

Analysis of population, earthquake and fault characteristics in Guiyang city

Feng Qian^{1,a,*}, Long Denghua¹, Wu Lei¹, Yang Xinwei¹, Liu Yu²

¹Information Center, Guizhou Earthquake Agency, Guiyang, Guizhou, 550001, China

²Guizhou Provincial Engineering and Earthquake Prevention Research Institute, Guizhou Earthquake Agency, Guiyang, Guizhou, 550001, China

^a939268275@qq.com

*Corresponding author

Abstract: To better cope with the needs of disaster prevention work, the Guiyang population, earthquake and fault zone space information, through indoor data analysis area population spatial pattern, fracture characteristics, using GIS density analysis method and spatial statistical analysis method of Guiyang earthquake distribution rule, to grasp the risk elements of Guiyang information, improve disaster risk prevention and control ability has certain practical significance.

Keywords: Population; historical earthquakes; fault zones; characteristics of spatial distribution

1. Introduction

This study analyzes the population distribution characteristics of 10 counties in 2020, based on the density analysis and spatial statistics of GIS tool in 1981-June 2022 historical earthquake directory data plane distribution, time distribution and focal depth characteristics, and find data summary of Guiyang fault characteristics, in order to provide an objective understanding of the comprehensive risk level of disaster, natural disaster and emergency management disaster risk factor information.

2. Overview of the study area

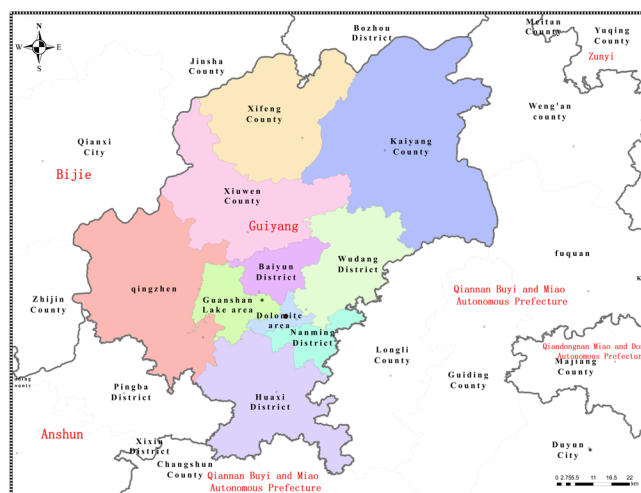


Figure 1: Location map of Guiyang city

Guiyang city is located between east longitude 106°07'-107°17', north latitude 26°11'-26°55', the total land area of the city is 8034km², In the southeast, it borders Weng'an, Longli, Huishui and Changshun counties of Qiannan Buyi and Miao Autonomous Prefecture, Pingba District of Anshun City and Zhijin County of Bijie City in the west, and Qianxi City, Jinsha County and Bozhou District of Zunyi City in the north. Guiyang city has 6 municipal districts: Nanming District, Yunnan District, Huaxi District, Wudang District, Baiyun District and Guanshanhu District, 1 county-level city: Qingzhen City, Kaiyang County, Xifeng County and Xiuwen County, 72 streets, 46 towns, 27

townships and 145 township-level administrative divisions.

Guiyang city is located in the middle of the original hills of Zhongshan, and the watershed area between the Yangtze River and the Pearl River. The total terrain is high in the southwest and low in the northeast. The landform belongs to the Qiuyuan basin area dominated by mountains and hills.

3. Data sources and research methods

3.1. Data Source

The study is based on the seventh population census of Guiyang and earthquakes with magnitude or above M0. Among them, the census data comes from the official website of Guizhou Provincial Bureau of Statistics and the official website of people's governments at all levels, and the earthquake data of magnitude or above M0 is derived from the earthquake catalogue provided by the Earthquake Platform of Guizhou Province. The bottom map data mainly includes: Guiyang administrative division map and related geographic information data, and the basic geographic data comes from the Guizhou Seismological Bureau and the Department of Culture and Tourism of Guizhou Province.

