# Environmental Geology

Edward A. Keller

**Charles E. Merrill Publishing Company**
**A Bell & Howell Company**
**Columbus, Ohio 43216**

BELL & HOWELL

**8617-5**

# ENVIRONMENTAL GEOLOGY

EDWARD A. KELLER
*University of California/Santa Barbara*

*With assistance from E. M. Burt,*
*Williams & Works, Grand Rapids, Michigan*

Charles E. Merrill Publishing Company
*A Bell & Howell Company*
Columbus, Ohio

For
JACKIE

Published by
Charles E. Merrill Publishing Company
*A Bell & Howell Company*
Columbus, Ohio 43216

This book was set in Times Roman and Helvetica.
The Production Editor was Margaret Shaffer.
The cover was designed by Will Chenoweth.



International Standard Book Number: 0–675–08617–5

Library of Congress Catalog Card Number: 75–44887

2 3 4 5 6 7 8 9 10—81 80 79 78 77 76

Acknowledgments for cover photographs
***U.S. Army Corps of Engineers***
***Ward's Natural Science Establishment, Inc.***
***ERTS photo***
***Hawaii Visitors Bureau***
***National Park Service***

Printed in the United States of America

# PREFACE

*Environmental Geology* is an in-depth treatment of relations between man and his geologic environment. Introductory chapters develop a philosophical framework that unites the cultural and physical environments while introducing the terminology necessary for the remainder of the book. Traditional subjects such as geologic hazards are introduced and discussed by interweaving geologic and human aspects of each hazard: flooding, landslides and subsidence, earthquakes, volcanoes, and coastal erosion. Other material includes hydrology and human use, waste disposal, geologic aspects of environmental health, resources and energy, land-use planning, site selection, landscape aesthetics, environmental impact, and environmental law. The main thrust of these topics is to emphasize the geologic aspect or geologic considerations that might arise under certain conditions in working in these areas.

The author is indebted to many individuals, companies, and agencies that supported the book by critical reviews or by providing photographs and illustrations.

Reviews of chapters by Samuel E. Swanson, Harold L. Krivoy, and James Dennis Rash are recognized, as are the reviews of the entire text by Douglas G. Brookins, John B. Droste, and Stanley P. Fisher.

The author is indebted to Maggie Shaffer for editing the text and making numerous suggestions for improvement. Special recognition is also given to the Bette Davis Company for typing the manuscript; Olive Pistor for assistance with government documents; drafting of illustrations by Mike Pearson; endless typing of letters by Deborah Blackmon and Mickey Gregory; and photographic assistance by Larry Ferguson. The index was prepared by Jacqueline J. Keller.

# CONTENTS

# Part One

# PHILOSOPHY AND FUNDAMENTAL PRINCIPLES

Everything has a beginning and an end. Our earth began approximately 5 billion years ago when a cloud of interstellar gas known as a *solar nebula* collapsed, forming protostars and planetary systems; life on earth began about 2 billion years later, or 3 billion years ago. Since then, a multitude of different types of organisms have emerged, prospered, and died out, leaving only their fossils to mark their place in earth's history. Several million years ago, on one of the more recent pages in earth history, our ancestors set the stage for the eventual dominance of man. As certainly as our sun will eventually die, man, too, will disappear. The impact of man on earth history may not be significant, but to us living now, our children and theirs, our environment is significant indeed.

Environmental geology is applied geology. Specifically, it is the application of geologic information to solving conflicts, minimizing possible adverse environmental degradation, or maximizing possible advantageous conditions resulting from man's use of the natural and modified environment. This includes evaluation of *natural hazards* such as floods, landslides,

earthquakes, and volcanic activity to minimize loss of human life and property damage; evaluation of the *landscape* for site selection, land-use planning, and *environmental impact* analysis; and evaluation of *earth materials* (such as elements, minerals, rocks, soils, and water) to determine their potential use as resources or waste disposal sites and the effects on human health, and to assess the need for conservation practices. In a broader sense, environmental geology is that branch of earth science that emphasizes the entire spectrum of man's interactions with the physical environment.

