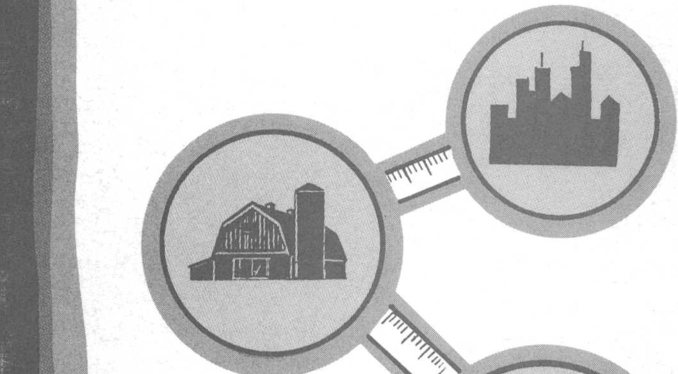
NATURE...

an Environmental Yardstick



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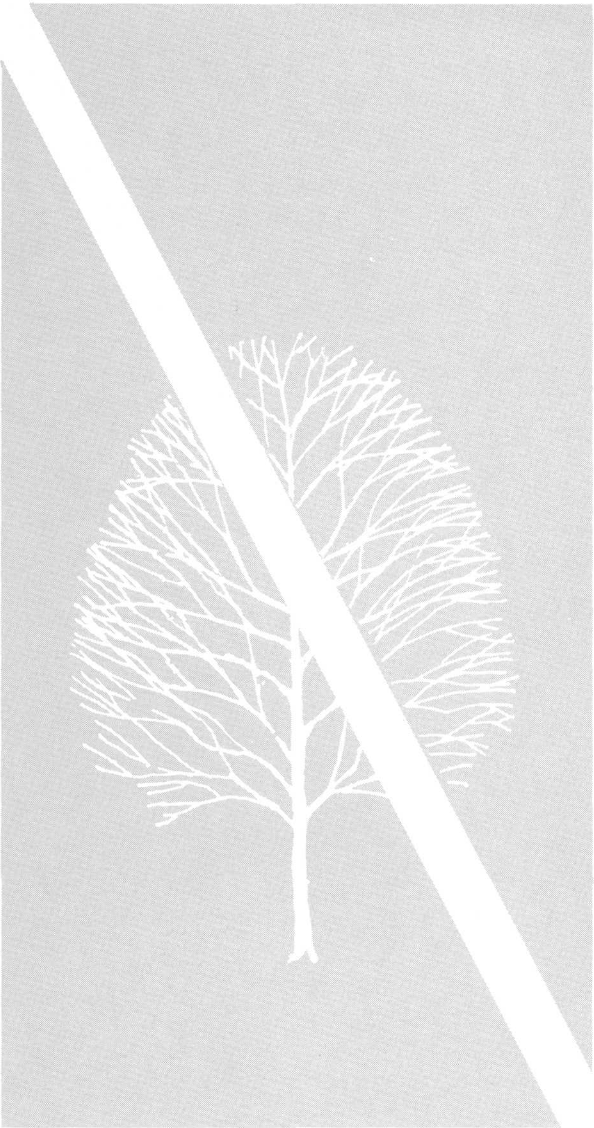
NATURE. . . AN ENVIRONMENTAL YARDSTICK

William T. Pecora, Under Secretary
Department of the Interior



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A Note about this publication . . . . . .

The message published here was first presented by Dr. Pecora as a speech entitled *Geologic Base Line For Conservation Philosophy* and given as a Horace M. Albright Conservation Lecture at the University of California, Berkeley, California, on January 18, 1972.

INTRODUCTION

To one who has spent his professional career in geologic science, conservation always has had special meaning. In the measurements so necessary to his work the geologist develops an integrity in the use of numbers and in the qualifications attending the validity of numbers. Scientific analysis of geologic events and sequence develops a keen sense of what is coincidental, correlative, and consequential. The geologist applies his science in evaluating hazards to man as natural catastrophes and/or benefits to man such as earth materials that form the resource base of his society. But more than these the geologist has acquired a deep appreciation for the planet as a whole, its inner structure, its landscape, and the living things that abound.

