minerals

MDPI

Review

Analysis of Glauconite Research Trends Based on CiteSpace Knowledge Graph

Ke Nong [1], Si Chen [1,*], Zepeng Ren [1] and Min Zeng [2,*]

[1] School of Earth and Planetary Sciences, Chengdu University of Technology, Chengdu 610059, China; nke77302@gmail.com (K.N.); zren909@gmail.com (Z.R.)
[2] School of Earth Sciences, Yunnan University, Kunming 650091, China
* Correspondence: chensi@cdut.edu.cn (S.C.); zengmin.inter@gmail.com (M.Z.)

Abstract: This paper aims to explore the current status and development trend of glauconite research through CiteSpace (version 6.2.R3) software tools. Based on the literature records from 1980 to 2024 in the Web of Science Core Collection database, this study visualizes the countries/regions, institutions, authors, journals, literature, and keywords related to glauconite. The results show that the United States, Russia, India, France, and England are the main contributing countries to glauconite research, the Russian Academy of Sciences is the institution with the largest number of publications, and Santanu Banerjee and Gilles S. Odin are the most influential authors. The field of glauconite has a high degree of international cooperation and multidisciplinary cross-disciplinary nature. The research hotspots of glauconite are also identified, including origin, basin, sediments, geochemistry, sandstone, and climate, and emerging research frontiers such as fertilizer, removal, provenance, composition characteristics, and Fe are pointed out. Glauconite research is not only of great significance in the field of geology, but its application potential in environmental management and agricultural development is also gradually being recognized, indicating that this field has broad research and application prospects in the future.

Keywords: glauconite; bibliometrics; knowledge graph; hot topics

check for updates

Citation: Nong, K.; Chen, S.; Ren, Z.; Zeng, M. Analysis of Glauconite Research Trends Based on CiteSpace Knowledge Graph. *Minerals* **2024**, *14*, 1260. https://doi.org/10.3390/min14121260

Academic Editors: Davide Lenaz and Filippo Parisi

Received: 5 November 2024
Revised: 3 December 2024
Accepted: 9 December 2024
Published: 11 December 2024

Copyright: © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

Glauconite is a layered silicate mineral rich in iron and potassium with a dioctahedral structure and a structural formula of $(K,Na,Ca)(Fe,Al,Mg,Mn)_2(Si,Al)_4O_{10}(OH)_2$ [1]. It is usually produced in transgressive sedimentary sequences and condensed layers together with phosphate grains and abundant fossils. This type of green marine sediments mainly composed of sand-sized glauconite was first named "glaucony" in 1980 by Odin [2]. It is generally believed that glauconitization is an autogenetic process that usually develops in low latitudes with water depths less than 500 m and suitable temperatures as well as in outer continental shelf and slope areas [1]. Although ancient glauconite has been reported in deep-sea (>2000 m), low-temperature (3–6 Celsius), and estuarine environments [3–6], marine authigenic glauconite is still considered an important indicator for basin analysis and stratigraphic correlation [7], as well as a paleoenvironmental indicator of climate history [8]. In the past few decades, many scholars have studied the glauconitization process and proposed a variety of models to explain the origin and composition evolution of glauconites, such as the "verdissement theory" [1,9], the "layer lattice theory" [10,11], and the "pseudomorphic replacement theory" [12]. The first two theories explain the origin of most Phanerozoic glauconites, while most Precambrian glauconites indicate the "pseudomorphic replacement" of the substrate [13]. To date, the "verdissement theory" is the most widely accepted explanation for the origin and evolution of glauconites. In addition, glauconite, as an important mineral adsorbent, has a certain purification effect on heavy metal pollution in the environment [14], and is also an important source of

potassium fertilizer, which helps to reduce the use of chemical fertilizers [15,16], and has broad application prospects in environmental restoration and ecological protection. Therefore, glauconite has been widely studied in various disciplines. To further clarify the current status of glauconite research, identify research hotspots, and track cutting-edge topics, this paper uses bibliometric analysis methods to conduct a knowledge graph analysis of related research on glauconite in the database.

Bibliometrics is a field of study that uses literature as its research object. It mainly uses quantitative statistical analysis to analyze the changes in the number, distribution, and laws of changes in literature. It is widely used in scientific research evaluation and the analysis of the current status, hot spots, and trends of disciplines or research fields [17–19]. The use of bibliometrics to analyze a certain field to study the development and frontier hot spots in the field has been increasing [20,21]. At present, there are many pieces of software for bibliometric analysis, such as Bibexcel, NetDraw, SATI, CiteSpace, Pajek, and VosViewer [22]. Among them, CiteSpace is a software tool developed by Dr. Chaomei Chen for analyzing, mining, and visualizing scientific research literature [23]. Compared to other literature analysis software, it has a large processing scale and can present more comprehensive and clearer bibliometric analysis results [24]. Based on the Web of Science (WOS) core collection database, this paper uses CiteSpace and other tools to conduct a statistical analysis of the publication metadata of glauconite research.

2. Data Collection, Screening, and Analysis Methods

2.1. Data Collection and Screening

In this article, the data come from the Web of Science Core Collection database of Clarivate Analytics. The search formula is: TS = (glauconite OR glauconites OR glauconitic OR glaucony), the language type was set to "English", the document type is "Article", the search date was not limited, and the time of search was 21 September 2024. A total of 1599 relevant documents were obtained. It should be noted that documents from 2024 were not fully included. The documents were exported in the "Plain text file" format, and the CiteSpace duplicate check showed that they were single occurrences without duplication. Large data sets and highly recognized databases are representative.

Figure 1 shows the annual distribution of the number of papers in the field of glauconite, with the blue dots indicating the number of papers published in the corresponding year. The change in the number of papers per unit of time reflects the research conditions, theoretical level, and development speed of academic research in this field, and is an important indicator for measuring the academic research situation in this field [25]. The R^2 value is an indicator of the degree of fit of the trend line. The closer the value is to 1, the higher the reliability of the trend line. As can be seen from Figure 1, the number of papers published is increasing in a curve (R^2 = 0.91). This trend shows that this field is highly valued by international scholars and has produced a large number of scientific research results. The first relevant document can be traced back to 1905 and was published by Prather [26], indicating that international scholars started research in this field early. In detail, the trend of the number of papers can be divided into three stages: (1) From 1905 to 1979, it was in the embryonic stage for a long time. In this stage, glauconite research was just starting, the number of published papers was small, and the number of papers published each year remained stable, with an average of fewer than two papers per year. (2) From 1980 to 2003, it was the development stage of the glauconite field. During this period, the number of pieces of literature related to glauconite has increased slowly year by year, indicating that the field of glauconite is attracting the attention of international scholars. (3) From 2004 to 2024, it is the explosive stage of the glauconite field. This stage shows that the number of papers published has a J-shaped rapid growth trend with an average annual number of 53.5 papers, reaching a peak in 2022 with 93 papers. The results show that international scholars are paying more and more attention to research in the field of glauconite, and their attention is significantly higher. Based on the small number of

relevant papers before 1979, this paper takes 1 January 1980 to 21 September 2024 as the main research period.

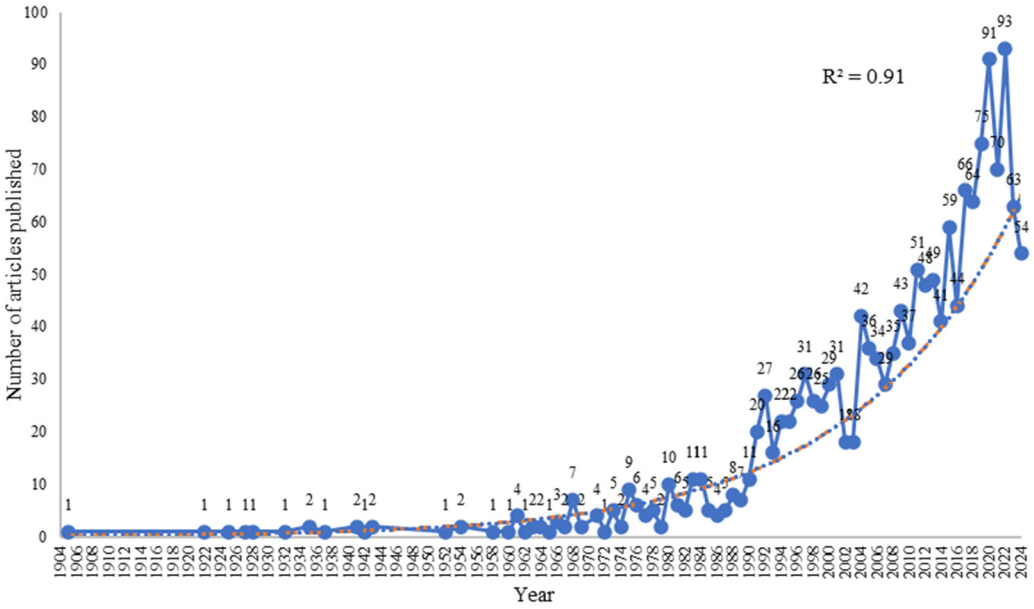


Figure 1. Annual publication volume.

