The Majiayao to Qijia Transition:

Exploring the intersection of technological and social continuity and change

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Abstract: The transition between the Majiayao (5300-4000 BP) and Qijia (4200-3500 BP) "cultures" in what is now northwestern China's Gansu Province has typically been defined by major technological changes in pottery forms, subsistence practices, and site locations. These changes are thought to have been driven by a combination of climate change induced cooling and drying as well as human migration into the region from areas further east. Based on our review of literature on the topic, as well as recent fieldwork in the northern Tao River Valley, we suggest that the picture is significantly more complex, with some new technologies slowly being experimented with, adopted, or rejected, while many other aspects of production and social organization persisted over hundreds of years. We hypothesize that these changes reflect the active agency of the inhabitants of southern Gansu during the fifth and fourth millennia BP balancing long-standing cultural traditions with influxes of new technologies. Unlike some societies in other regions at this time, however, increasing technological specialization does not appear to have resulted in growing social inequality, but the archaeological material instead reflects increasingly complex heterarchical organization.

Keywords: technology; social organization; China; Bronze Age; continuity; heterarchy

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1 Introduction: Technological and Social Change in Bronze Age Northwestern China

Technological changes during the fifth and fourth millennia BP in the region that is now Northwest China have been identified as major driving forces behind social changes across East Asia long before the

emergence of the historic Silk Roads. In the region of interest, which broadly encompasses the Hexi 河西 Corridor and the valleys of the Upper Yellow River and its tributaries in Gansu 甘肃 and Qinghai 青海 provinces (**Fig. 1**), there is evidence of several significant changes primarily associated with the emergence of the so-called "Qijia 齐家 Culture." This ceramic tradition is widespread across the region during the period between approximately 4200 and 3500 BP (Jaffe and Flad 2018). Archaeological research on the Qijia tradition has strongly emphasized the presence of new technologies and artifact types that set it apart from the preceding Majiayao 马家窑 ceramic tradition (5300-4000 BP). Increasing numbers of bronze and jade artifacts (Dodson et al. 2009), the use of lime plaster flooring (Chen H. 2013), the adoption of pyromantic methods of divination (Flad 2008; Yi 1959), and the raising of new domesticates including wheat, barley, caprines, cattle, and possibly horses (Brunson et al. 2020; Flad and Hruby 2007; Flad et al. 2010; Li S. 2008; Li X. et al. 2007; Linduff 2003; Yuan and Flad 2006), alongside a major shift in pottery forms and ceramic surface treatments (Chen H. 2013; Xie 1980), are all seen as marking a major cultural transformation.

Generally, the Majiayao to Qijia transition as well as the appearance of these new technologies have been approached along two vectors, which in turn reflect current trends in Chinese archaeology. First, a number of scholars have emphasized the importance of these new technologies for the development of historical "Chinese Civilization" in the Central Plain of northern China. For example, bronze vessels and horse drawn chariots, which were key components of early elite ritual and military activities, have been linked back to early appearances of bronze items and horse remains in northwestern China, potentially as a way of emphasizing the importance of an archaeological tradition that might otherwise be seen as peripheral to Chinese history (Han 2009; Yi 2014; Zheng 2002). Second, climatic changes that have been identified as occurring in the region around 4200 BP have been closely linked with social and technological change to the point that it has been suggested that a rapidly cooling and drying climate pushed the adoption of a pastoral lifestyle on previously sedentary farmers (An et al. 2004, 2005; Dong et al. 2012; Liu et al. 2010). This trend is related at least in part to the focus on climate change research among Chinese archaeologists in recent years (Jaffe et al. 2020; Jaffe and Hein 2020).

Both kinds of research often overlook the issue of whether or not a major social and technological shift actually took place between the Majiayao and Qijia periods. While the presence of indicators for new technologies such as lime plaster floors or bronze items are noted in excavation reports, very little research has been undertaken on production and use associated with these goods, or levels of adoption of new crops and animals, leaving a major gap in our understanding of the relationship between technology, society, and the landscape within which they were encapsulated. In this paper we will attempt to refine

our understanding of the Majiayao to Qijia transition by undertaking a review of literature on the subject and then comparing this with recent archaeological work in the northern Tao 洮 River Valley. By focusing on specific, measurable technologies including site layouts, architecture, ceramic and stone tool production, divination, and archaeobotanical and zooarchaeological remains, we seek to improve our understanding of webs of production and levels of adoption for particular technologies and explore how these are related to or independent of each other. We then examine similarities and differences between our results and those reported in previous research, offering up a new model that we suggest better fits our current data on the relationship between changes in technology, craft production, and social organization in the northern Tao River Valley between ca. 5000-3500 BP.

2 Previous Research on the Majiayao to Qijia Transition

Despite nearly 100 years of archaeological work in the region identifying the locations of Majiayao and Qijia sites and establishing ceramic chronologies (for early publications consult Andersson 1923, 1925, 1943; Xia 1946), very little systematic survey and excavation work has been conducted, and almost all fieldwork has focused on cemeteries (An 1981; Chen H. 2013; Debaine-Francfort 1995; Hung 2011; Xie 2002). This has left significant gaps in our knowledge of habitation size and layout, craft production, subsistence practices, social organization, and the relationship between habitation, production, and mortuary site components. What we do know about Majiayao and Qijia habitation sites primarily comes from rescue excavations, including work conducted at Baidaogouping 白道沟坪 (Majiayao) (Gansu 1957), Dahezhuang 大何庄 (Qijia) (Huanghe 1960; Zhongguo 1974), Huangniangniangtai 皇娘娘台 (Qijia) (Gansu 1960, 1978), Lajia 喇家 (Qijia) (Zhongguo & Qinghai 2002), Linjia 林家 (Majiayao) (Dongxiang 1984), Qinweijia 秦魏家 (Qijia) (Huanghe 1960, 1964; Zhongguo 1975), and more recently at the Majiayao type-site (Majiayao and Qijia), the late Bronze Age Siwa 寺洼 type-site Siwashan 寺洼山 (Majiayao and Siwa), and Shannashuzha 山那树扎 (Majiayao). The last three of these remain unpublished, although initial results have been reported at recent conferences in China. However, most of these sites are at a considerable distance from one another, scattered over nearly 200,000 km^2, and are poorly dated and only published in brief reports, making it difficult to distinguish whether variation between sites is due to geographic or chronological diversity (see Fig. 1). This also makes it difficult to determine when, where, and on what scale new technologies arrived or changes in cultural traditions first took place. Nevertheless, based on data from the aforementioned sites, as well as excavations of cemeteries and analysis of recovered artifacts, hypotheses of general trends of technological adoption and exchange have been put forward (Jaang 2015; Wang 2012). Here we will review the data available prior

to our own work in the northern Tao River Valley and will assess hypotheses of cultural change that have been proposed based on these data.

2.1 Pottery

During the Majiayao period, painted pottery appears in a wide variety of forms at both mortuary and habitation locales, with changes in painted design and colors being used to divide the period into three sub-phases, Majiayao (5300-4600 BP), Banshan 半山 (4600-4300 BP), and Machang 马厂 (4300-4000 BP). While there has been some discussion of changing site densities in different regions between these sub-phases (Hung 2011), generally the pottery is taken to be indicative of chronological change more than geographic variability. Along with painted vessels, Majiayao potters also produced coarse, cord-marked wares that are often decorated with appliqué, as well as plain greywares (**Fig. 2**). Generally, vessel sizes are quite large and include a variety of storage, cooking, and serving vessels, as well as smaller bowls and cups. While all types of vessels appear in habitation contexts, painted pottery appears to have been preferred for mortuary contexts, with some scholars proposing that vessels placed in graves were made expressly for that purpose (Allard 2002; Hung 2011). Decorative motifs on painted vessels include a wide variety of patterns that vary over time, and possibly regionally; however, a comprehensive study of these motifs have only been produced for certain sub-phases (Li 1988; Ren 2016; Zhao and Ren 2016). Some motifs, such as the whirlpool pattern that is common in the Banshan sub-phase, appear over a very large area, suggesting at least semi-regular interaction among communities throughout the region.

Interaction between regions, such as the Tao River Valley, northern Sichuan 四川, and eastern Qinghai 青海, has been suggested based on one chemical study of clay recipes used in painted vessels (Hung 2011): however, a second study using a different chemical method proposed that exchange was rare during the Majiayao period, but increased during the Qijia period (Cui et al. 2015). Given the different methodologies and sample sizes between the two studies, these competing results are difficult to reconcile. Turning to vessel production, processes of vessel manufacture were explored in the 1930s (Palmgren 1934), as well as more recently (Li X. 2005), and point to the use of the coiling method, with finishing performed on a slow wheel or turnette, and painting using a brush. Paint recipes have also been examined and pigment compositions identified; however, small sample numbers mean that it is currently unclear if pigment recipes were shared among potters or were specific to individual production groups (Chen et al. 2000; Ma 2000). Firing is generally thought to have taken place in kilns, although only a few examples of kilns have been discovered. In at least one case kilns were grouped together outside of a settlement (Gansu 1957), while in other cases kilns have been found among houses (Dongxiang 1984).

Qijia period ceramic vessels are generally smaller than those of the preceding Majiayao period and the elaborate painted designs seen on Majiayao vessels disappear, with painting occurring rarely and being limited to simple geometric designs (see **Fig. 2**). Many scholars have also noted significant changes in form and decoration, including the introduction of hollow tripod feet, the use of snake decorations, a major focus on "basket-impression" as a surface treatment, and the production of flat-bottom vessels with double handles (Wang 2012: 227). Given similarities in these vessel types to forms previously seen further east with the Keshengzhuang 客省庄 II ceramic tradition (4400-4000 BP) and the co-occurrence of late Majiayao and proto-Qijia style pottery at sites in Ningxia 宁夏 belonging to the Caiyuan 菜园 tradition (4800/4500-4200 BP) (Ningxia and Zhongguo 1988), it has been suggested that an influx of migrants from central China into the region may have been responsible for the transition in pottery styles (Duan 1976; Xia 1977), with Qijia pottery showing traits of both Caiyuan and Keshengzhuang II pottery (Wang 2012). Others have suggested that this shift towards smaller, plainer vessels reflects a move towards a more pastoral way of life (An et al. 2004). Vessel production, use, and distribution have generally not been investigated aside from the aforementioned chemical analysis on a very small number of Qijia sherds (Cui et al. 2015) as well as a study in the 1940s (Bylin-Althin 1946). Finds of kilns are extremely rare, although they have been identified at Lajia (Qinghai 2015). Typologically, pottery from several sites have been used to produce typological chronologies (Chen P. 2013; Xie 1980; Zhang 1987); however, due to different scholars focusing on collections from different sites, there is currently no widely agreed upon typology for Qijia sub-phases (Wang 2012).