By his training and avocation the geologist is an earth scientist and conservationist—therefore closer to nature in its entirety than any other scientist. There are many kinds of conservation in today's world. The classical stance showed its full face at the turn of the century with the voices of John Wesley Powell, W. J. McGee, and F. H. Newell, all leaders of the U.S. Geological Survey speaking to multiple and prudent use of the land and all of its resources. Gifford Pinchot, the first head of the U.S. Forest Service, adopted the McGee concept of "greatest good for the greatest number for the longest period of time" as the theme for the new conservation movement. He so impressed President Theodore Roosevelt, our first Conservation President, that it became the theme of the Governors' Conference in 1908.

Largely because of World War I and the postwar recovery period, the New Conservation movement suffered severely from the New Economics and GNP. Industry and development became prevalent themes and minimum cost econometrics superseded total cost in practice. Social and environmental issues were essentially put aside.

CONCEPT OF UNIQUENESS

One basic concept of a classical conservation philosophy is identity of uniqueness in the natural environment. Proper application of this concept includes biological and geological resources—both renewable and nonrenewable.

The establishment of Yellowstone Park a century ago was the first national step implementing the concept. Here, a major land area was set aside by Act of Congress in order to preserve unique natural features for the education and enjoyment of all people. The park has been protected in spite of great resource values known to exist within its boundaries such as gold, hydropower, and geothermal energy. The Everglades National Park is a similar preserve where visitors can enjoy a rare and delicate ecosystem peculiar to a subtropical water-based ecology in its natural state. Other areas, such as the Alaska Wildlife Refuge, are protected and exempted even from the kind of access permitted in National Parks. As of recent count the Federal Government has set aside 38 National Parks, 82 National Monuments, and 329 wildlife refuges. A wilderness system is currently in progress.

In like fashion mineral resource areas can be truly unique in their character and in their occurrence in the accessible part of the Earth's crust. Famous mineral districts like Butte, Montana; Bingham Canyon, Utah; and Lead, South Dakota, are rare occurrences on a planetary basis. Unlike the unique vistas and wildlife domains, unusual mineral deposits serve the public good if they are recovered in a systematic way. In the long history of man, exploration and development of mineral resources at specific sites have been temporary operations. With proper planning before extraction is begun and proper restoration of the terrain after extraction, there need be little adverse environmental impact in acceptable tradeoff of resource values and multiple use of the total resource base.

The concept of multiple use and sustained yield were two guiding principles of the classical conservation philosophy expressed at the turn of the century. Conflicting uses and permanent damage to other potential resource values have been elements of recent debate and will remain as important subjects in a pluralistic society which requires both renewable and nonrenewable resources to maintain its health, welfare, and vigor. It is understandable now that economic values received highest priority during the developmental stage of our society. Today the American society is mature in an economic sense. Understandable pressures are increasing to preserve our dwindling acreage of the natural terrain, particularly on the Public Lands.

The National Environmental Policy Act of 1969 represents the expression of a national conscience. This together with other bills before the Congress will eventually determine the course of our National Conservation policy. Hopefully, the voice of reason will be heard throughout the land, and prudent judgments will be made on the basis of factual information and thoughtful assessments. Only by examining man's effects in the light of natural processes can we reach long term decisions that will stand the test of time. For this reason any philosophy on conservation developed by an individual or a Nation must recognize geologic processes as a baseline for reference.

CHANGING ECOSYSTEMS

The primitive indigenous American exercised minimal impact on his environment and rarely did things that degraded or altered his environment irreparably. This was not so much a matter of choice as a matter of capability. Modern man, however, through the sheer force of numbers and through spiralling science and technology has made major changes, some of them necessary for his existence and others merely to suit his fancy.

