Investigation of Kazakh herdsmen settlement diseases in the northern foot of Tianshan Mountains based on GIS platform and infrared thermography technology

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Abstract

Based on the GIS platform and infrared thermal imaging technology, this paper investigates the Kazakh herdsmen settlements in the northern foot of the Tianshan Mountains. The results show that the two settlements have various wet diseases. Through the analysis of the pathological characteristics of the two settlements, the pathogenic factors of the "light, medium and severe" wet diseases in the two settlements are obtained, and the infrared heat is used. Imaging technology is used for preliminary quantitative analysis of disease status.

Keywords

GIS platform; Building pathology; Infrared thermal imaging; Traditional settlement.

1. Foreword

Kazak nationality is one of the main ethnic minorities in Xinjiang, whose origin can be traced back to the 3rd century BC. Most of Kazakhs live at the northern foot of Tianshan Mountain in Xinjiang (mainly Ili and Changji Prefecture), and they are mainly engaged in nomadic herding. In the early days, Kazak settlements were mostly nomadic settlements constituted by blood ties. These settlements were mostly located in the center of the proposed pasture, and the building construction was simple and convenient to transfer at any time. But with the development of the herdsmen settlement project and the adjustment of agricultural structure, the original production mode was no longer adapted to the requirement of development, so many of Kazak settlements featured collective settlement and grazing karmic connection. In the using process of settlement residential houses, due to the changes of local climate characteristics, the building pathological features related to local climatic conditions were also presented. Qiongkushitai Village and Two-Group of Muye Village of Yushugou Town in Changji City were selected in this paper to present the features through their pathological appearances.

2. Overview of typical settlements of kazakh herdsmen

2.1 Overview of Qiongkushitai Village

Qiongkushitai Village of Keladala Town in Ili's Tekes County is located in the middle of Kalajun Grassland. As early as the 1830s, the local Kazakh herdsmen successively moved to settle here. By 1870, large numbers of nomadic people in the surrounding areas began to move here due to the fertile meadows and convenient water conditions, forming the prototype (Figure 1) of the village layout in Qiongkushitai Village. The inhabitants gradually shifted from the diaspora to settled nomadism.

Because many kazakh herdsmen still chose to spend the winter in the village (some of them choose to live in Tekes County in the winter), a large number of wooden houses with the characteristics of kazak nomads have been preserved in the village up to now [1].

2.2 Overview of Two-Group of Muye Village of Yushugou Town in Changji City

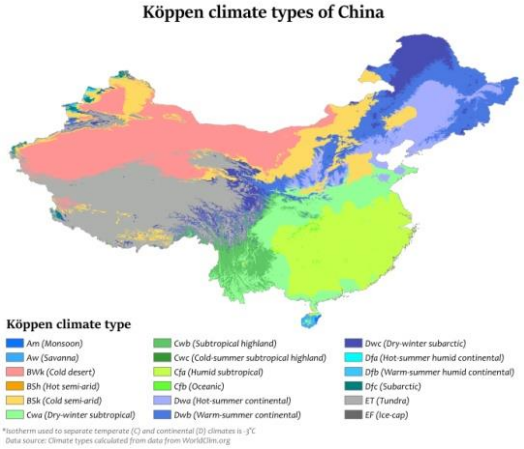

Fig. 1 Koppen's climatic provinces in China (picture source: https://en.wikipedia.org/wiki/China)

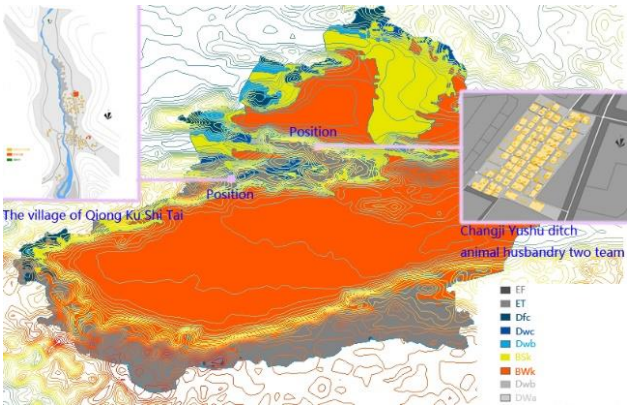

Fig. 2 Overlay analysis of GIS platform in two villages (picture source: the author drew it from Fig. 1)