*Environment* may be considered as the total set of circumstances that surround an individual or a community. It may be defined to include two parts: first, physical conditions such as air, water, gases, landforms, etc., which affect the growth and development of an individual or a community; and second, social and cultural aspects such as ethics, economics, aesthetics, etc., which affect the behavior of an individual or a community. Therefore, a complete introduction to environmental geology involves the consideration of philosophical and cultural aspects which influence how we perceive and react to our landscape, as well as the physical earth processes, resources, and landforms which may be more readily recognized by the observant earth scientist.

Chapters 1 through 3 provide the philosophical framework for the remainder of the book. Chapters 1 and 2 are designed to integrate the influence of cultural and physical activities of our total environment, and Chapter 3 introduces the physical environment through the geological cycle. The term *cycle* emphasizes that most earth materials, such as air, water, soil, minerals, and rock, although changed physically and chemically and transported from place to place, are constantly being reworked, conserved, and renewed by natural earth processes. Chapter 3 also introduces basic earth science terminology necessary to understand the remainder of the book.

# 1

# CULTURAL BASIS FOR THE ENVIRONMENTAL CRISIS

The cultural aspect of the environmental crisis involves the entire way of life that we have transmitted from one generation to another. Therefore, if we are going to uncover the roots of our present condition, we must look to the past and consider various functional categories and social institutions that have developed. The functional categories of society that are especially significant in environmental studies are ethical, economic, political, aesthetic, and, perhaps, religious. The interaction between individuals and the institutions responsible for maintaining these functions are intimately associated with the way we perceive and respond to our physical environment.

## Environmental Ethics

What started as the "quiet crisis" of the 1960s has evolved into what Stewart Udall, statesman and conservationist, refers to as the "crisis of survival" (1). More important than the certainty of a crisis is whether society believes that there is a crisis. In

other words, is there a new awareness that is destined to change our life-style, morals, ethics, and institutions, or is the environmental revolution just another prestigious fad that interests the intellectual community?

Aldo Leopold, in telling the story of Odysseus, who, upon returning from the war in Troy, hanged a dozen slave women for suspected misbehavior during his absence, emphasizes the lack of ethics regarding property. The hangings involved no question of ownership; the women were property, and the disposal of property was a matter of expediency, much as it is today. Although concepts of right and wrong were present in Greece three thousand years ago, these ethical values did not extend to slaves (2). Since that time, ethical values have been extended to many other areas of human behavior; but, apparently, only within this century has the relation between man and his environment begun to emerge as a relation with moral considerations.

Ecological ethics involve limitations on social, as well as individual, freedom of action in the struggle for existence in our stressed environment (2). A land ethic assumes that man is ethically responsible not only to other individuals and society but also to the total environment, that larger community consisting of plants, animals, soil, atmosphere, etc. The environmental ethic proposed by Leopold affirms the right of all resources, including plants, animals, and earth materials, to continue existence and, at least in certain locations, their continued existence in a natural state. This ethic effectively changes man's role from conqueror of the land to that of citizen and protector of the environment. This obviously requires us to revere and love our land and not, for instance, to allow economics to determine all land use.

There exists a possible dichotomy or source of confusion between an ideal and a realistic land ethic. To give rights to the plants, animals, and landscape might be interpreted as granting to individual plants and animals the fundamental right to live. However, if man is to be part of the environment, he, along with the other members, must extract the energy necessary to survive. Therefore, although the land ethic assigns rights for animals such as deer, cattle, or chickens to survive as a *species,* it does not necessarily assign rights to an *individual* deer, cow, or chicken. The same argument may be given to justify the use of stream gravel for construction material, or to mine and use the other resources necessary for our well-being. However, unique landscapes with high aesthetic value, like endangered species, are in need of complete protection within our ethical framework.

Environmental ethics and moral responsibility are re-restated by Stewart Udall. Each generation has its own rendezvous with the land, for despite our fee titles and claims of ownership, we are all brief tenants on this planet. By choice or by default, we will carve out a land for our heirs. We can misuse the land and diminish the usefulness of resources, or we can create a world in which physical affluence and spiritual affluence go hand in hand (1).

