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On the Exploration of Social Development during a Historical Period in the Eastern Tienshan Mountains via Archaeological and Geopolitical Perspectives

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Abstract: Natural and social environment changes have played important roles in social evolution in different times and spaces. Geopolitical change, in particular, might play a decisive role in social evolution during historical periods. The eastern Tienshan Mountains was a transportation hub for communication between the East and the West, where the natural environment is fragile and the social environment has been complex during the historical period. However, geopolitical change and its impact on local social development remain unclear due to fragmented historical records and limited studies. This study investigates the spatiotemporal variations of military facilities in the Hami region, and compares historical documents and archaeological and paleoclimate records to discuss geopolitical changes and social evolution during the historical period in the eastern Tienshan Mountains. A total of 84 visible organic remains from 38 historic beacon towers and 8 dak sites in the Hami region of the eastern Xinjiang Uygur Autonomous Region, northwestern China, were collected and the radiocarbon (^{14}C) dates of these ruins were systematically determined with accelerator mass spectrometry. The dating results show that these sites were mainly built during two major periods: ca. 600–900 cal AD and ca. 1600–1950 cal AD, which roughly correspond to the Tang Dynasty (618–907 AD) and the Qing Dynasty (1636–1912 AD) in ancient China. Human settlement intensity was high during the Han, Tang, and Qing dynasties, and relatively low when the area was controlled by nomadic or local regimes. This suggests that agricultural empires and nomadic/local regimes adopted different strategies for regional management. Climate change might have affected geopolitical patterns, which, in turn, profoundly influenced human activities and social evolution in the eastern Tienshan Mountains over the last two millennia. This study systematically reveals the spatiotemporal variations of beacon towers and dak ruins in the region through a large number of reliable direct ^{14}C dating, it reveals the remarkable differences in human activities in the eastern Tienshan Mountains under different administrations, and it explores the influence of geopolitics and climate change on social evolution in the eastern Tienshan Mountains from a multidisciplinary perspective.

Keywords: ^{14}C dating; military relics; human activities; geopolitics; eastern Tienshan Mountains

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1. Introduction

The history and driving forces of human social evolution are worldwide concerns and have been intensively discussed for decades. The major factors influencing social evolution vary across periods of human evolution. Climate change might have significantly influenced human evolution and led to mass migration during the Paleolithic era [1–7]. The origination, development, and diffusion of agriculture resulted in rapid population increases and social transitions in different corners of the Old World during the Neolithic period [8–13], while trans-Eurasian exchange promoted the emergence of ancient civilizations during the Bronze Age [14–18]. During the historical period, the factors influencing social evolution have been more complicated than during the Prehistoric Age, and geopolitics has been highlighted as a crucial factor, especially in areas along the ancient Silk Road [19–23].

The "Silk Road" was first proposed by Richthofen in 1877 [24] and refers to the main channel of cultural and trade exchanges between the Central Plains and Central Asia and even Europe over the past two millennia. However, the road networks across Eurasia have been taking shape since prehistoric times [25,26]. Through this channel, the exchange and integration of religions, arts, languages, and technologies between the East and the West were promoted [27,28]. The middle section of the Silk Road was located in China's Xinjiang territory; transportation routes changed during this period, and trade and cultural exchanges also experienced vicissitudes [29]. The communication channel was mainly along the north and south edges of the Tarim Basin during the Han Dynasty, while during the Tang Dynasty the route along the northern foot of the Tienshan Mountains (known as the New Northern Road) became most important [30].

The eastern Tienshan Mountains, in eastern Xinjiang Uygur Autonomous Region of northwestern China, was an important component of the New Northern Road of the ancient Silk Road during the Tang Dynasty (618–907 AD) (Figure 1). It was alternately controlled by multiple agricultural empires and nomadic/local regimes and is therefore an ideal area to explore how geopolitical change has influenced social evolution over the last two millennia. However, the eastern Tienshan Mountains was not part of the core area of ancient Chinese central governments; written records about the region are scarce and fragmented, and the history of geopolitical change remains unclear. However, abundant ruins related to military activities and transregional trade, such as beacon towers and dak sites, have been found by archaeological surveys in western China [31–34], especially in the Hami region [35,36]. Beacon towers were one of the key facilities in the military defense system of the ancient borderlands of China, allowing for the rapid transmission of military information through smoke or fire signals, and defending against incoming enemies, thus playing the same barrier role as the Great Wall [33]. A dak was an important place for transmitting government documents and military information and safeguarding trade [37]. These military facilities may provide important information about geopolitics and social evolution, but most age estimates of the ruins are uncertain due to the absence of reliable dates.

In this study, we conducted an extensive archaeological investigation in the Hami area, which is a distribution center of beacon towers and dak sites in the eastern Tienshan Mountains. We systematically collected visible plant remains from the ruins of those sites and determined the ^{14}C ages using accelerator mass spectrometry, which is the most effective and accurate method for recovering the chronology of these archaeological sites when the writing record is scarce.

The objective of this study was to accurately date the military facilities' ruins, analyze the management mode and level of the Central Plains dynasties in the region, compare and analyze the control mode of local authority and nomadic regimes, and discuss the spatial and temporal variations of human activity and geopolitics and their impact on regional social development over the past 2000 years.

The main significance of this study is that it confirms the substantive control of the eastern Tienshan Mountains by the Central Plains governments during the Tang and Qing dynasties via the ^{14}C dating of military facilities. We further recognize that, during the period under the control of different regimes, the spatiotemporal pattern of human activities, trade exchanges, and social evolution changed significantly, and geopolitical changes were the main influencing factor. Abundant original data for beacon towers and dak ruins in the eastern Tienshan Mountains were also provided, which are conducive to a subsequent comparative analysis of historical and geographical research.

