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Bibliometric Analysis of Organic Facies Studies Between 1979-2024

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Abstract: Organic facies constitute criteria aimed at assessing the distribution of organic accumulations across geological time and space, utilizing physical, chemical, and biological processes. In the realm of petroleum geology research, the assessment of organic facies stands as pivotal in determining the hydrocarbon source rock potential within a sedimentary basin or succession, employing organic petrographic and geochemical methodologies. Originally initiated by researchers focusing on coal-bearing units, this subject subsequently evolved into a cornerstone of petroleum geology studies. This study endeavors to furnish a comprehensive overview of organic facies research through bibliometric analysis, scrutinizing the evolution of organic facies, pinpointing significant contributions, and delineating the most fruitful research domains. Leveraging the Scopus database, this study conducted analyses utilizing the R Studio program and VOSviewer tool. The countries leading in terms of article count are China, the United States, and Brazil. The paper titled "Maturity parameters based on aromatic hydrocarbons: "Organic Geochemistry" emerges as the journal with the highest publication count in the field of organic facies, with China University of Petroleum emerging as the institution spearheading research in this domain. Since 2010, organic facies studies have found application in evaluating unconventional energy resources, making substantial contributions to the petroleum sector. The findings of this study furnish professionals and researchers in the field of organic facies with crucial insights into the current landscape and advancements, while also charting a course for future research endeavors.

Keywords: Organic facies, shale gas, Bibliometric Analysis, Biblioshiny, VOSviewer.

1979:2024 Yılları Arasındaki Organik Fasiyes Çalışmalarının Bibliyometrik Analizi

Özet: Organik fasiyes, organik birikimlerin jeolojik zaman ve mekandaki dağılımlarını kontrol eden fiziksel, kimyasal ve biyolojik süreçleri değerlendirmeye yönelik kriterlerdir. Petrol jeolojisi araştırmalarda organik fasiyes değerlendirmesinin en önemli nedeni bir sedimanter havza ya da sedimanter istifin hidrokarbon kaynak kaya potansiyelinin organik petrografi ve organik jeokimyasal yöntemler kullanılarak belirlenmesidir. Araştırmacılar tarafından kömürlü birimlerde başlatılan bu konu sonraki yıllarda petrol jeolojisi çalışmalarının başlıca alanı olmuştur. Bu çalışma, bibliyometrik analiz aracılığıyla, organik fasiyes araştırma konusuna bütünsel bir bakış sunarak organik fasiyes konusunun gelişimini incelemekte, önemli katkıda bulunan çalışmaları ve en etkili araştırma alanlarını belirlenmeyi amaçlamaktadır. Çalışmada Scopus veri tabanından yararlanılmış ve R Stüdyo programı ve VOSviewer araçlarını kullanarak analizler gerçekleştirilmiştir. Makale sayısı bakımından en çok çalışmanın yapıldığı ülkeler Çin, ABD ve Brezilya'dır. Organik fasiyes alanında en fazla çalışmanın yayımlandığı dergi "Organic Geochemistry", bu konuda en fazla araştırma yapan üniversite ise Chine University of Petroleum'dur. 2010 yılından itibaren petrol sektörüne önemli katkısı olan ankonvansiyonel enerji kaynaklarının değerlendirilmesi için de organik fasiyes çalışmaları kullanılmıştır. Bu çalışmanın bulguları Organik fasiyes alanıyla ilgili profesyonellere ve araştırmacılara mevcut durum ve gelişmelerle ilgili önemli bilgiler verirken, gelecekteki araştırmalar için yol haritası da sağlamaktadır.

Anahtar Kelimeler: Organik fasiyes, Şeyl gaz, Bibliyometrik Analiz, Biblioshiny, VOSviewer.

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1. 1. Introduction

1.1. Concept of Organic Facies

Although its use dates back to ancient times, oil has been the unchanging leader of the global energy sector for nearly 150 years, and its continued dominance in today's world ensures that exploration for new production areas continues. Increasing oil and gas demand leads to exploration in more difficult areas (such as deep and ultra-deep waters, Arctic region), which brings many challenges, especially cost [1-5]. Therefore, efforts are being made to increase the successful discovery rates in oil and gas targeted exploration with the use of advanced technology and detailed petroleum system modeling [6-10].

In petroleum geology, organic facies investigations hold paramount importance in assessing the hydrocarbon source rock potential of sedimentary basins or successions using organic petrographic and geochemical methods [11-17]. Geologists, during surface geology mapping, the initial step in petroleum or natural gas exploration, utilize organic facies analysis to predict the geographic distribution of petroleum source rocks, estimate petroleum production timing, and identify migration pathways to potential reservoir traps [15-18].

Organofacies analysis is often interpreted in combination with other sedimentological methods such as lithofacies analysis and geochemical analysis to provide comprehensive interpretations of sedimentary stacks. These studies play a vital role in unraveling the complex interplay between organic matter and sedimentary processes, facilitating the reconstruction of paleoenvironmental conditions. Therefore, by integrating findings from oil exploration and organic facies studies, oil and gas companies can make informed decisions regarding exploration and production activities, ultimately optimizing resource discovery and extraction efforts.

In essence, organic facies are criteria for assessing the distribution of organic sediments across geological time and space through physical, chemical, and biological processes [11-13,19].

1.2. Petroleum Geology and Organic Facies Studies

Since their inception in petroleum and natural gas research, palynofacies analysis and geochemical methods (such as TOC, pyrolysis, biomarkers) have been employed together to characterize sedimentary organic matter [12,18-24].

The first studies on organic facies started with the identification of different microlithotypes as organic facies by coal petrographers using various physical and chemical data. In the early 1960s, Krejci-Graf [25-27] categorized organic matter into four groups based on the oxygen content in the depositional environment and stated that low oxygen in the depositional environment indicates a high tendency of organic matter to form oil. Numerous researchers, such as Breger & Brown [28], Tissot et al., [29], Parparova & Nerucheu [30], Cornelius [31], Middelburg et al., [32], and Pasley [33], delved into the relationship between the depositional environment, organic matter type, and petroleum generation potential.

Cornford et al. [34] defined "organofacies" as organo-petrographic and geochemical parameters characterizing a specific sedimentary association. In the 1980s, organic facies studies gained popularity in petroleum geology, with Rogers [35] providing one of the earliest definitions, emphasizing organic content, source of organic matter, and depositional environment. Jones & Demaison [20] and Jones [36] defined organic facies as a mapable subdivision of a defined stratigraphic unit based on the characteristics of its organic constituents, excluding inorganic

components. Tyson [37] described organic facies as a sediment mass containing various organic components recognizable by microscopy or associated with characteristic bulk organic geochemical composition. Habib [38] recognized the palynological evaluation of organic matter as a determinable aspect of organic facies.

Powell [39] considered depositional processes' effects on organic matter composition for potential hydrocarbon source rock formation. Jones [19] classified organic facies into A, AB, B, BC, C, CD, and D based on organic geochemical data. Fang et al. [18] divided organic facies into five groups based on kerogen types in the Yitong Graben (China). Similarly, Tuweni & Tyson [23] stated that combining TOC and pyrolysis data with palynofacies analysis is an excellent tool for characterizing organic facies. Baskin [24] classified organic facies into A, B, B-C, C, and D based on organic matter composition utilizing Rock-Eval pyrolysis data. Peters et al. [40] defined organic facies by evaluating primary organisms, paleo-depositional environment, and diagenesis of organic matter together. Generally, "Continental Organic Facies" has been defined as gas-producing, and "Marine Organic Facies" as oil-producing. The accumulation of gas and oil within reservoirs depends not only on organic facies but also on the maturity level of organic matter in different geological settings.

Jones [19] defined seven organic facies primarily based on geochemical rather than optical data. Pepper & Corvi [22] classified six facies types based on organic matter and depositional environment characteristics.

In the 2000s, instead of conceptual studies, more practical applications, especially for the exploration of conventional resources such as shale gas, attracted attention [9,41-47]. Today, organic facies assessments for conventional petroleum geology studies or for shale gas exploration, especially from unconventional sources, are ongoing [48-55].

With this study, it is aimed to present some striking information about the change process of studies on this subject in the international arena. The bibliometric analysis used in this context is an important method used to investigate and analyze data in the scientific literature [56]. With this method, bibliometric analysis of articles related to organic facies was carried out. Through the following research questions, this paper aims to provide guidance through bibliometric analysis.

2. Material and Method

In this study, a single database was used to avoid including the same or overlapping articles in the analysis. Among the databases, Google Scooler makes it easier to find citations scanned in more indexes. However, Web of Science and Scopus effectively determine the citations scanned within their scope. In this study, the Scopus database, where reliable and qualified studies are published for bibliometric analysis, was preferred for the data [57-59]. Data related to organic facies was downloaded from the Scopus database using the keyword "Organic facies." Scientific studies containing this keyword were included in the evaluation scope. The search criteria limited the data to English-language publications with a publication date until February 2024. Non-English scientific studies were excluded. A total of 384 articles from 130 sources (journals, books, etc.) related to organic facies were analyzed from 1979 to 2024. The analysis covered aspects such as annual growth rate, authors, keywords, references, and citation per document.

