Musings on the History of Petroleum Geochemistry - From My Perch*

Wallace Dow[1]

Search and Discovery Article #80375 (2014)**
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*Adapted from oral presentation at Session Honoring 50 Years of Wallace Dow's Contributions to Petroleum Geochemistry and Source Rock Characterization, AAPG Annual Convention and Exhibition, Houston, Texas, April 6-9, 2014
Other presentations from this session and posted on Search and Discovery are Article #80385 (2014) by Robert Sterling and Anne Grau, Article #80386 (2014) by Kenneth Peters, and Article #80387 (2014) by Prasanta Mukhopadhy.

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Abstract

In the 1930's, Parker Trask in the USA and Alfred Treibs in Germany both recognized that crude oil was derived from organic matter in sedimentary rocks, and the field of organic geochemistry was born. Petroleum geochemistry is a sub-division and was first formally recognized in 1959 at the 5th World Petroleum Congress. In the 1950's, G.T. Philippi at Shell and J. M. Hunt at N.J. Standard competed to get new petroleum geochemical ideas into print. Their concepts spread rapidly in the 1960's, and several organic geochemical societies were formed, many papers written, and meetings held. By 1970, interest in petroleum geochemistry had exploded and many classic impact papers were published. Computer-driven technology made detailed analysis of sedimentary organic matter possible on a scale not seen before. Interest in petroleum geochemistry waned in the 1984-2003 recession period, and attention turned to other organic geochemical disciplines. Petroleum geochemistry had a new awakening in 2004 when conventional oil and gas source rocks became unconventional reservoirs. New technologies, improved computers, and an interdisciplinary approach defined source rocks and their production potential in more detail than was previously possible; petroleum geochemistry assumed an important place on exploration and production teams. Because of the pre-unconventional reservoir recession, experienced petroleum geochemists are in short supply and their future never looked brighter.

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Addendum

Figure A1 is copy of the article, “A Pioneer of Petroleum Geology” --**Wallace G. Dow**—in GEO EXPRO, March 2014, p. 48-50.

Musings on the History of Petroleum Geochemistry – *From my Perch.*

Wallace G. Dow
Chief Geochemist
Cimarex Energy Co.
Tulsa, Oklahoma

AAPG ACE Presentation
April 8, 2014

Presenter's notes: This talk is intended to be entertaining, as well as informative, to hold the audience's interest.

In the dark days of the "Great Depression" there was **Parker A. Trask,** a *geologist* in the USA and **Alfred E. Treibs,** an *organic chemist* in Germany.

Trask 1899-1961

Parker A. Trask recognized that organic matter in sediments and sedimentary rocks was important to the understanding of oil source beds.

Trask, P.D. 1932, Origin and environment of source sediments. The Gulf Publishing Company, Houston, TX, 323 p.

Trask, P.D., and H.W. Pathnode, 1942, Source Beds of Petroleum, AAPG, Tulsa, OK, 566 p.

Treibs 1899-1983

Alfred E. Treibs discovered organic molecules (porphyrins) in crude oil and demonstrated its biogenic origin.

Treibs, A., 1936. Chlorophyll und Haminderivate in Organischen Mineralstoffen. Angewante Chemie 49, p. 682-688.

The early work of Trask and Treibs tied ***geology*** and ***organic chemistry*** together and the new science of ***organic geochemistry*** was born.

geology

organic chemistry

Petroleum geochemistry is one aspect of organic geochemistry and was first *formally recognized* as a scientific discipline in 1959 at the 5th World Petroleum Congress in a meeting entitled *"General Petroleum Geochemistry Symposium".*

For his achievement, Alfred E. Treibs is recognized as *"The Father of Organic Geochemistry"*. In his honor, the Alfred E. Treibs Award is given annually by the Organic Geochemistry Division of the Geochemical Society for "Outstanding contributions to organic geochemistry".

W. Dow & A. Treibs with wives in 1975

Alfred E. Treibs Medal

Presenter's notes: The photo was taken at a reception in the Retiro Gardens in Madrid, Spain during the 1975 IMOG meeting. I was talking with Dr. Treibs at the time when a photographer wandered by, taking pictures. How lucky can you get!

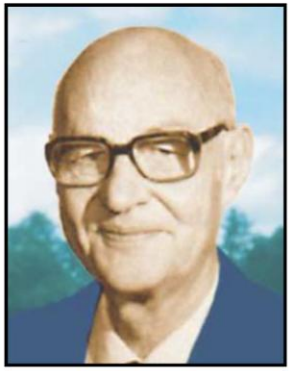
In the 1950's there were the Philippi - Hunt jousts.

G.T. Philippi (Shell) and J. M. Hunt (N.J. Standard) competed to be the first to publish new ideas on the organic origin of petroleum.

G.T. Philippi, 1956. Identification of oil source beds by chemical means. 20th Int. Geol. Congress, Mexico Reprints., p. 25-38.

J.M. Hunt and G. W. Jamieson, 1956, Oil and organic matter in source rocks of petroleum. Bull. AAPG vol. 40, p. 477-488.

Philippi received the 1st Tribes Medal in 1979 and Hunt the 4th in 1982.



Philippi - ?

Hunt – 1918-2005

Presenter's notes: Philippi retired to Estes Park, Colorado, about 20 years ago and has not been heard from since.

Beginning around 1960, geochemical societies were formed, meetings held, and awards given.

1959 – OGD: Organic Geochemical Division of The Geochemical Society.

1962 – EAOG: European Association of Organic Geochemists.

1968 – GRC: Gordon Research Conference on Organic Geochemistry.

1984 – TSOP: The Society for Organic Petrology.

1988 – ALAGO: Latin American Association of Organic Geochemistry

..... and many more.

Presenter's notes: There are many more geochemical societies around the world, and these are just a few of the more important earlier ones.

The ideas of Philippi and Hunt took root and petroleum geochemistry ***grew rapidly*** in the 1960's.

L.G. Weeks, 1958, Habitat of oil and some factors that control it. in L.G. Weeks. Ed. Habitat of oil, AAPG pp. 58-59.

E.E. Bray and E.D. Evans, 1961, Distribution of n-paraffins as a clue to the recognition of source beds. Geochim et Cosmochim Acta, v. 22, pp.2-15.

S.M. Manskaya and T.R. Drozdova. 1964, Geochemistry of organic matter. Nauka. Moscow.

E.T. Degens, 1965, Geochemistry of Sediments, Prentice Hall, Englewood Cliffs, N.J., 352 pp.

V.A. Sokolov, 1965, Processes of formation and migration of oil and gas. Nedra, Moscow, 276 pp.