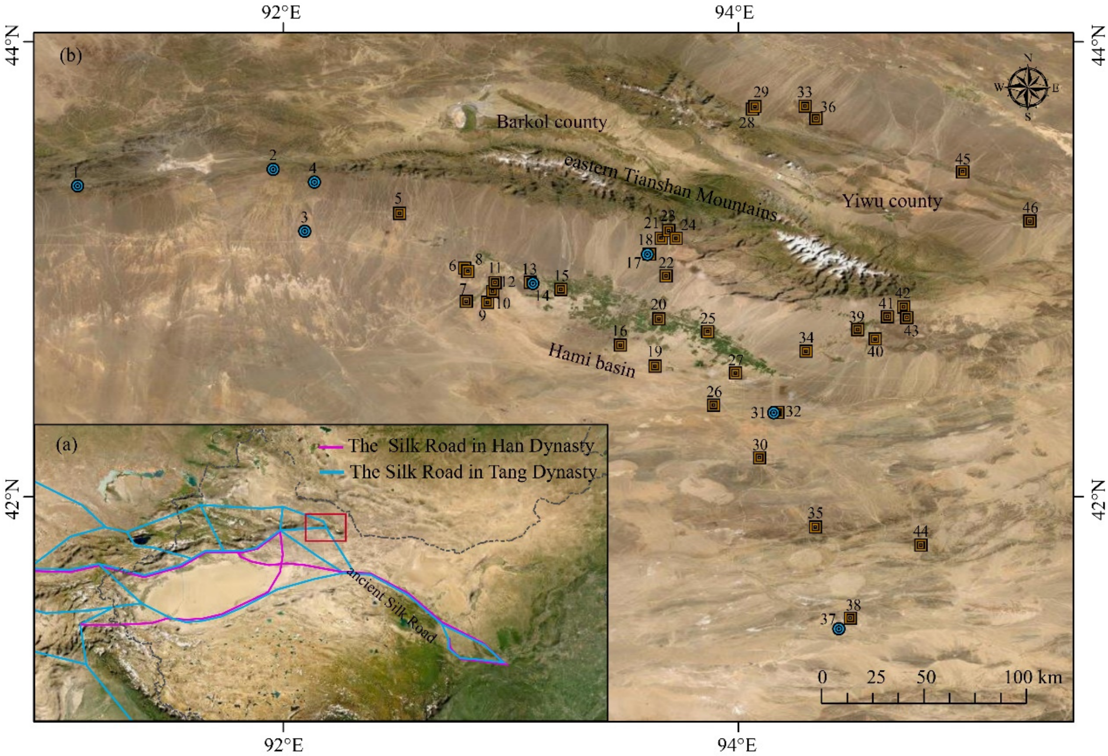

Figure 1. The spatial distribution of beacon and post sites in the Hami area. The pink and blue lines represent the ancient Silk Road (**a**). Brown boxes represent beacon towers and blue circles represent dak sites (**b**). Note: (1) Xiyanchi; (2) Cheguluquan; (3) Laoyiwanquan; (4) Yiwanquan; (5) Shadunzi; (6) Bohuozi; (7) Zhibiannongchang; (8) Daquanzi; (9) Maoliuquan; (10) Niumaoquan; (11) Kalaya; (12) Youkuribage; (13) Lakesumu; (14) Lakesumu; (15) Toubu; (16) Xiaonanhu; (17) Heizhangfang; (18) Heizhangfang; (19) Tuzidun; (20) Dundunwan; (21) Shiwulidun; (22) Bianguandun; (23) Nanshankou; (24) Youlegunluke; (25) Huanglonggang; (26) Dongchixi; (27) Changliushui; (28) Baishishannan; (29) Baishishanbei; (30) Kulukedun; (31) Geziyandun; (32) Geziyandun; (33) Kuotuer; (34) Jianquanzi; (35) Jingxia; (36) Keyin; (37) Liaodun; (38) Liaodun; (39) Qingshanzi; (40) Dundunshan; (41) Erdun; (42) Sandun; (43) Aketumuxiuke; (44) Dashui; (45) Youledun; (46) Xiamaya.

2. Materials and Methods

2.1. Study Area

The Hami region (91°06′33″ E–96°23′00″ E, 40°52′47″ N–45°05′33″ N) is located in the eastern portion of China's Xinjiang Uyghur Autonomous Region and the Tienshan Mountains and is connected to the Hexi Corridor at its southeastern side. The region includes the city of Hami and the counties of Barkol and Yiwu (Figure 1). Oases have developed in the piedmont belt on the southern side of the mountains, mainly nourished by ice and snow melt from the Tienshan Mountains; the Baiyang and Hami rivers are the two main bodies of surface water. The elevation of the oases lies between 800 and 500 m a.s.l., while Barkol and Yiwu counties are located in the intermountain basin area of the eastern Tienshan Mountains, with an altitude of over 1600 m a.s.l. The eastern Tienshan Mountains have a typical temperate continental arid climate with limited rainfall [38]. Annual precipitation in the basin oases is less than 50 mm, while the annual potential evaporation is more than 3000 mm [39]. Barkol county is relatively cold and humid, with a mean annual temperature of 1.1 °C, annual precipitation of about 200 mm, and annual potential evaporation of about 1640 mm [40].

The eastern Tienshan Mountains have been an important channel for cultural exchange between the East and the West since the prehistoric period [41–45]. Archaeological studies of the Bronze and Iron Ages show that elements of Eastern and Western cultures were both present in this region [41,42,46,47], and ethnicity also showed a transitional state between European and Mongolian races [48,49]. Over time, the eastern Tienshan Mountains became an important hub on the Silk Road trade route, especially during the Tang Dynasty (Figure 1). Since the Han Dynasty set up the Western Regions Military Protectorate (西域都护府; the highest level of administration set by the Central Plains dynasty) in 60 BC to govern the military, political, and economic activities of the western regions, Hami has been one of the most important transportation junctions between the Western Regions and Central China, and also a hot spot contested by different regimes (e.g., *Xiongnu (匈奴)*, *Tubo (吐蕃)*, *Gaochang Uighur (高昌回鹘)*, etc.). The alternation of dynasties, the transformation of the trade route, and the vicissitudes of trade over the past two millennia led to significant variations in human activities in the eastern Tienshan Mountains. A large number of ancient cities, Buddhist temples, beacon towers, dak sites, tombs, and other sites were left here, which together constitute the cultural heritage of the Silk Road.

2.2. Materials

In 2019 and 2020, we conducted detailed archaeological investigations of military facilities' ruins in the eastern Tienshan Mountains (Figure 2). These ruins can be divided into two categories, beacon towers and dak sites, both of which were mainly used for military defense and information transfer. We collected visible organic remains that represent the age of the buildings' construction and maintenance for radiocarbon dating. These samples included red willow branches, straw, charcoal, and bones. Most of these facilities were made of adobe masonry, and when adobe is made it is often fortified with the remains of plants that were growing at the time; these short-lived plant remains provide us with excellent materials for ^{14}C dating tests. Depending on the scale of the site, one or more dating materials were collected to accurately determine the construction or repair time. In total, 84 dating materials were sampled from 38 beacon towers and 8 dak sites.

Figure 2. Photographs of typical beacon towers and dak sites in the eastern Tienshan Mountains.

2.3. Methods

The samples' pretreatment, graphitization, and AMS testing were conducted in the Radiocarbon Laboratory of Lanzhou University. The pretreatment method was similar to that of Brock et al. (2010) [50], which involves treatment with an acid–base–acid, as outlined below. First, the plant residues were sonicated for 10 min to remove possible contaminants; subsequently, 10 mL HCl solution (1 mol/L) was added to remove carbonate contaminants within a water bath at 60 °C (repeated 3–5 times) until the solution was colorless and without bubbles, and the samples were washed with deionized water to a neutral pH. Next, 10 mL NaOH solution (0.5 mol/L) was added to remove possible humic acid at 60 °C; after the solution was colorless, we washed the samples to a neutral pH again. Then 10 mL HCl solution (1 mol/L) was added to remove the carbonate material that may have been generated during the alkaline treatment, and finally the samples were washed to neutralize them and dried in an oven (60 °C). The samples were graphitized using the AGE III system [51] and tested by MICADAS [52]. The ^{14}C ages were calibrated to calendar dates via the OxCal 4.4 online program [53,54] using the IntCal20 calibrated curve [55]. The calibrated ages were reported as "cal AD". The median values of calibrated age were used to correspond to the dynasties to which they belong.