2.2 Pyrotechnologies

Other elements of material and technological transformations and introductions associated with the Qijia tradition relate to aspects of pyrotechnology, including metallurgy, lime plaster production, and oracle bone divination. Among these, metallurgy is by far the most thoroughly studied. Bronze objects of the Qijia period are known primarily from cemeteries and include beads, earrings, and other decorative items, knives, tools, weapons, and mirrors (Gansu and Xibei 2009; Li 2005; Zhang 1987). Several scholars have suggested that Qijia metallurgical technology was derived from metalworking on the Central Asian steppe, as finds of Qijia knives, spearheads, and other items appear typologically very similar to earlier Central Asian materials (Fitzgerald-Huber 1995; Jaang 2011, 2015; Linduff and Mei 2009). Chemical analyses of the bronzes from mortuary contexts at Qinweijia, Qijiaping, and Huangniangniangtai show increasing sophistication of production, with a greater amount of intentional alloying of copper with either tin or arsenic over time (Li S. 2005:244). Although several copper and bronze objects are known from Majiayao and Banshan contexts (An 1981; Dodson et al. 2009; Mei 2003, 2009; Mei et al. 2017), there is a clear increase in the number and variety of bronze objects, and objects

made of other metals, including gold and even iron (Chen et al. 2012), in Qijia contexts. Generally, it is assumed that Qijia period inhabitants of Gansu and Qinghai were beginning to produce their own metal objects using locally available resources; however, production items, such as casting molds or smelting debris, have only been found during collections of a few surface scatters in the Hexi Corridor (Dodson et al. 2009), as well as more recently during excavations at Xichengyi 西城驿 near Zhangye 张掖 (Beijing and Gansu 2015; Li et al. 2015). While the surface scatters have been dated using ceramic typology and via radiocarbon dating, the lack of formal excavations make it difficult to securely contextualize these materials. Dates for Xichengyi vary between publications, but generally appear to match the later Qijia period, from 4000-3600 BP, based on a combination of radiocarbon dating and ceramic typology. One modern source of ore has been suggested as being potentially related to Qijia period production in the Hexi Corridor; however, no actual Qijia mine sites are known and the presence of bronze production outside of this small number of sites in the Hexi Corridor remains unclear (Dodson et al. 2009). Additionally, the relationship between the few copper and bronze artifacts from Majiayao sites and later Qijia metal production is currently unexplored.

Lime flooring seems to have been introduced during the Qijia period and lime floors are typically thought to be representative of Qijia residential areas (Chen H. 2013); however, no systematic study of this material has yet been undertaken in Qijia contexts. Based on limited research in other areas, lime plaster first appears during the early Yangshao 仰韶 period (7000-5000 BP) in northern central China, sees slow but increasing use over time there, and then jumps considerably in usage and geographic range during the Longshan 龙山 period (5000-3900 BP) to cover much of what is today northern China. While initially used to coat floors of main living areas of houses, over time its use is expanded to cover walls, entranceways, and other structures such as hearths, storage pits, and cisterns (Pei 2017). The raw materials for the creation of plaster could include calcium carbonate nodules that are common in the loess soils of northern China; however, this would need to be tested with further scientific analysis. While the timing of the first lime plaster use in the Gansu region remains unclear, it appears to potentially coincide with the arrival of other crafts and practices from northern Central China that rose in popularity during the Longshan period including the production of jade objects and the use of pyromantic methods of divination (Liu and Chen 2012).

Around the same time as these developments, pyromancy, a divination technique involving heating animal bones and studying the resulting cracks, also appears in this region. The origins of pyromancy appear to be in scattered sites across northern China, with the earliest examples coming from middle to late Neolithic sites in Inner Mongolia and Henan 河南, with one example also coming from Gansu.

However, it is not until the second half of the fifth millennium BP that it becomes more common, particularly at Longshan sites starting around 4700 BP (Brunson et al. 2016; Flad 2008). Based on research to date, very few oracle bones are known from Majiayao period sites, but numerous examples have been discovered at multiple Qijia period contexts (Brunson et al. 2020 manuscript). Thus, it appears likely that oracle bone divination was introduced to Gansu during the Qijia period, potentially alongside other technologies and practices from the northern Central Plain including lime plaster production, certain pottery forms, and jade carving. The precise timing of the transfer of this technology into the Gansu area remains unclear.

2.3 Lithics

Lithics from the Majiayao and Qijia periods are not well studied aside from Qijia jades, with most stone tools receiving only brief summaries in site reports. Tools generally include a wide variety of shapes including axes, adzes, chisels, knives, shovels, grinding tools and slabs, as well as projectile points and spindle whorls, although most tools are generally classified as either knives or axes. Several dozen of each have been found at excavated habitation sites from both periods, with occasional finds in burials. Stone types, production methods, use-wear, and sourcing are generally not discussed, although it has been proposed that stone grinding slabs and rollers were used for grinding grain (Chen H. 2013). Aside from tools, some stone ornaments have been recovered from graves, with nonspecific stone and turquoise being used during the Majiayao period (Kong 2015) and jade being added during the Qijia period. Ornaments include beads, pendants, and bracelets, all of which were highly polished.

Jade, typically nephrite, was also used in the Qijia period to make *bi* 璧 discs, ax heads, and *cong* 琮 tubes, similar to those found in eastern China. These objects show similarities to types seen in the Liangzhu 良渚 and Hongshan 红山 cultures on the east coast and northeast, respectively, but perhaps arrive more directly from contemporary Longshan settlements (Chen H. 2013). While significant research has focused on the typology and potential uses of jade objects, particularly as prestige goods or ritual objects, there is little information available on raw material sourcing and production in the regions inhabited during the Qijia period. Based on research on objects from other parts of China, it appears that jade object production would have been extremely time-consuming, with large blocks being slowly sawed using leather strings and wet sand, then drilled with wood or bamboo and sand (Sax et al. 2004). Among Qijia sites, locations of production, methods of production, as well as the sources of raw materials remain unclear. It has been suggested that some raw jade materials came from as far away as Xinjiang 新疆 as well as locally from Gansu and Qinghai (Chen H. 2013), however jade provenance is very difficult to track chemically, making definitive conclusions challenging (Wang R. 2011). The same is true for

turquoise, which, aside from use in ornaments, was also used for mosaic inlay on ceramic and bronze objects (Chen P. 2013). Turquoise-inlaid bronze plaques, in particular, show close similarities to those produced further east at Erlitou 二里头 (Allan 2007); however, these are extremely rare in Qijia contexts. It has been hypothesized that items made of both materials were important for marking status, possibly acquired through the control of ritual knowledge, as has been suggested for the use of jade in some early state-level societies in the northern Central Plain (Chen P. 2013) and elsewhere (Flad 2012).

2.4 Subsistence Technologies

Subsistence technology is another domain where significant changes associated with the Majiayao to Qijia transition have been proposed. During the Majiayao period, domesticated animals are thought to have been largely limited to pigs and dogs, with a number of new domesticated species appearing in the late Majiayao period and then expanding in use during the Qijia period. Some archaeological features, including stone circles seen at Dahezhuang, may reflect the penning of domesticated animals, and zooarchaeological data show that caprines were present in Northwest China starting in the fifth millennium BP (Brunson et al. 2020; Flad et al. 2007). Sheep and goats were first domesticated in southwest Asia over 11,000 years ago, and sheep are found in some Chinese sites contemporary with or prior to the Qijia Culture at places like Taosi 陶寺, in Shanxi 山西 (ca. 4300-3900 BP; Brunson et al. 2016) and Dashanqian 大山前, in Inner Mongolia (ca. 4000-3500 BP; Cai et al. 2011), as well as the Qijia Culture site of Changning 长宁, in Qinghai (Cai et al. 2011). Goats may have been introduced later. Cattle were also potentially brought into the area in the fifth millennium BP from points west (see Lu et al. 2017; Cai et al. 2014), but cattle are not well studied in the region. Horses represent another important animal technology developed around this era (Cai et al. 2008; Gansu 1978). To our knowledge, domesticated horses have not been conclusively demonstrated in fifth millennium or even early fourth millennium BP contexts in Northwest China; however, fragmentary horse remains have been recovered in small amounts from several Qijia sites (Xie 1980). Given the lack of direct radiocarbon dates from animal bones and the challenges of distinguishing between the bones of domestic taxa and their wild counterparts native to the region, the dates for the emergence of domesticated cattle, caprines, and horses remain subject to debate (Brunson et al. 2020).

Transitions in agricultural technology are documented for the fifth millennium BP by archaeobotanical data. Broomcorn and foxtail millet are the dominant domesticated crops for much of the Neolithic in northern and northwestern China; thus, the arrival of wheat and barley have been of particular interest to scholars. Wheat was domesticated in southwest Asia by the twelfth millennium BP and developed into an important staple over the course of the subsequent millennia across parts of Eurasia

(Harris 1996). By the middle of the fifth millennium BP, small amounts of wheat and barley remains appear at sites in East Asia, increasingly so by the end of the fifth millennium BP (An et al. 2010, 2013; Barton and An 2014; Betts et al. 2014; Dodson et al. 2013; Dong et al. 2017; Flad et al. 2010), and millet remains are evident moving westward into Central Asia around the same period (Frachetti et al. 2010; Leipe et al. 2019; Spengler et al. 2014; Stevens et al. 2016). Recently, cultivation of wheat and barley have been implicated in the establishment of sedentary communities in environments where the aridity, number of growing-degree-days, or severity of frosts made cultivation of millet not viable, including high elevations above 2500 masl around the Tibetan Plateau (Chen et al. 2014; d'Alpoim Guedes et al. 2013, 2015a, 2015b). Recent archaeobotanical, starch grain, and isotope studies at a small number of Majiayao and Qijia sites point to the arrival of wheat and barley around 4600 BP (Li X. et al 2007), with starch grain analysis indicating increasing use at some sites over time (Li M. et al. 2010, 2013). However, isotope studies at Qijia sites have yet to be based on macrobotanical remains themselves, meaning that isotopic baselines have not been established, making conclusive interpretations from other sources such as teeth and tools difficult. Additionally, in previous macrobotanical studies, sample sizes have been very small, the samples are rarely directly dated, and they come from a very limited number of widely dispersed sites, making localized processes of adoption of new subsistence practices difficult to gauge (Dodson et al. 2013; Li X. et al. 2007; for a critical review, consult Jaffe and Hein 2020).