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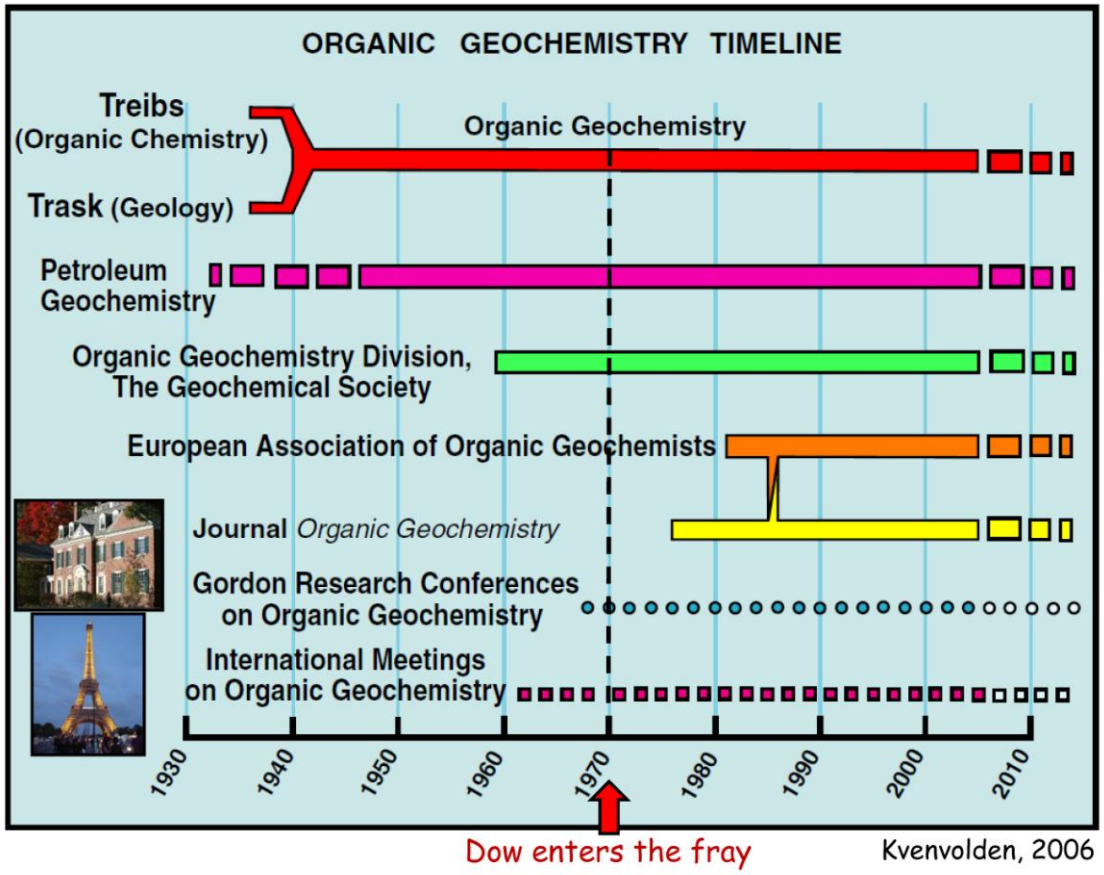
……. and many more.



Presenter's notes: Gordon Research Conferences on organic geochemistry are held in the USA (at the Holderness boarding School in Plymouth, New Hampshire) on even-numbered years, and the International Meetings on Organic Geochemistry (IMOG) are held at various venues in Europe on odd-numbered years.

So how did I get into petroleum geochemistry?

Career decisions to join the Amoco Research Geochemistry Group in 1969 and then in 1972 to stay with petroleum geochemistry rather than return to the much more popular exploration geology.

"Two roads diverged in a wood, and I,
I took the one less traveled by,
And that has made all the difference."

From "The Road Not Taken" by Robert Frost, 1916

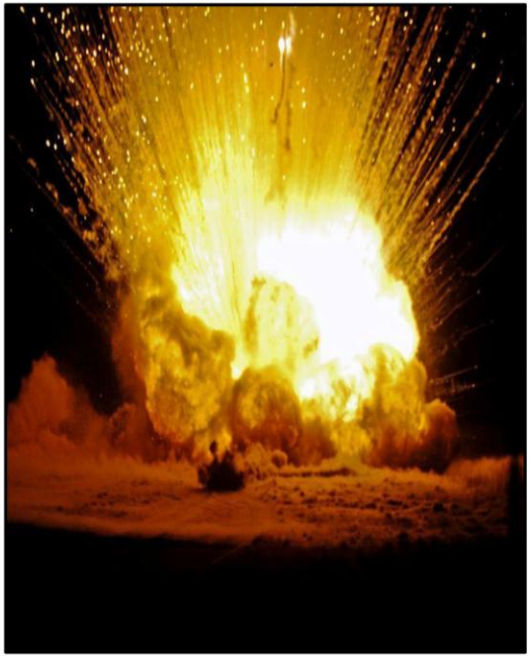
Presenter's notes: In 1972 while working at the Amoco Research Center in Tulsa, OK, I had a performance review and was told that I had little future with the company unless I got out of geochemistry. I had to decide whether to do something I liked and be on the bottom of the oil company food chain or do something I liked less and return to exploration geology. I chose "the road less traveled" and took a job in Houston with The Superior Oil Company to set up a geochemical lab; the rest is history.

Petroleum geochemistry ***exploded*** as technology improved and had its first Heyday in 1970 – 1984.

Major and independent oil companies established geochemical labs.

University, national oil company, and government labs were funded. Among the best were the USGS in the USA, IFP in France, and KFA in Germany.

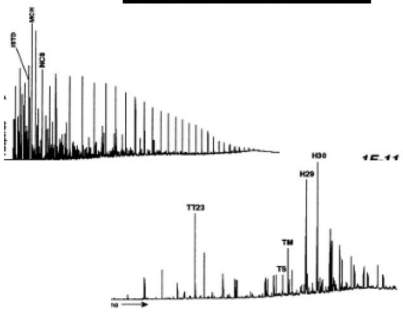
Vendor labs proliferated. The first in the USA was GeoChem in 1971, followed by Global in 1975, Robertson Research (US) in 1978, Brown & Ruth-Exlog in 1981, and *DGSI in 1984*.



Presenter's notes: DGSI (aka Dow Geochemical Services, Inc.) was founded from the rubble of Robertson Research (US), when the British "closed shop" and consolidated their services back in the UK--at the beginning of the 1984 recession.

Technology developments came when needed to make detailed analysis of organic matter possible.

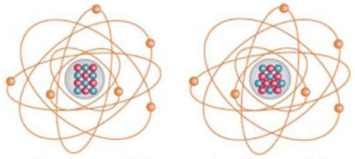
Rock-Eval pyrolysis replaced elemental analysis as a screening kerogen type and maturity measurement.



Capillary gas chromatography columns greatly increased resolution and compound identification.

GCMS permitted quick and easy identification of many more organic compounds and chemical structures.

Vitrinite reflectance became the kerogen maturity technique of choice.



GCIRMS extended carbon isotopes to individual compounds easily and quickly.

*And **computers** made it all possible.*

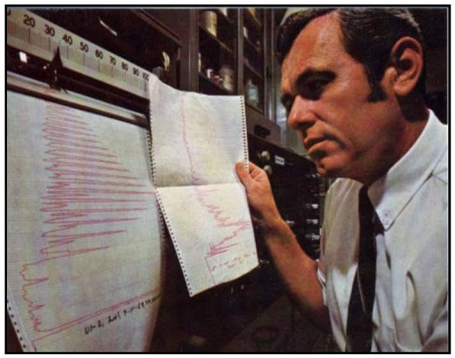
The Petroleum System Concept - 1971

Jack Williams at Amoco Research was first to recognize *genetic differences* among crude oils and correlate them to *specific* source rocks.

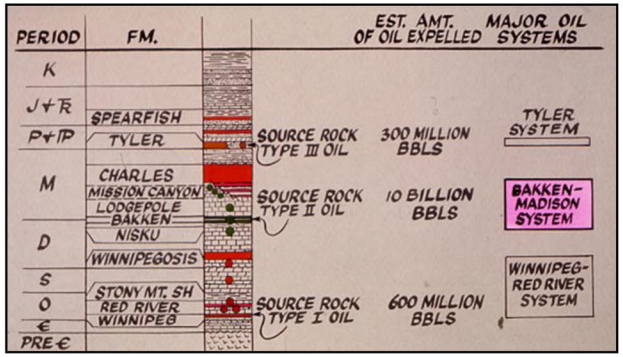
This led to the *Petroleum System Concept* developed by Wally Dow in 1971 at Amoco Research.

