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HOLLIS DOW HEDBERG

1903—1988

A Biographical Memoir by
GEORGES PARDO

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Biographical Memoir

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Hollis Hedley

HOLLIS DOW HEDBERG

May 29, 1903–August 14, 1988

BY GEORGES PARDO

ON THE OCCASION OF Hollis Dow Hedberg's retirement from Princeton University in 1972, he was honored by a conference on petroleum and global tectonic. Robert F. Gohen said of him:

In the course of a lifetime of distinguished service to his discipline, service which has earned him international recognition and honor, he has attained first-rank standing in academic circles while simultaneously pursuing a successful career in the petroleum industry, most notably, since 1946, with Gulf Oil as a senior officer concerned with exploration. In short at once a man of thought and a man of affairs, he has built bridges between the theoretical and the practical, contriving lines of communication that reach from the realms of teaching and research to provide a basis for decision making and action in the world of affairs.

I will attempt to describe the life that is so aptly summarized by this quote.

In the summer of 1940, after my first year at the Instituto de Geología, in Caracas, Venezuela, I was invited by my professor of stratigraphy, Dr. Ely Mencher (later of MIT) to join him on a field trip to eastern Venezuela. We stopped in San Tomé, the Mene Grande Oil Company (a subsidiary of Gulf Oil Corporation) main camp in the area. There we were greeted and guided through the geologic section along the recently built San Tomé–Puerto la Cruz highway

by a humble-looking, soft-spoken gentleman with a deep voice, strong bony hands, somewhat of a twisted posture, long steps, and always a ready smile. At the time I spoke no English and still understood very little about the profession I was entering, but he made every effort to communicate in Spanish with me. His general appearance and attitude made it difficult for me to believe that he was "El Doctor Hedberg," at the time a well-known and respected geologist in Venezuela, in charge of all geological operations for Mene Grande Oil Company in eastern Venezuela, which were considerable. I certainly could not have guessed then the impact this man was going to have on my life and the geological world.

Hollis Dow Hedberg was born on May 29, 1903, on the crowded second floor of a small stone farmhouse in the Swedish community of Falun, Kansas, during one of the worst floods in Kansas history. A midwife was rowed in, but she arrived too late to be of any assistance. His father, Carl August Hedberg, was born in Sweden and brought to the United States when he was four years old. He married Hollis's mother, Zada Mary Dow, of Scottish-English parents. Hollis has an older brother, James, and a younger sister, Carol. Strong family bonds and Swedish tradition dominate his childhood. He is raised in the midst of hard work, love, and a deep sense of values. By the age of eight, he is plowing fields behind a horse. Plowing the long rows, he learns to whistle the music that he hears at home. "What else can you do behind a horse and a plow?" he answers when asked where he learned to whistle so clearly. Whistling while concentrating on a problem will become one of his trademarks in life. The evening's entertainment consists of the family playing music together, Hollis playing the cello, his father the violin, his mother the piano, and brother James the viola, or of reading books to each other.

Throughout his life Hollis Hedberg remembered, and was fond of, the books they shared on such occasions. This tradition of family reading continues with his own family.

Young Hollis enters the Falun elementary school in 1909 and attends the Falun Rural High School from 1916 to 1920. After graduating from a class of four, he is admitted to the University of Kansas in Lawrence in 1920. His original intention is to obtain a degree in journalism, but his interest shifts to geology. In 1921 his father dies, and he has to interrupt his schooling to return home and run the farm. In 1922 he resumes his studies and in 1925 receives a B.A. in geology with a Phi Beta Kappa key. During the summers of 1924 and 1925 he was a field assistant for the Kansas State Geological Survey. In 1925 he is admitted to Cornell University in Ithaca, New York, under H. Ries, head of the Geology Department, and is awarded an M.S. in geology in 1926. His first paper, "The Effect of Gravitational Compaction on the Structure of Sedimentary Rocks" (1926), is the result of investigations carried out by him while at Cornell. Here he advances the theory that porosity in shales is an index of pressure metamorphism and could also be used as an indicator of the oil potential of a section. Only in recent years has the idea of a correlation between rock porosity and oil maturation reappeared in the literature. In March 1926 he applies for membership to the American Association of Petroleum Geologists (AAPG) and is elected associate in August of the same year. It is his first membership in a technical society. Many were to follow, twenty-four in all. During his lifetime, Hedberg serves this society on many committees and contributes frequently to the *Bulletin*.