Muye Village under the jurisdiction of Yushugou Town in Changji City is divided into two groups, there are two herdsmen settlements about 30km apart from each other, the meadow covers 108,000 hm2, with an arable land of 833.3 hm2, 262 herder households and a population of 1,145 people, and more than 94.6% of kazak [2]. Two-Group of Muye Village selected in this paper is about 23km away from downtown area in Changji City, with 132 herder households and a population of 563 people. Most of the inhabitants originally dwelt in the southern mountain area, and made a living by traditional nomadic herding. As the herdsmen settlement project was implemented, by the end of 2013, the local residents have been relocated to plain area at the northern foot of Tianshan Mountain[3], And it has changed from extensive nomadic herding to semi-intensive sedentary grazing in a new form of business [4].

2.3 Climatic conditions of settlements

According to Koppen's climatic province theory, GIS platform was used to make overlay analysis on Koppen's climatic province and topographic contour in Xinjiang, geographic coordinates and self-drawn master plane of two settlements in Xinjiang. The climate type of Qiongkushtai Village was monsoon subpolar climate (Dwc climate of Koppen Climate Classification), its monthly average temperature was more than 10 ℃ only in June, July and August, and the precipitation was mostly concentrated in April to September, its annual rainfall was 600 mm or so, reaching the standard of humid and semi-humid climate, which belonged to the monsoon subpolar climate. The precipitation threshold of Two-Group of Muye Village was 416 and the average annual precipitation was 216mm,

and the precipitation was mostly concentrated in April to June, accounting for 52% of the precipitation threshold, which belonged to the temperate semi-arid (grassland) climate. According to the climatic characteristics of the two settlements, there was a damp disease crisis in Xinjiang, especially the settlements in the Mount Tianshan Region. Moreover, due to the concentrated annual precipitation in the region, there was a large difference in monthly precipitation, and combing the freezing and thawing phenomenon in winter and spring, its moist disease presented different characteristics from those of humid areas.

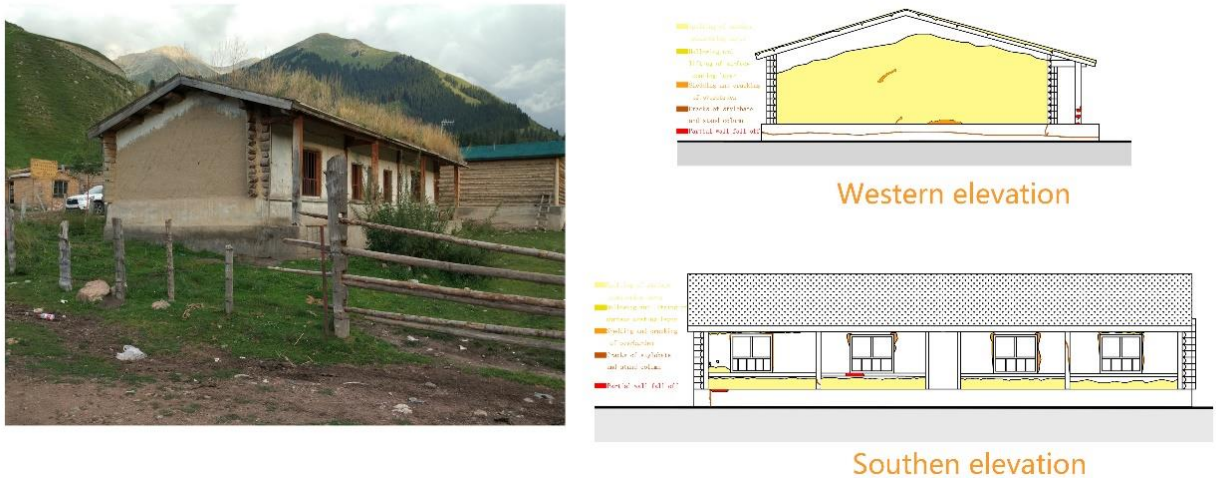

Fig. 3 Disease investigation and analysis in Qiongkushtai Village (picture source: photographed and drawn by the author)