3.1.1. Research Methods

1) Classification of Population Agglomeration Type and Scale

Refer to Ge Meiling et al^[1], Luo Ya snow^[1]Based on the classification of population density, the geographical distribution of population in Guiyang was divided into a population density of 0-1 person./km². Basically no man's land, 2-25 people/km². For extreme sparse areas, 26-50 people/km². For absolute sparse areas, 51-100 people/km². For the relatively sparse area, 101-200 people/km². For the general transition zone, 201-400 people/km². It is a low-degree concentration area, with 401-500 people/km². A moderate agglomeration area, 501-1,000 people/km². For a highly concentrated area and > 1,000 people/km². For 9 cluster types in the core area, the population types were calculated by calculating the population density of 10 districts and counties in Guiyang. At the same time, according to the five population size levels of > 1 million, 50-1million, 300,000-500,000, 10-300,000, <100,000^[2], Statistics of the population size characteristics of the 10 counties in Guiyang city.

2) Historical Earthquake Statistics

The study discusses the data of the historical earthquake catalogue of Guiyang from 1981 to June 2022 in different years, month and earthquake level respectively, Statistics were performed in four time periods: 1981-1990, 1991-2000, 2001-2010, and June 2011-2022, And for 12 months from 1981 to June 2022, The seismic magnitude begins at magnitude M0, They were classified into grades > M0-M2.0, M2.1-M3.0, M3.1-M4.0, M4.1-M5.0, M5.1-M6.0 and M6.0 or above.

3) Point Density Analysis

Using the core density analysis tool (used to calculate the density of the elements in their surrounding neighborhood, you can calculate the density of the point and line elements. Mainly used to measure building density, obtain crime reports, and find roads or public facilities pipelines that have effects on the town or wildlife habitat)^[3]. To conduct density analysis of all seismic points in Guiyang from 1981 to June 2022, visually express the evaluation results, and better analyze the agglomeration and disdispersion of seismic events in the study area.

4) Source depth analysis

Taking the depth range of 1-5km, 6-10km, 11-15km, 16-20km and > 20km as the evaluation grade, the depth range of Guiyang earthquake between 1308-2021 was counted respectively, and the average source depth was calculated to identify which category of Guiyang earthquake in shallow source (0-70km), middle source (70-300km) and deep source earthquake (> 300km).

4. Spatial feature analysis

4.1. Population Spatial Pattern

According to the corresponding population cluster type level and scale level, the 10 counties in Guiyang were analyzed. The detailed population density and cluster types of the 10 counties are shown in Table 1. In terms of population agglomeration type, the 10 counties in Guiyang mainly include four

categories: agglomeration core area, moderate concentration area, low concentration area and general transition area. Among them, there are 5 counties in the agglomeration core areas, 2 moderate agglomeration area, 2 low concentration area and 1 general transition area. Characteristics of the spatial distribution of cluster types are shown in Figure 1.

Table 1: Population Cluster Type and Population Scale Distribution Table in Guiyang City

City	county	Population number	Population Density (person /	Cluster type
Guiyang	Nanming	1047792	5005	Cluster core
	Yunyan	1056819	11294	Cluster core
	Guanshanh	642634	2093	Cluster core
	Baiyun	456250	1677	Cluster core
	Wudang	336363	490	Moderate
	Huaxi	966276	1002	Cluster core
	Qingzhen	629088	454	Moderate concentration
	Kaiyang	343871	170	General
	Xiuwen	288090	268	Low
	Xifeng	219835	212	Low

As can be seen from Figure 2, the core area of the cluster is mainly located in Yunyan District, Nanming District, Guanshanhu District, Baiyun District and Baiyun District and Huaxi District of Guiyang, especially Yunyan District has the largest population density of 11,294 people / square kilometer. The medium degree concentration area is Wudang District and Qingzhen City, and the general transition area is Kaiyang County. The low degree concentration area is located in Xiuwen County and Xifeng County of Guiyang City.

