Memoir 6

SEMICENTENNIAL COMMEMORATIVE VOLUME

Trek of the Oil Finders: A History of Exploration for Petroleum

by

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This book was published with the aid of a contribution to the A.A.P.G. Foundation by L. Austin Weeks given in memory of his mother, Una Austin Weeks, who spent many years abroad while her husband

> "waded down into rivers and mushy marshes gathering leeches . . . searching for those funny little anticlines"—*from Una's letters to her father.*

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TREK OF THE OIL FINDERS:
A HISTORY OF EXPLORATION FOR PETROLEUM

Commemoration

THIS History is the third and last of the volumes authorized to commemorate the Semicentennial of the founding of The American Association of Petroleum Geologists.

Any discipline owes a lasting debt to its pioneers. As the Russian geologist, N. B. Vassoyevich, wrote, ". . . even as ontogeny repeats the phylogeny, so does logical thinking go over the historical road of idea development."

No applied science is more indebted to its pioneers than is petroleum geology, but the debt went long unrecognized. Ideas that became popular and rewarding in the mid-twentieth century had been clearly propounded 100 years earlier, but, because drillers didn't read and readers didn't drill, such blessings of history remained unexploited.

A change came with the organization of the Association half a century ago, and the Association has had a leading role in the tremendous accomplishments since.

This *Trek of the Oil Finders* is *A History of Exploration for Petroleum.* In combination with its companion volume, *Sourcebook for Petroleum Geology,* the Association is presenting a comprehensive history of petroleum geology—the application of a science—fittingly to commemorate the Semicentennial of its founding.

Foreword

This book is one of three authorized in 1963 by the Executive Committee of The American Association of Petroleum Geologists to commemorate the Association's semicentennial. The others were Memoir 4, *Fluids in Subsurface Environments,* a symposium edited by Addison Young and John E. Galley, published in 1965, and Memoir 5, *Sourcebook for Petroleum Geology,* compiled by Robert H. Dott, Sr., and Merrill J. Reynolds, published in 1969. The Sourcebook and this memoir were designed as companion works, and their subject matter is interrelated in many respects. The reader is referred to Memoir 5 for a comprehensive account of the development of concepts that constitute the science of petroleum geology. The present volume treats the sciences of geology and geophysics only as to their role in the art of prospecting. The emphasis herein is on methods, men, and the industrial mechanism involved in the oil-finding effort.

I have had complete freedom from censorship, as the A.A.P.G. was the sole sponsor of the project. The Association was financially responsible for printing, editorial work, drafting, and some of the typing. I am grateful to the successive Executive Committees for their continued support and patience.

I am greatly indebted to the authors of the portions of this book which are presented under their names. The task could not have been completed without their participation. I have a similar obligation to the several men who supplied large amounts of material but do not appear as co-authors. The acknowledgments made to them in the text are inadequate to express my full appreciation.

Sources

In a study that is worldwide in scope and includes the entire period of oil operations, use of many secondary sources was necessary. Major sources are the accounts of American and foreign petroleum operations published periodically by the A.A.P.G., American Institute of Mining and Metallurgical Engineers, American Gas Association, American Petroleum Institute, U.S. Bureau of Mines, National Oil Scouts and Landmens Association, and numerous trade journals. Although they are slanted to the interests of their habitual readers, their data are highly credible as they constituted the corpus of information on which segments of the industry depended for planning, and were compiled as factually as possible within the capability of the contemporary reporting facilities. They vary in comprehensiveness, especially for the early years and countries where a degree of secrecy is enforced. I have used them much more constantly than is indicated by specific citations.

Many scientific and technical articles contain particular historical items incidental to their main theses, and have special virtue afforded by disciplined research and peer review. Most of those cited herein were more important for their scientific content than for their modicum of historical matter, but were significant milestones along the way. Hundreds of others, which I have not cited, were essential in setting the stage on which the action was viewed. Some of them were masterworks of their time.

Excellent histories of some oil companies and many phases of the industry have been published by competent historians who had access to corporate records and various original sources. Some other business histories, originating both inside and outside of the industry, have a large content of propaganda. I have used my own judgment and evidence from alternate sources as to their relative dependability.