3. Analysis of pathological features of residential buildings in settlements based on infrared thermal imaging technology

Table 1 Disease Classification (source: self-drawn by the author)

Severity	*Light*		*Medium*	*Heavy*	
Nameof pathology	Hollowing of surface plastering layer	Spalling of plastering materials	Shedding and cracking of overburden	Cracks of stylobate and stand column	Partial erosion occurred in structural member
Pathological symptoms	Water seepage in the plastering materials caused vaporization and expansion, the materials bulged out, deformed and then peeled off		Due to the large range of temperature variation day and night in the settlements, cracking and shedding occurred in the overburden of residential building under freeze-thaw action	Cracks were produced from structural members under the action of humidity and freeze-thaw, which resulted in local loosening and collapse	
Positions	Surface coating layer		General metope, window frame	Stylobate, bare wooden column	Stylobate, eave, windowsill
Legend					

According to the classification and diagnostic measures of building diseases for building pathology[5,6] and the degree of diseases of residential buildings in the settlement investigation site,

the pathological conditions of residential buildings in settlements were divided into light, medium and heavy grades (Table 1). The hollowing of the plastering layer and the spalling of the plastering materials on the walls of residential buildings were classified as "light". The cracking and shedding of overburden layer were classified as "medium", while the cracks and erosion of structural components such as stylobate and stand columns were classified as "heavy"

3.1 Disease investigation results in Qiongkushitai Village

According to the pathological investigation results of the buildings selected by Qiongkushitai Village (Figure 3), the residential side elevation (the west elevation was taken as an example in this paper) was affected by the rain and freeze-thaw action, and most of plastering layer of its gable end fell off, the cracks and detachment of overburden layer occurred locally, the eaves board on one side of its gable showed traces of shedding of coating layer due to rain; while the upward part of the stylobate below the windowsill for the south elevation wall showed the phenomenon that the large area of plastering layer was infiltrated and exfoliated, at the same time, in the shadow part of the wall covered by eave, the hollowing phenomenon of plastering materials appeared, the hollowing part showed slender shoulder pole shape, roughly along the eave part in parallel direction. Part of the hollowing material broke off due to its brittleness. Stylobate, eaves gallery wooden column and windowsill architrave showed the phenomenon of crack, erosion of partial materials, and mildew spot appeared in few parts. By judging the building stylobate, it was found that the temperature at the cracks of the stylobate was

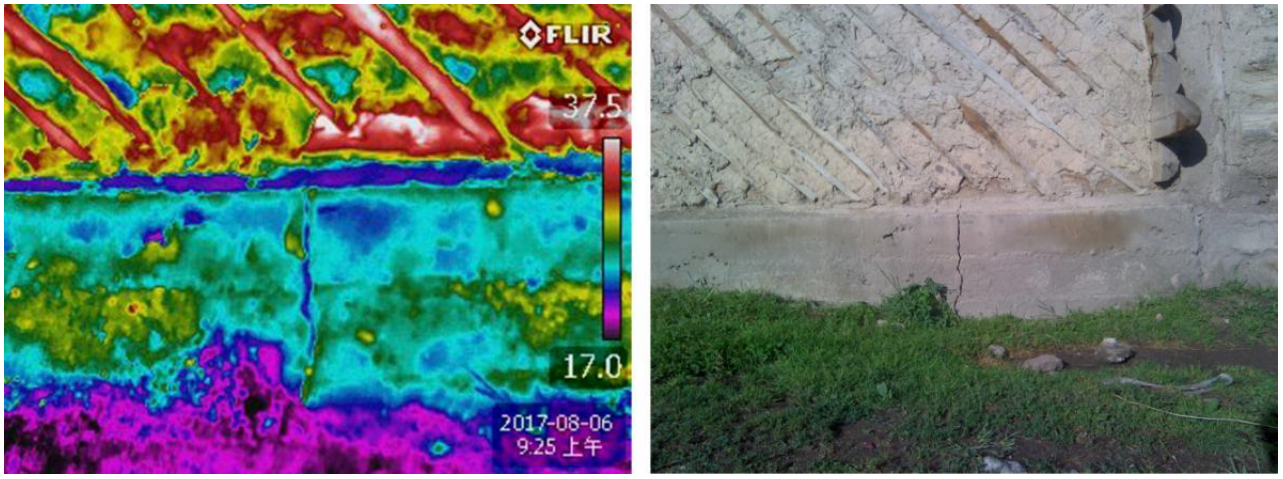

Fig. 4 Judgement of disease thermography in Qiongkushitai Village(picture source: photographed and drawn by the author)