Transformation of large areas of woodland, bottom land, and prairies into farms created an agricultural ecosystem that is now an essential element in our society, although the initial modification of land was in sharp conflict with the religious belief of the indigent Indian people. Cities have arisen which concentrate millions of people within a few hundreds of square miles. Natural shorelines of rivers and coasts have been modified for livelihood, industry, and recreation. The highway system of the United States aggregates the area of the States of Vermont, Rhode Island, Massachusetts, Connecticut, and Delaware (Ellsaesser, 1971). Many rivers have been dammed to create reservoirs to provide water resources for irrigation, industry, and municipal use. The environmental changes brought about by these activities have been relatively rapid in comparison to most which occur in the natural state.

By contrast massive changes in Earth features that have occurred slowly in geologic time are relatively inconspicuous. But for research in the field no awareness would have evolved of the validity of the Geologic Law of Uniformitarianism—that the present is key to the past (and the future). Seas exist where land masses once prevailed, and vice versa. Lakes formed and disappeared. Mountains became plains and gorges became broad valleys.

Only those catastrophic events of nature like earthquakes, volcanoes, landslides, floods, and hurricanes rival man's ability to wreak sudden change.

In small areas man's activity in grazing, agriculture, and settlement can increase sediment load 10-fold to 100-fold. Total sediment production in major drainage basins, however, is not significantly altered by man's activity. Annual average transport per square mile for U.S. rivers has essentially been the same since 1909 and an indication that nature dominates stream loads.

THE IMPURE ATMOSPHERE

Much concern has arisen over man's alteration of the Earth's atmosphere and the potential effect on climate and health. On a planetary basis the pollution of man has been miniscule in comparison to the natural baseline. On a local basis, however, concentrated emissions into the air by man are unacceptably high for reasons of aesthetics, nuisance, or potential damage to the environment, however temporary.

Rain is looked upon as a purifying phenomenon. The residence time of a particulate matter or chemicals in the lower atmosphere is indeed a function of the frequency of rainfall. This important role of rain and snow has been a boon in populous areas where industry exists in high concentration and the air needs clearing.

Rain itself, however, is not pure. In the hydrologic cycle, the moisture that eventually falls as rain or snow carries with it chemical compounds derived from the ocean and from atmospheric processes. These include such compounds as ammonia, chlorides, sulfates, bicarbonates, nitrates, and hydrocarbons. All are essential to the natural environment in which they serve as fertilizer to the plant kingdom that sustains all life.

From data of Robinson and Robbins (1968) one can calculate that about 95 percent of the estimated 9 billion tons of chemical compounds annually entering the Earth's atmosphere is derived from natural sources. Of this amount less than 1 percent of the nearly 1.7 billion tons of hydrocarbons is derived from human activity; about one-third of the more than 200 million tons of sulfur compounds is contributed by man; but only 1 percent of nearly 7 billion tons of nitrogen compounds. These data exclude natural emanations from volcanic regions. Kimble (1966) *estimated that 100 million tons of fixed nitrogen* alone are annually brought from the atmosphere to the Earth.

For the land area of the United States, Junge and Werby (1958) estimated that 44 million tons of natural chemical compounds are carried down to the Earth each year. In a local drainage basin covering 44,000 square miles of Virginia and North Carolina, Gambell and Fisher (1966) calculated that the 107 thousand tons of mixed solids (calcium, magnesium, sodium, sulfate, carbonate, nitrate) dropped from the air per year is equal to about one-half the annual load carried by the local streams in the drainage basin. The airborne salts, moreover, are enough to account essentially for all the sulfate and nitrate in those streams.