2.2. Data Analysis Methods

In this paper, MS Excel combined with CiteSpace (version 6.2.R3) software was used to visualize and analyze the countries, institutions, authors, and keywords in the data. Centrality and burst are two important indicators in CiteSpace. Centrality is used to identify and quantify the importance of nodes. Its centrality value ≥ 0.1 marks the key points in the knowledge graph with purple circles; burst refers to the sudden increase of nodes in a short period [27]. Pruning is a data processing method used to filter out unimportant nodes and segments. Pathfinder can enhance the stability and repeatability of analysis, and selectively retain nodes with higher importance in the knowledge network, which is conducive to improving the identification of key nodes [28]. When using CiteSpace to analyze data, to make the network diagram simple and clear and the centrality analyzability strong, the threshold and parameters are first set selectively [29].

3. Results and Analysis

3.1. Collaboration Network Analysis

The collaboration network generated by CiteSpace consists of two parts: nodes and segments. Nodes can represent countries, institutions, and authors. The larger the node, the more articles the corresponding institution or author has. The lines between nodes represent the collaboration between institutions or authors. The thicker the lines, the more collaborations there are. The color of the node rings represents the year in which the article was published. The darker the color is, the earlier it was published, and vice versa, the later it was published. In the function parameters area, set TimeSpan to 1980–2024, Slice length to 1, TopN to 100, select Country, Institution, and Author as the node type according to different purposes, and use the system default values for other parameters.

3.1.1. Country/Region Analysis

Using CiteSpace to analyze the co-occurrence of countries/regions helps to understand the co-occurrence relationship between different countries/regions in a specific research field. Figure 2 shows the country/region cooperation network in the field of glauconite, and Table 1 lists the top 10 countries/regions in terms of publication volume. The distribution of research output in countries/regions is uneven, and the publication volume of major

countries accounts for a considerable proportion. As can be seen from Figure 2 and Table 1, the country with the most publications is the United States (227 articles), followed by Russia (167 articles), India (146 articles), France (123 articles), England (120 articles), Germany (112 articles), Egypt (87 articles), Canada (82 articles), Italy (70 articles), and China (66 articles). The centrality of the United States (0.38), France (0.34), China (0.21), Germany (0.17), Russia (0.15), England (0.13), and Italy (0.10) is no less than 0.1, playing a supporting role in the network structure and indicating that the research results of these countries have a high global influence.

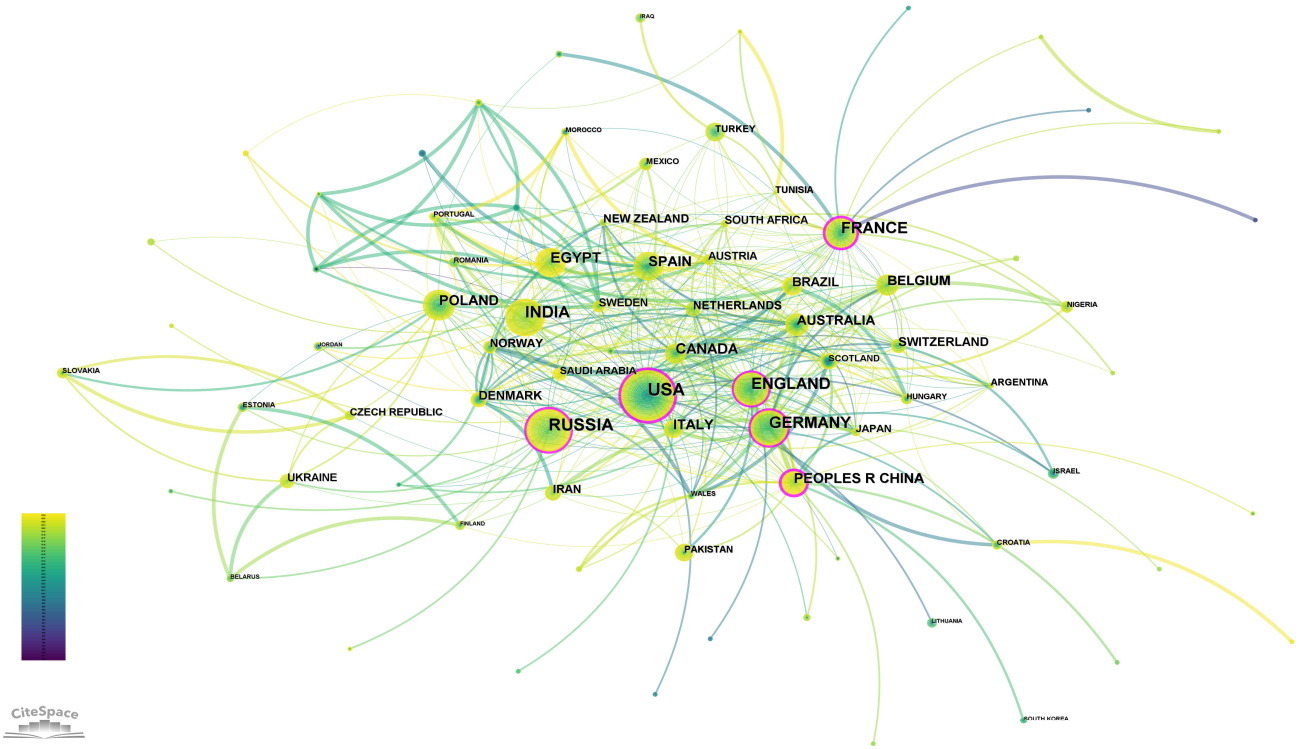


Figure 2. Collaboration network of glauconite research countries/regions from 1980 to 2024.

Table 1. Top 10 countries/regions.

No.	Countries	Count	Centrality
1	United States	227	0.38
2	Russia	167	0.15
3	India	146	0.08
4	France	123	0.34
5	England	120	0.13
6	Germany	112	0.17
7	Egypt	87	0.06
8	Canada	82	0.06
9	Italy	70	0.10
10	China	66	0.21

3.1.2. Institutional Analysis

The number of papers is the basis for measuring the academic influence of an institution, and the quality of papers is the key to improving the academic influence of an institution [30]. Figure 3 depicts the institutional cooperation network in the field of glauconite, and Table 2 lists the top 10 institutions in terms of the number of papers published. Among the top 10 institutions, 3 are from Russia, and 1 each is from France, India, England, Poland, Belgium, the United States, and Canada. Among them, the Russian Academy of Sciences (110 articles, 0.22) ranked first in terms of the number of papers published, with

its main research direction being the chemical composition and structural characteristics of glauconite; followed by the Centre National de la Recherche Scientifique (78 articles, 0.36), the Indian Institute of Technology-Bombay (61 articles, 0.18), the Geological Institute (47 articles, 0.02), the Natural History Museum London (28 articles, 0.06), the Polish Academy of Sciences (24 articles, 0.10), KU Leuven (24 articles, 0.04), the United States Geological Survey (23 articles, 0.02), Tomsk Polytechnic University (21 articles, 0.02), and University of Calgary (19 articles, 0.02). In summary, the Russian Academy of Sciences, the Centre National de la Recherche Scientifique, and the Indian Institute of Technology-Bombay have a significant advantage in the output of academic achievements in this field, and their output is of high quality.



Figure 3. Collaboration network of glauconite research institutions from 1980 to 2024.

Table 2. The top 10 institutions in terms of publication volume.