2.5 Site distribution and layout

Previous models for the shift from Majiayao to Qijia periods also focus on site size, distribution, and mortuary practices. Analysis of site sizes and distributions have been based primarily on the maps and lists available in the *Atlas of Chinese Cultural Relics* (Guo jia wen wu ju 2011). This resource pulls together all known sites in the province, including a mixture of sites identified through survey as well as reported by locals and then visited by provincial archaeologists; typically, site chronology and size is based on surface scatters of sherds. Only one systematic, on-the-ground study of Qijia site distribution has been undertaken, in this case in the Hulu 葫芦 River Valley in Ningxia and eastern Gansu Provinces. This survey pointed to an increase in number of sites, but decrease in site size, between the Majiayao and Qijia periods (Li F. et al. 1993). More recently, an effort has been made to directly date materials from a significant number of sites in northwestern China. This has involved collection of carbonized materials from trash pits and other features visible in profiles, which are then dated. However, for most sites visited in this manner, only a single, or at most two samples, have been dated, making the occupation length and chronology of these sites impossible to assess without significant additional work (Dong et al. 2013; 2018; Jaffe et al. in press). Based on results of these studies, combined with regional climate proxies,

climate cooling has been hypothesized as a main driving factor in shifting sites away from higher altitude areas in Qinghai, and potentially elsewhere, during the Qijia period (Hou et al. 2009; Liu et al. 2010).

Regarding site layout, based on a very limited number of excavations, Majiayao and Qijia settlements are thought to be typically located on river terraces and contain houses, cemeteries, and integrated production areas (Chen H 2013). Houses are square or circular, semi-subterranean constructions with wooden supports and wattle and daub walls. Most houses measured around 10 m^2, had doors facing south, and a central hearth. Occasionally, much larger structures have been uncovered, including a building at the Qijia period site of Dahezhuang which is 36 m^2. Aside from the appearance of lime plaster floors and occasional stone circles, there is little to differentiate Qijia habitation sites from Majiayao sites. The extremely small number of excavated habitation contexts from both periods makes comparison difficult.

2.6 Mortuary practices

Majiayao and Qijia period mortuary practices vary significantly between regions with a variety of burial locations, grave styles, body positions and orientations, and numbers and types of grave goods (Chen H 2013; Hung 2011). While at some sites burials are interspersed with living areas, in most cases they are placed in cemeteries, which may or may not be closely associated with habitation remains. Cemetery sizes vary between sites for both periods, with the smallest containing fewer than 100 graves while larger cemeteries, such as Liuwan 柳湾 (Qinghai and Beijing 1976) and Mogou 磨沟 (Gansu and Xibei 2009), have more than a thousand burials spanning multiple periods. Often, the graves are placed in orderly rows, with various sections of the cemeteries possibly reflecting kin groups. Generally, both Majiayao and Qijia graves were simple vertical pit burials containing only the body and a small number of grave goods—typically vessels and more rarely ornaments or tools (Chen H 2013). Other grave types are also known. For example, for the Majiayao period, slab burials and even cremations have been reported from Qinghai (Hung 2011). At the recently excavated Qijia cemetery at Mogou, side chamber burials, which include a shaft with a chamber dug into one or more sides for the placement of the body and grave goods, are dominant (Gansu and Xibei 2009). At some sites from both periods, there is clear differentiation between graves that contain only a few burial goods and those that contain over 100 pieces of decorated pottery (Allard 2002) or rare goods such as carved jade objects (Chen P 2013). In some cases, Qijia graves also contained pig or sheep mandibles, which may be indicative of funerary feasting (Chen H 2013). Grave furniture such as wooden coffins is very rare (Chen H 2013; Hung 2011). Most discussion of Majiayao and Qijia mortuary practices has focused on graves with large numbers of objects, which are seen to reflect increasing social stratification, or graves with unusual burial patterns (e.g., Allard 2002). The latter includes Qijia graves with two to three individuals, where it has been proposed that some individuals were sacrificial victims, reinforcing ideas of increasing social stratification, as well

as a connection with human sacrifice as it was practiced concurrently further to the east in northern central China (Chen H 2013).

In summary, based on previous research, the shift from the Majiayao to Qijia period has traditionally been characterized by a shift in pottery form and decoration, alongside the increasing importance of goods and technologies that arrived from Central Asia, such as metal objects, domesticated plants (wheat, barley) and animals (sheep, cattle, possibly horse) and knowledge about their planting/rearing and usage. Other new technologies that appear to have arrived from further east include jade carving, turquoise inlay, certain ceramic styles, lime plaster flooring, and, possibly, pyromantic divination. Explanations for their appearance typically present inhabitants of Northwest China as adopting new technologies in response to climatic change or as passively receiving technologies that came alongside an influx of migrants from further east. As receptors of technologies from the east and north, Qijia period people are often viewed as passive middlemen, transferring each technology onward with few alterations (Fitzgerald-Huber 1995), onto places where they would go on to play a major role in the development of Chinese civilization (bronze working, horses) and the "Sinicization" of the northwest (adoption of jade carving and millet) (Yi 2014). As for the Qijia period itself, it is viewed as a transitional stage in the move towards climate change-induced pastoralism which was fully realized in the regional subcultures that develop in the post-Qijia period such as the Kayue 卡约 tradition (An et al. 2004; Bai et al. 2017; Hou et al. 2009; Liu et al. 2010). This model of explanation that denies local populations of northwestern China any agency via local innovation or cultural/societal developments of their own is highly problematic and will be questioned below using both previous research and new discoveries.

3 Webs of Technology

One of the potential issues with this view of the Qijia period is that it provides the inhabitants of Northwest China at the time with little agency, particularly regarding the adoption of new technologies and practices. Technologies such as metallurgy from Central Asia are often viewed as being inherently desirable, so it is argued that in the Majiayao period the inhabitants of Northwest China used items they received, then in the Qijia period, local people learned how to smelt ore and quickly took to making objects themselves since metal technology is perceived as being superior to stone. The same goes for jade carving: it is beautiful and provides a direct connection to the rise of later Chinese states, so it is assumed people in the Northwest would necessarily want to adopt it. Pottery breaks this trend to some extent, since Qijia pottery is generally considered less aesthetically pleasing than Majiayao pottery. Adoption of pottery styles from further east, such as tripods, does occur, but is relatively rare. Instead, climate change has been suggested as a possible explanation for changes in ceramic types, with the suggested shift towards pastoralism in the later Qijia period being credited with leading to a need for lighter and smaller

pottery (e.g., Ma et al. 2016; for a summary consult Jaffe and Hein 2020). Once again, the inhabitants of Northwest China are portrayed as being at the mercy of outside forces, and what we see in the archaeological record is interpreted as being the result of local reactions to events beyond their control. To better understand the choices that people living in northwestern China made regarding the adoption of new technologies, we first need to consider the nature of technology itself.

As a number of archaeological studies have demonstrated, human societies do not always adopt what the modern observer would consider to be the best new technologies. Nor do they abandon long-standing traditions without careful consideration. Instead, new technologies are often carefully assessed and tested, weighed against tradition, and in many cases outright rejected or only adopted hundreds of years after their first arrival in a region (Dobres 2000; Skibo 2013). Technology itself can be defined in a variety of ways (Dobres 2000), from the study of techniques and their uses in society (Coupaye and Douny 2009), to the concretization of social thoughts (Lemmonier 1990, 1993). It can also seemingly be muddled by its use at several different levels of abstraction ranging from individual technologies that represent the "means to fulfill a human purpose," to domains of activities that involve "an assemblage of practices and components," to "the entire collection of devices and engineering practices available to a culture" (Arthur 2009: 28-29). At all of these levels, however, technology connects the "transformation of material resources, abstract and practical knowledge, social and political relationships, and cultural beliefs" (Brezine 2011: 82) by means of practices that are essential to the human condition. The process of technological change, therefore, fundamentally involves the change of relationships, including relationships between humans, objects, and the landscapes within which people live. This happens at a relatively local scale—that of the household, community, or the intercommunity network. Consequently, we need to examine technologies at these local scales in order to explore the ways that societies themselves (and the people that comprise them) are transforming or transformed (Maran and Stockhammer 2017).

While technologies can encompass many abstract components of society that are difficult or impossible to explore via the archaeological record, they can also be more directly manifested though the production and use of objects from all aspects of life. Ethnographic and archaeological studies of craft production, which can involve "any transformational process involving skill (knowledge, talent or proficiency, effort), aesthetics, and cultural meaning" (Costin 2005, 1036), often focus on the *chaîne opératoire* in order to elucidate the many steps and interrelated technologies that are contained within the production of any given item (Costin 2001; Clark 2007; Dobres 2000; Rice 1987; Sellet 1993; Sinopoli 1991). This can include everything from the knowledge needed for each step of any production process, the identification, extraction, and preparation of raw materials, ritual or sacred knowledge of proper

production times, places, people, and taboos, forming and decorative techniques, distribution and exchange of finished goods, and reuse or proper disposal of objects. While not all of these aspects of production can necessarily be known, attempting to explore each step can potentially reveal both the production processes of individual objects, as well as the ways these processes may be interconnected with other technologies and social, political, or religious aspects of society (Costin 2001). Here, we advocate moving away from tropes of large-scale cultural shifts directly resulting from climatic change or migration. Instead, we suggest that the Majiayao to Qijia transition should be approached via localized studies of discrete, but likely interrelated, production practices, alongside the landscapes and social structures in which they were situated. Only such a multi-perspective approach allows insights into the interplay between technologies, objects, and the people who created and used the items that we see in the archaeological record.

Additionally, when analyzing what some scholars view as Qijia responses to climatic change, we need to consider the wide range of forms that such adaptations can take, from shifting subsistence strategies (Cheung et al. 2019; McIntosh 2005), to exchange patterns (Borck et al. 2015), to changes in political and social organization or even religious beliefs (McAnany and Yoffee 2009; Middleton 2012). Therefore, to understand the decision making that underlies technological and social change, we need to take a close look at how each individual technology was adopted, adapted, or rejected on a local scale, examine how these developments correlate with other changes in society, for example in production organization, site layout and location, or mortuary practices, and then tease out possible connections between these human actions and potential shifts in the local environment. The data currently available from Majiayao and Qijia period sites are not sufficient to approach all of these questions in detail. However, when viewed together with the results of previous research, the findings of our recent fieldwork can provide a first step on the road to a more nuanced understanding of the technological and social continuities and changes that we suggest characterize the Majiayao to Qijia transition.

