Environmental Geology and Hydrology in New Mexico

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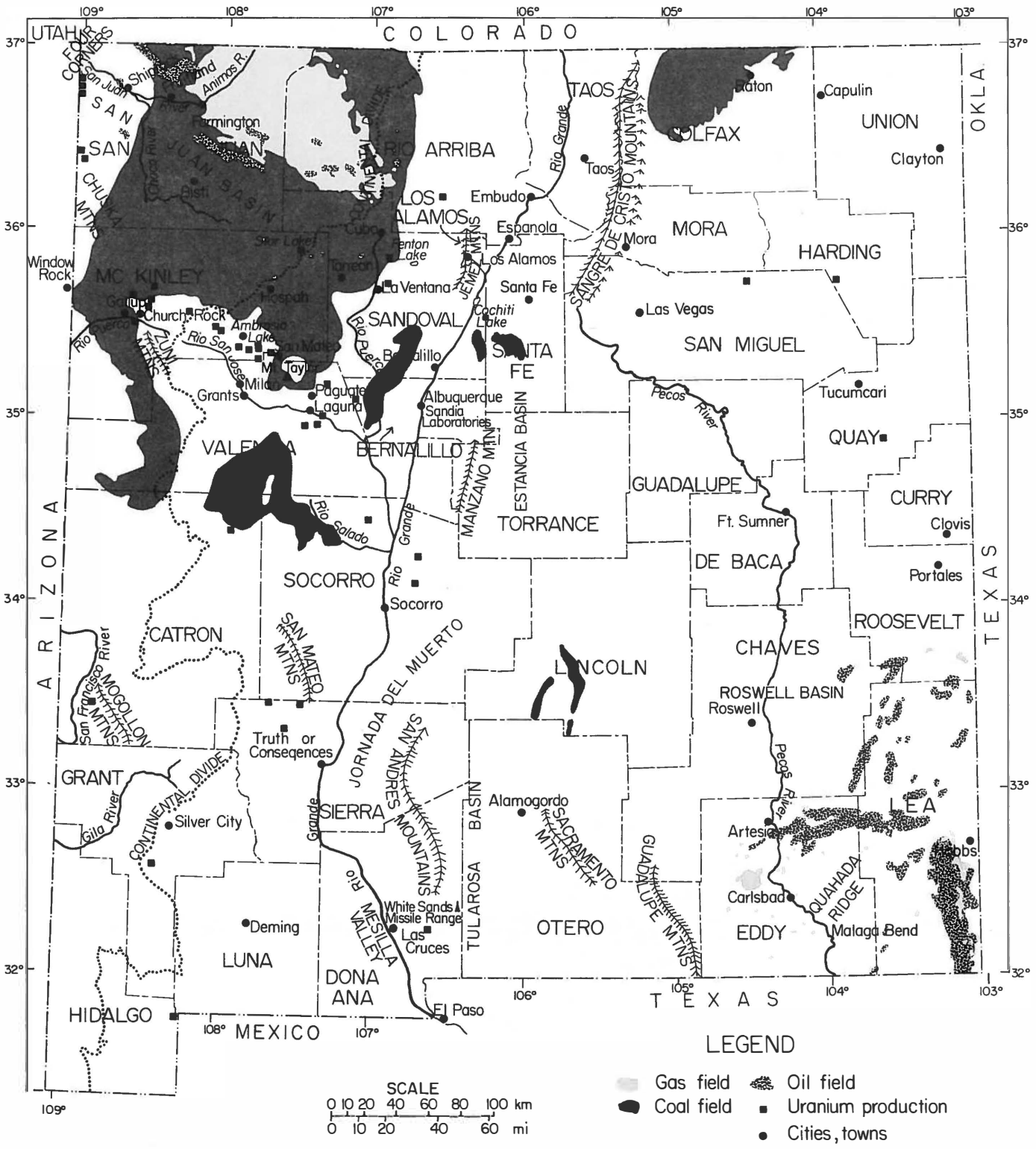

Distribution of energy-related resources in New Mexico, and localities mentioned in text but not shown in illustrations accompanying articles. Data on energy-related resources taken from Arnold, E. C. and Hill, J. M., compilers, 1980, New Mexico's energy resources '79—annual report of Bureau of Geology in the Mining and Minerals Division of New Mexico Energy and Minerals Department: New Mexico Bureau of Mines and Mineral Resources Circular 172, 55 p.

