

Bibliometric and visual analysis on research of freeze-thaw of rock slopes based on CNKI Data

Qinglang Zou^{1,2}, Shibo Huang^{1,2}, Long Zhao^{1,2}, Pengtao Zhao², Jie Huang^{3*} 通讯作者

(1.College of Engineering, Tibet University, Lasha 850000, China;

2.Yibin Research Institute of Southwest Jiaotong University, YiBin, 644000, China;

3.Institute of Education, Tibet University, Lasha 850000, China)

Abstract: In order to explore the research status of rock slope freeze-thaw problems, 228 domestic and foreign rock slope freeze-thaw papers were retrieved as the samples based on the CNKI database. CiteSpace was used to conduct bibliometric and knowledge map analysis on the number of paper publications, authors, and keywords. The results show that the annual publication volume in this field are generally increasing, indicating a large development space in future. There are many research teams and institutions in this field, but there is less collaboration between different teams. According to the timeline map, revealing that earlier literature focused mainly on understanding and prevention of rock slope freeze-thaw problems. New technologies from other fields have been gradually applied for innovation in recent years. The future research trend will involve micro-damage, multi-field coupling, dynamic responses, monitoring and warning of rock slope freeze-thaw problems.

Key words: Freeze-thaw cycles; Rock slope; CiteSpace; Visual analysis; Bibliometric analysis

Introduction

Freeze-thaw is a major trigger of geological disasters in the Hengduan Mountains in western Yunnan, western Sichuan and eastern Xizang, the high mountain valleys in south Sichuan, northeast Yunnan, east Guizhou and west Guizhou. The freeze-thaw process causes damage to natural systems such as rock and soil, vegetation and watersheds, and has a impact on the safety and reliability of railroads, highways, bridges and other infrastructures.

Huang et al. carried out bibliometric analysis of research on freeze-thaw erosion using Excel software, and put forward an outlook on model prediction; Li et al. showed the hotspots and trends of the research on rock fracture network through visual analysis; Deng et al. constructed the knowledge map of the research on the mechanics of freeze-thawed rocks both at home and abroad by using the software CiteSpace, carried out a visual analysis, and summarized the hotspots of the research. However, there is no bibliometric analysis of the freeze-thaw problem of rocky slopes using the visualization method, so it is necessary to sort out and summarize the existing research results at home and abroad, to reveal the development process of this research, clarify the structural relationship, explore the development trend, and visualize it in the form of a knowledge map, to provide a reference for future research work.

This study applies CiteSpace version 6. 2. R4 to perform statistical and visual co-occurrence analysis for the retrieved literature. The authors are mapped to understand the academic contributions of the research teams in the field, and the relationship layout of the keywords and their evolution paths are understood through the timeline analysis.

1 Preliminary analysis of the literature

This study utilized the CNKI database to search the English and Chinese literature on the freezing and thawing of external rocky slopes. The search rule was (subject = “freeze-thaw” + “slope”) * (abstract = “rocky”). A total of 233 articles were retrieved. A total of 228 articles were obtained by reading the titles and abstracts of the literature, manually excluding two journal catalog notifications and three irrelevant articles, and importing the screened literature into CiteSpace software for de-duplication.

1.1 Number of publications

The total number of annual publications of retrieved papers was less than 5 per year before 2005, and since then the overall trend has been on the rise, and only the number of publications in 2023 has exceeded 30 as of August 12, reaching the highest in history. For SCI, EI, CSSCI, CSCD, four categories of high-level journals, since 2009 almost every year there are two or more high-level papers published, and high-level papers issued and the total library of the number of articles issued by the growth trend is similar. The overall increase in the number of papers per year indicates that this kind of research is now in the “growth period” and has strong research value.

Among the retrieved articles, the earliest one dealing with this field is the study of two rock avalanches in the Karasawa Cirque area published by Masaki in 1996. The authors conclude and predicts the possible subsequent disaster scenarios. The earliest article retrieved from Chinese literature is a paper by Chen Guangxiang published in 2001, which analyzes the causes and hazards of slope damage on the slopes of the Sangna Reservoir dam project located in the high alpine region and proposes measures for its management.