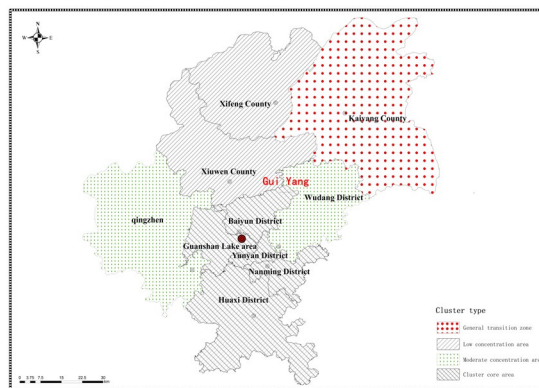


Figure 2: Distribution diagram of population agglomeration types in Guiyang city

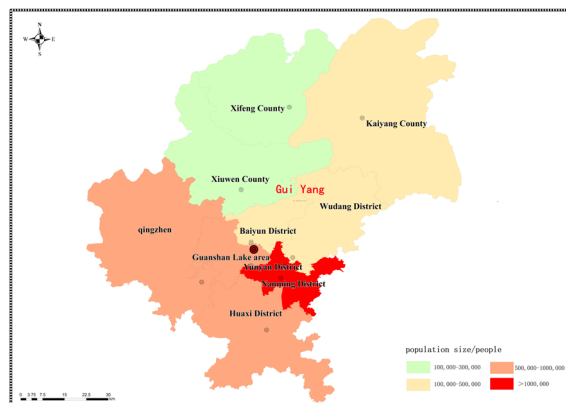


Figure 3: Distribution map of population size in Guiyang city

In terms of population size (Figure 3), there are 2 counties with > 1 million people, 3 counties with 500-1 million people, 3 counties with 300,000-500,000 people, 2 counties with 100,000-300,000 people, and 2 counties with <100,000 people. See Figure 3. In general, among the 10 counties in Guiyang, 500,000-1 million and 300,000-500-500,000, the same number of counties are 3, accounting

for 60% of the province; >1million and 100,000-300,000,000 counties are the same number, accounting for 20% of the province. From the spatial analysis, the counties with > 1 million people are mainly distributed in Yunyan District and Nanming District of Guiyang city, which are affected by the regional land area, and the counties with large population size do not correspond to the population agglomeration types.

4.2. Historical Seismic Distribution Characteristics

Through the analysis of annual, monthly and seismic level of the historical seismic catalogue from 1981-2022, we can: (1) Guiyang city has seismic records since 1981 (see Table 2), $M > 0$ magnitude of the occurrence of a total of 44 earthquakes, among, One earthquake in 1981-1990, two earthquakes in 1991-2000, 10 earthquakes in 2001-2010, and 31 earthquakes in June 2011-2022, The largest number of earthquakes occurred in the June 2011-2022 time period, The maximum magnitude earthquake occurs during this time period; (2) Guiyang has most earthquakes below $M2.0$, $> M0-M2.0$ earthquakes, $M2.0$ earthquakes occurred 12 times between 2000 and 2021, among, $M2.0-2.9$ earthquakes No $M3.0-3.9$, $M5.0-M5.9$, $M6.0$ or above earthquakes, The $M4.6$ -magnitude earthquake that struck in Xiuwen County on November 24, 2021 was the largest earthquake-magnitude earthquake since 1981.

Table 2: Historical Earthquake Statistics Table of Guiyang City

year	moon	sun	magnitu	dept	name	year	moon	sun	magnitud	depth	name
198	12	0	1.18	0	Xifeng	201	11	06	2.31	6	Kaiyang
199	04	0	1.97	0	Huaxi	201	01	29	1.18	10	Qingzhe
199	04	0	1.97	0	Qingzhe	201	06	14	2.3	8	Nanmin
200	06	0	2.31	0	Xifeng	201	10	09	1.75	9	Xifeng
200	02	1	1.41	3	Xifeng	202	02	02	2.76	10	Kaiyang
200	06	0	1.18	15	Nanmin	202	07	06	2.3	20	Xifeng
200	08	0	1.41	0	Xiuwen	202	09	15	1.4	16	Kaiyang
200	09	0	1.63	15	Qingzhe	202	09	16	1.7	10	Kaiyang
200	12	1	1.97	17	Xifeng	202	10	27	0.9	5	Kaiyang
200	10	2	1.86	8	Wudang	202	11	11	2	12	Kaiyang
200	06	2	2.08	8	Xifeng	202	11	28	1.6	7	Xiuwen
200	09	0	1.75	9	Huaxi	202	01	09	1.5	0	Xifeng
201	11	0	1.29	8	Kaiyang	202	01	30	1.7	10	Kaiyang
201	04	1	1.18	6	Kaiyang	202	06	28	2.5	5	Kaiyang
201	12	2	1.29	10	Huaxi	202	07	02	1.1	10	Kaiyang
201	03	1	1.7	10	Xiuwen	202	11	24	4.6	10	Xiuwen
201	07	2	2.2	10	Xifeng	202	11	24	0.1	5	Xiuwen
201	05	2	2.08	4	Huaxi	202	11	25	1.5	12	Xiuwen
201	06	1	1.75	9	Huaxi	202	12	06	2.2	10	Kaiyang
201	12	0	1.63	10	Kaiyang	202	01	16	0.6	5	Huaxi
201	08	1	1.63	20	Xiuwen	202	01	22	0.8	10	Huaxi
201	08	1	1.86	4	Xifeng	202	04	13	1.6	20	