3. Organic Facies Bibliometric Analysis

3.1 Descriptive Analysis of Publications

In this study, the articles were evaluated using descriptive analysis. Analyses such as the most prolific journals, the most cited articles, the countries with the most research in this field, and the most productive institutions were used.

3.1.1 Overview of the Database

Descriptive analyses for organic facies were conducted using Biblioshiny. The basic information in the data file is shown in Figure 1. A search in the Scopus database from 1979 to 2024 identified 384 articles related to organic facies in 130 sources (journals, books, etc.). The annual growth rate was 0%, with a total of 1075 authors, 52 of whom were single authors, and 27.86% of the articles were international collaborations. The number of co-authors per document was 3.7, the number of keywords used by the authors was 1029, there were 17510 references, the average age of the documents was 19.1 years, and the average citation per document was 32.6.

Figure 1. Key Data Obtained in the Scope of the Study.

3.1.2 Annual Article Number Increase

Figure 2 shows the change in the number of documents over time between 1979-2024 in the bibliometric analysis of organic facies studies. Although there are occasional decreases between "2011-2021", a general increase is observed, while a significant decrease is observed in the last 2 years.

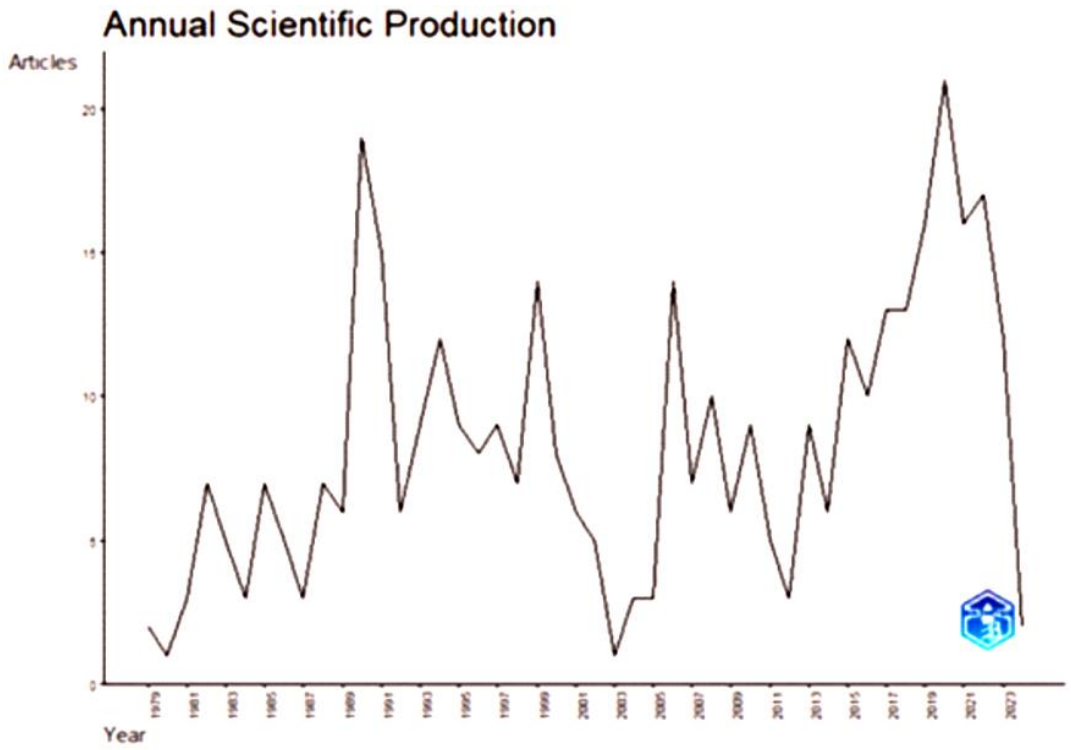

Figure 2. Distribution of "Organic Facies" Studies Over the Years in Research.

According to Figure 2, the interest among researchers worldwide in "Organic Facies" appears to vary from year to year. Regarding publication counts, there were 2 publications in 2024, 12 in 2023, 17 in 2022, 16 in 2021, and 21 in 2020. Particularly noteworthy are the years 2020, with 21 publications, 1990 with 19, and 2022 with 17 publications, which experienced the highest increase in the number of articles. In this analysis covering the years 1979-2024, it was determined that the least scientific production occurred in 2003 and 1980. It was determined that one article was published in 2003 and 1980.

3.1.3 Annual Average Citation Status

The annual citation status of "Organic Facies" studies in bibliometric analysis is illustrated in Figure 3.

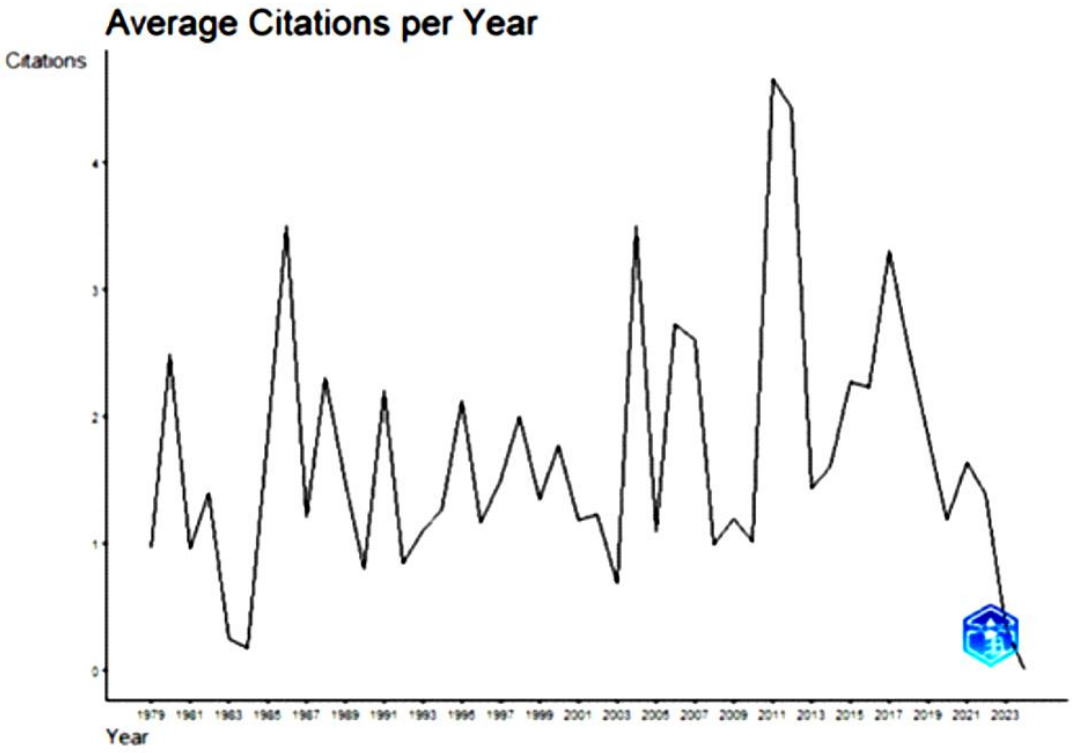

Figure 3. Annual Average Citation Trend of Organic Facies Studies.

When the average citation trends between 1979 and 2024 are examined, it can be said that the interest among scientists worldwide in Organic facies varies by year. The average total citation per article per year is 0.34 in 2023, 1.39 in 2022, and 1.64 in 2021. The peak average citation per article in studies concerning organic facies was 4.66 in 2011 and 4.44 in 2012. The lowest citation trend in studies on organic facies is in 1984 with 0.17. The distribution of article production and citation transitions according to the registration years scanned in Scopus until February 2024 analyzed in the research is shown in more detail in Table 1.

Table 1: Distribution of Organic Facies Studies over the Years and Annual Average Citation Trend

Year	Articles	MeanTCperYear	CitableYears
1979	2	0,96	46
1980	1	2,49	45
1981	3	0,96	44
1982	7	1,4	43
1983	5	0,25	42
1984	3	0,17	41
1985	7	1,84	40
1986	5	3,51	39
1987	3	1,21	38
1988	7	2,31	37
1989	6	1,48	36
1990	19	0,8	35
1991	15	2,21	34
1992	6	0,84	33

1993	9	1,11	32
1994	12	1,26	31
1995	9	2,13	30
1996	8	1,16	29
1997	9	1,5	28
1998	7	2,01	27
1999	14	1,34	26
2000	8	1,78	25
2001	6	1,19	24
2002	5	1,23	23
2003	1	0,68	22
2004	3	3,51	21
2005	3	1,1	20
2006	14	2,73	19
2007	7	2,61	18
2008	10	0,99	17
2009	6	1,2	16
2010	9	1,01	15
2011	5	4,66	14
2012	3	4,44	13
2013	9	1,44	12
2014	6	1,61	11
2015	12	2,28	10
2016	10	2,23	9
2017	13	3,31	8
2018	13	2,56	7
2019	16	1,85	6
2020	21	1,19	5
2021	16	1,64	4
2022	17	1,39	3
2023	12	0,34	2
2024	2	0	1

3.1.4 Three-Field Plot

The "Three-Field Plot" was configured within the software to associate three parameters (Country, Author, and Keyword), and Figure 4 depicts the most significant ones for each parameter based on this association. The size of the boxes in Figure 4 indicates the magnitude of the relationship between the parameters and the influential parameters. According to the keyword parameter "organic facies," Malaysia ranks first for the country parameter, and R. Littke ranks first for the author parameter.

