◆Research Paper

Geological Environment Assessment of Facing Stone Mine in Aojiang River Basin, Fujian, China

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Abstract: The author relies on the "Aojiang River Basin decorative stone centralized mining area UAV aerial image interpretation" project, obtained by aerial image interpretation of the Aojiang River basin in Fujian Province decorative stone geological evaluation of environmental indicators of the basic data. On this basis, it is put forward that it is suitable to evaluate the geology environment of facing stone mine by adopting the grid method and analytic hierarchy process. The geological environment evaluation of facing stone mine based on the grid method and AHP was studied, and the geological environment evaluation index of the mining face stone mining in Aojiang River Basin was collected. According to ARCGIS platform, the index assignment is converted into the corresponding raster data, and then the contrast matrix is calculated to calculate the index weight, and the raster data is used to calculate the comprehensive evaluation of the geological environment in the study area. Finally, the grading map of the geological environment assessment in the study area is obtained. Thus providing basic data and decision-making basis for eco-environmental protection in Aojiang River Basin and accumulating experience for the evaluation of mine geological environment in the province.

Key words: Aojiang drainage basin, the assessment of geological environment, analytic hierarchy process

1 Introduction

1.1 Research background

In recent years, mineral resources have played an important role in the rapid economic development of our country. The mineral resource exploitation is necessary while keeping a good living environment for human being is not less important [6]. However, high-intensity, long-term mining, causing serious geological problems. According to "Land and Resources", at the end of the year2005, as the number of geological disasters caused by mining was also very alarming, there were people who died in disasters and thus caused as much as 100 million yuan of economic losses. Therefore, it is very important to monitor the geological environment of mines. To strengthen the comprehensive evaluation of the mine geological environment, to predict the area, intensity and trend of the possible environmental engineering geological problems, and to put forward the preventive measures [7]. It is urgent to investigate the geological environment of mines in China and explore the problems and deficiencies of geological environment in depth so as to accelerate the evaluation of geological environment.

The author's unit undertakes the project of "Interpretation of UAV Aerial Image Interpretation in Centralized Mining Area of Aojiang River Basin". The project mainly utilizes remote sensing data of drone aerial photography to carry out remote sensing interpretation such as exploitation and utilization of mineral resources in mining concentrated area of Aojiang River basin in Fujian Province, mine geological environment and mine ecological restoration and treatment, obtaining objective basic data and establishing Ao River basin decorative stone mining area of the mine's archives.

1.2 Research progress at home and abroad

1.2.1 Domestic research status

Domestic scholars in the geological environment evaluation of mining and foreign countries have some differences. For example, Zhao Yinghong and Hu Ming'an from the China University of Geosciences selected the mines in southeastern Hubei Province for exploration in the "Study on Environmental Assessment of Large-scale Mining Bases" and established the evaluation index system on the basis of theory and practice to further evaluate the environmental conditions [1]. WANG Hai-qing, a member of China National Aero Geophysical Survey and Remote Sensing Center for Land and Resources, applied the vector polygon method, grid method and buffer zone method to Huludao Mine Area in Liaoning Province as an object of study in "Comparison and Selection of Evaluation Methods for Mine Geological Environment Based on GIS and RS" Evaluation of the mine geological environment, and each method of evaluation results in-depth comparison to understand the various methods in the evaluation of the role and effectiveness[2]. Xu Youning, Yuan Hanchun et al. In the study of "comprehensive evaluation index system of environmental geological problems in mines", this paper explores the environmental pollution, geological disasters and resource damage, and selects 23 evaluation indexes for evaluation. Through an analysis of the problem, based on local linearization, we define a class of methods that stabilize the iteration, and provide a robust solution. These methods are seen as generalizations of the well-known Singular Value Truncation and Marquardt Methods of iterative inversion [8]. The geological environment of mines have a deep understanding and understanding[3].

1.2.2 Foreign research status quo

Foreign scholars have made a great deal of research work in mine geological environment monitoring and evaluation. In 1989, Radbruch-Hall has researched and constructed the 1: 7.5 million Continent Geological Environment Assessment Map System of Ameirica. In the selection of evaluation indexes, it mainly evaluates the karst, landslide, earthquake probability and volcanic disasters, and generates the environmental geological quality evaluation map. Mularz monitored the Belchatow lignite open pit mining area in the southwest of Warsaw using SPOT-5 and Landsat TM remote sensing data. It is concluded that the fusion data of SPOT-5 panchromatic and TM images are the most economical and effective environmental monitoring data for open-cast mining[4] . The model(SiB_2)incorporates several significant improvements over the first version of the Simple Biosphere model described in Sellers et al. The improvements can be summarized

[12].Mineral resources are important material base for human survival and social development, mineral exploration always due to a great destruction of the around environment because of the limitation of recognizing the environmental protection; So far exploiting and using mineral resources efficaciously as well as protecting the living environment are one of the biggest issues in the whole world [11].

