GIS Based Analysis of Traffic Routes and Geological Division of Qinghai-Tibetan in Prehistoric Period

Changjun Xu, Yan Zhu and Ying Wang

ABSTRACT

The environment of Qinghai-Tibet Plateau is Harsh, but it is not a restricted area for life. The obviously evidence suggests that humans have expanded to the plateau area at the time of the last deglacial. Through long-term practice, the more stable pattern of traffic is formed. Through the construction of natural factor simulation - site distribution correction method, using GIS to obtain the traffic simulation results of Qinghai-Tibet Plateau in the prehistoric period, combined with archaeological evidence to confirm the simulation routes. Plateau is divided into four districts based on the simulation results, namely: northeast area, southeast area, southwest area and northwest area without man. The routes site density of the northeast area is high. And the number of sites falling into the routes accounted for 88.56% of the total number of sites in this area. The earliest routes were formed during the paleolithic period. The direction of the routes is east-west direction. The routes closely link to the internal of northeast area and link to out of the Loess Plateau and the northern area of China. The formation and development of the routes laid the foundation for the spread of pottery, wheat, millet and the formation of the Silk Road. The direction of routes is north-south direction in the southeast area. The northern part of the route connects the upper of the Yellow River area. And the southern part of the route connects the Sichuan Basin and Yunnan-Guizhou Plateau. The routes strengthen the cultural exchanges between the South and the North, and are the large corridors of national integration and communication. The southwest area is located in the center of the plateau. The routes of this area reflect the conquest of the main body in the Qinghai-Tibet Plateau. The total length of the routes is 4602.32km. It is the longest

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in three regions. The routes are the human to the plateau to enter the second important channel. Northwest area mainly for the alpine desert area, its natural environment is not suitable for human survival, so the area without route distribution.

KEYWORDS

The Qinghai-Tibet Traffic; Routes; Archeological Site; Simulation; GIS

INTRODUCTION

The Qinghai-Tibet Plateau Plateau is the highest plateau in the world with an average elevation of over 4400 meters (Yao et al, 2012). The Qinghai-Tibet Plateau is known as the “third polar region” because of its high altitude, thin oxygen, cold and dry climate, and extreme and harsh natural environment. Locations that are harsh in their natural environment are often thought to be late for human activity and less active. However, archaeological discoveries in recent years show that human activities in the Tibetan Plateau took place earlier. Ancient humans began to spread to the Qinghai-Tibet area in late late pleistocene. After a long period of adaptation, the ancients finally settled in a high altitude above 3000 meters of the Qinghai-Tibet Plateau in the mid-late Holocene (Zhang et al, 2016). At present a large number of archaeological evidence shows that the plateau Paleolithic culture and the North China Plain, the Loess Plateau and other prehistoric culture is closely linked. By the Neolithic and Bronze Age, contacts and contacts between the Tibetan Plateau and the surrounding areas were further expanded (Huo, 2013).

The route of migration and exchange often occurs along with human activities. Therefore, the study of the prehistoric traffic routes on the Qinghai-Tibet Plateau not only helps to understand the adaptation and conquest of humankind to extreme

DATA

The data used in this article are the data on the boundary of the Tibetan Plateau (Zhang et al, 2002), DEM data product with 1000m × 1000m spatial resolution (http://www.gscloud.cn), spatial distribution data of 1 million vegetation types in China (http://www.resdc.cn/data.aspx?DATAID=122) and prehistoric sites in the study site data (State Administration of Cultural Heritage, 1996; State Administration of Cultural Heritage, 1999; Xie, 2002; State Administration of Cultural Heritage, 2009; State Administration of Cultural Heritage, 2010; State Administration of Cultural Heritage, 2012).

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METHOD

In this paper, a natural factor simulation - site distribution correction method was constructed to reconstruct early Qinghai-Tibet Plateau traffic routes.

Simulation Based on Natural Factor Path

Geographical environment played a key role in the formation of early human civilization. Through research on the site, it was discovered that early humans lived mainly along the river (Groucutt et al, 2015). Places where people choose to live will choose places where the slope is gentle. The main production methods of early plateau humans were hunting collection and agriculture and animal husbandry, so areas with moderate vegetation coverage are suitable for human survival. The oxygen content of the air decreases with elevation, and altitude is one of the factors that limit human activities. Therefore, this paper simulates the transportation routes in prehistoric times through rivers, slopes, vegetation, and elevation elements.