No.	Institutions	Countries	Count	Centrality
1	Russian Academy of Sciences	Russia	110	0.22
2	Centre National de la Recherche Scientifique	France	78	0.36
3	Indian Institute of Technology-Bombay	India	61	0.18
4	Geological Institute	Russia	47	0.02
5	Natural History Museum London	England	28	0.06
6	Polish Academy of Sciences	Poland	24	0.10
7	KU Leuven	Belgium	24	0.04
8	United States Geological Survey	United States	23	0.02
9	Tomsk Polytechnic University	Russia	21	0.02
10	University of Calgary	Canada	19	0.02

3.1.3. Author Analysis

Author analysis can reflect the cooperation relationship between different authors in a certain research field and identify researchers with high influence in the research field. Figure 4 shows the co-occurrence analysis of authors in the field of glauconite, and Table 3 shows the top 10 authors in terms of the number of publications. Among the top

10 authors, Russia accounts for 5, India accounts for 2, and Italy, Germany and Belgium each account for 1. The researcher with the most papers is Santanu Banerjee (39 articles), whose main research directions are the origin, evolution, and chemical composition of glauconite; followed by Victor A. Drits (23 articles), T. A. Ivanovskaya (19 articles), Maxim Rudmin (17 articles), T. S. Zaitseva (16 articles), Alessandro Amorosi (12 articles), Tathagata Roy Choudhury (12 articles), Markus Wilmsen (12 articles), B. A. Sakharov (11 articles), Jef Deckers (9 articles). As can be seen from Figure 4, there is a wide range of cooperative relationships between the authors, and a large scientific research cooperation network has been formed with Santanu Banerjee, Victor A. Drits, Maxim Rudmin, Alessandro Amorosi, Tathagata Roy Choudhury, and Markus Wilmsen as the main researchers. Some of the research was completed in small groups. It should be noted that the data for this analysis are based on the WOS core database, and the lack of field information for books cannot be included, such as the important publications published by Odin [31,32], who laid the foundation for subsequent research.



Figure 4. Collaboration network of authors of glauconite research from 1980 to 2024.

Table 3. Top 10 authors by number of publications.

No.	Authors	Countries	Count
1	Santanu Banerjee	India	39
2	Victor A. Drits	Russia	23
3	T. A. Ivanovskaya	Russia	19
4	Maxim Rudmin	Russia	17
5	T. S. Zaitseva	Russia	16
6	Alessandro Amorosi	Italy	12
7	Tathagata Roy Choudhury	India	12
8	Markus Wilmsen	Germany	12
9	B. A. Sakharov	Russia	11
10	Jef Deckers	Belgium	9

3.2. Co-Citation Analysis

Co-citation analysis means that if two documents appear together in the reference list of a third citing document, the two documents form a co-citation relationship [33]. Since a basic cited document unit also contains information about the author and journal, in addition to co-citation analysis of the paper as a whole, you can also extract only the author information or journal information in the document to conduct co-citation analysis of the author or journal. Co-citation analysis of authors can obtain the distribution of highly co-cited authors in a certain field and identify influential scholars in the field. Co-citation analysis of journals provides a method to recognize important sources of knowledge in a certain field and can clarify which journals have influenced research in this field.

In the function parameter area, set TimeSpan to 1980–2024, Slice length to 1, TopN to 100, select Cited Journal, Cited Author, and Reference as node types according to different purposes and use the system default values for other parameters. Through co-citation analysis, we can obtain the ranking of the co-citation frequency of journals, authors, and documents.

3.2.1. Analysis of Co-Cited Journals

Academic journals, as important carriers of scientific knowledge, have a powerful role in promoting the communication and development of scientific research, and the analysis of the co-citation frequency of journals can determine the influence of journals [34]. Table 4 shows the top 10 journals in terms of co-citation frequency. Among them, *Sedimentology*, founded in 1962, has the highest co-citation frequency (601); followed by *Geology* (534), *Sedimentary Geology* (524), *Journal of Sedimentary Research* (481), *Palaeogeography Palaeoclimatology Palaeoecology* (452). Some comprehensive journals also have high co-citation frequencies, such as *Science* (412) and *Nature* (403). These journals have been cited more than 400 times in total and can be regarded as journals with important influence in the field of glauconite. The main publishing countries are the United States, England, and The Netherlands.

Table 4. Top 10 journals by co-citation frequency.

No.	Journals	Count	Centrality	CP	IF (2024)	JCR
1	*Sedimentology*	601	0.12	England	2.6	Q1
2	*Geology*	534	0.03	United States	4.8	Q1
3	*Sedimentary Geology*	524	0.01	The Netherlands	2.7	Q1
4	*Journal of Sedimentary Research*	481	0.03	United States	2	Q1
5	*Palaeogeography Palaeoclimatology Palaeoecology*	452	0.08	The Netherlands	2.6	Q1
6	*Clays and Clay Minerals*	440	0.05	United States	2	Q3
7	*Geological Society of America Bulletin*	436	0.27	United States	3.9	Q1
8	*Science*	412	0.23	United States	44.7	Q1
9	*Nature*	403	0.2	England	50.5	Q1
10	*Earth-Science Reviews*	402	0.1	The Netherlands	10.8	Q1

CP: country of publication; IF: impact factor.

3.2.2. Analysis of Co-Cited Authors

The co-cited author analysis identifies highly cited authors in a given field who are widely recognized by the academic community and whose contributions have undoubtedly had a significant impact on the respective field. Table 5 shows the top 10 authors in terms of co-citation frequency. The author with the most citations is Gilles S. Odin (432), who is one of the earliest authors to study glauconite. His theory of glauconite formation has made great contributions to subsequent research. The following are Alessandro Amorosi (215), Bilal U. Haq (152), Santanu Banerjee (136), Victor A. Drits (103), JF Burst (92), Andre Baldermann (88), SG McRae (88), SW Bailey (88), and Alain Meunier (86). The publications of these authors are worth studying because they have had a significant impact on glauconite research.

Table 5. Top 10 authors by co-citation frequency.

No.	Cited Author	Count	Centrality	Year
1	Gilles S. Odin	432	0.08	1980
2	Alessandro Amorosi	215	0.17	1995
3	Bilal U. Haq	152	0.30	1989
4	Santanu Banerjee	136	0.01	2013
5	Victor A. Drits	103	0.14	1986
6	J. F. Burst	92	0.22	1980
7	Andre Baldermann	88	0.01	2014
8	S. G. McRae	88	0.11	1980
9	S. W. Bailey	88	0.05	1983
10	Alain Meunier	86	0.05	2010

3.2.3. Analysis of Co-Cited Reference

The analysis of co-cited literature can reflect the composition of the knowledge structure of a research field, and the co-citation frequency is a direct indicator of the quality and attention of an academic paper, and the literature with a high co-citation frequency generally has an important impact on the development of the research field [35]. Table 6 shows the top 10 papers with the highest co-citation frequencies. The first-ranked paper is published by Santanu Banerjee. Four of the papers have Santanu Banerjee as the first author, which is consistent with the author analysis results. Three articles are from the *Journal of Palaeogeography*. Although this journal does not appear in Table 4, it still deserves special attention.

Table 6. Top 10 references by co-citation frequency.

No.	Count	Centrality	Year	Reference Information
1	43	0.01	2016	Banerjee S, 2016, *Journal of Palaeogeography*, V5, P43 [13]
2	34	0.01	2016	Banerjee S, 2016, *Sedimentary Geology*, V331, P12 [36]
3	26	0	2020	López-Quirós A, 2020, *American Mineralogist*, V105, P674 [37]
4	25	0	2019	López-Quirós A, 2019, *Scientific Reports*, V9, P13580 [8]
5	22	0.01	2017	Bansal U, 2017, *Marine and Petroleum Geology*, V82, P97 [38]
6	21	0.01	2017	Baldermann A, 2017, *Chemical Geology*, V453, P21 [39]
7	21	0.01	2018	Bansal U, 2018, *Journal of Palaeogeography*, V7, P99 [40]
8	19	0.01	2020	Banerjee S, 2020, *Journal of Palaeogeography*, V9, P27 [41]
9	19	0	2021	Choudhury TR, 2021, *Palaeogeography Palaeoclimatology Palaeoecology*, V571, P 110388 [42]
10	16	0.01	2015	Banerjee S, 2015, *Precambrian Research*, V271, P33 [43]

Santanu Banerjee et al. published an article titled "A review on palaeogeographic implications and temporal variation in glaucony composition" in the *Journal of Palaeogeography* in 2016. The article reviewed the paleogeographic significance and temporal variation of modern and ancient glauconite records [13]. Subsequently, Santanu Banerjee et al. published an article titled "Compositional variability of glauconites within the Upper Cretaceous Karai Shale Formation, Cauvery Basin, India: Implications for the evaluation of stratigraphic condensation" in *Sedimentary Geology* in 2016. The article studied the origin, evolution, composition, and structural variability of glauconites in the Cretaceous Karai Shale Formation in the Cauvery Basin, India and evaluated the effects of initial sedimentary material composition, genetic mode, stratigraphic condensation, and diagenetic alteration on the composition of glauconites [36]. López-Quirós et al. published an article titled "New insights into the nature of glauconite" in *American Mineralogist* in 2020. The article clarified the potassium-deficient characteristics of smectite (the predecessor mineral of glauconite) and that the maturation process of glauconite is completed by absorbing interlayer potassium ions (K^+) to stabilize the gradual loss of octahedral charge (Fe^{2+}/Fe^{3+}), thereby clarifying the process of transformation from smectite to glauconite from a mineralogical and structural perspective [37].

