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Geographic Approach: Identifying Relatively Stable Tibetan Dialect and Subdialect Area Boundaries

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Abstract: Updating dialect maps requires extensive language surveys. Geographic methods can be applied to identify relatively stable boundaries of dialect and subdialect areas, allowing language surveys to focus on boundaries that may change and thereby reduce survey costs. Certain scholars have pointed out that the watershed boundary can be employed as the boundary of Tibetan dialect areas. This paper adds that the lowest-grade road breakpoint line and no-man's-land boundary can also be used as essential indicators for determining stable (sub)dialect area boundaries. Combined with the revised First Law of Geography and the method of superposition analysis of geographic elements, this study identifies indicators that affect the stability of the Tibetan (sub)dialect area boundaries and evaluates the stability of each boundary segment. Due to the particularity of the study area, most Qinghai–Tibet Plateau (Chinese part) (sub)dialect area boundaries are stable. In addition, boundary inaccuracies caused by defects in the distribution of language survey samples can be identified by geographic approaches.

Keywords: dialect map; boundary; Qinghai–Tibet plateau; linguistic geography; cultural mapping

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1. Introduction

Language or dialect maps are important references for cross-regional communication. Currently, the frequency of cross-regional movement is increasing [1], which makes it imperative to determine whether language or dialect area boundaries are crossed. In the past three years, our group members have conducted four field surveys on the Qinghai–Tibet Plateau, covering three Tibetan dialect areas. People from different dialect areas were discovered to have little understanding of each other's dialect. These survey experiences prompt us to consider why dialects differ so much in today's age of increased mobility. Human geographers tend to analyze boundary issues from the perspective of man–land relationships, believing the stable boundaries of dialect areas can be seen as the communication boundaries that are constantly maintained under the dynamic interactions between human beings and the earth. However, the boundaries have been further questioned regarding their either-or dualistic nature since they are considered to imply more hybridity and permeability [2]. Therefore, in addition to discussing how to accurately determine the boundaries of Tibetan dialect and subdialect areas by geographic approaches, the more significant contribution of this paper is to further study the stability of each boundary segment. In the context of accelerating mobility, this study tells people which segments of the boundaries would not change if the Language Atlas of China could not be updated annually.

Understanding whether the boundaries of language or dialect areas are crossed can help predict and circumvent the linguistic challenges associated with immigration, investment, travel, and other spatial behaviors. Mapping the dialect area boundary is necessary to help multiple subjects establish the structure of regions. The distribution of dialect areas is vague in most people's minds, but it is human instinct to seek lucidity in the world [3] since it helps make more favorable decisions. In addition, maps are always context-related [4],

leading to different understandings of their meanings by different subjects. For individuals, clarifying the location of dialect area boundaries has important implications for interregional communication and the establishment of a sense of place. Language or dialect area boundaries comprise the medium for judging the depth of mutual understanding [5]. The less permeable the dialect area boundaries are, the greater the linguistic challenges people encounter when crossing them. As a result, individuals tend to connect with others in places where the language or dialect is closer to their own to improve satisfaction and efficiency of communication [6]. For firms, identifying language or dialect area boundaries can help determine whether cross-regional investment and business can bring benefits. Language or dialect similarity can facilitate the cross-regional blending of knowledge for spillover benefits [7]; cultural differences in language and dialect are the source of cultural innovation and new economic growth [8]. For the government, dialect area boundaries can strengthen the sense of place and identity of people within the boundaries [9,10], which also contribute to promoting social cohesion [11].

Language surveys are costly and time-consuming [12] since an insufficient number of survey samples can yield inaccuracies in the boundaries of dialect areas [13]. The linguistic method is based on vocabulary, pronunciation, and grammar surveys and is utilized to determine the boundaries of language and dialect areas [14,15]. There are currently only two atlases of the Chinese language: the 1987 edition and the 2012 edition. The Survey Operation Technical Specification (2012) stipulates that in minority areas, at least one survey site should be set for each language area and that for languages with large dialect differences, one survey site should be established for each dialect area [16]. However, the spatial units in the Tibet Autonomous Region and Qinghai Province are relatively large, and the internal geographic conditions vary greatly. The limitation of survey sites cannot fully reflect the differences in dialect areas in the region, causing a decrease in the accuracy of the boundaries. Additionally, the dialect area boundaries determined by linguistics methods cannot reflect the stability of every segment.

Analyzing the superposition of multiple geographic elements through maps can help quickly locate the boundaries of dialect areas and subdialect areas and assess the stability of the boundaries. A map is not only a medium of representation but also a means of analysis. Zelinsky claimed that maps are an important way to understand the meaning of language, but only a few studies have combined maps (such as topographic maps) with linguistics [17]. Jagessar believes that linguistics needs to be analyzed in conjunction with the spatial knowledge and geographic methods [18]. Moreover, language diffusion is a process that is constantly changing in time and space [19,20]. It is necessary to identify ways to optimize the survey plan to update the language map continuously. This paper utilizes a geographic approach to identify relatively stable (sub)dialect area boundaries, allowing language surveys to be concentrated in places more prone to change and reducing survey costs.

2. Literature Review

2.1. Geographic Approach to Determining Boundaries of Dialect Areas

Stable physical geography elements can be employed to accurately determine the boundaries of (sub)dialect areas. The Annales School suggests that physical geographic elements, such as the environment, ecology, and climate, maintain the basic stability of the regional structure over a long period [21]. The stability of this physical condition is the basis of the stability of human activities, thus affecting the formation of dialect area boundaries. Certain studies have discussed the influence of geographic elements on dialect area boundaries [22,23], for example, explaining the reasons for different vocabularies and grammars from a topographic perspective [24]. Mountains, dense forests, swamps [25], and beaches [26] can also serve as dividing lines between language and dialect areas., For example, some German and Italian speakers live on either side of a major ridge of the Alps [27]. The Qinling–Huaihe Line divides North China and South China and is an important Chinese dialect area boundary [28].