Many persons have supplied first-hand information for use in this study (*see* Special Acknowledgments below). I am very grateful to them, and regret that only a few have re-

ceived appropriate recognition in the text. In all cases except where acknowledgment is made to particular corporations, I have avoided recourse to primary sources subject to public-relations screening. Much of the material herein was derived from my own business relationships, committee assignments, and informal contacts during 57 years of professional work as petroleum geologist, landman, and occasional participant in producing operations. Oil explorationists, like other avid hunters, are addicted to conversations about their experiences, triumphs and frustrations—the wildcat they won and the big one that got away. In early years, the hunt was often an individual effort and the trophy could be claimed accordingly; the later prevalence of team play precluded possibility of determining who fired the decisive shot. I apologize to those who justly feel that they have not been awarded due credit. I have been exceptionally fortunate in personal acquaintance with men whom I admired for their ability, integrity, and, in many cases, strength seasoned by humility. This book is my tribute to them.

Interpretations and opinions, in which I have indulged freely, are my own unless specifically attributed to others. Objectivity is an ideal that inevitably is diluted by subjective factors. I have tried to keep the reader aware of my personal bias, which is a consequence of education in the United States and experience mainly in North America as an employee or consultant for independent oil operators and, in recent years, as part-time teacher at the University of Texas.

Documentation is less detailed than the academic model, as the Association's customary form of citation is more suitable to the usual scientific articles than to a work of this kind. References frequently pertain to several items in a paragraph, thus avoiding excessively obtrusive repetitions. Published sources are identified in the text by parenthetical insertion of author's name and year of publication, which is a cross-reference to the bibliography at the end of each chapter or subdivision. Quotations are treated in the same manner, but with addition to the pertinent page number. Special permission for reproduction of quoted material, where required, has been obtained from publisher and author, and is gratefully acknowledged.

The various parts of the text were written at different times during a period of several years, so are not consistent as to the terminal dates of their treatment. This deficiency has been remedied only partly by later insertion of supplemental information.

Since 1966, the *Bulletin* of The American Association of Petroleum Geologists has been publishing near the back of most issues, "SCENES OF THE PAST" and "HOLOSCENES." These photographs depict many of the personalities, and in localities that are mentioned in the text.

I hope this book may indicate many areas worthy of more scholarly research. A wealth of information exists throughout the world in hundreds of institutional and private archives, corporate records, and the memories of thousands of persons who participated in the action. Most of my documentary material will be deposited in the Petroleum History and Research Center, the Library, University of Wyoming, Laramie.

Special Acknowledgments

The assistance of the persons named below was indispensable. My appreciation of their service was augmented by the pleasure of working with them.

Robert H. Dott, Sr., edited the entire book. His expertise, wisdom, and eager cooperation enlightened every step of the way.

Wallace E. Pratt devoted untiring effort to a critical review of most of the manuscript, contributed an immense amount of information from his great store of knowledge, and supplied constant encouragement. The sagacity, kindliness, and modesty that characterized his lifetime leadership in the oil industry and the geological profession have been a major inspiration.

Arthur A. Meyerhoff, former Publications Manager of the Association, has been generous with assistance, criticism, and valuable advice.

The late George H. Coates, independent oil producer, practical geologist, and esteemed friend, Southern Minerals Corporation, and

The University of Texas afforded opportunity and facilities to forward this effort during my part-time connections with them.

Great credit must go to members of the Association's Semicentennial Celebration Committee of the years 1962–1965: Raymond F. Baker, Arthur E. Brainerd, Robert H. Dott, Sr., John L. Ferguson, Frank J. Gardner, Merrill W. Haas, Kenneth C. Heald, William J. Hilseweck, Jesse V. Howell, Kenneth K. Landes, Joseph Lintz, Jr., John D. Moody, Frank A. Morgan, Harold T. Morley, Homer J. Steiny, John M. Vetter, and Wilber H. Young, Jr. They initiated the project, participated in the planning, and obtained much information from archives and individuals. Bill Hilseweck was an active collaborator, and generously contributed transcripts of taped interviews which he had conducted for another purpose.

I thank Everett L. DeGolyer, Jr., for making the valuable collection of his father's records available to Hilseweck and me.

George Elliott Sweet was generous with suggestions and information during his preparation of *The History of Geophysical Prospecting*.

Gene M. Gressley, Director of the Petroleum History and Research Center at the University of Wyoming, was always eager to supply material from the rich collections under his management.

Gerald T. White contributed information and criticism which were exceptionally valuable because of his expertise as a historian.