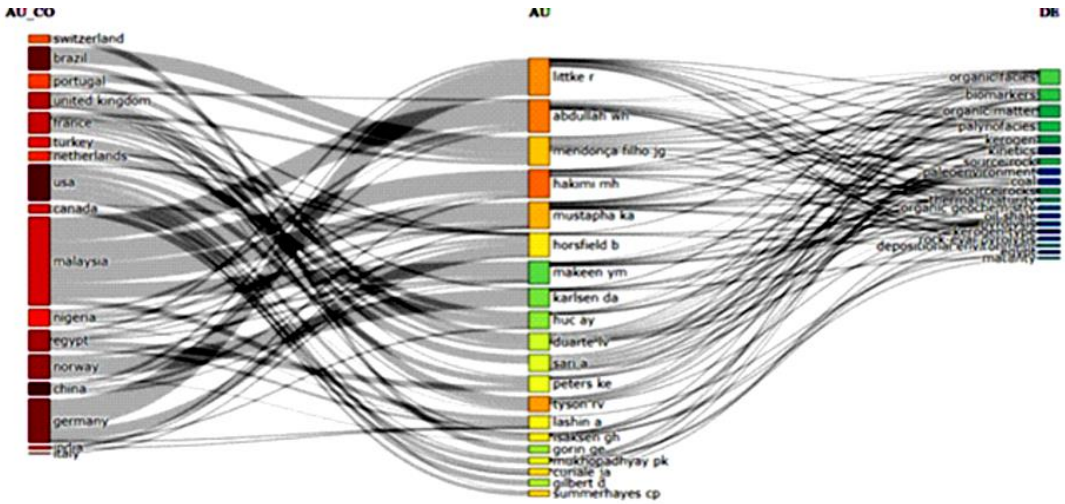

Figure 4. Sankey Diagram for Country, Author, and Keyword

3.1.5. Most Productive Journals

The ranking of source journals on the subject of "Organic facies" is shown according to the total number of publications as depicted in Figure 5.

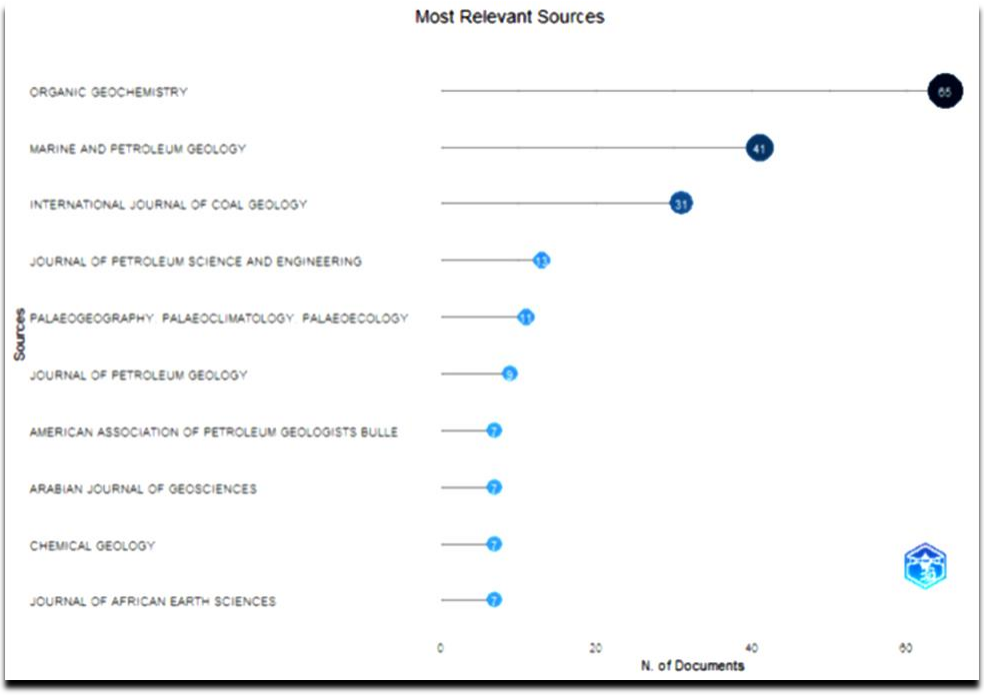

Figure 5. Most Productive Journals

According to Figure 5, "Organic Geochemistry" ranks first with 65 publications, "Marine and Petroleum Geology" ranks second with 41 publications and "International Journal of Coal Geology" ranks third with 3 publications.

3.1.6. Most Prolific Researchers in this Field

Figure 6 highlights the researchers who have published the most in this context globally. MH. Hakimi ranked first with 15 papers, WH. Abdullah and R. Littke ranked second with 11 papers

and RV. Tyson ranked third with 9 papers. Table 2 lists the top 10 sources according to the productivity of publications in the "Organic facies" corpus.

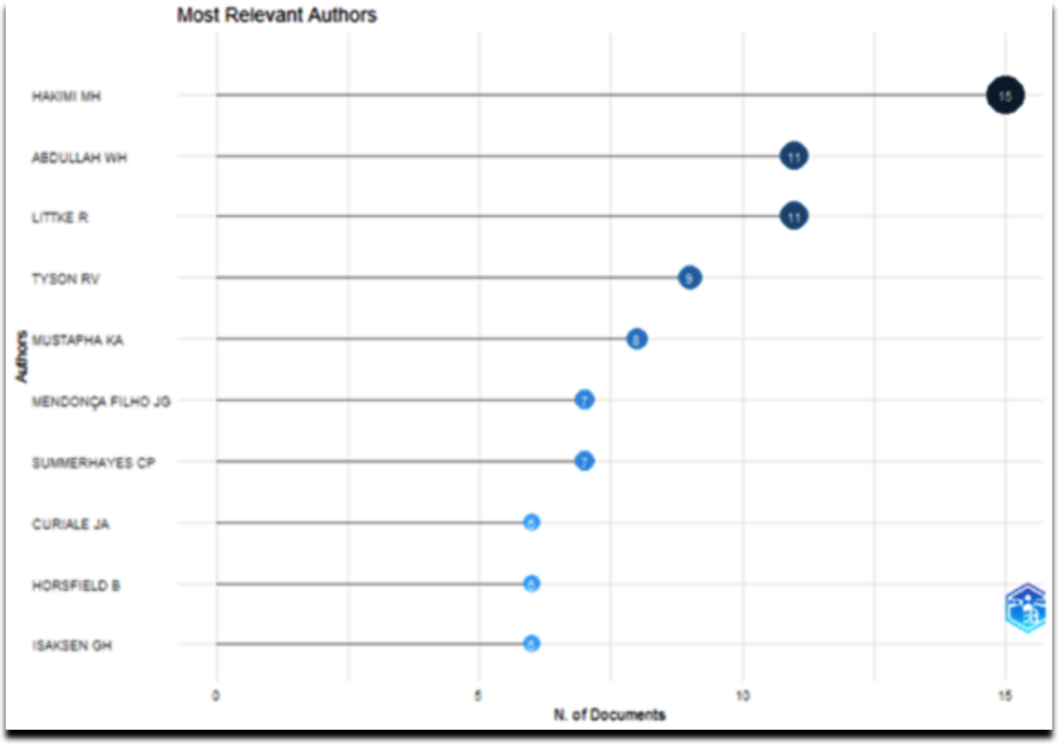

Figure 6. Most Prolific Researchers

Table 2. Top 10 Authors Based on h-index for "Organic facies" Studies

Yazar	h_index	TC	Number of documents	PY_start
Lıttke R	9	356	11	1989
Tyson RV	9	278	9	1994
Abdullah WH	7	153	11	1999
Hakımı MH	6	82	15	2015
Mendonça Fılho JG	6	88	7	2013
Summerhayes CP	6	187	7	1981
Curıale JA	5	171	6	1991
Horsfield B	5	330	6	1997
Huc AY	5	223	5	1988
Makeen YM	5	76	5	2015

Littke R (9), Tyson, RV. (9) and Abdullah WH (7) are the top three authors in h-index citations. Hakimi MH (15), Littke R (11), Abdullah WH (11) are the top three authors with the most research in this context. Littke R (356), Horsfield B (330) and Tyson RV (278) received the most citations.

4.1.7. Most Important Organizations

The publication outputs of the organizations where the authors who contributed to "organic facies" research work are given in Figure 7.

