

Review

Organic geochemistry – A retrospective of its first 70 years [☆]

Keith A. Kvenvolden ^{*}

U.S. Geological Survey, 345 Middlefield Road, MS 999, Menlo Park, CA 94025, USA

Institute of Marine Sciences, University of California, Santa Cruz, CA 95064, USA

Received 1 September 2005; accepted 1 September 2005

Available online 18 October 2005

Abstract

Organic geochemistry had its origin in the early part of the 20th century when organic chemists and geologists realized that detailed information on the organic materials in sediments and rocks was scientifically interesting and of practical importance. The generally acknowledged “father” of organic geochemistry is Alfred E. Treibs (1899–1983), who discovered and described, in 1936, porphyrin pigments in shale, coal, and crude oil, and traced the source of these molecules to their biological precursors. Thus, the year 1936 marks the beginning of organic geochemistry. However, formal organization of organic geochemistry dates from 1959 when the Organic Geochemistry Division (OGD) of The Geochemical Society was founded in the United States, followed 22 years later (1981) by the establishment of the European Association of Organic Geochemists (EAOG). Organic geochemistry (1) has its own journal, *Organic Geochemistry* (beginning in 1979) which, since 1988, is the official journal of the EAOG, (2) convenes two major conferences [International Meeting on Organic Geochemistry (IMOG), since 1962, and Gordon Research Conferences on Organic Geochemistry (GRC), since 1968] in alternate years, and (3) is the subject matter of several textbooks. Organic geochemistry is now a widely recognized geoscience in which organic chemistry has contributed significantly not only to geology (i.e., petroleum geochemistry, molecular stratigraphy) and biology (i.e., biogeochemistry), but also to other disciplines, such as chemical oceanography, environmental science, hydrology, biochemical ecology, archaeology, and cosmochemistry.

Published by Elsevier Ltd.

1. Introduction

Organic geochemistry is a modern geoscience that results from the amalgamation of many aspects from the two fundamental, but disparate, scientific disciplines of geology and organic chemistry. The

latter half of the 18th century saw the independent rise of each of these basic disciplines. Geology began in the 50 years between 1775 and 1825 with the musings of James Hutton (see McIntyre, 1963); organic chemistry, during approximately the same time interval, grew out of the recognition of the basic difference between organic and inorganic chemical compounds – organic compounds always contain carbon (see Noller, 1957). Geology and organic chemistry continued to evolve independently until the early part of the 20th century when geologists realized the scientific and practical

[☆] Material in this paper was presented orally at the 229th American Chemical Society National Meeting, San Diego, CA, March 2005 in a symposium “History of Organic Geochemistry”.

^{*} Tel.: +1 650 329 4196.

E-mail address: kkvenvolden@usgs.gov.

importance of organic matter in rocks, and organic chemists discovered that rocks contain an abundance of organic compounds of fundamental and applied interest. The purpose of this paper is to (1) update information about the formal organization of organic geochemistry, (2) summarize the lives of early practitioners in the field, (3) gauge the content of the subject matter, and (4) acknowledge those who organized organic geochemistry and those who have helped sustain the field through their editorships of *Organic Geochemistry*. Fig. 1 shows a timeline of events in the development of the history of organic geochemistry.

2. Origins and awards

Two individuals can be identified who successfully merged geology and organic chemistry in the 1930s. From the geologic side, Parker D. Trask (Fig. 2A) related the organic materials in sediments (Trask, 1932) and sedimentary rocks (Trask and Patnode, 1942) to an understanding of the source beds of petroleum. From the organic chemistry side, Alfred E. Treibs (Fig. 2B) discovered organic (porphyrin) pigments in shale, crude oil, and coal (Treibs, 1936), and demonstrated that these pigments were degradation products from biological sub-

stances (chlorophyll and hemin), thus linking geomolecules to biomolecules. These men were contemporaries, both born in 1899, but it is unlikely that their paths ever crossed.

2.1. Parker D. Trask

Parker Trask (Fig. 2A) came from New England in the United States, and was educated in California, obtaining an advanced degree in geology from the University of California at Berkeley. From 1926 to 1931 he was a research associate with the American Petroleum Institute (API), working on studies related to petroleum source rocks. In 1931 the source-bed project became a joint undertaking with the API and the U.S. Geological Survey (USGS), and Trask became a USGS employee, a connection he retained full time for 15 years and part time thereafter until his death in 1961. The joint API/USGS project, which he led, continued for 10 years during which time the chemical and physical properties of more than 25,000 samples from many geological formations from most parts of the United States were studied. The goal was to determine possible relationships between these samples and oil reservoirs in a search for clues to the recognition of true petroleum source beds. During