Keene Ferguson and Francis J. Munch kindly made available much archival material that they collected in the course of their respective historical researches.

I thank Florence Hendee, Librarian, for material in the Orton Memorial Library at The Ohio State University.

Thelma Guion, Geological Sciences Librarian, and C. V. Kielman, Archivist, at the University of Texas in Austin, were most cooperative. Among my colleagues on the University faculty, Fred M. Bullard, Ronald K. DeFord, Samuel P. Ellison, Jr., William M. Rust, John A. Wilson, and Keith P. Young were especially helpful.

Aurèle LaRocque kindly pointed out obscure literary sources, supplied a copy of his valuable unpublished *Biographic Index* of geologists, and checked some of my translations from the French. Mrs. Jan A. Winter was helpful in checking some of my German translations. Neither of these friends is responsible for the awkwardness of many translations from the European literature which were made without their assistance.

The critics who read the parts of the manuscript dealing with areas of their special knowledge eliminated many errors of commission and omission, offered valuable suggestions, and contributed much vital information. I thank them sincerely and absolve them from responsibility for whatever deficiencies remain. Notably helpful were: John Emery Adams, Herman T. Ashmore, Edward Bloesch, Frank R. Clark, P. T. Cox, Parke A. Dickey, John C. Freeman, John T. Galey, John E. Galley, Eduardo J. Guzmán, Kenneth C. Heald, Hollis D. Hedberg, Frank A. Herald, John M. Hills, William J. Hilseweck, Donald A. Holm, Jesse V. Howell, Richard Hughes, John Kay, Robert E. King, G. M. Knebel, Kenneth K. Landes, Aurèle LaRocque, Theodore A. Link, Joseph Lintz, Jr., Rolfe McCollom, Roy P. McLaughlin, Charles V. Millikan, William R. Moran, Frank A. Morgan, Francis J. Munch, L. Murray Neumann, Jerry B. Newby, Wallace E. Pratt, Noel F. Rasmussen, Richard B. Rutledge, Charles Ryniker, C. L. Severy, Homer J. Steiny, Jacob Van Den Berg, Charles A. Warner, F. E. Wellings, John W. Wells, Gerald T. White, and Philip C. Withrow.

My greatest appreciation must go to my wife, Ollie, dependable companion during 54 years of the adventure. My sister-in-law, Mrs. Mirva C. Owen, and my niece, Susan Owen Owen, typed most of my handwritten manuscripts. Members of the Editorial Department at A.A.P.G. Headquarters—Amy Lee Brown, Nancy Greeson, Ann Mayes, Peggy Pendergast, Carol Thompson, Ernestine Voyles, and Debby Zikmund were very helpful in typing and proofreading, and Peggy Rice and E. M. Tidwell helped with editing and proofreading; H. A. Meyerhoff, in addition to reading proof, contributed valuable information and criticism; and finally, I owe a great debt to Mrs. Kathryn Mey-

erhoff for her excellent rendition of the maps and other illustrative material. Also, I wish to express my personal gratitude to L. Austin Weeks for his generous financial assistance to the Association for publication of this book.

Notes

Notice should be given to some of the verbal usage herein.

Words are used generally as defined in the *Merriam-Webster International Dictionary*, 2nd ed., unabridged. As far as feasible, uncommon and specialized scientific terms are avoided. Some words are used in the peculiar colloquial sense customary in American oil fields, *e.g.*:

Trend—an alignment of features which are deemed significant of oil and gas prospects. The significant alignments may comprise producing fields, wells with favorable showings, surface or subsurface structures, geophysical anomalies, stratigraphic relationships, physiographic features, or any combination of these.

Pool and *field* were practically synonymous before 1944, when F. H. Lahee defined them separately. I have followed the original custom for the early period and adhered to the Lahee classification in later developments. (*see* Chap. 11, References.)

Wildcat usually denotes a well remote from existing production, but often is applied to almost any exploratory test.

Billion is synonymous with milliard and denotes 1,000 million. *Trillion* has the value of 1,000 billion. Some nations use values other than these.

The several nations vary in their customary units of measure. Conversion of weight to volume of liquids from available statistics is generally imprecise. Customary reporting of the production of petroleum liquids and the output of gases is highly variable. Consistent use of either the metric or English systems in this book would be impossibly laborious. This is not a mathematical treatise, and statistics are employed only to convey a general sense of magnitude.