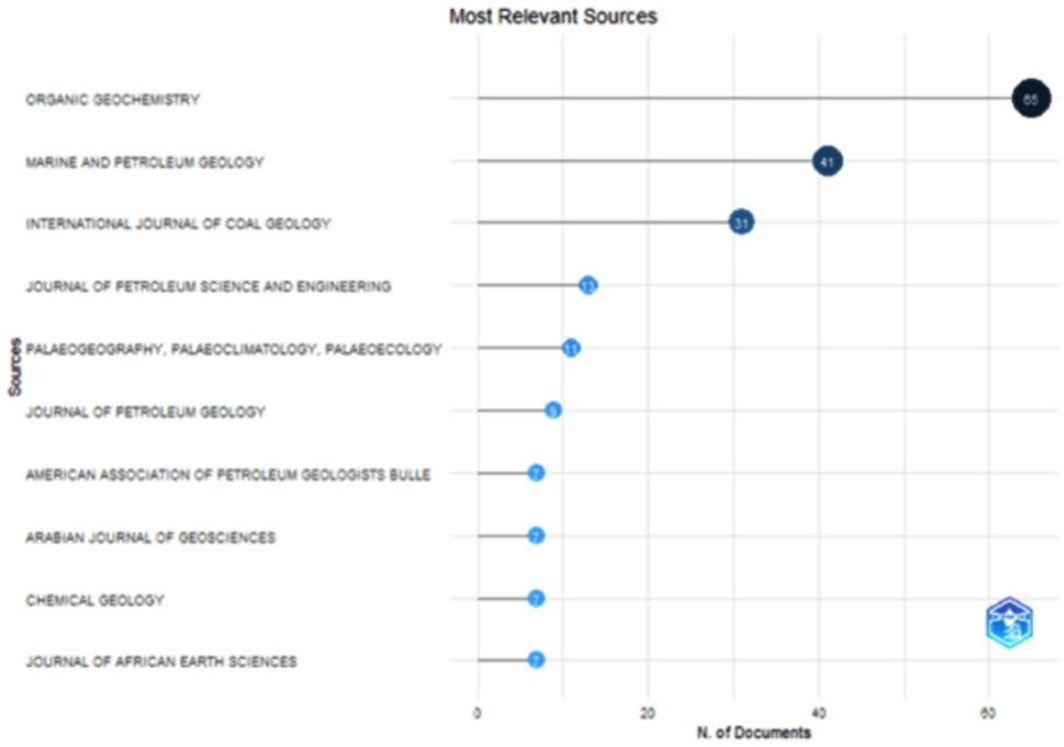

Figure 7. Major Institutions Engaged in Research in this Field (Universities and Research Centers)

According to Figure 7, the most productive institutions are China University of Petroleum with 53 publications, followed by University of Malaya with 34 publications and China University of Geosciences with 25 publications.

3.1.8. Most Prolific Countries

In the organic facies research area, the top publishing countries in Table 3 and Figure 8 and the relationship map between countries in Table 4 and Figure 9 were determined with RStudio software. According to Table 3, China ranks first with 258 papers, USA ranks second with 179 papers and Brazil ranks third with 92 papers.

Table 3. Most Prolific Countries.

Region	Freq
China	258
USA	179
Brazil	92
Germany	91
Norway	71
Egypt	60
United Kingdom	50
France	43
Malaysia	43
Canada	35

Table 4. Top 10 Countries with the Most Collaboration.

		Frekans
Malaysia	Yemen	11

Brazil	Portugal	7
Saudi Arabia	Yemen	7
Malaysia	Saudi Arabia	6
USA	United Kingdom	6
China	Germany	5
Egypt	United Kingdom	5
Germany	Netherlands	5
Malaysia	Nigeria	5
USA	Egypt	5

According to Table 5, Malaysia - Yemen, Brazil - Portugal and Saudi Arabia - Yemen are the most cooperative countries, respectively. In the collaboration map obtained from the relevant table in Figure 8, bold lines indicate high links. Figure 10 shows the most cited countries respectively.

Figure 8. Collaboration Map of Countries

In the articles written in the field of organic facies, Germany ranks first with 1084 citations, China ranks second with 801 citations and the USA ranks third with 769 citations (Figure 9).

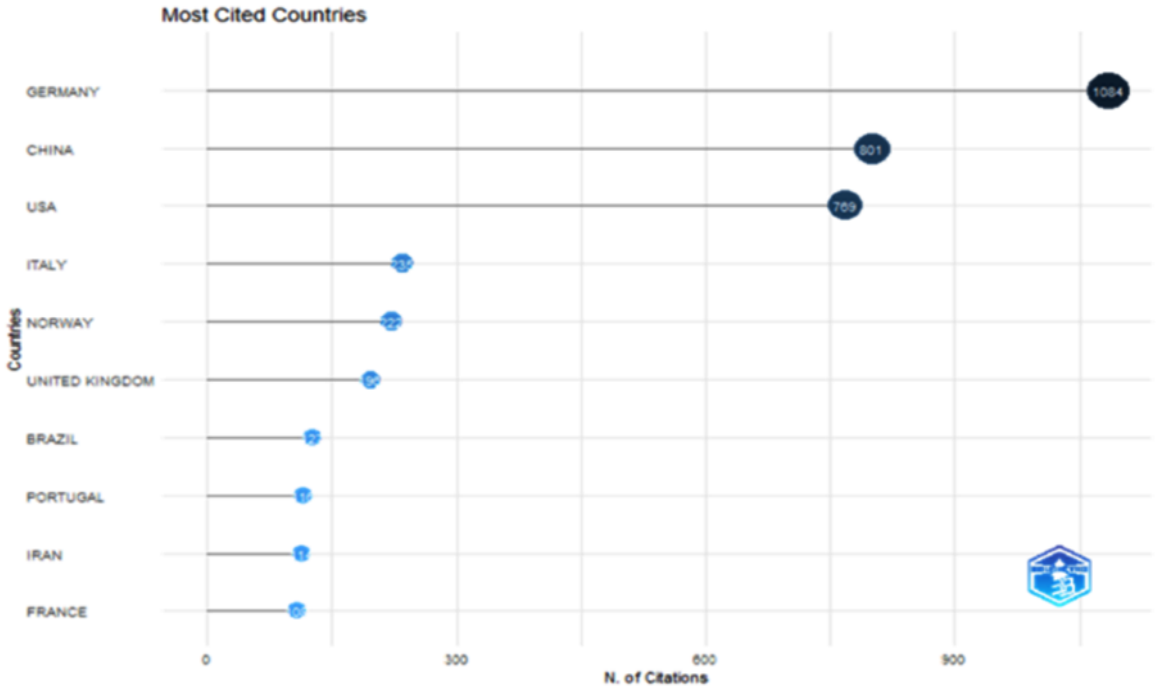

Figure 9. Countries with the Highest Citations

3.1.9. Most Influential Articles

Studies with the highest total number of citations (TC) were defined as influential articles and these 10 articles are shown in Table 5.

Table 5. Most Influential Articles.

Paper	DOI	Total Citations	TC per Year	Normalized TC
Radke M, 1986, Org Geochem	10.1016/0146-6380(86)90008-2	646	16,5641026	4,71532847
Peters KE, 1991, Org Geochem	10.1016/0146-6380(91)90039-M	628	18,4705882	8,34366696
Radke M, 1988, Mar Pet Geol	10.1016/0264-8172(88)90003-7	503	13,5945946	5,89782245
Waples DW, 1985,		372	9,3	5,06614786
Totman Parrısh J, 1982, Palaeogeogr Palaeoclımatol Palaeoecol	10.1016/0031-0182(82)90084-0	337	7,8372093	5,61666667
Hao F, 2011, Org Geochem	10.1016/j.orggeochem.2011.01.010	281	20,0714286	4,30981595
Hıll RJ, 2007, Am Assoc Pet Geol Bull	10.1306/11030606014	264	14,6666667	5,61702128
Mukhopadhyay PK, 1995, Org Geochem	10.1016/0146-6380(95)90010-1	243	8,1	3,80347826
Kleıneıdam S, 1999, Envıron Scı Technol	10.1021/es9806635	215	8,26923077	6,18069815
Chakhmakhchev A, 1997, Org Geochem	10.1016/S0146-6380(97)00022-3	196	7	4,67904509

Radke et al., [60] published in Organic Geochemistry "Maturity parameters based on aromatic hydrocarbons: Influence of the organic matter type" was cited 646 times. This article was followed by "Effects of source, thermal maturity, and biodegradation on the distribution and isomerization of homohopanes in petroleum" published in Organic Geochemistry by Peters and Moldowan [61] with 628 citations. In third place with 503 citations was the article "Application of aromatic compounds as maturity indicators in source rocks and crude oils" by Radke, M. [62] published in Marine and Petroleum Geology.

3.2. Scientific Mapping Analysis

Bibliometric analysis includes techniques such as performance analysis and science mapping [56].

3.2.1 Conceptual Structure Map of Articles

In this section, a conceptual structure map of the studies on Organic facies and maps of keywords based on the topic dendrogram are shown. A conceptual structure map is shown in Figure 10.