In the next section, we present recent research from the Tao River Archaeological Project (TRAP), an international collaboration between Peking University, Harvard University, and the Gansu Provincial Institute of Archaeology, which includes members from across East Asia, North America, and Europe. In the project as a whole, we have focused on careful dating of sites and individual finds in order to determine whether adoptions and adaptions of new technologies are concurrent with other changes. We have also attempted to situate these finds within the wider landscape of sites and natural resources in the northern Tao River Valley to improve our understanding of the technological and raw material options available to past inhabitants of the area. While we are still at a preliminary stage of our research, the results of our first five years of fieldwork, and the model we have developed based on them, differ in

many respects from previous research and hypotheses for technological and social shifts between 4500-3500 BP. Here we present our results in detail to allow for comparison with previous research in the region and to support our proposed model of technological and social continuity and change between the Majiayao and Qijia periods.

4 Recent Fieldwork in the Tao River Valley, Gansu Province

Beginning in 2011, TRAP laid the groundwork for new investigations into the Majiayao to Qijia period transition through a series of site visits in the Tao River Valley. TRAP focuses on the Tao River Valley because of the large number of Neolithic and Bronze Age sites that have been identified there as well as the comparatively long history of research in the region going back to Andersson (1925; 1943) and Xia Nai (1948) in the 1920s to 1940s. After the initial assessment of the 531 known sites in the valley using satellite imagery, and under the authority of the Gansu Provincial Institute of Archaeology, TRAP conducted visits to 58 sites over the course of three preliminary seasons (2011-2013) (Flad et al. in preparation). At each site we assessed the degree to which intact archaeological materials seemed to be present and the chronology of the site based on surface collections and examination of field cuts and terraces.

Our preliminary work identified four known sites that provide the best opportunities for collecting data on technological change: the Majiayao and Qijia site of Dayatou 大崖头, the Qijia type-site of Qijiaping 齐家坪, the Majiayao and later Siwa period type-site of Siwashan 寺洼山, and the Majiayao type-site, which also contains Qijia material (see Fig. 1). While we also undertook work at the later Siwa period site of Huizuiwa 灰嘴洼, the results of that work are not directly related to the topic at hand and are addressed elsewhere (Jaffe et al. forthcoming). Initial investigations included total coverage surface survey and selective magnetometry survey, as well as detailed digital mapping at Dayatou, Qijiaping, and Siwashan, magnetometry at Majiayao, and excavation by TRAP at Dayatou (2018) (Womack et al. 2019b) and Qijiaping (2016-17) (Womack et al. 2017; Hung et al. 2019). Majiayao and Siwashan were concurrently excavated by a team from the Archaeology Department at the Chinese Academy of Social Sciences (CASS), and members of TRAP were able to analyze some materials from these investigations.

Excavations were based on the results of our magnetometry and targeted anomalies that appeared to be caused by archaeological materials including trash pits, ditches, and pyrotechnological features. After feature detection and augering, we then returned in subsequent years to undertake excavations of selected anomalies. In each case identified anomalies turned out to be directly associated with archaeological features, which guided both TRAP excavations as well as CASS excavations in some areas at the Majiayao and Siwashan sites. TRAP excavations proceeded using the locus system of combined natural and arbitrary levels, with soil samples being taken for flotation from each locus and all completed loci

being recorded through hand drawings, measurement, and photogrammetric modeling. Artifacts recovered from excavation underwent initial conservation and macroanalysis at the Gansu Provincial Institute of Cultural Relics and Archaeology, with further analysis being undertaken by project members at their home institutions. This work provided the foundation for our understanding of the layout, use, and dating of each site, as well as providing initial insights into aspects of subsistence and craft production.

5 Results of Fieldwork and Analysis

5.1 Initial results: site layout and periodization

The combination of surface survey, magnetometer survey, and digital mapping has allowed us to better understand potential site layouts at each of the locations we have investigated. Dayatou, perched atop a bluff overlooking a major bend in the Tao River, appears to have been occupied from at least the early Majiayao through later historical periods. While this site was previously interpreted as containing a Majiayao cemetery, due to the large number of painted pottery sherds present on the surface as well as a number of looters trenches, our surveys revealed that it is in fact a complex, multiperiod habitation site (Womack et al. 2019b). In particular, the results of our magnetometer survey point to at least five discrete occupation areas, some of which appear to have been demarcated using ditch features. Dates taken from auger cores of key anomalies identified through magnetometry, as well as from excavated remains, point to distinct early, middle, and late Majiayao occupations as well as Qijia period occupation (**Table 1**). Thus, it appears that this site was occupied if not continuously, then at least separately during multiple sub-phases of the Majiayao as well as the Qijia period. It is unclear if the site only contains habitation remains or also has distinct cemetery and production areas, as have been noted for other Majiayao sites (Gansu 1957).

The nearby site of Qijiaping, on the other hand, appears to have been occupied primarily during the late Qijia period as well as during the Song 宋 Dynasty (Womack et al. 2017). Our surface survey and selective magnetometry survey complimented a previous auger survey of the site. The results of these combined efforts indicate that the main habitation area is located underneath and adjacent to the modern village of Qijiaping, while a cemetery, which was partially excavated in the 1970s, lies nearby, separated from the main habitation area by a gully. Further survey and excavation are needed to confirm whether anomalies identified near the main village area during the magnetometry survey are related to production features, such as kilns and hearths; however, several anomalies do seem consistent in signal strength and size with this type of feature.

At the site of Majiayao, our magnetometry survey was used to guide excavations of one portion of the site by a team from CASS. The team identified a number of features associated with habitation as well as a large ditch containing Majiayao materials, which is consistent with anomalies identified in our magnetometry map (**Fig. 3**). CASS excavations revealed that the site was occupied during both the Majiayao and Qijia periods; however, the exact chronology of the site is awaiting the outcome of analysis of radiocarbon samples. We are also awaiting publication of the final excavation report in order to better understand the layout of the site. Generally, however, it appears that in more than one case Majiayao sites were occupied either continuously into the Qijia period or separately during the Majiayao and then Qijia period.

Finally, at Siwashan, our geophysical and surface survey revealed a very large site occupied during at least the Majiayao and Siwa periods, which postdates Qijia. Interestingly, the Majiayao remains appear to be a mix of habitation and craft production features, with numerous kilns already having been uncovered, while the Siwa remains are all mortuary in nature, a fact first reported by Xia Nai (1949). The Majiayao remains are quite widespread, and additional excavation and dating will be required to understand if these areas were occupied concurrently or represent a drifting of the occupation area over the course of hundreds of years. In sum, our investigations have clarified that several sites were occupied during both the Majiayao and Qijia periods, clearly refuting the idea that these groups occupied different locations or lived at significantly different elevations, even in the late Qijia period when climatic drying and cooling is seen as being most severe (Liu et al. 2010). Additionally, our survey at Dayatou indicates that site sizes should not be calculated off of surface scatters of pottery alone (Womack et al. 2019b), calling into question whether there was a meaningful shift in site sizes between the two periods.

5.2 Initial results: landscape analysis

Beginning in the summer of 2018 we turned our attention to the wider landscape in which these sites are situated, with a particular focus on locating raw materials sources that may have been used by Majiayao and Qijia craftspeople. Using a combination of geological maps and discussion with modern potters, villagers, and farmers, we began to identify areas of interest within and adjacent to the Tao River Valley. After a small pilot survey in valleys near the site of Siwashan in 2018, we moved on to a larger geological survey in 2019. This survey focused on the Dabi 大碧 River, a tributary to the Tao that meets it near the sites of Qijiaping and Dayatou. Interestingly, the name of the river initially meant “Making (jade) *bi*” river, although the Chinese characters have changed over time, and locals also related to us that the mountain from which northern tributaries of the Dabi flow, Maxianshan 马衔山, contains a small jade quarry. In 2019 we carried out a geological survey, walking the banks and low terraces of the Dabi, as well as in the Guojiagou 郭家沟 valley, which is formed by a tributary that flows from below the jade

quarry area on Maxianshan into the Dabi. Previously, there were no identified sites in the Dabi River Valley and in general almost no identified sites from the Majiayao and Qijia periods east of the Tao River Valley (**Fig. 4**).

Over the course of two weeks we identified eight new Qijia sites and collected dozens of clay, sand, and stone samples, including samples of jade from the quarry area. Locals recalled to us how jade used to be commonly found in the river until a dam was built to divert the water to another area for irrigation. Stone types included schist and slate, which were also used for stone tools recovered from Dayatou and Qijiaping, as well as granite, gabbro, and gneiss. Clay was also widely available, as was gypsum, which can be used in lime plaster production, and a variety of soft-colored stones, which could potentially be used for pigment production (**Fig. 5**). Additional analysis is currently underway on these raw materials to determine if they were potentially used in production of items found at sites we have excavated.

Interestingly, of all the sites identified and hundreds of sherds collected, only a single Majiayao style sherd was found, and this sherd was recovered quite close to the Tao River. Among the identified Qijia sites, the largest was located far up the Guojiagou valley, only 10 km from the jade quarry. Based on these preliminary findings, it appears that this valley was first occupied during the Qijia period, with minimal earlier Majiayao presence. Of course, this was not a systematic surface survey, which would be extremely difficult given the vertical nature of the landscape. However, ridge tops and high terraces were periodically visited throughout the survey and no material from either period was recovered in these areas. We suggest that Qijia expansion towards Maxianshan was possibly driven by the exploitation of resources used in new types of craft production, such as jade carving and lime plaster production. Whether this had an impact on other crafts, such as pottery and other stone tool production, remains unclear.

5.3 Initial results: pottery

Analysis of pottery included macroanalysis of Majiayao and Qijia period surface collections from each site, as well as macroanalysis of excavated materials from Qijiaping and Dayatou. Additionally, excavated materials and surface collections from Qijiaping and Dayatou, as well as a small number of sherds from Siwashan and a surface collection from the nearby Banshan sub-phase cemetery of Dibaping 地巴坪 (Gansu 1978) were investigated using petrographic analysis (see Womack and Hein 2018). This was paired with a separate use-alteration analysis of previously excavated whole vessels from Qijiaping and Dibaping. In total, more than 30,000 sherds have been recorded for macroanalysis while 273 have

undergone petrographic analysis. Additionally, clay, sand, and rocks were sampled around each of these sites in order to establish possible connections to locally available raw materials.

