Bibliometric Analysis of China's Green Mining Development Based on CNKI Database

Li Mingyang1, Cheng hong1*, Wang Bin1, Zheng Kaiwen1, Li Ping1

1 College of Management Science, Chengdu University of Technology, Chengdu, Sichuan, 610059, China

* Correspondence: chenghong@cdut.edu.cn

Abstract. Green development of mining requires the requirements of healthy and sustainable development, the development of green mining and the construction of green mines are important directions for the reform and development of the mineral resources management system. This article conducts data mining and exploration analysis of high-quality literature (core, CSSCI retrieval) on the theme of green mining included in CNKI from 1999 to 2019. The result shows that: according to the search criteria, we retrieved a total of 190 articles, since 2003, the number of documents on the topics of green mining has risen sharply, we found that the role of policy in promoting academic research is obvious. China University of Mining and Technology is the most published institution, studies from universities, institutions, and social groups have different research focuses on green mining. In the whole cycle of green mining construction, green exploitation and green mines construction play a vital role.

1. Introduction
China's mineral resources are very rich, and mining plays an important role in social and economic development, but the exploitation and utilization of mineral resources in China has been at the expense of wasting resources and sacrificing the environment for a long time. The extensive development of China's mining industry has caused serious environmental problems, such as the destruction of natural landscape and land, induction of various geological disasters, destruction of water balance in mining areas, and the generation of air pollution and acid rain. If this old model does not change, mining production activities will become an important factor restricting the sustainable development of China's economy and society. In this context, the state put forward the concept of developing green mining industry [1].

Green mining is relative to the traditional "black or brown mining" and is the product of the third technological revolution and the era of ecological civilization. Promoting "green mining" is one of the important contents to promote the construction of ecological civilization. In recent years, it has received more and more attention. With the advancement of mining greening, academic research has gradually increased. Wang Xuefeng et al [2] summarized and borrowed a series of policies and measures adopted by developed countries in mine environmental protection, and put forward that “green mining” should be protected first and then developed from the perspective of actual domestic environmental problems, the concept of sustainable development has penetrated into each stage of mineral development, and put forward a series of practical suggestions from the aspects of reducing costs, relying on technology, strengthening the construction of management systems and monitoring mechanisms, and laws. Based on this view, the concept of green mining in China was proposed.
Long Y et al [3] standing on the two aspects of resource development and environmental protection, it puts forward the connotation of green mining in it, and emphasizes that the fundamental of green mining is technological innovation. the main purpose of management innovation is people-oriented. By integrating the development experience of green mining in foreign countries, Cao Xianzhen et al [4] proposed that green mining should proceed from three aspects of mine environmental carrying capacity assessment, technological innovation and environmental restoration before development, deepen green mining reform and establish a green mining system. Since then, the understanding and interpretation of green mining has been further expanded to include the three aspects of resource development, environmental protection and environmental restoration. Specifically, one is to protect the ecological environment and consider the carrying capacity of the environment during the development of mineral resources; the second is to minimize environmental pollution through high-tech means; the third is to address the environmental issues that have already occurred actively solve. On the basis of the connotation of green mining in the past, Li Guozheng et al [5] raised it to the level of conceptual thinking, green mining is no longer a simple maintenance and governance of the ecological environment in mineral mining and processing, but is a green concept, green way organic combination of green goals. From the perspective of China's current economic development basic national conditions, Hou Huali et al [6] pointed out that there are three links in the realization of green mining: one is to establish an environmental evaluation index system and technical standards through pre-development regional environmental capacity or carrying capacity assessment and mine environment disturbance assessment, and to develop green mining planning; second, through technological innovation optimizing the technological process to achieve small disturbance, non-toxicity and less pollution in the mining, beneficiation and smelting process; the third is to minimize environmental disturbances and optimize ecological reconstruction through mine environmental governance and ecological restoration.

Chinese scholars have put forward their own understanding of the concept of green mining, they all believe that the realization of green mining is an important method to promote the sustainable development of mining, the difference is that the scholars have put forward different construction priorities and implementation paths. We obtain relevant articles through condition setting as follow, and use bibliometric tool (provided by CNKI) to conduct data mining and exploration analysis on the development of China's green mining in terms of time of publication, keywords, highly cited articles, major journals, authors, and several aspects. The research status and construction focus of China's green mining development are obtained.

