

Study on interpretation system of world geopark based on tourists' needs and preferences: A case study of Dali Mount Cangshan Global Geopark, Yunnan, China

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ABSTRACT This study takes the Cangshan World Geopark as the research object, focusing on the needs and preferences of tourists. Through a questionnaire survey method, 562 valid samples were collected, and the principal component analysis method was used to systematically explore tourists' preferences for the service types, thematic information, and media forms of the geological park interpretation system. The study found that tourists have significantly higher preferences for basic park guide services, natural environment-related interpretation themes, and multimodal audio-visual interpretation media. They also have dual needs of geological science popularization and local culture experience. Optimizing the interpretation system that meets tourists' needs can not only enhance tourists' geological park tour experience and knowledge acquisition efficiency, but also strengthen tourists' awareness of geological heritage protection and local culture identification, thereby promoting the sustainable development of ecological tourism and community support in world geological parks.

KEY WORDS geopark – visitor demand and preference – interpretation system – principal component analysis method – questionnaire survey

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1. Introduction

World Geoparks, as the core carrier for the protection of geological heritage, popularization education and regional development, its functions highly depend on an efficient Interpretation system (UNESCO 2021). Geotourism, as a specialized tourism form focusing on the appreciation of geological relics and the dissemination of scientific knowledge, has become an important growth point of global ecotourism (Dong, Liu 2015). The Interpretation system, as a bridge connecting tourists and the value of geological heritage, directly determines the depth of tourists' cognition, the quality of their experience and the effectiveness of their protection awareness cultivation. The Cangshan Mountain in Dali was included in the World Geopark list in 2014, making it the second World Geopark in Yunnan Province and a core tourist destination in Dali. Its ecological tourism revenue accounts for 90% of the park's total income. Visitor management is mainly carried out through soft and hard methods: soft management relies on information carriers such as display screens, signs, and mobile apps, while hard management is achieved through facilities such as visitor centers, viewing platforms, and walkways. Currently, only the geological heritage exhibition hall of Cangshan Mountain has systematic Interpretation facilities such as electronic display boards, scenic area models, and manual explanations. The facilities of the two tourist centers, Qionglongnu Pool and Xiamatian Pool, only remain at the basic display screen and photo display level, which is difficult to meet tourists' deep needs for geological knowledge and cultural connotations. In existing studies, discussions on the Interpretation system of heritage mostly focus on a single design principle or specific group preferences (Zhou et al. 2023), lacking systematic empirical analysis that combines the characteristics of geotourism and the heterogeneity of tourists, especially insufficient targeted research on mountainous geological parks in the southwest region. Therefore, accurately identifying the Interpretation needs and preferences of tourists based on their perception becomes the key to optimizing the service system of Cangshan World Geopark and promoting the sustainable development of geotourism.

This study integrates the theories of tourist experience, perceived value, and information processing to construct an analytical framework of "perception - preference - behavior", aiming to address the fragmentation of theoretical application in existing research. At the same time, using the Cangshan World Geopark as a case, it supplements empirical data on mountainous-type geoparks, enriching the research results in the intersection of geological tourism and the Interpretation system, and providing support for cross-regional comparative studies.

Clarifying the preference characteristics of tourists for Interpretation services, themes, and media can provide direct basis for optimizing the existing interpretation system and improving service quality in Cangshan World Geopark. The

research results can guide the park to balance scientificity and entertainment, as well as the application of traditional media and modern technology, thereby enhancing tourists' awareness of geological protection and cultural identity, and promoting the sustainable operation and community development of the geopark.

This study follows a logical sequence of "theoretical support – empirical analysis – conclusion optimization": Firstly, it reviews the core theories and the related research progress of geological tourism and the Interpretation system; Secondly, it collects data through questionnaires and uses principal component analysis to identify the factors influencing tourists' preferences; Finally, based on the results, it discusses the existing problems and proposes targeted optimization strategies.

2. Theoretical foundation and literature review

2.1. Theoretical support for tourism experience

The tourist experience theory (Pine, Gilmore 1999) states that the core of tourism experience lies in creating unforgettable memories through multi-sensory stimulation and interactive design. In the context of a geological park, the Interpretation system serves as the experience carrier, and it needs to balance the professionalism of geological knowledge with the Entertainment value of the presentation form – by integrating visual, auditory, and other multi-sensory elements, complex geological processes can be transformed into perceptible content, helping tourists form a deep experience (Chen et al. 2022). This theory provides a core perspective for the analysis of tourists' preferences for interpretation media and activity participation in this paper. The perception value theory (Zeithaml 1988) defines perception value as the comprehensive evaluation by tourists of the functional value and emotional value of the product. For the Interpretation system of the geological park, the functional value is reflected in the acquisition of practical information such as geological knowledge and tour guidance, while the emotional value stems from cultural resonance and aesthetic pleasure (Huang et al. 2023). Research shows that tourists' preferences for the interpretation system are essentially an attempt to balance these two types of values, and this theory provides support for analyzing the logic of tourists' choices regarding information content and presentation methods. The information processing theory (Atkinson, Shiffrin 1968) emphasizes that the presentation method of information directly affects the retention of memory and the depth of understanding by the audience. In geological interpretation, the integration of multimodal information (text, audio, interaction) can significantly enhance the perceptual fluency of tourists (Chen 2022), while the excessive use of technical terms can lead to cognitive obstacles

(Zhao 2024). This theory provides a theoretical basis for analyzing the preference differences among different media types and optimizing information presentation in this paper.