Qualitative and quantitative petrographic analysis proceeded according to methodology laid out by Quinn (2013) and Stoltman (1989, 1991, 2001), respectively. The results identified nine fabric groups among all analyzed sherds, which included samples of plain, painted, cord-marked, and basket-marked wares from both habitation and mortuary contexts. To summarize the conclusions, for the earlier Banshan sub-phase of Majiayao there is a marked difference between pottery observed at habitation and mortuary contexts. In habitation contexts, cord-marked pottery is extremely diverse in paste type, indicating that the pottery itself, or the raw materials used to make it, comes from a number of different locations. Painted and plain sherds, on the other hand, appear to be almost entirely made of fine local clay with minimal variation in silt and sand content. At the nearby mortuary context, however, painted and plain sherds appear to come from multiple geological sources, with a mixture of local and nonlocal pastes. Cord-marked sherds were not available for sampling from this context. When combined with the results of the use-alteration and manufacturing mark study (Womack and Wang 2020), which pointed to significant diversity in vessel form, paint recipes, and use-lives, we hypothesize that funerals may have been contexts where vessels and their contents were brought from a variety of communities to participate in mortuary rituals (Womack et al. 2019a). Banshan funerals may have been key locales for bringing members of regional communities together to build, reinforce, and/or negotiate social ties, as has been suggested for such contexts in other areas of the world (Flad 2002; Liu 1996; Parker Pearson 1999; Underhill 2000).

During the Qijia period, however, no such difference between pottery from mortuary and habitation contexts is apparent in either macro or petrographic analysis (Hung et al. 2019; Womack 2017). Indeed, analysis of whole vessels from mortuary contexts at Qijiaping revealed that most, if not all vessels were used extensively in daily life before being placed in graves. However, both cord-marked and basket-marked vessels, which were the only two types examined for petrographic analysis, appear to be made of a mixture of local and non-local raw materials. In each case, around half of the vessels have pastes that match local materials, while the other half are made up of up to six other paste groups. Perhaps most interesting is that for cord-marked vessels, these paste groups are a nearly exact match of the pastes seen in Banshan period cord-marked vessels and appear in similar proportions to the sample from Dayatou. Thus, it appears that at least for cord-marked vessels, while vessel shapes and sizes changed significantly, paste recipes, both local and non-local, remained nearly identical between the two periods. Also, either knowledge of the location of non-local raw materials, or exchange relationships with communities producing non-local pots, also persisted. Based on recent radiocarbon dates from excavations at both sites, it appears that this persistence carried on over 700 years, as sampled Banshan contexts at Dayatou date to around 4300 cal BP while contexts at Qijiaping date to 3500-3600 cal BP. This persistence in

technological knowledge likely points to persistence in the communities of practice who were making these items and passing down this knowledge over time (Womack et al. 2019a), even as other aspects of production, such as pottery forms, changed. Similar examples of change in one aspect of ceramic production, but continuity in others, especially local resource use, has also been demonstrated in other archaeological contexts (e.g. Ting 2017).

5.4 Initial results: archaeobotanical analysis

Regarding archaeobotanical remains, we conducted flotation on soil samples from each excavated locus at Dayatou adding up to a total of 102 flotation samples. Due to time constraints, a sub-sample of 33 samples was analyzed. These sub–samples contained a total of 10,217 macrobotanical remains (excluding wood charcoal counts) and were selected to represent all of the trenches and each one of the identified features and contexts. While we are awaiting radiocarbon dates from the seeds recovered from Dayatou, we can already say that the vast majority of recovered seeds come from broomcorn and foxtail millet, which were the dominant domesticated crops throughout northern China during the Neolithic period.

In addition to millet, two trenches contained comparable amounts (by standardized weight) of wheat, and to a lesser extent, barley (**Fig. 6**). While wheat appears in all three of our excavated trenches, barley only appears in one section of one trench. Each of the contexts where wheat was found primarily contained Majiayao-style pottery, although some pottery that may relate to the early Qijia period was also found in some contexts. Thus, it appears that at Dayatou, wheat is first adopted in the middle Majiayao period and persists at a low level of cultivation into at least the early Qijia period. Interestingly, the barley only appears in a trench with Majiayao materials, perhaps indicating that it was experimented with and then abandoned at Dayatou, however we will need the results of radiocarbon dating to verify these associations. Additionally, the presence of Emmer wheat in noteworthy quantities might further suggest agricultural experimentation. This teraploid wheat cultivar is generally considered to be a precursor to the hexaploid, free-threshing wheat found at this site and other contemporary sites across northwestern China.

Millet proportions at the site of Dayatou consistently show a predominance of foxtail millet over broomcorn millet throughout the site, with the exception of one trench where broomcorn millet dominates the assemblage. At the late Qijia period site of Qijiaping there is a much more equitable proportion of millets to wheat and barley. While foxtail millet continues to be the main millet variety, the ratio of foxtail to broomcorn millet is substantially lower than at Dayatou. Furthermore, at Qijiaping we also see a more substantial presence of barley. The gradual adoption and incorporation of new crops alongside long-standing staples is known from multiple archaeological contexts and points the importance of experimentation on the part of local communities (Weber and Fuller 2008). This also appears to have

been the case for Majiayao and Qijia adoption of wheat and barley, with both crops slowly becoming well established parts of the local diet by the late Qijia period at the latest.

5.5 Initial results: zooarchaeological analysis

Faunal remains from Dayatou and Qijiaping include a mixture of wild and domesticated species (see Brunson et al. 2020 for a detailed discussion of the zooarchaeological results) (**Fig. 7**). At Dayatou, excavations of Majiayao period trash pits revealed bones of pigs, cattle, sheep, and goat. These remains likely represent domesticated animals, although it is possible that some wild bovids and wild boar were also present. Pig bones are overall the most common faunal remains, making up 18% of total recovered remains. However, the MNI for pig remains is only one due to the small total number of bones recovered. Ancient DNA analysis confirms the identification of domesticated sheep (*Ovis aries*) and goat (*Capra hircus*) bones at Dayatou, but the direct radiocarbon dates for these bones are quite late (ranging from 3900-3750 cal BP for three sheep bones and 3000-2850 cal BP for a single goat bone). Rodent chew marks on the bones indicate that there may have been stratigraphic mixing. Further investigation and dating are still needed to determine whether sheep and goats were used during the Majiayao period at Dayatou. Remains of wild animals identified at Dayatou include those of hares, deer, rodents, and birds, as well as a single small fish vertebra found in the flotation heavy fraction. For deer, most remains are in the form of worked antler or bones, perhaps indicating that these items were traded into the site from other areas, since larger, meat-rich portions of the animal are absent. Generally, it appears that the Majiayao period inhabitants of Dayatou included a mixture of wild and domesticated species in their diet.

At Qijiaping, faunal remains were recovered from our two seasons of targeted excavation of trash pits at this site. Remains of what are most likely domesticated pigs were recovered in significant numbers, including remains of at least three young pigs dating to the Qijia period. Ancient DNA analysis and radiocarbon dating of caprine bones indicate that both domesticated sheep and goats were present, with dates for these samples ranging from about 3600-3400 cal BP (see Brunson et al. 2020 for details). Other remains include bones belonging to domesticated dogs, wild or domesticated cattle, as well as wild deer, rodents, and at least one bird. Two caprine scapulae were found at the bottom of a trash pit with burn marks resulting from pyromancy and in context with the bird remains, perhaps pointing to ritual use relating to the initial opening of the pit. In comparison to Dayatou, faunal remains are relatively similar in overall type; however, there appears to be at least a small increase in the presence of sheep remains compared to pigs and wild animal remains. Nevertheless, the reliance on domesticated pigs, alongside a variety of wild species, continued between the two periods (Brunson et al. 2020). This slow increase in numbers of new domesticates is not entirely surprising, since based on research in other parts of the

world, the adoption of caprines and cattle into existing agricultural systems often occurs gradually (e.g., Jones 2015).

5.6 Initial results: analysis of stone tools & jade

A number of lithics have been recovered from surface survey and excavation at Dayatou and Qijiaping. These include stone tool blanks, possible debitage, broken tools, and ornaments. Jade (nephrite), stone tools, and metal objects were also recovered during the excavation of the cemetery at Qijiaping in 1975, but aside from the metal, none of these objects have undergone more than initial macroanalysis (Chen P. 2013). In total, 13 stone objects were recovered during our excavations at Qijiaping, while 242 stone objects were recovered during survey and excavation at Dayatou. Given the large number of objects and blanks found during survey, including some semi-finished products such as arrowheads, axes, and chisels, it seems that Dayatou may have been a center of stone tool production. Several semi-finished stone objects were recovered from Majiayao and Qijia-style ceramic-bearing layers of Trench 1 at Dayatou during TRAP excavations in 2017, indicating that production occurred during both periods. Production remains include a stone adze which was being reworked from a previously broken, perforated stone tool, as well as a rectangular stone slate of unknown function.

Based on preliminary analyses, there is little difference in the style and materials used to produce tools found at Qijiaping and Dayatou. Predominant stone types include sandstone, slate, schist, and gabbro. Sandstone and gabbro are available locally in the form of river cobbles, while, based on examination of geological maps and our initial geological surveys, slate and schist are available in rock outcrops near Maxianshan and in the Dabi River Valley 20-30 km away, as well as in the Qinling 秦岭 mountains around 80 km south. These stone types are not available in the river since they are generally destroyed over even short distances of water transport. Aside from jade objects from graves at Qijiaping, a single piece of jade production debris was recovered, in this case from Dayatou (**Fig. 8**). Since this was found during survey, the period of production remains unknown. Raw jade is available locally at Maxianshan. Overall, aside from the development of jade carving or import of carved jade during the Qijia period (Chen H. 2013; Chen P. 2013), there appears to be little change in stone tool production between the Majiayao and Qijia periods in the northern Tao River Valley.

6 Discussion

As can be seen from the outcomes of TRAP fieldwork and analysis, our results depart in many ways from what is expected from previous models of the Majiayao to Qijia transition. This is consistent with

our view of local communities as actively adopting, adapting, and rejecting technologies based on a combination of political, religious, and environmental factors. As has been demonstrated in numerous archaeological contexts (Bernbeck et al. 2017; Lemonnier 1993; McIntosh 2005), past peoples did not accept every new innovation or change in political and environmental climates, but proactively and selectively innovated or adopted technologies, belief systems, and organizational structures based on available knowledge. For example, in the realm of pottery, while vessel form and some aspects of surface treatment, specifically painting, changed significantly over time, the underlying production techniques and raw materials remained remarkably similar. Even vessels made using non-local paste recipes, which likely indicate exchange of vessels or the raw materials used to produce them, continue at similar levels. In the realm of lithics, while a new technology, jade carving, is introduced during the Qijia period, other aspects of lithic production, such as the stone types and forms of daily-use stone tools, remain remarkably similar. And while new architectural technologies, such as lime plaster and stone circles, are introduced, site layouts and house sizes and shapes do not show significant differences. These technologies, including new ceramic forms, jade carving, and lime plaster production, along with pyromantic divination, all appear to have likely been introduced from Longshan or related settlements further east, but considering the continuities in many aspects of production, they do not seem indicative of a mass migration and population replacement. Instead it appears that new technologies from further east were incorporated alongside longstanding traditions of production and exchange.