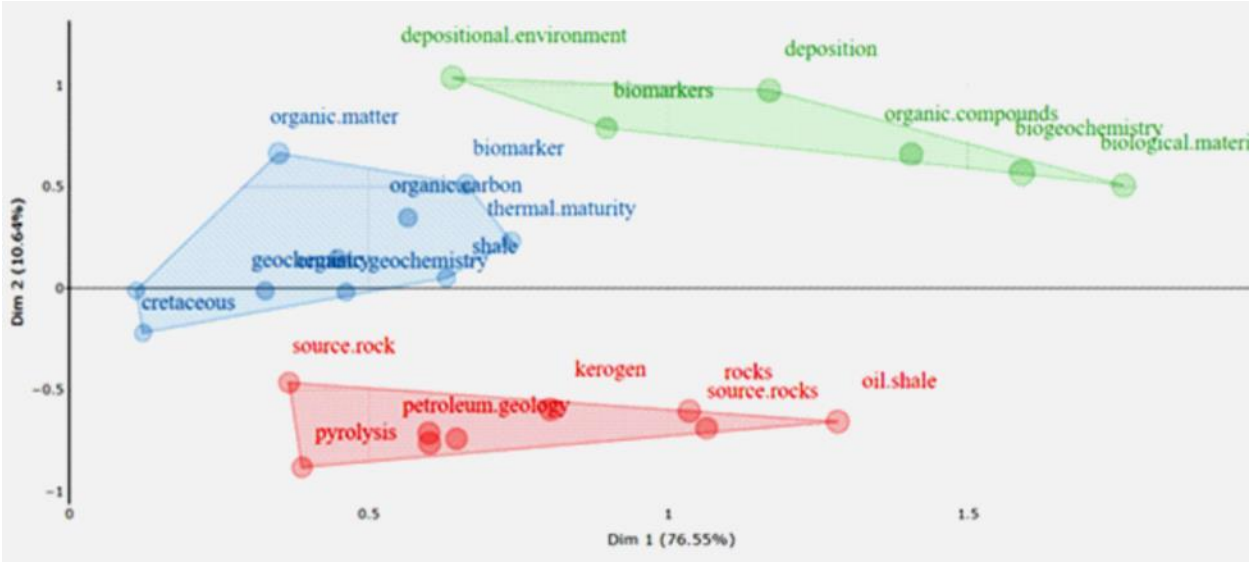

Figure 10. Conceptual Structure Map of Organic Facies

As a result of the conceptual structure map (factor analysis) related to organic facies, when the keywords in the articles are analyzed, it is seen that the concepts are gathered in three dimensions with high factor loadings.

In the first dimension (red) the words source rock, kerogen, hydrocarbons, petroleum geology, hydrocarbon generation, rocks, oil shale, pyrolysis, source rocks were included. The second dimension (blue) includes the words Geochemistry, organic facies, organic matter, shale, organic geochemistry, thermal maturity, biomarker, cretaceous, organic carbon, analytical geochemistry. In the third dimension (green) the words depositional environment, biogeochemistry, biomarkers, deposition, organic compounds, biological materials.

3.2.2 Topic Dendrogram

The diagram illustrating the hierarchical relationship between keywords is shown in Figure 11.

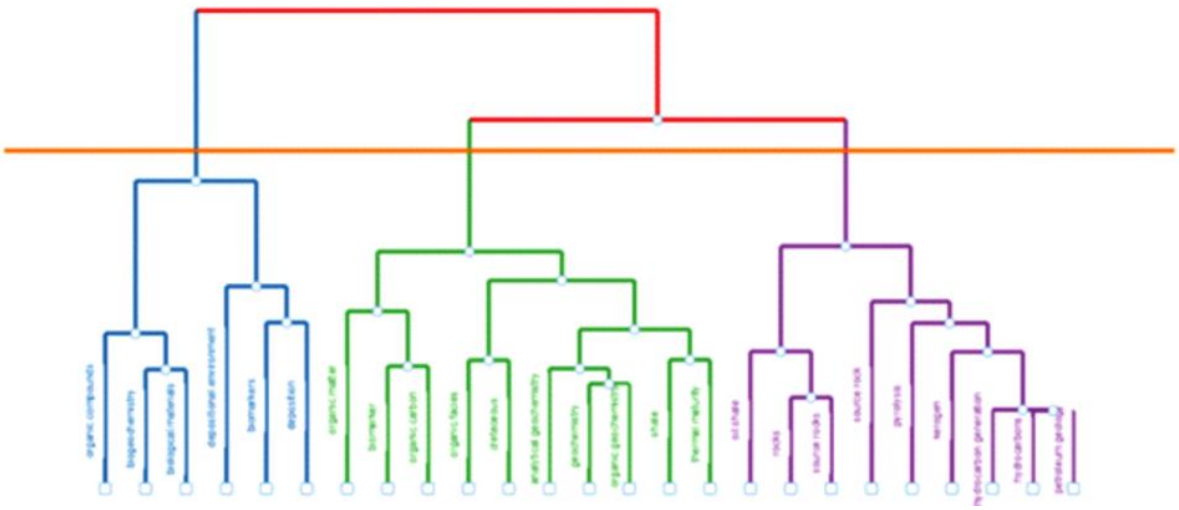

Figure 11. Topic Dendrogram of Organic Facies Keywords

In Figure 11, the keywords under the horizontal line (orange) drawn along the diagram consist of 3 clusters (blue, green and purple). These clusters explain how the topics are related to each other. In the first cluster, shown in blue, topics such as "depositional environment, biogeochemistry, biomarkers, deposition, organic compounds, biological materials" constitute the main components. The second large green cluster, which meets the central cluster at this height, deals with themes such as "Geochemistry, organic facies, organic matter, shale, organic geochemistry, thermal maturity, biomarker, Cretaceous, organic carbon, analytical geochemistry". The third cluster is related to the terms "source rock, kerogen, hydrocarbons, petroleum geology, hydrocarbon generation, rocks, oil shale, pyrolysis, source rocks".

3.2.3 Thematic Map

A thematic review of organic facies articles was conducted using keywords to identify the main topics of study in the field. Figure 12 shows that there are three different concentrations of articles on Organic facies. When keywords are taken into account in Figure 12; the area shown in blue represents both the main themes in the research and the motor themes that show the most used keywords in the field, such as "Kerogen, organic facies, organic matter, depositional environment, oil shale, biogeochemistry, Cretaceous, organic carbon, source rocks, petrology, palynology, palaeoenvironment, organic compounds".

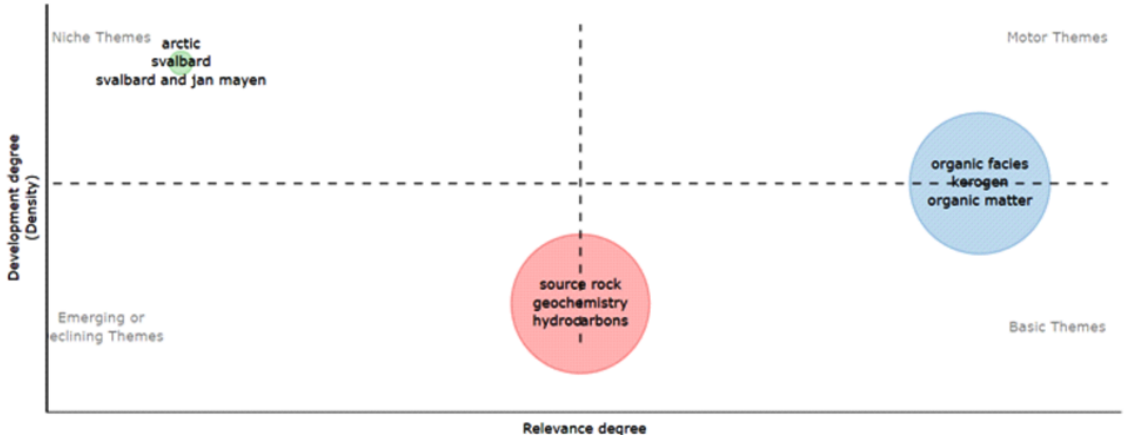

Figure 12. Thematic Map Based on Keywords

Special themes with high centrality and low intensity, shown in green, consist of the words "arctic, Svalbard, svalbard and jan mayen, arctic ocean". Both the core themes and the set of words that have weakened or emerged over time, shown in red, include words such as "source rock, geochemistry, hydrocarbons, organic geochemistry, petroleum geology, thermal maturity, biomarker, hydrocarbon generation, rocks, pyrolysis, biomarkers, analytical geochemistry, coal, carbon, hydrocarbon, jurassic, crude oil".

3.2.4 Trend Topics

Trend topics in the literature related to Organic facies from 2016 to 2024 are presented in Table 6.

Table 6. Trend Topics

İtem	Freq	Year_q1	Year_med	Year_q3
Shale gas	6	2021	2022	2023
Qaidam basin	5	2021	2022	2022
Organics	12	2020	2021	2022
Gasoline	17	2019	2020	2021
Well logging	8	2019	2021	2022
Egypt	14	2018	2019	2020
Brazil	12	2018	2020	2023
Reflection	12	2017	2019	2020
Macerals	5	2017	2021	2021
Biogeochemistry	49	2016	2018	2020

The term "shale gas" was repeated 6 times in the first quarter of 2021, the second quarter of 2022 and the third quarter of 2023, ranking first. The "Qaidam basin" ranked second with 5 occurrences in the first quarter of 2021, the second quarter of 2022 and the third quarter of 2022. The word "organics" was repeated 12 times in the first quarter of 2020, the second quarter of 2021 and the third quarter of 2022, ranking third.