However, the boundaries formed by some physical elements are no longer insurmountable dialect area boundaries [1]; thus, it is more important to determine the stability of dialect area boundaries through interregional communication. In a unified communication space, people interact more frequently, and their dialects are more consistent. Geographers have agreed that watershed boundaries can serve as stable boundaries for dialect areas [29,30] since valleys can become centers for the locals to organize their activities, thus forming similar dialects [31]. The Basque language in northern Spain is centered in the barren limestone mountain area, and the lack of resources has kept the language boundary stable for a long time without attracting attention and entry from outsiders [32]. There is an Indo-European and Dravidian boundary between the water-retaining black soil and the thin red dry soil [33]; this soil-type boundary determines a human's life boundary. Another example is Bhutan, where the farmers in Mangde Valley and pastoralists in nearby mountains communicate by exchanging agricultural and pastoral products, thus forming a unified dialect area [34].

Researchers have discussed geographic methods to identify language or dialect area boundaries, but improvement is still needed. First, researchers have focused on geographic elements without judging the stability of these elements as dialect area boundaries. The types and levels of geographic elements reflect the difficulty of language transmission to a certain extent and affect the stability of language or dialect area boundaries. For instance, a higher mountain represents a great barrier to communication on both sides of the mountain. Second, how to identify the communication boundaries through geographic elements is a problem that needs to be further explored. The layers of the analysis are continuously enriched by the method of overlaying geographic elements. An additional geographic element layer means one more indicator for correcting the dialect area boundary.

2.2. Existing Methods for Determining the Tibetan Dialect Area Boundary

The Tibetan language in China has three major dialect regions (refer to Figure 1). Hermanns [35] suggested that the boundary between the Amdo dialect and the Kham dialect area is the watershed between the Yellow River Basin and the Yangtze River Basin. Chamberlain [36] comprehensively plotted the basin boundaries in the Qinghai–Tibet Plateau and revealed a high degree of coincidence with the Tibetan language-type distribution classified by Tournadre [37], a well-known expert in Tibetan studies. Roche [38] also drew the boundaries of the three Tibetan dialect areas according to watershed boundaries. Rongze Chen [39] proposed that the distribution boundary of the three Tibetan dialect areas basically overlapped with the watershed boundaries of the main rivers. Scholars in China and abroad have agreed that the Bayan Har Mountains and the Gangdise-Nyenchen Tanglha Mountains are the boundaries of the three major Tibetan dialect areas. However, researchers have not analyzed the level of each watershed. The influence of different watersheds on the Qinghai–Tibet Plateau in forming dialect area boundaries should differ.

Certain researchers have investigated the relationship between the socioeconomic region boundaries and the Tibetan subdialect area boundaries. The 1987 edition of the Tibetan dialect map was based on the classification of Aitang Qu [40]. According to the living forms of the locals, Qu divided the Amdo dialect into agricultural, pastoral, semiagricultural and semipastoral subdialect areas. According to the historical administrative region, the Dbus–Gtsang dialect area was divided into subdialect areas of Dbus, Gtsang, and Ngari. The Kham dialect area was divided into core, northern, western, and southern subdialect areas. Jumian Kelsang and Yangjing Kelsang divided the Kham dialect area into northern, southern, and pastoral subdialect areas according to the distribution of two highways and people's living forms [41]. Di Jiang further integrated the Tibetan dialect and subdialect areas into the Language Atlas of China published in 2012 [42] (refer to Figure 1).

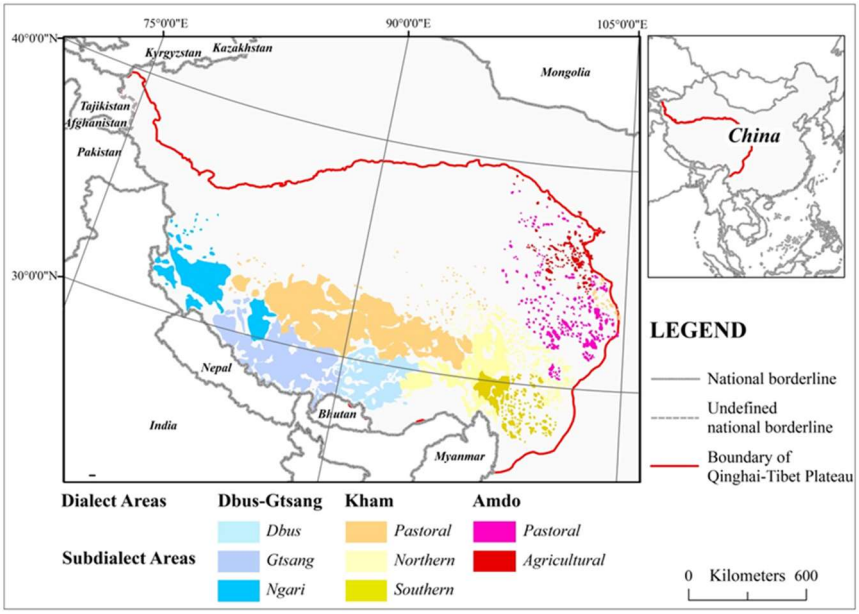


Figure 1. Location of the study area. (The Qinghai–Tibet Plateau of the Chinese part is located in southwestern China. The distribution map of the Tibetan dialect areas and subdialect areas was drawn by the Chinese Academy of Social Sciences in 2012).