3.3. Research Hotspots and Frontier Analysis

3.3.1. Subject Co-Occurrence Characteristics

According to the subject classification of WOS, with the help of CiteSpace to analyze the retrieved literature data, we can know the subject coverage of glauconite-related literature published from 1980 to 2024. Table 7 lists the top 10 subject categories, which shows that the subject distribution of glauconite research is mainly concentrated in geosciences multidisciplinary, geology, mineralogy, and other related disciplines. Among them, geosciences multidisciplinary has the largest number of documents, up to 606 articles, accounting for 23.57% of the total. Soil science has the highest centrality of 0.46, reflecting the close relationship between glauconite and soil, followed by mineralogy, geology, and environmental sciences, showing a diversified interdisciplinary development trend.

Table 7. Top 10 subject categories.

No.	Subject	Count	Centrality
1	Geosciences Multidisciplinary	606	0.16
2	Geology	370	0.23
3	Mineralogy	197	0.41
4	Paleontology	184	0.09
5	Geochemistry Geophysics	168	0
6	Chemistry Physical	108	0
7	Soil Science	74	0.46
8	Environmental Sciences	71	0.22
9	Oceanography	54	0.2
10	Mining Mineral Processing	52	0.03

3.3.2. Research Hotspot Analysis

Keywords are a high-level summary of the topic of an article. Co-occurrence analysis of keywords in an article helps researchers understand the research hotspots, thematic directions, and research trends in a certain research field [44]. In the function parameter area, set TimeSpan to 1980–2024, slice length to 1, g-index to 10, node types to keyword, pruning to pathfinder, and other parameters are system default values. After analysis, a keyword knowledge graph is obtained, as shown in Figure 5. The top 10 keywords are ranked according to the frequency and centrality indicators, as shown in Table 8.

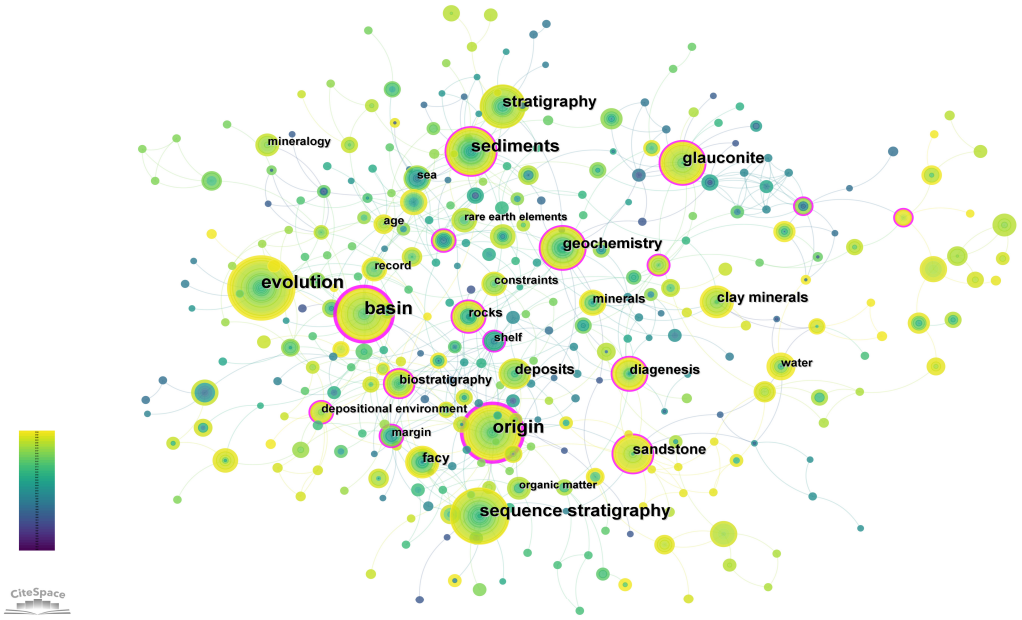


Figure 5. Keyword knowledge map of glauconite research from 1980 to 2024.

Table 8. Top 10 keywords by frequency and centrality.

No.	Keywords	Count	Keywords	Centrality
1	origin	175	origin	0.31
2	evolution	163	basin	0.21
3	basin	150	sediments	0.2
4	sequence stratigraphy	125	geochemistry	0.19
5	sediments	116	sandstone	0.16
6	stratigraphy	86	continental margin	0.14
7	glauconite	81	diagenesis	0.13
8	geochemistry	62	rocks	0.13
9	sandstone	54	glauconite	0.12
10	clay minerals	44	biostratigraphy	0.12

From the analysis of Table 8, we can see that the high-frequency keywords are origin, evolution, basin, sequence stratigraphy, and sediments. However, not all high-frequency keywords have high centrality, and it is not possible to accurately determine research hotspots by relying on high-frequency keywords. In the CiteSpace software, keywords with high centrality are easily regarded as turning points in the keyword knowledge graph and to a certain extent represent the research hotspots in this field [45]. From the perspective of centrality, the centrality of keywords such as origin, basin, sediments, geochemistry, sandstone, continental margin, diagenesis, rocks, glauconite, and biostratigraphy all exceeds 0.1. They are the supporting points of the network and play an effective supporting role. As a search term, glauconite appears relatively frequently and has little reference value, so it will be eliminated. Overall, origin, basin, sediments, geochemistry, and sandstone are the main research hotspots. In addition, through reading relevant literature, it was found that climate is also one of the research hotspots.

- Hotspot 1: Origin. The origin of glauconite is an important research topic in geology. There are three common explanations for the origin of glauconite, namely, verdissement, layer lattice, and replacement. Among them, the "verdissement theory" [1,9] proposed by Odin et al. is still widely accepted. This theory divides the formation and maturation of glauconite into two stages: the first stage is the formation of potassium-poor, iron-rich glauconite smectite (Fe (III) smectite precursor) via aggregation and precipitation in a water–rock interfacial environment rich in organisms, in the cavities of the organisms, or nucleated by fecal pellets; the second stage is that the Fe (III) smectite gradually enriches K^+ to form potassium-rich and iron-rich glauconite mica—that is, mature glauconite [37]. According to the "verdissement theory", the origin of glauconite is considered to be a dissolution, precipitation–recrystallization process [1,9].
- Hotspot 2: Basin. As an important type of geological structure, the basin has a significant impact on the distribution and formation of glauconite. The sedimentary environment in the basin is relatively stable, which is conducive to the accumulation and preservation of sediments, thus providing favorable conditions for the formation of glauconite. A large number of studies are related to it, such as the Jane Basin on the southern margin of the South Orkney Microcontinent (SOM) [46], the German Basin in Germany [47], the Guadalquivir Basin in Spain [48], the Cauvery Basin in India [36], the Narmada Basin in central India [40], the Jaisalmer Basin in India [42], and the Chhattisgarh Basin in India [43].
- Hotspot 3: Sediments. Long-term chemical exchange between sediments and seawater is a prerequisite for the formation of glauconite [1]. This chemical exchange can only occur at very shallow burial sites, which means that the physical characteristics of sediments (porosity, permeability, tortuosity) play a decisive role in the glauconite process [49]. Glauconite, as an authigenic clay mineral, usually forms distinct and easily recognizable green pellets at the sediment–seawater interface, which can serve as an important indicator for assessing clay authigenic in marine sediments [47].