Major oil company is an imprecise term in general usage, and arbitrary definitions (*e.g.*, Lahee, 1952, p. 989-990; *see* Chap. 11, References) have not been widely accepted except for special statistical purposes. As used herein, it refers to approximately 30 American oil companies with the greatest financial assets at any given time and to foreign companies of similar size. Most, but not all, are integrated with respect to the four main activities of the petroleum industry—exploration, transportation, refining, and marketing. Membership in this class has varied with time, but more than half of the present *majors* have been members for a half-century or longer.

Independent has been used variously as a descriptive term for an operating company or individual. Prior to 1911, an *independent* was one who did not belong to the Standard Oil Trust or to any great foreign corporation. Several meanings have been attached to it since, *e.g.*, (a) any oil company or individual operator other than a *major;* (b) producer not affiliated with an integrated company or government; (c) an operating entity which had no stock available to the public. I have used it for those operators not affiliated with major companies or controlled by governments. The *major* and *independent* usages are significant only in their contemporary contexts; all majors were initially independents.

Edgar W. Owen
San Antonio, Texas
January 3, 1975

Introduction

by

WALLACE E. PRATT

IT HAS BEEN POINTED OUT that "Petroleum Geology is, in point of fact, one of the younger divisions of Geological Science." Oil producers in the United States, where the modern industry had its birth, have been engaged for more than 100 years in a vigorous—at times hectic—search for new oil fields. Yet, over the first half of that period the "wildcatter" looked askance at geologists. So long did this skeptical attitude persist that the distinguished career of the author of this volume spans the entire life of his profession in the United States. In Europe, the large oil companies organized geological departments decades earlier than their American competitors and realized on their investments in the "younger division" of geology through numerous discoveries in many far-flung corners of the globe. Although the modern oil industry started in the backwoods of Pennsylvania, American producers lagged notably in bringing the science of geology into their operations.

The American oil industry had advanced well into the second decade of the present century before it conceded to geology greater efficacy in the art of oil finding than to its own pioneer hypotheses—"trends" and "creekology." Even then, the geologist's reception was lukewarm. Experience had taught the "practical oil man" to distrust expert oil finders—"dowsers," "witchers," and "doodle-buggers," alike. To him the geologist was suspect—another expert.

Who needed experts? Certainly not the practical oil man! "Trends" and "creekology" had been satisfactory working hypotheses; they had pointed the way to discovery of all the oil needed—the oil found by wildcatters was supplying all of America's and much of the world's requirements. Moreover, the geologist's principal stock in trade was the anticlinal theory of accumulation, and this theory just didn't work along Oil Creek in Pennsylvania.

The industry's cool reception naturally chilled the fledgling geologist's spirits, already depressed by the attitude of most of his former mentors and colleagues in Academia. They deplored his "commercialism," which to them was "prostitution of his science to Mammon."

But a change was coming, an economic revolution was on the way, which, within a few short years, would integrate science with industry, place the latter securely on a basis of research and development, and so usher in modern technology—"the great multiplier." The geologist's invasion of the oil industry coincided roughly in time with, and indeed, constituted one aspect of, this more general technical revolution.

The technical revolution had many facets and numerous causes. The petroleum industry was pushed inexorably into it by two stimuli, one accelerating the other—the explosive (no pun intended) expansion in the use of the internal combustion engine with its voracious appetite for petroleum products and World War I, an even greater glutton.

Petroleum geology in the United States first attained the status of a profession when, in 1917, near the time that the United States entered the war, The American Association of Petroleum Geologists was organized. It was to commemorate the fiftieth anniversary of this important event that the preparation and pub-

lication of this history and its companion volume, *Sourcebook for Petroleum Geology*, were conceived and authorized by the Executive Committee.

One of the founders later declared that "At the time of the organization of the Association the usefulness of geology in prospecting for oil had been established." Although this modest claim was amply justified, the complete adequacy of the young profession to meet contemporary needs of the industry may be questioned.

The practicing geologist brought with him, when he first attacked the problems of the oil-finding branch of the industry, only an elementary knowledge of the crust of the earth and its hydrocarbon content. Frequently, the wildcatter's drill surprised him by encountering subsurface conditions totally at variance with beliefs the geologist had long cherished. His outstanding tool for oil finding was his prestigious anticlinal theory, the validity of which was indisputable. But his single-minded quest for anticlines and domes under the spur of this theory tended to blind him to the potentialities of other trap-forming agencies, such as faults, unconformities, and "sand pinchouts."