In addition, there are some studies on the relationship between roads and (sub)dialects, but most of them are about the similarity of (sub)dialects caused by road connectivity, while studies on (sub)dialect area boundaries are insufficient. The roads are the carrier of the flow of people so that the spread of dialects can be continuous [43]. Some scholars have found that the dialects of villages situated near the same road are more similar to each other [44]. However, the boundaries of (sub)dialect areas still consist of the counties' boundaries, reducing the accuracy to some extent. Further exploration is needed to find a way to more accurately determine the boundaries of the (sub)dialect areas by road.

2.3. Combination of Maps and Language

Mapping is an important method of visual representation. Rich cultural meanings contained in language can be recorded and presented through maps. Geomedia is an intersection field of communication and geography, playing an essential role in helping spread knowledge [45]. Language and dialect act as carriers for promoting knowledge and thought transfer [46] and cultural sharing [47]. Place names are the most obvious linguistic marks and cultural landscapes on maps. Griebel gives an example to show that the place names on the map reflect Inuinnait's understanding of local natural conditions and provide valuable local knowledge [48]. Aporta believes adding the stories narrated by the indigenous Gwich'in to each place's name on the map is beneficial for recording the cultural significance of their living places [49].

Compared with the traditional language or dialect map, the multimedia sound map has more advantages in conveying embodied local feelings. The auditory dimension is the most prominent nonvisual dimensions, whose stimuli are highly correlated with the impressions and meanings generated when people experience the place [50]. Krygier first proposed that sound can expand the scope of map visualization [51]. The embedding of real soundscapes into multimedia maps can evoke people's feelings about places and maintain more lasting memories [50]. For instance, the background sound of the howling of the wind in a multimedia map is a way to enhance the sense of the Antarctic continent [52]. In addition, the development of sound in 3D and virtual reality technology allows people to be more immersive and feel an unprecedented sense of realism [53]. More real feelings of the first person can be obtained in the sound environment of the virtual map, which cannot be formed from God's perspective of the flat map. It is worth noting that sound

maps can be applied not only to tourism, leisure, and entertainment but also to the medical and healthcare fields. Auditory maps help people better identify terrain [54], and users can generate a significantly stronger perception of spatial presence under immersive sound conditions [53]. All these practical studies are beneficial for improving the ability of visually impaired groups to perceive and acquire spatial information more accurately.

3. Study Area

The Qinghai–Tibet Plateau is an inland plateau in the southwestern part of China known as the "roof of the world". This plateau includes the entire territory of the Tibet Autonomous Region and Qinghai Province, as well as parts of the Xinjiang Uygur Autonomous Region, Gansu Province, Sichuan Province, and Yunnan Province. Following the Language Atlas of China (the 2012 edition): Minority Languages Volume (C1–25 Tibetan), this paper divides the Tibetan dialect area into three dialect areas and several subdialect areas (refer to Figure 1).

There are two reasons for choosing the Qinghai–Tibet Plateau (Chinese part) as the study area. First, the three major Tibetan dialect areas have a low degree of interoperability and relatively clear dialect area boundaries. Second, the density of the road network in the Qinghai–Tibet Plateau is low, and the breakpoints of the road network can be clearly identified on the map. The terrain of the Qinghai–Tibet Plateau fluctuates sharply, and the weather is harsh, making it difficult to build roads. In addition, the Qinghai–Tibet Plateau has a low population density, low total demand for road traffic, and low road network density in sparsely populated areas.

4. Research Methods

The main method of studying the (sub)dialect area boundary was to define the more accurate human communication boundary by road breakpoint lines and no-man's-land boundaries on the basis of the watershed boundary and then judge the stability of every segment of the (sub)dialect area boundary. The logical basis of this research was the revised First Law of Geography (Figure 2). The First Law of Geography states that everything is related to other things, but things that are spatially close are more closely related [55]. However, the law does not clearly define spatial proximity. This work defined spatial proximity as the distance that people in the Qinghai–Tibet Plateau interact with each other by road.

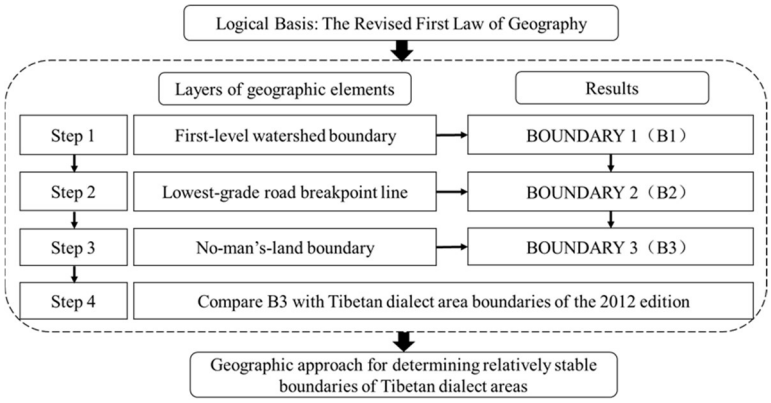


Figure 2. Method framework. (The logical basis of this study is the revised First Law of Geography. Three superimposed geographic elements are selected to determine the (sub)dialect area boundary: the boundary of the first-level watershed, lowest-grade road breakpoint line, and no-man's-land boundary).