Hundreds of volcanic eruptions during historical time have contributed vast amounts of particulate matter and gases to the atmosphere, in addition to devastating land areas and damaging large biosystems. Recorded eruptions for example in the Mediterranean Region, Caribbean Islands, Central America, East Indies, and other places, have accounted for many thousands of human fatalities, as well as damage to soil and plant and animal life. From my own calculations three eruptions alone—Krakatoa in 1883, Mount Katmai in 1912, and Mount Hekla in 1947—have contributed more particulate matter and may have contributed more combined natural gases to the atmosphere than all of man's activity. The force of these volcanic eruptions carries fine ash higher into the atmosphere than man's pollution and therefore results in residence times measurable in months or years (instead of days) and in fallout range in hundreds or thousands of miles (instead of miles).

Smoke stacks emitting products of the combustion of coal produce a continuing environmental harassment in populous areas and are also looked upon as esthetic intrusion in pristine areas. If these smoke stacks are judged to be necessary, then heightening of the vertical column and technologic dust and gas collectors must be introduced in order to reduce the aggravation of emissions. Also, waste disposal systems for the ash and liquids thus collected must be devised.

It has been said in many places that man's combustion of energy fuels will seriously deplete the oxygen component of the atmosphere. Measurements show that oxygen makes up about 21 percent of the atmosphere and that no meaningful change has taken place in the past century. One group (MIT, 1970) calculated that if the world's reserves of coal, oil, and natural gas were all burned the amount of oxygen thus used up would be less than one tenth of 1 percent of the existing reservoir of oxygen in the atmosphere.

Since the beginning of the Industrial Revolution it has been calculated that a significant increase in carbon dioxide has been generated over that normally generated by nature. For example, carbon dioxide now makes up about 320 parts per million (by volume) of the atmosphere and by the year 2000 about 60 parts per million increase could be generated. Volcanoes also add CO_2. Because of the three massive planetary reservoirs for gasses—the biosphere, the atmosphere, and the hydrosphere—one cannot readily conclude that man's generation of CO_2 will be significant in climatic effect. Unexplained climatic changes in geologic time have resulted in periodic glacial episodes (ice ages) on the planet. Less spectacular climatic changes have occurred over centuries and millenia without influence of man. I frankly doubt that man's effect on the atmosphere is significant enough to change or speed up the massive natural trends.

It is apparent that natural atmospheric processes can have both beneficial and harmful effects locally. It is also apparent that a conservation philosophy should require better control of man's pollution of the air in response to his desire for an esthetic environment and his requirement for reduction of aggravation from particulate matter or abusive gases. Prevention of adverse climatic effects appear to be less significant but more research is needed to confirm this.

IMPURE OCEAN

As the major sink for waste products of Earth processes the oceans have developed their present character over a few billion years. Rubey (1951) assessed these chemical changes over geologic time. My own analysis leads me to a conclusion that man's activities have significantly altered the natural state in some estuaries and near-shore zones; but the mass effect of man on the chemical and physical character of the ocean has been negligible.

It has been estimated by Nace (1967) that 97.3 percent of all the Earth's water is contaminated by natural salt and the ocean contains 317 million cubic miles of saltwater. Durum and others (1960) calculated that 225 million tons of salt are carried to the ocean by U.S. rivers each year. More than 50 percent of this total is contributed by the Mississippi River alone, and most of that is from natural sources. In geologic time salts are recycled in Earth processes and many ancient geologic formations that were developed under marine conditions are characterized by beds of mixed salt compounds.

Marine fishkills reported offshore are frequently cited as a consequence of man's pollution. Discolored waters ("Red Tides") and related fishkills are mentioned in the Bible, in the Iliad, by Tacitus, and in logs of navigators of the 16th century. Brongersma-Sanders (1957) and Rounsefell and Nelson (1966) have summarized historical references that document many past events of worldwide occurrence. Geologists have long been interested in the causes of mass mortality and attempts to explain some of the remarkable examples of catastrophic deaths of marine animals, the records of which are preserved in geologic formations. For example at Lompoc, California, Jordan (1920) reported that a Miocene (10 million years ago) catastrophe resulted in death of more than a billion herring, 6 to 8 inches long, over an area of 4 square miles. Similar massive deaths and burial are found in many horizons in the geologic record, far back into Paleozoic time, where the record of the past one-half billion years shows extinction of many billions of species from the Earth.