Hedberg's first employment is with the Lago Petroleum Company, a Venezuelan subsidiary of the Standard Oil Company of Indiana, as a petrographer in their Maracaibo labo-

ratory. He leaves New York for Maracaibo on June 1926. It is his first trip outside the United States. The extent of Hollis's attachment to his family is demonstrated by the fact that since the day he leaves home he writes his mother several letters a week, every week he is away, until her death in 1945. In addition to his work, he travels on his own. He is fascinated by this tropical country and its inhabitants, and his candid remarks are fortunately preserved in the correspondence to his mother. He always remembered the time he spent in Venezuela with fondness. In July 1927 he is nearly killed during one of his excursions by himself. He gets lost during a rainstorm in the Misoa River area, on the east side of Lake Maracaibo, and is swept away by the swollen waters of the Raya River while trying to ford it. Although he is a powerful swimmer, he eventually goes under exhausted. Later he writes his mother "... strange to say, I didn't feel frightened at all, although I was certain it was the end. I felt more surprised than anything else. It seemed such an unexpected way to end up there by myself" Somehow he manages to crawl along the bottom of the river and emerges, hanging onto a boulder sticking out of a steep bank. He is mostly upset, of all things, by his camera being ruined and the loss of a brand new Stetson hat that he saw last floating away down the river. During that period of time he uses some of his work to publish "Some Aspects of Sedimentary Petrography in Relation to Stratigraphy in the Bolivar Coast Fields of the Maracaibo Basin, Venezuela" (1928). There he expresses, for the first time in print, his belief that criteria other than fossils can be used for correlating and dating rocks. However, he is dissatisfied in general with his job. He corresponds with K. C. Heald, of the National Science Foundation, whom he had met while at the University of Kansas, regarding a possible NSF grant and meets M. N. Bramlette, in charge

of the geological laboratory of Venezuelan Gulf Oil (subsidiary of Gulf Oil Corporation), who suggests that he join Gulf. By mutual agreement, his contract with Lago Petroleum is not renewed and he returns to the United States in March 1928. On the recommendation of K. C. Heald and M. N. Bramlette, E. S. Bleeker, chief geologist of the Venezuelan Gulf Oil Company, offers him a job in the geological laboratory in Maracaibo as a stratigrapher.

He shortly returns to Maracaibo, leaving New York on May 18, 1928, arriving there on June 3 after the first ship, a tanker, is diverted to Port Arthur. He refuses to take a pilot boat back to New York, leaving behind all his possessions, and he has to take the train back from Port Arthur to New York to start the trip all over. Fate has it that on board the second ship he meets Frances Murray, a freshman in college, whose father works in Maracaibo, on her way to spend a vacation with her family. He starts his duties as stratigrapher and on Bramlette's departure he takes charge of the geological laboratory in October 1928. He writes "Cretaceous Limestones as Petroleum Source Rock in Northwestern Venezuela" (1931), in which he proposes that the La Luna Formation, of Cenomanian/Turonian Age, is the main source for the petroleum accumulated in tertiary sediments in the Lake Maracaibo area. This thesis has stood the test of time. He carried out field trips to many areas of Venezuela and Colombia with the purpose of establishing a solid network of measured, consistently described and dated stratigraphic sections, among them the Rio Querecual in eastern Venezuela. In addition to the normal laboratory duties, he performs further analytical work in connection with his studies of compaction of clays and shales. He lives a very arduous life and has on-and-off bouts with malaria, pleurisy, and dysentery. His

attitude toward people is exemplified by the following: While doing some field work in the Perija Mountains, he used the help of local Indians. He notices that one of them, a young Indian wearing only a loincloth, sits under a lamp with a worn-out book after work, while the rest of his companions talk or play games. Hollis asks him what he is doing, and Inocencio Sanchez replies that he is trying to teach himself to read. When the field work is finished and the local help dismissed, he offers Inocencio a job as assistant in the laboratory in Maracaibo. Inocencio accepts, learns how to read and much more, raises a nice family, and remains, until his death many years later, one of the best technicians Gulf has ever had. This pattern of helping deserving people in all walks of life will be repeated countless times during Hollis Hedberg's lifetime. He starts lifelong friendships with prominent geologists such as M. N. Bramlette and Hans Kugler from Trinidad Leaseholds Ltd. He dates Frances Murray when she visits Venezuela, and during a vacation trip to the States in September 1932 he is engaged to her. They get married on November 11 of the same year. He returns to Venezuela in December, and Frances joins him in June of 1933.