Reconstructing social environment change was one of the key goals of this study, and our results, combined with literature records, provided the basis for semiquantitative, quantitative, and qualitative analyses. Summed probability density (SPD) of radiocarbon dates was usually employed to reflect changes in human activity intensity [6], as a semi-quantitative and comparable indicator for intensity variations. The SPD for all dates in this study was considered to discuss the diachronic intensity changes in military forces. In addition, the number of archaeological sites, population, and wars were also counted and collected from historical records to provide a quantitative comparison. Major events were qualified as a qualitative analysis. In terms of the impact of natural environmental changes on human activities, the impact of climatic changes (including temperature and precipitation) on the oasis living environment was analyzed, and extreme climate events (such as the mega droughts recorded in the literature) were also considered and discussed.

3. Results

Eighty-four AMS ^{14}C ages and calibrated results are reported in Table 1 and shown in Figure 3. It is obvious that the dates were concentrated in two periods, ca. 600–900 cal AD and ca. 1600–1950 cal AD, roughly corresponding to the Tang Dynasty (618–907 AD) and Qing Dynasty (1636–1912 AD), respectively. Thirty-one calibrated dates from 18 beacon towers corresponded to the Tang Dynasty. Among these data, three calibrated dates from the Xiamaya, Baishishanbei, and Dundunwan beacon towers range from 600 to 775 cal AD, with median values ranging from 624 to 696 cal AD, corresponding to the early period of the Tang Dynasty. Twelve calibrated dates from the Bianguandun, Keyin, Youlegunluke, Lakesumu, Toubu, Dundunshan, Dundunwan, Youledun, Baishishanbei, and Daquanzi beacon towers range from 658 to 873 cal AD, with rather concentrated median values ranging from 723 to 731 cal AD, corresponding to the middle period of the Tang Dynasty. Sixteen calibrated dates from the Bianguandun, Lakesumu, Liaodun, Niumaoquan, Youledun, Shadunzi, Youlegunluke, Daquanzi, Baishishannan, Kuotuer, Dongchixi, and Jingxia beacon towers range from 682 to 974 cal AD, with median values ranging from 789 to 884 cal AD, corresponding to the late period of the Tang Dynasty.

Forty-eight calibrated dates from 19 beacon towers and 8 dak ruins corresponded to the Qing Dynasty. Among them, five calibrated dates from the Cheguluquan and Geziyandun dak sites, and the Sandun, Zhibiannongchang, and Kulukedun beacon towers range from 1523 to 1800 cal AD, with median values ranging from 1642 to 1667 cal AD, corresponding to the early period of the Qing Dynasty. Twenty-one calibrated dates from Heizhangfang, Geziyandun, Xiyanchi, Yiwanquan, and Lakesumu dak sites, and the Bohuozi, Geziyandun, Huanglonggang, Kulukedun, Tuzidun, Zhibiannongchang, Heizhangfang, Kalaya, Youkuribage, Aketumuxiuke, and Liaodun beacon towers range from 1648 to 1950 cal AD, with median values ranging from 1765 to 1805 cal AD, corresponding to the middle period of the Qing Dynasty. Twenty-two calibrated dates from the Laoyiwanquan, Liaodun, Lakesumu, and Geziyandun dak sites, and the Bianguandun, Jianquanzi, Toubu, Liaodun, Tuzidun, Dongchixi, Nanshankou, Qingshanzi, Heizhangfang, Shiwulidun, Changliushui, Erdun, Geziyandun, Maoliuquan, and Shiwulidun beacon towers range from 1673 to 1944 cal AD, with median values ranging from 1829 to 1845 cal AD, corresponding to the late period of the Qing Dynasty.

Table 1. Radiocarbon dates of beacon towers and dak ruins in Hami area.

Lab. Code	Sites	Type	Material	^{14}C Age (BP)	Calibrated Range (cal. AD), 95.4%
LZU21327	Aketumuxiuke	Beacon	Straw	160 ± 20	1666–...
LZU21354	Baishishanbei	Beacon	Populus branch	1340 ± 20	650–773
LZU21307	Baishishanbei	Beacon	Straw	1250 ± 20	677–873
LZU21351	Baishishannan	Beacon	Populus branch	1200 ± 20	774–885
LZU21071	Bianguandun	Beacon	Red willow branch	60 ± 20	1695–1916
LZU21061	Bianguandun	Beacon	Grass root	1270 ± 20	670–798
LZU21593	Bianguandun	Beacon	Bone	1240 ± 20	682–878
LZU21341	Bohuozi	Beacon	Grass root	180 ± 20	1661–...
LZU21335	Changliushui	Beacon	Grass root	130 ± 20	1681–1940
LZU21340	Cheguluquan	Dak	Populus branch	270 ± 20	1523–1794
LZU21306	Daquanzi	Beacon	Red willow branch	1250 ± 20	677–873
LZU21080	Daquanzi	Beacon	Achnatherum splendens	1220 ± 20	706–883
LZU21305	Daquanzi	Beacon	Red willow branch	1220 ± 20	706–883
LZU21075	Dashui	Beacon	Populus branch	1150 ± 20	773–978
LZU21361	Dongchixi	Beacon	Reed	100 ± 20	1692–1919
LZU21362	Dongchixi	Beacon	Red willow branch	1180 ± 20	772–944
LZU21350	Dundunshan	Beacon	Populus branch	1290 ± 30	660–776
LZU21304	Dundunwan	Beacon	Reed	1320 ± 20	656–775
LZU21355	Dundunwan	Beacon	Grass root	1310 ± 20	658–775
LZU21364	Dundunwan	Beacon	Grass root	1270 ± 20	670–798
LZU21325	Erdun	Beacon	Grass root	130 ± 20	1681–1940
LZU21326	Geziyandun	Dak	Reed	270 ± 20	1523–1794
LZU20069	Geziyandun	Beacon	Reed	190 ± 20	1659–...
LZU20070	Geziyandun	Beacon	Grass root	170 ± 20	1663–...
LZU21596	Geziyandun	Dak	Human bone	170 ± 20	1663–...
LZU20070R	Geziyandun	Beacon	Wood chock	130 ± 20	1681–1940
LZU21330	Geziyandun	Dak	Reed	110 ± 20	1689–1924
LZU20059	Heizhangfang	Dak	Withered grass	190 ± 20	1659–...
LZU21062	Heizhangfang	Beacon	Grass root	170 ± 20	1663–...
LZU20060	Heizhangfang	Dak	Straw rope	150 ± 20	1669–...
LZU21063	Heizhangfang	Beacon	Grass root	110 ± 20	1689–1924
LZU21349	Huanglonggang	Beacon	Grass root	190 ± 20	1659–...
LZU21363	Jianquanzi	Beacon	Branch	60 ± 20	1695–1916
LZU21366	Jingxia	Beacon	Red willow branch	1170 ± 20	772–956
LZU21058	Kalaya	Beacon	Populus branch	170 ± 20	1663–...
LZU21344	Keyin	Beacon	Populus branch	1270 ± 20	670–798
LZU21338	Kulukedun	Beacon	Wood	230 ± 20	1640–1800
LZU20067	Kulukedun	Beacon	Grass root	190 ± 20	1659–...
LZU20068	Kulukedun	Beacon	Achnatherum splendens	190 ± 20	1659–...
LZU21328	Kulukedun	Beacon	Achnatherum splendens	160 ± 20	1666–...
LZU21066	Kuotuer	Beacon	Reed	1200 ± 20	774–885
LZU21322	Lakesumu	Dak	Branch	150 ± 20	1669–...
LZU21324	Lakesumu	Dak	Branch	90 ± 20	1694–1917
LZU21368	Lakesumu	Beacon	Withered grass	1310 ± 20	658–775
LZU21316	Lakesumu	Beacon	Reed	1240 ± 20	682–878
LZU21323	Laoyiwanquan	Dak	Achnatherum splendens	100 ± 20	1692–1919
LZU21076	Laoyiwanquan	Dak	Reed	50 ± 20	1696–1912
LZU21371	Liaodun	Beacon	Charcoal	640 ± 20	1290–1395
LZU20071	Liaodun	Beacon	Branch	160 ± 20	1666–...
LZU21365	Liaodun	Beacon	Branch	120 ± 20	1683–1930