Jack and Wally's ideas were presented at the AAPG Annual Meeting in Denver in 1972 *because management saw no value in them.*

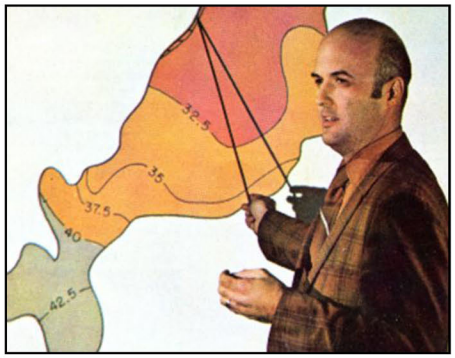
Two papers were published in the AAPG Bulletin in 1974 defining the "oil system" concept as it applied to the Williston Basin.



Jack Williams-1971



AAPG Bulletin. 1974



Wally Dow-1971

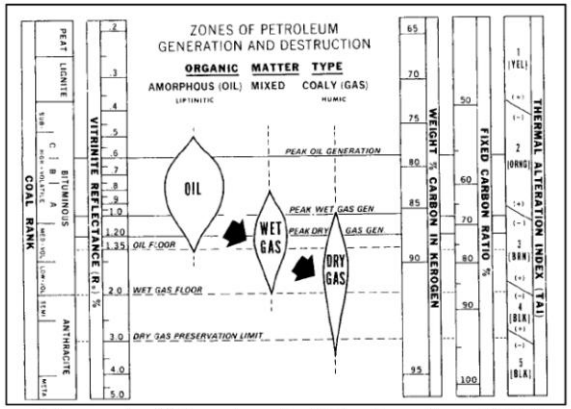
Vitrinite Reflectance Microscopy - 1973.

The Superior Oil Co., got vitrinite reflectance from Tenneco & Shell in 1972, and it was further developed by Wally Dow and Dolores O'Connor.

Microscope was interfaced with a DEC PDP 8-L computer with 12 bit processor, 8K core memory, punch paper tape recorder & Teletype interface.

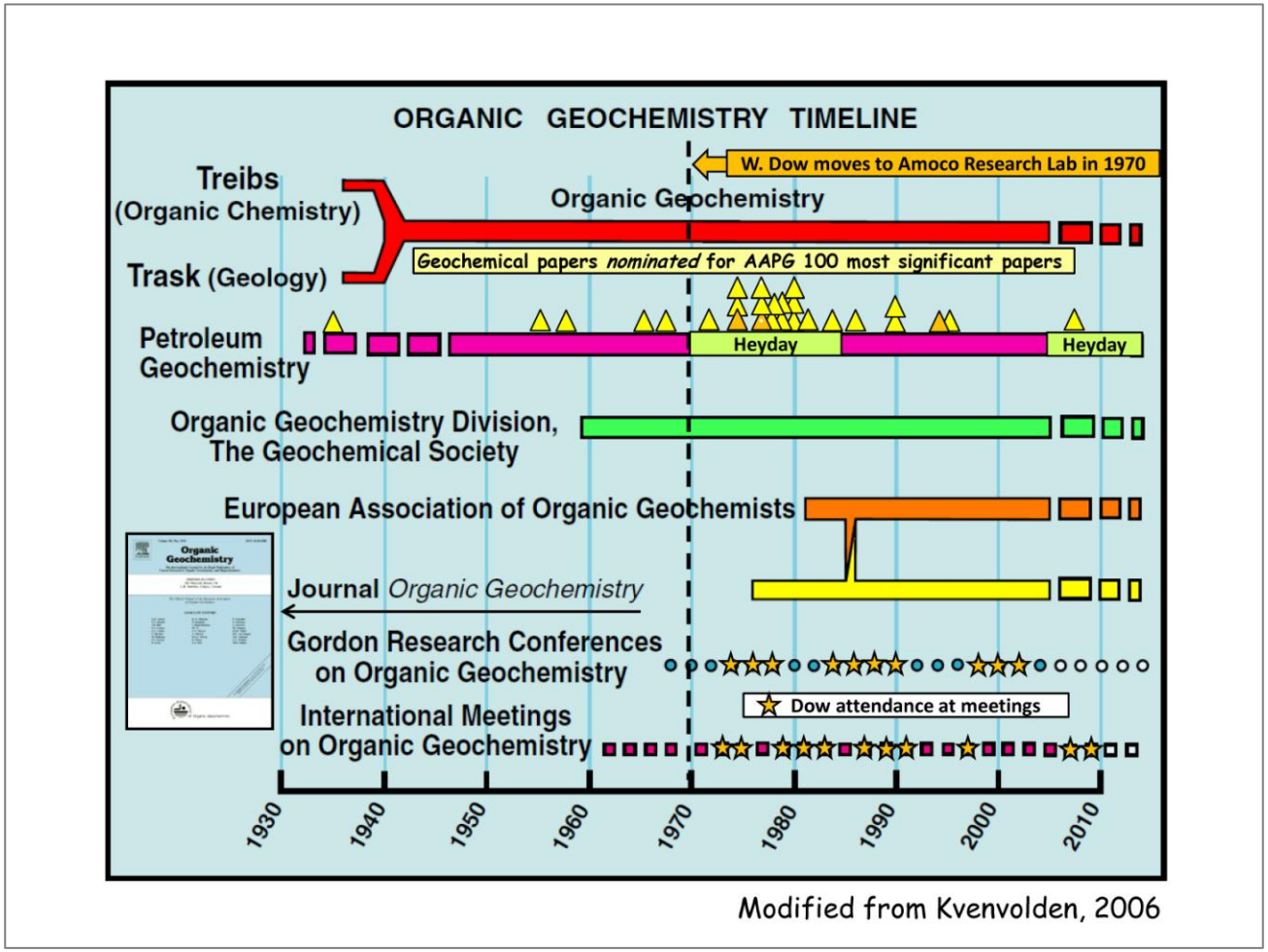
Dow & O'Connor wrote papers, taught courses, and introduced many oil companies to the vitrinite reflectance kerogen maturity technique.

Zeiss microscope DEC, PDP-8L computer, 1972



Journal of Geochemical Exploration, 1977

Presenter's notes: The PDP MC8L system (1968-1971) cost $8000 in 1970 and had a 12 bit processor, 8K of core memory, paper tape reader, punch recorder, and Teletype interface--no operating system, just run and halt switches, and built with diodes and transistors. The PDP family was introduced in 1965 and became the first widely sold minicomputer series (>50,000 systems)!

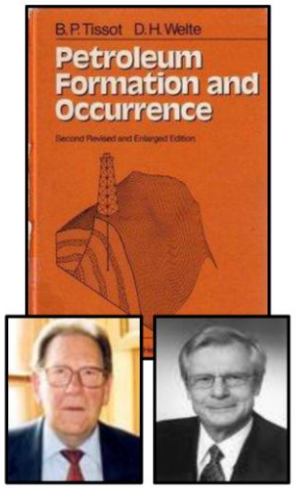


Presenter's notes: Repetition of previous slide, but with a few additions. Dow's activities are shown in orange, the two geochemical "Heyday" periods in green, and the 27 geochemical papers nominated to be included in the 100 most influential papers list for AAPG 100th anniversary in 2017 are shown in yellow. There is a good correlation between the first "Heyday" and the number of influential papers as that period produced 16 of those nominated.

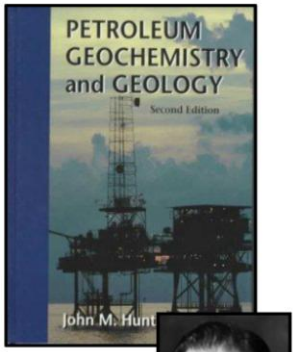
The first petroleum geochemistry textbooks.