2. Data Sources and Analysis Methods
   In CNKI （CNKI is the abbreviation of China National Knowledge Infrastructure, which is China's academic knowledge innovation, learning and application exchange and cooperation platform） database, the search method is journal, and the search condition is limited to "green mining" as the subject word (plus the expansion of Chinese and English), from the time interval is set to January 1, 1999 to December 31, 2019, Journal source category select from PKU(Core journal of Peking University) and CSSCI （Chinese Social Sciences Citation Index）. A total of 190 articles were obtained, including 186 PKU journals and 25 CSSCI journals(PKU and CSSCI do not exist independently). This papers is organized as following. Firstly, by using the quantitative analysis function provided in the literature retrieval of CNKI, the data mining of the above literature is carried out, Secondly, the analysis results form a visual knowledge map or information table, among which important documents are selected for exploration and analysis. thirdly, analyze and summarize the research direction and focus of the academic community on the theme of green minesAnother section of your paper

3. Analysis of Green Mining Research
   3.1. Analysis of Literature Quantity
Timeline analysis of the 190 articles detected, from 1999 to 2003 the total number of published journal articles was only 5, after 2003, the number of documents on the theme of green mining has risen sharply. In 2003, 2007, 2010, and 2017, respectively, there was a significant increase, although a small drop after each rise, the overall upward trend is obvious, and reached 27 articles in 2019.

Explain the changes in the number of publications from a policy perspective, in 2003, the scientific outlook on development was formally proposed to build, provides the basis of thought and theory for green mining construction. Four years later, the 9th China International Mining Conference was held in Beijing, this conference vigorously advocated the development of green mining and became an important time node for domestic academics to study green mining, subsequently, the Ministry of Land and Resources of China approved “the National Mining Resources Planning (2008 ~ 2015)”, which clearly stated the goals and requirements of "green mine construction", and the development of green mining has become a national strategy. The Ministry of Land and Resources issued the “Guiding Opinions on Implementing the National Mineral Resources Planning and Development of Green Mining Construction and Green Mine Work” in 2010, proposing the basic conditions for national-level green mine construction, thus marking the official launch of China ’s green mine construction. In 2017, six ministries and commissions including the former Ministry of Land and Resources jointly issued the "Implementation Opinions on Accelerating the Construction of Green Mines", which took a solid step from concept to practice for the construction of green mines in China. Every change of the curve in the Fig.1 can find the implementation of relevant policies, it is fully explained that the influence of the policy in promoting green mining research.

Fig.1 Time distribution of the number of published papers

| Rank | Keyword          | Frequency |
|------|------------------|-----------|
| 1    | Green mining     | 81        |
| 2    | Green mines      | 71        |
| 3    | Mineral resources| 59        |
| 4    | Mining development| 52      |
| 5    | Mine enterprises | 41        |
| 6    | Green exploitation| 34      |
| 7    | Mine environment | 27        |
| 8    | Green development| 17        |
| 9    | Coal resource    | 15        |
| 10   | Mineral exploitation| 15    |
Fig. 2 Keyword co-occurrence map in the field of green mining

According to the keywords listed in the literature, the distribution of word frequency is counted. The top ten keyword sets in the field of green mining research from 1999 to 2019 is listed in Table 1. Meanwhile, perform network analysis on the topic keywords to obtain the co-occurrence network distribution diagram of the topic keywords in Figure 2. The line segments in the figure represent the relationship between the two keywords, the thicker the line, the closer the relationship between the two keywords.

We can see from Figure 2 that green mining is show a very strong correlation with green mines, mining development, mine enterprises, mineral resources etc. Green mining development involves a wide range of areas, including early stage mineral census, mine construction, mineral resource exploitation, mid-term metallurgical processing and later stage pit repair and ecological environment reconstruction. Green mining is the trend of mining development and needs to be promoted by mining policies, among them, the construction of green mines is the foothold of the development of green mining, mine enterprises are the main implementation body of green mining development. From the perspective of green mine construction, green mines have a strong correlation with mineral exploitation, green development, mine enterprises, mine construction, and mineral resources, it shows that green mines are related to theoretical research, policy guarantee, and comprehensive management directions. In fact, green mines is the construction focus of green mining development, and green mining is also the main trend and direction of mining development in recent years.

