

STATE GEOLOGICAL SURVEY OF KANSAS

FRANKLIN D. MURPHY, M.D.
*Chancellor of the University, and ex officio
Director of the Survey*

FRANK C. FOLEY, PH.D.
State Geologist and Director

BULLETIN 137

SYMPOSIUM ON GEOPHYSICS IN KANSAS

Edited by
WILLIAM W. HAMBLETON



*Printed by authority of the State of Kansas
Distributed from Lawrence*

UNIVERSITY OF KANSAS PUBLICATIONS
JULY 1959

STATE OF KANSAS

GEORGE DOCKING, *Governor*

STATE BOARD OF REGENTS

CLEMENT H. HALL, *Chairman*

WHITLEY AUSTIN
CLAUDE C. BRADNEY
GEORGE B. COLLINS
RAY EVANS

CHARLES V. KINCAID
LEON N. ROULIER
RUSSELL R. RUST
HARRY VALENTINE

MINERAL INDUSTRIES COUNCIL

B. O. WEAVER, *Chairman*
HOWARD CAREY
SIMEON S. CLARKE
LEE H. CORNELL
E. W. HENKLE
GEORGE K. MACKIE, JR.

BRIAN O'BRIAN, *Vice-Chairman*
CHARLES COOK
JOE E. DENHAM
DANE HANSEN
CHARLES F. SPENCER
W. L. STRYKER

STATE GEOLOGICAL SURVEY OF KANSAS

FRANKLIN D. MURPHY, M.D., Chancellor of the University of Kansas, and ex officio Director of the Survey
FRANK C. FOLEY, Ph.D., State Geologist and Director
WILLIAM W. HAMBLETON, Ph.D., Associate State Geologist and Associate Director
RAYMOND C. MOORE, Ph.D., Sc.D., Principal Geologist
JOHN M. JEWETT, Ph.D., Senior Geologist
BETTY ALVORD, Secretary

STRATIGRAPHY, AREAL GEOLOGY, AND PALEONTOLOGY

Daniel F. Merriam, M.S., Geologist
Wallace Lee, E.M., Geologist Emeritus
R. O. Kulstad, M.S., Geologist
William Ives, M.S., Geologist
Stanton M. Ball, M.S., Geologist
Carolyn Ingels, Clerk-Stenographer
Dorothy Wheeler, Clerk-Typist

PETROGRAPHY, MINERALOGY, AND X-RAY

Ada Swineford, Ph.D., Petrographer
Paul C. Franks, M.S., Geologist

OIL AND GAS

Edwin D. Goebel, M.S., Geologist
Paul L. Hilpman, M.S., Geologist
Claude Shenkel, Jr., Ph.D., Geologist*
Wells W. Rood, Scout
Ruby Marcellus, Well Sample Curator
Rhett J. Noever, Clerk-Typist
Carol Laughlin, Clerk-Typist
Sharon Lea Schick, Clerk-Typist
Anna Flory, Laboratory Assistant

INDUSTRIAL MINERALS AND GEOCHEMISTRY

Russell T. Runnels, M.S., Chemist
Walter E. Hill, Jr., A.B., Chemist
Kenneth E. Rose, M.S., Metal. Engr.*
Wanda N. Waugh, Chemist
Karmie Galle, B.S., Chemist
Agnes Bouton, Clerk-Stenographer

MINERAL ECONOMICS AND COAL

Walter H. Schoewe, Ph.D., Geologist

PETROLEUM ENGINEERING

Floyd Preston, Ph.D., Petroleum Engr.**

SOUTHEASTERN KANSAS FIELD OFFICE

Allison L. Hornbaker, M.S., Geologist
Douglas L. Beene, B.S., Geologist
Maxine Stewart, Clerk-Stenographer

PUBLIC INFORMATION AND EDUCATION

Grace Mullenburg, B.S., Pub. Rel. Dir.
Joetta Remby, Clerk-Typist

WICHITA WELL SAMPLE LIBRARY

Della B. Cummings, Curator
Ivetta Maple, Clerk

CERAMICS

Norman Plummer, A.B., Ceramist
Maynard P. Bauleke, Ph.D., Ceramist
William B. Hladik, Ceramist
Clayton Crosier, M.S., Civil Engr.*
Clarence Edmonds, Ceramist