In retrospect, this seems rather anomalous. Actually, early nineteenth-century geologists had at least hinted at the importance of faults and fissures and unconformities to the accumulation of oil; and, in the 1870s and 1880s, John Franklin Carll, geologist *par excellence* of the Second Geological Survey of Pennsylvania, had clearly stated the role of sand pinchouts in controlling accumulations in the Venango-sand fields of that state. Half a century would elapse before the concept found its way generally into the geologist's kit of exploration tools.

As for the location and distribution of sedimentary basins—their form and architecture, facies changes, paleogeology, reef "build-ups," evaporite deposition, ancient shorelines, and continental shelves—all these vital factors, the pioneer petroleum geologist had still to evaluate. And the terms "hydrodynamics" and "stratigraphic traps" had not yet been coined.

Perhaps the most pressing need of the American oil industry at the time it first turned to the geologist was leadership in its efforts to find oil fields associated with salt domes on the Gulf Coast. But it was just here, in his ignorance of salt domes, that the American geologist was least helpful. The published comments of eminent geologists when the discovery well at Spindletop (drilled without benefit of geology) "blew in," in 1901, express complete surprise and confusion of thought. This same confusion of thought still prevailed 17 years later, as the papers and discussions recorded in the first and second volumes of the *Bulletin* of The American Association of Petroleum Geologists testify. On these pages are set down various bizarre theories—"lateral secretion," "volcanic action," and "the expansive force of growing crystals"—to account for the diapiric intrusion of salt domes.

This debate went on—nay, began—in America long after European geologists had already grasped the validity of the theory which is the basis of the modern concept of salt-dome origin and growth. Moreover, the Europeans had published their findings widely in scientific journals. Eventually, of course, American geologists embraced the European view of salt-dome mechanics, but it is puzzling that their conversion was so long delayed.

Europe's early contributions to the still callow profession of petroleum geology were by no means confined to a clarification of salt-dome mechanics. Fossil reefs, facies changes, and other phenomena now known to be important to oil accumulation were first recognized, understood, and described by European geologists long before they were added to the American explorationist's vocabulary.

In the early 1920s petroleum geologists in the United States appealed to geophysicists to assist them in mapping the structure of beds deeply buried beneath the surface. The resulting joint effort succeeded beyond all expectation in a remarkably short time, vastly increasing the efficiency of the art of oil finding. But it was Europe that first provided the theory, and later furnished the essential instrumental equipment for the first field parties. Hungary supplied the earliest torsion balances; Germany, the first seismic apparatus, together with "know-how." About the same time, France sent to the United States the earliest devices for electric logging—a technique so vitally in-

formative that, almost overnight, it became indispensable to the oil-finder.

Considering the vigor with which these nineteenth-century ideas and techniques are being applied today in the search for new oil and gas fields, one may well be puzzled by the long delay in their exploitation. Certainly much of the literature was already in libraries and must have been read by at least a few of the geologists in ivory towers, even in America. Why did the ideas remain so long in limbo? Perhaps the pioneer practicing petroleum geologist was so preoccupied with drilling and developing the new oil fields located on the anticlines he was finding so successfully that he was not concerned with learning about other modes of trapping; perhaps, as author Ed Owen states in a different, though related, context, "Several likely prospects [concepts] remained unexploited by drillers who didn't read and readers who didn't drill."

Except for its recognition of the phenomenal success of the application of the anticlinal theory, the foregoing part of this essay may be subtitled "Blessings of History Ignored." It is interesting to note that the anticlinal theory and its handmaiden—structural contouring—were contributions of nineteenth-century American geologists. Surely, in view of the early and continuing importance to oil finding of this particular blessing of history, its complete acceptance by the pioneer petroleum geologist absolves him fully of his sins of omission.

The technical revolution of the opening decades of the twentieth century, accelerated by World War I, was slowed down by the great depression of the 1930s, only to move forward again at an infinitely greater pace under the impact of World War II. Developments in electronics—a technical revolution in itself—improved the instrumentation of the geophysicist and provided the computer which seemingly has unlimited applications to all phases of petroleum exploration and production.