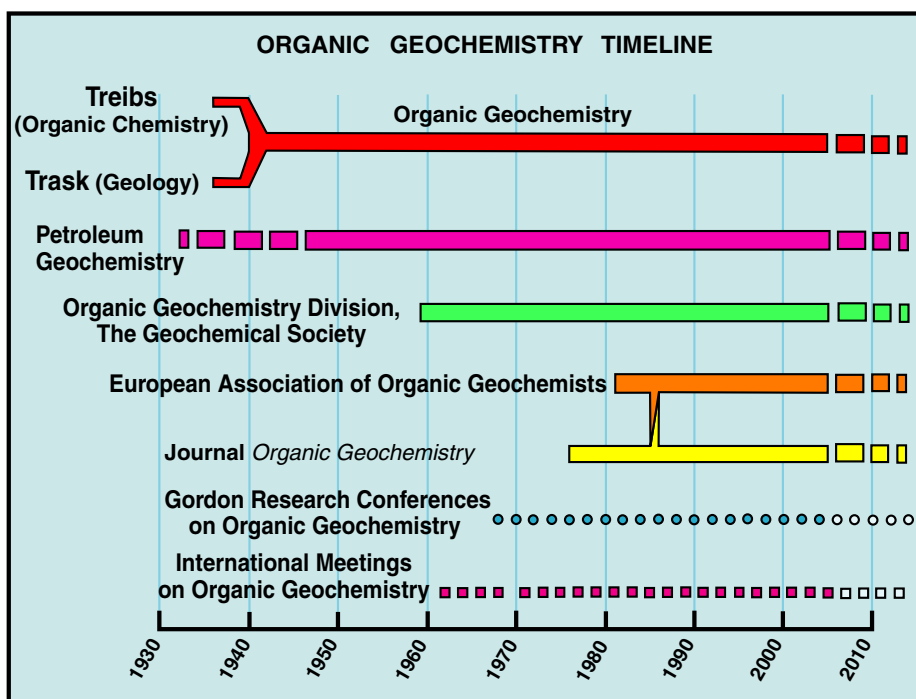


Fig. 1. Timeline showing the history of the development of organic geochemistry.




Fig. 2. Early practitioners of organic geochemistry: (A) Parker D. Trask (~1960), a geological organic geochemist; (B) Alfred E. Treibs (1979), a chemical organic geochemist, and the “Father of Organic Geochemistry”; (C) G.T. Philippi (~1979), first recipient of the A.E. Treibs Award.




Fig. 3. The organizers of organic geochemistry as a geoscience discipline: (A) Bart Nagy, founder of OGD; (B) Pieter Schenck, founder of EAOG.


EDITORS OF THE JOURNAL *ORGANIC GEOCHEMISTRY*





From
Organic Geochemistry
vol. 1 - 4, 1978-1982


1978 - 1982 -- I.A. Breger
 1983 - 1986 -- E.W. Baker
 1987 - 1988 -- E.W. Baker & P.A. Schenck
 1989 - 1992 -- E.W. Baker & A.G. Douglas
 1992 - 2002 -- J.A. Curiale & A.G. Douglas
 2002 - 2002 -- J.A. Curiale & J.R. Maxwell
 2003 - -- L.R. Snowdon & J.R. Maxwell






Irving Breger


Earl Baker


Pieter Schenck


Archie Douglas


Joe Curiale


James Maxwell



Lloyd Snowdon

Fig. 4. The Editors of the journal *Organic Geochemistry*: Irving Breger, Earl Baker, Pieter Schenck, Archie Douglas, Joe Curiale, James Maxwell, and Lloyd Snowdon.

much of his later life (after 1941) Trask devoted his attention to engineering geology, and he is better remembered as an engineering geologist than an organic geochemist (Bailey, 1962; Gilluly, 1963). He probably did not even consider himself an organic geochemist, and perhaps did not even know that he was, in essence, an early practitioner of organic geochemistry on a grand scale, emphasizing the “geo” aspects of the subject.

2.2. Alfred E. Treibs

In contrast to Trask, Alfred Treibs (Fig. 2B) was well recognized during his lifetime as an organic geochemist. His scientific research on porphyrin pigments in various geological materials, spanning almost five decades, set the stage and the standard for the new geoscience of organic geochemistry. His pioneering body of work is internationally recognized, and he was acclaimed and honored on his 80th birthday in 1979 by the symposium entitled “The Impact of the Treibs’ Porphyrin Concept on the Modern Organic Geochemistry” (Prashnowsky, 1980). In 1999, 16 years after his death, a symposium was “Dedicated to the Memory of Alfred Treibs, the Father of Organic Geochemistry on the 100th Anniversary of his Birthday” (Prashnowsky, 2002).

Treibs was born in the German village of Idar-Oberstein; his home is now marked with a bronze plaque [GEBURTSHAUS VON PROF. DR. ALFRED TREIBS (1899–1983) BEGRÜNDER DER ORGANISCHEN GEOCHEMIE]. He studied chemistry in Aachen and later in Munich where he obtained advanced academic degrees at the Technical University (TU). He continued on the staff at the TU for most of his career, except for the time from 1936 to 1945 when he worked at Wacker-Chemie, an industrial research institute. During his 50-year association with the TU, he was involved with research on porphyrins, first as a student supervised by Han Fischer (awarded a Nobel Prize for the utilization of physico-chemical methods applied to pyrroles, the basic structures of porphyrins), and later as Fischer’s colleague, as a research leader, and as a teacher. At the TU, Treibs laid the foundations of the science of Organic Geochemistry with his fundamental research leading to an understanding of the significance of porphyrin pigments in shale, oil, and coal (Treibs, 1936). With the recognition of Treibs as the “father” of organic geochemistry, the date 1936 represents the begin-

ning of the geoscience of organic geochemistry, 70 years ago. A tribute to Treibs has been provided by Seifert (1977), who was one of Treibs’ many students.