In the summer of 1934, the Hedbergs come back to the United States on a leave of absence and move to Palo Alto, California, and he completes with flying colors the Stanford University curriculum requirements for Ph.D. in geology between September 1934 and May 1935. His first son, Ronald, is born there in 1934. He meets and is influenced by Eliot Blackwelder, H. G. Schenck, from Stanford, and J. A. Cushman, among others. While in school he presents "Gravitational Compaction of Clays and Shales" (1936,2) and, with H. G. Schenck and R. M. Kleinpell, "Stage as a Stratigraphic Unit" (1936,1) at a Geological Society of America meeting in Palo Alto in April 1935. This last paper is the

first public manifestation of his lifelong concern about stratigraphic nomenclature.

They return to Venezuela in September 1935, where he resumes his duties as director of Gulf's geological laboratory. A Ph.D. in geology is granted to him in absentia in June 1937. His dissertation "Stratigraphy of the Rio Querecual Section of Northeastern Venezuela" (1937,3) is published and includes "Foraminifera of the Carapita Formation of Northeastern Venezuela" (1937,4). In the Rio Querecual paper he makes a clear distinction between age (Time), stage (Time-Stratigraphic), formation (Lithogenetic), and zones (Faunizone, Mineral-zone, etc.) independent of the former units. This forms the bases of his concepts on stratigraphic classification that he will strongly support and defend later in life. On February 1936 he is elected Fellow of the Geological Society of America. The Hedbergs' second son, James, is born in 1936.

In June 1937 he is appointed stratigrapher and director of the new geological laboratory in Oficina (El Tigre) and is put in charge of geological operations in eastern Venezuela for Mene Grande Oil Company (former Venezuelan Gulf), where the first wildcat Oficina No. 1, spudded in February 1933, 170 kilometers from the nearest production, is brought in as a producer in the same month as his arrival. He writes "Evaluation of Petroleum in Oil Sands by Its Index of Refraction" (1937,2), in which he calls attention to a little known, or understood, relationship between density and refractive index of crude oils and to its practical importance in evaluating the content of oil reservoirs. Today it is a standard technique. He becomes associate editor for the AAPG in October 1937 and will hold this position for forty-six years! The Hedbergs' third son, William, is born in 1938.

In December 1939 Hollis Hedberg is appointed assistant

chief geologist in charge of all geological operations in eastern Venezuela, and the family moves to the nearby new camp of San Tomé. He has reservations about accepting a management position. Should he rather dedicate his life to science? During a trip to Trinidad he seeks the advice of his very good friend and mentor Hans Kugler. He is told, "The one way you may become a great geologist (who knows). But the other way, you may be the making of *many* great geologists through the favorable environment you may create for their development. Which do you think is the greater?" He managed to do both. He assumes very heavy responsibilities; between June 1937, the date of the completion of Oficina No. 1, and January 1946, shortly after his departure from Venezuela, fifty-five wildcats and exploratory stepouts and nearly 550 development wells are drilled, resulting in the discovery of twenty new fields with total reserves, estimated at the time, of over half a billion barrels and a production of nearly 150 million barrels of oil. And all this during the wartime shortage of technical personnel. Geologically the situation is a complex one, consisting of heavily faulted multiple linear sand bodies. He is the prime force behind every aspect of this exceptional operation, in which he makes full use of sound geological and geophysical methods and is not afraid to experiment with new techniques. It is a rational and thorough exploration and development program of a major petroliferous province. Today it has produced several billion barrels of oil. However, Hedberg never relaxes in his scientific objectives. In December 1940 he participates in a discussion of C. W. Tomlinson's on "Techniques of Stratigraphic Nomenclature" (1941,1), in which he further expands his ideas and proposes flexibility in the usage of "stage." During this period of time he meets Walter Bucher of Columbia University, for whom he develops great respect.

In July 1945 the family moves to Caracas, where he becomes assistant chief geologist in charge of all geological operations in Venezuela. Their fourth son, Franklin Augustin, is born there in 1946.