The method employed in this paper was the layer overlay Geographic Information System (GIS) analysis method, which was divided into four steps. The first step was to select natural elements with high stability as basic dialect area boundaries. The second step was to determine the (sub)dialect area boundaries by connecting the breakpoints of

the lowest-level roads. The third step was to refine the boundaries of (sub)dialect areas by identifying the boundaries of no-man's-land in the Qinghai–Tibet Plateau. The fourth step was to compare the boundaries of Tibetan (sub)dialect areas drawn by the above steps with the Tibetan dialect map of the 2012 edition and determine the relatively stable boundary segments. This paper aimed to develop a set of geographic methods for identifying the boundaries of (sub)dialect areas.

5. Analysis

5.1. Determine First-Level Watershed Boundaries (B1)

The high-grade mountains that constitute the boundaries of the first-level watershed in the Qinghai–Tibet Plateau are selected as the basis for the boundaries of the Tibetan dialect areas. There are many first-class rivers on the Qinghai–Tibet Plateau, including the Yangtze River, the Yellow River, the Lantsang River (also referred to as the Mekong River in Southeast Asia), the Nujiang River (also referred to as the Salween River in Southeast Asia), the Yarlung Zangbo River (also referred to as Brahmaputra River in Southeast Asia), and the Seng-ge Kambab River (which downstream becomes the Indus River in Pakistan). Not every mountain range that forms the boundary of a first-level watershed can be a boundary for dividing dialect areas. Referring to the hierarchical structure of the mountain ranges, we selected the highest-level mountain ranges as the basis for the boundaries of dialect areas. The Geographic Atlas of China [56] classified the mountain system in China. Based on the absolute and relative altitudes, the authors divided the mountains into extremely high mountains, moderately high mountains, and low mountains. However, most mountains on the Qinghai–Tibet Plateau are extremely high mountains (more than 3500 m above sea level), and differences in height cannot be identified on the map. Therefore, digital elevation model data of the Qinghai–Tibet Plateau are utilized to extract the ridgelines and divide the mountains into three grades according to their height and length.

The first-level mountain ranges have established the basic pattern of the three Tibetan dialect areas, which is consistent with the judgment of other scholars. As shown in Figure 3, the Kunlun-Bayan Har Mountains and the Gangdise-Nyenchen Tanglha Mountains form two important dividing lines between the Amdo and Kham and the Kham and Dbus-Gtsang dialect areas, respectively. This result is basically consistent with the boundaries of the three major Tibetan dialect regions presently agreed upon by related researchers. Therefore, the watershed boundaries formed by the first-class rivers are selected as the basic boundaries of the three Tibetan dialect areas, as shown in Figure 3, B1.

The hierarchy of mountain ranges affects the stability of (sub)dialect area boundaries, and the boundaries of (sub)dialect regions formed by high mountain ranges are more stable. In general, the stability of the boundaries of the three Tibetan dialect areas is higher than that of the subdialect areas, with exceptions. The mountain pass is an area with strong population flow, reducing the stability of the dialect area boundary. The exact location of the dialect area boundary here cannot be determined by the mountain range element but needs the assistance of other elements. For instance, the southeastern end of the Bayan Har Mountains has a wide mountain pass, which has become a communication channel between the Amdo dialect area and the Kham dialect area. Another example is the mountain pass between the Hengduan mountains and the Nyenchen Tanglha Mountains, which is also the intersection of the Kham and Dbus-Gtsang dialect areas.

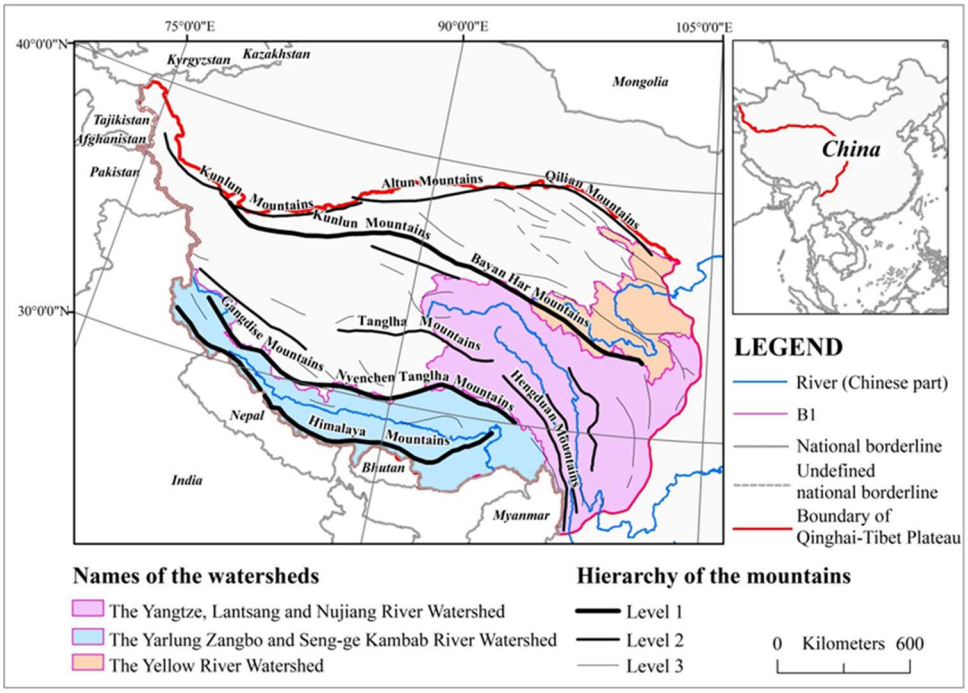
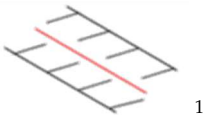
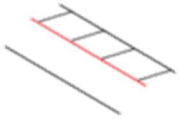


Figure 3. First-level watershed boundaries (B1). (The first-class rivers and high-grade mountains define the basic boundaries of the three dialect areas on the Qinghai–Tibet Plateau of the Chinese part).