The most frequently used keyword cloud related to Organic facies is presented in Figure 13.

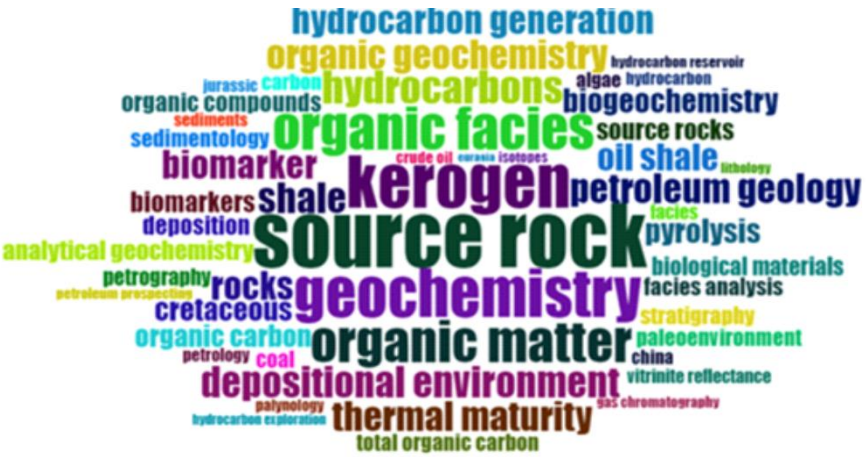

Figure 13. Keyword Cloud

Figure 13 shows that source rock (129), kerogen (105), geochemistry (97), organic facies (87), organic matter (84), hydrocarbons (67), depositional environment (63), shale (62), organic

geochemistry (60), petroleum geology (60), thermal maturity (60), Biomarker (58), hydrocarbon production (58) are the most used keywords.

3.2.5 Co-occurrence Keyword Analysis

In the co-occurrence analysis, VOSviewer was used to reveal the common effects of studies with keywords and research knowledge base. As shown in Figure 14, 6 clusters, 123 networks and 140 total relationship networks were identified by creating at least five keyword criteria in VOSviewer software. According to the co-occurrence of these keywords, organic facies, biomarkers, palynofacies, source rock, organic matter, kerogen, source rocks, thermal maturity are the most commonly used keywords.

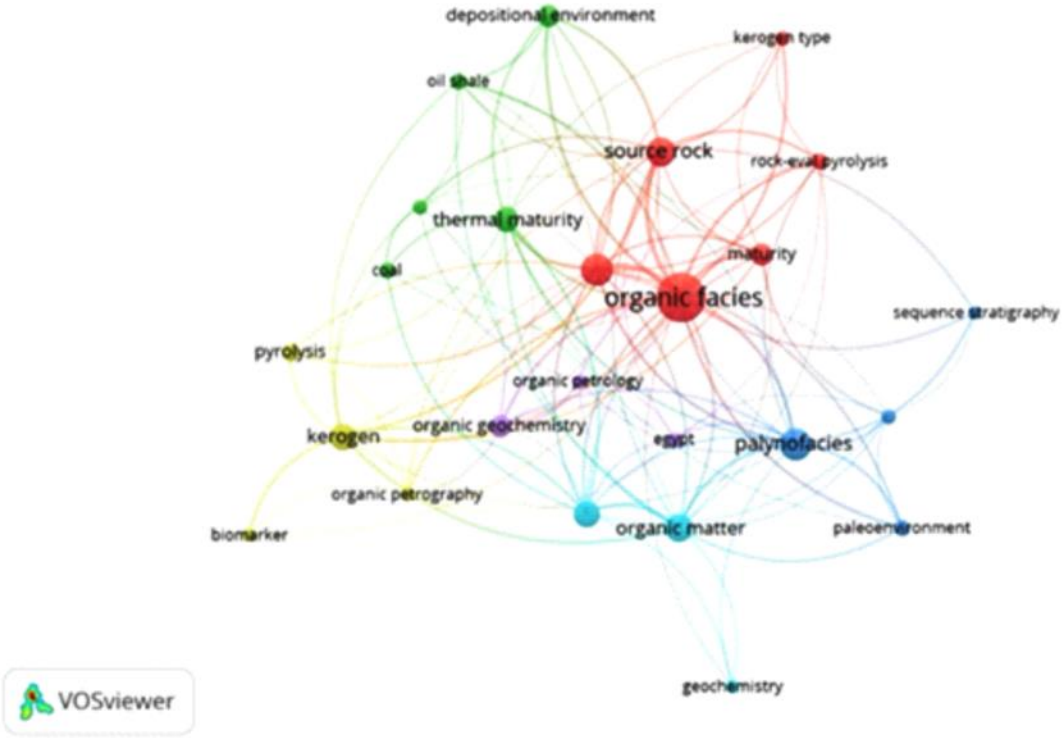

Figure 14. Network Map of Most Frequently Used Keywords Related to Organic Facies.

4. Results

Organic facies assessments allow the identification of different depositional environments in defined lithostratigraphic units and provide information on source rock potential. In this study, 384 articles published between 1979 and 2024 in the Scopus database were bibliometrically analyzed. In the related scientific studies with a total of 1075 authors, there was the highest increase in articles in 2020. The average number of citations per article was highest in 2011 and 2012.

In the relationship formed according to the Country, Author and Keyword parameters established with the Sankey diagram, it was determined that the keyword organic facies, Litke R. as the author and Malaysia came first in the country parameter relationship.

The most prolific journals in the field of organic facies were "Organic Geochemistry", "Marine and Petroleum Geology" and "International Journal of Coal Geology".

In the rankings based on the number of articles, Hakimi MH, Abdullah WH and Tyson RV were the most important authors in the field of Organic facies. In the ranking based on citations based on the H-index, the most prolific authors were Littke R, Tyson RV and Abdullah WH.

The most important institutions in this field are China University of Petroleum in first place, University of Malaya in second place and China University of Geosciences in third place.

As a result of the analysis, China, USA and Brazil are the most productive countries leading in scientific studies in this field. The top three collaborators are Malaysia-Yemen, Brazil-Portugal and Saudi Arabia-Yemen.

Germany, China and USA were the most cited countries in the field of organic facies.

The most cited paper published in Organic Geochemistry by Radke et al., [60] titled "Maturity parameters based on aromatic hydrocarbons: Influence of the organic matter type" is the most cited paper. The second most influential papers are "Effects of source, thermal maturity, and biodegradation on the distribution and isomerization of homohopanes in petroleum" by Peters & Moldowan [61] in Organic Geochemistry and the third most influential paper is "Application of aromatic compounds as maturity indicators in source rocks and crude oils" by Radke, M. [62] in Marine and Petroleum Geology.

Three clusters were formed based on the topic dendrogram of keywords in the field of organic facies. In the first cluster, topics such as "depositional environment, biogeochemistry, biomarkers, biomarkers, deposition, organic compounds, biological materials" were the main topics. In the second dimension (blue) the words "geochemistry, organic facies, organic matter, shale, organic geochemistry, thermal maturity, biomarker, Cretaceous, organic carbon, analytical geochemistry" were included. The third cluster is related to the themes "source rock, kerogen, hydrocarbons, petroleum geology, hydrocarbon generation, rocks, oil shale, pyrolysis, source rocks".

In the themes of the keywords related to organic facies, both the main themes in the research and the engine themes showing the most used keywords were composed of words such as "Kerogen, organic facies, organic matter, depositional environment, oil shale, biogeochemistry, Cretaceous, organic carbon, source rocks, petrology, palynology, palynology, palaeoenvironment, organic compounds". Special themes with high centrality and low intensity consist of the words "Arctic, Svalbard, svalbard and Jan Mayen, Arctic ocean". Both the core themes and the set of words that have weakened or emerged over time include words such as "source rock, geochemistry, hydrocarbons, organic geochemistry, petroleum geology, thermal maturity, biomarker, hydrocarbon generation, rocks, pyrolysis, biomarkers, analytical geochemistry, coal, carbon, hydrocarbon, Jurassic, crude oil".

In the literature on organic facies, the words "shale gas, Qaidam basin, organics, gasoline, well logging, Egypt, Brazil, reflection, macerals biogeochemistry" are trending topics in the studies by years from 2016 to 2024. This shows that the topic remains topical in the exploration of unconventional energy sources (especially shale gas), which has increased rapidly on a global scale after 2010. In addition, the regions where studies are concentrated in hydrocarbon research are also reflected by the keywords used on basin and country basis.

In articles on organic facies, words such as source rock, kerogen, geochemistry, organic facies, organic facies, organic matter, hydrocarbons, depositional environment, shale, organic geochemistry, petroleum geology, thermal maturity, biomarker, hydrocarbon generation were the most commonly used keywords. According to the co-occurrence of keywords, words such as

organic facies, biomarkers, palynofacies, source rock, organic matter, kerogen, source rocks, thermal maturity are the most used keywords.

Discussion

A noteworthy finding is the significant increase in the number of papers, particularly in 2020, indicating increased interest and research activity in organic facies. In particular, the peak in average citations per article in 2011 and 2012 highlights the impact of research for new oil exploration areas in these years.