To sum up, people will pay more and more attention to the problems of geological environment of mines, and the government will also increase the investment in the geological environment of mines as people continue to increase their exploitation and utilization of mines and cause the problems of geological environment of mines becoming more and more serious.

1.3 Research goals and key technical issues

1.3.1 Research goals

UAV aerial photography technology provides a new method for the supervision and evaluation of the current situation of mine geological environment. In the research of this paper, it is hoped that through the application of modern theory and technology, the theory of mine geological environment evaluation will be further improved and perfected. Based on the UAV aerial image interpretation, the establishment of mine geological environment evaluation index system provides a new method for mine geological environment monitoring and provides more support for mine geological environment improvement.

1.3.1 Key technical issues

The purpose of this paper is mine geological environment assessment, the related technical problems include the following aspects:

(1) The establishment of UAV based on aerial image interpretation of the veneer stone mine geological environment survey and evaluation of the actual situation. The key points include the construction of relevant evaluation index system and the UAV aerial image interpretation method.

(2) Through the aerial image of drone, the numerical value of mine geological environment evaluation index of the mining area of Aojiang river basin concentrated mining area was extracted, and the relevant data were searched, a comprehensive and in-depth understanding of its actual situation was made, test its rationality.

2 Research area overview

The unreasonable exploitation and utilization of mineral reasources in a long period of time, resulting in the mine geological environment probloms. Differences between the complex and geographical region in our country due to geological conditions, mine geological environment problems are serious[9]. The Aojiang River Basin decorative stone concentrate mining area (Aojiang River Basin Research Area for short), the study area adjacent to Fuzhou urban area, located in the northeast of Fuzhou, across the Lianjiang, Luoyuan and Gutian County, latitude 26.2 -26.74 , longitude 119.00 -119.62 , with an area of 996 km^2, involving Hetang Town of Gutian County, Feizhu Town , Xilan Township, Hongyang Township, Baita Township, Qibu Town, Zhongfang Town of Luoyuan County and Niaoyan Township, Danyang town of Lianjiang County, as shown below.

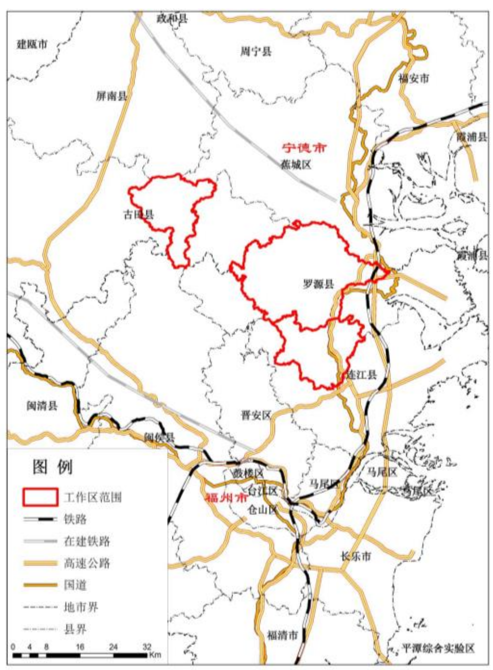


Figure 1 Traffic location map

Most of Aojiang River Basin decorative stone is in the open mountain. The thickness of the ore body is exposed to a large extent, and many open-pit mining methods are adopted. According to the topography and geology of the mining area and the conditions of occurrence of ore bodies, open-air workers are employed and mechanized mining is carried out.

3 Mine geological environment evaluation

3.1 Mine geological environment assessment methods and integrated model

The author chose grid method as the study area of mine geological environment evaluation method. In this paper, the study is divided into 10m×10m grids, and each grid is assigned according to the selected evaluation indexes.

Analytic Hierarchy Process (AHP) is selected as the mine geological environment assessment model in this study area. Comprehensive assessment model is structured by using analytic hierarchy process (AHP) to an index system weight assignment. Importance scales should be acquired according to the expert scoring and experience data [15].The specific evaluation process is as follows: belongs to a multi-criteria evaluation method, and practicality, which will simplify a variety of complex issues, making it an orderly process of decision-making in a variety of qualitative and quantitative factors, a complicated the problem is further decomposed, the various elements of the distribution according to the dominant relationship, to build an orderly hierarchical structure, and the use of separate ways to determine the importance of each of the factors, combined with human judgment after each The factors are important to be clear, which is mainly divided into the following steps: First, the level of hierarchical structure of the building; The second is to establish a pair of contrast matrix; Third is a single criterion under the relative weight of a clear element; Fourth, Each factor combination weight calculated; Fifth, each factor will have an impact on the score to determine the value of the way through the assessment of the integrated partition [5].

In the process of exploring this paper, the application of analytic hierarchy process to build a comprehensive evaluation model, the geological environment of the mine to evaluate. The model is generally divided into three levels: the target layer, the guideline layer and the indicator layer.

(1) Target layer:

In general, the goal of the target layer should be the first to achieve its goal to determine, which is the first level of clarity. In this level, the quality level of mine geological environment is only one element.