5.2. Modify B1 with the Lowest-Grade Road Breakpoint Line (B2)

The breakpoint lines of the lowest-grade road (B2) form the edge of the road network. Among places where even the lowest-level of road connections are not available, dialects and subdialects can vary widely. The first law of geography points out the relationship between the closeness of connection and spatial proximity. People's communication and other activities are basically carried out along roads, so the similarity of (sub)dialects among areas with a short communication distance through roads is higher. Therefore, the road breakpoint line defines where the (sub)dialect area boundary is easily formed. Road grades in China include national highways, provincial highways, county roads, township roads, and other roads from high to low. This paper designates "other roads" as the lowest-level roads and uses GIS to identify the breakpoint line (B2) (Figure 4). Table 1 shows two methods for determining B2.

Table 1. Two ways to determine B2.

Situation	Schematic	Drawing Method
Lowest-grade road breakpoints appear on both sides		Join the midpoint of the two endpoints in turn
Only one side has the lowest-grade road breakpoints		Connect the road breakpoints directly in turn

[1] Note: Red lines represent lowest-grade road breakpoint lines; black lines represent roads.

Generally, the lowest-level road breakpoint lines between two dialect regions are relatively clear, while those between two subdialect regions are blurred. In areas with high connectivity of roads, it is impossible to identify the boundaries of subdialect areas based on road breakpoints, such as the boundaries of the Dbus and Gtsang subdialect

areas. Therefore, other potential factors need to be included in the superposition analysis to identify the boundaries of the (sub)dialect areas.

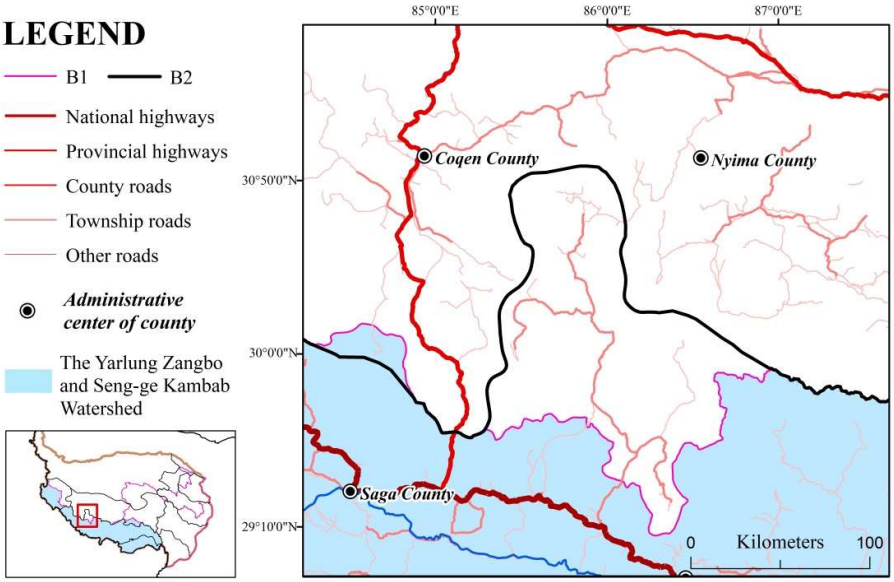


Figure 4. Example Area with B1 and B2. (At the junction of the three counties of Saga, Coqen, and Nyima, the basic boundary of the Yarlung Zangbo and Seng-ge Kambab River Basins (B1) is modified by the lowest-grade road breakpoint line (B2)).

5.3. Amend B2 with No-Man's-Land Boundaries (B3)

This paper modifies B2 with the no-man's-land boundary (B3) in the land cover type data. GlobeLand30 data include 10 main land cover types in the Qinghai–Tibet Plateau: cropland, forest, grassland, shrub, wetland, water, tundra, man-made surface, bare land, glacier, and permanent snow. Wetlands, water bodies, glaciers, and permanent snow are not suitable for human habitation; these three categories are defined here as depopulated areas. The boundaries of dialect or subdialect area defined by the lowest-grade road breakpoint lines may continue to extend, but no-man's-land boundaries are the limits of future road extension and can form more stable (sub)dialect area boundaries. Figure 5 shows the correction of B3 to B2 in Cuona and Lhunze County in southeastern part of Shannan city.