2.3. Awards

In recognition of the pioneering work of Alfred Treibs, an award was established in his name. The Alfred E. Treibs Award (consisting of a Medal and Certificate) is given for “outstanding contributions to Organic Geochemistry”, and was presented as an honorary award to A.E. Treibs in 1979. In the same year, the first designated recipient was G.T. (Ted) Philippi (Fig. 2C) for his pioneering work in petroleum geochemistry, a major part of organic geochemistry. Much of his research was conducted from 1936 to 1968 in various laboratories of Shell Oil Company. His publications, though not numerous, were recognized by the organic geochemical community as conceptually important and very stimulating. Appearing late in his professional career, after a lifetime of experience, his publications, beginning about 1957, dealt with (1) the chemical recognition of petroleum source rocks, (2) the importance of subsurface temperatures on the formation and composition of petroleum, (3) the roles of marine and terrestrial plants as the ultimate sources of petroleum, and (4) the nature and extent of bacterial affects on petroleum. His active life as a petroleum geochemist continued unabated after his retirement in 1968, and many of his publications appeared after that date. His early contributions to petroleum geochemistry have been outstanding.

From 1979 through 2002, 17 organic geochemists have received the Treibs Award (Kvenvolden, 2002). Since 2002 this award has been presented to Roger Summons (2003), Eric Galimov (2004), and Jaap Sinninghe Damsté (2005). Two other awards are given to recognize organic geochemists – the Pieter A. Schenck Award and the Australian Organic Geochemistry Medal. The Schenck Award is given every second year to a scientist under 35 years of age who has made a major contribution to any specific area of organic geochemistry or related field. The awardees have been J. Sinninghe Damsté (1993), Mark McCaffrey (1995), Kate Freeman (1997), Stefan Schouten (1999), and Kliti Grice (2001). The Australian Organic Geochemistry Medal for lifetime achievement in organic geochemistry has been awarded to John Smith (1991).

Basil Johns (1993), Trevor Powell (1995), Dave McKirdy (1996), Bob Alexander (1998), Barry Batts (2000), Roger Summons (2002), and John Volkman (2004).

3. Organizations and conferences

Organic geochemistry was formally organized and recognized as a geoscience about 30 years after Treibs and Trask set the stage (Fig. 1). In 1959 Bart Nagy (Fig. 3A) established the Organic Geochemistry Division (OGD) of The Geochemical Society (GS), which met for the first time in 1960 at the annual meeting of the Geological Society of America. By early 1961, OGD was recognized as an integral part of GS. Pieter Schenck (Fig. 3B) organized the European Association of Organic Geochemists (EAOG) in 1981, and EAOG met at the 11th International Meeting on Organic Geochemistry at The Hague, The Netherlands in 1983. The officers (Chairperson and Secretary) through 2003 for both organizations were tabulated in Kvenvolden (2002). Since this compilation the 2003–2005 officers for OGD are M. Whiticar, Chairperson, and T. Dickneider, Secretary. For EAOG the officers since 2002 are R. Patience, Chairperson, and S. Derenne, Secretary.

After OGD was formally organized in 1959, two series of conferences have been devoted specifically to organic geochemistry for more than 40 years (Fig. 1) – International Meetings on Organic Geochemistry (IMOG) and Gordon Research Conferences (GRC) on Organic Geochemistry. IMOG began in 1962 with a gathering in Milan, Italy, and has met consistently every other year (except for a three-year hiatus between 1968 and 1971) since 1962. A tabulation of the first 20 IMOGs (from 1962 to 2001) appears in Kvenvolden (2002). The 21st IMOG (2003) took place in Kraków, Poland, with M. Kotarba (Chairperson) and B. Stankiewicz & M. Kotarba (Proceedings Editors). The 22nd IMOG (2005) took place in Seville, Spain, with F. González-Vila as Chairperson.

GRCs on Organic Geochemistry have been held every other year at Holderness School, New Hampshire, since 1968. The 1968 conference was titled “Organic Geochemistry”, but in 1970 and 1972 the conferences were titled “Geochemistry”, although the main topic of discussion was organic geochemistry. From 1974 to the present, the name “Organic Geochemistry” has been used to identify

the subject matter of these conferences. The idea of a GRC on organic geochemistry seems to have originated in 1963 with a conference entitled “Origin of Petroleum”. For the next six years, GRCs were convened and dealt with broad issues in geochemistry, including organic geochemistry, but it was not until 1968 and thereafter that GRCs focused specifically on organic geochemistry. A tabulation of GRCs (from 1968 to 2002) is given in Kvenvolden (2002). One GRC has met since in 2004 with S. Wakeham as Chairperson.