2.2. Relevant research progress

The United Nations Educational, Scientific and Cultural Organization (UNESCO 2022) defines the Interpretation System of Geological Parks as “a comprehensive information system that conveys the scientific value, aesthetic features, and cultural significance of geological heritage to the public through various media”, with its core functions covering scientific education, cultural narrative, and experience enhancement. In domestic research, Zhou et al. (2023) proposed a three-dimensional model of “content - medium - perception”, emphasizing that the system needs to balance scientific accuracy and entertainment value; Ke and Liu (2019) through grounded theory research found that tourists’ demands for geological interpretation present a progressive feature of “knowledge acquisition - emotional resonance - behavioral transformation”.

The core attraction of geological tourism lies in the uniqueness and educational value of geological relics (Dong, Liu 2015). In foreign studies, Chen (2010) found that there were significant differences in the interpretation styles preferred by Western and Eastern tourists. Western tourists preferred inquiry-based questions, while Eastern tourists were more receptive to conclusion-based knowledge delivery. Liu et al. (2022) pointed out that VR technology has a particularly prominent appeal to young tourists (18–35 years old), but there is a technological acceptance gap among the elderly. Domestic studies mostly focus on single park cases. For example, Huang et al. (2023) took Yunnan Stone Forest as an example and confirmed that cultural integration-based interpretation can enhance tourists’ local attachment. However, research on multi-dimensional preferences for mountainous geological parks is still scarce.

Geological interpretation is the core component of geological tourism, emphasizing the transformation of complex geological scientific knowledge into information that the public can understand. Its quality directly affects the educational value and experience effect of geological tourism (Li et al. 2023).

Recent studies have shown that geological interpretation should be combined with the local cultural context and enhance tourists’ emotional resonance through narrative storytelling (Zhang, Pearce 2023); at the same time, the application of digital technologies (such as VR/AR) can break through time and space limitations, allowing tourists to intuitively experience the geological evolution process (Chen et al. 2022). However, existing research pays insufficient attention to the differentiated strategies of interpretation for different types of geological parks, and

lacks a systematic analysis of tourists' interpretation preferences in mountainous geological parks.

The current research has three shortcomings: Firstly, the application of theories is fragmented, lacking a systematic integration of multiple theories; Secondly, the regional cases are unbalanced, with relatively few empirical studies on mountainous geological parks in the southwest region; Thirdly, the literature support is single, with insufficient citation of the latest frontier achievements in geological tourism and geological interpretation, mostly relying on UNESCO documents and local literature, and lacking dialogue with international cutting-edge research.

3. Research design and methods

3.1. Research site

The Cangshan World Geopark is located in Dali City, Yunnan Province, China (Fig. 1). It borders Yongbing County and Erlian County. The total area is 520 square kilometers, with a length of 50 kilometers from north to south and 10–20 kilometers from east to west. Cangshan is a landmark mountain peak with distinctive

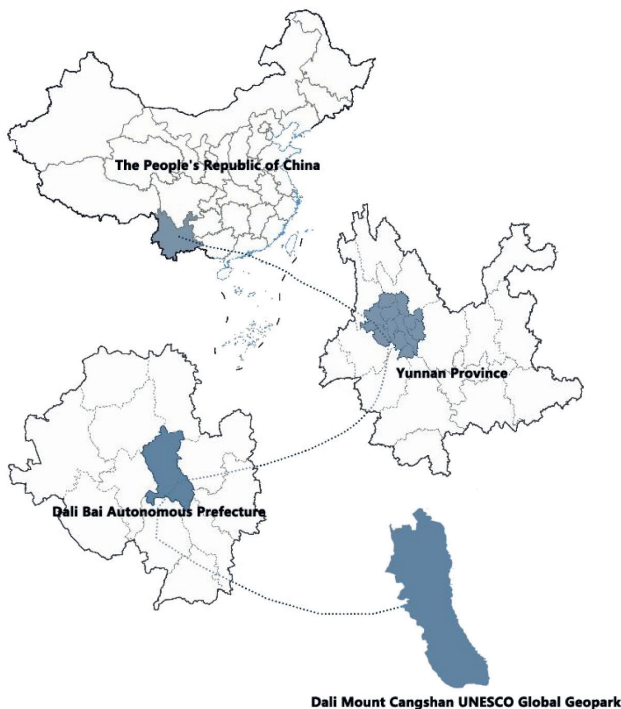


Fig. 1 – Location of Dali Mount Cangshan UNESCO Global Geopark

Tab. 1 – Demographic statistical characteristics of samples

Demographic characteristics	Outcome
Gender	47.5% male, 52.5% female
Age	The average age is 39.3 years
Mother tongue	Chinese (92%), English (8%)
Place of residence	Yunnan (38%), Sichuan (27%)
Total annual income	> 60,000 yuan (40%)
Number of co-visitors	The average is 3.4 people
Residence time	3.2 nights on average
High school degree or above	90.9% (511)

