Volume One

ENERGY AND ENVIRONMENTAL CHEMISTRY

Fossil Fuels

Edited by
LAWRENCE H. KEITH

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ACKNOWLEDGMENTS

This is the first of a series of volumes entitled, "Energy and Environmental Chemistry." These volumes are collected papers from distinguished authors on the North American Continent and abroad, and span several national and international meetings beginning with the Second Chemical Congress of the North American Continent in Las Vegas, Nevada (1980).

These symposia were jointly sponsored by the American Chemical Society's Committee on Environmental Improvement and the Division of Environmental Chemistry. However, it was only with the help of the following people that various sessions of these symposia were organized. Without their help and commitment, the symposia, and hence this volume, could never have been accomplished. Special thanks go to:

- José Alberto Celestinos I. and Amanda Cortés-Rubio of the Refinación y Petroquímica Instituto Mexicano del Petróleo, Mexico City, Mexico, for organizing the symposium on "Assessment of the Environmental Impact of Accidental Oil Spills in the Oceans," at the Second Chemical Congress of the North American Continent;

- Dr. Robert Meglen, University of Colorado, Denver, and Dr. Donald W. Denney, Syncrude of Canada, Ltd., Ft. McMurray, Alberta, Canada, for organizing the symposium on "Oil Shale and Tar Sands," at the Second Chemical Congress of the North American Continent;

PREFACE

Energy and Environmental Chemistry—they are inextricably entwined. As we progress toward an increasingly industrialized and energy hungry world the demands of producing more and more energy are going to require greater care if we are to maintain a clean environment. There is no question that we will continue to produce more energy—progress demands it and people demand progress. The only question is how much we will let our continuous quest for energy affect our environment.

Learning about the effects of energy production—directly or indirectly—on the environment is one of the first steps to controlling adverse effects of that production. That's what these volumes are all about. They do not cover it all—do not even come close; the subject area is much too large and complex and we are only in the early stages of learning about the interrelations of energy and environmental chemistry. But it is hoped that the information in these books will bring us one step closer to understanding some of these relationships and hence to ultimately controlling unwanted pollution from energy production.

Lawrence H. Keith

- Dr. Donald D. Rosebrook and Dr. Robert G. Wetherold, Radian Corporation, Austin, Texas, for organizing the symposium on "Fugitive Hydrocarbon Emissions" at the 181st National ACS Meeting, Atlanta, Georgia; and

- Mr. Ronald K. Patterson, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, for organizing the symposium on "Coal Gasification" at the Second Chemical Congress of the North American Continent.

Finally, I wish to express my appreciation to the many authors who, by their hard work, dedication and commitment, provided the main substance of this work—scientific facts and evaluations on newly emerging technologies.

Lawrence H. Keith's current technical interests continue to center around analyses of organic pollutants in the environment, with emphasis on developing new methods or improving on old ones. Techniques for the safe handling of carcinogenic and/or extremely toxic materials are also an important aspect of Dr. Keith's current research efforts.

Dr. Keith was formerly involved with the selection of many of the U.S. Environmental Protection Agency's initial 129 Priority Pollutants, and he also helped to formulate some of the initial methodology for analyzing for these pollutants. He is presently involved in the selection of representative compounds and methodologies for the Appendix C Priority Pollutants and for the synfuel industry.

A member of the American Chemical Society's Division of Environmental Chemistry Executive Committee, Dr. Keith has served as secretary, alternate councilor, program chairman and chairman of the division. He is also a past chairman of the Central Texas Section of the American Chemical Society and past secretary and councilor of the Northeast Georgia Section of the American Chemical Society.

In other professional activities, Dr. Keith served as Vice-Chairman of the Gordon Research Conference on Environmental Sciences: Water, and is currently a delegate of the U.S. National Committee to the International Association of Water Pollution Research. He is also a member of the National Research Council Committee on Military Environmental Research. Dr. Keith edited the two-volume *Advances In the Identification & Analysis of Organic Pollutants In Water*, published by Ann Arbor Science.

He and his wife, Virginia, reside in Austin, Texas.

CONTENTS
VOLUME 1

Part 1: Impact of Tar Sands and Oil Shale

Part 2: Impact of Oil Spills at Sea

CONTENTS
VOLUME 2

Part 1: Point Source Effects

Part 2: Regional Effects

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PART 1

IMPACT OF TAR SANDS AND OIL SHALE

CHAPTER 1

THE ALBERTA OIL SANDS ENVIRONMENTAL RESEARCH PROGRAM

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INTRODUCTION

Energy is of major concern in industrial countries and considerable activity is directed to finding, developing and using every form of energy resource. Canada is no exception, and in this country the Province of Alberta is the major supplier of hydrocarbon energy forms to the entire nation. A considerable fraction of Canada's energy is still imported, however.

Alberta has immense supplies of various forms of energy, in comparison to the total energy resource considered to exist in Canada. Natural gas and conventional oil are the two prime resources. Coal, low in sulfur, is abundant for thermal and metallurgical uses, and its production is going through a period of rapid development. Hydroelectric potential has been developed on a couple of rivers, and is presently being rigorously assessed on two others in the north. By far the largest source of energy exists in the oil sands of Alberta, containing an estimated 960 billion barrels of bitumen. (Bitumen is the unrefined hydrocarbon obtained from the oil sands.) Located in the northern half of the province, there are four distinct deposits considered viable for energy recovery: Athabasca (720 billion), Wabasca (24 billion), Cold Lake (159 billion) and Peace River (64 billion).