4. The journal *Organic Geochemistry*

Responding to the proliferation of technical papers addressing organic geochemical topics, Irving Breger established the journal *Organic Geochemistry* in 1977, published by Pergamon Press. He served as Editor-in-Chief until the time of his death in 1982. In volume 1, number 1 (1977) of the journal, Breger wrote the FORWARD which read:

Organic Geochemistry has been established in response to the need for a specialized medium for the publication of research in this highly interdisciplinary field. At present papers concerned with interrelated fields such as organic chemistry, inorganic chemistry, geology, mineralogy, biogeochemistry, oceanography, hydrology, atmospheric and extraterrestrial subjects are published in many scattered journals. It is intended that *Organic Geochemistry* serve as a medium for the publication of reports on all phases of geochemistry in which organic substances play a role. Interpretation of this policy will be liberal to permit the broadest possible exchange of ideas. Among others, papers related to crude oils, coals, natural gas and shales and their associated substances will be welcome, as will reports of studies on the roles of organic substances in the geochemical cycles of various elements. Reports of paleontological and coal petrographic studies will be considered favorably if they are geochemically oriented. Letters to the Editor, relevant news and book reviews will be published. Individual issues of *Organic Geochemistry* may be devoted to papers at Symposia.

This statement became the **Aims and Scope** of the journal through v. 20, n. 3 (1993); in the next issue [v. 20, n. 4 (1993)] the **Aims and Scope** were expanded and have appeared in most issues of the journal to the present. The expanded version

can be found at the frontmatter of this issue of *Organic Geochemistry*. In addition to the major points of the original statement, the current version includes several more specific aspects of organic geochemistry, such as molecular and isotope geochemistry (including compound-specific isotope techniques), environmental geochemistry, organic matter in marine and non-marine sediments, organic-rich rocks and soils, archaeological chemistry, biogeochemical ecology, biomolecular paleontology, and molecular stratigraphy. The journal seeks papers covering the full range of research activities in organic geochemistry. Earl W. Baker assumed editorship of the journal in 1983 with v. 5, n. 1 (1983). Also this issue noted the journal's official affiliation with EAOG. With v. 12, n. 1 (1988)

Organic Geochemistry became “The Official Journal of EAOG” with co-editors Earl Baker and Pieter Schenck. To date seven individuals have served as Editors of *Organic Geochemistry* (Fig. 4).

5. Textbooks in Organic Geochemistry

In addition to the journal *Organic Geochemistry*, several books and compilations of papers have been prepared which serve as textbooks on the subject. Table 1 lists the Proceedings of IMOG. Each of these 21 (as of 2005) compilations of papers is assembled under the title “Advances in Organic Geochemistry” and presents an up-to-date view of organic geochemistry as of the date of each IMOG conference. Examples of textbooks containing

Table 1

Advances in Organic Geochemistry. Proceedings of the International Meetings on Organic Geochemistry (IMOG)

| IMOG | Year | Publication details |
|------|------|---|
| 1st | 1962 | International Series of Monographs on Earth Sciences, No. 15, Pergamon Press, distributed by The Macmillan Company, USA (1964), 488p |
| 2nd | 1964 | International Series of Monographs on Earth Sciences, No. 24, Pergamon Press, UK (1966), 330p |
| 3rd | 1966 | International Series of Monographs in Earth Sciences, No. 32, Pergamon Press, UK (1970), 577p |
| 4th | 1968 | International Series of Monographs in Earth Sciences, No. 31, Pergamon Press, UK (1969), 617p |
| 5th | 1971 | International Series of Monographs in Earth Sciences, No. 33, Pergamon Press, UK (1972), 736p |
| 6th | 1973 | Éditions Technip, France (1974), 1080p |
| 7th | 1975 | Empresa Nacional Adaro de Investigaciones Mineras, S.A. (ENADIMSA), Spain (1977), 911p |
| 8th | 1977 | Abstracts only published in meeting program. Index to Abstracts in Organic Geochemistry, 1, 115–121 (1978) |
| 9th | 1979 | Physics and Chemistry of the Earth, vol. 12, Pergamon Press, UK (1980), 784p |
| 10th | 1981 | Organized by EAOG, John Wiley & Sons, Ltd., UK, (1983), 880p |
| 11th | 1983 | Organized by EAOG, <i>Organic Geochemistry</i> 6, 1–892 (1984) |
| 12th | 1985 | Organized by EAOG, Part I, Petroleum Geochemistry. <i>Organic Geochemistry</i> 10(1–3), 1–648 (1986); Part II, Molecular and General Organic Geochemistry. <i>Organic Geochemistry</i> 10(4–6), 649–1142 (1986) |
| 13th | 1987 | Part I, Organic Geochemistry in Petroleum Exploration. <i>Organic Geochemistry</i> 13(1–3), 1–572 (1988); Part II, Analytical Geochemistry. <i>Organic Geochemistry</i> 13(4–6), 573–1168 (1988) |
| 14th | 1989 | Part I, Organic Geochemistry in Petroleum Exploration. <i>Organic Geochemistry</i> 16(1–3), 1–640 (1990); Part II, Molecular Geochemistry. <i>Organic Geochemistry</i> 16(4–6), 641–1237 (1990) |
| 15th | 1991 | Part I & Part II, Advances and Applications in Energy and the Natural Environment. <i>Organic Geochemistry</i> 19(1–6), 1–556 (1992) |
| 16th | 1993 | <i>Organic Geochemistry</i> 22(3–5), 355–884 (1994) |
| 17th | 1995 | Part I, Paleoclimate and Palaeoceanography. <i>Organic Geochemistry</i> 24(4), 399–472 (1996); Part II, Biopolymers and Macromolecules. <i>Organic Geochemistry</i> 24(6/7), 593–750 (1996); Part III, Origin of Natural Gas; Petroleum Geochemistry; Impact of Organic Geochemistry on Exploration; Migration and Expulsion of Oil and Gas. <i>Organic Geochemistry</i> 24(10/11), 947–1096 (1996); Part IV, Reservoir and Production Geochemistry. <i>Organic Geochemistry</i> 24(12), 1097–1198 (1996); Part V, Environmental Organic Geochemistry; Microbial Geochemistry. <i>Organic Geochemistry</i> 25(1/2), 1–130, (1996); Part VI, Palaeoenvironmental and Source Rock Occurrence; Biogeochemical Cycling of Sulphur and Other Elements. <i>Organic Geochemistry</i> 25(5–7), 265–626 (1996); Part VII, Analytical Developments in Organic Geochemistry; Archaeological and Palaeontological Organic Geochemistry. <i>Organic Geochemistry</i> 26(1/2), 1–154 (1997) |
| 18th | 1997 | Part I, Petroleum Geochemistry. <i>Organic Geochemistry</i> 29(1–3), 1–810 (1998); Part II, Biogeochemistry. <i>Organic Geochemistry</i> 29(5–7), 1025–1835 (1998) |
| 19th | 1999 | Petroleum Geochemistry; Biogeochemistry. <i>Organic Geochemistry</i> 31(12), 1263–1804 (2000) |
| 20th | 2001 | Petroleum Geochemistry; Organic Matter Structure and Reactivity; Depositional Environments and Biogeochemistry; Soil and Environmental Geochemistry. <i>Organic Geochemistry</i> 33(12), 1273–1770 (2002) |
| 21st | 2003 | Diagenesis of Molecules and Sediments; Environmental and Soil Geochemistry; Petroleum Geochemistry. <i>Organic Geochemistry</i> 35(11–12), 1197–1634 (2004) |