With the new technical facilities and greatly expanded research in all related sciences available to him, the petroleum geologist is rapidly acquiring the essential knowledge he lacked at the beginning.

At the time the geologist entered the oil industry he possessed too little knowledge of the occurrence of hydrocarbons in the earth's crust to organize and direct an efficient search for new oil fields. Nevertheless, over the ensuing years tremendous volumes of oil and gas—volumes many times larger than any one had anticipated—have been found. And at all times this recent search has gone forward under the direction of the geologist. As exploration progressed over the earth, the geologist rapidly expanded his horizons of knowledge. By probing deeper and deeper beneath the surface, as its technology developed, the industry revealed to the geologist sufficient new information about the crust of the earth to enable him to perfect—or vastly to improve—the art of oil finding.

The achievement was possible only through teamwork—science harnessed with industry. Gradually the winning of the earth's fossil fuels assumed its true character—a dominantly geological enterprise. The specter of imminent exhaustion of reserves vanished. Hydrocarbons were recognized as normal constituents of marine sediments—sediments ranging in age from earliest Paleozoic to Quaternary, even Holocene. And the enlightenment which came with this more comprehensive knowledge of the crust of the earth is as valuable to science, and to society at large, as are all the additional oil and gas fields the geologist has found.

Tucson, Arizona
September 3, 1968

石油发现者的历程：石油勘探的历史

本书是美国石油地质学家协会为纪念该会创立50周年而编辑的多卷集中的一册。所述的石油勘探历史，涉及美国情况较多，但其他主要产油国，诸如加拿大、委内瑞拉、墨西哥、中东各国、苏联、利比亚、阿尔及利亚、印尼和北海油田等，也作了比较全面的介绍。本书引用了较多的文献、蒐纳了不少资料，可供从事石油地质、地球物理等工作的科研情报及教学工作人员的参考。

全书共24章。目次按内容归纳介绍如下：①—⑩主要是对石油勘探及生产情况的历史回顾，以及初期石油地质理论的发展。⑪介绍石油勘探技术的发展情况，包括钻井和油田生产技术，地球物理勘探及有关技术以及实验室显微镜研究(包括岩石及古生物)。⑫—㉓分别介绍世界各主要产油国家的地质和含油气情况，重点介绍了勘探情况。这些章节是本书重点，值得参考，可供勘探工作借鉴。㉔小结和分析。书末附主题索引、地理名词检索、人名及机构索引。

Contents

[1] References to illustrations will be found in the Geographical Index, *e.g.*, 1320f.

CHAPTER 1

The Earliest Oil Industry

¶ 1. The Paradox of the Origin of the Modern Oil Industry

INCEPTION OF THE modern petroleum industry can be fairly said to have occurred at Oil Creek, near Titusville, Crawford County, northwestern Pennsylvania, on August 28, 1859. Nevertheless, some 5,000 years of experience and tradition elsewhere had anticipated the event. Europe and Asia had made some economic use of petroleum and its products for many centuries. Tangible evidence of important oil pools in Rumania, Poland, and the Middle East had been recognized long ago, and large fields in Burma and at Baku had been exploited casually, but no viable industry had arisen. The British knew more than anybody else about the universal occurrence of petroleum. The Germans were most sophisticated in organic chemistry and technology—and the French were sophisticated about everything. The principal store of capital was in Europe; even the basic American enterprises were dependent on European money. Western Europe was more industrialized than the United States, and the greatest potential markets for oil and its products were there. In spite of all the advantages elsewhere, one of the world's most essential industries was left to grow up in the backwoods of Pennsylvania. The fact that the cumulative experience became productive at this location—and that the ancient tradition did not mature until this time (1859)—constitutes one of the great paradoxes of economic history. The course of events and the factors which led to American origin and dominance of the industry are the immediate subjects of our inquiry.

¶ 2. The Ancient Record[1]

Asphalt is found among the building materials in the oldest ruins at Ur in Mesopotamia, dated about 3,000 B.C. Each successive tribe of intruders into the rich valleys of the Middle East—Sumerians, Akkadians, Assyrians, Medes, and Persians—found multiple uses for petroleum products. They had several names for different forms of the material; "naphtha" is an Akkadian word about 4,000 years old. Cuneiform talbets from excavations of the ancient cities record contracts for the oil trade, complaints about the shortage of supply, almost everything except import regulations. The prices approved by King Hammurabi's federal trade commission about 1875 B.C. are officially reported. The bricks in the walls of Jericho and Babylon were cemented with bituminous mortar. Noah's ark and the basket in which the infant Moses floated were probably caulked with asphaltic pitch in accordance with the customs of the region. The ghosts of the ancient oil men who supplied the raw materials could have guided modern geologists to the greatest oil fields in the world.