Based on GIS [spatial analysis] tool to extract rivers in the Qinghai-Tibet Plateau (Tang et al, 2012). First, the DEM data of the Qinghai-Tibetan Plateau were processed using the [filling] tool in [Hydrology Analysis] to obtain the DEM data of the unblemished land. Secondly, use the [Flow Direction] tool to calculate the flow direction of the DEM data of the unblemished land. Use the flow direction data to calculate the flow accumulation and use the [Flow] tool to get the cumulative flow data. Use the [Raster Calculator] tool in [Map Algebra] to calculate the flow data by setting the threshold to finally get the grid river. The distribution of the valley with a threshold value of 600,000 in the Tibetan Plateau was obtained through GIS processing. The generated river network can reflect the conditions of the hydrological elements in the early Qinghai-Tibet Plateau well, which is conducive to the simulation of the route. The generated river network generates five levels of
river buffers based on 1km, 2.5km, 5km, 7.5km, and 10km, and assigns values to each buffer. This paper divides natural factors into 6 levels according to 0~5. The greater the value of the level, the greater the likelihood of the existence of a route. The following are the same, as shown in Table 1. Taking the river factor as an example, water sources play a key role in human production and life. Humans often live near rivers. Therefore, the closer to the river the higher the valuation. A value of 5 is assigned to the river buffer zone 0~1km. It is less likely that there is a site in the area 10 km away from the river. The value assigned to this area is 0. The buffers are reclassified according to the assigned index, and a river buffer grading diagram is finally generated, as shown in Figure 2.

<table>
<thead>
<tr>
<th>River/km</th>
<th>Slope/°</th>
<th>Vegetation</th>
<th>Elevation /m.a.s.l</th>
<th>Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>0~1</td>
<td>0~5</td>
<td>Temperate Grassland - Forest Vegetation</td>
<td>&lt;1600</td>
<td>5</td>
</tr>
<tr>
<td>1~2.5</td>
<td>5~10</td>
<td>Temperate forest - shrub vegetation, and forest vegetation</td>
<td>1600~2400</td>
<td>4</td>
</tr>
<tr>
<td>2.5~5</td>
<td>10~20</td>
<td>Coniferous and broad-leaved mixed forest and meadow vegetation</td>
<td>2400~3600</td>
<td>3</td>
</tr>
<tr>
<td>5~7.5</td>
<td>20~30</td>
<td>Subtropical vegetation and sparse steppe vegetation</td>
<td>3600~4500</td>
<td>2</td>
</tr>
<tr>
<td>7.5~10</td>
<td>30~40</td>
<td>Tropical Vegetation and Desert Vegetation</td>
<td>4500~5500</td>
<td>1</td>
</tr>
<tr>
<td>&gt;10</td>
<td>&gt;40</td>
<td>No vegetation area</td>
<td>&gt;5500</td>
<td>0</td>
</tr>
</tbody>
</table>

With a gradient of >70°, humans will not be able to walk. In human-walkable terrain, human activities mainly focus on terrain with a gradient of <40°, so the terrain with a gradient of <40° is analyzed (Groucutt et al, 2015). The slope of the DEM data was extracted using the [Slope] tool in the GIS [Surface Analysis], and the slope was divided into 5 classes at intervals of 5°, 10°, 20°, 30°, and 40°. Grades >40° are areas of less human activity that are uniformly grouped and assigned. With increasing altitude, the amount of oxygen in the air continues to decrease. Medical research shows that when the altitude is higher than 5500m, human beings cannot survive long-term in this interval. When the altitude is less than 1600m, it is suitable for humans to carry out production activities (Wu, 2006). This paper uses the GIS to reclassify the DEM data of the Qinghai-Tibet Plateau in accordance with the different degree of adaptation of the human body to the altitude.

The development of human activities depends on the material basis. Therefore, human activities cannot leave rich biological resources. The area with the most
abundant edible biological resources is the area bordering the grasslands and forests. Human activities are also relatively concentrated here (Chen, 2006). Therefore, the highest value of the warm forest grassland is 5, and the minimum value of the non-vegetated lands such as lakes and swamps is 0. The specific values of the vegetation types are shown in Table 1.

Using the Analytic Hierarchy Process (AHP) to obtain the weight of each factor, build a natural factor simulation result, and build a natural simulation index formula. The formula is:

\[ I = 0.339R + 0.241S + 0.221V + 0.199H \] (1)

In the formula, I is the natural simulated route index, R is the river factor, S is the slope factor, V is the vegetation factor, and H is the elevation factor. The higher the simulation result index, the greater the importance of the index.