Similarly, while TRAP fieldwork has revealed the presence of new domesticates, including wheat, barley, caprines, and possibly cattle from Central Asia, they do not occur at levels that one might associate with a rapid shift in subsistence practices or cuisine during either period. Indeed, while our data largely match that from other studies regarding local growing of small amounts of wheat and barley during the Majiayao period, it does not support the idea of a wholesale transition towards these new crops and abandonment of millet during even the late Qijia period. While domesticated caprines appear alongside domesticated pigs beginning in the Qijia period, they make up a relatively small portion of total animal remains. Additionally, aside from possible Qijia expansion into the Dabi Valley, we do not see a significant change in site locations, with many sites showing occupation during both periods. Site sizes also remain similar, now that it has been determined that Dayatou, which was once thought of as an unusually large Majiayao site, is actually made up of the overlapping remains of multiple occupations from multiple periods. Thus, the idea that a shifting climate forced major changes in subsistence practices or site sizes and locations between the two periods is not supported by current evidence from the northern Tao River Valley. This does not mean that the climate was not changing or that the local population was not dealing with this change; however, it appears that earlier suggestions of the ways local people

responded to such a shift, for example, by drastically changing their habitation locales and subsistence practices, are not borne out in this region.

Nevertheless, Majiayao and Qijia period inhabitants of Northwest China did choose to adopt new technologies, including technologies that must have radically changed the ways they consumed food and beverages, spent their time, and interacted with the landscape. For example, the transition to smaller vessels in the Qijia period must have had an impact on food preparation and consumption, or vice versa, even if the foods being consumed, such as millet and pork, and to a lesser extent wheat, barley, and possibly mutton, were largely similar between periods. The introduction of barley and wheat during the Majiayao period may be indicative of the adoption of new types of consumables, such as beer, as has been seen with the spread of new vessel types in other parts of China (Liu et al. 2020). This in turn may have required new specialized knowledge of cooking and brewing, which in turn would require people to curate and pass down knowledge of these complicated processes over time. Similarly, in adopting jade carving and lime plaster production, new resources and knowledge would be needed for local production. The search for jade and gypsum may have led the inhabitants of the Tao River Valley during the Qijia period to establish sites in new areas, such as the Dabi Valley, while local jade carving would have required huge amounts of time and the transfer of specialized knowledge of this new craft. This may have resulted in certain members of society adopting new specializations in finding or mining jade, roughing out the stone, carving and polishing objects, and then transmitting them between sites. Regarding jade use, it is not clear if the ritual applications of jade objects such as *cong* and *bi* as practiced in other regions were also known in the Tao River Valley. If they were, or if new applications were developed locally, then new specialists would have been needed to utilize and pass down the knowledge associated with these rituals. Similarly, the adoption of pyromantic divination would have required the use of specialized knowledge in the preparing and burning of bones, making associated sacrifices, and interpreting the results. If metallurgy was taking place locally, then knowledge of raw material location, smelting, alloying, and casting would all be needed. Thus, even selective incorporation of new technologies would require entirely new webs of production tying together raw materials, production processes, and specialized knowledge that were adopted alongside longstanding traditions.

In other parts of China, the creation and use of jade and metal objects have in some cases been associated with increasing social inequality. For example, in Liangzhu 良渚 burials, inclusion of multiple jade objects has been seen as one of several markers of increasing social inequality (Qin 2013). Bronze vessels recovered from late phase graves at Erlitou are thought to have been used in a similar manner to signal elite status (Liu and Chen 2012). However, the inclusion of the occasional bronze or jade object in Qijia period graves does not appear to have signaled significant differences in status in the northern Tao River Valley. When looking at social structures, which incorporated significant specialized production in

the realms of food production, potting, architecture, divination, and stone working, we view Majiayao and Qijia communities as having significant heterarchical complexity (see McIntosh 1999: 62), but without clear signs of increasing inequality. During both periods we see skilled participation in various forms of production, as well as local to regional level exchange for certain products (deer antler tools, pottery, bronze items, shells). During the Qijia period, new technologies likely led to the addition of new specialized tasks that potentially increased heterarchical complexity but did not necessarily lead to increased social inequality. For example, graves at both Dibaping and Qijiaping exhibit few differences in grave size, shape, or the amount of pottery or other items interred (Chen P. 2013; Womack and Wang 2020). Even the few Qijiaping graves with unusual items, such as carved jade, a bronze knife, or a single turquoise inlaid plaque, are not otherwise distinguishable from graves with just a few daily-use pottery vessels. While at other sites during both periods, such as Liuwan and Mogou, more obvious signs of inequality, such as large numbers of ceramic vessels (Allard 2002), inclusions of multiple metal objects, or increasing violent trauma (Dittmar et al. 2019) are present, this is simply not the case in the northern Tao River Valley. Instead, it appears that selective technological adoptions and adaptations from 4500-3500 BP resulted in increased heterarchical complexity, potentially at both the individual and community level, as some communities or individuals specialized in the production and use of new technologies. However, these adoptions do not appear to have led to a significant increase in inequality among or between local communities, nor did it result in a significant shift in the physical location and layout of sites, or the social organization of sites as reflected in layout, location, grave size, or organization of craft production. While additional research will be necessary to see if these patterns hold true outside of the limited area encompassed by our study, and to better understand other aspects of society such as ritual activities and political organization, we suggest that the general nature of the Majiayao to Qijia transition should be reexamined in light of these results.

7 Conclusion

Technological change has long been a defining characteristic of proposed cultural change in many parts of the world, including China. While making for an easy tool for indexing change over time, pottery itself is just one of many technologies that groups and individuals innovate, adopt, adapt, reject, or abandon due to a wide variety of social, political, economic, or environmental reasons (D'Ercole et al. 2017). We suggest that changes in pottery form or decorations should be investigated alongside wider webs of technology and social organization in order to better understand how these complex relationships may shift over time.

In northwestern China, the transition between Majiayao and Qijia style pottery has been associated with the adoption or increased use of new technologies arriving in the region from two directions. From the west, in Central Asia, came new technologies and domesticates including metallurgy, wheat, barley, caprines, and cattle. From the east, in what is now northern central China, came jade carving, pyromantic divination, lime plaster flooring, and new pottery styles. The adoption and use of these new technologies have typically been seen as resulting from a mixture of migration from the east as well as a response to climate change induced cooling and drying during the Qijia period, which forced the increased use of new crops, a shift towards a more pastoral lifestyle, and a move to new site locations. However, the data that led to these views have come from a small number of widely dispersed sites, many of which are not precisely dated. In order to better understand this transition on a local scale, the Tao River Archaeological Project investigated several sites in the northern Tao River Valley dating to the Majiayao and Qijia periods.

The initial results of our studies present a somewhat different picture from previous models of regional change. While shifts were undoubtedly occurring as Majiayao period peoples incorporated low levels of new domesticates into their subsistence practices and then Qijia period peoples incorporated new technologies including new pottery forms, crafts, architecture, and possibly rituals, the signs of underlying continuity between the two periods are nevertheless quite strong. For example, while the use of wheat and barley do increase over time, millet still makes up the majority of domesticated botanical remains at both Qijia and Majiayao sites. Site locations do not change significantly, and new architectural features, such as lime plaster, are incorporated into traditional house layouts. In the Tao River Valley, the appearance of new types of craft production and ritual practices that are closely associated with increasing inequality at some sites in northern and eastern China, such as jade carving, metal production, and pyromancy, do not appear to have had a major impact on social structures as reflected in mortuary practices including sizes of graves and numbers of objects. Indeed, most of these new technologies seem to be carefully integrated into longstanding traditions of production and social organization, with clear continuity being seen in areas including ceramic production and exchange, stone tool manufacture, site locations and layout, and even mortuary practices. Thus, we suggest that instead of viewing the Majiayao to Qijia transition as the result of climate change or mass migration, it should be seen as a slow, nuanced adoption of new technologies that begins in the middle Majiayao period and continues through the Qijia period.

We suggest that the incorporation of new technologies and subsistence practices resulted not in increased social stratification, but in increased heterarchical complexity, as new skilled tasks, such as jade carving, metallurgy, and possibly ritual specialization were integrated alongside long-standing traditions of pottery production, hunting, farming, and stone and bone tool making. While during later periods there

do appear to have been more dramatic shifts in subsistence practices (Jaffe et al. under review), and in other parts of what is now China there were clear signs of increasing social stratification during the late Neolithic and early Bronze Age (Liu 1996; Shao 2000; Underhill 2002; Zhao 2013), that simply does not appear to be the case for the period from 4500-3500 BP in the northern Tao River Valley. There, technological and social transitions certainly did take place, but in a much more integrated fashion than previously suggested, which involved selective incorporation of new technologies alongside long-standing traditions.