slightly lower than that of other stylobate surfaces, while at the same time, the soil water infiltration part of the stylobate showed a low temperature, and the area shown in the thermal image showed a relatively large humid part, indicating that the moisture condition could not be observed by the naked eye within the stylobate still existed.

3.2 Disease investigation results of Two-Group of Muye Village of Yushugou Town in Changji City

According to the pathological investigation results of the buildings selected by Two-Group of Muye Village of Yushugou Town in Changji City (Figure 5), the main elevation (south elevation) of the residence was mostly affected by the disease, and the damage to the gable part was relatively mild, only the cracking and shedding of the overburden layer was found, and the local mortar shedding was found in the stylobate. Affected by weathering and freeze-thaw action, most of plastering layer at eaves position for its main facade fell off, and the upward part of the stylobate below the windowsill showed the facing hollowing, spalling and the wall cracking phenomena. The pathological condition of the stylobate was the most serious, with a large area of facing peeling-off and bare water wall,

accompanied by mildew. It could be seen from the judgment of the infrared thermal imaging technology for the building stylobate that the temperature at the shedding of the stylobate facing was higher than that of other stylobate facings because the investigation time was in August and the climate was dry and rainy during that month, indicating that the heat insulation capacity of the wall decreased at the same time of the pathological conditions of the wall.