Table 2

Examples of Organic Geochemistry textbooks that contain papers by many authors, assembled by an Editor or Editors

-
- Breger, I.A., 1963. *Organic Geochemistry*, International Series of Monographs on Earth Sciences, vol. 16. The Macmillan Co., New York, USA, 658p
- Nagy, B., Colombo, U., 1967. *Fundamental Aspects of Petroleum Geochemistry*. Elsevier, The Netherlands, 388p
- Eglinton, G., Murphy, M.T.J., 1969. *Organic Geochemistry – Methods and Results*. Springer-Verlag, Germany, 828p
- Durand, B., 1980. *Kerogen – Insoluble Organic Matter from Sedimentary Rocks*. Editions Technip, France, 519p
- Kvenvolden, K.A., 1980. *Geochemistry of Organic Molecules*, Benchmark Papers in Geology, vol. 52. Dowden, Hutchinson and Ross, Inc., USA, 357p
- Brooks, J., 1981. *Organic Maturation Studies and Fossil Fuel Exploration*. Academic Press, UK, 441p
- Atkinson, G., Zuckerman, J.J., 1981. *Origin and Chemistry of Petroleum*. Pergamon, UK, 116p
- Brooks, J., 1983. *Petroleum Geochemistry and Exploration of Europe*, The Geological Society Special Publication No. 12. Blackwell Scientific Publications, UK, 379p
- Isaacs, C.M., Garrison, R.E., 1983. *Petroleum Generation and Occurrence in the Miocene Monterey Formation, CA*. Pacific Section, Society of Economic Paleontologists and Mineralogists, USA, 228p
- Miknis, F.P., McKay, J.F., 1983. *Geochemistry and Chemistry of Oil Shales*, ACS Symposium Series 230. American Chemical Society, USA, 565p
- Palacas, J.G., 1984. *Petroleum Geochemistry and Source Rock Potential of Carbonate Rocks*, AAPG Studies in Geology, No. 18. American Association of Petroleum Geologists, USA, 208p
- Brooks, J., Welte, D., 1984. *Advances in Petroleum Geochemistry*, vol. 1. Academic Press, UK, 344p
- Demaison, G., Murriss, R.J., 1984. *Petroleum Geochemistry and Basin Evaluation*, AAPG Memoir 35. American Association of Petroleum Geologists, USA, 426p
- Johns, R.B., 1986. *Biological Markers in the Sedimentary Record*. Elsevier, The Netherlands, 364
- Magoon, L.B., Claypool, G.E., 1986. *Alaska North Slope Oil/Rock Correlation Study – Analysis of North Slope Crude*, AAPG Studies in Geology No. 20. American Association of Petroleum Geologists, USA, 682p
- Baumont, E.A., Foster, N.H., 1988. *Geochemistry, Treatise of Petroleum Geology*, Reprint Series No. 8. American Association of Petroleum Geologists, USA, 660p
- Degens, E.T., 1989. *Perspectives on Biogeochemistry*. Springer-Verlag, Germany, 423p
- Moldowan, R.M., Albrecht, P., Philp, R.P., 1992. *Biological Markers in Sediments and Petroleum*, Prentice-Hall, USA, 411p
- Whelan, J.K., Farrington, J.W., 1992. *Organic Matter: Productivity, Accumulation, and Preservation in Recent and Ancient Sediments*. Columbia University Press, USA, 533p
- Engel, M.H., Macko, S.A., 1993. *Organic Geochemistry – Principles and Applications*. Plenum Press, USA, 861p
-