In August 1946 he is appointed chief geologist, Foreign Exploration Division of the Gulf Oil Corporation, in charge of all geological activities in foreign countries (except Venezuela and Canada) and is transferred to New York. He is promoted to exploration manager of the same division in 1951. However, before leaving Venezuela he fulfills what he considers his obligation toward the geological community by writing with former colleagues H. J. Funkhouser, A. Pyre, and L. C. Sass three papers describing the eastern Venezuela oil province. They are published in the *AAPG Bulletin* in January 1944, December 1947, and October 1948. In his new position he becomes particularly interested in Africa, where no oil has as yet been discovered. He personally digests all the literature and information that he can find about the continent and, alone, goes on a field trip for several weeks to visit all the localities that he considers pertinent. He comes back convinced of the petroleum potential of West Africa and initiates exploration programs that extend from the Spanish Sahara to Southwest Africa. These programs are in large part responsible for Gulf Oil's important position in West Africa and discoveries in Nigeria and Cabinda. Further, he personally negotiates favorable concession agreements with the governments involved. He writes the yearly "Petroleum Developments in Africa" for the *AAPG Bulletin* until 1960. The Hedberg family is living now in Summit, New Jersey. The fifth child and only daughter, Mary Frances, is born there in 1952.

In September 1952 he is appointed chief geologist, responsible for all geological activities of Gulf Oil Corporation worldwide. The family moves to Oakmont, a suburb

of Pittsburgh. He is named exploration coordinator in 1953 and vice-president for exploration in 1957. In these positions he becomes increasingly discouraged by management's negative attitude toward petroleum exploration while emphasizing short-term returns. He is also strongly opposed to the decentralization of exploration that is taking place. He believes that fragmenting exploration and putting the pieces under the control, and budget, of arbitrarily defined profit centers will damage the entire exploration effort of the corporation. The future proves him right. Taking advantage of the rule, in effect in Gulf at the time, that employees with foreign service must retire at age fifty-five, he requests retirement in 1959. The chief executive, W. K. Whiteford, will not accept it, and he stays on in the capacity of vice-president until 1964, when he is appointed exploration advisor to the executive until 1968, the year of his retirement from Gulf. In the meantime, encouraged by friends, notably Harry Hess, and expecting to be retired, he has accepted the position of full professorship of geology, on a part-time basis, at Princeton University starting in 1959. He also had planned for him and the family to move to Princeton. They move and there he maintains his primary home and commutes between Princeton and Pittsburgh, where he keeps a small apartment across the street from the office. He obtains a Gulf grant for Lamont-Doherty Geological Observatory and meets Maurice Ewing, with whom he develops a strong friendship.

In 1958 he is elected vice-president of the Geological Society of America and is elected president in 1959. He is elected to the National Academy of Sciences in 1960, where he participates in many committees, and president of the American Geological Institute in 1962.

The period of time from 1946 until his death is one of incredible variety of endeavor and intensity of work. Only

through exceptional will, discipline, determination, and ability can a man produce what he did. None of his activities are pro forma. When he goes to scientific society's meetings, he attends the sessions, listens to the papers and is always fully prepared for discussions, often knows well the speaker's background, and can quote his earlier statements if needed. He is asked to participate in countless committees, seldom refuses, and always does his homework. He travels extensively in the United States and abroad either on Gulf business or to attend conferences. Much of his travel expenses are out of his own pocket, and all the Hedbergs' vacation trips are centered around some geological activity such as visiting type sections and universities or meeting with geologists.

During this period Hollis Hedberg undertakes one of the most difficult tasks of his career. In addition to his workload, in 1946 he becomes a member of the American Commission on Stratigraphic Nomenclature and will remain in this capacity until 1960. In response to a request for comments by R. C. Moore, chairman of the commission, he writes "Time-Stratigraphic Classification of Sedimentary Rocks" (1948,1), in which he fully develops his thesis of a clear distinction between Time, Time-Stratigraphic, and Rock-Stratigraphic units. Time units are conceptual, while others are material. The properties of Rock-Stratigraphic units are used to establish Time-Stratigraphic units and determine their position in the Time scale. He advocates a more widespread use of "stage" and pleads for simplicity and flexibility. He also points out, having considerable experience in paleontology himself, that although fossils have been the most commonly used property to determine the age of a rock, they are not the only or most infallible property, and therefore biostratigraphic units should never be considered Time-Stratigraphic units. This last point becomes a