Table 1. *Cont.*

Lab. Code	Sites	Type	Material	^{14}C Age (BP)	Calibrated Range (cal. AD), 95.4%
LZU20072	Liaodun	Beacon	Red willow branch	110 ± 20	1689–1924
LZU21068	Liaodun	Beacon	Grass root	90 ± 20	1694–1917
LZU21301	Liaodun	Dak	Achnatherum splendens	80 ± 20	1694–1917
LZU20073	Liaodun	Beacon	Red willow branch	1240 ± 20	682–878
LZU21067	Liaodun	Beacon	Achnatherum splendens	1170 ± 20	772–956
LZU21064	Liaodun	Beacon	Reed	1160 ± 20	772–974
LZU21065	Liaodun	Beacon	Reed	1200 ± 20	774–885
LZU20055	Maoliuquan	Beacon	Straw	320 ± 20	1496–1642
LZU21359	Maoliuquan	Beacon	Grass root	130 ± 20	1681–1940
LZU21069	Nanshankou	Beacon	Branch	100 ± 20	1692–1919
LZU21313	Niumaoquan	Beacon	Reed	1240 ± 20	682–878
LZU21296	Qingshanzi	Beacon	Straw	140 ± 20	1673–1944
LZU21312	Sandun	Beacon	Wood	260 ± 20	1527–1795
LZU20066	Shadunzi	Beacon	Populus branch	1500 ± 20	545–634
LZU21360	Shadunzi	Beacon	Grass root	1230 ± 20	702–881
LZU21070	Shiwulidun	Beacon	Red willow branch	120 ± 20	1683–1930
LZU21329	Shiwulidun	Beacon	Reed	110 ± 20	1689–1924
LZU21059	Toubu	Beacon	Reed	80 ± 20	1694–1917
LZU20166	Toubu	Beacon	Reed	1310 ± 20	658–775
LZU21372	Toubu	Beacon	Charcoal	1280 ± 20	671–774
LZU21297	Tuzidun	Beacon	Reed	180 ± 20	1661–...
LZU21298	Tuzidun	Beacon	Reed	170 ± 20	1663–...
LZU21073	Tuzidun	Beacon	Straw	90 ± 20	1694–1917
LZU21369	Xiamaya	Beacon	Grass root	1430 ± 20	600–652
LZU21370	Xiaonanhu	Beacon	Grass root	930 ± 30	1032–1203
LZU21332	Xiyanchi	Dak	Grass root	210 ± 20	1648–...
LZU21314	Yiwanquan	Dak	Branch	210 ± 20	1648–...
LZU21083	Youkuribage	Beacon	Reed	170 ± 20	1663–...
LZU21342	Youledun	Beacon	Populus branch	1260 ± 20	675–823
LZU21336	Youledun	Beacon	Straw	1240 ± 20	682–878
LZU21367	Youlegunluke	Beacon	Populus branch	1270 ± 20	670–798
LZU21072	Youlegunluke	Beacon	Grass root	1230 ± 20	702–881
LZU21081	Zhibiannongchang	Beacon	Reed	250 ± 20	1529–1799
LZU21300	Zhibiannongchang	Beacon	Straw	190 ± 20	1659–...

In addition, five calibrated dates corresponded to the Sui Dynasty, Gaochang Uighur, Yuan Dynasty, and Ming Dynasty. The dating materials of these five results were charcoal, branches, and grass roots, which are not the most ideal dating materials. We speculate that the dating results might be influenced by the "old wood" effect of the tree branches [56], or the long residence time of charcoal before it is deposited in mud [57], which could lead to an older age estimate than is correct. This may require more testing on other materials in the future. The dates of the Bianguandun, Dongchixi, Toubu, and Liaodun beacon towers indicate that they were first built during the Tang Dynasty and were repaired and used during the Qing Dynasty (Figure 3). The ^{14}C date results of the military facilities show that they were extensively built and used by the Tang and Qing dynasties; very few or none dated from the other periods.