4. Analysis of cause of building defects and diseases in settlements

4.1 Pathological cause analysis of Qiongkushitai Village

4.1.1 Pathological analysis of hollowing and spalling for wall plastering layer

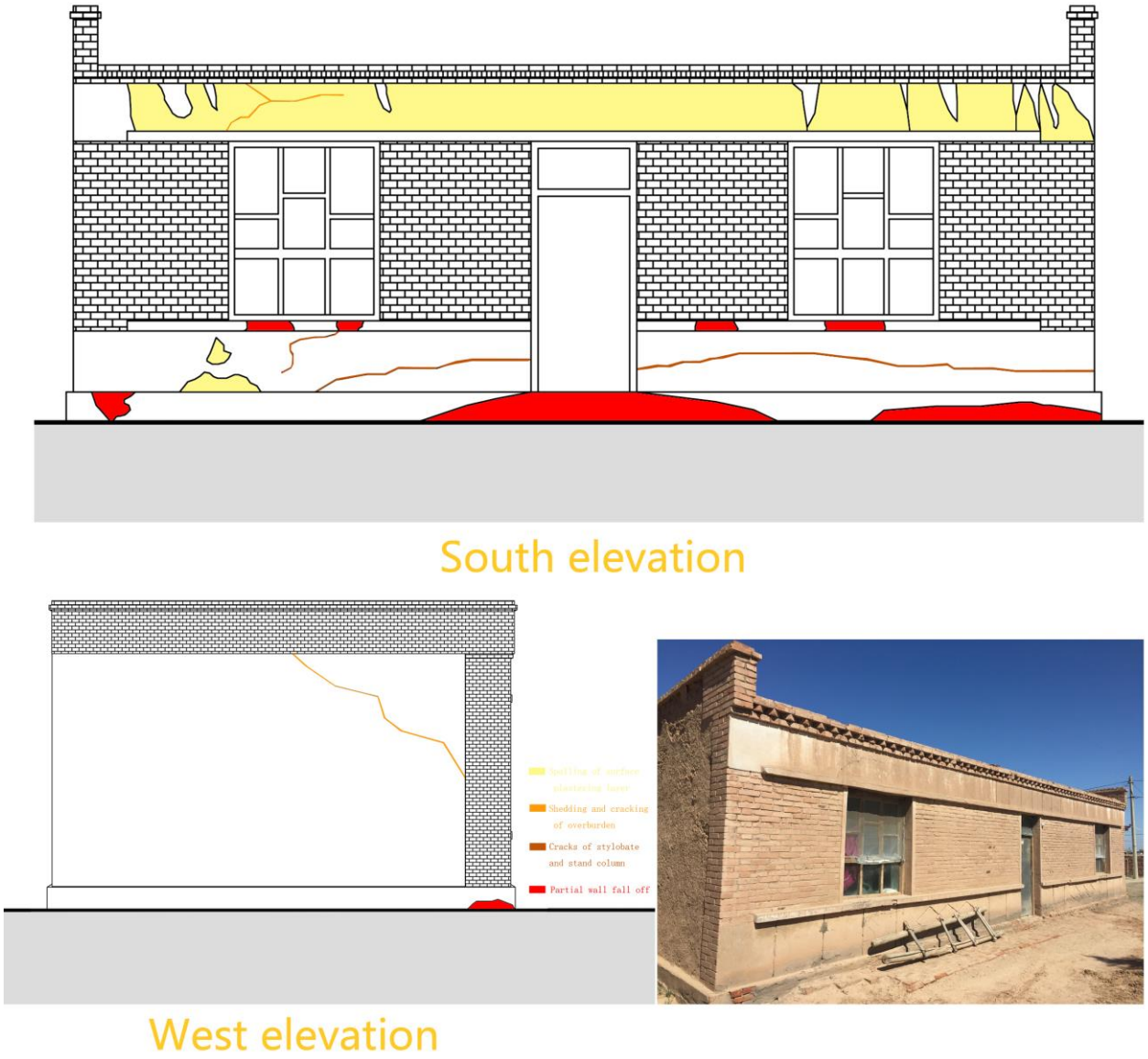

Fig. 5 Disease investigation and analysis of Two-Group of Muye Village in Yushougou Town (picture source: photographed and drawn by the author)

As mentioned above, because Qiongkushitai Village is located in the Ili River Valley which belongs to themonsoon subpolar climate (Dwc), and in its environment, the temperature difference in a year and during day and night is bigger, the precipitation is mostly concentrated in April to September, and

combined with the village layout along the river and the bigger surrounding soil moisture content, the buildings in the settlements were affected by rain wash of late spring or early summer, soil moisture and the resulting freeze-thaw, thus a lot of diseases were produced.

As the local precipitation was mostly concentrated in April to September, the settlement was scoured by the rainwater during this period. The rainwater passed through the roof and penetrated into the wall because of the special civil structure and combined with the limited water storage ability of the roof overburden soil. At this time, Kuerdai River just defrosted, and the water flow reached the peak of a year, making the soil moisture content affected by the river to show a trend of rise. The soil water was elevated along the stylobate due to capillary action, making its damp in serious condition at the point. Because of valley's big temperature gap between day and night, especially in April, and the higher day temperature as well as the vaporized and expanded ooze water, the plastering layer was deformed to produce hollowing. And because the night temperature could drop below 0 ℃, ooze water could freeze and expanded, making the plastering layer break and fall off.

4.1.2 Analysis of cracking and shedding of overburden layer

The cracking of the overburden layer of the building was relatively obvious, while the cracking reason of the overburden layer was similar to that of the spalling of the plastering layer, both due to rain washing, soil moisture and freeze-thaw action. However, compared with the cracking and shedding of the plastering layer, it needed a slow and long process, which was often the result of the accumulation over the years.

To sum up, the "light", "medium" and "heavy" diseases in Qiongkushitai Village were caused by the local climate characteristics and the soil moisture generated by the river flowing through the village.