Figures

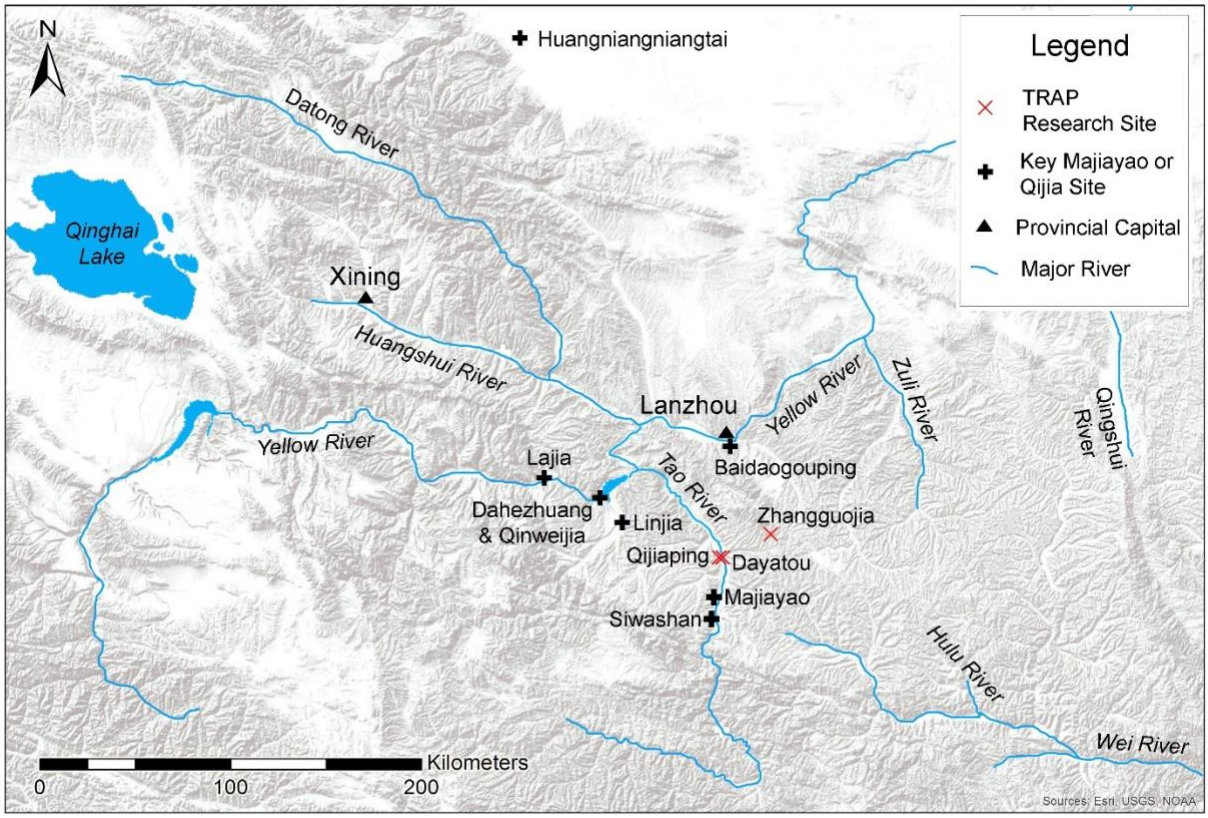

Fig. 1 Map of northwestern China including location of sites discussed in the article (map by Andrew Womack)

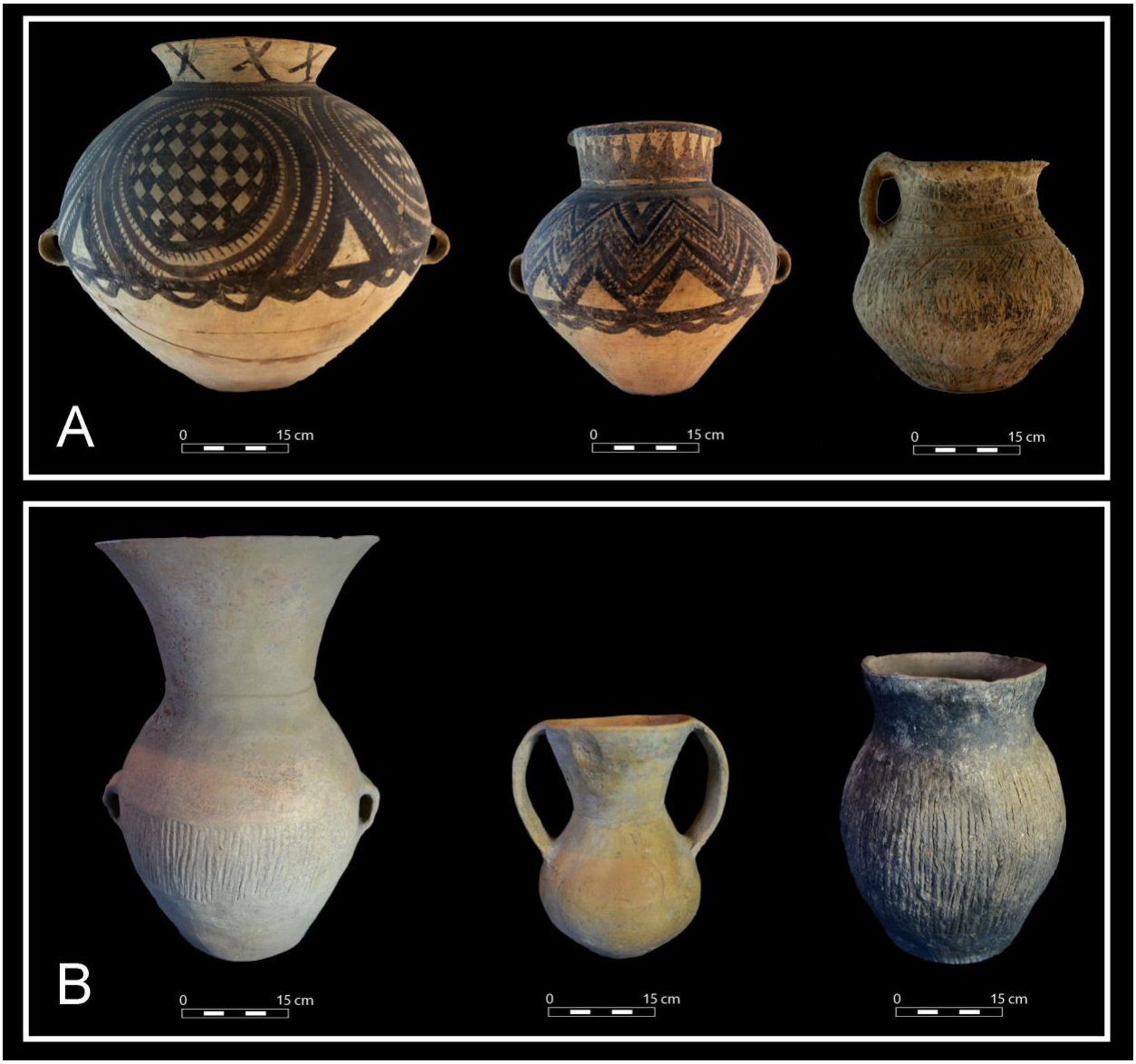

Fig. 2 Images of typical (A) Majiayao and (B) Qijia period pottery from the northern Tao River Valley (photos by Andrew Womack)

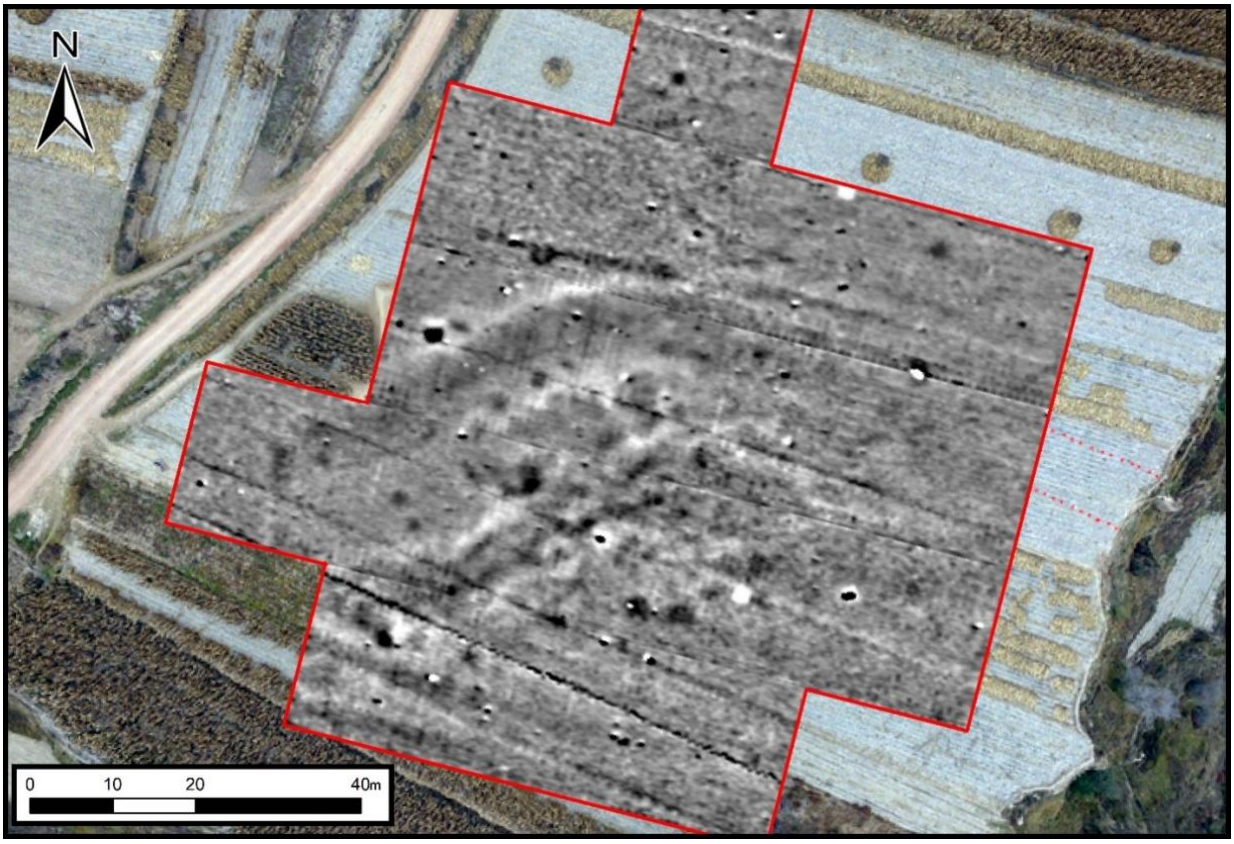

Fig. 3 Magnetometry results from the site of Majiayao that helped guide later excavations. Features revealed included a large ditch and numerous trash pits (figure by Andrew Womack)