Table 3

Examples of Organic Geochemistry textbooks in which the content has been prepared by the listed textbook authors

-
- Swain, F.G., 1970. *Non-marine Organic Geochemistry*. Cambridge University Press, UK, 445p
- Tissot, B.F., Welte, D.H., 1978. *Petroleum Formation and Occurrence*. Springer-Verlag, Germany, 538p
- Hunt, J.M., 1979. *Petroleum Geochemistry and Geology*. Freeman, USA, 617p
- Waples, D., 1981. *Organic Geochemistry for Exploration Geologists*. Burgess, USA, 151p
- Tissot, B.F., Welte, D.H., 1984. *Petroleum Formation and Occurrence*, second ed. Springer-Verlag, Germany, 699p
- Philp, R.P., 1985. *Fossil Fuel Biomarkers – Applications and Spectra*. Elsevier, The Netherlands, 294p
- Waples, D.W., 1985. *Geochemistry in Petroleum Exploration*. International Human Resources Development Corporation (IHRDC), USA, 232p
- Waples, E.W., Machihara, T., 1991. *Biomarkers for Geologists – A Practical Guide to the Application of Steranes and Triterpanes in Petroleum Geology*, AAPG Methods in Exploration No. 9, American Association of Petroleum Geologists, USA, 91p
- Killops, S.D., Killops V.J., 1993. *An Introduction to Organic Geochemistry*. Longman Group, UK, 265p
- Peters, K.E., Moldowan, J.M., 1993. *The Biomarker Guide – Interpreting Molecular Fossils in Petroleum and Ancient Sediments*. Prentice-Hall, USA, 363p
- Hunt, J.M., 1996. *Petroleum Geochemistry and Geology*, second ed. Freeman, USA, 743p
- Killops, S.D., Killops, V.J., 2005. *Introduction to Organic Geochemistry*, second ed., Blackwell, USA, 393p
- Peters, K.E., Walters, C.C., Moldowan, J.M., 2005. *The Biomarker Guide*, second ed. Cambridge University Press, UK, 1155p
-

papers in organic geochemistry by many different authors are listed in Table 2, and textbooks in which the entire content was prepared by one to three authors are listed in Table 3. These textbooks range

in subject matter from general organic geochemistry to specialties such as petroleum geochemistry and the organic geochemistry of non-marine sediments, oil shales, and carbonate rocks.

Table 4
Organic Geochemistry Division, Best Paper Award Winners

| Award year | Title | Authors | Source |
|---------------------------------------|---|---|---|
| <i>Molecular Organic Geochemistry</i> | | | |
| 1971 | Nonprotein amino acids in the Murchison meteorite | K. Kvenvolden, J. Lawless, C. Ponnampertuma | Proceedings, National Academy of Sciences (U.S.) 68 (2), 486–490 (1971) |
| 1972 | Proof of structure of steroid carboxylic acids in a California petroleum by deuterium labeling, Synthesis and mass spectrometry | W. Seifert, E. Gallegos, R. Teeter | Journal American Chemical Society 94, 5880–5887 (1972) |
| 1974 | Tri- and tetraterpenoid hydrocarbons in the Messel shale | B. Kimble, J. Maxwell, P. Philp, G. Eglinton, P. Albrecht, A. Ensminger, P. Arpino, G. Ourisson | GCA 38, 1165–1181 (1974) |
| 1975 | Rearranged steranes in shale: occurrence and simulated formation | I. Rubinstein, D. Sieskind, P. Albrecht | Journal Chemical Society 1975, 1833–1836 (1975) |
| 1977 | Diterpenoid compounds in other lipids in deep-sea sediments and their geochemical significance | B. Simoneit | GCA 41, 463–476 (1977) |
| 1987 | Identification of aryl isoprenoids in source rocks and crude oils: biological markers in the green sulphur bacteria | R. Summons, T. Powell | GCA 51, 557–566 (1987) |
| 1989 | Quenching of labile functionalized lipids by inorganic sulphur species: evidence for the formation or sedimentary organic sulphur compounds at the early stages of diagenesis | J. Sinninghe Damsté, W. Rijpstra, A. Kock-van Dalen, J. de Leeuw, P. Schenck | GCA 53, 1343–1355 (1989) |
| 1998 | Variability in radiocarbon ages of individual compounds from marine sediments | T. Eglinton, B. Benitez-Nelson, A. Pearson, A. McNichol, V. Bauer, E. Druffel | Science 277, 796–799 (1997) |
| <i>Biogeochemistry</i> | | | |
| 1977 | Biogeochemistry of Mono Lake, California | W. Reed | GCA 41, 1231–1245 (1977) |
| 1979 | Sterol geochemistry of sediments from the western North Atlantic Ocean and adjacent coastal areas | C. Lee, J. Farrington, R. Gagosian | GCA 43, 35–46 (1979) |
| 1982 | Volatile fatty acid cycling in organic-rich marine sediments | F. Sansone, C. Martens | GCA 46, 1575–1589 (1982) |
| 1986 | Biogenic methane formation in marine and freshwater environments: CO ₂ reduction vs. acetate fermentation – Isotope evidence | M. Whiticar, E. Faber, M. Schoell | GCA 50, 693–709 (1986) |
| 1989 | The occurrence and identification of series of organic sulphur compounds in oils and sediment extracts: II. Their presence in samples from hypersaline and non-hypersaline palaeoenvironments and possible application as source, palaeoenvironmental and maturity indicators | J. Sinninghe Damsté, W. Rijpstra, J. de Leeuw, P. Schenck | GCA 53, 1323–1341 (1989) |
| 1996 | Dependence of phytoplankton carbon isotopic composition on growth rate and [CO ₂] _{aq} : theoretical considerations and experimental results | E. Laws, B. Popp, R. Bidigare, M. Kennicutt, S. Macko | GCA 59, 1131–1138 (1995) |
| 1997 | Reactivity of recently deposited organic matter: degradation of lipid compounds near the sediment–water interface | E. Canuel C. Martens | GCA 60, 193–1806 (1996) |
| <i>Petroleum Geochemistry</i> | | | |
| 1973 | Bacterial degradation of crude oil: comparison of field and experimental data | N. Bailey, A. Jobson, M. Rogers | Chemical Geology 11, 203–221 (1973) |
| 1973 | Alteration of crude oil by waters and bacteria – evidence from geochemical and isotope studies | N. Bailey, H. Krouse C. Evans M. Rogers | American Association of Petroleum Geologists Bulletin 57, 1276–1290 (1973) |
| 1974 | Origine et migration des hydrocarbures dans le Sahara Oriental (Algérie) | B. Tissot, J. Espitalié, G. Deroo, C. Tempere, D. Jonathan | In Advances in Organic Geochemistry, 1973, Editions Technip, France, 315–334 (1974) |