Red Tides are caused by a variety of organisms and apparently represent an unusual coincidence of circumstances involving water temperature, natural nutrients, and hydrodynamic conditions. In some circumstances the oxygen concentration exceeds saturation and hence becomes a natural poison. Some organisms, for example dinoflagellates like Gynnodinium, are toxic to fish and cause widespread devastation. Other agents inorganic in origin that have likewise caused catastrophic death in the sea include volcanic eruptions, earthquake shock, and sudden changes in salinity or temperature. Increasing research and better observations in recent years have brought the mortality phenomenon to our attention more frequently and are probably responsible for the widely held but erroneous conclusion that man's pollution is the prime agent.

In the area of the Mississippi Delta, according to St. Amant (1972), ditches dug into natural marshes have resulted in an increase of salinity which, coupled with increase in temperature induced by pipelines, has resulted in an epidemic increase in a fungus known to have a deleterious effect on oysters. In other areas of the U.S. coastal zone, waste plumes carrying chemicals can be damaging to marine life, and certain waste waters with wide-ranging temperature can locally affect marine biota. In the Santa Barbara Channel, off Coal Oil Point, natural tarry substances escaping from the seafloor have been known certainly for at least hundreds of years but appear to permit a healthy and rich marine biota nevertheless. On the other hand, massive catastrophic spills of crude petroleum or its derivatives are known to have severe immediate effects on some sea life, particularly sea birds.

Because man's activities can in effect cause severe local damage to marine life, research should be speeded up to increase our understanding of cause and effect. In some places harvesting by man would appear to have even greater effect on certain species than natural or human pollution. Proper assessment of research and systematic observational data can certainly lead to regulatory controls that would prevent irreparable damage. A conservation philosophy demands this information in order to exercise proper controls.

TOXIC HEAVY METALS

The so-called toxic metals like mercury, lead, cadmium, zinc, selenium, arsenic, nickel, and chromium are widely distributed in nature. They occur as chemical components of minerals, ores, soils, rocks, and waters and are natural trace components of the biosystem. Among them mercury is probably the most mobile (Pecora and others, 1970).

The mercury content of the atmosphere and the ocean apparently is derived primarily from degassing the Earth's crust (Weiss and others, 1971). This process probably injects 10 to 100 times as much mercury into the planetary atmosphere as all man's industry combined, including chloralkali plants, fossil fuel combustion plants, cement plants, and smelters. The rate of escape of mercury from such geological arenas as the geothermal area of Yellowstone National Park, volcanic centers, and mineralized provinces is measurable and noteworthy. The ocean and seabed is the long term sink for much of the mercury involved in successive exhalations and fallout.

In seawater the mercury content ranges widely but is estimated to average 0.15 to 0.25 parts per billion, exclusive of the amount held in seabed sediments. In recent decades annual world production of newly mined mercury falls in the range of 5,000 to 10,000 metric tons. All the mercury mined by man throughout history would total less than 0.001 percent of that contained in ocean water. It is clear that mercury in the natural environment has been a persistent trace element throughout geologic time. Its toxicity, however, is a function of its chemical state and ingestion history.

Organic mercury compounds are much more troublesome than inorganic compounds, because they are more readily absorbed in the life chain. At Minamata Bay, Japan, human mercury poisoning developed from eating of fish and shellfish contaminated by effluent from a chemical plant that used mercury as a catalyst. Use of mercury compounds as agricultural pesticides has enlarged the sphere of toxic influence in the biosphere.

Recent press reports on the discovery of mercury in many parts of the environment have created great apprehension and resulted in decrease in the public market for certain commercial fish. New information discloses comparable mercury contents in preserved fish caught many decades and centuries ago, lending credence to the conclusion that mercury ingestion by fish is not primarily from recent marine contamination.