features, unique geological wonders, and potential special geological scientific value. Its special geography, geology, and landforms have created a natural landscape combining mountains and water, with wind, flowers, snow, moon, and stones coexisting. Cangshan belongs to the southern end of the Yunling Mountains in the Xiangdong Mountain Range. It is an important geological, geographical, biological, and climatic transition zone in China and Southeast Asia, and is a landmark area in regional division. The east side of Cangshan is Erhai Lake. Cangshan and Erhai Lake complement each other, which is the result of the difference in crustal uplift (Huang et al. 2018).

3.2. Sampling strategy and sampling error

This study employed a non-probability sampling method. The survey period was from June to September 2024. Electronic questionnaires were distributed to tourists visiting the Cangshan World Geopark. According to the sample size calculation standard of Krejcie, Morgan (1970), when the total population exceeds 1 million, the minimum sample size at a 5% precision level is 384. This survey collected a total of 562 questionnaires, and the effective recovery rate met the research requirements. The respondents of the questionnaire could be summarized as 47.5% males and 52.5% females, with an average age of 39 years old. The majority of the respondents were domestic tourists, accounting for 92%, and most came from the southwestern provinces of China. The average stay time in Dali was 3.2 nights, and the average number of visits to the park was 1.4 times (Table 1).

3.3. Questionnaire design

The questionnaire consists of three parts: The first part covers demographic characteristics and basic tourism information, including gender, age, education level,

income, and duration of stay; the second part is the Interpretation Preference Survey, which includes 14 service preferences, 18 thematic information preferences, and 18 media preferences, using a 5-point Likert scale (1 = strongly disagree / not important at all, 5 = strongly agree / extremely important). The variables in this part are based on the specific features of the park, such as the park's flora and fauna, geological features, cultural characteristics, and the World Geopark Heritage List. The third part presents the overall evaluation by tourists of the significance of the Interpretation service. The questionnaire was designed based on the park's characteristics and existing research results. After a pre-survey (with a sample size of 50) and revision, it ensured content validity and readability.

3.4. Data processing methods and model construction

The research will place the data obtained from the survey into Microsoft Excel, and then conduct statistical analysis using the social science statistical software SPSS. The data analysis consists of three stages: In the first stage, descriptive results (such as age, gender, native language, and place of residence) of the data will be analyzed, revealing the demographic statistics profile of these visitors; In the second stage, principal component analysis will be conducted on 14 Interpretation service preference items, 18 preference themes and information items, 18 themes and information range items, and skew rotation and Kaiser normalization will be performed, and 18 preferred media items will be considered to improve the interpretability of each factor structure. Among them, the KMO test measures a value > 0.7 , which is considered acceptable (Bartels, Orenburg, Giao 2007). Therefore, all factors with eigenvalues greater than 1 were used, and all items with factor loadings > 0.3 were regarded as contributing to the factor structure. Items with factor loadings > 0.4 and cross-loadings onto two factors were classified as the best interpretable factors. All factors with Cronbach's α coefficient higher than 0.6 and item correlations between 0.15 and 0.55 were considered acceptable reliability indicators. Factor scores are calculated as the average of all items contributing to a specific factor, for interpretation on the applicable five-point Likert scale.

Principal component analysis is an attempt to combine many original indicators (such as P indicators) with certain correlations into a set of new uncorrelated composite indicators to replace the original indicators. It is a multivariate statistical method for studying the correlations between multiple variables, and it studies how to reveal the internal structure of multiple variables through several principal components, that is, to derive several principal components from the original variables to retain as much information as possible. Usually, the original P indicators are linearly combined to form the new composite indicators (Wang et al. 2021).

It is represented by the variance of F_1 (the first linear combination, that is, the first composite index), that is, the larger the $\text{VaR}(F_1)$, the more information F_1 contains. Therefore, the F_1 selected from all linear combinations should have the maximum variance, so F_1 is called the first principal component. If the first principal component is not sufficient to represent the information of the original P indicators, then consider selecting F_2 , that is, the second linear combination. To effectively reflect the original information, the existing information of F_1 does not need to appear in F_2 . In mathematical language, $\text{cov}(F_1, F_2) = 0$, then F_2 is called the second principal component. By analogy, the third, fourth, ..., and the P_{th} principal components can be constructed. The steps are as follows:

$$F_p = a_{1i} \times ZX_1 + a_{2i} \times ZX_2 + \dots + a_{pi} \times ZX_p \quad (1)$$

where $a_{1i}, a_{2i}, \dots, a_{pi}$ ($i = 1, \dots, m$) are the eigenvectors of the covariance matrix Σ eigenvalues of X , corresponding to ZX_1, ZX_2, \dots, ZX_p are the normalized values of the original variables.

$$A = (a_{ij})_{p \times m} = (a_1, a_2, \dots, a_m), Ra_i = \lambda_i a_i \quad (2)$$

R is the correlation coefficient matrix, λ_i and a_i are the corresponding eigenvalues and unit eigenvectors, $\lambda_1 \geq \lambda_2 \geq \dots \geq \lambda_p \geq 0$.