Table 4 (continued)

| Award year | Title | Authors | Source |
|----------------------|---|--|--|
| 1978 | Applications of steranes, terpanes and monoaromatics to the maturation, migration and source of crude oils | W. Seifert, M. Moldowan | GCA 42, 77–95 (1978) |
| 1980 | Molecular parameters of maturation in the Toarcian shales, Paris Basin, France – I. Changes in the configurations of acyclic isoprenoid alkanes, steranes and triterpanes | A. Mackenzie, R. Patience, J. Maxwell, M. Vandenbroucke, B. Durand | GCA 44, 1709–1721 (1980) |
| 1983 | Isomerization and aromatization of hydrocarbons in sedimentary basins formed by extension | A. Mackenzie, D. McKenzie | Geology Magazine 120, 417–470 (1983) |
| 1990 | Origin of Beatrice oil by co-sourcing from Devonian and Middle Jurassic source rocks, Inner Firth, United Kingdom | K. Peters, M. Moldowan, A. Driscoll, G. Demaison | American Association of Petroleum Geologists Bulletin 73, 455–471 (1989) GCA 54, 1315–1323 (1990) |
| 1991 | The origin of light hydrocarbons in petroleum: a kinetic test of the steady-state catalytic hypothesis | F. Mango | GCA 54, 1315–1323 (1990) |
| 1993 | Extraction of whole versus ground source rocks: fundamental petroleum geochemical implications including oil-source rock correlations | L. Price, J. Clayton | GCA 56, 1213–1222 (1992) |
| 1994 | Hydrocarbon composition of authigenic inclusions: application to elucidation of petroleum reservoir filling history | D. Karlsen, T. Nedkvitne, S. Larter, K. Bjørlykke | GCA 57, 3641–3659 (1993) |
| <i>Miscellaneous</i> | | | |
| 1976 | Land-derived organic matter in surface sediments from the Gulf of Mexico | J. Hedges P. Parker | GCA 40, 1019–1029 (1976) |
| 1976 | Thermal alteration of young kerogen in relation to petroleum genesis | R. Ishiwatari, M. Ishiwatari, I. Kaplan, B. Rohrbach | Nature 264, 347–349 (1976) |
| 1981 | Thermal alteration of Cretaceous black shale by diabase intrusions in the eastern Atlantic – II. Effects on bitumen and kerogen | B. Simoneit, S. Brenner, K. Peters, I. Kaplan | GCA 45, 1581–1602 (1981) |
| 1984 | Thermal reactions of kerogen with added water, heavy water and pure organic substances | T. Hoering | Organic Geochemistry 5, 267–278 (1984) |
| 1985 | Evaluation of petroleum generation by hydrous pyrolysis experimentation | M. Lewan | Philosophical Transactions, Royal Society, London, Series A, 315, 123–134 (1985) GCA 55, 1041–1050 (1991) |
| 1992 | Chemical evidence of kerogen formation in source rocks and oil shales via selective preservation of thin resistant outer walls of microalgae: origin of ultralaminae | S. Derenne, C. Largeau, E. Casadevall, C. Berkaloff, B. Rousseau | GCA 55, 1041–1050 (1991) |
| 1995 | Evidence for metastable equilibrium between hydrocarbons under hydrothermal conditions | J. Seewald | Nature 370, 285–287 (1994) |

6. Content

Organic geochemistry is highly interdisciplinary, as outlined above in the **Aims and Scope** of its journal *Organic Geochemistry*. An understanding of the breadth and depth of the subject matter can be gained by perusing the numerous papers within each volume (Table 1) published for the twenty-one IMO conferences that have been held since 1962. Also the textbooks in Tables 2 and 3 contain a variety of papers on subjects dealing with the multiple aspects of organic geochemistry.