B.P. Tissot and D.H. Welte raced with J.M. Hunt to get the first petroleum geochemistry textbook into print. Tissot and Welte in 1978 edged out Hunt who followed in 1979. Their second editions came out in 1984 and 1996, respectively. All three were early recipients of the Treibs Medal. *W. Dow was privileged to edit portions of both textbooks.*

1978 & 1984



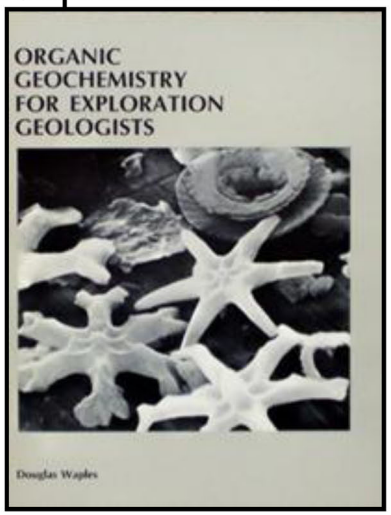
1979 & 1996



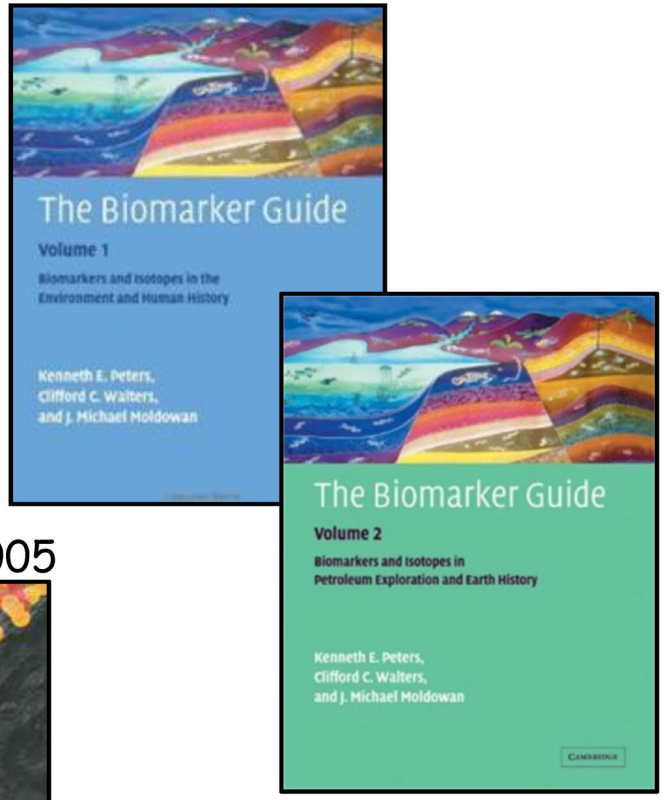
Presenter's notes: There really was competition to get the first book publishedt. The first printing of Tissot and Welte's book has "Ocurrence" (sic) spelled incorrectly and the covers had to be reprinted.

Some other petroleum geochemistry textbooks.

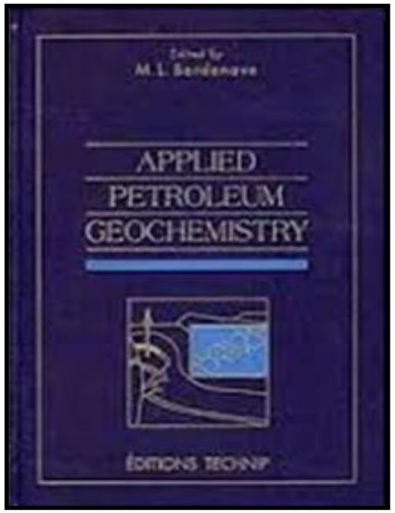
Waples 1981 & 1985



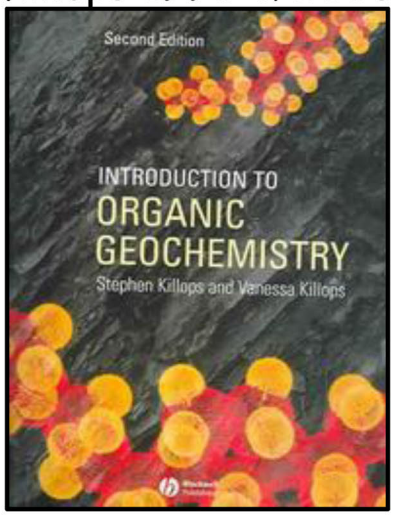
Peters 1993 & 2005



Bordenave 1993



Killops 1993 & 2005



Some additional historical resources:

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K.A. Kvenvolden, 2002, History of the recognition of organic geochemistry in geoscience. Organic Geochemistry, V. 33. pp. 517-521.

J.M. Hunt, R.P. Philp, K.A. Kvenvolden, 2002, Early developments in petroleum geochemistry, Organic Geochemistry, v. 33, pp. 1025-1052.

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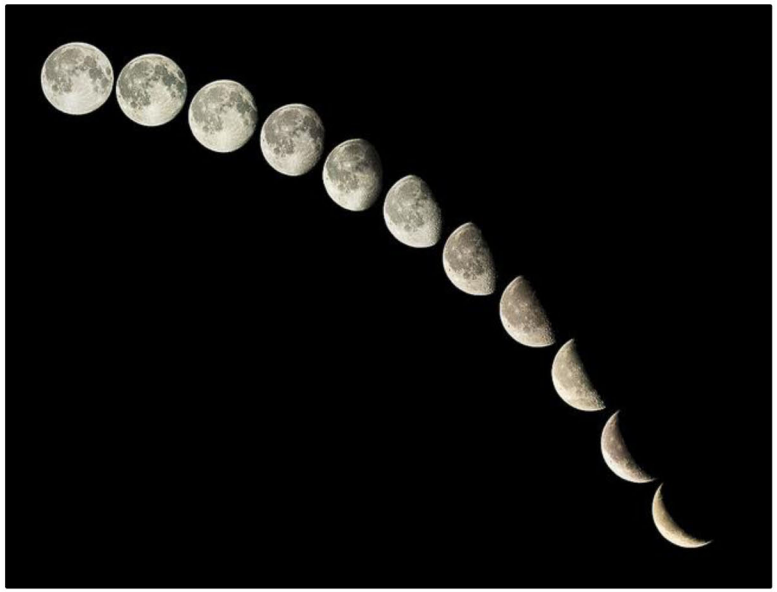
K.A. Kvenvolden, 2006, Organic geochemistry – A retrospective of its first 70 years. Organic Geochemistry, v. 37, pp. 1-11.

B.J. Katz, et. al., 2008, A review and technical summary of the AAPG Hedberg Research Conference on "Origin of petroleum-biogenic and/or abiogenic and its significance in hydrocarbon exploration and production". AAPG Bull., v. 92, pp. 549-556.