4. Research results

4.1. Interpretation service preference principal component analysis

Through principal component analysis, the preferences of tourists for Interpretation services were extracted into three common factors (Fig. 2). Respondents indicated that they needed park guides (Factor 1), activity participation (Factor 2), and information structure (Factor 3) to obtain a high-quality park tourism experience. The cumulative variance explained by all three factors was 56.4%, and the Cronbach's α coefficients of each factor were all > 0.75 , with the inter-item correlation being higher than 0.42. The reliability was good (Table 2). A factor loading of 0.30 was considered significant, while a factor loading of 0.50 was considered very significant (Chen et al. 2022).

Factor 1 (park guide): Average score 4.28, including tourist route signs, park rules brochures, staff consultations, free maps, etc. The factor load is between 0.503 and 0.831, and it is the service type that tourists value the most; Factor 2 (activity participation): Average score 3.47, covering food experiences, science popularization film screenings, local culture experiences, and related book sales, etc. The factor load is between 0.449 and 0.807; Factor 3 (information structure): Average score 4.05, including digital display of geological relics, digital

Tab. 2 – Interpretation services preferred by visitors

	Pattern matrix Variance 56.4%	Component factors		
		Factor 1	Factor 2	Factor 3
Park guide	Information on park rules and regulations that can be clearly communicated, such as trail signs and pamphlets	0.831	—	—
	Clear directions to the park (e.g. rest areas, tour times)	0.742	—	—
	Park staff who are able to answer most questions, both general and professional	0.747	—	—
	Information and activities about the park should be displayed on the website	0.614	—	—
	A map of the park at no extra cost	0.503	—	—
Event participation	Culinary experiences (e.g. game dishes or local cultural dishes)	—	0.795	—
	Activities (e.g. nature, culture and education, popular science film screenings, photography)	—	0.807	—
	Experience the lifestyle of a local culture or community	—	0.769	—
	Magazines, books, and newspapers on the Geopark environment and geological heritage are sold	—	0.634	—
	A guide to digital interaction systems	—	0.449	—
Information structure	A digital display of the geological heritage release	—	—	0.856
	A digital display of the viewing platform in the park	—	—	0.724
	Animal and plant identification information (e.g., species name, species information)	—	—	0.751
	An information board for the day's scene	—	—	0.627
Kronbach coefficient		0.775	0.784	0.756
Average value		4.28	3.47	4.05
Inter-project dependencies		0.437	0.422	0.454
Methods: Principal component analysis				

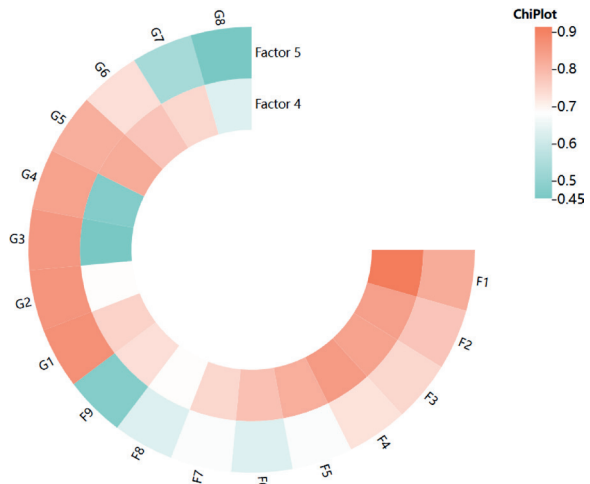
Fig. 2 – Heatmap of the correlation among Interpretation service's influencing factors



Tab. 3 – Topics required for the interpretation center

	Pattern matrix Variance 58.26%	Component factors	
		Factor 4	Factor 5
Heritage	The geological heritage of the park	0.856	—
	The cultural and community context surrounding the park	0.821	—
	History of the park	0.775	—
	The significance of the historical and cultural city in the park	0.744	—
	The significance of the park as a global geopark	0.728	—
	Dali Bai (such as the history, culture and lifestyle of the Bai people)	0.677	—
	Other related attractions in the park (e.g. Erhai Lake, Shimen Pass, etc.)	0.632	—
	The status of parks in China's geoparks	0.473	—
	The archaeological value of the park (e.g. historical sites of the Nanzhao Kingdom and the Dali Kingdom)	0.459	—
Natural	Ecological environment of the park (relationship with the surrounding environment)	—	-0.855
	Climate of the park (climate and weather of the park)	—	-0.832
	Animals of the park (e.g. birds, insects, mammals, carnivores)	—	-0.840
	Plants of the park (e.g. trees, flowers, shrubs, etc.)	—	-0.775
	The geography of the park (i.e., the physical characteristics of the park's earth and atmosphere)	—	-0.753
	Hydrogeography of the park (i.e. water movement in the park, water quality and impacts of the water system in the park)	—	-0.687
	Practical issues about environmental modification (e.g. recycling technology or water conservation)	—	-0.454
	Celestial observations (e.g. stargazing) in the park	—	-0.471
Kronbach coefficient		0.883	0.875
Average value		4.08	4.36
Inter-project dependencies		0.473	0.528
Methods: Principal component analysis			