Knowledge of the Athabasca deposit goes back two hundred years, when

Alexander Mackenzie reported observations of oil sands along the river. A process to extract bitumen was developed by Dr. K. Clark in 1923, and this was followed by several attempts to produce a commercial product. Today there are two surface mines in operation, Suncor (formerly Great Canadian Oil Sands) and Syncrude, both located in the Athabasca deposit. Numerous pilot plants exist, all of which attempt to extract bitumen from underground by way of in situ processes: for example, by fire-flooding, or the injection of steam and hot water. At present two new plants are being proposed; one will be a surface mine in the Athabasca deposit, the other an in situ operation in the Cold Lake deposit. It should be noted that these deposits have considerably different characteristics. The Athabasca Oil Sands contain a bitumen-clay-sand mixture which requires specific treatment to release the bitumen; the Cold Lake deposit contains a heavy crude which must be thermally induced to achieve reasonable flow for pumping to the surface. As shown in Figure 1, the bituminous sands are under glacial drift, Cretaceous shale and sandstones, and overlay a limestone formation [1]. Oil sands contain 0 to 18% by weight bitumen, averaging about 12%. Overburden depth varies; surface mining can take place where overburden is up to 60 m thick, whereas other methods will be required to extract bitumen with greater overburden depths.

Industrial interests have concentrated on developing technology for energy recovery. In order to stimulate this interest, the Alberta Government established the Alberta Oil Sands Technology and Research Authority (AOSTRA) in 1974. Originally provided with a budget of $100,000,000 for five years, the Authority now estimates it will have approximately $250,000,000 in funds to be spent over several years. The major portion of funds is spent jointly with industry in pilot operations, and other funds are spent on general research.

Environmental issues related to oil sands development became of central interest only in the early 1970s as industrial activity rapidly increased. In 1975, the governments of Canada and Alberta entered into an agreement to jointly sponsor the ten-year Alberta Oil Sands Environmental Research Program (AOSERP). Funding was anticipated to be $40,000,000 during the lifetime of AOSERP.

AOSERP is not the only sponsor of environmental research in the oil sands. Industry has undertaken its own research, primarily restricted to specific leases, and numerous companies have formed the Oil Sands Environmental Study Group (OSESG) to further their general interests.

In this chapter, the work sponsored by AOSERP from 1975 to 1980 is reviewed, and particular attention is paid to baseline studies and research of interest to chemists. Emphasis is on the processes and effects of pollutants on the ecosystem.

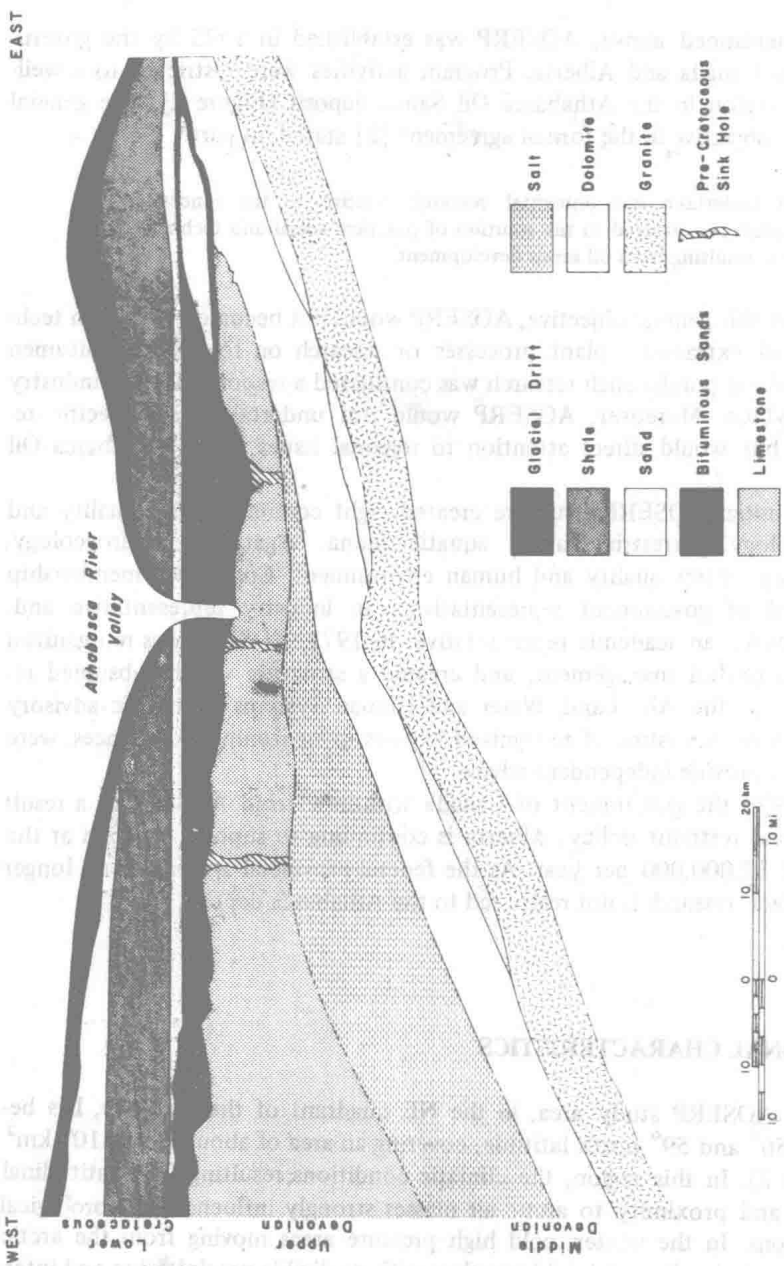

Figure 1. A simplified cross section of the Athabasca Oil Sands deposit [1].