Inasmuch as trace metals in toxic amounts place life and health in jeopardy, Government controls in use and disposal of wastes containing them are warranted. However, conservative attitudes should prevail until present quality standards are carefully evaluated against experience and records of the past. In the light of knowledge of the ocean's mercury balance, I am impelled to state that the occasional practice of eating tunafish sandwiches or fish steaks need not be modified and that apprehension is not justified.

CHANGES IN THE LANDSCAPE

Nature has made many billions of scars on the surface of the land through normal geologic processes. Dry gulches, badlands, landfalls, alluvial washes, and terraces are among many landforms so common to the geologist.

Meteor Crater in Arizona is a natural circular feature attractive to many tourists, as is a large open pit near Bingham Canyon, Utah, created by man to recover billions of pounds of copper for industry. Natural terrains underlain by limestone or salt formations display sinks and cave-ins, as do terrains underlain by underground mines. Roads and highways lace the country as do stream courses in drainage basins. Lands are necessarily cleared for airports, transmission lines, railroads, and pipelines.

Some look upon any intrusion of the pristine wilderness by man's construction as a desecration of nature. The technical development that has set man's development on Earth apart from the rest of the animal world has indeed made a profound impact on the surface of this planet in many places. In order to sustain man on Earth, landscape tradeoffs have been a necessary consequence. A burgeoning population requires more natural resources each decade. Even if zero population growth is attainable, mankind's demand for resources is staggering. Some estimate that cumulative demand will triple or more by the year 2000.

The mature technical society of the United States has provided 50 to 100 times the worldly goods of its frontier counterpart. Today 1 penny's worth of gasoline provides the work of 25 men. Three people now provide the basic food for 100. Like it or not, this has been the accepted and preferred path of affluent consumers and skillful technology.

Appalachia is studded with remnants of poorly practiced open-pit coal mines that were operated without regulatory controls. For less than 2 percent of the value of the coal marketed, most of these abandoned sites might have been acceptably restored. Today the cost would reach hundreds of millions of dollars. On public lands in the Western States, the Department of the Interior imposes restoration and reclamation requirements as part of the resource-recovery mining system and part of the cost of operation. All leasings of public lands carry this contractual requirement.

A mature Nation like the U.S.A. so dependent upon its natural resources cannot turn off its economic pattern of development without a major impact on its welfare and way of life. Nor can this Nation continue its economic development without more regard for the environmental impact of its industry. The public interest is a multifaceted structure requiring the full attention and prudence of Government.

Under consideration in Congress is a major reorganization plan whereby a proposed Department of Natural Resources can serve as a focal point for national policy in this area. Along with management responsibilities for land, water, wildlife, and energy the new Department would combine research capability in total science of the Earth. How better to develop management judgments about nature than with science and technology as handmaidens?

CONCLUSION

Over the past decade, increasing public concern over alteration and degradation of the human environment has focused serious attention on indiscriminate industrial development. Recognizing that alteration of the environment is not necessarily hazardous to man and his associates in the biosystem, environmental change, nevertheless, is being subjected to intensive review and critical analysis. Some vocal and active extremists demand full halt to all further economic development. Others require stipulations that all industrial activity, present and future, absorb substantial costs to avoid any further pollutants to air, land, and water and to initiate specific and costly recovery technology to enhance the environment or to offset unacceptable practice. These concerns and demands are generating new laws and regulations aimed at curbs and controls that have significant impact on our national resource base.

Inadequate data persist in the arena of assessment and decision making. Consumers demand a continuing supply of energy and resource products on one hand and demand maximum pollution protection on the other. Scientists and engineers are now victims of their own success. They have provided what the people wanted in a frame of lowest cost requiring great innovations in a maturing society, and they now must respond in a short timeframe to continue productivity without adding wastes to the environment.