Figure 2. The classification of the natural factor.

Route Simulation Combined With Site Distribution

The place where ancient humans live is called a site. It is a comprehensive demonstration of the natural environment, social relations, and economic and technological level in which human society was at that time (Xia, 2010). The study of the spatial pattern of the site can reflect the direction of settlement migration and is an important way of deriving ancient transportation routes. Therefore, the choice of transportation routes depends not only on natural factors, but also on social and cultural factors. The site is an important manifestation of humanities and social factors.
First, the GIS was used to extract early sites of cultural sites related to the study area. According to different periods, the sites were divided into three categories: the Paleolithic (15~6ka BP), the Neolithic (6~4ka BP), and the Bronze Age. (4~2.2ka BP). Based on Chinese cultural relic atlases and other data, a total of 4,695 sites were extracted. The number of site sites in each period totalled 83 during the Paleolithic period, a total of 1221 during the Neolithic period and a total of 3391 during the Bronze Age. The areas where there are no sites in the study area represent weak human activities or no human activities, and the possibility of a communication route is extremely low. However, there are close human exchanges in areas where the sites are densely distributed and there must be routes. This article uses the [Select by Location] tool in the GIS [Select] tool to place the site data into a grid of natural factor simulation results. The route with the distribution of sites is screened out, and the route lacking the site distribution is removed.

RESULTS

Based on Natural Factor Simulation Results

Using the grid computing tools in GIS, the data of Figure 2 is based on formula (1) to obtain the results of natural factor simulation (Figure 3a). After calculation, the natural analog line index range is 0~5. The greater the index range of a point, the higher the degree of importance of this point. This represents the high probability that humanity will pass through it, and the more likely it is to become a route. Calculate its importance based on the value of its index range. Taking into account the coherence and feasibility of the simulation results, this paper defines the range that accounts for more than 60% of the maximum value of the simulated line index.

Combined Archaeological Evidence Simulation Results

Combining natural factor simulation results with vectorized sites. Filter out the route with the distribution of sites. Eventually generated site correction simulation results (Figure 3b).

The results based on the simulation of the natural factor simulation-site distribution will be divided into the following four regions based on the route direction and the differences in the communication external regions, namely the northeast, southeast, southwest, and northwest uninhabited regions (Figure 4). Due to the harsh natural environment and relatively closed geographical environment in the northwest region, there are basically no traces of human life in prehistoric times and even some parts of the region are still in no man's land. Therefore, this article will not discuss this region.
Northeast Region

The northeastern part of the Tibetan Plateau is one of the areas where mankind first settled on the plateau and the most active human activities (Brantingham et al, 2006; Madsen et al, 2006). The simulated route in this area plays an important role in the exchange and dissemination of highland culture.

This paper mainly analyzes and discusses the direction of the simulation route, length, altitude drop, number of sites, site density, and communication area (Table 2).

There are 5 routes simulated in the northeast region (Table 2). The total length of the route is 2,895.23 km. The length of the route is the shortest among the three zones, but the number of sites is the largest (4146). The Northeastern region has high density of sites and frequent human exchanges. The route in the region is of a high degree of importance.

I-1 Datong River Valley Route, this route is mainly from the Kawaguchi Township in Minhe County along the Datong River Valley to the Aridha region in Gangcha County. The hydrothermal conditions in this distribution area are good, and many people settle here.

I-2. The Weishui River Valley line. This route is mainly from Chuankou Town in Minhe County along the main Qinshui River from the Qinghai-Hubei margin to the Buha River Basin to Xinyuan Town in Tianjun County. The number of sites that fell into the site was 1793, which accounted for 38.19% of the total.

I-3 Yellow River valley line, this route is mainly traced from Jishi Township of Xunhua County along the main trunk road of the Yellow River to Nima Town of Maqu County. In the Yellow River Valley line, 2034 sites were located in the valley, which accounted for 43.32% of the total site sites. It is the largest number of sites in the simulated route. This route not only promotes cultural integration within the plateau, but also plays an important role in the communication of cultural exchanges outside the plateau.

I-4 The Utu Meiren River Valley line, which is basically the same as the beginning of the Utumiren River, is located in the center of the Qaidam Basin.

I-5 Qaidam Basin Line, this route is located at the southern edge of the Qaidam Basin. From the starting point on the west side of the Utu-Mei River to the east
along the present National Highway 109, it passes through Golmud City and Dulan County. In the Bronze Age, humankind achieved a permanent occupation of the Qaidam Basin.