Environmental Geology and Hydrology in New Mexico

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The Rio Puerco and Cabezon Peak as seen in the winter of 1884 from the town of Cabezon, Sandoval County, New Mexico (SE¼ sec. 12, T. 16 N., R. 3 W.). View is to the south. The Rio Puerco flows in a shallow, unincised channel marked by cottonwood trees. Cattle and burros graze in the fields bordering the channel. A high water table is indicated by the presence of the cottonwood trees, and the shallow channel is suitable for the practice of flood-irrigation agriculture. Photograph No. 36, Cabezon Peak, by E. A. Bass, Socorro, New Mexico (Library of Congress, Prints and Photographs Division, Lot No. 3268).

Duplicate of Bass photograph No. 36, taken June 13, 1977 at 1412 hours mountain daylight time by H. E. Malde, U.S. Geological Survey, Denver, Colorado. View is S. 1° E. The Rio Puerco has changed dramatically in the 93 years since the Bass photograph, and, as a consequence, the way of life in the Cabezon area has changed just as dramatically. The Rio Puerco now flows in a deeply incised arroyo 15 meters deep. There has been downcutting of the stream and lowering of the water table, restricting the opportunities for flood irrigation. The fields no longer exist and the town of Cabezon has been abandoned except for occasional use as a movie set. The reasons for the downcutting of the Rio Puerco have long been debated, but whatever the cause, the history of the Rio Puerco illustrates well the fragile nature of the New Mexican landscape (Malde photograph No. 985 in U.S. Geological Survey Photo Library, Denver, Colorado).

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Overviews of Environmental Geology and Hydrology in New Mexico

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FOREWORD

New Mexico encompasses four physiographic provinces with diverse geologic, hydrologic, and vegetative characteristics: rolling grassland plains, elongate desert basins, high semiarid plateaus, and towering forested mountains. Much of this land occurs within zones of transition from one landscape or climatic type to another, creating an especially fragile natural environment. New Mexico is a state with abundant and rich energy and mineral resources including oil, gas, coal, uranium, copper, molybdenum, gypsum, and sand and gravel as well as geothermal, solar, and wind resources. Add to this setting a variety of people with different industrial and agricultural endeavors, cultural backgrounds, and political pursuits, and it is easy to see that New Mexico is a state with an ample share of environmental geologic and hydrologic concerns.

The interactions of humans with the geologic and hydrologic environment has been a fact of life since humans first set foot in what is now New Mexico. These interactions range from the attempt of Indians to halt the fall of Threatening Rock in Chaco Canyon several hundred years ago to the recent attempts of scientists to evaluate the suitability of bedded salt in southeastern New Mexico for the long-term disposal of radioactive wastes. As noted by Hawley and Love in this volume, the hallmark of environmental geology and hydrology is the gathering and presenting of scientific information to the public. The application of geology and hydrology as a means of maximizing advantageous use of the natural environment and minimizing adverse environmental changes requires a scientifically sound data base. W. C. Mendenhall, fifth Director of the U.S. Geological Survey, stated simply "There can be no applied science unless there is science to apply." In order to maintain a proper stewardship of our geologic and hydrologic resources, we must continue in our endeavors to acquire, analyze, and communicate scientific information.

This volume, which includes both regional overviews and detailed case studies, has been prepared for the meeting of the Rocky Mountain Section of the American Association of Petroleum Geologists in Albuquerque, April 13-15, 1981. The theme of this meeting is energy diversity, and in accordance with this theme, a majority of the articles in this volume reflect the diverse environmental concerns associated with energy-resource development in New Mexico. In addition, the volume contains articles dealing with the environmental geologic and hydrologic aspects of hazardous-waste disposal and watershed management. The articles have been contributed by scientists in private industries, consulting firms, universities, national laboratories, and State and Federal agencies. This diversity of contributors and affiliations indicates the broad spectrum of talents and interests that are currently being applied in the search for solutions to the complex environmental geologic and hydrologic problems facing the citizens of New Mexico.

The title of this volume, "Environmental Geology and Hydrology in New Mexico," is not intended to imply an exhaustive review of this topic, but rather is intended to illustrate some of the major environmental problems which face the State of New Mexico. These major problems are summarized in the four parts of this volume. Part 1 provides an overview of the regional geologic, hydrologic, and economic setting of New Mexico; Part 2 includes detailed studies concerning the interactions of humans and the hydrologic environment; Part 3 includes research related to energy-mineral development and the geologic and hydrologic environment; and Part 4 includes detailed studies concerning the geologic and hydrologic environment and the disposal of hazardous waste. We hope this volume will be enlightening and helpful to both the geologist and nongeologist.