PUBLICATIONS AND RECORDS

Ralph H. King, Ph.D., Geologist, Editor
Margaret Buie, B.A.E., Draftsman
Joan A. Smith, B.F.A., Draftsman
Jack H. Riegler, Draftsman
Judy Crissler, Draftsman
Darlyne Williams, B.F.A., Draftsman
Key Sung Kwak, Draftsman
William Swartz, Draftsman
Lucille Robertson, Clerk-Typist
Lila Watkins, Clerk-Typist

COOPERATIVE DEPARTMENTS WITH UNITED STATES GEOLOGICAL SURVEY

GROUND-WATER RESOURCES

V. C. Fishel, B.S., Engineer in Charge
Charles K. Bayne, A.B., Geologist
Henry V. Beck, Ph.D., Geologist*
Stuart W. Fader, B.S., Engineer
Warren G. Hodson, M.S., Geologist
Charles W. Lane, B.S., Geologist
William N. Lockwood, M.S., Geologist
Leslie E. Mack, M.S., Geologist
Howard G. O'Connor, B.S., Geologist
Don E. Miller, B.S., Geologist
William Gellinger, Core Driller

E. L. Reavis, Core Driller
Nancy L. Chamney, B.F.A., Draftsman
Eleanor Gulley, Stenographer
Lottie I. Rodenhous, Typist

MINERAL FUELS RESOURCES

W. D. Johnson, Jr., B.S., Geologist
W. L. Adkison, B.S., Geologist

TOPOGRAPHIC SURVEY CENTRAL REGION

D. L. Kennedy, Regional Engineer
W. S. Beames, District Engineer

SPECIAL CONSULTANTS: Eugene A. Stephenson, Ph.D., Petroleum Engineering; Robert W. Wilson, Ph.D., Vertebrate Paleontology; A.B. Leonard, Ph.D., Invertebrate Paleontology.

COOPERATING STATE AGENCIES: State Board of Agriculture, Division of Water Resources, Robert Smrha, Chief Engineer; State Board of Health, Division of Sanitation, Dwight Metzler, Chief Engineer and Director, and Willard O. Hilton, Geologist.

*Intermittent employment only.

**On leave.

PREFACE

During recent years, personnel of the Kansas Geological Survey engaged in geophysical studies have become increasingly aware of the paucity of literature concerning geophysical work in Kansas. Decision was made, therefore, to assemble a group of papers dealing with geophysics and geophysical exploration in Kansas for publication as a special volume, to be entitled *Symposium on Geophysics in Kansas*. This volume would have special significance also in commemorating the activities of the International Geophysical Year.

In marked departure from previous publication policy of the Geological Survey, papers were solicited from individuals, industries, and governmental agencies known to have participated in geophysical studies in Kansas. Response to request for papers was heartwarming; thus, this volume is a truly representative collection of papers dealing with all phases of geophysics and geophysical exploration. Some of the papers are provocative and significant in terms of understanding of the earth's crust in Kansas; others are case histories, which will provide a foundation for subsequent exploratory studies; and still others outline the special problems of geophysical exploration and provide some of the answers. All papers contribute to the published literature and serve as a useful guide to future geophysical studies that may enhance our knowledge of the earth's crust or aid our search for fuels and other raw materials beneath the earth's surface.

For many contributors to this Symposium, the experience of writing for publication is new. We sincerely hope that the experience has been pleasant and that the habit of writing has been encouraged; we would hope to see other papers by these same authors in the future. The efforts of all contributors are warmly appreciated.

Regarding the technical aspects of manuscript preparation, the editor wishes to point out that all manuscripts have been shaped to the uniform style of Kansas Geological Survey publications. Effort has been made to seek conformity in stratigraphic and structural nomenclature. The views of the authors, however, are their own and may serve to stimulate others to re-examine old and established concepts.