The ancient literature of Greece and Rome contains many references to oil and gas, most often as distant wonders. Heredotus, the observant traveler and gossipy historian of 450 B.C., complained about the evil smell of Persian oil and described the production of oil and salt from springs and wells. Diodorus, some 50 years B.C., recorded

[1] There are literally thousands of published references to the knowledge of petroleum prior to the commencement of the modern oil industry. The items mentioned in this chapter are only a few which seemed to the writer to be of special interest or significance.

> Whereas many incredible miracles occur in the Babylonian country, there is none such as the great quantity of asphalt found there. . . . It is not only sufficient for so many and such large buildings, but . . . the yield, as with a rich well, remains inexhaustible. (Forbes, 1955, p. 36.)

Many of the occurrences were magical—the roaring gas at Kirkuk

> . . . the father of sound, [and gas seeps] where the voice of the gods issueth from the rocks. (Forbes, 1955, p. 39.)

The Byzantine emperor, Heraclitus, on an expedition in 624 A.D. destroyed many temples near Baku, where fire worshippers had bowed down before burning gas wells since time immemorial. But petroleum was also handy stuff to have around the house. Dioscorides, a surgeon in Nero's army, reported that the people of Sicily burned liquid bitumen instead of olive oil in their lamps (Forbes, 1955). Pliny the Elder wrote that Medea burned her husband's mistress with naphtha. The fearsome "Greek fire," used in defense of the Byzantine Empire as early as 700 A.D., probably had a petroleum base (Partington, 1957, p. 40).

The Arab world preserved the oil-man's tradition during Europe's darkest ages. The Ichwan es-Safa of Basra formulated a nonmagical theory of the origin of naphtha and asphalt in the current alchemical idiom of 950 A.D. (Forbes, 1958, p. 150). Ibn Jubayr in 1184 stopped along the road to Mosul to describe the large seepages in detail.

Cesar Fredericke paused during his journey to the Indies in 1536 to observe a hole near the Euphrates River, from which pitch is thrown, and

> . . which continuall smoake. . . . The Arabians of that place say that that hole is the mouth of hell. (Forbes, 1955, p. 41.)

Pierre Belon, a prominent French naturalist, observed production of petroleum from hand-dug wells in the Near East in his travels of 1546–1549.

The history of oil in the Orient seems to be unrelated to that in the West. The Chinese found petroleum and gas while drilling for salt in Szechwan as early as 250 A.D. and utilized them for heating and lighting.[2] The salt industry was already old; Confucius about 600 B.C. mentioned wells which were probably a few hundred feet deep. Gas was used in some salt works to evaporate the brine. The Chinese developed drilling tools which reached depths of 800 feet by 347 A.D. and 3,000 feet by the year 1132. Father Imbert published a detailed description of their percussion method of drilling in 1828; its capability surpassed that of the best contemporaneous European and American equipment. In Japan, rock oil was found at Echigo about 615 A.D. Wells, which had been dug by hand, were reported to be operating there in 1818. Benjamin S. Lyman made an official survey of Japanese oil deposits in 1877. He found the Echigo production at that time to be 26 barrels per day from 522 wells, the deepest of which was at 732 feet. Shinano province was producing 5 barrels per day from 22 wells. Sumatra was also utilizing oil before the arrival of the first Europeans. Jan Huygen van Linschoten reported oil seeps there in 1596. Samples of the oil were brought to Holland in 1636, although export was prohibited by the local ruler. (Clements, 1918; Forbes and O'Beirne, 1957; Forbes, 1958; Brantly, 1961; Strubell, 1968.)

¶ 3. The Burmese Prodigy

The early oil industry of Burma was the largest in the world, but the date of its origin is not known. Major M. A. Symes visited the Yenangyaung oil field in 1795,

> . . . the celebrated wells of petroleum which supply the whole Empire and many parts of India. . . . The mouth of the creek was crowded with large boats waiting to receive a lading of oil. (Forbes, 1958, p. 169.)