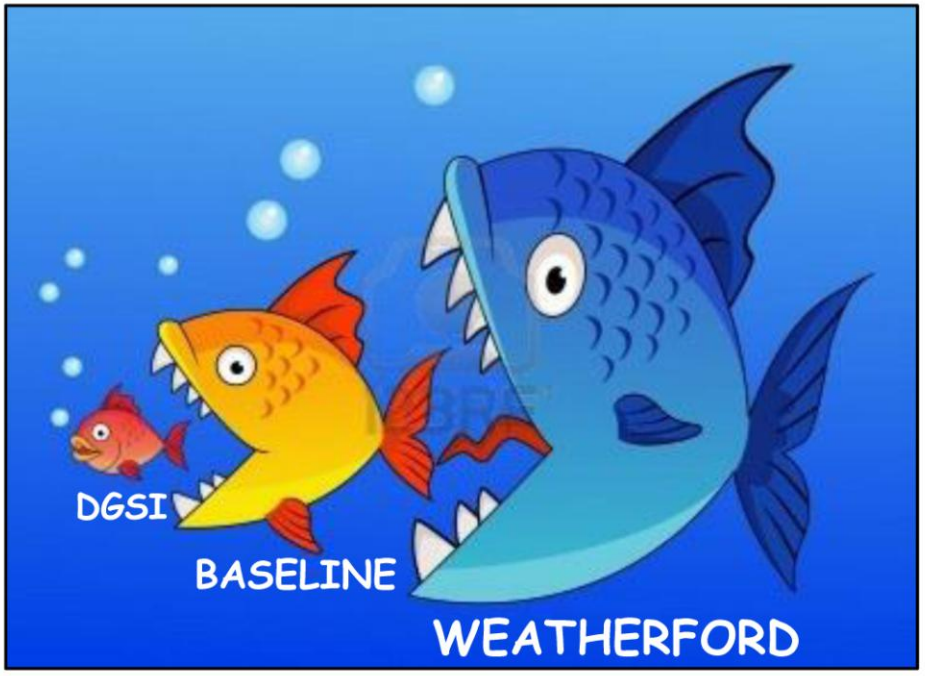
Interest in petroleum geochemistry *waned* in the 1984-2003 recession and organic geochemistry emphasis turned elsewhere.



University and government labs picked up the slack and focused on academic and other organic geochemistry disciplines (environmental, forensic, sedimentary microbiology and ore deposits).

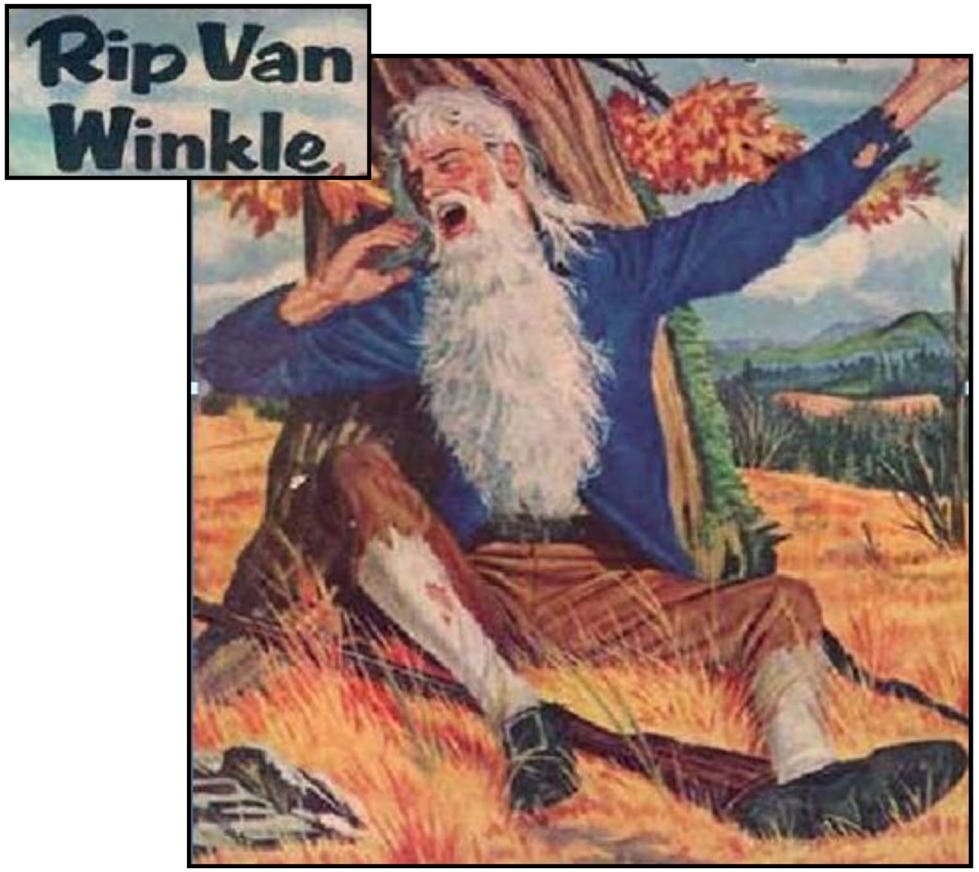
Many oil company labs either closed or were "spun off" as vendors. Vendor labs then closed or consolidated due to increasing competition in a recession-starved market. Weatherford bought up everyone except GeoMark and Westport which was acquired by Intertek.

Geochemical lab consolidation in the recession period.



Presenter's notes: One example of the 1984-2003 geochemical laboratory consolidation. Sometimes fish that eat too much too fast get indigestion, and their analytical quality and service deteriorate.

Petroleum geochemistry had a ***new awakening*** in 2004 when oil and gas source rocks became "unconventional reservoirs".



Washington Irving, 1819

CONVENTIONAL SOURCE ROCKS = *UNCONVENTIONAL* RESERVOIRS

Calvin and Hobbs by Bill Watterson

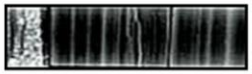
..... *my source rock is now my reservoir!*

Quinn R. Passey, 2010

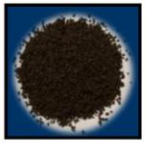
When conventional oil source rocks became unconventional reservoirs, geochemists learned more about them than ever before.

When source rocks became reservoirs, geochemists *finally* gained respect and were allowed to join exploration teams.

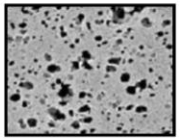
Many **cores of black shale** source rocks were taken *intentionally* without threat of termination.



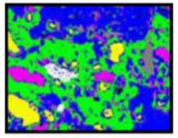
CT scans of cores showed internal structure, fractures, and density variations.



Tight rock analysis permitted porosity and permeability measurement of shales and other tight reservoirs.



***Argon ion milling* SEM** revealed pores, mineralogy, and rock fabrics in fine-grained rocks never seen previously.

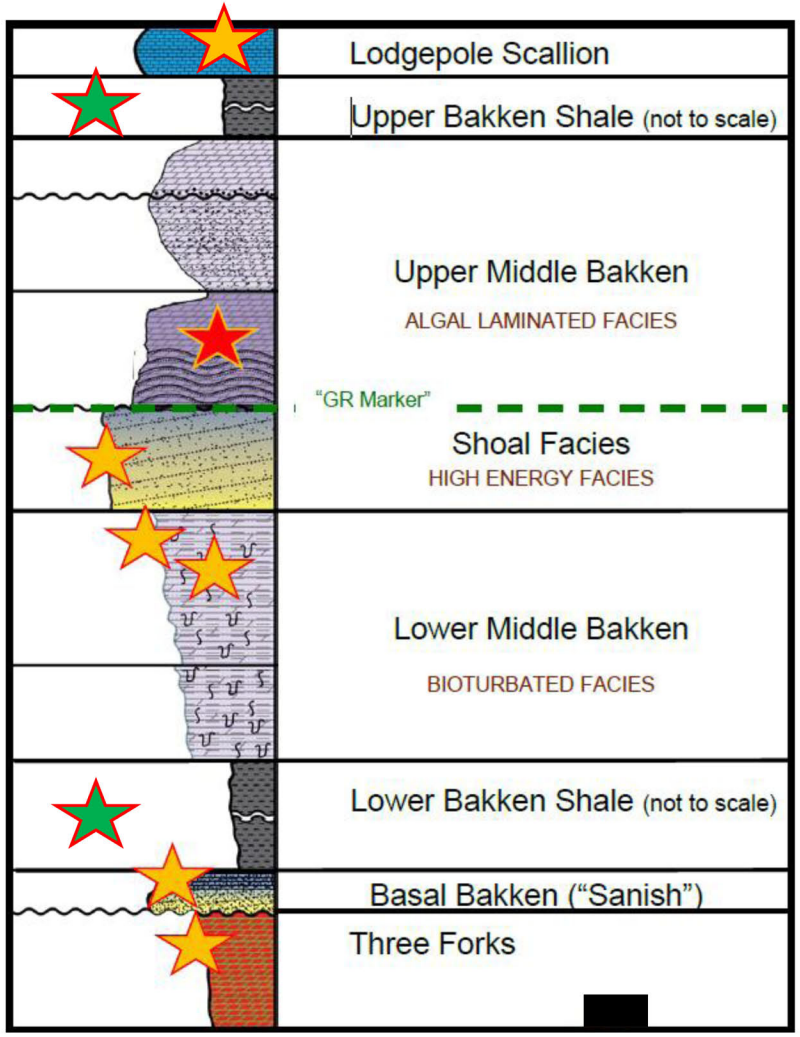


X-Ray dispersion spectroscopy (EDS) identified mineral distribution in fine-grained rocks never seen before.