3.3. Analysis of High-Cited Literature

Table 2: High-cited literature analysis in the field of green mining

| Rank | Article Title                                                                 | Author              | Journal                             | Cited Frequency |
|------|------------------------------------------------------------------------------|---------------------|-------------------------------------|-----------------|
| 1    | Green Technique in Coal Mining                                               | Qian Minggao Xu     | Journal of China University of Mining & Technology | 1400            |
| 2    | Research on Green Mining of Coal Resources in China: Current Status and Future Prospects | Miao Xiexing Qian Minggao | Journal of Mining & Safety Engineering | 639             |
| 3    | Green mining of coal resources harmonizing with environment                  | Qian Minggao        | Journal of China Coal Society       | 334             |
| 4    | Study and Application of Mining-induced Fracture Distribution in Green Mining | Xu jialin           | Journal of China University of Mining & Technology | 242             |
| 5    | Resources and Environment Harmonics(Green Mining and Its Technological System) | Miao Xiexing Xu jialin | Journal of Mining & Safety Engineering | 139             |
| 6    | Building The Green Mine for The Development of Green mining                  | Qiao Fansheng Li Xin | China Mining Magazine               | 76              |
| 7    | Green Mining Construction Work Progress and Effect                           | Qiao Fansheng       | China Mining Magazine               | 53              |
| 8    | The Trend and Direction of Green Development of The Mining Industry in China | Li Xin               | China Mining Magazine               | 52              |
| 9    | Distribution of Important Exploitation Are as of Mineral Resources in China   | Liu Hailing         | Resource Industrial Economy         | 50              |
Developing Recycling Economy on Mining and Building Green Mines

Yang Ling
China Mining Magazine

Sorted by citation frequency descending order, we counted the literature information of cited TOP10, mainly including author, journal and citation times. Through reading the literature, we have summarized that the domestic green mining industry chain mainly includes mineral census, mine planning, construction, mining, beneficiation, metallurgy, deep processing, mine closure, reclamation and ecological environment reconstruction.

At the same time, we found that the top five articles cited in frequency are mainly related to green exploitation, there is no doubt that green exploitation plays an important role in the whole green mining construction. From Table.2, Qian Minggao et al [7] published he "Green Technique in Coal Mining" in "Journal of China University of Mining & Technology" in 2003, which has been cited the most times, reached 1,400 times, the author proposed concept of green exploitation, expounding its connotation and technical system, including the theoretical basis of green exploitation and the main green exploitation technology, pointing out that green exploitation is one of the core contents to realize the development of green mining. In terms of green mining theory construction, Qiao Fansheng et al [8]'s "Building The Green Mine for The Development of Green mining" published in "China Mining Magazine" further explained the relationship between green mining and green mines, the author fully discussed green mining in the article with the concept of green mines, it is pointed out that the construction of green mines is an important foundation for the development of green mining. The latest paper in TOP10 is "The Trend and Direction of Green Development of The Mining Industry in China" published by Ju Jianhua et al [9] in "China Mining Magazine" in 2017, the author proposes that green development of mining is an inevitable choice for China's ecological civilization construction, it is also an important way for the transformation and upgrading of the mining industry and puts forward the main ideas, key tasks and suggestions for comprehensively and deeply promoting the green development of the mining industry in the new period.

3.4. Analysis of Publishing journals and Institutions

| Rank | Journal | Number of Publications | Proportion | Organizer | If |
|------|---------|------------------------|------------|-----------|----|
| 1    | CHINA MINING MAGAZINE COAL TECHNOLOGY | 61 | 32.1% | China Mining Association | 0.757 |
| 2    | CHINA COAL | 16 | 8.4% | Harbin Coal Mine Machinery | 0.462 |
| 3    | JOURNAL OF CHINA COAL SOCIETY CHINA POPULATION,RESOURCES AND ENVIRONMENT JOURNAL of CHINA UNIVERSITY of MINING&TECHNOLOGY | 8 | 4.2% | IIEM&CII | 0.541 |
| 4    | JOURNAL OF CHINA UNIVERSITY of MINING&TECHNOLOGY | 7 | 3.7% | China Coal Society | 2.315 |
| 5    | CHINA UNIVERSITY of MINING&TECHNOLOGY | 6 | 3.2% | Chinese Society for Sustainable Development | 3.457 |
| 6    | CHINA UNIVERSITY of MINING&TECHNOLOGY | 6 | 3.2% | China University of Mining and Technology | 2.042 |

Table.4 TOP10 of papers published by major institutions in the field of green mining

| Institution character | Institution name | Number of Publication |
|----------------------|------------------|-----------------------|
| University           | China University of Mining and Technology | 28 |
|                      | China University of Geosciences | 15 |
|                      | Liaoning Technical University | 8 |
|                      | Xi'an University of Science and Technology | 7 |
|                      | China University of Mining and Technology (Beijing) | 4 |
|                      | China University Of Geosciences (Wuhan) | 4 |
|                      | Henan Polytechnic University | 3 |
|                      | Shandong University of Science and Technology | 3 |
Through analysis of the journal, we found that the number of articles issued by CHINA MINING MAGAZINE reached 61, accounting for 32.1%, more than one-third of the total number of articles issued. China Mining is hosted by the China Mining Federation and is a very important academic journal for the green mining industry and even the mining industry.