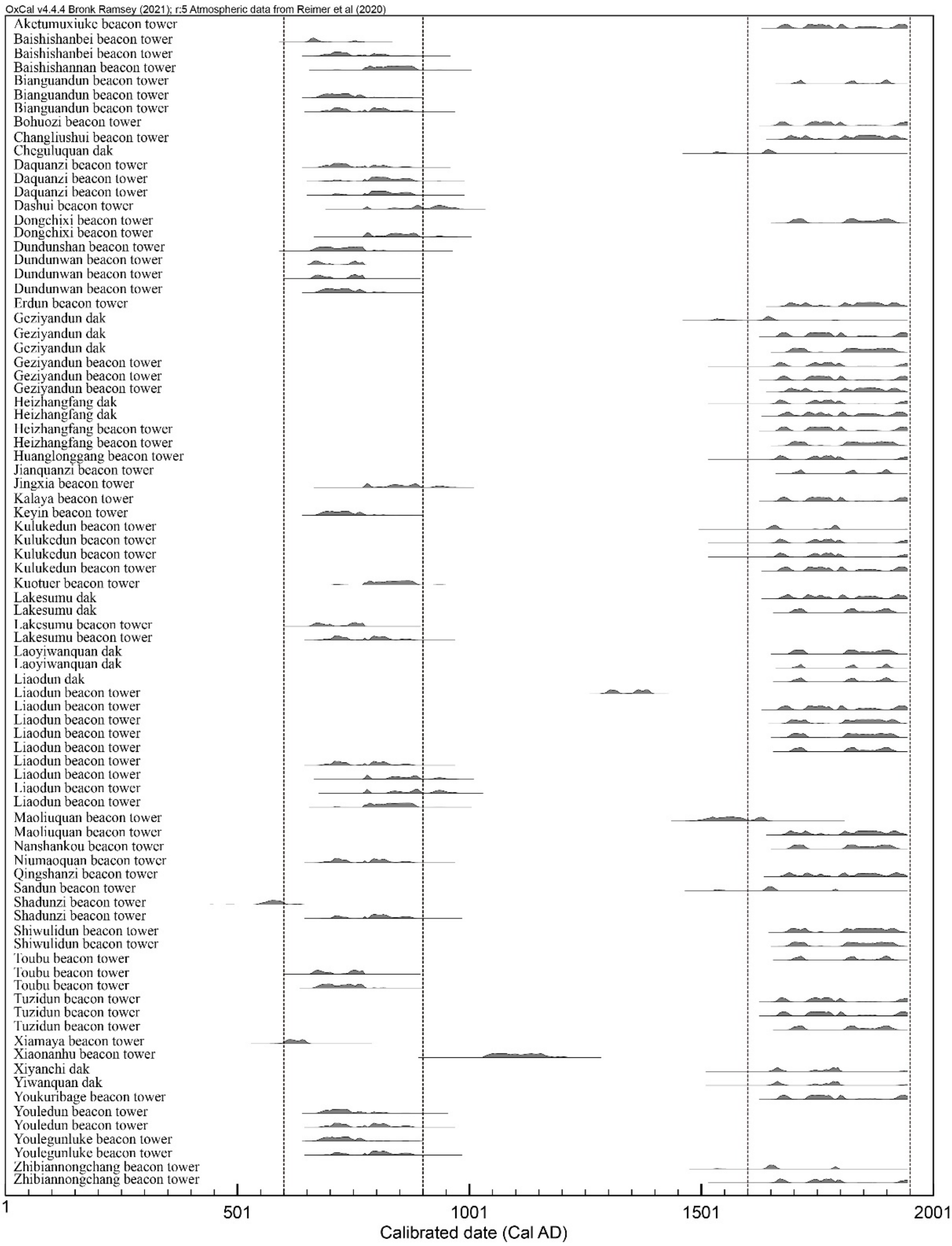

Figure 3. Calibrated dates of beacon towers and dak sites in the eastern Tienshan Mountains.

4. Discussion

4.1. Spatiotemporal Variations of Military Installations and Human Settlements in the Eastern Tienshan Mountains over the Past Two Millennia

The number of beacon towers and dak sites could reflect the intensity of military activity in the area by the Central Plains dynasty. In addition, other archaeological sites may also reflect the intensity of human settlement. Our dated beacon towers and dak sites, together with other archaeological sites from the third national archaeological survey conducted by the Xinjiang Uygur Autonomous Region, present significant spatiotemporal distribution variation in the eastern Tienshan Mountains (Figure 4).

Figure 4. The spatiotemporal distribution of ancient ruins in the Hami region from the Han Dynasty to the Qing Dynasty. Data on the beacon towers and dak sites are from this study; data on military installations and other archaeological sites are from the Third National Cultural Relics Census in the Xinjiang Uygur Autonomous Region.

No beacon tower or other military facility was found from the Han Dynasty (206 BC–220 AD) or the Wei Jin Southern and Northern Dynasties (220–589 AD) in the eastern Tienshan Mountains, according to our dating results and the Third National Archaeological Survey (Figure 4a,b), which may be due to the fact that there were few military facilities built here during these periods, and/or they were too badly damaged to be recognized. In any case, this also indicates that the military management level of the Central Plains dynasty was low in the eastern Tienshan Mountains during these periods. The other archaeological sites (mainly cemetery sites) were relatively abundant during the Han Dynasty, and were mainly distributed along the eastern Tienshan Mountains, but sparse in the basin oasis (Figure 4a). The Han Empire conducted several Tuntian activities (屯田; a system of collective farming directly organized and operated by the government) in 73 AD, 81 AD, 119 AD, and 131 AD. However, farming activities were interrupted by conflict between the Xiongnu, a nomadic tribe of the Eurasian Steppes, and the Han Dynasty, as recorded in the *Book of the Later Han: Western Regions Record* (后汉书·西域传). The number of archaeological sites in the eastern Tienshan Mountains decreased significantly during the Wei Jin Southern and Northern Dynasties, indicating that the intensity of human settlement also decreased. During this period (Figure 4b), the Central Plains dynasty had a low level of administration over the region; no records of Tuntian activities were found and the eastern Tienshan Mountains experienced dozens of administrative changes. The Gaoche (高车), Rouran (柔然), Tujue (突厥), and other nomadic tribes fought several times for control of the area according to the *Book of Wei* (魏书), which led to social unrest for a long time.

Archaeological survey and dating results show that the beacon towers and other military facilities in the eastern Tienshan Mountains were constructed during the Tang Dynasty; they were distributed along the northern and southern sides of the eastern Tienshan Mountains and connected the Hami basin and Barkol (Figure 4c). The beacon towers of the Hami basin extend to the southeast and, together with the beacon towers of Dunhuang in the Hexi Corridor, formed an information transmission and defense network. In our study, 18 beacon towers were dated to this period; furthermore, nearly 30 other military facilities in the study area might have been built during this period according to our new field survey and the third national archaeological survey. However, this needs to be confirmed by more ^{14}C dating work.

The Tang Dynasty deployed strong military forces in the eastern Tienshan Mountains and the Western Regions, among which the Yiwu troops were stationed in Barkol, as recorded in the *Old Book of Tang · Geography* (旧唐书-地理志). The powerful military deployment resisted the invasion of the Western and Eastern Turks (*New Book of Tang*; 新唐书) and ensured regional security and stability. The number of other archaeological sites also increased significantly; they were mainly distributed in the mountains and basins during this period (Figure 4c). The intensity of human settlement and military activities increased significantly during the Tang Dynasty, when humans began to intensively settle in the Hami oases, especially along the Baiyang River, where abundant archaeological sites from this period (including many Buddhist temple sites) are distributed [58].