Table 1 Mine geological environment quality classification table

Serial number	Mine geological environment
1	No influence area
2	General area
3	More serious area
4	Serious area

(2) Guidelines layer:

This is a level that describes the target level in more detail, also called the middle level, because all intermediate levels of the target level to be implemented in this level are covered. There are several general guidelines. Aojiang River basin decorative stone mine geological environment evaluation criteria are mainly: basic geology, natural geography, resource damage, geological environment.

(3) Indicator layer:

At this level, the standardization layer is refined. Usually, it includes direct and indirect measurement factors. At this level, the target layer provides a solution to the problem, so it is also called scheme or measure layer. In AHP, this layer belongs to the bottom. The evaluation index layer of geological environment of Aojiang River basin decorative stone mine includes structure, lithology combination, topography, vegetation coverage, regional importance, mining intensity, main mining methods and main minerals.

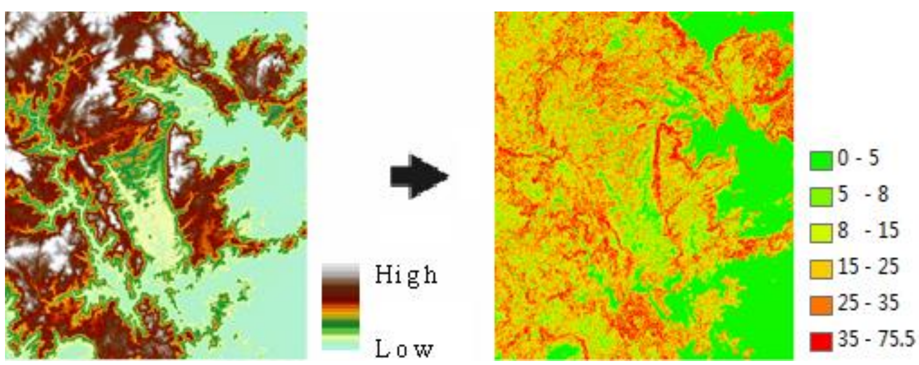
3.2 Evaluation index information extraction

3.2.1 Natural Geography

3.2.1.1 Topography

Through the software to understand the slope of the situation, the slope of the data, and ultimately through the spatial analysis function to generate format.

This article carries on the slope calculation, the application platform carries on. In fact, the slope is the slope of the ground surface at this point, which is the angle between the plane and the horizontal plane. The spatial data obtained by the spatial analysis is in the shape of a slope, as shown in the following figure. The resulting slope data is then divided into six levels and a regional slope map is formed.

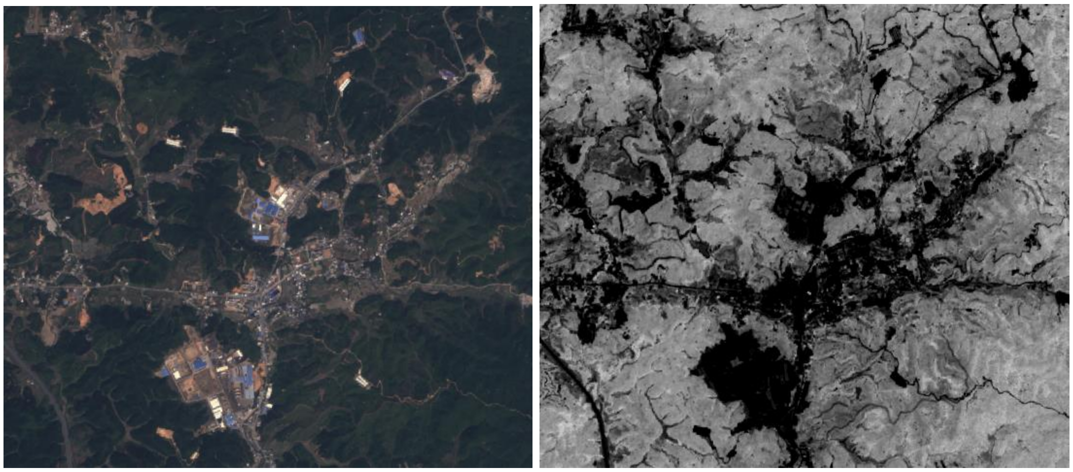


a. DEM renderings b. Gradient chart

Figure 2 DEM-based slope generation diagram

3.2.1.2 Vegetation coverage

Vegetation coverage to some extent, can reflect the degree of destruction of the geological environment of the mine, mine geological environment assessment is an essential indicator. In this paper, NDVI model is used as a model of vegetation index. The following figure shows the NDVI information extraction.