1.2 Distribution of disciplines

From the distribution of research disciplines, the research on the freezing and thawing of rocky slopes contains more than 5 papers in the disciplines of building science and engineering (71 papers), highway and waterway transportation (59 papers), mining engineering (50 papers), industrial general technology and equipment (17 papers), water conservancy and hydropower engineering (13 papers), and railroad transportation (9 papers), and the number of papers issued in these 6 disciplines accounts for 96% of all the retrieved papers. A large number

of the papers involved disciplines concentrated in the field of engineeringz, which is of great significance for construction and operation and maintenance, meanwhile the results reflect the insufficient use of cross-disciplines in this research direction and the lack of certain innovativeness.

2 Visual analysis

2.1 Author mapping analysis

All retrieved documents were imported into CiteSpace software for author collaboration network analysis. The calculation yielded 296 nodes and 466 node links, and the density of the cooperation network was only 0.0107. That is, a total of 296 people have conducted research, and there are 466 collaborations among authors, and different colors in the nodes represent different years of publication. The authors with two or more publications are filtered to display their names to obtain the author collaboration network mapping for the study of freeze-thaw on rocky slopes, as shown in Figure 1(A). It shows that there are many research teams in rocky slope freeze-thaw research, but there is a lack of stronger leaders and research teams that have close cooperation with all parties. Most of their institutions are located in the southwest and northwest regions. Chengdu University of Science and Technology has unique geographical and disciplinary advantages for geohazard problems in southwest China, and has made outstanding contributions in the field of freeze-thaw on rocky slopes

2.2 Timeline mapping analysis of keywords

After obtaining the keyword co-occurrence network through Citespace, the LLR (Log-Likelihood Ratio) algorithm was chosen to analyze the clustering of keywords. In the obtained clustering results, the clustering module value $Q=0.814$, it is generally believed that $Q>0.3$ means that the clustering structure is significant; the average silhouette value of clusters $S=0.9347$, it is generally believed that the clustering with S value above 0.7 is considered to be highly efficient and very credible. In this study, 35 keyword clusters were finally obtained, but since most of the clusters have a small number of nodes, only the top 11 clusters are shown in Figure 1(B), where the node sizes and colors indicate the frequency and age of occurrence, respectively. According to the time of various types of keywords in a horizontal comparison, to further reflect the cluster keywords implied by the temporal characteristics. Combined with the timeline mapping of keyword, the spatial changes of the research hotspots over time can be clearly seen: before 2010, the research on freeze-thaw of rocky slopes was still concentrated in the stage of recognizing and proposing prevention and control measures for general freeze-thaw hazards, and the representative keywords such as “high alpine mountainous area”, “stability”, “prevention and control measures” and so on. After 2010, other details or research in other fields were derived, representing keywords such as “frost heaving force”, “numerical simulation”, “mechanical properties”, “open-pit mins”, “acoustic emission”, “micro-structure” and so on. The application of these new techniques, such as nuclear magnetic resonance, acoustic emission, and CT scanning, represents the emergence of new research frontiers, but it often takes a period of exploration before a representative research theme for a period of time, similar to numerical simulation, is developed.

