and Bronze Age, millet (both broomtail and foxtail varities) was the staple crops in the Central China Plain, with wheat and barley being introduced to the area through the Hexi Corridor during the late Neolithic period (Barton, et al. 2009; Flad, et al. 2010). Liu et al. (2014) interpreted the large-scale adoption of wheat and barley among certain communities in the Hexi Corridor as a response to the sudden increase in population in the region during the late Neolithic period. The authors recognized that millet consumption was "deeply socially embedded" among many prehistoric groups, and argued that the harsh ecological and climatic conditions of the region had forced some of

the communities to rapidly adopt (or at least incorporated) the more energy-efficient wheat and barley over millet (Liu, et al. 2014:673). Stable isotopic evidence contends that the adoption of certain crops was central to the definition of a "Culture". It was observed that communities of the same culture tended to share similar dietary practices. For example, the three sites with the most enriched $\delta^{13}C$ values, *Xiahaisi*, *Mozuizi*, and *Wuba* all belonged to the *Machang* Culture, despite spanning an area of about 200km in radius. Meanwhile, even though *Zhanqi* (*Siwa* Culture) and *Lianhuatai* (*Xindian* Culture) were relatively close both geographically and temporally, individuals from each site had drastically different $\delta^{13}C$ values, and hence practiced very different subsistence strategies.

With this in mind, results from this study prompt a rethinking of the processes of cultural transition from one archaeological culture to another. The adoption of a new crop is more than a mechanical response to an environmental or ecological crisis, the action also reflects on some fundamental sociological and cultural ideologies of a community. Earlier studies tended to focus on the continuation and evolution of material culture and burial customs when examining cultural transitions in the archaeological records. However, through palaeodietary reconstruction using stable isotope analysis, archaeologists are now able to also analyze the nature of changing subsistence economies through time.

For example, based on several decades of archaeological investigation, many scholars now believe that the *Siwa* and *Xindian* cultures originated from the *Qijia* culture (Chen 2013; Jiang 2011). It is generally believed that the severe climatic anomalies brought about by the "Holocene Event 3" at around 4000 BP may have triggered the collapse of many Neolithic cultures in the Central Plain of China, including the *Qijia*

Culture (Shui 2001; Wu 1961; Wu and Liu 2004). Zooarchaeological studies of several *Qijia* sites suggested that the subsistence economy of the *Qijia* Culture was primarily based on dry-farming, with millet as the staple crop (Jiang 2011). However, with the sudden onset of a colder period, millet-growing communities, including those of the *Qijia* Culture, were rapidly replaced by other groups practicing mixed pastoral-farming agriculture, such as the *Siwa* Culture (Wu and Liu 2004; Yang 2013). Still, in certain regions, groups characterized by a more traditional millet-farming subsistence economy persisted (e.g. the *Xindian* Culture) (Liu 2009a). So far isotopic data generated in this study agree well with this hypothesis, as demonstrated in the $\delta^{13}C$ values of individuals from *Lianhuatai* (*Xindian* Culture; $\delta^{13}C$: –10.0 ± 0.4‰), *Zhanqi* (*Siwa* Culture; $\delta^{13}C$: –16.0 ± 1.5‰), and *Qijiaping* (*Qijia* Culture; $\delta^{13}C$: –8.9 ± 1.1‰), respectively.

Different crops have different labour and production requirements. Therefore, the nature of a group's subsistence economy could have a paramount effect on its social structure. By switching from dry-farming to mixed pastoralism, the cultural transition from the *Qijia* Culture to the *Siwa* Culture was more complicated than a mere change in dietary composition, but also resulted in extensive social reorganization. Many archaeologists have noticed that *Siwa* sites were characterized by smaller settlement sizes and a general lack of labor-intensive architectural structures, compared to the precedent *Qijia* Culture and the contemporaneous *Xindian* Culture (Liu 2009a; Shui 2001; Wu and Liu 2004). Certainly, more evidence is required to further explain why certain groups respond to natural disasters in one way while others do not. Other than geographical differences, the manner in which a community was organized and the strength of social coercion, for example, could all contribute to how a group reacts to resource shortages:

whether to remodel the existing social structure or remodel the landscape to accommodate ecological change. Hence, the fundamentally different subsistence strategies adopted by these different groups most likely stemmed from the more deep-seated socio-cultural traditions of the respective groups.

Nevertheless, the discussion on how these different social processes came into being is not within the scope of this thesis. This study has underscored how changes in subsistence strategy can help to identify changes in other social processes. By recognizing diet as an outward expression of cultural identity, palaeodietary reconstruction offers an alternative perspective for examining the transitions between archaeological cultures, especially when the "cultural transition" is accompanied by isotopically distinguishable dietary changes.