a. RGB321 combination of images b. NDVI image

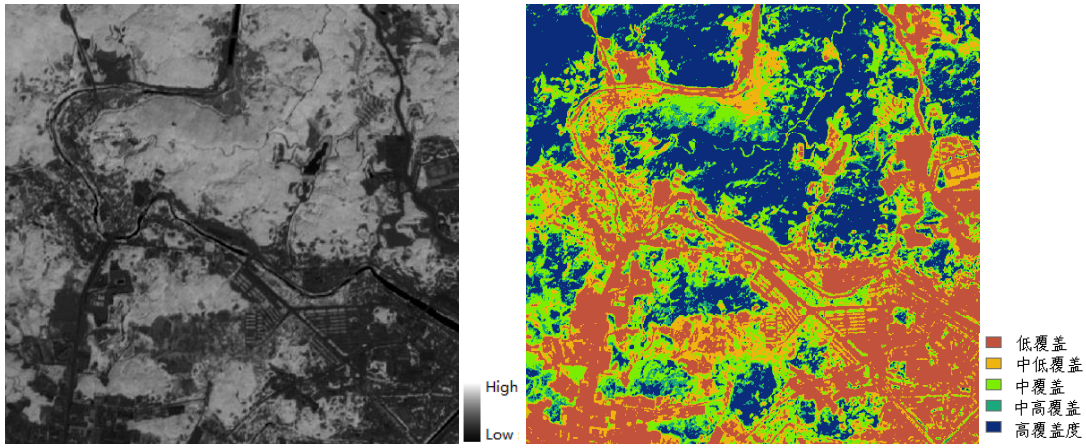
Figure 3 UAV aerial NDVI information extraction

Through Zhang Renhua proposed vegetation cover and vegetation index model to explore.

$$F = \frac{\text{NDVI - NDVImin}}{\text{NDVImax - NDVImin}} \times 100 \tag{1}$$

Among them, the vegetation coverage is used to represent; image in the same as the origin of the normalized vegetation index, said the maximum and minimum, respectively, and said.

According to the characteristics of vegetation cover in a true color remote sensing image, the coverage and coverage of vegetation in a region within a region are inquired and the mean value is calculated to determine the vegetation coverage so as to obtain the vegetation coverage Figure (Figure 4).



a. NDVI picture b. Vegetation coverage map

Figure 4 Vegetation coverage by NDVI

3.2.1.3 Regional importance

The grading of regional importance is as follows.

Table 2 Ranking of regional importance

Important area	More important area	General area
More than 500 inhabitants live in concentrated residential areas	Distribution of 200 to 500 residents concentrated in residential areas	Residents living scattered, residents living in concentrated population less than 200 people
Distribution of highway, a highway, railway, above the medium-sized water conservancy, power engineering or other important construction facilities	Distribution of secondary roads,small water conservancy, power engineering or other more important construction facilities	No important traffic or building facilities
Mining area close to the national nature reserve (including geological parks, scenic spots, etc.) or important tourist attractions (points)	Close to provincial, county-level nature reserves or more important tourist attractions (points)	Away from all levels of nature reserves and tourist attractions (point)
There is an important source of water	There are more important water sources	No more important water source
Destroy farmland, garden.	Destroy the woodland, grassland.	Destroy other types of land

In this paper, we use GIS software platform to extract the relevant information of important areas, more important areas and general areas from the second national land survey 2015 point change database and assign the values to get the regional importance distribution maps. Local map detail see below.

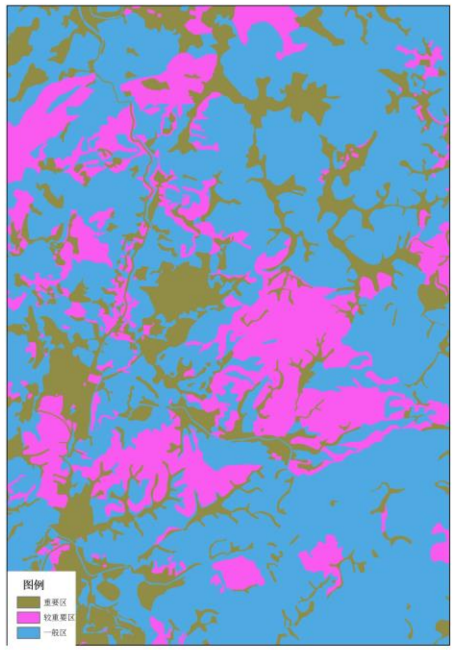


Figure 5 Regional importance distribution (partial)

3.2.2 Basic Geology

3.2.2.1 Construction

The evaluation of tectonic factors is mainly reflected by the degree of fault development. Therefore, interpreting the degree of fault development from remote sensing images becomes the key point of tectonic information extraction.