Fig. 3 – Heatmap of information relevance



Tab. 4 – Breadth of information contained in the interpretation center

	Pattern matrix Variance 57.12%	Component Factors	
		Factor 4	Factor 5
Heritage	The geological heritage of the park	0.915	—
	The cultural and community context surrounding the park	0.843	—
	History of the park	0.836	—
	The significance of the historical and cultural city in the park	0.851	—
	The significance of the park as a global geopark	0.817	—
	Dali Bai (such as the history, culture and lifestyle of the Bai people)	0.784	—
	Other related attractions in the park (e.g. Erhai Lake, Shimen Pass, etc.)	0.745	—
	The status of parks in China's geoparks	0.687	—
	The archaeological value of the park (e.g. historical sites of the Nanzhao Kingdom and the Dali Kingdom)	0.732	—
Natural	Ecological environment of the park (relationship with the surrounding environment)	—	0.874
	Climate of the park (climate and weather of the park)	—	0.865
	Animals of the park (e.g. birds, insects, mammals, carnivores)	—	0.858
	Plants of the park (e.g. trees, flowers, shrubs, etc.)	—	0.837
	The geography of the park (i.e., the physical characteristics of the park's earth and atmosphere)	—	0.815
	Hydrogeography of the park (i.e. water movement in the park, water quality and impacts of the water system in the park)	—	0.732
	Practical issues about environmental modification (e.g. recycling technology or water conservation)	—	0.536
	Celestial observations (e.g. stargazing) in the park	—	0.454
Kronbach coefficient		0.928	0.917
Average value		3.95	4.13
Inter-project dependencies		0.672	0.614
Methods: Principal component analysis			

Fig. 4 – Heatmap of topic relevance



presentation of viewing platforms, and identification information of animals and plants, etc. The factor load is between 0.627 and 0.856.

4.2. Information and topic principal component analysis

In Tables 3 and 4, respondents rated two aspects: what information (i.e., topics) the Interpretation center should provide and the extent to which they expect to obtain specific topic information in the Interpretation. Both aspects include two factors: heritage (Factor 4) and natural environment (Factor 5). The Cronbach's α coefficients of both factors are higher than 0.8, and the inter-item correlation is higher than 0.4.

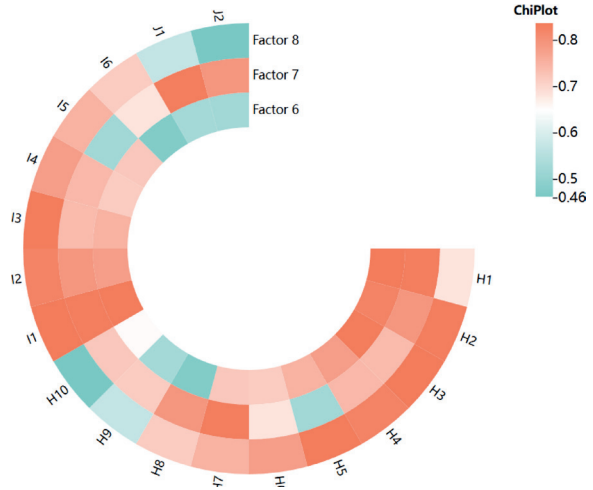
The topic preference analysis (Fig. 3, Table 3) extracted two factors: heritage (Factor 4) and natural environment (Factor 5). The cumulative variance explained rate was 58.26%, with α coefficients both > 0.88 , indicating excellent reliability: Factor 4 (heritage): average score 4.08, covering geological relics, cultural community background, historical evolution, Bai ethnic culture, etc., factor loadings 0.459–0.856; Factor 5 (natural environment): average score 4.36, including ecological environment, climate, flora and fauna, geographical and hydrological information, factor loadings 0.454–0.855. These are the most concerned topic categories by tourists.

The information breadth preference analysis (Fig. 4, Table 4) extracted two common factors, with a cumulative variance explanation rate of 57.12%, and the α coefficients were all > 0.91 , indicating excellent reliability. The average score of heritage-related information was 3.95, with factor loadings ranging from 0.687 to 0.915. The average score of natural environment-related information was 4.13, with factor loadings ranging from 0.454 to 0.874, which was consistent with the results of the topic preference, and the demand for natural environment-related information was higher than that for heritage-related information.