We would like to thank H. E. Malde of the U.S. Geological Survey for contributing the photographs for the frontispiece and J. A. Salas for drafting several of the illustrations. A map of New Mexico showing localities mentioned in the articles but not shown in illustrations accompanying the articles can be found inside the front cover. A table of conversion factors is inside the back cover. The cover illustration of Navajo Churchrock near Gallup, New Mexico and the filler illustrations are from publications of the U.S. Geological Survey and the New Mexico State Engineer. Captions for the cover illustrations and filler illustrations are from the original works.

Stephen G. Wells
Wayne Lambert

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OVERVIEW OF GEOLOGY AS RELATED TO ENVIRONMENTAL CONCERNS IN NEW MEXICO

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ABSTRACT

New Mexico faces a special set of environmental problems associated with rich mineral resources, a dry climate, and vast areas of low population. Complex interactions between geology and environmental concerns involve geologic processes that have adverse effects on human activities, and modern society's use of mineral, land, and water resources. Geologic processes include moderate-intensity earthquakes, surface subsidence due to rock dissolution, stream floods, debris flows, and landslides. Geologically related human impacts on the environment include surface and subsurface extraction of economic mineral deposits (primarily energy minerals), ground-water development, construction of dams and power plants, disposal of hazardous wastes, and establishment of large-area reserves for military operations and scientific research.

Geologists have a major role in helping solve environmental problems resulting from effects of geomorphic processes and development of mineral, water, and land resources. Inventories must be made of these processes and resources in order to put complex process-resource-human interactions in proper space and time perspective. Guidelines can then be formulated for mitigation or prevention of geology-related problems. For example, mined lands need to be reclaimed, cities need to be planned, and sites need to be selected for hazardous-waste disposal. Finally, geologists must clearly present available information on relationships between geology and human concerns. The hallmark of environmental geology should be effective communication with nongeologists.

INTRODUCTION

Modern technological society's use of the Earth produces an overwhelming variety of human-environmental interactions. The expanded outline which forms the body of this paper demonstrates that there are few, if any, aspects of geology that are unrelated to "environment" in the broad sense, i.e., "the surrounding conditions, influences, or forces that influence or modify . . . the whole complex of climatic, edaphic, and biotic factors that act upon an organism or ecological community and ultimately determine its form and survival" (Gove, 1971). The phrase "environmental concerns" implies limitations of this broad concept to those aspects of the environment, including geological processes and resources, that are of concern to current and future human affairs.

The impact of geology on human affairs, throughout New Mexico's history, primarily relates to development of mineral resources (Sheffer and Eveleth, 1978; U.S. Geological Survey, 1965; New Mexico State Engineer Office, 1967). In a 20th century context, energy-mineral and water-resources development dominates the environmental scene, as well as the economy, in many areas (Arnold and Hill, 1980; Grant, McLean, Wilson, this volume).

Another important aspect of environmental concerns is that New Mexico's open space has become a major resource in itself because of very dry climate and low population density. Vast areas are reserved for scientific research and technological development, including military weapons testing and civilian research in nuclear energy, space exploration, and radio astronomy. Also, vast areas have been reserved for recreation. In the past 30 years hazardous-waste disposal problems have developed. Long-term activities involve disposal of nuclear waste at Los Alamos (Rogers, 1977) and uranium-mine mill tailings in the San Juan Basin (Gallaher and Goad, Stephens and Siegel, this volume). Recent planning and site-specification studies on radioactive-waste disposal (Office of Nuclear Waste Isolation, 1980) have focused on potential repositories for military and commercial wastes, respectively, in deep-bedded salt deposits (Mercer and Gonzalez, Powers, this volume) and unsaturated materials near the land surface (National Research Council/ National Academy of Sciences, 1976; Winograd, 1974; Herkenhoff, G. and Associates, Inc., Summers, W. K. and Associates, 1977). In the past year there has been much public concern about industrial-waste production and disposal strategies (New Mexico Environmental Improvement Division, 1980). Longmire and others (this volume) discuss criteria for near-surface disposal of solid hazardous wastes; and aspects of liquid-waste (brine) disposal in oil and gas fields are described by Stephens and Siegel (this volume).