Analysis based on the Sankey diagram revealed interesting relationships between countries, authors and keywords. For example, the prominence of the keyword "organic facies" in connection with author Litke R. and the country parameter led by Malaysia suggests that these organizations have made notable contributions in this field.

The fact that journals such as "Organic Geochemistry", "Marine and Petroleum Geology" and "International Journal of Coal Geology" have taken the lead in publishing comprehensive studies on organic facies emphasizes that organic facies studies are preferred by researchers as platforms for disseminating their research findings and that the journal attaches importance to this issue.

Institutional analysis shows that countries that emphasize the exploration of conventional and unconventional hydrocarbon resources also support academics and research groups in their educational institutions, with China University of Petroleum, University of Malaya and China University of Earth Sciences becoming key players in advancing organic facies research.

The dominance of countries such as China and the United States in scientific research and models of international cooperation underscore the global nature of scientific research, which always brings fruitful results. Moreover, China's 14th Five-Year Plan is designed to strengthen economic development by 2035, and the combination of different disciplines - academia, government and industry - is driving the quality and quantity of this research.

This study is limited to the scopus database for publications used in Organic facies studies. English language articles on Organic facies up to 2024 are included in the study. Works such as conferences, book chapters, notes, etc. were excluded. Future studies could include other academic works with articles in different languages and utilize other databases (such as Web of Science, Pubmed). This research provides a comprehensive overview, identifies potential research directions, and provides important and up-to-date information for future researchers to evaluate the field of Organic facies.

Today, organic facies assessments for conventional petroleum geology studies or for shale gas exploration, especially from unconventional sources, are ongoing [48-55, 63-64].

The main purpose of research in the field of organic facies is to describe organic petrology and geochemical properties. There is limited information on the use of multivariate statistical techniques in large geochemical data analysis [65]. The findings of this study provide information on organic facies types. This study contributes to the field of organic facies research, and geologists, in guiding researchers in surface geology mapping, which is the first step in oil or natural gas exploration, in estimating the geographic distribution of oil source rocks and the timing of oil production [15-18].

In conclusion, this study provides comprehensive and objective information on research trends, patterns and dynamics in organic facies. It provides a comprehensive overview for future

petroleum exploration. It provides insight into possible research directions for future researchers and may create important opportunities for collaborative work among co-authors.

References

[1] Hamilton, J.M. (2011). The challenges of deep-water arctic development. *International Journal of Offshore and Polar Engineering*, 21.

[2] Morgunova, M. (2015). *Arctic offshore hydrocarbon resource development: Past, present and vision of the future* (Doctoral dissertation, KTH Royal Institute of Technology).

[3] Dziublo, A., & Storozheva, A. (2021). *Technologies for efficient development of hydrocarbon resources on the Arctic and sub-Arctic shelf of Russia*. In IOP Conference Series: Earth and Environmental Science, 678, 012001).

[4] Armenteros, M., Marzo-Pérez, D., Pérez-García, J.A., Schwing, P.T., Ruiz-Abierno, A., Díaz-Asencio, M., ... Murawski, S.A. (2024). Setting an Environmental Baseline for the Deep-Sea Slope Offshore Northwestern Cuba (Southeastern Gulf of Mexico) Using Sediments and Nematode Diversity. *Thalassas: An International Journal of Marine Sciences*, 1-15.

[5] Zecheng, W.A.N.G., Jiang, Q., Jufeng, W.A.N.G., Guohui, L.O.N.G., Cheng, H., Yizuo, S.H.I., ...Huang, L. (2024). Hydrocarbon accumulation characteristics in basement reservoirs and exploration targets of deep basement reservoirs in onshore China. *Petroleum Exploration and Development*, *51*, 31-43.

[6] Jacobson, S.R. (1991). *Petroleum source rocks and organic facies*. In: Source and Migration Processes and Evaluation Techniques, Merril, R.K. (Ed.), Tulsa, Treatise of Petroleum Geology, American Association of Petroleum Geologists, 3-11.

[7] Deaf, A.S., Tahoun, S.S., Gentzis, T., Carvajal-Ortiz, H., Harding, I.C., Marshall, J.E., & Ocubalidet, S. (2020). Organic geochemical, palynofacies, and petrographic analyses examining the hydrocarbon potential of the Kharita Formation (Albian) in the Matruh Basin, northwestern Egypt. *Marine and Petroleum Geology*, *112*, 104087.

[8] Esegbue, O., Jones, D.M., van Bergen, P.F., & Kolonic, S. (2020). Quantitative diamondoid analysis indicates oil cosourcing from a deep petroleum system onshore Niger Delta Basin. *AAPG Bulletin*, *104*, 1231-1259.

[9] Katz, B., Gao, L., Little, J., & Zhao, Y.R. (2021). Geology still matters–unconventional petroleum system disappointments and failures. *Unconventional Resources*, *1*, 18-38.

[10] Diab, A.I., Sanuade, O., & Radwan, A.E. (2023). An integrated source rock potential, sequence stratigraphy, and petroleum geology of (Agbada-Akata) sediment succession, Niger delta: application of well logs aided by 3D seismic and basin modeling. *Journal of Petroleum Exploration and Production Technology*, *13*, 237-257.

[11] Tissot, B.P., & Welte, D.H. (1984). *Petroleum Formation and Occurrence*. Springer-Verlag, Berlin. 699.

[12] Huc, A.Y. (1990). *Understanding Organic Facies: A Key to Improved Quantitative Petroleum Evaluation of Sedimentary Basins*: Chapter 1.

[13] Hunt, J.M. (1995). *Petroleum geochemistry and geology*. W.H. Freeman and Company, New York, 743.

[14] Follows, B., & Tyson, R.V. (1998). Organic facies of the Asbian (early Carboniferous) Queensferry Beds, Lower Oil Shale Group, South Queensferry, Scotland, and a brief comparison with other Carboniferous North Atlantic oil shale deposits. *Organic Geochemistry, 29*, 821-844.

[15] Peters, K.E., Schenk, O., Hosford Scheirer, A., Wygrala, B., & Hantschel, T. (2017). Basin and petroleum system modeling. *Springer handbook of petroleum technology*, 381-417.

[16] Stasiuk, L.D. (1996). Organic facies in black shale of Devonian-Mississippian Bakken Formation, southeastern Saskatchewan. *Geological Survey of Canada. Current Research*, 15-22.

[17] Stasiuk, L.D., & Fowler, M.G. (2004). Organic facies in Devonian and Mississippian strata of Western Canada Sedimentary Basin: relation to kerogen type, paleoenvironment, and paleogeography. *Bulletin of Canadian Petroleum Geology, 52*, 234-255.

[18] Fang, H., Jianyu, C., Yongchuan, S., & Yaozong, L. (1993). Application of organic facies studies to sedimentary basin analysis: a case study from the Yitong Graben, China. *Organic Geochemistry, 20*, 27-42.

[19] Jones, R.W. (1987). *Organic facies: advanced in Petroleum Geochemistry* (Brooks, J., and Welte, D. Eds.).

[20] Jones, R.W., & Demaison, G.J. (1982). Organic Facies - stratigraphic concepts and exploration tool. In: Proceedings of the Second ASCOPE Conference and Exhibition, Saldivar-Sali, A. (Ed.)., Manilla, *Asean Council on Petroleum*, 51-68.

[21] Jones, R.W. (1984). Comparison of carbonate and shale source rocks. *AAPG Bull. 68*,163–80. https://doi.org/10.1306/AD460EA4-16F7-11D7-8645000102C1865D

[22] Pepper, A.S., & Corvi, P.J. (1995). Simple kinetic models of petroleum formation. Part I: oil and gas generation from kerogen. *Marine and petroleum geology, 12*, 291-319.

[23] Tuweni, A.O., & Tyson, R.V. (1994). Organic facies variations in the Westbury Formation (Rhaetic, Bristol Channel, SW England). *Organic Geochemistry, 21*, 1001-1014.

[24] Baskin, D.K. (1997). Atomic H/C ratio of kerogen as an estimate of thermal maturity and organic matter conversion. *AAPG bulletin, 81*, 1437-1450.

[25] Krejci-Graf, K. (1963). Origin of oil. *Geophysical Prospecting, 11*, 244-275.

[26] Krejci-Graf, K. (1964). Geochemical diagnosis of facies. *Proceedings of the Yorkshire Geological Society, 34*, 469-521.

[27] Krejci-Graf, K. (1975). Geochemical facies of sediments. *Soil Science, 119*, 20-23.

[28] Breger, I.A., & Brown, A. (1963). Section of Geological Sciences: Distribution and types of organic matter in a barred Marıne Basin. *Transactions of the New York Academy of Sciences, 25*, 741-755.

[29] Tissot, B., Durand, B., Espitalie, I., & Comba, A. (1974). Influence of mature and. diagenesis of organic matter in formation of petroleum. *A.A.P.G. Bull., 58*, 499-506.

[30] Parparova, G., & Neruchev, S. (1977). Bases of A Genetıc Classıfıcatıon of The Organıc Matter Dıspersed In Rocks. *Geologıya I Geofizıka*, 5.