4.3. Interpretation of media components analysis

The study analyzed the interpretation of the required media for the park and presented the results in Table 5 and Figure 5. Interpretation of media extracted three common factors, with a cumulative variance explanation rate of 64.28%, and the α coefficients were all greater than 0.68, indicating acceptable reliability (Table 5): Factor 6 (audio and visual): The average score is 3.58, including audio and visual media, visual images, prop displays, audio playback, 3D displays, VR experiences, etc. The factor loadings range from 0.475 to 0.837, making it the most preferred type of media; Factor 7 (creative text): The average score is 3.29, covering concise

Fig. 5 – Heatmap of interpretation media relevance



and understandable texts, non-academic expressions, game-like media, etc. The factor loadings range from 0.524 to 0.834; Factor 8 (connection): The average score is 2.34, including commemorative merchandise sales, life-like size displays, etc. The factor loadings range from 0.463 to 0.571, with the lowest preference.

5. Discussion

This study takes the Cangshan World Geopark as a case, using the principal component analysis method to systematically identify the tourists' preferences for the geological park's interpretation system in terms of service, theme, and medium. The research results not only confirm the common patterns in the field of geological tourism, but also reveal the unique demand characteristics of mountainous and culturally integrated geological parks. This section combines the relevant research results on geological tourism and geological interpretation to deeply analyze the formation reasons and practical connotations of tourists' preference characteristics, compares the similarities and differences between this study and existing research, and points out the limitations and future research directions of this study, providing theoretical and empirical support for the optimization of the geological park's interpretation system.

The tourists' preference for park guide services ranks first (average 4.28), which is highly consistent with the conclusion proposed by Liu et al. (2023) that "tourist convenience is the fundamental guarantee of the tourism experience". As a mountainous geological park, Cangshan has a wide scenic area and complex terrain, and tourists have an inevitable demand for clear tour routes, rule notifications, and

Tab. 5 – Important media required for interpretation at the DMCUGG visitor center (interpretation center)

	Pattern matrix Variance 64.28%	Component factors		
		Factor 6	Factor 7	Factor 8
Audio and visual	Audiovisual media (e.g. videos explaining the history of the Geopark)	0.837	—	—
	Visual media (e.g. pictures and charts showing interesting information about the Geopark)	0.824	—	—
	Displays of props or objects (e.g. archaeological, plant, insect, or cultural displays)	0.836	—	—
	Audio media (such as bird or animal sounds)	0.781	—	—
	2D display (e.g. park information poster)	0.752	—	—
	3D displays (e.g. life-size examples of animals, cultural artefacts, or virtual tours)	0.715	—	—
	Print media (e.g. brochures and posters with interesting information for visitors, interpretation centers)	0.721	—	—
	Virtual reality (e.g. a virtual tour of a traditional local house)	0.475	—	—
	Smart media (interactive touch screens with information of interest to visitors)	0.527	—	—
	Guided tour of the Interpretation Center for Tourists	0.656	—	—
Creative Texts	Easy-to-read text and information in relevant media (e.g., appropriate fonts)	—	0.834	—
	None of the media uses technical or academic jargon (for ease of understanding)	—	0.793	—
	All mediums are presented in a concise manner	—	0.739	—
	Expressions in all media should be lively, rich, lively, and exciting	—	0.742	—
	Game-based media (e.g. quizzes, puzzles)	—	0.524	—
	The staff in the Visitor Interpretation Center need to be able to answer all questions on display	—	0.684	—
Contact	The Interpretation Center sells souvenirs as memories of the experience	—	—	-0.571
	The size of the monitor and media should show the size of everyday life in order to better convey the relevant information	—	—	-0.463
Kronbach coefficient		0.904	0.843	0.687
Average value		3.58	3.29	2.34
Inter-project dependencies		0.526	0.488	0.482
Methods: Principal component analysis				
Rotation method: maximum oblique rotation				

free maps, etc., as these services are necessary for tourists to conduct in-depth tours and obtain geological and cultural information. The high preference for information structure services (average 4.05) reflects the core demand of digital era tourists for visualized and convenient geological information. Mountainous geological parks have geological relics distributed outdoors, and digital display can break through time and space limitations, allowing tourists to obtain geological

relics, viewing platforms, flora and fauna and other related information at any time during the tour, which is in line with the viewpoint in information processing theory that “multiple scenarios of information access enhance perceptual fluency” (Wang, Wang 2025). The preference for activity participation services is relatively low (average 3.47), not because tourists lack experience needs, but due to the limitations of existing service design and tour scenarios. The ecological tourism of Cangshan is mainly outdoor, and tourists’ stay times are scattered. However, existing cultural experiences and science popularization activities are mostly concentrated in the tourist center, with a relatively simple form, which is difficult to match the outdoor tour rhythm of tourists. At the same time, the transportation and venue conditions of mountainous scenic areas also limit the implementation of interactive activities, and this result also provides a clear direction for the subsequent optimization of activity design and the creation of mobile experience projects in the park.