- Hotspot 4: Geochemistry. Geochemistry integrates the basic principles and methods of geology and chemistry, becoming an important interdisciplinary subject in Earth science. In the study of glauconite, geochemical methods are widely used. By analyzing the chemical composition of major elements, trace elements, and isotopes in glauconite, the formation mechanism, material source, and evolution process of glauconite can be revealed. The geochemical methods currently used in the study of glauconite are mainly electron probe microanalysis (EPMA), energy dispersive spectroscopy (EDS), Fourier transform infrared absorption spectroscopy (FTIR), inductively coupled plasma optical emission spectroscopy (ICP-OES), and inductively coupled plasma mass spectrometry (ICP-MS). The chemical composition of glauconite, such as the content of K_2O, TFe_2O_3, MgO, and Al_2O_3, can be determined by electron probe microanalysis (EPMA) [8]. The proportion and variation of these components can reveal the maturity and formation environment of glauconite. Geochemical signatures can be used to infer the sedimentary environment at the time of glauconite formation, such as Ce anomaly values of the glauconite provide valuable information regarding redox conditions of the depositional setting [40,43].
- Hotspot 5: Sandstone. Sandstone is an important carrier for glauconite research, and a large amount of glauconite has been reported to be found in sandstone [13]. Studying glauconite in sandstone can provide information about the sedimentary environment, diagenesis, and mineral composition. For example, glauconite in sandstone can be used as an indicator to identify oil and gas reservoirs [50]. Glauconitic sandstone has been reported in many countries, including Russia, England, the United States, and India. Millet farms in Madhya Pradesh, India obtain higher yields using this sandstone as a potash fertilizer [51,52].
- Hotspot 6: Climate. Marine authigenic glauconite can be used as an important indicator of paleoclimate and paleoenvironment [8]. By studying the composition of glauconite in different strata, it is possible to reveal the evolution of paleoclimate over time, especially the alternation between cold and warm periods. Banerjee et al. pointed out that the high abundance of glauconite corresponds to warm climate intervals [13,41]. Specific paleoclimate events can affect the formation of glauconite, such as changes in the marine environment during the Paleocene–Eocene Thermal Maximum (PETM). Warm and humid climates are conducive to the long-term stability of glauconite, while extreme precipitation and runoff at the beginning of the PETM and the accelerated sedimentation rate hinder marine lithification [42].

3.3.3. Research Frontier Analysis

Keyword burst strength can detect keywords with a high-frequency change rate, the higher the burst intensity indicates that researchers pay more attention to them in a certain period, to determine the research frontier of the research field [45]. Through analysis, it was found that 21 keywords in the field of glauconite research had experienced bursts, as shown in Figure 6. In the figure, Year represents the earliest year when the keyword appeared, Intensity represents the burst intensity, and Begin and End represent the start and end times of the keyword burst. The light blue line segment indicates that there is no relevant literature published with the keyword, the dark blue line segment depicts the publication time of the relevant literature, and the red line segment corresponds to the start and end times of the keyword burst.

In terms of burst intensity, the shelf has the highest burst intensity (9.08), indicating that many scholars focused on the sedimentary environment of glauconite between 1994 and 2008. Modern glauconite minerals are formed in water at a depth of more than 50 m and are most commonly found in shelf and slope environments at depths of 200–300 m [4]. Santanu Banerjee et al. counted the modern and ancient production of marine glauconite, and the shelf origin of marine glauconite accounts for about 71% of the total records, and the study suggests that the shelf environment is a favorable site for the formation of glauconite [13]. In terms of period, the five keywords' sediments (1993–2007), shelf (1994–2008), margin

(1995–2005), sea (1998–2009), and sea level (2001–2016) all appeared for more than 10 years, reflecting the academic community's continued attention and research interest in these aspects during the corresponding period. Most Phanerozoic glauconites originated from shelf environments; warm seawater and high sea levels are conducive to the formation of glauconites, while deep sea conditions and low seawater temperatures are not conducive to their formation [13]. Fe, fertilizer, sandstone, removal, compositional characteristics, and provenance are keywords that have appeared frequently in recent years, reflecting the current research frontiers and future research trends in the field of glauconites. Through literature reading and WOS subject classification, the current research frontiers can be divided into three directions: Geology, Soil Science, and Environmental Science.

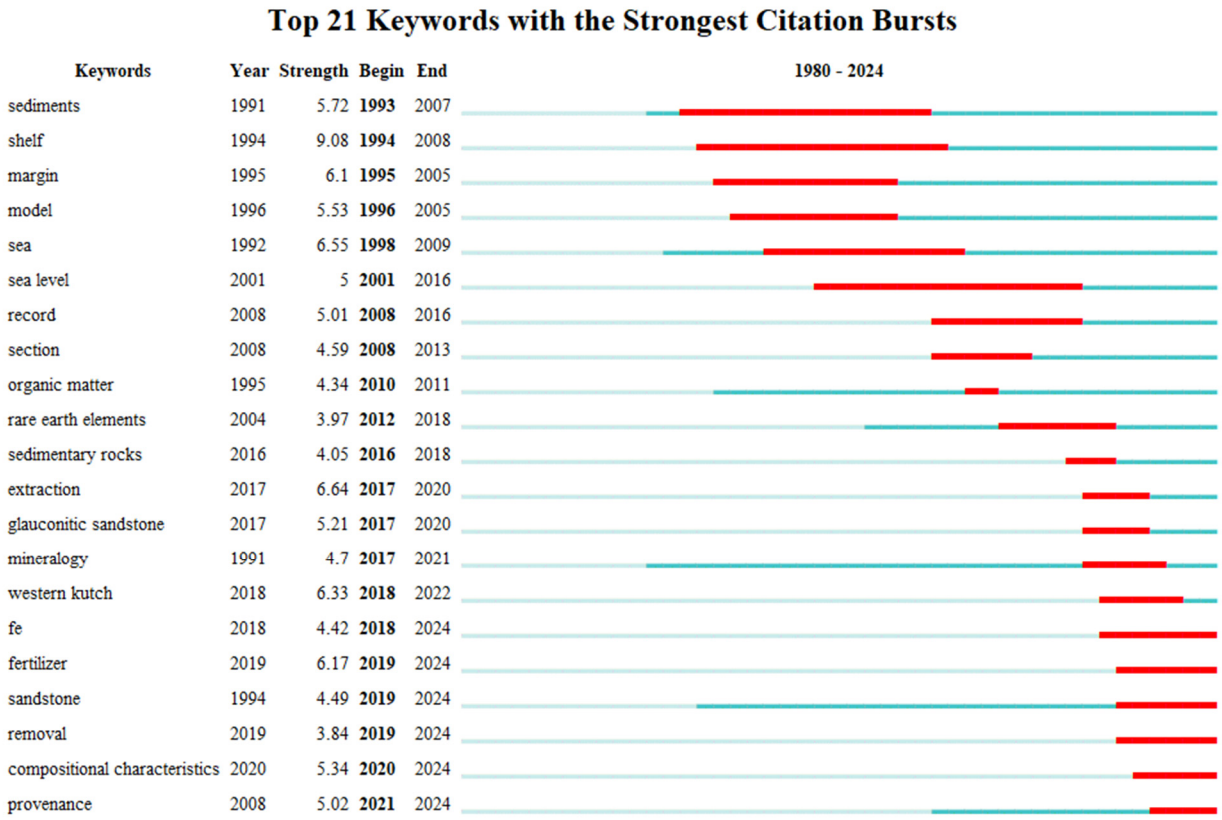


Figure 6. Keywords burst map of glauconite research from 1980 to 2024.

(1) Geology

The keywords are Fe, compositional characteristics, and provenance. Fe is very important for the formation of glauconite. López-Quirós A et al. pointed out that during sediment burial, due to anoxic conditions, Fe^{2+} was reduced and precipitated as sulfides, which limited the further development of glauconitization [8]. Baldermann et al. believed that the availability of Fe^{2+} in the reducing microenvironment (fecal pellets and foraminifera chambers) limits the rate of glauconitization and the maturity of glauconite minerals [6,39]. Glauconite, as an enricher of Fe, is crucial to understanding the marine Fe cycle. Rivers carry large amounts of soluble and highly reactive Fe to the ocean each year, with 8–33% of this elemental Fe enriched in the shallow water environment in the form of glauconite [47].

Compositional characteristics are the basis for studying the composition and properties of materials. Precambrian glauconite has chemical composition characteristics of high K_2O, Al_2O_3, MgO, and medium–low TFe_2O_3(total) content; most Phanerozoic glauconites have low–high K_2O, medium MgO, Al_2O_3, and high TFe_2O_3 content [40,43]. Glauconite can be divided into four types according to the percentage of K_2O content: nascent type (2%–4%), slightly evolved type (4%–6%), evolved type (6%–8%), and highly evolved type (>8%) [1,7]. The degree of glauconite mineral evolution depends on the residence time of the pellets

near the sediment-seawater interface, so the sedimentation rate is very important [13]. The variation in potassium content reflects the time scale of the formation process of glauconite, which may take about 10^3–10^4 years from the beginning of formation to the formation of early glauconite clay minerals and about 10^5–10^6 years to form highly evolved glauconite [1,37]. Odin and Matter regarded the TFe_2O_3 content between 10% and 15% as a compositional gap to distinguish illite (<10% TFe_2O_3) from glauconite (>15% TFe_2O_3) [1].