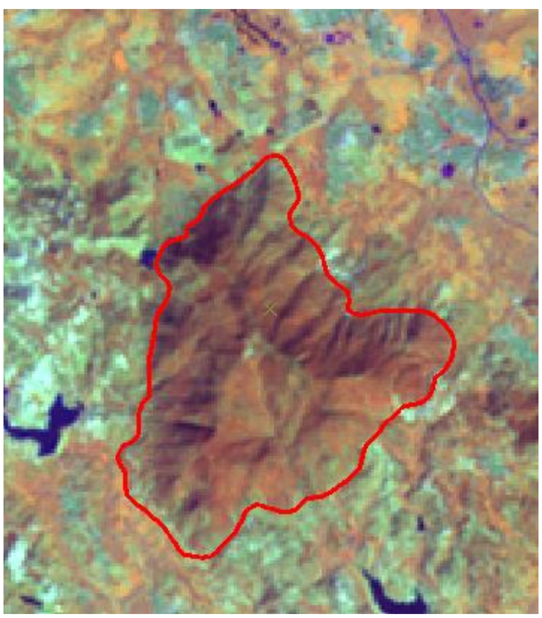
The construction is classified into three levels, namely (1) the fault length is less than 50m, the folds are not developed; (2) others; (3) the fault length is more than 500m or the fault length is more than 50m and the folds are extremely developed.

Multi-temporal multi-species remote sensing images are constructed using interpretations. The method of contrast, direct interpretation, integrated landscape analysis, logical reasoning and other methods are used.

3.2.2.2 Lithology combination

The lithology combinations are (1) hard rock-based (2) soft rock-based (3) loose accumulation. Traces of other primary minerals (dolomite, ankerite, illite, opal, feldspars and marcasite) and weathering products (gypsum, melanterite and hematite) can be found in several coal seams [10]. Based on the geological data of the study area, the remote sensing images are visually interpreted according to the geological map of the study area.

Such as the South Park Formation: was a surface, block, the color is more uniform in the TM453 band was brick red, more complete.



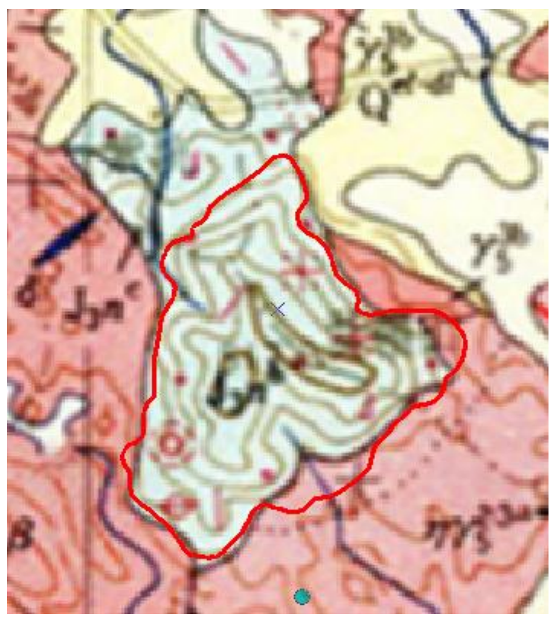
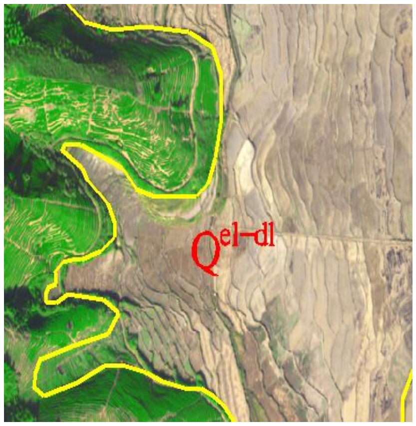


Figure 6 ETM453 remote sensing image Figure 7 Regional geological map

Quaternary residual layer: mainly distributed in the clay surface, hilly or hilly slopes, undulating terrain, usually dry land or garden, the image texture is coarse, the grid or terraced or irregular shadow pattern.

Uaternary alluvial accumulation: mainly distributed in the mountain basin or river on both sides or one side, especially at the bend, multi-directional river slopes, flat terrain, multi-development for the farmland, criss-cross the road, the image texture is delicate, smooth, Basic grid or chicken claw shadow pattern.



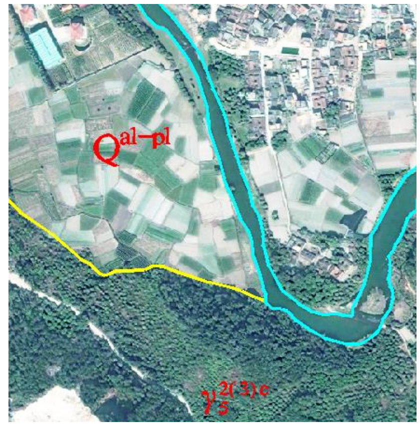


Figure 8 Residual layer accumulation   Figure 9 Alluvial accumulation

3.2.3 Resource damage

Resource damage is divided into three categories of indicators, namely, mining intensity, the main mode of exploitation, the main mining species. All three indexes use GIS software platform to extract information and assign values from the survey results of tenements and mine development status to obtain the distribution of each indicator. Local map detail see below.