The preference for natural environment-related themes is significantly higher than that for heritage themes (mean 4.36 vs 4.08). This is the result of the joint influence of the resource characteristics of Cangshan Geopark and the tourists’ travel motivations. As an important geological, biological and climatic transition zone in Southeast Asia, Cangshan has a unique ecological environment, hydrological geography, animal and plant resources and geological relics that deeply intermingle. The tourists’ travel motivations include both geological science popularization and natural landscape appreciation. The high demand for natural environment-related information essentially reflects the tourists’ urgent need to understand the “natural background” of the geological park. While heritage-related themes still maintain a relatively high preference, it reflects the “cultural empowerment” feature of geological tourism. The Bai ethnic culture, the history of the Nanzhao-Dali Kingdom and the geological relics in Cangshan form a unique “geological-culture” symbiotic system. The tourists’ demand for such information reflects the transformation of the geological park’s interpretation system from a single scientific dissemination to a “science + culture” integrated narrative (Zhao et al. 2019), which is in line with the cutting-edge viewpoint proposed by You et al. (2026) that “heritage interpretation should be combined with the local cultural context”. From the perspective of information breadth preference, the high scores for natural environment and heritage-related information (mean 4.13, 3.95) indicate that tourists’ information needs for the geological park are not fragmented but have systematic and comprehensive characteristics. This requires the content design of the interpretation system to balance the depth and breadth of information, achieving the organic integration of natural and cultural information.

Audio and visual media have become the tourists’ top choice (mean 3.58), confirming the core value of multi-modal information integration in geological interpretation (Xia 2013). The geological relics in Cangshan, such as Quaternary

glacial deposits and fault structures, have complex formation processes and temporal-spatial characteristics. Simple textual explanations are difficult to enable tourists to intuitively understand them. However, multi-modal media such as audio-visual media, 3D displays, VR experiences, etc., can transform abstract geological processes into visual and auditory experiences, breaking through the cognitive barriers of geological science. At the same time, the outdoor tour scenarios of mountain-type geological parks also determine that tourists prefer intuitive and convenient visual media rather than lengthy textual information. The medium with medium preference (mean 3.29) emphasizes the core principle of geological interpretation being “popularization and entertainment”. Li et al. (2025) pointed out that the relationship between professional terms in geological interpretation and tourists’ understanding degree is an inverted U-shaped curve. The results of this study further verify this viewpoint – tourists need concise and understandable text expressions without academic terms, even preferring game-like media and other entertaining forms. This requires the geological park interpretation system to ensure scientificity while also considering the readability and entertainment value of the information. The lowest preference for associative media (mean 2.34) is due to the weak correlation between carriers such as souvenirs and the core goal of geological interpretation. The tourists’ core needs are immediate knowledge acquisition and experience improvement, rather than commemorative consumption. Such media can only serve as supplementary to the interpretation system rather than a core component.

The results of this study effectively echo and complement the existing research in the fields of geological tourism and geological interpretation. Consistent with the conclusion of Yang and Zhu (2023) that “digital media is favored by tourists”, this study further reveals that tourists in mountain-type geological parks have more scene-specific demands for digital media, and are more inclined towards mobile and visual digital media that can match outdoor tours, rather than being limited to fixed digital facilities in tourist centers. The sample of this study is mainly composed of domestic tourists (92%), and their preferred “conclusion-based” knowledge transmission method conforms to the cognitive habits of Eastern tourists, which provides a targeted basis for the expression style of geological park interpretation content – prioritizing the presentation of clear geological scientific conclusions, followed by in-depth exploratory content, while balancing the efficiency and depth of popularization. At the same time, this study takes Gangshan Mountain as the case of a mountain-type geological park, revealing the uniqueness of tourists’ preferences in such parks, such as a higher demand for basic guided tours and the urgent need for outdoor digital interpretation, enriching the case library of tourists’ preferences in geological parks and providing differentiated references for the design of interpretation systems for different types of geological parks.

Although this study has achieved certain empirical results, it still has three limitations: Firstly, the sampling method used is non-probability sampling, and the samples mainly come from western provinces such as Yunnan and Sichuan. The geographical representativeness is limited, and it fails to cover different regional and different tourism motivation groups of tourists, which may affect the generalizability of the research results. Secondly, it did not deeply analyze the moderating effect of tourists' heterogeneity on preferences, such as the correlation between demographic characteristics like age and educational background and tourists' preferences, making it difficult to achieve precise design of the interpretation system. Thirdly, it only identified tourists' preference characteristics, but did not explore the matching issue of media and themes, that is, which media form is suitable for different interpretation themes (such as geological relics, Bai ethnic culture), lacking precise guidance for the design of the interpretation system. In response to these limitations, future research can be conducted in three aspects: Firstly, adopt stratified probability sampling method to expand the geographical and group scope of the sample, and enhance the universality of the research results; Secondly, introduce structural equation models, regression analysis, etc., to explore the influence mechanism of tourists' heterogeneity on the preferences of the interpretation system, reveal the differences in the needs of different groups, and provide a basis for precise interpretation services; Thirdly, conduct research on the matching of media and themes, through experimental methods and in-depth interviews, identify the optimal media presentation form for different interpretation themes, and achieve refined and personalized design of the geological park interpretation system; In addition, it can also conduct research on the effectiveness verification of the optimization of the interpretation system, by comparing the tourists' experience and knowledge acquisition efficiency before and after optimization, to test the effectiveness of the optimization strategies.