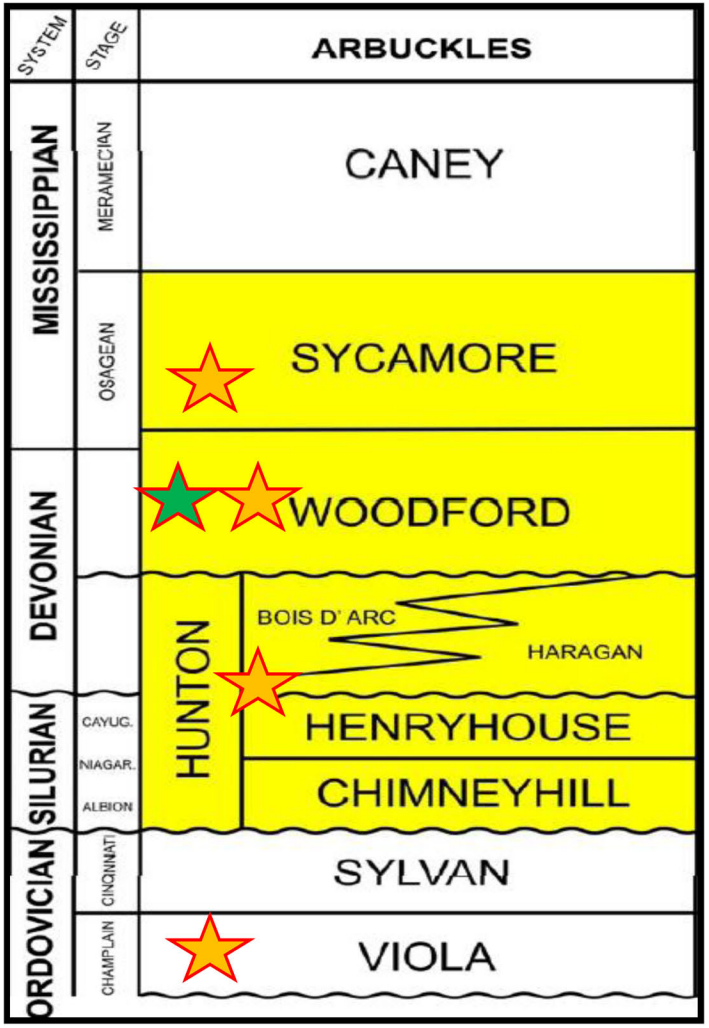
*And **computers** made it all possible.*

Presenter's notes: Geologists really were fired for accidentally taking too many shale cores in the 1960's. Reservoirs should be cored, not source rocks! EOG took over a half mile of Eagle Ford source rock shale cores in eight wells before committing full bore to the play.

Bakken and Woodford unconventional *petroleum systems* – not only source rocks



Grau and Sterling, 2011



Krystyniak, 2003

In its *second Heyday*, petroleum geochemistry became an important link between reservoir petrophysics and engineering.

Interdisciplinary studies of "unconventional reservoirs" led to a much better understanding how source rocks form and function.

Most of the 1970's geochemical notions about how source rocks generate and expel oil and gas were found to be basically correct.

Digital rock physics combined with petroleum geochemistry led to improved reservoir property description, especially in tight reservoirs.

Petroleum geochemistry linked rock petrophysics and reservoir engineering to solve practical production problems.

*And **computers** made it all possible.*

Geochemical contributions to unconventional resources exploration teams.

First you get the maturity right. *Then you get respect!*

Organic matter affects P & P data (lab and logs).

Organic richness and facies help define most unconventional plays.

Organic porosity is important especially in gas reservoirs.

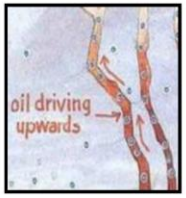
Geochemical data can help predict yield, GOR, BTU value, & API gravity.

Produced oil and gas data helps interpret PVT tests.

While all this was going on, in a dark energy universe on THE FAR SIDE of reality, abiogenic theorists were promulgating their wild and crazy notions.

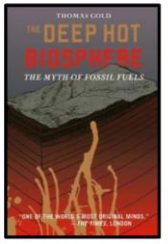
L.P. Gaucher said *"Three to four billion years ago dense clouds of hydrocarbons rained oil which filled all the surface depressions present at the time".* AAPG Bulletin, 1972.

Bob Hirsch claimed that *"Oil is formed from Gingko leaves after 1" of burial by catalysts which are used up in the reaction"* (1975).



Tom Gold speculated that *"Hydrocarbons seeped upward from the mantle through cracks and became oil and coal by cold fusion processes that have not yet been defined"* (1982). Then, faced with growing evidence of biological compounds in oil, he conjured up his *"deep, hot biosphere"* fantasy (1992).

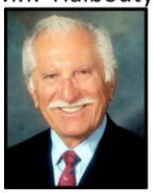
Gold, T., 1992, The deep hot biosphere: the myth of fossil fuels. Proceedings of the National Academy of Sciences. V. 89. pp. 6045-6049. (Also a book by Springer, 1999).



Presenter's notes: There are many versions of the inorganic oil/gas source notions; these are just a few.

Two diametrically opposing views.

M.T. Halbouty



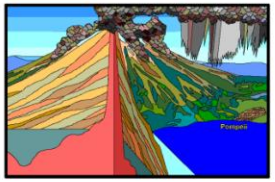
AAPG Research Conference, Calgary, 2005, "Origin of petroleum – biogenic and/or abiogenic and its significance in hydrocarbon exploration and production".

W. Dow gave the biogenic keynote emphasizing the scientific method.

Hedberg from Hell

The West – mainly biogenic

The East – largely abiogenic



V.B. Porfir'ev, 1974, Inorganic origin of petroleum. AAPG Bulletin, v. 58, pp. 3-33. Abiogenic diatribe.

V.A. Krayushkin, 1984, The abiotic, mantle origin of Petroleum. (in Russian): Kiev, Naukova Dumka, 176 pp.

J.F. Kenney, et al, 2002, The genesis of hydrocarbons and the origin of petroleum. Proceedings of NAS, of USA, v.99, pp. 10,976-10,981.

Presenter's notes: Michel Halbouty wanted a Hedberg Conference on this subject to answer once and for all the organic/inorganic source question. It was postponed three times and finally wound up as non-Hedberg research conference at the Calgary AAPG Annual Meeting in 2005. The reason was because speakers were nearly impossible to locate: The organic camp didn't want to be associated with such nonsense, and the inorganic camp saw no reason to attend because they had already solved the problem and could see no purpose in debating the issue. Hence it became "The Hedberg from Hell".