TABLE 2. THE RELATED PARAMETERS OF THE SIMULATION ROUTE.

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Toward</th>
<th>Length /km</th>
<th>Elevation /m</th>
<th>Site number</th>
<th>Site density</th>
<th>Communicate outside areas</th>
<th>Formation period</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-1</td>
<td>Datong Valley Line</td>
<td>East-west direction</td>
<td>445.17</td>
<td>1918</td>
<td>1793</td>
<td>4.03</td>
<td></td>
<td>Loess Plateau</td>
</tr>
<tr>
<td>I-2</td>
<td>Huangshui River Valley Line</td>
<td>East-west direction</td>
<td>440.84</td>
<td>2553</td>
<td>281</td>
<td>0.64</td>
<td></td>
<td>Loess Plateau</td>
</tr>
<tr>
<td>I-3</td>
<td>Yellow River Valley Line</td>
<td>East-west direction</td>
<td>1110.75</td>
<td>1629</td>
<td>2034</td>
<td>1.83</td>
<td></td>
<td>Loess Plateau</td>
</tr>
<tr>
<td>I-4</td>
<td>Utu Meinen Valley Line</td>
<td>East-west direction</td>
<td>297.49</td>
<td>296</td>
<td>7</td>
<td>0.02</td>
<td></td>
<td>/</td>
</tr>
<tr>
<td>I-5</td>
<td>Qaidam Basin Line</td>
<td>East-west direction</td>
<td>600.98</td>
<td>1261</td>
<td>31</td>
<td>0.05</td>
<td></td>
<td>/</td>
</tr>
<tr>
<td>I</td>
<td>Northeast District Summary</td>
<td>East-west direction</td>
<td>2895.23</td>
<td>7647</td>
<td>4146</td>
<td>1.43</td>
<td></td>
<td>Loess Plateau</td>
</tr>
<tr>
<td>II-1</td>
<td>Blackwater Valley Line</td>
<td>North-south</td>
<td>161.45</td>
<td>1787</td>
<td>44</td>
<td>0.27</td>
<td></td>
<td>Sichuan Basin</td>
</tr>
<tr>
<td>II-2</td>
<td>Dakincheon Valley Line</td>
<td>North-south</td>
<td>530.03</td>
<td>2039</td>
<td>115</td>
<td>0.22</td>
<td></td>
<td>Sichuan Basin</td>
</tr>
<tr>
<td>II-3</td>
<td>Yang River Line</td>
<td>North-south</td>
<td>530.33</td>
<td>2018</td>
<td>3</td>
<td>0.01</td>
<td></td>
<td>Sichuan Basin</td>
</tr>
<tr>
<td>II-4</td>
<td>Jinya River Line</td>
<td>North-south</td>
<td>1774.58</td>
<td>2260</td>
<td>31</td>
<td>0.02</td>
<td></td>
<td>Yungui Plateau</td>
</tr>
<tr>
<td>II-5</td>
<td>Minjiang Line</td>
<td>North-south</td>
<td>1100.84</td>
<td>2746</td>
<td>24</td>
<td>0.02</td>
<td></td>
<td>Yungui Plateau + Sichuan Basin</td>
</tr>
<tr>
<td>II</td>
<td>Southeast District Summary</td>
<td>North-south</td>
<td>4077.23</td>
<td>10850</td>
<td>217</td>
<td>0.05</td>
<td></td>
<td>Yungui Plateau + South Asia</td>
</tr>
<tr>
<td>III-1</td>
<td>Brahmaputra Line</td>
<td>Southeast-Northwest</td>
<td>2158.92</td>
<td>2118</td>
<td>197</td>
<td>0.09</td>
<td></td>
<td>South Asia</td>
</tr>
<tr>
<td>III-2</td>
<td>Nu River Line</td>
<td>Southeast-Northwest</td>
<td>1608.29</td>
<td>3068</td>
<td>89</td>
<td>0.06</td>
<td></td>
<td>Yungui Plateau + South Asia</td>
</tr>
<tr>
<td>III-3</td>
<td>Plateau Lake Line</td>
<td>Southeast-Northwest</td>
<td>835.11</td>
<td>549</td>
<td>38</td>
<td>0.05</td>
<td></td>
<td>/</td>
</tr>
<tr>
<td>III</td>
<td>Southwest District Summary</td>
<td>Southeast-Northwest</td>
<td>4602.32</td>
<td>5735</td>
<td>324</td>
<td>0.07</td>
<td></td>
<td>Yungui Plateau + South Asia</td>
</tr>
</tbody>
</table>

Note: The site density = site number/length.