Among them, the mining strength is divided into three levels, namely, (1) no mines (2) annual mining capacity of less than 50,000 tons (3) annual mining volume between 50,000 to 500,000 tons. The main mining methods are (1) non-mining area (2) open-pit mining (3) underground mining. The main mining species are divided into three levels, namely (1) non-mining area (2) non-metallic ores (3) metal ore.

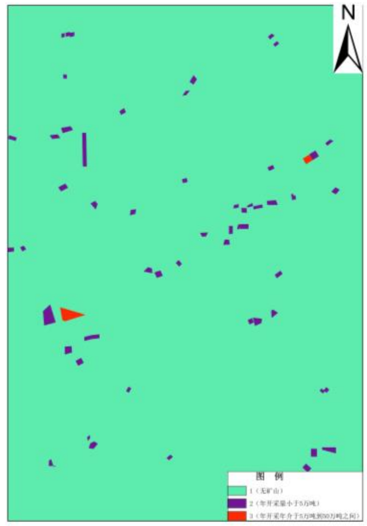


Figure 10 Mining intensity level partial schematic

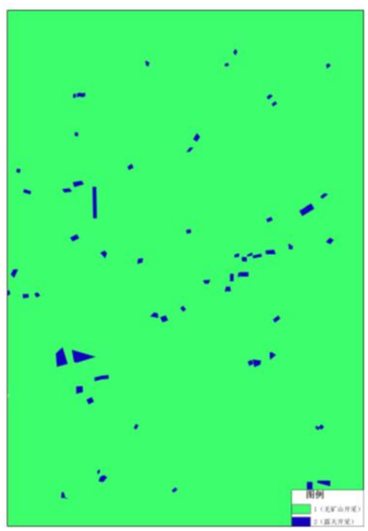


Figure 11 Partial schematic diagram of main mining methods

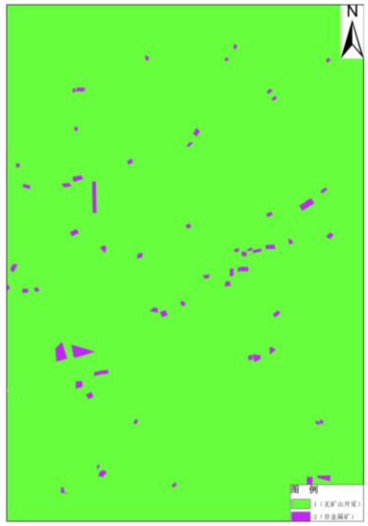


Figure 12 Partial schematic diagram of the main mining species

3.2.4 Geological environment

3.2.4.1 Earthquake disaster

Major hazards are mainly from the remote sensing images of the study area and field survey data to extract the relevant information and grading. Divided into three levels, namely, (1) no hidden dangers of disaster (2) less serious hidden dangers of disaster (3) large-scale disaster risks.

Landslides and other potential disaster remote sensing interpretation as shown below.

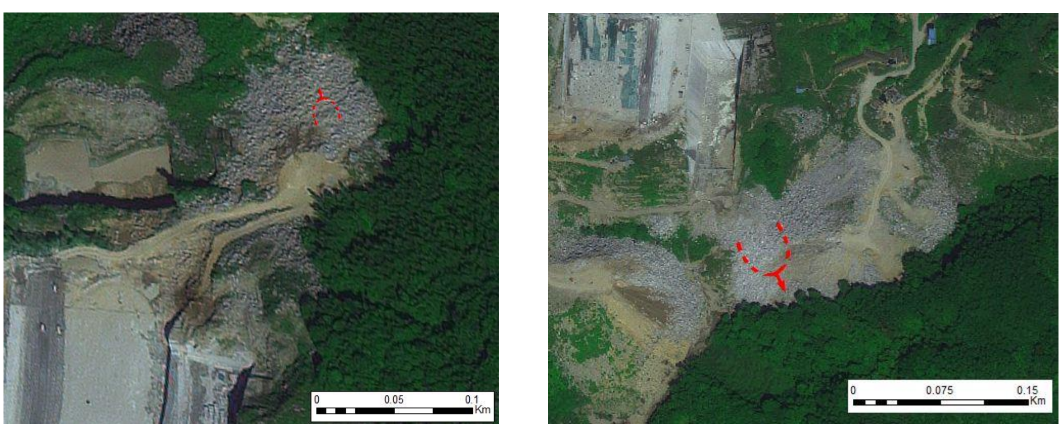


Figure 13 Landslide hidden image

Figure 14 Debris flow hidden point image

Figure 15 Collapse hazard point image

In this paper, the GIS software platform is used to extract relevant information from the remote sensing images and field survey data in the study area and assign values to obtain the hazard distribution map of the disaster area. Local map detail see below.