Capt. H. Cox said that 520 wells were active in 1797. John Crawfurd, a fellow of the Geological Society of London, investigated the field in 1827 in the course of his diplomatic mission from the Governor-General of India to the Burmese ruler at Ava. He saw two hundred boats waiting for cargoes of oil. The wells were shafts about four feet square, dug by hand and

[2] The date of discovery of natural gas in commercial quantity at Chi-lui-ching, Szechwan Province, is stated as 211 B.C. by Meyerhoff (1970)

lined with timber. The depth of a typical one, which he measured, was 210 feet. The best information which Crawfurd could get indicated an annual output of about 40,000 tons (250,000 to 300,000 barrels). About one-fourth of the products was used in house construction and boat building, principally as wood preservative, insect repellant, and waterproofing. All families within reach of water transportation used the oil as an illuminant, which accounted for most of the consumption. Crawfurd estimated the population of the kingdom from the figures of total oil production and average family use (Crawfurd, 1829). Some evidence indicates that the earliest exploitation of petroleum in the region was along the coast of Arakan, and that well-diggers were brought in from there to Yenangyaung.

¶ 4. Petroleum in the Caspian-Caucasus Region and Central Europe

The natural flows of oil and gas at Baku were some of the most spectacular in the world and had been known since very early in the history of civilized man. Stories of Baku's "eternal fires" have emanated from the area for at least 2,500 years, and authenticated reports, since the sixth century B.C. These fires have been called the "everlasting fires of Persia," and "the eternal fire at Aaku." Zarathustra (Zoroaster) even travelled to see the fires with his own eyes (McLaurin, 1896, p. 8; Forbes, 1958, p. 154–160).

The oil springs have been of some use since ancient times, as attested by numerous accounts by such diverse observers as officials of the Byzantine Empire and Marco Polo. The latter said in 1298 (Komroff edition, 1926) that

> To the north lies Georgiania, near the confines of which there is a fountain of oil which discharges so great a quantity as to furnish loading for many camels. The use made of it is not for the purpose of food, but as an unguent for the care of cutaneous distempers in men and cattle, as well as other complaints; and it is also good for burning. In the neighbouring country no other is used in their lamps, and people come from distant parts to procure it. (p. 26.)

There are many other deposits in the region; among the more famous are those of Neftalan (Naftalan), Azerbaydzhan SSR, 260 kilometers west of Baku. According to the Academy of Sciences of Azerbaydzhan 1957 report,

> The Neftalan deposits are to the southeast from Kirovabad. The Neftalan medicinal and industrial oil, unique in the world as to its composition, is known since ancient times. Even hundreds of years ago people came here for cures from India, Iran, Arabia, and other distant countries. . . .
>
> Balneological research established that beneficial results are obtained in cases of women's skin and nervous diseases. A sanatorium [resort] has been built in Neftalan, where patients . . . are taking cures. An industry in this crude oil is used for the conservation of industrial leather and footwear. A regular type of petroleum is obtained from lower strata of the Neftalan field. (p. 82.)

The early history of commercial exploitation of the Baku–North Caucasus oil springs and hand-dug wells is not completely known. The Caliph of Baghdad, in 885–886 A.D., granted the revenues from the springs "to the citizens of Darband," but in 904, the Governor of Darband (Derbent) decided that the revenues were more appropriate for furbishing his own estates. He robbed the citizenry of the revenues and left many Darbandians without work.

Although numerous visitors had taken flasks of oil with them from Baku and Neftalan, the first record of deliberate export of the oil appears during the tenth century (Forbes, 1958, p. 154–156). By 1737, 52 hand-dug wells were productive on the site of the present-day giant Balakhany field. In 1829, Alexander von Humboldt counted 82 such wells (Forbes, 1958, p. 161–162).

There were other oil springs along the eastern Caspian shore and in the Crimea, some of which were utilized. On the island of Cheleken in the Caspian Sea petroleum was being obtained from about 3,500 pits and seepages in 1838. According to Felkner (Völkner?), the product was employed for lighting and as a substitute for tallow (Archiac, 1847, p. 414).

A small, primitive refinery was built at Baku in 1723, but its products were accessible only to the backward region around the Caspian Sea. The Imperial Academy of St. Petersburg sent Johann Lenz to investigate the oil field in