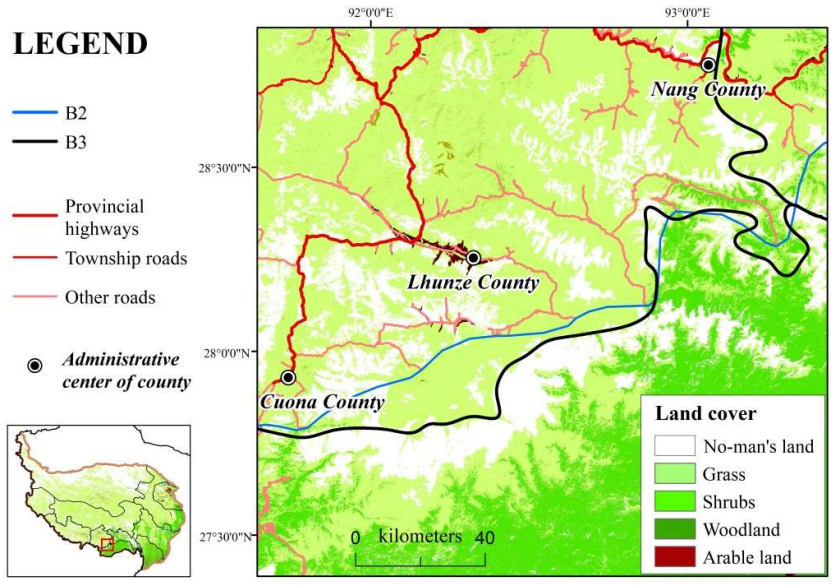


Figure 5. Example Area with B2 and B3. (In the southern part of Lhunze, Cuona, and Nang Counties, the breakpoint line of the lowest-grade roads (B2) is amended by the boundary of no-man's land (B3)).

5.4. Correct Seven Segments of the (Sub)Dialect Area Boundaries

Comparing the revised Tibetan (sub)dialect area boundaries with the 2012 version of the Tibetan dialect map, it reveals that 82.67% of the boundaries are consistent and that only seven boundary segments have significant differences, as shown in Table 2. The boundaries of the (sub)dialect areas, where the differences appear, are mainly composed of the lowest-grade road breakpoint lines, whose stability is lower than that of the physical elements.

Table 2. Seven boundary segments of (sub)dialect areas with significant differences and reasons.

Location	Type in the 2012 Map	Type after Modification	Possible Reasons for the Difference
Northeast of Coqen and Zhongba County (Ngari and Shigatse, Tibet)	Ngari and Gtsang (Dbus-Gtsang)	Pastoral (Kham)	First-level watershed boundary and road breakpoint line
Northern Baxoi County (Qamdo city, Tibet)	Northern (Kham)	Pastoral (Kham)	Road breakpoint line extends south to Bowo county and northern Baxoi County
Most of Gongbo'gyamda County (Nyingchi city, Tibet)	Gtsang (Dbus-Gtsang)	Northern (Kham)	No-man's-land boundary on the west
Northeastern Batang County and Litang County (Garze Prefecture, Sichuan)	Southern (Kham)	Northern (Kham)	Clear road breakpoint line
Nangchen County and Yushu city (Yushu city, Qinghai)	Northern (Kham)	Pastoral (Kham)	Road breakpoint line
Xinghai County and Zeku County (Hainan Tibetan Autonomous Prefecture, Huangnan Tibetan Autonomous Prefecture, Qinghai)	Pastoral (Amdo)	Agricultural (Amdo)	Road breakpoint line
Eastern Gangca County, eastern Menyuan Hui Autonomous County (Haibei Tibetan Autonomous Prefecture, Qinghai)	Pastoral (Amdo)	Agricultural (Amdo)	Road breakpoint line

5.5. Evaluate the Stability of (Sub)Dialect Area Boundaries

Fragments of (sub)dialect area boundaries are graded for stability by evaluating the stability of forming elements. This work classifies the level of mountains, clarity of the lowest-grade road breakpoint line and no-man's-land boundaries into two or three grades. The specific method for evaluating the stability level is shown in Table 3. The (sub)dialect area boundaries are divided into 27 segments according to the different combinations of geographic elements. The stability ratings for each segment are shown in Table 4.

Table 3. Method to determine the stability of the (sub)dialect area boundaries.

Indicators	Level of Stability	Grade	Index
First-level watershed boundary (mountains)	High	Level 1	++++ [1]
		Level 2	+++
		Level 3	++
No-man's-land boundary	Medium	Clear	+++
		Generally clear	++
Lowest-grade road breakpoint line	Low	Clear	++
		Generally clear	+

[1] Note: The symbol "+" represents the degree of stability of indicators of different types and grades, and the more "+", the higher the degree of stability.

Table 4. The influencing indicators and level of stability of each (sub)dialect area boundary segment.

Segment Number	Boundary	Stability Influencing Indicators	Level of Stability
1	Dbus-Gtsang and Kham	Clear road breakpoint line, clear no-man's-land boundary, level 1 mountains	+++++++++ [1]
2	Dbus-Gtsang and Kham	Generally clear road breakpoint line, generally clear no-man's-land boundary	+++
3	Dbus-Gtsang and Kham	Clear road breakpoint line, clear no-man's-land boundary	+++++
4	Dbus-Gtsang and Kham	Clear no-man's-land boundary, level 1 mountains, generally clear road breakpoint line	++++++++
5	Dbus-Gtsang and Kham	Clear road breakpoint line	++
6	Dbus-Gtsang and Kham	Generally clear road breakpoint line	+
7	Dbus-Gtsang and Kham	Generally clear road breakpoint line, level 1 mountains, generally clear no-man's-land boundary	+++++++
8	Dbus-Gtsang and Kham	Generally clear road breakpoint lines, generally clear no-man's-land boundary, level 2 mountains	++++++
9	Northern and Southern subdialect area	Clear road breakpoint lines, clear no-man's-land boundary, level 3 mountains	+++++++
10	Dbus-Gtsang/Kham dialect area and no-man's land	Clear road breakpoint lines, clear no-man's-land boundary, level 1 mountains	+++++++++
11	Dbus-Gtsang and Kham	Generally clear no-man's-land boundary, level 3 mountain range, generally clear road breakpoint line	+++++
12	Dbus and Gtsang	Generally clear no-man's-land boundary, generally clear road breakpoint line	+++
13	Ngari and Gtsang	Clear road breakpoint line, generally clear no-man's-land boundary	++++
14	Kham dialect area and no-man's land	Clear road breakpoint line	++
15	Kham dialect area and no-man's land	Clear road breakpoint line, generally clear no-man's-land boundary, level 2 mountains	+++++++
16	Northern and pastoral subdialect area	Clear road breakpoint line	++
17	Northern and pastoral subdialect area	Generally clear road breakpoint line, clear no-man's-land boundary	++++
18	Northern and pastoral subdialect area	Clear road breakpoint line, generally clear no-man's-land boundary	++++
19	Southern and Northern subdialect area	Clear road breakpoint line	++
20	Amdo dialect area and no-man's land	Clear road breakpoint line, generally clear no-man's-land boundary	++++
21	Amdo dialect area and no-man's land	Clear road breakpoint line, generally clear no-man's-land boundary	++++
22	Amdo and Kham	Clear road breakpoint line, level 1 mountains	++++++
23	Amdo and Kham	Generally clear road breakpoint line, level 1 mountains	+++++
24	Amdo and Kham	Generally clear road breakpoint line, level 3 mountains	+++
25	Agricultural and pastoral subdialect area	Generally clear road breakpoint line, level 2 mountains	++++
26	Agricultural and pastoral subdialect area	Clear road breakpoint line	++
27	Agricultural and pastoral subdialect area	Clear road breakpoint line, level 3 mountains	++++