6.6 Conclusion and Future Studies

This study compares the variations in bone collagen carbon, nitrogen, and sulfur isotopic compositions among and between different groups in the Central Plain of China. A Bayesian-based area metrics was used to evaluate the intra-site variability among different sites. Results confirmed the "multi-center" hypothesis and suggested that there were more than one cultural center in the Central China Plain area. Low intra-site variability among the sacrificial victims also supported the argument that these victims came from a single source. Based on the data generated from 64 sacrificial victims, preliminary analysis suggests that these sacrificial victims likely came from west of the Taihang Mountains. Although the exact location of their origin cannot be determined, the *Siwa* group *Zhanqi* was ruled out as the main source of Shang sacrificial victims. Instead,

results suggested the sites *Mozuizi*, *Wuba*, and *Xiahaishi* were more likely related to these sacrificial victims.

Furthermore, this study presented the first large-scale stable sulfur isotope analysis of archaeological samples in the Central Plain of China. Unfortunately, there were S measurements from only a total of five sites (including *Yinxu*). Still, our results demonstrated that 1) δ^{34}S values in the Central Plain of China were variable enough to enable the identification of residence mobility; and 2) C and N measurements alone were not effective enough to differentiate between different communities from the Central Plain of China. Therefore, the combination of C, N, and S isotope analysis can help to further elucidate the webs of interregional interactions between *Yinxu* and other early Bronze Age communities.

To allow for a better understanding of the social dynamics of early Bronze Age China, as well as to better account for intra- and inter-site variability, future studies should expand to include more samples from more sites. Currently, there are two layers of information urgently required: 1) in-depth intra-site analysis of other sites, with special attention paid to the finer contextual information (e.g. mortuary evidence, gender differences, and etc.); and 2) the incorporation of archaeological fauna to establish the local isotopic baselines.

In addition, future analysis would be more efficient if only sites that were contemporaneous to Shang were included. Thus, a better chronology for sites in the Central China Plain area needs to be established. The current chronology for many archaeological cultures from the Shaanxi/ Gansu region is based on too few dates, often obtained from associated materials instead of directly from the cultural deposits.

Even though stable sulfur isotope analysis has proved to be effective in distinguishing groups from different geographical regions, without an established S isotope baseline map of China, S measurements cannot be used to replace the usual Sr, Pb, and O analysis. In fact, extended studies using Sr, Pb, and O analysis on samples that have been analyzed for C, N, and S isotopes should be conducted. This will help to clarify and possibly confirm current hypotheses regarding migratory activities in the Central China Plain area. With sulfur isotope analysis being more routinely applied in Chinese archaeological studies, a more comprehensive baseline map of S isotopes in ancient China should be established in the near future. With an ever-growing isotopic database, more meaningful interpretations of ancient social phenomenon can be made, ultimately contributing to a better understanding of the social processes behind the complex political geography of early Bronze Age China.

7. Thesis Conclusions

The aim of this research was to examine the social dynamics of early Bronze Age China, focusing on the ancient networks surrounding the late Shang capital *Yinxu*. With a dual focus on both cultural and biological concerns, this study has offered an alternative narrative on the political and social conditions of the Shang people. The following sections will summarize the major findings and their archaeological implications, as well as offer a critical look at methodology and suggest future research directions.

7.1 Summary of Major Findings and Archaeological Implications

The first project investigated the internal social dynamics of *Xin'anzhuang* (XAZ) through comparing the reconstructed diets of 39 residents with other archaeological and mortuary evidence (Chapter 4). This project revealed that the varying dietary patterns of the local XAZ inhabitants corresponded with certain mortuary practices, which reflects complex internal social stratification within this neighbourhood. The results generated from this project are significant in several ways. First, they offer a glimpse into the social conditions of the lower class commoners in *Yinxu*, which would be difficult to obtain using conventional archaeological techniques alone. Second, they have described and defined the dimensions of a lower class subsistence pattern during the late Shang period, which can then serve as a reference point for future studies. For example, when analyzed in conjunction with osteological and zooarchaeological evidence, the health profiles of

these XAZ residents could be reconstructed and compared with other resident groups both within and outside of *Yinxu*.

The second project used multi-isotope analysis (C, N, and S) to reconstruct the palaeodietary and palaeomobility patterns of 64 sacrificial victims, which were then compared to the isotopic signatures of the local *Yinxu* residents (XAZ) analyzed in the first project (Chapter 5). Results suggest that these sacrificial victims were likely non-local, but moved to *Yinxu* and adopted the local diet for at least a few years before being killed. Analytically, these results provide unique insights into the experiences of these sacrificial victims, and thus shed some light onto the political and economic organization of the late Shang society. In terms of methodological contribution, this was the first study to present direct chemical evidence from biological remains to identify the presence of migrants in *Yinxu*. While strontium and oxygen isotope analysis are typically used to detect migratory activities in archaeology, these techniques could not be applied due to the absence of cranial materials, particularly teeth, for the majority of the sacrificial victims in *Yinxu*. By demonstrating that in early Bronze Age China, differences in dietary patterns among different cultural groups are significant enough to allow detecting mobility through C, N, and S isotopic analysis, this study has offered a new methodological framework for similar studies in the future.