[31] Cornelius, C.D. (1978). Muttergesteinfazies als parameter der erdölbildung. *Erdoel-Erdgas-Zeitschrift, 3*, 90–94.

[32] Middelburg, J.J., Calvert, S.E., & Karlin, R. (1991). Organic-rich transitional facies in silled basins: Response to sea-level change. *Geology, 19*, 679-682.

[33] Pasley, M.A. (1991). *Organic matter variation within depositional sequences stratigraphic significance of implication to petroleum source rock prediction*. The Louisiana State, University and agricultural and MechanicalCol. Louisiana (USA). PhD. Thesis. 150 pp.

[34] Cornford, C. (1979). *Organic deposition at a continental rise: organic geochemical interpretation and synthesis at DSDP Site 397, eastern North Atlantic*. Initial Reports of the Deep Sea Drilling Project. Part. 1: Washington (US GovernmentPrinting Office), 503-510.

[35] Rogers, M.A. (1980). *Application of organic facies concepts to hydrocarbon source rocks evaluation*. In: Proceedings of the 10th World Petroleum Congress, Bucharest 1979, Heyden, London, 2, 23-30.

[36] Jones, R.W. (1983). Organic matter characteristics near the shelf-slope boundary. *Society of Economic Paleontologists and Mineralogists(SEPM), Special Publication, 33*, 391– 405.

[37] Tyson, R.V. (1995). *Sedimentary Organic Matter. Organic facies and palynofacies*. Chapman and Hall, Londons, 615.

[38] Habib, D. (1982). *Sedimentary supply origin of cretaceous black shales. In: Nature and origin of Cretaceous Carbon-rich Facies*, Schlanger S.O., Cita M.B. (Eds.), Academic Press, London, 113-27.

[39] Powell, T.G., 1987. Depositional controls on source rocks character and crude oil composition. In: World Petroleum, 12, Congress, Proceedings, Houston, 2, 31-42.

[40] Peters, K.E., Walters, C.C., & Moldowan, J.M. (2005). *The Biomarker Guide*. Cambridge University, New York, 1132.

[41] Zou, C., Dong, D., Wang, S., Li, J., Li, X., Wang, Y., ... Cheng, K. (2010). Geological characteristics and resource potential of shale gas in China. *Petroleum exploration and development*, *37*, 641-653.

[42] Froidl, F., Littke, R., Baniasad, A., Zheng, T., Röth, J., Böcker, J., ... Strauss, H. (2021). Peculiar Berriasian "Wealden" Shales of northwest Germany: organic facies, depositional environment, thermal maturity and kinetics of petroleum generation. *Marine and Petroleum Geology*, *124*, 104819.

[43] Ehsan, M., Gu, H., Ali, A., Akhtar, M.M., Abbasi, S.S., Miraj, M.A.F., & Shah, M. (2021). An integrated approach to evaluate the unconventional hydrocarbon generation potential of the Lower Goru Formation (Cretaceous) in Southern Lower Indus basin, Pakistan. *Journal of Earth System Science*, *130*, 90.

[44] Li, C., Zeng, J., Liu, H., Li, H., Bu, X., & Liu, S. (2023). Sedimentary Organic Facies Division and Hydrocarbon-Generation Potential of Source Rocks in Coal-Bearing Strata─ A Case Study of the Upper Paleozoic in Huanghua Depression, Bohai Basin, China. *ACS omega*, *8*, 28715-28732.

[45] dos Santos, M.A.M., do Nascimento, C.A., Souza, E.S., Martins, L.L., Ribeiro, H.J.P.S., & Rodrigues, R. (2020). Degradation-resistant biomarkers in the Pirambóia Formation tar sands (Triassic) and their correlation with organic facies of the Irati Formation source rocks (Permian), Paraná Basin (Brazil). *Journal of South American Earth Sciences*, *104*, 102873.

[46] Adeyilola, A., Zakharova, N., Liu, K., Gentzis, T., Carvajal-Ortiz, H., Ocubalidet, S., & Harrison III, W.B. (2022). Hydrocarbon potential and Organofacies of the Devonian Antrim Shale, Michigan Basin. *International Journal of Coal Geology*, *249*, 103905.

[47] Ogbesejana, A.B., Liu, B., Gao, S., Akinyemi, S.A., Bello, O.M., & Song, Y. (2023). Applying biomarkers as paleoenvironmental indicators to reveal the organic matter

enrichment of shale during deep energy exploration: a review. *RSC advances, 13*, 25635-25659.

[48] Menezes, T.R., & Mendonça Filho, J.G. (2004). Aplicação da faciologia orgânica na análise paleoceanográfica do talude continental superior recente da Bacia de Campos - RJ. *Revista Brasileira de Paleontologia, 7*, 177-188.

[49] Vandenbroucke, M., & Largeau, C. (2007). Kerogen origin, evolution and structure. *Organic geochemistry, 38*, 719-833.

[50] Filho, J.G.M., Menezes, T.R., de Oliveira Mendonça, J., de Oliveira, A.D., da Silva, T.F., Rondon, N.F., & da Silva, F.S. (2012). Organic facies: palynofacies and organic geochemistry approaches. *In Geochemistry–Earth's system processe*, 211-248.

[51] de Andrade, C.L.N., Cardoso, T.R.M., Santos, R.R., Dino, R., & de Jesus Machado, A. (2020). Organic facies and palynology from the middle to late Devonian of the Pimenteiras Formation, Parnaíba Basin, Brazil. *Journal of South American Earth Sciences, 99*, 102481.

[52] Gonzalez, L.D.C., Mastalerz, M., & Mendonça Filho, J.G. (2020). Application of organic facies and biomarkers in characterization of paleoenvironmental conditions and maturity of sediments from the Codó Formation in the west-central part of the São Luís Basin, Brazil. *International Journal of Coal Geology, 225*, 103482.

[53] Wesenlund, F., Grundvåg, S.A., Engelschiøn, V.S., Thießen, O., & Pedersen, J.H. (2021). Linking facies variations, organic carbon richness and bulk bitumen content–A case study of the organic-rich Middle Triassic shales from eastern Svalbard. *Marine and Petroleum Geology, 132*, 105168.

[54] Amiri, S., & Alipour, M. (2023). Organic facies and organic petrographic characteristics of the Pabdeh Formation in the Kilur-Karim Oilfield, SW Iran. *Journal of Stratigraphy and Sedimentology Researches, 39*, 1-14.

[55] Saleh, R.A., Makled, W.A., Moustafa, T.F., Ela, N.M.A., & Tahoun, S.S. (2023). Organic facies and hydrocarbon source rock potentiality of the Neogene succession in the Central South Mediterranean, offshore Nile Delta Basin, Egypt. *Journal of African Earth Sciences, 207*, 105066.

[56] Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W.M. (2021). How to do bibliometric analysis: Overview and guidelines. *Journal of business studies, 133*, 285-296.

[57] Alper Ay, F. (2024). The relationship between work motivation and productivity: Bibliometric analysis of articles from 1953 to 2024. *Human Systems Management*, (Preprint), 1-22.

[58] Lim, W. M., Rasul, T., Kumar, S., & Ala, M. (2022). Past, present, and future of customer engagement. *Journal of Business Research, 140*, 439-458.

[59] Martín-Martín, A., Orduna-Malea, E., Thelwall, M., & López-Cózar, E. D. (2018). Google Scholar, Web of Science, and Scopus: A systematic comparison of citations in 252 subject categories. *Journal of informetrics, 12*(4), 1160-1177.

[60] Radke, M., Welte, D.H., & Willsch, H. (1986). Maturity parameters based on aromatic hydrocarbons: Influence of the organic matter type. *Organic Geochemistry, 10*, 51-63.

[61] Peters, K.E., & Moldowan, J.M. (1991). Effects of source, thermal maturity, and biodegradation on the distribution and isomerization of homohopanes in petroleum. *Organic geochemistry, 17*, 47-61.

[62] Radke, M. (1988). Application of aromatic compounds as maturity indicators in source rocks and crude oils. *Marine and petroleum geology, 5*, 224-236.

[63] Yin, Y., Lan, L., Wang, D., Chen, Y., Liu, Y., Li, Y., ... & Liu, J. (2024). Formation environment and hydrocarbon potential of the Paleogene Enping Formation coal measures in the Zhu I Depression of northern South China Sea. *Acta Oceanologica Sinica, 43*(4), 119-135.

[64] Babai, A. M. A., Gebbayin, O. I. M. F. A., Ehinola, O. A., & Ibrahim, M. A. E. (2024). Source rock characterization and biomarkers analysis of Adar and Galhak Formations, Rawat central sub-basin, White Nile basin, Sudan. *Journal of African Earth Sciences*, *210*, 105-146.

[65] Wang, X., Liu, G., Wang, F., Wang, X., Sun, M., Song, Z., Chen, R., & Geng, M. (2024). Geochemical characteristics and classification of Oligocene source rocks with different facies in Bozhong Sag, Bohai Bay Basin, East China. *Journal of Asian Earth Sciences*, *276*, 106304. https://doi.org/10.1016/j.jseaes.2024.106304