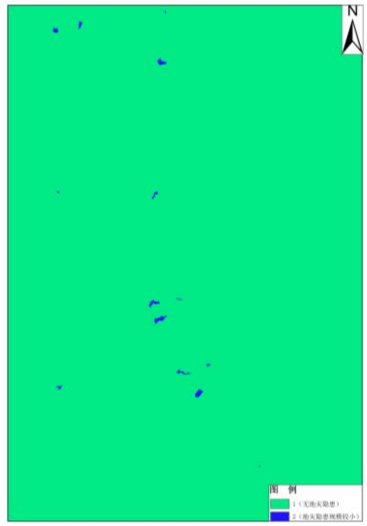


Figure 16 Partial schematic diagram of disaster risk

3.2.4.2 Dust pollution

Dust pollution is divided into three levels, namely (1)no pollution area (2)slight pollution (3)serious pollution.

Remote sensing interpretation of dust pollution as shown below:

Figure 17 Air dust pollution image

In this paper, the GIS software platform is used to extract the relevant information from the remote sensing images and field survey data in the study area and assign values to obtain the dust pollution distribution map.

3.3 Research Area Geological Environment Assessment

3.3.1 Construct the contrast matrix

Valuation index is divided into guidelines and indicators layer. The comparison matrix of evaluation criteria is shown in the following table:

Table 3 Comparison between evaluation factors of the criterion layer

	Basic Geology	Natural Geography	Resource damage	Geological environment
Basic Geology	1	1/2	1/8	1/9
Natural Geography	2	1	1/7	1/9
Resource damage	8	7	1	1/3
Geological environment	9	9	3	1

Calculate the consistency index CI = 0.0588, then the matrix has a satisfactory consistency.

The evaluation of the indicator level and the matrix of the comparison are summarized in the following table.

Table 4 Correlation Matrix of Evaluation Factors of Basic Geologic Strata

	structure	Lithological combination
structure	1	3
Lithological combination	1/3	1

Table 5 Comparison of evaluation factors of natural geography layer

	topography	Vegetation coverage	Regional importance
topography	1	3	3
Vegetation coverage	1/3	1	2
`Regional importance	1/3	1/2	1

Calculate the consistency index CI = 0.0516, then the matrix has satisfactory consistency.

Table 6 Comparison matrix of each evaluation factor of resource damage layer

	Mining intensity	The main method of exploitation	Main mining species
Mining intensity	1	3	3
The main method of exploitation	1/3	1	1
Main mining species	1/3	1	1

Calculate the consistency index CI = 0.0516, then the matrix has satisfactory consistency.

Table 7 Geological environment layer evaluation factor comparison matrix

	Earthquake disaster	Dust pollution
Earthquake disaster	1	3
Dust pollution	1/3	1

3.3.2 Evaluation index weight analysis

By calculating the above matrices, the final weight value is obtained, as shown in the following table:

Table 8 Evaluation of each factor weight

Guidelines layer	Indicator layer	Indicator layer weight	Guidelines layer weights
Basic Geology	structure	0.75	0.0426
	Lithological combination	0.25	
Natural Geography	topography	0.5936	0.0616
	Vegetation coverage	0.2493	
	Regional importance	0.1571	
Resource damage	Mining intensity	0.6	0.3069
	The main method of exploitation	0.2	
	Main mining species	0.2	
Geological environment	Earthquake disaster	0.75	0.5889
	Dust pollution	0.25	

3.3.3 Evaluation unit division

The study area covers an area of 996 square kilometers, involving Hetang Town of Gutian County, Feizhu Town , Xilan Township, Hongyang Township, Baita Township, Qibu Town, Zhongfang Town of Luoyuan County and Niaoyan Township, Danyang town of Lianjiang County.The study area is divided into 10m*10m square as the evaluation unit, a total of 9,960 evaluation unit.

3.3.4 Evaluation unit assignment

According to the evaluation index assignment method introduced in the previous section, the geologic environment evaluation indicator layer factors are assigned and normalized.

3.3.5 Mine geological environment evaluation model

The comprehensive score of mine geological environment evaluation S is the sum of the various evaluation factors on a unit multiplied by the corresponding weights on the geological environment of the mine and can be described as follows:

$$S = \sum Z_{\mathrm{i}} \bullet C_i \tag{2}$$

In the formula :S--Geological environment evaluation index of mine

Z_i --The i-th rating factor level;

C_i --The i-th evaluation factor weight;

The evaluation factor score and weight into the formula, calculate the comprehensive evaluation of mine geological environment evaluation score:

$S = \sum Z_{\mathrm{i}} \bullet C_i$

=structure0.03195+ Lithological combination0.01065+ topography0.036566+ Vegetation coverage0.015357+ Regional importance0.009677+ Mining intensity0.18414+

The main method of exploitation0.06138+ Main mining species0.06138+ Earthquake disaster0.441675+ Dust pollution0.147225

Through the above model, the comprehensive score of mine geological environment evaluation for each evaluation unit is calculated, and its value is distributed between1-1.76793.

3.3.6 Evaluation Results

(1) Geological environment grade standards

According to the integrated score of mine geological environment evaluation S of each evaluation unit, the geological environment of the mine is divided into four grades, that is, no-affected area, general area, serious area, serious area. As shown in Table 9.