great source of controversy and argument, mostly with paleontologists. He becomes chairman of the commission from 1950 to 1952 and reiterates his position in "Nature of Time-Stratigraphic Units and Geologic Time Units" (1951). At the 19th International Geologic Congress in Algier, in 1952, in "Procedure and Terminology in Stratigraphic Classification" (1954,2), he proposes to the International Commission on Stratigraphy the creation of an International Commission on Stratigraphic Nomenclature. As a consequence, what is to become the International Subcommittee on Stratigraphic Classification (ISSC) is created. Hedberg is appointed chairman from 1952 to 1976. It is the opportunity to bring to fruition one of his lifelong ambitions: to bring forth his concepts on stratigraphic procedures and have them agreed on, accepted, and used as "guide" (not law) by the international geological community. To him stratigraphic classification, terminology, and procedures are the fundamental international language of geologists, and without clear understanding of the meaning of the terms, an unequivocal representation of the earth's history is impossible: "Uniformity in the procedure and terminology used in classification is essential to world wide understanding among geologists" (1954,2). This endeavor costs him an incredible amount of effort and a large amount of money. He prepares forty-six circulars, some two thousand pages, resulting from discussions with some fifty-five individual members, thirty-five individual ex-officio members, and forty organizational members around the world (these numbers varied somewhat from time to time). They are deposited in a number of libraries. In addition, there are seven published ISSC reports. He submits to the members many questionnaires, and there are endless discussions, even arguments, bringing out the fundamental differences in philosophy between stratigraphy schools. For instance, the

representatives of the Federal Republic of Germany maintain that the goal of stratigraphy is to classify rocks in terms of Time *only* and therefore all other formalization is unnecessary, and the USSR has a similar position in addition to arguing for the existence of worldwide *natural* time breaks that must be the basis of stratigraphic classification. Hedberg's efforts culminate with the publication in 1976 of the *International Stratigraphic Guide* (1976,1), of which he is the editor. It is interesting to note that on the vote on whether or not to publish the *Guide* there are eighty-five yeases and three noes—the USSR and the Federal Republic of Germany naturally among them. The beauty of the *Guide* is its simplicity and general applicability, making it unnecessary to fundamentally modify it if new techniques or geological concepts were to appear. Hedberg is a strong influence on the ISSC until his death, and between 1954 and 1976 he publishes twenty-five papers pertinent to stratigraphic classification. In 1983 the North American Commission on Stratigraphic Nomenclature publishes *North American Stratigraphic Code*,¹ which, although it has some new terms, follows the guidelines set the by ISSC *Guide*.

During the 1960s he becomes increasingly interested in the geology of the oceans, and in 1962 he is appointed chairman of the AMSOC Mohole Committee of the National Academy of Sciences. He, and the majority of the committee members, are skeptical on whether the information obtained by drilling one hole through the Mohorovicic discontinuity would justify the enormous cost. He is much concerned with wisely utilizing public funds. He proposes, instead, to start with a more feasible and cost-efficient worldwide program of shallower holes as a prerequisite to the Mohole. However, in 1963 he resigns, and the committee dissolves itself, as a protest to the political pressures to drill immediately a Mohole "spectacular" with-

out the benefit of experience in deep water operations or "ultra-deep" hole technology. He and Creighton Burk, chief scientist of the committee, summarize the circumstances in "Drilling the Ocean Crust" (1964,2). The Mohole is never drilled, and a few years later the AMSOC Committee proposal becomes, in effect, the highly successful Joides Deep Sea Drilling Program, of which Hedberg becomes chairman of the Panel on Safety and Pollution Prevention from 1970 to 1977. Also during the same time he begins to stress the economic potential and strategic importance of offshore exploration and convinces Gulf Oil management to build a ship for the purpose of evaluating and exploring offshore sedimentary basins around the world. In late 1966 the project is approved, and the R/V *Gulfrex*, a multisensor ship, is built. It operates around the world from 1967 to 1975, logging 160,000 miles of surveys, and is replaced in 1974 by the R/V *Hollis Hedberg*, which logs over 200,000 miles around the North American Continent and the Caribbean before being decommissioned in 1985. He writes "Why Explore the Deep Offshore?" (1967,2), in which he expresses the thought that the petroleum industry needs to know "the other side of the basin" and should cooperate with governments and academic institutions in noncompetitive activities aimed at understanding the limits of potential economic petroleum occurrences. Between 1979 and 1981 he writes several articles expressing his concern that the United States is neglecting its offshore petroleum resources and proposes a multi-company/government/academic institutions consortium to evaluate the offshore potential. To stimulate exploration he also suggests the replacement of cash bonus bidding by work commitment bidding and government participation in exploration. Predictably this proposal meets with a lack of enthusiasm from the government and the petroleum industry. Neverthe-