Southeast Region

The southeastern part of the Qinghai-Tibet Plateau mainly refers to the western Sichuan Plateau and the eastern part of the Tibetan Plateau. The Western Sichuan Plateau is connected to the Tibetan Plateau in the west. The number of sites in the area is the least and the minimum site density is 0.05. The importance of the route in this area is weak compared with the other two areas. The route to the north-south
direction, the southern Sichuan Basin and the Yunnan-Guizhou Plateau. The main routes within the region are divided into:

II-1 Heishui River Valley Line: from Weigu County, Heishui County to Wenchuan County.

II-2 Dajincheon River Valley Line: From Ake River to Maekang County in Kehe Town, Aba County and then to Dading County in the direction of Dadu River.

II-3 Yalong River Line: It is from the Xianshui River tributary of Xianshui River to Yalongjiang Main Road from the village of Stontongda, Luhuo County, and then along its main road to Bawolong Township of Jiulong County. The line communicates northeast to the north and connects the Sichuan Basin to the south.

II-4 Jinsha River Line: Yelating Village, Autonomous County, heading south along the main Jinsha River to Deqin County. The Jinsha River line is the longest route in the Southeast, and it is one of the important channels for the spread and development of the East Asian population.

II-5 Minjiang Line: from Badi County in Weixi Yi Autonomous County along the Lancang River to the county seat of Nangqian County. It is located in the Tanggula region in the north of the plateau and the Yunnan-Guizhou Plateau is the main route to the South Asian region.

Southwest Region

The southwestern part of the Tibetan Plateau refers to the southern part of the Tibetan Plateau and the southwest of Qinghai Province. The length of the circuit in this area is the longest, and the density of sites is second, which is the second most important area for human exploration to the plateau. The lines in the area are:

III-1 Yarlung Tsangpo River Line: It starts from the Yarlung Zangbo River main road in the county of Medog County and goes to the county seat of Zanda County. The route is 2179.92 km long and the site number is 197. It is the longest route in
this area and the largest number of sites. Therefore, it is more important than the other two routes.

III-2 Nujiang Valley Line: This line begins in the county town of Gongshan Dulong Autonomous County along the Nujiang River Valley to the Tibet Plateau Lake Area. In the plateau lake area, the river network is dense, and there are numerous rivers and lakes that form the south-north direction.

III-3 Plateau lakes and rivers: This route is from Tibet’s Rito County to Coqen County. It is mainly composed of many lakes and rivers in the plateau and communicates with the interior of the Southwest.

CONCLUSIONS

The simulation route was obtained through the simulation of natural factors in the Qinghai-Tibetan plateau area and site distribution correction. The simulation results are divided into four areas: the northeast, southeast, southwest and northwest uninhabited areas. After the analysis of the route found:

Human activities in the northeastern region are frequent and the route in this area is the most important. The main ones are the Weishui River Valley Line, the Datong River Valley Line, the Yellow River Valley Line, the Utu Meiren River Valley Line, and the Qaidam Basin Line.

The simulated routes in the Southeast are: the Black River Valley Line, the Dajinchuan River Valley Line, the Yalong River Line, the Jinsha River Line, and the Minjiang River Line. The route in the southeast is north-south and its site density is only 0.05. However, the Southeast route connects the Qinghai-Tibet Plateau with the Sichuan Basin and the Yunnan-Guizhou Plateau. The route promotes mutual exchanges between the southern cultures, and the northern and southern cultures are developed through the collision and integration of this channel.

Southwest China is located in the heart of the Plateau. The simulation of its regional route shows that humans conquered the main body of the Qinghai-Tibet Plateau. The total length of the simulated routes in the region is the longest in the three regions, reaching 4602.32 km. This route can be used to communicate with the high altitude and the heart of the belt. It is the second most important channel for mankind to enter the plateau. Among them, the Brahmaputra Line and the Nu River Valley Line, which also communicate with South Asia, are important ways for Chinese and foreign cultures to communicate and influence each other.

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REFERENCES

11. Xia H J. 2010. Study on the spatial distribution characteristic of the historical and cultural sites based on GIS: Case study about Yulin city[D]. Xi'an, China: Xi'an University of Architecture and Technology.