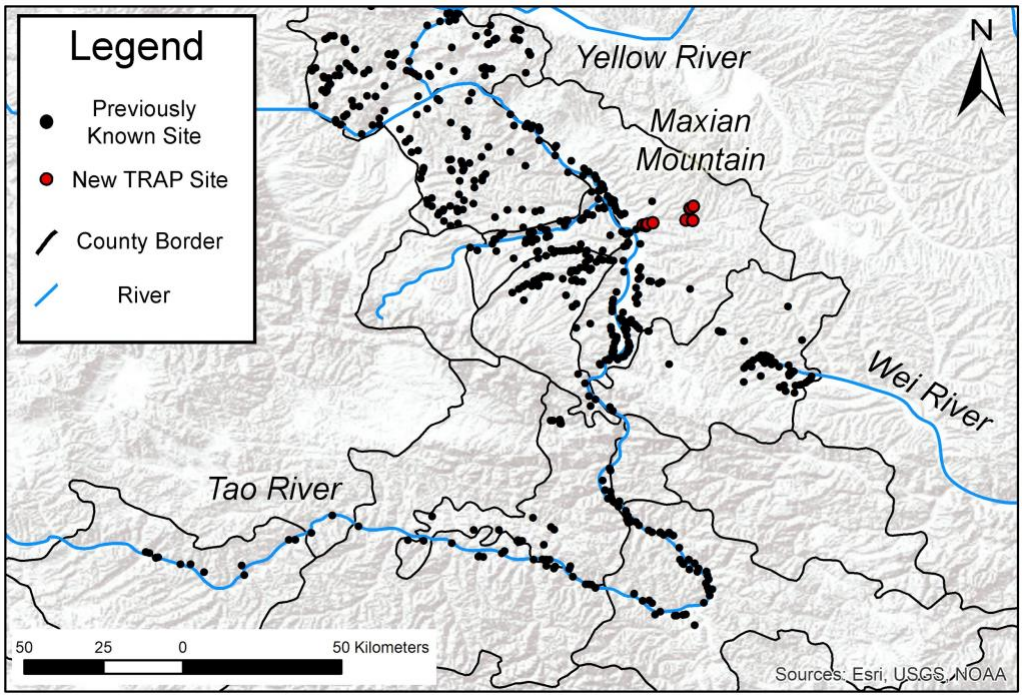

Fig. 4 Map of previously known archaeological sites in counties bordering the Tao River as well as sites discovered during the 2019 TRAP survey of the Dabi River valley (map by Andrew Womack with data provided by the Gansu Institute of Archaeology)

Fig 5 Clay outcropping along a hillside (left) and weathered stones containing colorful materials possibly associated with pigment production (right), both found in the Dabi River Valley (photos by Andrew Womack)

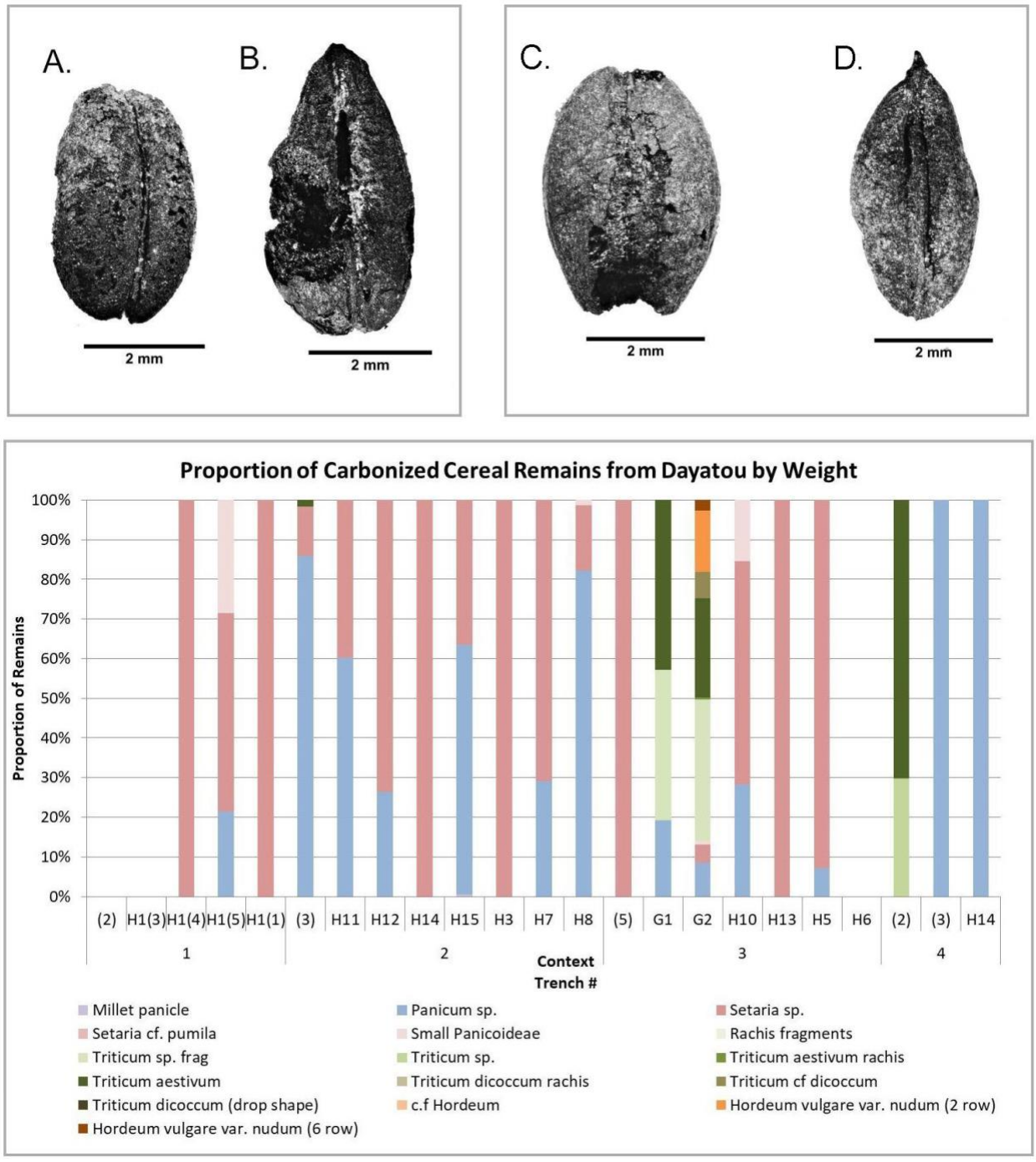

Fig. 6. Stacked bar chart showing the relative proportion of cereal taxa by standardized weight from Dayatou (bottom) as well as: A. *Hordeum vulgare* subsp. nudum (2-row naked barley) (Ventral); B. *Hordeum vulgare* subsp. nudum (6-row naked barley) (Ventral); C. *Triticum dicoccum* (ventral emmer wheat); D. *Triticum dicoccum* (drop shape emmer wheat) (ventral) (figure by Fabian Toro)

Fig. 7 Zooarchaeological remains from excavations at Dayatou including a roe deer antler (top left); a sheep phalanx (top right); and a fish vertebrae (center left); and from excavations at Qijiaping including a goat metacarpal (center right), and two caprine oracle bones (bottom left and right). All scales in centimeters (photos by Katherine Brunson)

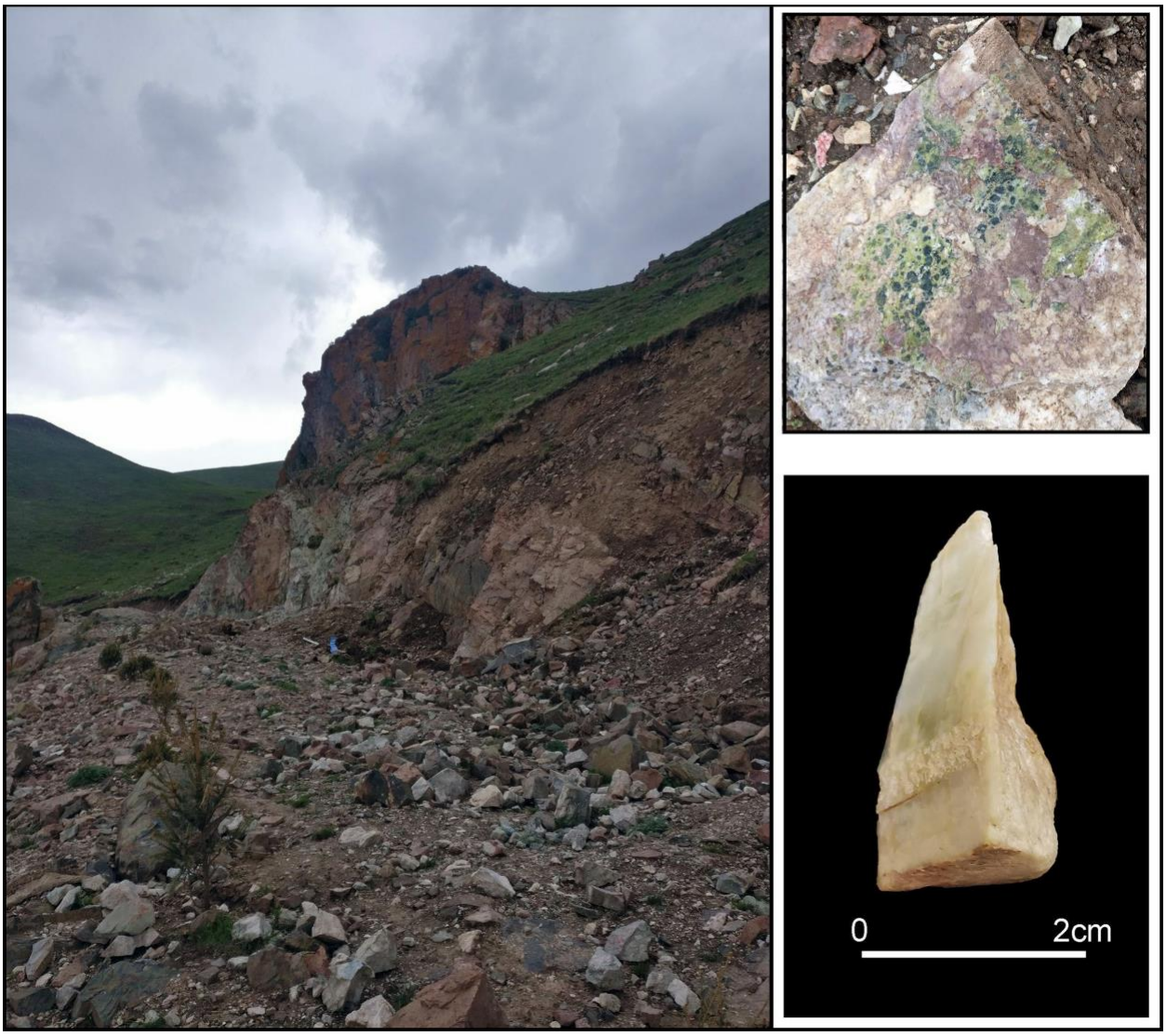

Fig. 8 An active artisanal jade quarry on Maxianshan (left); jade stone found near the quarry (top right); and worked jade recovered from the surface of the Dayatou site (bottom right) (photos by Andrew Womack and Su Xin)

Table 1 Combined ^{14}C AMS dates taken by TRAP at Dayatou and Qijiaping. All samples run at the Archaeometry and Archaeological Dating Laboratory at Peking University (Lab Code: PKU).

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