less, he is appointed to an Advisory Energy Task Force for Ronald Reagan's 1979 presidential campaign. His interest in worldwide exploration of the oceans leads him naturally to the problems of the ownership of mineral resources under the sea. At that time there is no internationally accepted law governing the offshore extension of countries, and whatever practice in effect is hopelessly embroiled with the problems of surface activities such as fishing and sailing rights. Further, proposals were presented to the Third United Nations Conference for the Law of the Sea for a draft that could seriously affect the future of natural resources allocation. In 1968 he is appointed chairman of the Technical Subcommittee on Petroleum Resources of the Ocean Floor of the National Petroleum Council and remains in that post until 1973. He strongly objects to limits of national jurisdiction proposed in 1969 by a report of the President's Commission on Marine Sciences, Engineering and Resources, and he proposes instead to use a "boundary line" drawn between the physiographic base of the slope and that of the rise. He calls it the "base of the slope" method. This line would be fixed by some international technical commission. This idea is presented at the 1969 annual meeting of the American Association of Petroleum Geologists in Dallas. To prove the feasibility of the method, he personally draws from bathymetric maps a "boundary line" for all the continents and islands. The proposed technique is well explained and exemplified in *National-International Jurisdictional Boundary on the Ocean Floor*.² Unfortunately, the Third United Nations Law of the Sea Conference seems to be unable to reach an agreement due to conflicting self-interests of nations and moves toward a compromise boundary definition that he considers a "hodgepodge and travesty." In numerous papers and articles written between 1973 and 1983 he asks the United

States not to sign the treaty. He uses as an argument the signing of a draft treaty between the United States and Mexico in 1978 based, in large part, on the arbitrary 200 nautical miles limit. Under this treaty the United States would lose 25,000 square miles of deep-water, oil-prospective Gulf of Mexico as compared to his proposed "base of the slope" method. In "Evaluation of U.S.-Mexico Draft Treaty on Boundaries in the Gulf of Mexico" (1980,2) he strongly criticizes the U.S. policy regarding the Law of the Sea and urges the Senate not to ratify the treaty. Thanks to his actions, the Senate requests from the USGS an evaluation of the oil potential of the deep waters of the Gulf of Mexico, and as a consequence of the results, the treaty is never ratified. Further, President Reagan announces on July 9, 1982, that he will not sign the Law of the Sea Convention, and the United States walks out of the Third United Nations Conference on the Law of the Sea. This chapter is not closed yet, and let's hope that Hedberg's patriotic and rational opinion will influence the final outcome.

From 1959 to 1972 Hedberg teaches at Princeton University. He gives one course, "Stratigraphic Systems," for graduate students. It has the format of a seminar wherein each system is analyzed in historical sequence. Through discussions and examples, he leads the students so they become aware of past and present stratigraphic problems. He is as thorough as usual and invites visiting prominent geologists to participate and meet the students. He is very informal, and most of the seminar sessions are held in his home, in the living room, with pretzels and beer always appearing toward the middle of the sessions. He never complains about beer spilled onto the Oriental rugs, which happens with alarming frequency. He serves in an advisory capacity to the Department of Geology. After his retirement from Princeton University in 1972, he becomes professor emeritus.

As a matter of fact, Hollis Hedberg, in his lifetime, has been advisor to many universities and other institutions: New York University, Columbia, Western Reserve, Pittsburgh, Kansas, Woods Hole Oceanographic Institution, MIT, Lamont-Doherty Geological Observatory, and Stanford.

Having reached a professional summit in both academic and industry circles, he is a living example of his strong belief that a close interaction between the two is essential for the progress of both. He expresses his thoughts on the subject at the 24th William Smith Lecture, in London in 1970: "Petroleum and Progress in Geology" (1971,1).