WILLIAM W. HAMBLETON
Editor

CONTENTS

	PAGE
PREFACE	3
FOREWORD, by Wallace E. Pratt	6
GEOLOGIC FRAMEWORK OF KANSAS—A Review for Geophysicists, by John M. Jewett and Daniel F. Merriam	9
EXPLORATION GEOPHYSICS IN KANSAS, by Daniel F. Merriam and William W. Hambleton	53
THE RELATION OF GRAVITY TO GEOLOGY IN KANSAS, by G. P. Woollard	63
THE GREENLEAF ANOMALY, A SIGNIFICANT GRAVITY FEATURE, by Paul L. Lyons	105
REGIONAL GRAVITY OF KANSAS, by Don W. Jopling and Kendall Cashion	121
TWO AEROMAGNETIC PROFILES ACROSS WESTERN KANSAS, by Elizabeth R. King	135
COMPARISON OF BASEMENT DEPTHS FROM AEROMAGNETICS AND WELLS ALONG THE NORTHERN BORDER OF KANSAS, by W. B. Agocs	143
RELATION OF MAGNETIC AND AEROMAGNETIC PROFILES TO GEOLOGY IN KANSAS, by Daniel F. Merriam and William W. Hambleton	153
AIRBORNE MAGNETOMETER PROFILES, MORRIS AND WABAUNSEE COUNTIES, KANSAS, by W. B. Agocs	175
GEOPHYSICAL INVESTIGATIONS ON PROJECTS OF THE UNITED STATES BUREAU OF RECLAMATION IN KANSAS, by Dart Wantland	181
UTILIZATION OF EARTH-RESISTIVITY MEASUREMENTS BY THE STATE HIGHWAY COMMISSION OF KANSAS, by C. F. Crumpton and W. A. Badgley	199
ELECTRICAL RESISTIVITY STUDIES IN BRINE POLLUTION PROBLEMS, by Ralph E. O'Connor and Charles K. Bayne	209
A RADIOACTIVITY SURVEY OVER ROSE DOME, WOODSON COUNTY, KANSAS, by R. A. Hartenberger	219
TECHNIQUES USED IN INTERPRETING SEISMIC DATA IN KANSAS, by Robert H. Glover	225
THICKNESS AND SALT PERCENTAGE OF THE HUTCHINSON SALT, by Robert O. Kulstad	241
A CASE HISTORY OF THE KOELSCH SOUTHEAST POOL, STAFFORD COUNTY, KANSAS, A STUDY IN MICROSEISMICS, by B. W. Beebe	249
GEOPHYSICAL PROBLEMS ON PRATT ANTICLINE, PRATT COUNTY, KANSAS, by John E. Brewer	275
GEOPHYSICAL CASE HISTORY OF THE ENGEL POOL, by John L. Care, Lee Brooks, and Charles H. Wallace	281

A GEOPHYSICAL CASE HISTORY OF THE LINDSBORG POOL, MCPHERSON COUNTY, KANSAS, by Ralph R. Brewer, Jr.	287
CASE HISTORY OF THE DUNES POOL, PAWNEE COUNTY, KANSAS, by John J. Rupnik	297
HISTORY OF THE WINDOM POOL, MCPHERSON AND RICE COUNTIES, KANSAS, by M. W. Smith	309
GEOPHYSICAL HISTORY OF THE FALL CREEK POOL, SUMNER COUNTY, KANSAS, by B. L. Bass and L. H. Lukert	321
LAW SOUTHEAST POOL—A SUCCESSFUL SEISMIC DISCOVERY IN GRAHAM COUNTY, KANSAS, by Richard L. Winchell	335
A SUCCESSFUL SEISMIC PROGRAM ON THE CENTRAL KANSAS UPLIFT, by Edward A. Koester	351
GEOPHYSICAL INVESTIGATIONS IN THE TRI-STATE ZINC AND LEAD MINING DISTRICT, by William W. Hambleton, Joseph P. Lyden, and Douglas C. Brockie	357

FOREWORD

WALLACE E. PRATT

"The great revolutions in outlook are long in the making, . . . at last they change all our ways of thought."
J. Bronowski. *The Common Sense of Science* (1953).

The achievements of geophysicists have been less conspicuous in Kansas than in some of her sister states. Nevertheless, geophysics has already contributed an imposing array of new knowledge on the structure and composition of that part of the earth's crust which underlies Kansas. With the constant improvement of existing techniques and the prospect of continuing vigorous effort, geophysicists may confidently expect to make even greater future additions to this knowledge.