Provenance is the key to studying the origin and transportation of sediments. Glauconite is formed in different substrates, including fecal pellets, bioclasts, feldspar, mica, and quartz; fecal pellets and bioclasts are the most favorable substrates for glauconite formation, accounting for more than 76% of the records [13]. The source of the chemical elements necessary for glauconite formation remains controversial. Due to the low content of Fe, Al, and Si in normal seawater, there are no favorable conditions for direct precipitation of glauconite [8]. Instead, large inputs of continental crustal weathering products (including Fe, K, and Si) are the most commonly cited viable source of glauconitization in shallow marine sediments [1,53].

(2) Soil Science

The keywords are mainly fertilizer and sandstone. The application of glauconitic sandstone in soil, especially the research on its use as fertilizer, is an important research frontier. Glauconite is rich in potassium, iron, and other elements which are essential for the growth and development of plants. Therefore, many scholars have explored the potential of glauconitic sandstone as a fertilizer, which can be used as a substitute for potassium fertilizer [15,16,54]. Santos et al. used thermal and chemical treatment methods to study the dissolution of potassium in glauconitic sandstone [55]. Shekhar et al. developed a combined reduction roasting-leaching method to effectively recover potassium chloride suitable for fertilizer application in glauconitic sandstone [56]. Studies have shown that glauconite as a slow-release fertilizer can gradually release potassium and other trace elements, improve soil structure, increase crop yields, and reduce the use of chemical fertilizers, thereby being more environmentally friendly [57,58]. Some studies have reported the positive effects of glauconite on the growth of plants, such as wheat [57], sunflowers [59], and coffee [60].

(3) Environmental Science

The keyword is removal. The application of glauconite in environmental science has received widespread attention and has been studied for the removal of heavy metals and other pollutants from wastewater. Glauconite, as a low-cost and non-toxic natural adsorbent, is capable of removing contaminants such as Cs, Cr (VI), NH^{4+}, and PO^{4-} from aqueous solutions [61–64]. Modified ferrocyanide adsorbents based on aluminosilicates (glauconite and clinoptilolite) can effectively remediate land contaminated with radioactivity [65]. Additionally, studies have reported the modification of glauconite through thermal activation (TAG), acid activation (AAG), and the use of polyaniline (PAN) to enhance its removal efficiency and adsorption capacity [66,67].

4. Conclusions and Prospect

This article uses CiteSpace software to conduct a comprehensive visual analysis of glauconite research, covering countries/regions, institutions, authors, journals, references, and keywords, revealing the research status, hot spots, and future trends in this field. The following are the main conclusions of the study:

1. Research in the field of glauconite has shown a gradual growth trend in the past few decades. In the fitting curve, $R^2 = 0.91$. Especially since 2004, the number of publications has shown a significant J-shaped growth, showing that this field has received increasing attention and attention from the international academic community.
2. Glauconite research has formed an extensive international cooperation network, of which the United States, Russia, India, France, and England are the main contributors to research in this field. The Russian Academy of Sciences, the Centre National de la Recherche Scientifique, the Indian Institute of Technology-Bombay, and the Geological

Institute are institutions that publish a large number of papers. These institutions have a significant academic influence on glauconite research.

3. A large-scale scientific research cooperation network has been formed mainly by Santanu Banerjee, Victor A. Drits, Maxim Rudmin, Alessandro Amorosi, Tathagata Roy Choudhury, and Markus Wilmsen. The author with the most citations is Gilles S. Odin. These authors have great experience in the field of glauconite research. It has high academic influence, and its research results have promoted scientific development in this field.
4. In addition to comprehensive journals such as *Science* and *Nature*, journals such as *Sedimentology*, *Geology*, *Sedimentary Geology*, *Journal of Sedimentary Research*, *Palaeogeography Palaeoclimatology Palaeoecology*, and *Journal of Palaeogeography* are also important journals in the field of glauconite, and their publishing countries are mainly the United States, England, and the Netherlands. In addition, the top 10 cited documents from 1980 to 2024 are also identified and are worth referring to.
5. Glauconite research involves disciplines such as geology, mineralogy, soil science, and environmental science, showing its interdisciplinary characteristics and broad application prospects. Keyword analysis shows that origin, basin, sediment, geochemistry, sandstone, and climate are the hot spots of glauconite research. Keyword burst analysis reveals the rapid growth of keywords such as Fe, composition characteristics, provenance, fertilizer, sandstone, and removal, indicating the application potential of glauconite in environmental management and sustainable agricultural development in addition to the field of geology.

Glauconite research is an active and multidisciplinary field with important scientific significance and application potential. With the strengthening of international cooperation and the introduction of new technologies, glauconite research is expected to achieve more breakthrough results in the future and make greater contributions to solving environmental problems, improving agricultural productivity, and promoting sustainable development.

Through this analysis, we found that although CiteSpace is powerful, it also has some limitations. First, the data source is limited. The coverage of the database is limited and the data are incomplete. Second, CiteSpace does not support some document types. It is mostly concentrated on academic journal articles and conference papers. It has weak processing capabilities for other types of documents such as books, reports, patents, web pages, etc., and may not be able to provide comprehensive document analysis. The premise of using this software is that the user needs to conduct a certain literature review in the research field to ensure the objectivity of the data.

Author Contributions: Conceptualization, M.Z. and S.C.; methodology, K.N.; software, K.N.; validation, K.N., S.C. and Z.R.; formal analysis, K.N.; investigation, K.N.; resources, K.N.; data curation, K.N.; writing—original draft preparation, K.N.; writing—review and editing, K.N.; visualization, K.N.; supervision, S.C.; project administration, M.Z.; funding acquisition, M.Z. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Chinese National Natural Science Foundation (NO. 41102065, 41872110), Yunnan University (CZ21623201, C1762101030017).

Data Availability Statement: Data are available upon request from the authors.

Acknowledgments: Many thanks to the anonymous reviewers.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Odin, G.S.; Matter, A. De Glauconiarum Origine. *Sedimentology* **1981**, *28*, 611–641. [CrossRef]
2. Odin, G.S.; Letolle, R. Glauconitization and Phosphatization Environments a Tentative Comparison. In *Marine Phosphorites—Geochemistry, Occurrence, Genesis*; Bentor, Y.K., Ed.; SEPM Special Publication: Claremore, OK, USA, 1980.
3. Morton, A.C.; Merriman, R.J.; Mitchell, J.G. Genesis and Significance of Glauconitic Sediments of the Southwest Rockall Plateau. *Initial. Rep. Deep. Sea Drill. Proj.* **1984**, *81*, 645–652.