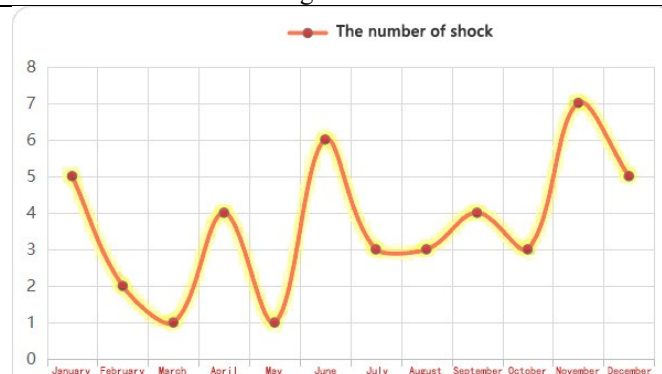


Figure 4: Spatial distribution map of historical earthquakes above magnitude $M0$ in Guiyang city

According to monthly statistics, during the June earthquake in Guiyang in 1981-2022, 5 earthquakes occurred in January and December, 2 earthquakes in February, 1 earthquakes in March and May, 4 earthquakes in April and September, 6 earthquakes in June, 3 earthquakes in July, August and October, and 7 earthquakes in November. The most earthquakes occurred in November, followed by more earthquakes in June, January and December. See Figure 4:

Using the nuclear density analysis of the Spatial Analyst tool in GIS, Population is the magnitude field, and the search radius is the default. Each seismic point was calculated according to the magnitude size, and the calculation results were reclassified to finally form the seismic heat map of Guiyang city, as shown in Figure 5. As can be seen from the figure, from 1981 to June 2022, the nuclear center of the earthquake space in Guiyang was mainly concentrated in Xifeng County, Kaiyang County and the border area, Xiuwen County and Huaxi District.

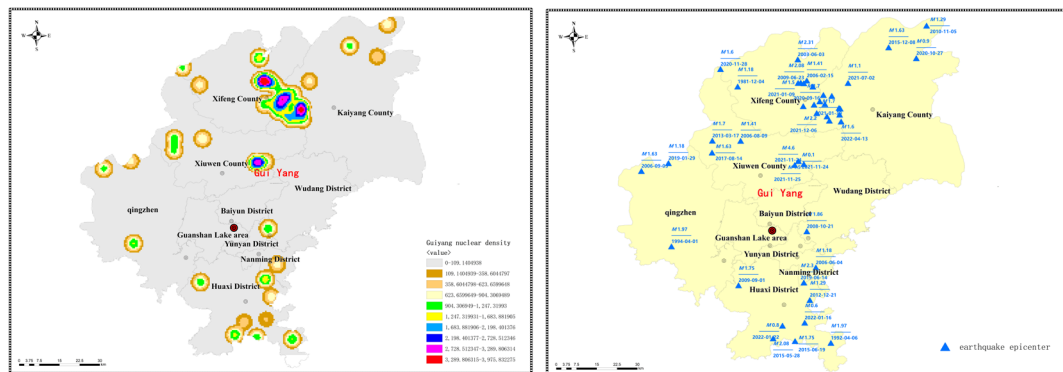


Figure 5: Spatial distribution map of historical earthquakes above magnitude M0 in Guiyang city

According to the earthquake recorded in source depth in the M 1.0 earthquake from 1981-June 2022, and the regional earthquake source depth characteristics are analyzed (see Table 3 source depth statistics of Guiyang City), the statistics show that the average source depth of Guiyang City was 9.89 km, and 100% earthquake depth is within 20km. Earthquakes in the area are mainly concentrated in the upper crust, which is a shallow source earthquake.

Table 3: Statistical Table of focal source depth in Guiyang City

Depth range / km	The number of earthquakes	Total /%
1-5	7	18.42
6-10	22	57.89
11-15	4	10.53
16-20	5	13.16
>20	0	0

5. Main fault characteristics of Guiyang city

Mainly developing NE and NNE faults in Guiyang, See Figure 6 for the distribution map of the fault zones in Guiyang city, the main faults are described as follows:

5.1. NE Fracture

Meitan fault: located between Meitan Yongxing and Zunyi Wujiang River, about 100km long, overall toward northeast 45, inclined to southeast, inclination of about 75, cut the Cambrian to Triassic strata, stratum fracture distance of about 300m, and the nature of the reverse fault, the fault new tectonic activity landform is straight valley, control the development of the water system^[4].