He still manages to have time to do his own research on problems that have been on his mind for a long time. He writes "Geologic Aspects of the Origin of Petroleum" (1964,1), in which he summarizes the nature of petroleum occurrences in terms of rock types, fluids, age, temperature, etc., discusses the sedimentary environment, processes, timing, and sources, and suggests some lines of investigation, all based on observed relationships. In "Significance of High Wax Oils with Respect to Genesis of Petroleum" (1968,3), he supports the thesis, from field evidence, that oils with a high wax content must have been sourced in beds with a high non-marine plant content. Later he writes "Relation of Methane Generation to Undercompacted Shales, Shale Diapirs, and Mud Volcanoes" (1974,2), in which he proposes that pressures higher than hydrostatic, sometimes higher than geostatic, can be generated in shales due to the decomposition of organic matter, thus causing diapirism and sedimentary volcanism. He presents "Methane Generation and Petroleum Migration" (1980,1), a related subject, at the 1978 annual AAPG convention. In these studies he emphasizes his long held belief that geology is an inductive science and that theories should always be based on solid observations of nature.

After his retirement from Gulf in 1968, he remains associated with the company as a consulting exploration advisor. In this capacity, in the late 1970s he recommends to management the investigation of an area, somewhat neglected by the industry, where seeps and mud volcanoes are abundant: northwestern Colombia. He personally travels to Bogota, meets with ECOPETROL high officials and, against all odds, obtains for Gulf excellent terms over essentially the entire prospective area in exchange for a joint ECOPETROL-Gulf systematic exploration program. It is a marvelous expression of personal confidence from the Colombians. Only Hollis could do it, but he also had a feeling of heavy responsibility toward them. Hedberg actively participates in the program from 1982 to 1986, even after the acquisition of Gulf by Chevron in 1984, going to the field many times, advising, and following closely the progress of the studies, even though his health is beginning to fail toward the end of his involvement. Unfortunately he cannot see the completion of the project due to the increase in guerrilla warfare and drug trafficking, which renders the whole area unsafe for Americans and Colombians alike. From 1976 to 1984, he is a member of Gulf Oil Corporation's Science and Technology Council, whose main objective is to monitor and advise Gulf Research & Development Company. It is ironical that in 1981, after several generations of Gulf executives ignoring his advice on organizational matters, the chairman of the board asks him, seventy-eight years old, and another retired Gulf executive, I. G. Davis, to make a study of the Exploration Department organization, personnel, and programs and recommend improvements. Recommendations are presented in November of the same year. One of them is the creation of a Gulf Exploration Council. Under his guidance, it operates from 1982 to 1984. Hedberg is a member, and he takes a very

active part in it in an attempt to stimulate and improve the quality of the exploration program. Unfortunately, Gulf Oil Corporation runs out of time. In retrospect, Hollis Hedberg's life was closely intertwined with that of Gulf. Except for the early, short period with Lago Petroleum, it was the only company that he was ever associated with, and he strongly believed that Gulf's health depended on a solid exploration effort. In spite of frustrations and disappointments, he was extremely loyal to it and, to the end, was always prepared to be of assistance. Although he was accused of having orange blood, the color of Gulf's logo, he always emphatically stood for what he believed was right, even if it did not agree with management views. He derived much satisfaction from the fact that he was admired and respected by everyone he came in contact with in exploration, especially the younger generations, and he was able to guide the careers of many of them.

During his entire life Hollis Hedberg was interested in the history of geology, and he became quite a scholar on it. His fine collection, gathered over the years, of old editions of books by early geologists and explorers, as well as of old maps, testify to it. Due to his heritage he was naturally interested in the role of Swedish geologists. His first paper on the subject, "Influence of Torbern Bergman (1735-1784) on Stratigraphy" (1969,1), is published in 1969. He participates in the translation from Swedish of "A Description of a Cliff. . ." by Göran Vallerius,³ published in 1970, and *Hermann Karsten, Pioneer Geologist in Northern South America, 1844-1856* (1974,1), a paper on a German, is published in 1974. Finally, *The 1780 Description by Daniel Tilas of Stratigraphy and Petroleum Occurrence at Osmundsberg in the Siljan Region of Central Sweden* (1988) is published. This is to be his last work. It is an extensively annotated translation from the Old Swedish of one of the earliest published

sets of stratigraphic correlations and a description of the occurrence of petroleum with suggestions of its source rock. He receives the first published copy less than two months before his death. The letter accompanying the copy said, "On a personal note, I am particularly gratified to be able to make this presentation to someone who has had such an important impact on my career as a petroleum geologist—not to mention the fact that the same someone was the first dinner guest of a newly married couple in Oberlin, Ohio, who so much appreciated his stopping by to say hello," signed Larry Funkhouser, President of AAPG.