But maybe they are *both* wrong. There are those who believe:

"The biogenic origin is a seriously deficient idea."
"The abiogenic origin is scientifically ill-defined."
"Therefore, we must conclude that:"

1) "*Oil and gas were made by God in the Creation Week and moved into their present positions during the biblical Flood".*
2) *"This conclusion confirms that the bulk of the fossiliferous geologic strata are Flood deposits".*

J.D. Mathews, 2008, Building the Creation Model.
www.answersingenesis.org/articles/arj/v1/n1/origin-of-oil

Presenter's notes: This person is quite serious about his view and actually puts forth a rather complete discussion which ignores all science at the end.

Presenter’s notes: Well, from my perspective and experience anyway.

.....and why I'm still doing it after all these years.

Presenter's notes: Well, from my perspective and experience, anyway.

A Pioneer of Petroleum Geochemistry

RASOUL SORKHABI, Ph.D.

Geochemistry of petroleum source rocks was developed in relatively recent times. **Wallace Dow**, celebrating his fifth decade of professional life this year, played a pioneering role in the advancement of vitrinite reflectance and kerogen type studies as well as the concept of oil-source correlation, all paving the way to modern petroleum system analysis.

Wallace Gilmore Dow was born on June 4, 1937 in New Jersey and grew up in that state. He found his love for chemistry in high school. "In those days," Dow recalls, "there were four major science subjects in my high school: physics, chemistry, biology, and something called physiography, a combination of astronomy, meteorology, and geology, and two were required for graduation. Physics did not appeal to me and I did not fancy cutting up frogs in biology, so I chose chemistry and physiography which became my first introduction to geology." In 1955, Dow entered Rutgers University in New Brunswick, N. J. and graduated in geology four years later. After serving in the US Army for three years, Dow applied for a Master's program in geology at several universities. He selected the University of North Dakota in Grand Forks because "they sent me a telegram saying that they would waive my tuition fees and even pay me money. Not a bad deal for a penniless student." In 1964, Dow graduated with an M.S. with honors in Geology and Stratigraphy. In the same year, his first research papers were published: 'Effect of the salinity on the formation of mud cracks' in *The Compass of Sigma Gamma Epsilon*, and a paper on the Spearfish Formation (Triassic Red Beds) in the Williston Basin of North Dakota (in *Third Williston Basin Symposium Guidebook*), which was actually his Master's thesis and was formally published as the *North Dakota Geological Survey Bulletin 52*.

Courtesy of Wallace Dow

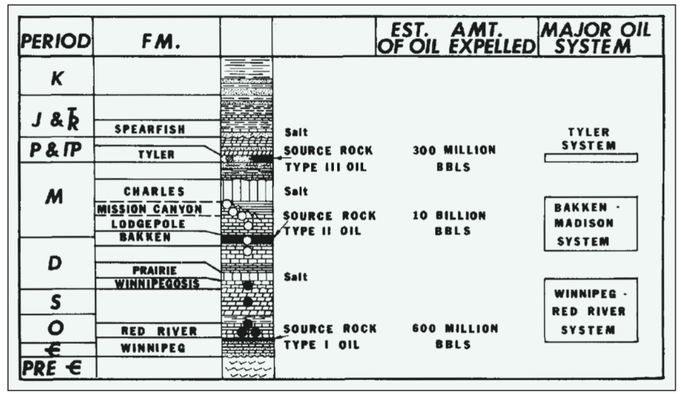
Williston Basin

"In the subsurface of the Williston Basin in western North Dakota, the Spearfish Formation can be divided into three lithologic units. In ascending order these are: (1) a lower gray shale and red siltstone unit, (2) a middle salt unit, and (3) an upper red siltstone, shale, and fine grained sandstone unit." (Dow, 1964)

With a significant oil discovery in 1951, the Williston Basin was a hotspot for oil exploration during the 1950s and 60s, and the University of North Dakota and the North Dakota Geological Survey held a central position in studies of the basin. It was only logical for Dow to focus his Master's research there. His thesis advisor was Walter Moore, a geologist who had worked for Gulf Oil before joining the University in 1960. Dow was also supported by the department chair and State Geologist Wilson Laird (1915–1977), a prominent geologist in North Dakota who later served as the AAPG President as well as Director of the Office of Oil and Gas in the US Department of the Interior (1969–71).

It was also at North Dakota that Dow met his would-be wife and life-long companion Marlys, who had taken a geology laboratory class in 1963 for which Dow was a teaching assistant. "I needed someone to type my Master's thesis," Dow admits, "and she pretended to need tutoring." They married in August 1965, a year after Dow had got his first job as a geologist for Pan American Production Company (later Amoco). Initially, Dow worked in Casper, Wyoming where he studied Mesozoic sandstones of the Rocky Mountain basins and in 1965 the company moved to Denver, Colorado. He spent the next four years alternating as a well-site geologist and working on Paleozoic carbonates, especially the Ordovician Red River Formation. "When my first son Thomas was born in Denver in 1967, I was in the field drilling Pan American Hove No. 1 into naturally fractured Bakken Shale. I rushed to Denver when I was informed of his birth, eight weeks early." Dow's second son Kevin was born in 1968. The Dows now have five grandchildren.

What drew Dow to petroleum geochemistry was not only his interest in chemistry, but also his unique situation: "As a well-site geologist I collected hundreds of oil samples for the new Amoco geochemistry lab in Tulsa, Oklahoma to analyze." In 1969, Dow was transferred to Amoco's Research Center in Tulsa where he was responsible for interpretation of geochemical data and prepared over 100 internal reports covering many US and overseas exploration blocks. There, he enrolled in the Ph.D. program in organic geochemistry and business management at Tulsa University (1970–1972) and took classes from legends like Colin Barker, Parke Dickey and Norman Hyne. In 1972, Dow left to work for The Superior Oil Company in Houston and never completed his Ph.D. degree.



Courtesy of Wallace Dow

'Oil systems' for the Williston Basin proposed by Wallace Dow in AAPG Bulletin in 1974. This was a germinal idea for what was later developed as the petroleum system analysis in the 1980s.

'Oil System'

"Most Williston basin oils belong to one of three basic types… isolated vertically by evaporates… All three oil types can be correlated to their source facies. Lithofacies maps of these source sequences, when combined with thermal alteration measurements, provide effective oil-source-area definition." (Dow, 1974)

While at Amoco Research, Dow and organic chemist Jack A. Williams developed the idea of oil-to-source rock correlation based on geochemical data from the Williston and several other basins and presented it to one of the company's vice-presidents who flew in from Chicago. "We basically handed him the concept of what later came to be known as 'the petroleum system', but he was unimpressed and declared it of little use in petroleum exploration! The bright side was that the company permitted us to present our work at the AAPG Annual Convention in 1972 in Denver in a session entitled 'New Ideas in Petroleum Exploration' which was later published in the 1974 AAPG Bulletin." Dow suggested "three major source-reservoir oil systems" for the Williston Basin: (1) the Winnipeg-Red River oil system below the Devonian Prairie salt; (2) the Bakken-Madison oil system between the Devonian Prairie and Mississippian Charles salts; and (3) the Tyler system above the Mississippian Charles salts.

Ten years later, Dow teamed up with Leslie B. Magoon (then at US Geological Survey) and formalized the original 'oil-system' ideas into the 'petroleum system' concept, culminating in AAPG Memoir 60 titled *The Petroleum System: From Source to Trap*, edited by Magoon and Dow. This volume, still the 'Bible' in its field, won the AAPG Robert H. Dott, Sr. Memorial Award for the best special publication of 1994. (See *GEO ExPro* Vol. 8, No. 5 for more about petroleum systems.)