Analysis of major research institutions: From 1999 to 2019, the top 10 papers were published in the field of green mining, with a total of 93 articles, accounting for 48.95% of the total, according to the character of the institution, it is mainly divided into university, public institution and social groups.

University are the main participants in the field of green mining research, among the total number of TOP10 articles published, colleges and universities publish 72 articles, accounting for 69.03%. China University of Mining and Technology has the largest number of published articles, up to 28. The establishment of the university can be traced back to 1909, is one of the best mining universities in China, which has a very strong strength of green mining research. The university mentioned above are constantly developing from specialized mining / address colleges to multidisciplinary comprehensive universities. There are 13 statistical documents issued by Chinese Academy of Natural Resources Economics, only less than China University of mining and China University of Geosciences, Chinese Academy of Natural Resources Economics is an public institution directly under the Ministry of Natural Resources, provide critical business support and decision consulting services for it.

China Mining Association is composed of mining companies, geological exploration enterprises, national mining industry associations, mining related research institutes and mining cities, it is an important social organization in the field of mining in China, has published eight articles related to green mining. China Mining Association is the explorer and leader of green mining theory and standardization, released “Measures for acceptance of national green mine pilot units (Implementation) and “Guidelines for the construction of solid mineral green mines [Implementation]” in 2014 and 2017 respectively [10]

3.5. Analysis of Authors Published in Papers

| Rank | Author name | Number of Publication | Affiliated Institution | Research Field |
|------|-------------|-----------------------|------------------------|---------------|
| 1    | Qian Minggao | 5                     | China University of Mining and Technology | Green exploitation |
| 2    | Qiao Fansheng | 5                   | China Mining Association | Green mine construction |
| 3    | Li Xin       | 5                     | China Mining Association | Green mine construction |
| 4    | Fan Fujun    | 5                     | Liaoning Technical University | Corporate Social Responsibility |
| 5    | Lu Mingyin   | 4                     | China University of Mining and Technology | Mining area reclamation |
| 6    | Xu Jialin    | 4                     | China University of Mining and Technology | Green exploitation |
| 7    | Song Ziling  | 4                     | Liaoning Technical University | Green exploitation |
| 8    | Zhu Zhencai  | 3                     | China University of Mining and Technology | Ground surface subsidence |
| 9    | Miao Xiexing | 3                     | China University of Mining and Technology | Green exploitation |
| 10   | Hou Lihua    | 3                     | Chinese Academy of Natural Resources Economics | Green mining development |

In the TOP10 list of author statistics, the authors are mainly from three research institutes, including China University of Mining and Technology, China Mining Association and Liaoning Technical University. Main research field engaged in include green mining development, green mine construction, green mining, and mineral resource management. Three research scholars from China University of Mining and Technology: Qian Minggao, Miao Xiexing, Xu Jialin have published many
papers on the theme of green exploitation from 2003 to 2009, focusing on the demonstration the importance of mining technology is related to highly cited documents. Qiao Fansheng and Li Xin from the China Mining Association, started from the theoretical basis, existing problems and corresponding solutions of green mine construction to explore the role of green mine construction in promoting the development of green mining. Fan Junfu and Song Zilin from Liaoning Technical University carried out various researches on green exploitation in open pit coal mines, including green mining technology and evaluation index system, land dynamic evolution law, mining technology, etc.

4. Conclusion

- From a timeline perspective, 2007 is an important time node for academic research on green mining. The cumulative number of documents from 1999 to 2007 was 32, accounting for 16.84%, with an average of 3.5 per year, while the number of published from 2008 to 2019 was 158, accounting for 83.16%, an average of 14.4 articles per year, with a growth rate of more than 400%.
- From the perspective of keywords, the development of green mining relies on the joint action of multiple dimensions and indicators. Among them, the construction of green mines plays a foundation and main role, from the analysis, it can be summarized as before the large-scale use of green technology, the management system was used and discussed more quickly and widely.
- From the perspective of the document issuing institution, from the perspective of the entire life cycle of green mining, or policy research, mining engineering technology innovation, etc., the number of colleges and universities and the depth of research are more prominent. Geological and mining colleges also reflect from the side that few new colleges and universities are engaged in geological and mining research. Institutions and social groups conduct more research in terms of policies and promotion of industry development. From the point of view of the author of the article, almost all the authors who cooperated in the article belong to the same institution, and cross-institution cooperation is rarely found.
- Judging from the main publication journals, "China Mining" sponsored by the China Mining Federation published the most literature on the theme of green mining, accounting for more than one-third. In terms of the number of posts, its composite and comprehensive impact factors have also increased year by year. At the same time, the green development of mining industry also has a large number of articles published in journals with high impact factors such as "China Population · Resources and Environment" and "Journal of Coal".

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