Geologic science demonstrates that nature is a massive polluter of the environment. In comparison, man's activity is of little consequence on a planetary scale in some issues, but may be of serious consequence in a local context. Conservation ethic requires a better understanding of the natural baseline before rigorous actions are taken out of apprehension and ignorance. Science and research are needed more than ever to provide guidance to courses of national action aimed at fulfilling human needs. As the most intelligent species on Earth, man can certainly provide for himself and yet prudently protect the total ecosystem from unnecessary and unacceptable degradation.

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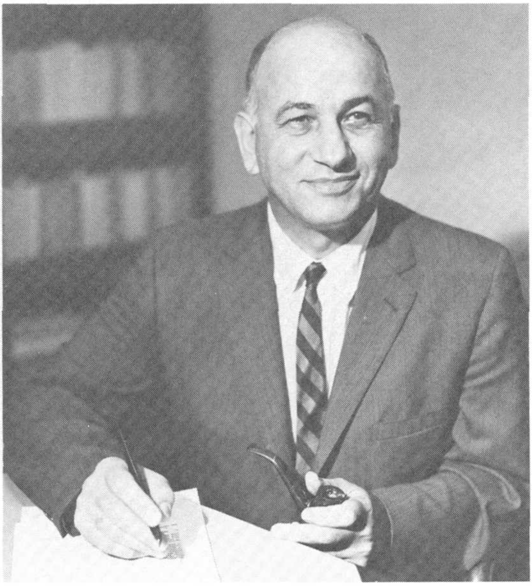
ABOUT THE AUTHOR........



Dr. William Thomas Pecora served as Under Secretary of the U.S. Department of the Interior from May 1971 until his death on July 19, 1972.

A widely acclaimed expert in mineralogy, petrology, and geochemistry, with special emphasis on determinations of scientific principles as guides in the exploration of mineral, fuel, and water resources, Dr. Pecora was a career scientist with the U.S. Geological Survey from 1939, and was the Survey's eighth Director from 1965 until he became Under Secretary.

Born February 1, 1913, in Belleville, New Jersey, Dr. Pecora attended public schools in Newark, New Jersey. He graduated with honors in geology from Princeton University in 1933, and received his Ph.D. in geology at Harvard University in 1940.

The author of more than 50 scientific publications, Dr. Pecora received international recognition for his work in a number of geologic fields, such as rare minerals and volcanic regions. His research studies were made throughout the United

States and in many parts of Latin America. As the result of his work in Brazil, nine minerals were identified for the first time.

In 1965, Dr. Pecora was elected to the National Academy of Sciences for "distinguished and continuing achievements in original research." That same year, he was elected a Fellow in the American Academy of Arts and Sciences. In 1968, he received the Interior Department's highest honor, the Distinguished Service Award, and in 1969, was a recipient of the Rockefeller Public Service Award for career civil servants.

Under his direction, the Geological Survey assumed leadership of the Interior Department's EROS (Earth Resources Observation Systems) Program. He also established the Survey's National Center for Earthquake Research at Menlo Park, California. Most recently Dr. Pecora coordinated and guided the preparation of the massive environmental statement on the trans-Alaskan oil pipeline proposal, and helped Secretary Morton formulate the Department's position on numerous and complex problems relating to development of the Nation's mineral, water, and energy resources.

Dr. Pecora's numerous professional affiliations included the Geological Society of America (Fellow and Councillor); Mineralogical Society of America; American Association of Petroleum Geologists; American Institute of Professional Geologists; Mining and Metallurgical Society of America; Society of Economic Geologists, the Cosmos Club of Washington, D.C. (President, 1968); and the American Philosophical Society.

He was a President of the Geological Society of Washington (1964); on the Executive Committee, National Research Council, Division of Earth Sciences; on the Advisory Committee for Graduate Records Examination to Geology, Educational Testing Services, Princeton, New Jersey; Chairman, U.S. Civil Service Commission's Board of Examiners for Geology; Honorary Member of the Rocky Mountain Association of Geologists; and a Foreign Member of the Brazilian Academy of Sciences.

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As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.