The final project was situated within the larger socio-political reality of early Bronze Age China, focusing on the interregional interactions between communities within the Central China Plain (Chapter 6). The C, N, and S isotopic compositions of 55 local *Yinxu* residents and 64 sacrificial victims were compared with an additional 260 individuals from 12 roughly contemporaneous neighbouring sites. Results from this

project have not only helped locate the possible source of sacrificial victims in *Yinxu*, but have also provided valuable insights into the dynamic nature of the political geography of early Bronze Age China. Residents of *Yinxu* and *Zhouyuan* showed significantly greater dietary variability compared to the homogeneity of the other groups sampled, which reinforces the proposition that *Yinxu* and *Zhouyuan* were major cultural centers in early Bronze Age China. The results from this project proved that when used in conjunction with other evidence, population-scale palaeodietary reconstruction can offer a new avenue to identify and examine interregional interactions between communities in the past. This is particularly important in China, as the application of large-scale stable isotope analysis in archaeological studies is still relatively rare. The rewarding outcome of such analyses should encourage more similar studies to be done in the future.

7.2 Future Research Directions

Light stable isotopes analyses (specifically those of C, N, S) allow archaeologists to directly quantify and analyze the dietary and mobility patterns of past populations from their biological remains. With a substantial sample size, and combined with other lines of evidence, it can also offer in-depth insights into the social developments and dynamics of past societies. The three projects in this thesis demonstrate that the use of stable isotope analysis to reconstruct dietary and mobility patterns can reveal the flow of traffic between various regions and highlight the socio-political complexity of early Bronze Age China. However, the dimensions of this research are limited in several ways and can be remedied by focusing on two aspects: 1) increasing sample size and expanding on sampling localities; 2) incorporating multiple lines of evidence during analysis.

Increasing sample size and expand on sampling localities

Unfortunately, the inherent incompleteness and biased nature of the archaeological record is a condition that cannot be remedied by technology (Jackes 2011). One of the most common critiques of archaeological studies is the problem with small sample sizes and how representative the samples are of the studied population. This study is clearly not exempt from concerns over small sample size as it attempted to address archaeological questions concerning the population dynamics of early Bronze Age China with less than 400 samples. Small sample sizes should not stop the interpretation of datasets. Instead, factors that could affect the representativeness of small datasets should be addressed explicitly and only careful and non-generalizing statements based on the evidence generated from the study should be made.

Furthermore, while stable isotopic data from this thesis suggest that many individuals from *Yinxu* (including the sacrificial victims) could have been migrants, it is difficult to determine where these migrants were originally from without sufficient baseline data from the potential places of origin. To solve this problem, more samples from other sites need to be collected to establish a geographical baseline map for a more informative analysis of interregional interactions of the region. As this is the first study to use stable isotope analysis to look at population dynamics and interregional interactions in early China, this data forms the beginnings of a baseline for further comparison. It is anticipated that many similar studies will be done in the future, which would ultimately help to build a stronger database for more solid and creditable analyses.

Incorporation of multiple lines of evidence during analysis

Researchers should be aware that C, N, and S isotopes can only be used to distinguish migrants who came from a group with diets that were isotopically different from the diets of the *Yinxu* locals. It is possible that the actual social stratification of *Yinxu* was far more complex and intense than presented here. Future research should exploit new developments in archaeological sciences and make use of other available techniques such as strontium (Sr), lead (Pb), and oxygen (O) isotope analysis to corroborate and refine interpretations of C, N, and S analysis. By cross-examining multiple lines of evidence, including those from stable isotope analyses and other archaeological evidence, researchers can better interpret the data within the larger political, economic, social, cultural, and physical realities, and ultimately give a more faithful reconstruction of the past.

7.3 Concluding Remarks

This thesis presented three studies aimed at examining the larger social processes and dynamism in early Bronze Age China, through analysis of bone collagen $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ values of a total of 387 human from 13 sites in the Central China Plain, including 260 samples obtained from published reports. Preliminary results suggested that the interregional exchange network in the Central China Plain during the early Bronze Age was both active and extensive. Hosting a highly diversified population, *Yinxu* was likely one of many cultural centers in Bronze Age China. It is hoped that this study will encourage a wider application of stable isotope analysis in Chinese archaeology, especially to address larger questions such as those concerning the emergence of early

complex societies, cultural interaction and integration. As shown in this thesis, the application of stable isotope analysis to a relatively large dataset can offer powerful insights into the socio-economic organization and dynamics of past societies. These results have not only verified early hypotheses regarding the social constitution of the late Shang state and the non-local origins of sacrificial victims, but have also added new information to the understanding of population dynamics in the larger context of early Bronze Age China.

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