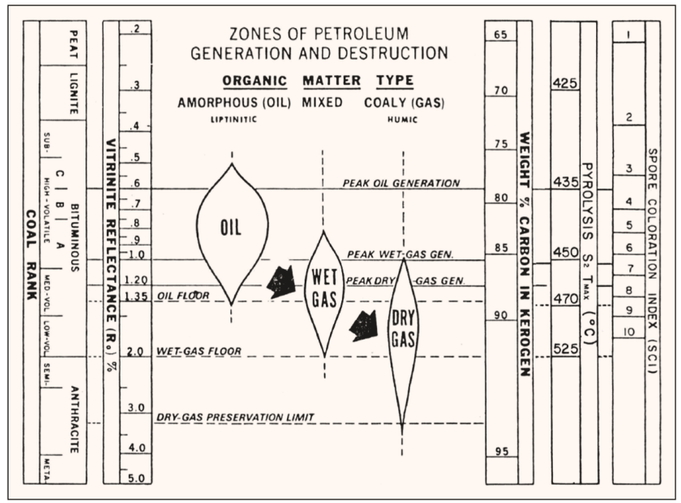
Thermal Maturity

"The primary purpose of kerogen maturation is to determine whether petroleum has been generated in source beds." (Dow, 1977)

Dow left Amoco to work for The Superior Oil Company in Houston because they had just begun using reflected light microscopy to study kerogen and Dow recognized it as an important new frontier in petroleum geochemistry. He hired Dolores O'Connor to do most of the microscopy work and together they advanced geochemical techniques and interpretations for the characterization of sedimentary organic matter including vitrinite reflectance (VR), which is now commonly used by oil explorers to assess the thermal maturity of source rocks. The VR technique was originally developed for ranking of coal with burial depth and temperature, but its application to petroleum source rocks revolutionized both the technique and petroleum geology. Dow and O'Connor's 1982 SEPM report is still a useful guide to the VR technique. Dow extended his studies to kerogen typing and published a seminal paper titled 'Kerogen studies and geological interpretations' in the *Journal of Geochemical Exploration* (1977), which remains one of his most cited works.

Dow and O'Connor left Superior Oil when management changed and after a short stint at Getty Oil joined Robertson

The famous droplet diagram showing the correlation of maturity indicators for oil and gas windows first presented by Wallace Dow in the Journal of Geochemical Exploration in 1977.



Courtesy of Wallace Dow

Research (US) Inc. in Houston. In the 1970s, through his interactions with international conferences like International Meeting on Organic Geochemistry, the Gordon Research Conference on Organic Geochemistry, and AAPG meetings and conferences, Dow was befriended by many of the pioneers in the field, including Alfred Treibs (the father of organic geochemistry), John Hunt (author of *Petroleum Geochemistry and Geology*, 1979, 1995), Bernard P. Tissot and Dietrich H. Welte (authors of *Petroleum Formation and Occurrence*, 1978, 1984). Hunt, Tissot and Welte, who wrote the first textbooks on petroleum geochemistry, cited Dow's papers. Dow regards the American geologist Parker Trask (1899–1961) and the German organic chemist Alfred Treibs (1899–1983) as two giants who began petroleum geochemistry during the Great Depression of the 1930s. Dow also wrote a biography of John Hunt (1918–2005) on his seventieth birthday in 1988, published in a proceedings volume, *Organic Matter* (Columbia University Press, 1992).

What is in a Word?

By Wallace Dow

Kerogen: "The portion of organic matter in sedimentary rocks that is insoluble in organic solvents; it is formed from formerly living organic materials by diagenetic processes in the first hundred meters of burial and is partially converted, under the influence of temperature and time, into petroleum." (1977)

Vitrinite: "The most common maceral group occurring in humic coals and also the most abundant constituent of most sedimentary kerogens. It is formed after sedimentation in the diagenetic environment by humification of lignin and cellulose of plant cells." (1982)

Deepwater Petroleum Source Rocks

"Continental slopes commonly are sites of high marine organic productivity and frequently contain reducing bottom conditions, quiet water, and intermediate sedimentation rates, all of which favor deposition of organic-rich sediments." (Dow, 1978)

The oil industry aggressively moved to explore deepwater basins in the 1970s. Although our knowledge of deepwater plays has increased over time, questions about petroleum source rocks in these basins is still hotly debated. It is, therefore, of interest to note Dow's 1978 *AAPG Bulletin* paper titled (far ahead of its time) 'Petroleum source beds on continental slopes and rises.' This paper resulted from Dow's involvement in the geochemical analysis of cuttings and cores from the offshore Gulf Coast and Atlantic coast (drilled as part of the US Continental Offshore Stratigraphic Test program) as well as those from several bore holes of the Deep Sea Drilling Project offshore North Atlantic. For the Gulf of Mexico, Dow found that the organic carbon content increases from shelf/neritic (0.23%) to bathyal/abyssal (0.60%) sediments.

DGSI and Recent Years

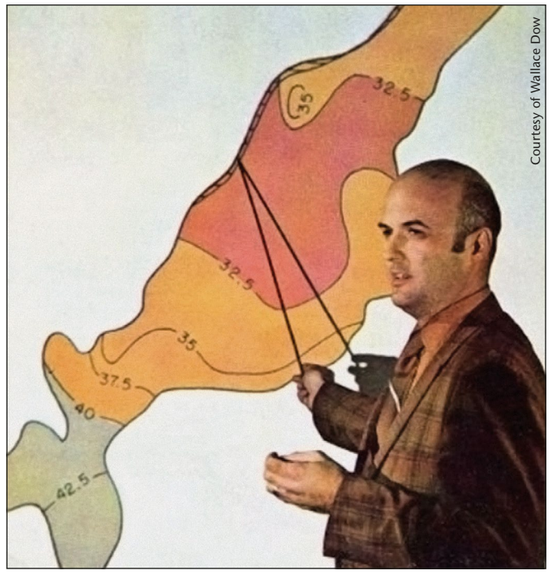
"My life philosophy is this: if you have a lemon, make lemonade. Faced with a failure and hardship, work hard and turn adversity into something even more successful. Publishing papers helps our professional career." (Dow in an interview with the author).

In 1983, when the global oil market collapsed, the Robertson Research (US) laboratory in Houston closed down, throwing many people out of work. Almost in desperation, Dow and his wife Marlys formed Dow Geochemical Services Inc. (later known as DGSI), which became one of the most active geochemical services companies for the oil industry during the following 16 years. It also trained a number of petroleum geochemists who later obtained leading positions in the industry. In 2000, DGSI was sold to Baseline (now part of Weatherford). During 2001–06, Dow was an independent geochemical consultant for several oil companies until one of these companies, EOG Resources in Houston, offered him the position of Chief Geochemist. Interest in petroleum geochemistry was literally 'born again' when oil source rocks became reservoirs in unconventional oil plays. In 2011, Dow retired, but ever a man in love with his job and science, he started another tenure as Chief Geochemist for Cimarex Energy Co. in Tulsa, Oklahoma where he and his wife currently live.

The 1970s witnessed the emergence of the geochemistry of petroleum source rocks. It is apt to end this essay with a statement Dow made in his 1977 paper: "As petroleum becomes more difficult to find and the search more expensive, the utilization of modern technology, including organic geochemistry, will play an increasingly important role in petroleum exploration." This statement is still valid and very much so for the unconventional shale gas plays such as those in the Williston basin where Dow began his fruitful career five decades ago.

In 2000, Wallace Dow was awarded the Arthur Gray Leonard Medal by the University of North Dakota for "outstanding achievement in the geosciences, especially in geochemical research and petroleum exploration and development." ■

Wallace Dow during a presentation of his research work in 1971.



Courtesy of Wallace Dow