[1] Note: The symbol "+" represents the level of stability of different segments of (sub)dialect area boundaries. The more "+", the higher the level of stability.

Judging the stability of dialect area boundaries is a refinement of and supplement to the Tibetan Dialect Map of the 2012 edition. The results show that the middle section of the boundary between the Dbus-Gtsang dialect area and the Kham dialect area is affected by

the road passing through the Nyenchen Tanglha Mountains, where the stability decreases. The stability of the dialect area boundary in the southern Dbus-Gtsang area is high, mainly due to the blocking effect of the Himalaya Mountains. However, the boundaries of the Dbus and Gtsang subdialect areas have low stability, which is mainly affected by the dense road networks. The northwestern boundary of the Kham dialect area is relatively stable and largely blocked by the Tanglha Mountains, but the central part continues to expand to the interior of the Qinghai–Tibet Plateau. The boundaries of the subdialect areas within the Kham dialect area are mainly affected by roads and have low stability. The western part of the Amdo dialect area is the uninhabited area, and the boundary is relatively stable, while on its southeast side, the blocking effect of the lowest-level mountain is reduced by the development of roads. The internal road networks in the Amdo dialect area form gradually, and the stability of this subdialect area boundary decreases.

6. Conclusions and Discussion

6.1. Conclusions

Three conclusions are drawn based on the above analysis.

First, the road breakpoint line can be a reliable and effective indicator for determining the boundaries of (sub)dialect areas. This paper shows that the stability of each (sub)dialect area boundary segment is not the same everywhere in the Qinghai–Tibet Plateau. The huge mountains determine the breakpoint lines of the road systems and the frequency of people's interaction, thereby affecting the consistency of the dialect or subdialect.

Second, due to the particularity of the study area, most of the (sub)dialect area boundaries are stable. Owing to the superposition analysis of the first-level watershed boundaries, the lowest-level road breakpoint lines and no-man's-land boundaries, the stability of the dialect area boundaries is basically higher than those of the subdialect area boundaries, with some exceptions in the Dbus-Gtsang and the Kham dialect areas.

Third, the geographic method can be applied to identify inaccurate locations of (sub)dialect area boundaries that lack survey samples, and it also comprises a good alternative to linguistic methods for mapping (sub)dialect area boundaries. There are only a few inconsistencies between the (sub)dialect map drawn by geographic methods and the 2012 edition of the Tibetan dialect map. The main reason for the inconsistency is the instability caused by road expansion. Geographic methods can update (sub)dialect area boundaries according to physical and human geographic data, saving considerable manpower and material resources. With the continuous development of geographic technologies such as remote sensing and geographic information system, various methods of obtaining geographic data have become increasingly convenient. Therefore, exploring the (sub)dialect area boundaries through geographic methods before linguistic fieldwork would be more feasible.

6.2. Discussion

The boundaries between the three Tibetan dialect areas remain remarkably stable, predicting that it will continue to maintain the basic pattern of the three dialect areas in the Qinghai–Tibet Plateau in the future. High-grade mountains have been confirmed to have the greatest influence on the stability of dialect area boundaries. The boundaries of dialect areas with high stability are almost always east–west, which is consistent with the direction of the main mountain ranges. In addition, the mountain passes are the locations where roads are most likely to extend. Almost all the road breakpoint lines have changed at mountain passes, thus changing the stability of the boundaries of the dialect area. From the perspective of time geography, people's travel behavior will be constrained to a certain space-time range [57]. However, the construction of roads saves people's travel time, thus greatly expanding the scope of people's movement. Therefore, with the construction of roads, the boundaries of the three dialect areas not only expanded to the interior part of the Qinghai–Tibet Plateau but also overlapped and intersected with each other, thus decreasing the stability of certain boundary segments of the three dialect areas.

This study has some limitations. First, most of the seven differences between the results of this study and the Tibetan dialect map of the 2012 edition are related to road breakpoint lines, which create some uncertainty. We speculate that there are two possible reasons for the difference. One is that there are not enough superimposed layers, leading to a lack of accurate judgment of the results. More elements need to be explored for overlay analysis to further determine the location and stability of the (sub)dialect area boundary. The other reason would be that the boundary of the (sub)dialect area has already changed to some extent due to road network expansion, especially in some places without any impact of insuperable natural factors. Hence, we strongly recommend that linguists conduct language surveys for further confirmation in areas where the results drawn by geographic methods are inconsistent with those of linguistic studies.