All in all, during his lifetime, Hedberg published 177 papers and fifteen reviews. However, the bulk of his writings is in countless private reports and memoranda which unfortunately might never be published. Many of them are probably lost by now. It is a pity because some, such as the ones describing Colombian and Venezuelan geologic sections or his very unconventional heavy mineral zonation in eastern Venezuela (an early attempt at multivariate analysts), were classics.

Hollis Hedberg received many honors and awards during his lifetime: the Medalla de Honor de la Instrucción Pública by the Venezuelan Government in 1941 (first foreign recipient and his first award) in recognition to his contribution to Venezuelan geology; the AAPG Sidney Powers Medal and the University of Kansas Distinguished Service Award in 1963; the Geological Society of London William Smith Lecture in 1970; the AAPG President's Award, and is honoree of Princeton University Conference on Petroleum and Global Tectonic in 1972; the National Academy of Sciences Mary Clark Thompson Award and the AAPG Human Needs Award in 1973; the Offshore Technology Conference Distinguished Achievement Award and the Geological Society of London Wollaston Medal in 1975; Doctor

Honoris Causa, University of Uppsala, Sweden, 1977; the Geological Society of America's Penrose Medal, the highest award for a geologist in the United States in 1980; honoree at the AAPG 1981 Hedberg Research Conference in Galveston, Texas; the AGI Ian Campbell Medal and the Louisiana State University Hollis D. Hedberg Award in Energy in 1983; and the AGI William Heroy Jr. Award in 1987.

In addition, he was awarded honorary memberships in the Sociedad Científica Matemática, Física y Natural de Venezuela in 1941, the Geological Society of London in 1957, the Asociación Venezolana de Geología, Minería y Petróleo in 1959, Geological Society of Stockholm in 1960, and The Danish Royal Academy of Sciences and Letters in 1970.

Hollis Hedberg had a personal life as successful and rewarding as his professional life. Frances was his close and understanding companion for fifty-six years. In addition to the normal load of housework, under all kinds of circumstances and frequent moves, she ran plane-table for him in the Rio Querecual, coauthored a paper with him, kept geological files in San Tomé, accompanied him on countless trips, and drove the car to their summer home in Cape Cod so he could type on the back seat. They raised their family with the same sense of values with which he had been raised, and today three sons have Ph.D.'s in geology, one has two M.A.'s, in classics and journalism, and the daughter has a Ph.D. in molecular biology. They are all successful professionals and have given them fourteen grandchildren and five great-grandchildren. More important, the family bonds are as strong as they were between Hollis and his parents. Although his work was his principal "hobby," he was also a fine athlete for much of his life, a good swimmer and outstanding tennis player. He and Frances enjoyed square dancing, and occasionally he played the

accordion, but most of all he cherished his vegetable gardens, of which the most extensive and complete was at their vacation home in Cape Cod.

With the death of Hollis Hedberg on August 14, 1988, came an end to an astonishing career full of accomplishments. He is unquestionably one of the great geologists of our time, but he made significant contributions in areas that required more than just being a great geologist. To succeed in convincing a corporation management to invest in areas with no previous success, to bring about an international consensus in the language of stratigraphic classification and procedures, and to help keep the United States out of the Law of the Sea Convention as drafted by the United Nations required an incredible amount of determination, persistence, hard work, discipline, self-confidence, courage and patience. To be admired, respected, and cared for by everybody who came in contact with him required kindness, humility, understanding, and love. Incredibly, he did all of this in addition to having a wonderful, close-knit family.

It is very difficult to come to the realization that the man in the perennial gray suit with the somewhat crooked posture, the big smile, and the handshake that almost tore your arm out of its socket is no longer here. We, the many who in one way or another had the luck to come in contact with him and the geological community as a whole, will miss him very much.

IN PREPARING THIS MEMORIAL I have had the assistance of Mrs. Frances Hedberg and access to Hollis Hedberg's letters and personal files and drew from my personal experiences, having had the good fortune to be a close friend and professional associate for forty-eight years.

NOTES

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2. Law of the Sea Institute, University of Rhode Island, Occasional Paper 16 (1972), 19 pp.
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