Weng Zhao fault: is located in kaiyang WengZhao to qingjiang line, about 15km long, overall north east about 50, unclear, unknown nature, cut the green white to the carboniferous strata, fault neotectonic activity is obvious, landform on straight valley, along the two hot spring dew, water temperature of 40 degrees Celsius, the north of the late Cretaceous basin development^[4].

Baima Cave fault: located in Xiuwen Shaping to Kaiyang line, about 50km long. Overall direction to north east 70, inclined to south east, inclination of about 70, cut the Cambrian to Cretaceous strata,

developing fault fracture zone more than 10m, with structural lens, fault mud, local silicate, common sub-section scratches, with multi-stage activity characteristics. The activity in the neotectonic period of the fault is more obvious, with the abrupt boundary of straight valley and basin mountain, and the low-temperature hot spring near baima Cave and Shuangshui is exposed^[4].

Two intersection fault: located in Zhijin County Baini to Guiyang Yangchang line, about 88.5km long. The overall trend is about 75 north east, the section tends to south east or north west, inclination 70-85, cutting Cambrian system to Cretaceous, stratum fracture distance is more than 1000m, crushing bandwidth is tens of meters, silicate phenomenon, fault common oblique, horizontal and vertical direction of scratches, multiple activity is obvious^[4].

Small house ji fault: located on the side of Ba Jiangbei from Guiyang city to Longli County, about 60km long, about 70 generally to the northeast, nearly upright, cutting the Cambrian to Cretaceous strata, with significant fracture zone, internal fault breccia, strong silicate, and positive fault properties. The fault neotectonic period was obvious, and the landform showed a linear gully valley, which controlled the development of the Late Cretaceous basin near the east wind in the middle section, and cut the Late Cretaceous strata^[4].

Longli south fault: located in the east line of Longli to Qingyan, about 30km long, generally about 70 north, inclined to south, inclination of about 75, cutting the Devonian to Triassic strata, about 500m, with the nature of the positive fault, the fault is linear gully, and the eastern section controls the Longli Basin^[4].

Shanping fault: is located in the Huishui dam to your old zhi west, is about 40km long, overall to about 60 north east, south slightly bend, section tendency south east, inclination about 60, cut the Devonian to the carboniferous strata, strata break distance of about 200m, and positive fault properties, the fault new constructor activity landform for linear valley, middle bay village near seismic records, magnitude 3.0^[4].

5.2. NNE Fracture

Rock foot fault: is located in Zunyi xinmin to kaiyang bell, about 31km long, overall direction, about 25, tendency, inclination generally 50-70, cut the white to triassic strata, strata break above 1000m, compressive characteristics, fault neotectonic activity, middle feng hot springs near hot springs exposed, water temperature of 57 degrees Celsius^[4].

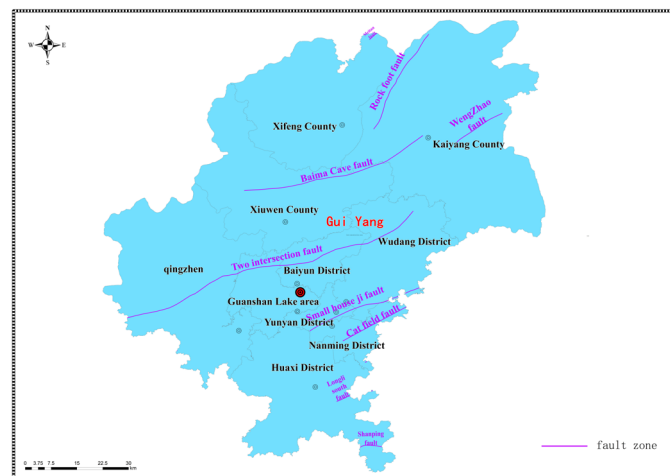


Figure 6: Distribution map of the fault zone in Guiyang city

6. Conclusion

The historical earthquake data of magnitude M0 or above in Guiyang from 1981 to 2021 were superimposed with the population agglomeration type and population size of the seventh census (Figure 7), taking one with another, 10 Counties in Guiyang for more than 40 years, earthquakes mainly occurred in Xifeng County, Kaiyang County, Xiuwen County and Huaxi District, Especially in Xifeng County, Kaiyang, the county border and Kaiyang County, the largest number of earthquakes, The population agglomeration types in the above areas are the agglomeration core area, low-degree