Second, due to data availability, this study utilized only data on watersheds, roads, and land cover types to delineate the boundaries of dialect and subdialect areas. More overlapping influencing factors should be explored in the future. The habit of following historical administrative boundaries is a factor that affects the stability of the boundaries of (sub)dialect areas. Certain scholars suggest that the boundaries of administrative regions are representative of other boundaries formed by various elements over a long period and that they are better suited to become the boundaries of dialect areas than the boundaries of religious or economic regions [58]. Geographic boundaries are also constantly undergoing the process of reification–naturalization–fetishization [59]; that is, once an administrative boundary is formed, people will continue to strengthen their awareness of it as a boundary, and this habitual consciousness will become an important factor affecting the stability of the boundaries of (sub)dialect areas. For example, a vast swamp between Upper Carniola and Lower Carniola in Slovenia has long formed a boundary between dialect areas in the two regions, but a few years after the swamp dried up, the dialect area boundary did not disappear [25]. In addition to determining boundaries through tangible entities, the influence of historical, political, emotional, and other factors must be considered, and the influence of these factors will be more difficult to identify.

The administrative boundaries of the Yuan Dynasty had a great influence on the division of dialect areas and showed a certain continuity and heritability. Xuan Zheng Yuan was established during the Yuan Dynasty in China. It was an administrative department directly under the jurisdiction of the central government, responsible for national Buddhist affairs and managing military and political affairs in Tubo (roughly corresponds to the Qinghai–Tibet Plateau). It governed three administrative regions that were consistent with the three Tibetan dialects areas of Amdo, Kham, and Dbus-Gtsang. Future studies will continue to explore the historical impact on the stability of (sub)dialect area boundaries.

Third, our research still needs to be improved in terms of the combination of Tibetan dialects and mapping, which will be a vast and promising field. In terms of the representation forms, our future research will try to demonstrate more audio-visual materials of Tibetan dialect culture to help map readers have more embodied experiences. Tibetan opera, songs, and legends are all spread through different (sub)dialects. We believe that attaching these audio-visual materials to maps could greatly enhance users' perception dimensions of the Qinghai–Tibet Plateau, thereby expanding the usability of the dialect map. As for the application fields, the (sub)dialect difference reflected by the Tibetan dialect can be seen as a cultural parameter to explain social and economic relationships between different regions. Jackson proposed that cultural geographers should pay more attention to the social meanings mapped by language [60]. Therefore, Figure 6 shows not only the boundaries of dialect areas or subdialect areas but also the boundaries of people's social interactions on the Qinghai–Tibet Plateau.

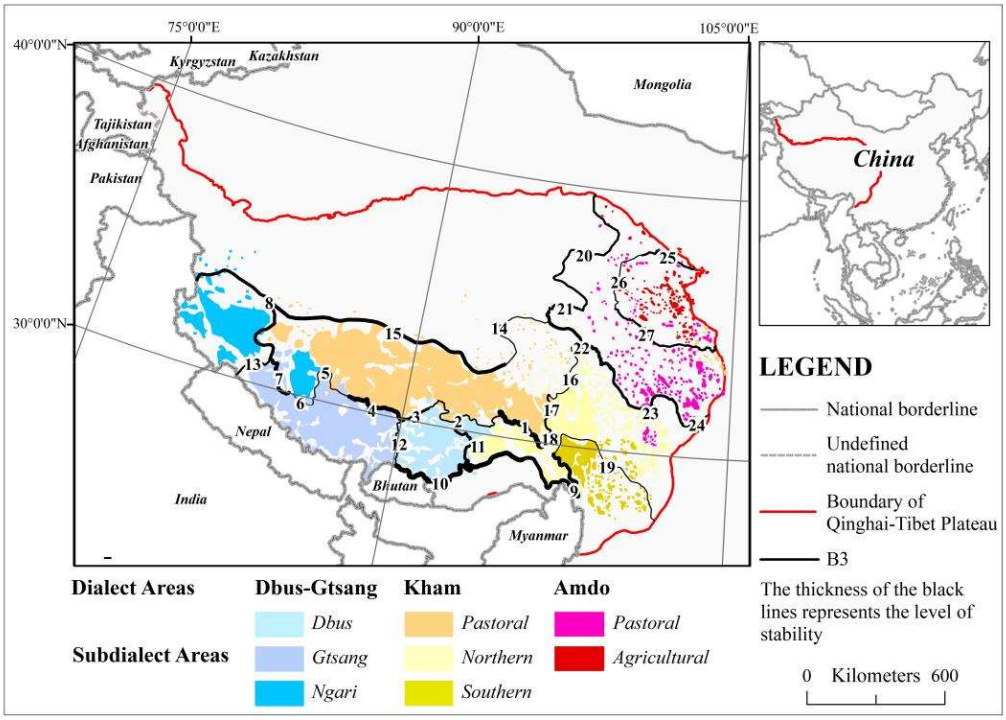


Figure 6. Segmentation of Tibetan (sub)dialect area boundaries. (Compare B3 with boundaries drawn by the Chinese Academy of Social Sciences in 2012 formed by language surveys. The positions of the two boundaries are similar, but the stability of the boundaries of each segment differs. The numbers in Figure 6 represent the serial numbers of the (sub)dialect area boundaries of each segment, corresponding to those in Table 4).

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