Another way to judge the content of this field is to review the published papers that have been selected by committee as Best Papers and Best Student

Papers in Organic Geochemistry. To date, 32 Best Paper Awards and 4 Best Student Paper Awards have been presented. Best Papers were first selected starting in 1971 and have been identified every year (except 1988) thereafter until 1998. The 32 Best Papers have been organized here under four categories (Table 4), although some papers could fit under more than one category: **Molecular Organic Geochemistry** (8 papers); **Biogeochemistry** (7 papers); **Petroleum Geochemistry** (10 papers); and **Miscellaneous** (7 papers). Nineteen of these papers were published in *Geochimica et Cosmochimica Acta* (GCA, 1974–1986).

The papers classified under **Molecular Organic Geochemistry** deal with the discovery and

Table 5
Organic Geochemistry Division, Best Student Paper Award Winners

| Award year | Title | Authors | Source |
|------------|---|--|-----------------------------------|
| 1994 | Laboratory studies of oxic and anoxic degradation of chlorophyll- <i>a</i> in Long Island sediments | M-Y. Sun, C. Lee, R. Aller | GCA 57, 147–157 (1993) |
| 1995 | The geochemical evolution of low-molecular-weight organic acids derived from the degradation of petroleum contaminants in groundwater | L. Cozzarelli, M. Baedecker, R. Eganhouse, D. Goerlitz | GCA 58, 863–877 (1994) |
| 1996 | A novel triterpenoid carbon skeleton in immature sulfur-rich sediments | S. Schouten | GCA 59, 953–958 (1995) |
| 1998 | Hydrolysis of peptides in seawater and sediment | S. Pantoja | Marine Chemistry 57, 25–40 (1997) |

structural determination of several classes of organic molecules found in geological materials. These molecules include di-, tri-, and tetraterpenoid hydrocarbons, aryl isoprenoid hydrocarbons, steranes, carboxylic and amino acids, and sulfur-containing lipids. In addition, the radiocarbon ages of individual organic compounds have been measured. **Biogeochemistry** papers are concerned mainly with organic geochemical processes mediated by organisms. For example, papers address the biogeochemistry of lacustrine and marine sediments, lipid cycling, microbial generation of methane, including the use of carbon and hydrogen isotopes, and palaeoenvironmental implications of organic sulfur compounds. The category **Petroleum Geochemistry** has papers on both bacterial and thermal processes as applied to petroleum occurrence, including studies of isomerization and aromatization of petroleum molecules during basin development. Organic molecules such as steranes, terpanes, and monoaromatic and isoprenoid hydrocarbons are used in the identification of petroleum source rocks, in oil-rock correlations, in assessment of organic matter maturity, and in understanding the origin and migration of petroleum. Papers in the **Miscellaneous** category treat the geochemistry of bulk organic carbon (kerogen) and include thermal alteration experiments. The four Best Student Papers were identified for the years 1994–1998, and they also reflect some of the content of organic geochemistry (Table 5).

Thus, the numerous publications in the IMOG conference proceedings (Table 1), in organic geochemical textbooks (Tables 2 and 3), in *GCA*, *Organic Geochemistry*, specialty journals, such as *Chemical Geology*, *Applied Geochemistry*, *Marine Chemistry*, *Marine and Petroleum Geology*, *Bulletin of the American Association of Petroleum Geologists*,

Environmental Science and Technology, [notably the Best Papers (Table 4) and the Best Student Papers (Table 5)], and general journals, such as *Science* and *Nature*, attest to the rich content of the field of organic geochemistry.

7. Summary

In 70 years, organic geochemistry, an amalgamation of aspects of organic chemistry and geology, has become a mature and widely recognized geoscience. The beginnings can be traced back to the early part of the 20th century when Alfred E. Treibs, an organic chemist, turned his attention to geological materials and discovered the presence of significant organic molecules in shale, coal, and crude oil. Not only did he find complex organic molecules but, perhaps more important, he traced the source of these molecules to their biological precursors. For his visionary and pioneering work, he is generally regarded as the “father” of organic geochemistry. Formal recognition of organic geochemistry came about in 1959, when an organization was established to promote organic geochemical research, and conferences focusing on organic geochemical topics have been convened and have met regularly since 1962. Because of the proliferation of scientific papers on organic geochemistry, a need was identified for a journal, and *Organic Geochemistry* was founded in 1977. Outstanding contributions to the subject have been acknowledged with the presentation of various awards starting two years after the journal was founded. Organic geochemistry is a highly interdisciplinary field, comprising fundamental and applied research, and it is now an important component of many studies in geology and in other fields such as oceanography, hydrology, archaeology, and cosmochemistry.

Acknowledgements

Many thanks go to B.R.T Simoneit for providing encouragement for the preparation of this paper and for valuable information on A.E. Treibs from the comprehensive “Alfred Treibs Memorial Volume”, which unfortunately has had very limited distribution. Thanks also go to B.W. Rogers, who prepared the figures for this paper. Critical reviews by Joe Curiale and James Maxwell are gratefully acknowledged.

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