The number of beacon towers and other archaeological sites in the Hami region decreased significantly during the Song and Yuan dynasties (960–1368 AD) and the Ming Dynasty (1368–1644 AD) (Figure 4d,e). There are only three beacon towers dated to this period, with Xiaonanhu beacon tower (1032–1203 Cal AD) located in the middle reaches of the Hami River, Liaodun beacon tower (1290–1395 Cal AD) located in the border area between Hami and Dunhuang, and Maoliuquan beacon tower located in the lower reaches of the Baiyang River (Figure 4d,e). In fact, the dates of these beacon towers may not be accurate due to material limitations; the Central Plains dynasty probably did not build or use beacon towers here during these periods and very sporadic beacon towers could also not play the function of transmitting information station by station, so the dates of these beacon towers require further confirmation. Only a few other sites (mainly cemeteries) of this period were found during the third national archaeological survey and were located mainly in the mountains. The intensity of military activity and human settlement in the eastern Tienshan Mountains decreased significantly again. During this period, the eastern Tienshan Mountains were controlled by nomadic groups, and written records are limited.

The Qing Dynasty built a large number of beacon towers and military facilities in the eastern Tienshan Mountains that were especially densely distributed around Barkol (Figure 4f). All the dak sites reported in this study were dated to the Qing Dynasty (Figure 3). Military activities in the eastern Tienshan Mountains reached the highest level during this period. At the same time, the number of other archaeological sites increased significantly, concentrated in Barkol County and near the Baiyang River; they include ancient cities, religious buildings, mining and metallurgy sites, and numerous irrigation facilities (Figure 4f). Military activities and human settlement show a trend of simultaneous increase. A large number of written records indicate that the Qing Empire made great efforts to carry out Tuntian activities in the eastern Tienshan Mountains (*Qingshi*, 清史).

Overall, the intensity of human activities and the construction of military facilities show significant spatiotemporal differences. The Tang and Qing dynasties built a large number of military facilities in the Hami area, and the intensity of human activities also increased correspondingly during these periods. However, during the other periods, the military deployment activities carried out by the Central Plains dynasty in the Hami area decreased or even ceased, and the intensity of human activities also decreased significantly. The Han, Tang and Qing dynasties were good at building beacon towers, which strengthened their unified border management, while local separatist forces were not good or capable and there was no need to build beacon towers. The nomadic forces on the steppe mainly lived in nomadic life and lacked the ability to build cities. Differences in living habits also contributed to the variation in the number of sites.

4.2. The Impact of Geopolitical and Climatic Changes on Human Activities in the Eastern Tienshan Mountains

The military activities and human settlement in the Hami area experienced prominent temporal and spatial variations over the past 2000 years, and exploring the influencing factors of these changes will help us to better understand the process and mechanism. Geopolitical changes had a remarkable influence on human activity during the period under study [21,23,24] and climate change is also closely related to the evolution of the natural and socioeconomic environment [59–62] and human subsistence [63–67]. Based on the study of the spatiotemporal distribution of the beacon towers and dak sites, combined with historical documents and archaeological and paleoclimatic records, we examined the geopolitical and climatic changes and their impact on human activities in the eastern Tienshan Mountains through the historic period.

A favorable climate could provide suitable environmental conditions for human survival and cultural diffusion [68], as well as a solid material foundation for nomadic and farming groups by enhancing their productivity [62]. The climate of northwestern China was relatively warm and humid during the Han Dynasty [69], which might have helped the Han Dynasty and Xiongnu to develop into two great empires. The Han Dynasty expelled the Xiongnu and set up the Western Regions Military Protectorate in 60 BC to govern military and economic activities in the western regions (*Book of Han*; 汉书). The military facilities of the Han Dynasty in the Western Regions were relatively few: they were mainly stationed around the Tarim Basin in southern Xinjiang [70]. The eastern Tienshan Mountains were on the border between the Han Dynasty and the Xiongnu [71]. The Xiongnu occupied the Barkol grassland and attacked the Han Dynasty several times, which hindered the long-term Tuntian activities of the Central Plains dynasty (*Book of the Later Han–Western Regions Record*). Due to the limited military force deployed by the Central Plains dynasty in the eastern Tienshan Mountains, the Han Dynasty could not completely repel the Xiongnu, resulting in a significant increase in the number of wars in the region (Figure 5f). As a result, the intensity of human activities in agricultural oasis areas was low. Management policies may also have been one of the main factors affecting human activities during this period. The Han Dynasty adopted the "Jimi" (羁縻) policy (a policy of regional governance for border areas; except for political subordination to the central dynasty and the economic obligation to pay tribute, all other affairs were managed by the minority leaders themselves), similar to "bridle–halter," which may lead to a low management level in the area, few military facilities, and low human settlement intensity.

The intensity of human settlement in the eastern Tienshan Mountains declined further during the Wei Jin Southern and Northern Dynasties (Figure 4b). The climate during that period was cold and dry, especially in 500–630 AD (Figure 5a,b), which was a crucial trigger for the political division in the monsoon area of China [72]. Therefore, the central government's control in the western regions during this period was greatly weakened in comparison to the Han Dynasty, and many local regimes successively controlled the Hami region. Moreover, nomadic groups, including the Gaoche, Rouran, and Tujue, successively controlled the eastern Tienshan Mountains (*Book of Wei*; 魏书), when turbulent social and adverse climatic conditions significantly influenced human settlement (Figure 5).

During the Tang Dynasty, the growing national strength promoted the cultural belonging and identity of border areas, and the eastern Tienshan Mountains became part of the core area of the Tang Dynasty [71]. The Tang Dynasty set up Anxi Military Protectorate (安西都护府) and Beiting Military Protectorate (北庭都护府) to govern the Western Regions; it also established Yiwu (伊吾), Rouyuan (柔远), and Nazhi (纳职) counties and adopted the same governmental institutions as in the Central Plains to administer Hami. Many beacon towers were built during this period in the eastern Tienshan Mountains (Figure 4c) and around the Tarim Basin [31,73]. The Tang Dynasty had great military power in the Western Regions, defending against the invasion of Tujue [74], and long-term regional social stability was maintained. During this period, the climate was also relatively warm and wet (Figure 5a,b), which could contribute to the improvement of the oasis environment. A favorable climate and a stable geopolitical pattern both contributed to the increase in human activity intensity (Figure 5). During this period, the Silk Road passageway in the western regions shifted from the Southern and Northern routes in the Han Dynasty to the Southern, Northern, and the New Northern Road (Figure 1). The New Northern Road, which passed through the eastern Tienshan Mountains, became the most important exchange route, and the Tang Empire's solid military presence in this area provided a stable environment for agricultural production and trade exchange. The An-Shi rebellion event (755–763 AD), which led to the gradual decline of the power of the Tang Dynasty [75], coupled with the deterioration of climatic conditions in 750–900 AD, may have facilitated the Tubo occupation of a large area of the Western Regions for more resources (Figure 5).