concentration area and relatively sparse area, The population size is 100,000-300,000, 300,000-500,000, 500,000 and 500,000. In terms of fault zone, there are rock foot fracture zone, Meitan fault zone, Meitan fault zone, Wengzhao fault zone, Baima Cave fault zone, two intersection fault zone, Xiaozhai Ji fault zone, Longli South fault zone and Shanping fault zone in Guiyang, and the fault zone passes through the earthquake-prone areas. The fracture direction can be divided into NE and NNE. Except the rock fault is NNE. Except the rock fault is NNE ion, the other faults are NE direction.

The population agglomeration type area does not directly correspond to the population size level, and the damage and impact caused by the earthquake is huge. No matter what type of population agglomeration characteristics and the size of the population, it will have a large or small impact. Areas with complex geological structure are vulnerable to "small earthquakes and major disasters". This requires us to improve the concept of earthquake prevention and shock absorber, and the relevant departments should do a better job in earthquake prevention, disaster reduction and relief related work.

Specific measures include: spread earthquake knowledge through WeChat, Weibo, TikTok and other new media platforms, strengthen science popularization; regularly promote earthquake knowledge, earthquake knowledge contests and emergency drills, deeply grasp the basic business connotation of earthquake disaster prevention, develop earthquake warning technology, enhance monitoring and forecasting, earthquake prevention and emergency preparedness, improve earthquake prevention and relief work, and better serve the national economic and social development, and ensure the safety of people's lives and property.

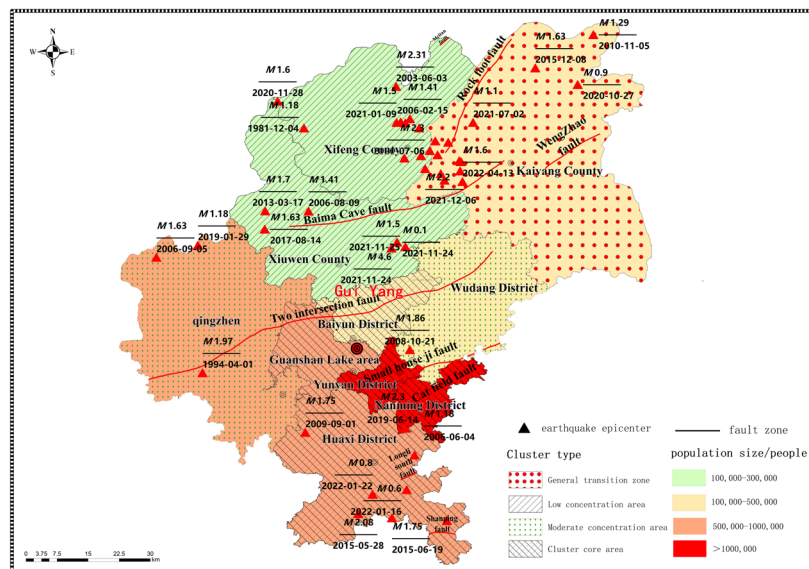


Figure 7: Distribution map of the population cluster type and population scale of the historical earthquake above magnitude M0 in Guiyang city from 1981-2022

Acknowledgment

Earthquake Science and Technology Fund Project of Guizhou Seismological Bureau "Analysis of spatial Distribution Characteristics of Emergency shelters in Guiyang" (GZSDZJDZKJJ-202206).

References

- [1] Ge Meiling, Feng Zhiming. Analysis of the density classification and center of gravity curve characteristics of Chinese population distribution [J]. Journal of Geography, 2009, 64 (02): 202-210.
- [2] Luo Yaxue, Zhou Qiuwen, Xiao Yongqin. Spatial distribution and change of population in Guizhou Province based on stratigraphic topography [J]. Guizhou Science, 2018, 36 (04): 50-55.
- [3] Yu Qipeng, Dong Jianping. — takes the Yangtze River Delta region as an example [J]. Journal of Disaster Prevention and Reduction, 2022, 38 (02): 66-72.
- [4] Lu Dingbiao. Evaluation of active structure characteristics and crustal stability in Guizhou Province [M]. Beijing: Geological Publishing House, 2011.