6. Conclusions

This study focused on the Geopark of Cangshan Mountain, taking the tourists' perception as the entry point. Through questionnaire surveys, 562 valid samples were collected. Using the principal component analysis method, the study systematically explored the tourists' preferences for the geological park's interpretation system in terms of service, theme, and medium. The following core conclusions were ultimately drawn:

1. In terms of service preferences, tourists showed the characteristics of "prioritizing basic guided tours, having a strong need for digital information structure, and needing to optimize experience activities". The basic service of park guides is the core demand of tourists. The digital display of geological and

landscape information has become an important necessity. However, cultural experiences and science popularization activities have not yet met the tourists' needs due to design and scene limitations.

2. In terms of theme preferences, tourists prioritize information related to the natural environment, while also having a demand for the integration of geological heritage and local culture. The demand for natural and cultural information is characterized by systematicness and comprehensiveness, reflecting the integration trend of "science + culture" in geological tourism.
3. In terms of medium preferences, tourists highly favor multimodal audio-visual media. They also require the popularization and entertainment of the interpretation text and consider commemorative items as supplementary, which cannot become the core interpretation medium.
4. Overall, the interpretation needs of tourists in Cangshan Mountain present the characteristics of "balancing scientificity and entertainment, balancing professionalism and popularization, and integrating traditional forms with modern technology". And influenced by the resource characteristics and tour scenarios of mountain-type geological parks, the requirements for the convenience of services and the scene adaptability of media are higher.

Based on the empirical conclusion of tourists' preferences, combined with the resource characteristics of the Cangshan World Geopark and the existing problems of the interpretation system, targeted optimization strategies are proposed from four dimensions: popular science education, interpretation system, tourism products, and service facilities, to achieve precise matching between the interpretation system and tourists' needs:

Deeply explore the scientific connotation of the geological relics on Cangshan, sort out the internal connections of geological evolution, tectonic movement, and ecological environment, and compile scientific and popular science popularization materials that are both scientific and easy to understand, avoiding excessive use of professional terms; combine modern technologies such as VR and AR to create immersive geological popularization experience projects, such as VR simulation of the formation process of glacial deposits and AR visualization display of fault structures, allowing tourists to intuitively experience the complex geological process; rely on the outdoor geological relics of the park, carry out regular on-site geological exploration and popular science lecture activities, invite geological experts and local cultural scholars to participate in the explanation, achieving the integration and dissemination of geological science and local culture.

Improve the basic service of the park guide, optimize the design of tour route signs and free maps, add information consultation points at key scenic spots in the scenic area, and enhance the professional answering ability of staff; build a "online + offline, fixed + mobile" diversified interpretation media system, add

3D display, interactive touch screens and other fixed digital facilities at the tourist center, set QR code interpretation signs beside outdoor geological relics and viewing platforms, realize “listening while walking while looking”, matching the tour scenarios of mountainous-type scenic areas; simplify the expression of interpretation texts, adopt a combination of pictures and text, and interesting expression forms, design geological knowledge quizzes, puzzles and other game-like media at some nodes, to enhance tourists’ participation.

Based on the “geology + culture” integrated demand of tourists, develop characteristic tourism products that integrate geological science and Bai ethnic culture, such as “geological relics + Bai ethnic village” study tours, “Cangshan geology + Erhai Lake + ecology” comprehensive experience tours, etc. According to the demand characteristics of different tourist groups, design differentiated tour routes, for scientific tourists, create deep geological relic exploration routes, for leisure tourists, create “geological landscape + natural viewing” light experience routes, for parent-child tourists, create interesting geological science popularization routes, achieving precise supply of tourism products.

Upgrade the interpretation facilities of the seven dragon goddess pool and wash horse pond tourist centers, make up for the basic deficiencies of existing facilities, add systematic display areas with geological and cultural themes, achieve complementary functions of the three tourist centers, improve the outdoor infrastructure of the scenic area, add shading, seats and other facilities at rest areas and viewing platforms, combine with simple interpretation display boards, allowing tourists to obtain information while resting, optimize the network coverage of the scenic area, ensure the normal use of mobile digital interpretation media, providing technical support for multi-modal and mobile interpretation.

The results of this study indicate that the interpretation system of a World Geopark is not merely an “information dissemination tool”, but a crucial link that connects geological heritage protection, popular science education, tourism experience, and community development. Its design and optimization must adhere to the principles of “centering on the needs of tourists, based on resource characteristics, aiming for scientific dissemination, and empowering through cultural integration”, while balancing scientificity and entertainment, professionalism and simplicity, traditional forms and modern technologies. For mountainous geological parks, particular attention should be paid to the convenience of services and the scene-appropriate nature of media, to create an interpretation system suitable for outdoor tourism scenarios. Additionally, the optimization of the interpretation system in a geological park is a dynamic and continuous process. A long-term monitoring mechanism for tourists’ needs should be established to promptly capture changes in tourists’ demands and continuously adjust and optimize the content, form, and carriers of interpretation. Only by making the interpretation system truly meet the needs of tourists can its core functions of popular science

education, experience enhancement, and cultural dissemination be fully exerted, promoting the coordinated improvement of ecological, economic, and social values of the World Geopark.

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