The climate was relatively warm and dry in 950–1300 AD (roughly corresponding to the Song and Yuan dynasties), and was getting colder and wetter during 1300–1600 AD (roughly corresponding to the Ming Dynasty; Figure 5a,b). During these periods, the eastern Tienshan Mountains was practically controlled by nomadic regimes, including the Gaochang Uighur, West Liao, Meng-Yuan, and the Chagatai Khanate (Figure 5), while the historical record during these periods is limited. According to the limited records in *Yuanshi (History of the Yuan Dynasty)*, the Hami region suffered from frequent wars (but there are few descriptive records and no quantitative records) and successive droughts during 1209–1289 AD (*Yuanshi*). During the Ming Dynasty, the colder and wetter climate probably triggered more frequent wars over resources among the nomadic tribes in the Hami region (Figure 5f), which led to several waves of migration from the Hami region to the Hexi Corridor (in 1460 AD, 1488 AD, and 1524 AD) according to *Mingshi (History of the Ming Dynasty)*. Compared with the densely populated characteristics of agricultural activities, the population density of nomadic activities is significantly lower. Furthermore, the unfavorable climate and social instability may have severely inhibited human activity during these periods.

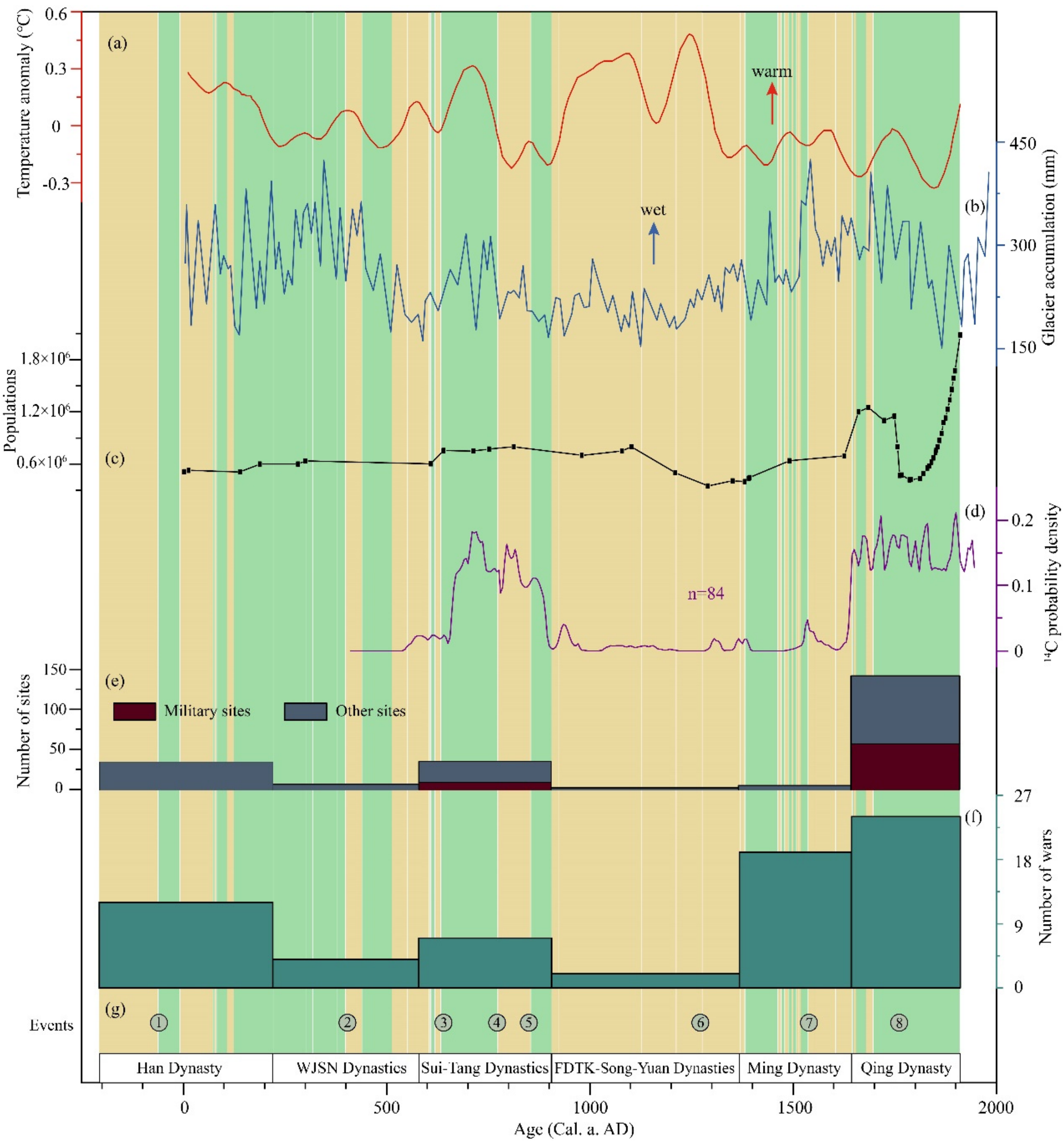

Figure 5. Comparisons between paleoclimate records and historical/archaeological information. The region was mainly controlled by nomadic (yellow) or agricultural regimes (green). (**a**) Temperature reconstructed from multiple paleoclimate proxy records in China [76]; (**b**) glacier accumulation variations [77]; (**c**) population of the Xinjiang region, reconstructed from historical documents [78]; (**d**) summed probability density of ^{14}C ages dated from beacon towers and post stations in this study; (**e**) changes in the number of archaeological sites (including military and other sites) in the Hami region through the dynasties (*The Third National Archaeological Survey Conducted by the Xinjiang Uygur Autonomous Region*); (**f**) changes in the number of wars through the dynasties, reconstructed from the *Hami Regional Records*; (**g**) major events in the study area were recorded from historical documents (1. The Han Dynasty set up the Western Regions Military Protectorate in Xinjiang in 60 BC; 2. Establishment of Roran Khanate in 402 AD; 3. The Tang Dynasty established the Anxi Military Protectorate in 630 AD; 4. The Turbo conquered the Hami region in 770 AD; 5. The Guiyi Army regained the Hami region in 851 AD; 6. The war led to people fleeing in 1272 AD, followed by successive droughts in 1288–1289 AD; 7. The Ming Dynasty quit Hami in 1529 AD; 8. The Qing Dynasty suppressed the Junggar rebellion in 1757 AD).

During the Qing Dynasty, the climate was still cold and continued to become drier (Figure 5a,b). Deterioration of the climate may have increased human survival pressure, which in turn led to more wars over resources (Figure 5f). Nevertheless, the Qing Dynasty built a large number of beacon towers in the eastern Tienshan Mountains to further enhance their military management capabilities and effectively control the region for a long time (Figure 5). The Qing Dynasty began its Tuntian activities in the eastern Tienshan Mountains in 1716 AD, and they lasted for nearly 200 years. A large number of immigrants gradually became the main labor force in the Tuntian activities; barley and wheat became the important crops during this period; and Barkol became the largest Tuntian region in the Xinjiang. The continuous enhancement of Tuntian activities provided the material foundation for the Qing Empire to recover Xinjiang. Despite nomadic tribes repeatedly invading the eastern Tienshan Mountains to seize resources under unfavorable climate conditions, the massive military deployment of the Qing Empire ensured that the region long remained under its effective rule. Geopolitical factors therefore played a decisive role in the changes in human activities in the eastern Tienshan Mountains.