AN EXPANDED OUTLINE OF GEOLOGY IN RELATION TO ENVIRONMENTAL CONCERNS

Complex relationships between geology and environmental concerns in New Mexico are divided into three broad topics and many subtopics that are briefly outlined in Table 1. This table serves as an index (with standard alpha-numeric coding) to the expanded outline below. Figure 1 shows locations of physiographic features and towns mentioned in this paper. The major topics include the following:

I. Geological processes, materials and landforms as part of a dynamic earth-surface environment, their complex interactions, and their adverse effects on human affairs (geologic hazards).
II. Geological materials and landforms as resources, and their environmental impact with respect to mineral development, intensive land use, and preservation of scientific, scenic and cultural values.
III. Geological contributions to the inventory, planning, and site-selection process as part of a statewide environmental geology program.

Topics I and II are presented in the context of human affairs versus the environment; whereas, geologists normally view processes (I) and resources (II), respectively, as phenomena for scientific

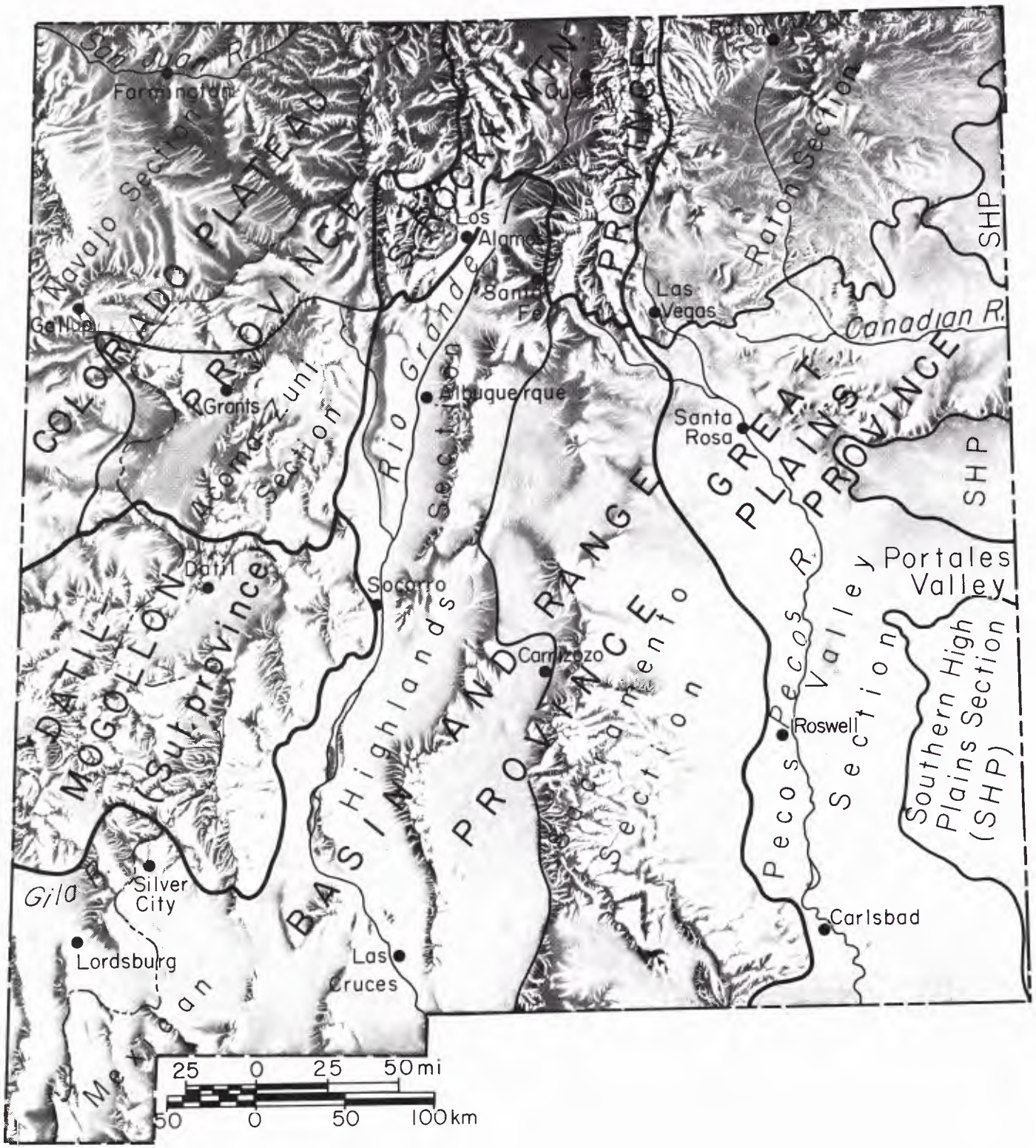

Figure 1. Location of major physiographic features and towns mentioned in the text.