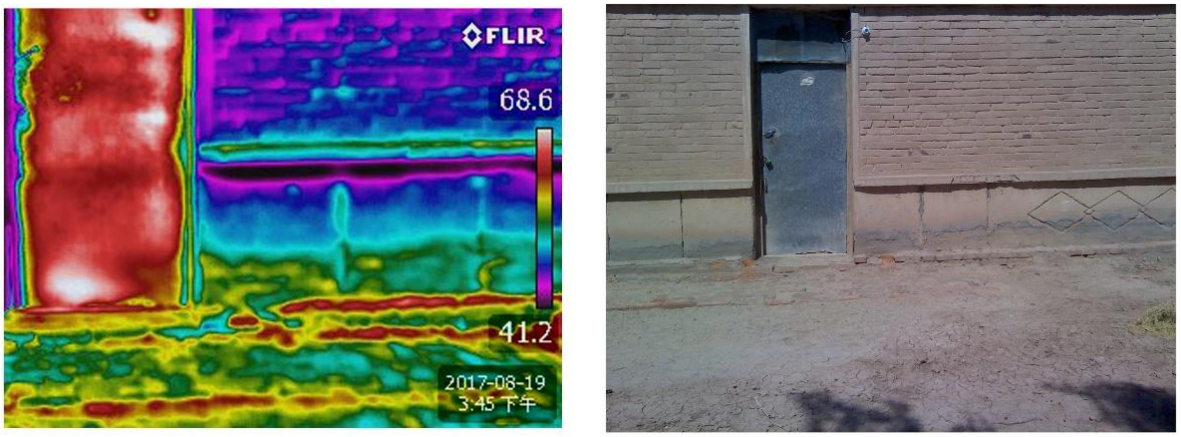

Fig.6 Thermal imaging judgement of disease of Two-Group of Muye Village in Yushougou Town(picture source: photographed and drawn by the author)

4.2 Pathological cause analysis of Two-Group of Muye Village of Yushugou Town in Changji City

4.2.1 Pathological analysis of spalling of the wall plastering layer

Because Two-Group of Muye Village of Yushugou Town is located at the northern foot of Tianshan Mountain which belongs to temperate semi-arid (grassland) climate (BSk), and in its environment, the mean monthly rainfall difference was bigger, the precipitation was mostly concentrated in April to June, and combined with the larger annual temperature difference, the earlier and long frost time and the serious sand storm, the buildings in the settlements were affected by rain wash of late spring or early summer, freeze-thaw and weathering, thus the phenomenon of spalling of the wall plastering layer was produced.

As the local precipitation was mostly concentrated in April to June, the settlement was similarly scoured by the rainwater during this period. The rainwater acted on the eave part, causing the shedding of the lower plastering layer of the eave. Due to the earlier frost time at the northern foot of Tianshan Mountain (as early as the end of September), a lot of snow in winter and the rapid temperature rising in Spring (April), the plastering layer was affected by the frost biochemistry to produce the hollowing, then flaking and spalling due to the uneven stress. The weathering of the facing layer caused by the relatively large local wind-sand was also one of the reasons for the spalling of the wall plastering layer.

4.2.2 Crack and erosion of structural members

The building cracks of Two-Group mostly occurred at the stylobate and on the walls below windowsill of residential buildings, and the cause of the diseases was mostly the same as the pathogenic mechanism of the plastering layer. Flaking of mortar and erosion of clay bricks occurred more frequently at the stylobate. The reason for the diseases was that the local topography was low in the rainy season (it was estimated to be 1.8m lower than the county road visually). In addition, the snow melted in April and there was a lot of water at the stylobate from April to June, so that mildew spot and spalling occurred as time passed.

To sum up, the "light", "medium" and "heavy" diseases in Qiongkushitai Village were caused by the local climate characteristics and the soil moisture generated by the river flowing through the village. The diseases of Two-Group of Muye Village in Yushugou Town were mostly related to the local climate, water accumulation and weathering.

5. Conclusion

In conclusion, according to investigation and analysis of the two settlements in Kazak nationality based on GIS platform, the author thought that due to the location and climate characteristics of the two settlements, they were greatly affected by the humid conditions in the spring and summer, presenting diverse moist disease characteristics. Qiongkushtai Village, located in the Ili River Valley, was built along the river. Its soil moisture was relatively high, the persistence and accumulation of the humidity diseases were stronger. While Two-Group of Muye Village of Yushugou Town is located at the northern foothill plain of Tianshan Mountain, its precipitation changed greatly because of the monthly average temperature, the instantaneity of moist diseases suffered were greater. According to these characteristics, infrared thermal imaging technology was used to detect and study the moisture disease in these settlements from the perspective of architectural pathology, thus providing the basis for further research.

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