Table 9 Mine geologic environment quality classification table

Serial number	Scoring value	Mine geological environment level
1	11.01935	No influence area
2	1.019361.14211	General area
3	1.142121.38763	More serious area
4	1.387641.76793	Serious area

(2) Evaluation of mine geological environment in the study area

The results of mine geological environment assessment in the study area are shown in Figure 18. Table 10 shows the proportions of the area of mine geological environment at all levels in the study area.

Table 10 Mine Geological Environment Quality Classification Form

Mine geological environment level	Scoring value	Area(ha)	The proportion of the total area (%)
No influence	11.01935	99196.12	99.5945
General area	1.019361.14211	322.05	0.3233
More serious	1.142121.38763	81.53	0.0819
Serious area	1.387641.76793	0.30	0.003

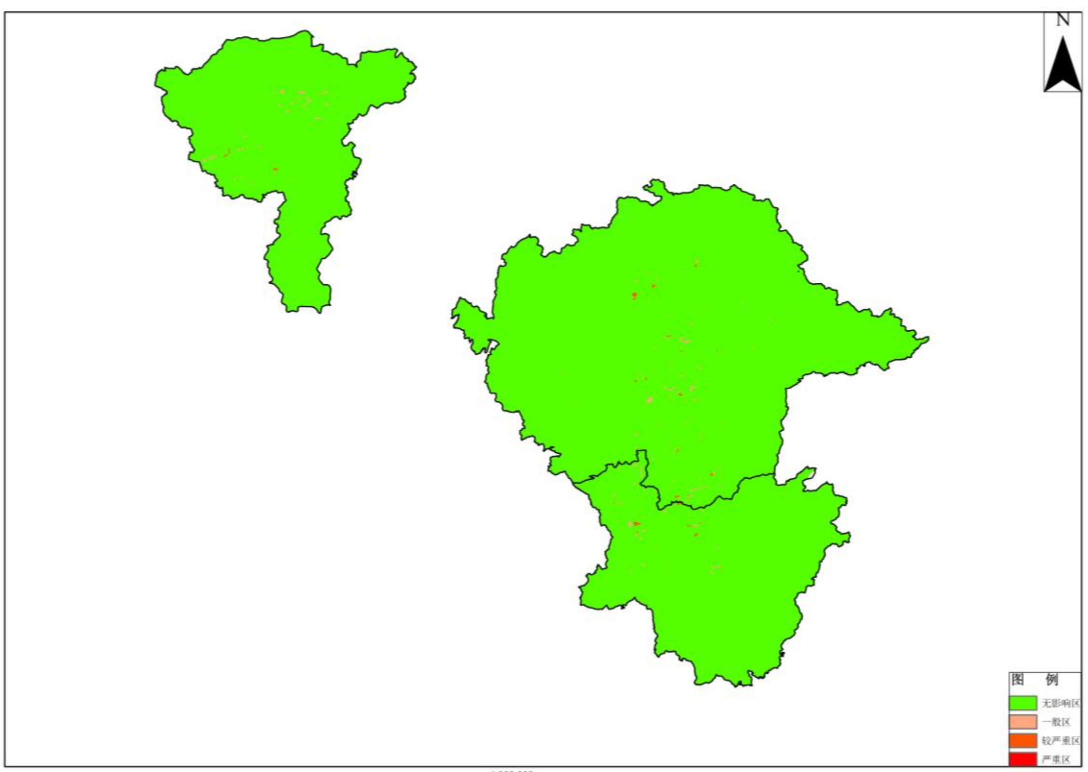


Figure 18 Classification of geological environment assessment of the decorative stone mining in the Aojiang River Basin

4 Conclusion

This article relies on the project of "Interpretation of UAV Aerial Photograph Interpretation in Centralized Mining Area of Stone Faced Stone in Aojiang River Basin", and obtains the exploitation and utilization of mineral resources in mining concentrated area of Aojiang River Basin, the geological environment of mines and the ecological restoration and management of mines, and other remote sensing interpretation of the objective basis of data, proposed mining area geological environment evaluation methods and models, access to exploration area geological environment rating grading chart. Thus providing basic data and decision-making basis for eco-environmental protection in Aojiang River Basin, accumulating experience for the evaluation of mine geological environment in the province and providing reference data for environmental restoration and management of similar types of mines.

Summarizing the theoretical and empirical research, the following conclusions can be drawn:

(1) In the area covered by the development of facing stone mines, the area occupied by solid waste is relatively large, and a large amount of solid waste accumulation not only occupies a large amount of land but also poses a potential safety hazard.

(2) Finished stone mines mostly adopt open-pit mining. The types of damage are mainly excavation and ditching. The main geological and environmental problems caused by the damage include resource destruction, pollution caused by "three wastes" and hidden dangers of earthquakes.

(3) The grid method and AHP used in this study are more suitable for evaluating the geological environment of the facing stone mine.

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