The resounding message is that man is an integral part of the environment. He is no less than any other being, and he has a moral obligation to those beings who will follow. This obligation is to insure that they will also have the opportunity to experience the pleasure of belonging to and cooperating with the entire land community.

# Economic and Political Systems

Arriving in late fall of 1620, after two months on the stormy North Atlantic, 73 men and 29 women from the *Mayflower* confronted what they considered a wild and savage land. The colonists were not equipped with the skills and knowledge necessary to adapt quickly to their new environment. Regardless of these shortcomings and despite their fear of the wilderness, they brought three things which assured their success in the New World. First, they brought a new technology. Reportedly, when the Pilgrims landed, they did not even have a saw, but they did have Iron Age skills necessary to insure relentless subjugating of the land and its earliest inhabitants, the Indians. In the long run, the ax, gun, and wheel asserted their supremacy. Second, the colonists brought with them the blueprints to remake the New World. They knew how to organize work, utilize work animals, and sell their surplus to overseas markets. Third, they brought with them a concept of land ownership completely different from that of the Indians whose bonds to the land were religious and held by kinship and nature rather than exclusive possession. The Indian had a deep affection for the land and had a notion of ownership different from that of the colonist, whose idea of ownership involved an absolute title to land regardless of who worked the land or how far away the owner was. After the Indians were displaced, land use or abuse depended entirely on the attitude of the owner.*

America now, as in its early years, suffers greatly from the Myth of Superabundance. This myth assumes that the land and resources in America are inexhaustible and that, therefore, management of resources is unnecessary. Management of the people and their society, however, had and continues to have the deep roots transposed from the Old World.

Stewart Udall writes that the land myth was instrumental in environmental degradation from the "birth of land policy" in the eighteenth century throughout the "raid on resources" which lasted into the twentieth century. Even young Thomas Jefferson, who in later life was to become aware of the value of conservation, stated that there was such a great deal of farmland that it could be wasted as he pleased. However, the real raid on resources probably began with the mountain men and their trapping of beaver in the 1820s. This was only the beginning and was followed by machines that for the first time were capable of large-scale removal of resources and landscape alteration. These inventions included the sawmills which precipitated the destruction of the American forests, and the "Little Giant" hoze nozzle that could tear up an entire hillside in the search for California gold.

The "Great Giveaway" of land which resulted in the destruction of forests and consequent soil erosion eventually ended, and in 1884 hydraulic mining was outlawed. However, the effects of these repugnant land-use practices can still be viewed today. Similar examples of the raid on resources can be given: the plights of the fur seal, the buffalo, and the passenger pigeon; and the Dust Bowl of the 1930s (1).

---

*Stewart Udall, *The Quiet Crisis,* pp. 25–27.

The seeds of conservation were planted in the latter part of the nineteenth century by men such as Carl Schurz, Secretary of the Interior, and John Wesley Powell, geologist and explorer. Their messages concerning conservation of resources and land-use planning, although largely ignored when first introduced, today stand as landmarks in perceptive and innovative conservation (1).

The historical roots of our landscape heritage, while not a pretty picture, are full of lessons to be learned. For example, we painstakingly learned that our resources are not infinite and that land and water management is necessary for meaningful existence. This conclusion has become even more significant over the years as American society continues to urbanize and consume resources at an ever-increasing rate.

The convergence of available resources with the needs of society, along with an ever-growing production of waste, has produced what is popularly referred to as the *environmental crisis*. This impending crisis in America, according to Lewis W. Moncrief, is a result of individual and institutional inability in our democratic system to organize technology, conservation, urbanization, and the capitalistic mission to the betterment of our landscape (3). He further contends that the present condition is characterized by three features that tend to restrict a quick solution to environmental problems: first, the absence of individual and personal moral direction concerning the way we treat our natural resources; second, the inability of our social institutions to make adjustments to reduce environmental stress; and third, an abiding faith in technology.