4. Chafetz, H.S.; Reid, A. Syndepositional Shallow-Water Precipitation of Glauconitic Minerals. *Sediment. Geol.* **2000**, *136*, 29–42. [CrossRef]
5. Giresse, P.; Wiewióra, A. Stratigraphic Condensed Deposition and Diagenetic Evolution of Green Clay Minerals in Deep Water Sediments on the Ivory Coast–Ghana Ridge. *Mar. Geol.* **2001**, *179*, 51–70. [CrossRef]
6. Baldermann, A.; Warr, L.N.; Grathoff, G.H.; Dietzel, M. The Rate and Mechanism of Deep-Sea Glauconite Formation at the Ivory Coast-Ghana Marginal Ridge. *Clays Clay Miner.* **2013**, *61*, 258–276. [CrossRef]
7. Amorosi, A. The Occurrence of Glaucony in the Stratigraphic Record: Distribution Patterns and Sequence-Stratigraphic Significance. In *Linking Diagenesis to Sequence Stratigraphy*; John Wiley & Sons, Ltd.: Hoboken, NJ, USA, 2013; pp. 37–53. ISBN 978-1-118-48534-7.
8. López-Quirós, A.; Escutia, C.; Sánchez-Navas, A.; Nieto, F.; Garcia-Casco, A.; Martín-Algarra, A.; Evangelinos, D.; Salabarnada, A. Glaucony Authigenesis, Maturity and Alteration in the Weddell Sea: An Indicator of Paleoenvironmental Conditions before the Onset of Antarctic Glaciation. *Sci. Rep.* **2019**, *9*, 13580. [CrossRef]
9. Odin, G.S.; Fullagar, P.D. Chapter C4 Geological Significance of the Glaucony Facies. In *Developments in Sedimentology*; Odin, G.S., Ed.; Green Marine Clays; Elsevier: Amsterdam, The Netherlands, 1988; Volume 45, pp. 295–332.
10. Burst, J.F. "Glauconite" Pellets: Their Mineral Nature and Applications to Stratigraphic Interpretations. *AAPG Bull.* **1958**, *42*, 310–327. [CrossRef]
11. Hower, J. Some Factors Concerning the Nature and Origin of Glauconite. *Am. Mineral.* **1961**, *46*, 313–334.
12. Dasgupta, S.; Chaudhuri, A.K.; Fukuoka, M. Compositional Characteristics of Glauconitic Alterations of K-Feldspar from India and Their Implications. *J. Sediment. Res.* **1990**, *60*, 277–281. [CrossRef]
13. Banerjee, S.; Bansal, U.; Thorat, A.V. A Review on Palaeogeographic Implications and Temporal Variation in Glaucony Composition. *J. Palaeogeogr.* **2016**, *5*, 43–71. [CrossRef]
14. Nassar, M.Y.; El-Shahat, M.F.; Osman, A.; Sobeih, M.M.; Zaid, M.A. Adsorptive Removal of Manganese Ions from Polluted Aqueous Media by Glauconite Clay-Functionalized Chitosan Nanocomposites. *J. Inorg. Organomet. Polym. Mater.* **2021**, *31*, 4050–4064. [CrossRef]
15. Rudmin, M.; Banerjee, S.; Mazurov, A.; Makarov, B.; Martemyanov, D. Economic Potential of Glauconitic Rocks in Bakchar Deposit (S-E Western Siberia) for Alternate Potash Fertilizer. *Appl. Clay Sci.* **2017**, *150*, 225–233. [CrossRef]
16. Shekhar, S.; Mishra, D.; Agrawal, A.; Sahu, K.K. Physical and Chemical Characterization and Recovery of Potash Fertilizer from Glauconitic Clay for Agricultural Application. *Appl. Clay Sci.* **2017**, *143*, 50–56. [CrossRef]
17. Hu, H.; Dai, J.; Jin, Y.; Liu, X. Bibliometric Analysis on Desertification Restoration Based on CiteSpace. *Arab. J. Geosci.* **2021**, *14*, 72. [CrossRef]
18. Chen, S.; Duan, Y. Research on status, focus, and developing trend of agricultural carbon effect in China. *Adv. Earth Sci.* **2023**, *38*, 86–98. (In Chinese with English Abstract) [CrossRef]
19. Wang, Q.; Chang, C.; Wu, L.; Zhang, X. Using CiteSpace to Visualize Black Shale Research of China. *Adv. Earth Sci.* **2023**, *38*, 1224–1242. (In Chinese with English Abstract)
20. Zhang, H.; Xin, H.; Zhao, M.; Bi, C.; Xiao, Y.; Li, Y.; Qin, C. Global Research Trends on the Relationship between IBD and CRC: A Bibliometric Analysis from 2000 to 2023. *J. Health Popul. Nutr.* **2024**, *43*, 83. [CrossRef]
21. Wei, S.; Du, T.; Zhang, L.; Li, X.; Wang, Z.; Ning, Y.; Tang, Y.; Wu, X.; Han, J. A Comprehensive Exploration of Astrocytes in Migraine: A Bibliometric and Visual Analysis. *Eur. J. Med. Res.* **2024**, *29*, 321. [CrossRef]
22. Yang, L.; Wang, Q.; Bai, X.; Deng, J.; Hu, Y. Mapping of Trace Elements in Coal and Ash Research Based on a Bibliometric Analysis Method Spanning 1971–2017. *Minerals* **2018**, *8*, 89. [CrossRef]
23. Chen, C. CiteSpace II: Detecting and Visualizing Emerging Trends and Transient Patterns in Scientific Literature. *J. Am. Soc. Inf. Sci. Technol.* **2006**, *57*, 359–377. [CrossRef]
24. Freeman, L.C. Centrality in Social Networks: Conceptual Clarification. In *Social Network: Critical Concepts in Sociology*; Scott, J., Ed.; Routledge: London, UK, 2002; Volume 1, pp. 238–263.
25. Yu, D.; Xu, Z.; Pedrycz, W.; Wang, W. Information Sciences 1968–2016: A Retrospective Analysis with Text Mining and Bibliometric. *Inf. Sci.* **2017**, *418–419*, 619–634. [CrossRef]
26. Prather, J.K. Glauconite. *J. Geol.* **1905**, *13*, 509–513. [CrossRef]
27. Kim, M.C.; Chen, C. A Scientometric Review of Emerging Trends and New Developments in Recommendation Systems. *Scientometrics* **2015**, *104*, 239–263. [CrossRef]
28. Zhang, Q.; Zhou, Y.; He, J.; Zhu, B.; Han, F.; Long, S. A Review on Global Cooperation Network in the Interdisciplinary Research of Geochemistry Combined with Artificial Intelligence. *Minerals* **2023**, *13*, 1332. [CrossRef]
29. Chen, C.; Dubin, R.; Kim, M.C. Emerging Trends and New Developments in Regenerative Medicine: A Scientometric Update (2000–2014). *Expert Opin. Biol. Ther.* **2014**, *14*, 1295–1317. [CrossRef]
30. Yang, Q.; Liu, M.; Chen, H.; Xu, X. Research on the Influence Evaluation of Scientific Research Institutions Based on the Output of Journal Papers: Case Study of Research Field of Wuyishan Biology. *Inf. Res.* **2020**, *1*, 96–101. (In Chinese with English Abstract) [CrossRef]
31. Odin, G.S. *Numerical Dating in Stratigraphy*; John Wiley & Sons Publication: Hoboken, NJ, USA, 1982.
32. Odin, G.S. *Green Marine Clays: Oolitic Ironstone Facies, Verdine Facies, Glaucony Facies and Celadonite-Bearing Rock Facies—A Comparative Study*; Elsevier: Amsterdam, The Netherlands, 1988; ISBN 978-0-08-086959-9.