The diachronic evolution of archaeological sites and military facilities suggests that geopolitical changes had significant influences on the spatiotemporal patterns of human activities in the eastern Tienshan Mountains (Figure 5). Climate change also played an important role in the rise and fall of the regimes [79,80] and influenced the relationships between nomadic and farming groups [62].

4.3. Geopolitical Changes Influenced Social Development in the Eastern Tienshan Mountains

Social development refers to the progress of various elements that constitute society, including the overall development of a series of social entities, such as economy, culture, politics, customs, and institutions. It is very challenging to evaluate the social development status of the eastern Tienshan Mountains through history, mainly because of the alternate control of agricultural and nomadic regimes, the adoption of different production of economic models, the fragmented historical documentation, and the lack of unified and universal indicators. We therefore made tentative use of population changes in Xinjiang to reflect social developments; the main logic is that population growth requires a sufficiently high level of social production economy, whether it be agricultural or nomadic. In addition, economic development and population increase can also promote culture and trade, all of which should be the concrete embodiment of social development.

Cultural exchanges between the East and the West across Eurasia in prehistoric times followed the globalization patterns of food and technology [81–83], which further facilitated the prosperity of civilization and the growth of the population [11]. Trade has made a significant contribution to economic growth and social development [84]. Geopolitics has played a key role in the evolution of trade and human activities, which have significantly influenced historic human settlement patterns in the Hexi Corridor [23] and the eastern Tibetan Plateau [21]. Human activities in the eastern Tienshan Mountains were closely related to the geopolitics; the different strategies for territorial defense and production lifestyles adopted by agricultural empires and nomadic/local groups significantly influenced social development.

The Han Dynasty adopted the bridle–halter policy to manage the Western Regions and constructed several beacon towers on the northern and southern edges of the Tarim Basin [31] to secure trade routes. Limited military force in the eastern Tienshan Mountains made it difficult to guarantee regional social stability and effective production, which was not conducive to population growth, and long-term wars between the Han Dynasty and Xiongnu further blocked the flow of trade in the region and impeded social development.

During the Wei Jin Southern and Northern Dynasties, the eastern Tienshan Mountains were alternately controlled by more than 10 regimes (Figure 5). The agricultural regimes mainly included Wei, Jin, Former Liang, Former Qin, Western Liang, and Northern Wei (*Book of Wei*). The disputes of the Central Plains may have weakened the administration and development of the Western Regions to an extent, and the regions were occupied repeatedly by nomadic groups such as the Rouran, Gaoche, and Turkic Khanates after 400 AD. Human activity intensity in the eastern Tienshan Mountains decreased notably during this period. Trade was not as prosperous as during the Han Dynasty.

Trade achieved unprecedented prosperity during the Tang Dynasty, benefiting from the stable social environment and the open-mindedness of the Tang Dynasty. Trade routes were divided into the Southern Road, the Middle Road (the North Road in the Han Dynasty), and the New North Road (*New Book of Tang–Western Regions Record*), which promoted the commercial economic progress of the Western Regions, with the New Northern Road being the most prosperous area. Effective management by the Tang Dynasty played a key role; a large number of beacon towers and military facilities, as well as a large garrison, enhanced the administration of the Central Plains dynasty and ensured the stability of the region for hundreds of years (Figure 5). The establishment of county and prefectural institutions and the implementation of essentially the same form of administration as in the Central Plains ensured the integrated development of the Western Regions and the Central Plains [85]. In addition, agricultural activities based around garrisons and beacon towers facilitated the rapid development of an agricultural economy [74,85], which laid the foundations for population growth and also provided materials for trade.

In 900–1370 AD, the eastern Tienshan Mountains was successively occupied by nomadic regimes, including the Gaochang Uighur, Western Liao, the Mongol Khanate, and other local forces (Figure 5). Agricultural cultivation and trade activities also decreased compared with the Tang Dynasty. Around the 13th century, wars caused people to flee several times, while frequent natural disasters (especially drought) had a remarkable influence on human activities, and the population was significantly reduced (Figure 5c,e). The Ming Dynasty also adopted the bridle–halter policy to govern the Western Regions. The eastern Tienshan Mountains were frequently disturbed by nomadic tribes, leading to a rapid increase in wars. Finally, the Ming Dynasty had to abandon the Western Regions and retreat to the Jiayuguan Pass (*Mingshi*). Additionally, the Ming Dynasty paid more attention to the development of maritime trade than to land trade [86]. Social development in the eastern Tienshan Mountains during these periods was blocked.

The Qing Dynasty strengthened its control over the eastern Tienshan Mountains and built a large number of beacon towers [30], which ensured that the area remained under the effective jurisdiction of the Central Plains dynasty for a long time. The Qing Dynasty attached great importance to agricultural activities in the eastern Tienshan Mountains; the garrison, civilians, merchants, immigrants, and repatriated prisoners all became main laborers in the cultivation activities (*Qingshi*). The high-intensity agricultural activities provided food security for the Qing Dynasty to recover Xinjiang. The rapid development of agriculture, industry, commerce, and transportation was the foundation for the formation of towns in the eastern Tienshan Mountains, and the development of the agricultural economy also promoted the rise of the urban economy and cultural exchanges and integration [87]. In addition, the Qing Dynasty implemented the same prefecture–county system in Barkol and other places as they had in the Central Plains, which strengthened the administration of the Qing government [88]. Ultimately, efficient management significantly improved the level of social development in the eastern Tienshan Mountains, which meant the area could sustain more people.

5. Conclusions

This paper has explored geopolitical changes and their impacts on social development in the eastern Tienshan Mountains of northwestern China through the multidisciplinary perspectives of archaeology, history, and geography. Accelerator mass spectrometry radiocarbon dating of beacon towers and dak facilities showed that these military facilities were built and used intensively by the Tang and Qing dynasties, which strengthened the information transfer and management level over the eastern Tienshan Mountains. The effective management of the Central Plains dynasties promoted relative social stability, agricultural activities, and an increase in population in this area, which laid the foundation for the prosperity of trade along the Silk Road during the Tang Dynasty, and also for the construction of water conservation infrastructure during the Qing Dynasty, both of which improved the human living environment significantly. In contrast, frequent wars between the Han Dynasty and the Xiongnu, as well as competition between different local regimes around the Hami during the Southern and Northern Dynasties, and the Yuan and Ming dynasties, led to an unstable social environment and many refugees, which was not conducive to social development. Geopolitical changes significantly affect the stability of regional society and human living environment, which further influence the development of culture, trade, and economy. Climate change may play an additional indirect role.

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