Overpopulation, urbanization, and industrialization, combined with little ethical regard for our land and inadequate institutions (or perhaps too many institutions stumbling over one another) to cope with environmental stress, may well be the immediate source of the crisis. The overpopulation, urbanization, and industrial factors, although part of the political and economical systems, currently tend to transcend those systems.

Political and economic theorists are often surprised to learn that disruption of the environment is as serious a problem in the USSR as in the United States. Goldman reports that the Soviets have greatly misused their natural resources. For example, most major Soviet cities have air pollution problems, and water pollution there has resulted in massive fish kills, in turn resulting in an increase in mosquitoes and malaria peril. The oil-covered Iset River was accidentally ignited in 1966, as was the Cuyahoga River in Ohio. Over 65 percent of the factories in Russia discharge their waste without treatment, and 60 percent of the cities and suburbs have no water treatment facilities. Land-use problems in Russia include a system of dams, reservoirs, and canals that have diverted such a large quantity of water that there is serious concern for the future of the Caspian Sea and its famous caviar fisheries. The reservoirs have also increased evaporation, which is disrupting natural moisture patterns and changing rainfall cycles. Furthermore, seepage from unlined canals has caused the water table to rise in normally dry areas, facilitating the deposition of harmful salts in the soil. In addition, the mining of beach deposits for construction material in conjunction with decreased supply of sediment to the beaches (the reservoirs are holding back the natural flow of sediment) has resulted in serious coastal erosion, for without the sand and gravel to impede the impact of waves, the coastline is subject to rapid erosion.

The factors responsible for environmental problems in the USSR, as in America, are population explosion and rapid industrialization. Furthermore, the Russian government, as sole owner of the productive resources, has not been any more successful than other countries in regulating or controlling environmental degradation. In fact, the national commitment to centralized control of industry has given rise to unique environmental problems resulting from uniform regulations for industry regardless of local conditions.

Goldman notes several other disadvantages of an urbanizing, socialized system. First, there are no private interests that can challenge government proposals. Thus, a well-intentioned program leading to possible unanticipated degradation to the environment might be introduced. Such a program would more likely be terminated in a society that allows public criticism. Second, there is environmental disruption due to a lack of private ownership. For example, the removal of gravel and subsequent erosion of the Black Sea coast is a result of the absence of private control. Because no one owns the gravel, it is free to anyone who can carry it away. Consequently, contractors in need of gravel need not worry about infringing on the rights of coastal property owners worried about aesthetic degradation erosion and loss of tourist trade. Third, because the Soviet government is the sole owner of the country's industry, it is generally unable to take the role of an impartial referee between consumer and industry. This condition is not likely to change as long as the USSR, which has only recently become industrialized, stresses rapid growth and production.

On the other hand, Goldman notes some aspects of socialism in the USSR that have by design, or more likely by fortuitous circumstances, resulted in lesser environmental disruption. For example, Russia has de-emphasized the production of consumer goods, resulting in less prolific production of easily disposed of items and less waste material. Furthermore, relatively low labor costs, which are not necessarily a planned characteristic of their system, facilitate trash collection and sewage disposal despite the general lack of a sewer system. This results because the collection of sewage "nite soil" is apparently offset by its value as fertilizer. The central power of the state may also be an advantage in situations where expediency is sought. For example, establishment of national parks may be a relatively quick, inexpensive process there compared to countries with private ownership of property.*

The conclusion from consideration of political systems is that rather than private enterprise, industrialization, urbanization, economic consideration, and lack of a land ethic are primarily responsible for environmental degradation. Therefore, the salvation of the landscape community involves social, economic, and ethical behavior on the part of individuals rather than the political systems as they exist today.

Optimistically, it appears that the emerging environmental ethics inherent in the spirit of individual actions and new legislation will facilitate the types of changes needed. These changes are possible because our democratic system with private ownership of resources and free enterprise has the flexibility necessary to allow meaningful change. However, it is emphasized that the system cannot be

---

*M.I. Goldman, *Environmental Disruption in the Soviet Union*, pp. 63-65.