33. Li, J.; Chen, C. *CiteSpace: Text Mining and Visualization in Scientific Literature*, 3rd ed.; Capital University of Economics and Business Press: Beijing, China, 2016; pp. 145–184.
34. Wang, K.; Huang, X.; Wu, J. Comprehensive Evaluation of Journals Based on Altmetrics and Citation Analysis. *Inf. Sci.* **2021**, *39*, 169–177. (In Chinese with English Abstract) [CrossRef]
35. Yang, Y.; Li, H.; Ma, K.; Wang, Y.; Niu, S. Actinomycetes and their metabolites: Visual analysis based on CiteSpace. *Acta Microbiol. Sin.* **2022**, *62*, 3825–3843. (In Chinese with English Abstract) [CrossRef]
36. Banerjee, S.; Bansal, U.; Pande, K.; Meena, S.S. Compositional Variability of Glauconites within the Upper Cretaceous Karai Shale Formation, Cauvery Basin, India: Implications for Evaluation of Stratigraphic Condensation. *Sediment. Geol.* **2016**, *331*, 12–29. [CrossRef]
37. López-Quirós, A.; Sánchez-Navas, A.; Nieto, F.; Escutia, C. New Insights into the Nature of Glauconite. *Am. Miner.* **2020**, *105*, 674–686. [CrossRef]
38. Bansal, U.; Banerjee, S.; Pande, K.; Arora, A.; Meena, S.S. The Distinctive Compositional Evolution of Glauconite in the Cretaceous Ukra Hill Member (Kutch Basin, India) and Its Implications. *Mar. Pet. Geol.* **2017**, *82*, 97–117. [CrossRef]
39. Baldermann, A.; Dietzel, M.; Mavromatis, V.; Mittermayr, F.; Warr, L.N.; Wemmer, K. The Role of Fe on the Formation and Diagenesis of Interstratified Glauconite-Smectite and Illite-Smectite: A Case Study of Upper Cretaceous Shallow-Water Carbonates. *Chem. Geol.* **2017**, *453*, 21–34. [CrossRef]
40. Bansal, U.; Banerjee, S.; Ruidas, D.K.; Pande, K. Origin and Geochemical Characterization of the Glauconites in the Upper Cretaceous Lameta Formation, Narmada Basin, Central India. *J. Palaeogeogr.* **2018**, *7*, 99–116. [CrossRef]
41. Banerjee, S.; Choudhury, T.R.; Saraswati, P.K.; Khanolkar, S. The Formation of Authigenic Deposits during Paleogene Warm Climatic Intervals: A Review. *J. Palaeogeogr.* **2020**, *9*, 27. [CrossRef]
42. Roy Choudhury, T.; Banerjee, S.; Khanolkar, S.; Saraswati, P.K.; Meena, S.S. Glauconite Authigenesis during the Onset of the Paleocene-Eocene Thermal Maximum: A Case Study from the Khuiala Formation in Jaisalmer Basin, India. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* **2021**, *571*, 110388. [CrossRef]
43. Banerjee, S.; Mondal, S.; Chakraborty, P.P.; Meena, S.S. Distinctive Compositional Characteristics and Evolutionary Trend of Precambrian Glaucony: Example from Bhalukona Formation, Chhattisgarh Basin, India. *Precambrian Res.* **2015**, *271*, 33–48. [CrossRef]
44. Li, X. Research Progress and Trend of Integration of Chinese Cultural Industry and Tourism Industry: Based on Catespace Analysis. *Econ. Geogr.* **2019**, *39*, 212–220. (In Chinese with English Abstract) [CrossRef]
45. Li, J.; Zhao, X.; Wang, Y.; Yang, F. Analysis of hot spots and trends of e-commerce logistics distribution in China. *J. Commer. Econ.* **2017**, *17*, 90–92. (In Chinese with English Abstract)
46. Bohoyo, F.; Galindo-Zaldívar, J.; Maldonado, A.; Schreider, A.A.; Suriñach, E. Basin Development Subsequent to Ridge-Trench Collision: The Jane Basin, Antarctica. *Mar. Geophys. Res.* **2002**, *23*, 413–421. [CrossRef]
47. Baldermann, A.; Banerjee, S.; Czuppon, G.; Dietzel, M.; Farkaš, J.; Löhr, S.; Moser, U.; Scheiblhofer, E.; Wright, N.M.; Zack, T. Impact of Green Clay Authigenesis on Element Sequestration in Marine Settings. *Nat. Commun.* **2022**, *13*, 1527. [CrossRef]
48. Fernández-Landero, S.; Fernández-Caliani, J.C. Mineralogical and Crystal-Chemical Constraints on the Glauconite-Forming Process in Neogene Sediments of the Lower Guadalquivir Basin (SW Spain). *Minerals* **2021**, *11*, 578. [CrossRef]
49. Meunier, A.; El Albani, A. The Glauconite–Fe-Illite–Fe-Smectite Problem: A Critical Review. *Terra Nova* **2007**, *19*, 95–104. [CrossRef]
50. Yang, X.-F.; Ma, Z.-Z.; Zhou, Y.-B.; Zhang, Z.-W.; Liu, Y.-M.; Wang, D.-D.; Zhao, Y.-B. Reservoir Characteristics and Hydrocarbon Accumulation of the Glauconitic Sandstone in the Tarapoa Block, Oriente Basin, Ecuador. *J. Pet. Sci. Eng.* **2019**, *173*, 558–568. [CrossRef]
51. Rawlley, R.K. Mineralogical Investigations on an Indian Glauconitic Sandstone of Madhya Pradesh State. *Appl. Clay Sci.* **1994**, *8*, 449–465. [CrossRef]
52. Rao, C.S.; Rao, A.S. Characterization of Indigenous Glauconitic Sandstone for Its Potassium—Supplying Potential by Chemical, Biological, and Electroultrafiltration Methods. *Commun. Soil Sci. Plant Anal.* **1999**, *30*, 1105–1117. [CrossRef]
53. Peters, S.E.; Gaines, R.R. Formation of the 'Great Unconformity' as a Trigger for the Cambrian Explosion. *Nature* **2012**, *484*, 363–366. [CrossRef]
54. Franzosi, C.; Castro, L.N.; Celeda, A.M. Technical Evaluation of Glauconies as Alternative Potassium Fertilizer from the Salamanca Formation, Patagonia, Southwest Argentina. *Nat. Resour. Res.* **2014**, *23*, 311–320. [CrossRef]
55. Santos, W.O.; Mattiello, E.M.; da Costa, L.M.; Abrahão, W.A.P.; de Novais, R.F.; Cantarutti, R.B. Thermal and Chemical Solubilization of Verdete for Use as Potassium Fertilizer. *Int. J. Miner. Process.* **2015**, *140*, 72–78. [CrossRef]
56. Shekhar, S.; Mishra, D.; Agrawal, A.; Sahu, K.K. Physico-Chemical Treatment of Glauconitic Sandstone to Recover Potash and Magnetite. *J. Clean. Prod.* **2017**, *147*, 681–693. [CrossRef]
57. Rudmin, M.; Banerjee, S.; Makarov, B.; Mazurov, A.; Ruban, A.; Oskina, Y.; Tolkachev, O.; Buyakov, A.; Shaldybin, M. An Investigation of Plant Growth by the Addition of Glauconitic Fertilizer. *Appl. Clay Sci.* **2019**, *180*, 105178. [CrossRef]
58. Rudmin, M.; Banerjee, S.; Makarov, B.; Belousov, P.; Kurovsky, A.; Ibraeva, K.; Buyakov, A. Glauconite-Urea Nanocomposites As Polyfunctional Controlled-Release Fertilizers. *J. Soil Sci. Plant Nutr.* **2022**, *22*, 4035–4046. [CrossRef]
59. Dos Torqueti, S.T.S.; Boldrin, K.V.F.; do Nascimento, Â.M.P.; de Paiva, P.D.O.; Furtini Neto, A.E.; Luz, I.C.A. Alternative Potassium Source for the Cultivation of Ornamental Sunflower. *Ciênc. Agrotec.* **2016**, *40*, 257–264. [CrossRef]

60. De Dias, K.G.L.; Guimarães, P.T.G.; do Carmo, D.L.; Reis, T.H.P.; de Lacerda, J.J.J. Alternative Sources of Potassium in Coffee Plants for Better Soil Fertility, Productivity, and Beverage Quality. *Pesq. Agropec. Bras.* **2018**, *53*, 1355–1362. [CrossRef]
61. Xia, L.; David, T.; Verbeeck, M.; Bruneel, Y.; Smolders, E. Iron Rich Glauconite Sand as an Efficient Phosphate Immobilising Agent in River Sediments. *Sci. Total Environ.* **2022**, *811*, 152483. [CrossRef] [PubMed]
62. Younes, H.; Mahanna, H.; El-Etriby, H.K. Fast Adsorption of Phosphate (PO_4^-) from Wastewater Using Glauconite. *Water Sci. Technol.* **2019**, *80*, 1643–1653. [CrossRef]
63. Belousov, P.; Semenkova, A.; Egorova, T.; Romanchuk, A.; Zakusin, S.; Dorzhieva, O.; Tyupina, E.; Izosimova, Y.; Tolpeshta, I.; Chernov, M.; et al. Cesium Sorption and Desorption on Glauconite, Bentonite, Zeolite, and Diatomite. *Minerals* **2019**, *9*, 625. [CrossRef]
64. Naghipour, D.; Taghavi, K.; Ashournia, M.; Jaafari, J.; Arjmand Movarrekh, R. A Study of Cr(VI) and NH4+adsorption Using Greensand (Glauconite) as a Low-Cost Adsorbent from Aqueous Solutions. *Water Environ. J.* **2020**, *34*, 45–56. [CrossRef]
65. Voronina, A.V.; Blinova, M.O.; Semenishchev, V.S.; Gupta, D.K. Returning Land Contaminated as a Result of Radiation Accidents to Farming Use. *J. Environ. Radioact.* **2015**, *144*, 103–112. [CrossRef]
66. Younes, H.; El-Etriby, H.K.; Mahanna, H. High Removal Efficiency of Reactive Yellow 160 Dye from Textile Wastewater Using Natural and Modified Glauconite. *Int. J. Environ. Sci. Technol.* **2022**, *19*, 5659–5674. [CrossRef]
67. Salah, D.; Hamd, A.; Soliman, N.K.; Elzanaty, A.M.; Alanazi, A.M.; Shaban, M.; El-Sayed, R.; Ahmed, S.A. Polyaniline/Glauconite Nanocomposite Adsorbent for Congo Red Dye from Textile Wastewater. *Separations* **2022**, *9*, 384. [CrossRef]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.