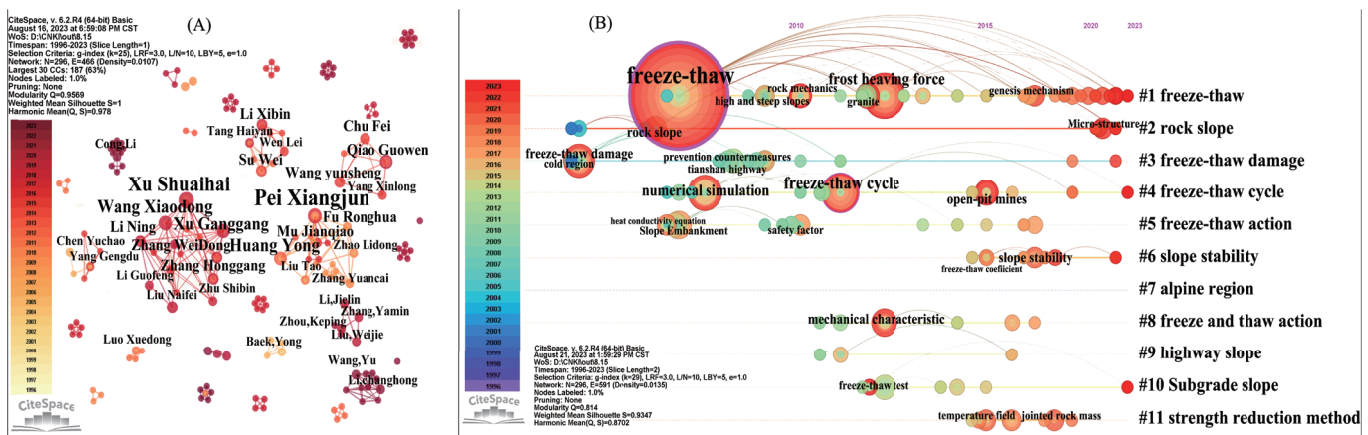


Fig. 1 Author co-occurrence mapping and timeline of clustered keywords

3 Conclusion

The research on the freeze-thaw problem of rocky slopes started relatively late, but since the first publication in 1996, the number of annual publications has been on the rise overall, and the number of high-level papers is similar to the overall number of publications. This indicates that the research enthusiasm in this field is gradually increasing, and there is a great research prospect and development potential in the future.

This research direction has formed several typical author groups with outstanding research results and close teamwork, such as the teams dominated by Xu Shuanhai, Pei Xiangjun, and Qiao Guowen, respectively, but it lacks a strong leader or group.

In the keyword co-occurrence analysis, it can be seen that numerical simulation, safety factor, freezing and expansion force, open pit mine, temperature field and so on are the research hotspots of freezing and thawing problems of rocky slopes; In the keyword clustering analysis, 11 representative clusters are selected for time co-occurrence analysis to get the distribution of keyword emergence and year under different clusters, and it is found that the research on the freeze-thaw problem of rocky slopes in recent years combines the application of

technology in other fields.

References:

- [1] 中华人民共和国自然资源部. 全国地质灾害防治“十四五”规划 [EB/OL]. [2022 — 12 — 07] http://gi.mnr.gov.cn/202301/t20230103_2772003.html.
- [2] Huang S. L., Yang D. S., Yu W., et al. Literature analysis on freeze-thaw erosion in China: A case study from 1985 to 2020. *Agriculture and Technology*, 2021,41(11):104-106.
- [3] Li C. L., Yang F., Jia C., et al. Research advance of rock fracture network based on bibliometrics. *Yangtze River*, 2021,52(Supplement 1):140-146.
- [4] DENG Hongwei, TIAN Guanglin. Analysis on Hot Topics of Rock Mechanics Research in the Freeze-Thaw Environment from 2013 to 2020 Based on Visual Analysis of CiteSpace. *Gold Science and Technology*. 2021,29(02):275-286.
- [5] IWAFUNE M. Rock Avalanches Occurred in the Snow-melt Season at the Karasawa Cirque in Mt. Hotaka-dake, the Japanese Alps[J]. *Journal of Geography (Chigaku Zasshi)*, 1996,105(5).
- [6] CHEN Guangxiang. A special form of slope failure in alpine region and its treatment measures[J]. *Water Resources and Hydropower Engineering*. 2001(09):8-9.
- [7] Baek Y. Stability Analysis of Rock Slope with Consideration of Freezing-Thawing Depth[J]. *The Journal of Engineering Geology*, 2001, 11(1).
- [8] CHEN Xianchun. GONG Zhengwei. SHENG Guojun. Mechanism of freeze-thaw failure of highway rock slope in mountainous area and treatment countermeasures. *Highway*. 2011(03): 71-74.
- [9] CHEN Yue, CHEN Chao-mei, LIU Ze-yuan, HU Zhi-gang, WANG Xian wen. The methodology function of Cite Space mapping knowledge domains. *Studies in Science of Science*. 2015,33(02): 242-253.

Foundation: “High-level Talent Training Program” for Graduate students of Tibet University (grant number:00061096, 2021-GSP-S148).