Although relatively few people other than specialists in the field of geophysics have realized the scope of geophysical exploration in Kansas, the State Geological Survey has kept itself fully informed of the progress of this effort. Moreover, it has been commendably anxious that the economic and scientific importance of this work be generally realized. So informed and so moved, the Survey resolved to take advantage of the widespread interest created by the activities of the International Geophysical Year to publish a description of the methods employed and an analysis of the results obtained by geophysical exploration in Kansas. This project now takes form as a *Symposium on Geophysics in Kansas*.

To appreciate fully the change in "our ways of thought" already wrought by geophysics in Kansas, we must resurrect and ponder the viewpoint that prevailed among geologists in Kansas before geophysics had revealed any of the amazing facts with which it now confronts us. Fifty years ago it was the privilege of this writer to participate as a student assistant in the preparation of Volume IX, University Geological Survey of Kansas (1908), a Special Report on Oil and Gas. Then the pre-geophysical concept of Kansas geology was in its finest flower.

The successive chapters of the text and the illustrations in Vol. IX—the discussion of the stratigraphic sequence and the graphic cross sections of measured outcrops—all testify eloquently to the presence uniformly beneath the surface of Kansas

of an unbroken sequence of very great thickness—several thousands of feet at least—of bedded rocks of marine origin. Yet even before the manuscript for the report was completed, persistent reports came to the office of the State Geologist that granite had been encountered at shallow depths (barely more than 2,000 feet) in different wells currently drilling in Kansas in search for oil.

These reports served only to strengthen the all but sacrosanct belief that only marine sedimentary rocks were to be found, down to profound depths, anywhere in Kansas. The established climate of geologic opinion steadfastly denied the validity of the reports. From several wells samples of cuttings were submitted, consisting of sharp fragments of fresh quartz and pink feldspar. Even this evidence was rejected. The cuttings were identified as sandstone.

This incident reveals how little we had learned of subsurface conditions in Kansas, even years after we had begun to study the logs and examine the drill cuttings of relatively deep exploratory wells. The "Granites of Kansas" were still a live subject of debate and mild controversy a decade after Volume IX was issued. It was not until February 1917 that Ray Moore, who had recently succeeded to the position of State Geologist, could announce to his colleagues, with some degree of finality: "So far as Kansas is concerned we can assert that there is crystalline rock in our back yard".

It is probably true, as the popular view holds, that the bulk of our accumulated knowledge of the earth's crust beneath Kansas has been revealed to us, not by geophysics, but by the wells we have drilled in search for oil. Certainly most of the oil discovered in Kansas so far has been found without recourse to geophysics. But these statements only conceal a more significant truth. Geophysics only came into common use in Kansas in the middle 1930's. By that time Kansas' six major oil fields—the ultimate production of which will exceed 100 million barrels each—had already been discovered. Geophysics could hardly have contributed importantly to these discoveries. It is a very different story with discoveries over the last decade, nearly all of which involved the use of geophysics. Future exploration for oil seems destined to lean even more heavily on geophysics. And if it is true that great volumes of information have come to us from

the records of exploratory wells, it is equally true that much information of more revealing character has been obtained—and could only be obtained—through geophysics.

Without geophysics we would not be able to visualize as clearly and as confidently as we do the general conformation of the major structural lineaments beneath Kansas; the Forest City Basin, the Salina Basin, the Barton Arch, and the Nemaha Tectogene, as examples. Neither would we be able to map with equal precision the minor structural details. A single gravity or seismic profile across the length of Kansas would have revealed these features to us. With such a profile we would have been more comprehensively informed of subsurface structure in Kansas than we actually were after the logs of thousands of exploratory wells had been analysed. Possessing such a profile we could never have fallen into the errors that for so long blinded us and stood in the way of more rapid economic progress.

To the surprise of veteran Kansas geologists of that day, some of the earliest successes in geophysical exploration in Kansas were obtained with the magnetometer. But the largest number of oil field discoveries must be credited to the seismograph, and the seismograph continues to be Kansas' most widely used geophysical technique. Gravity surveys have proved less useful than the seismic method in the past, but with markedly increased proficiency in interpretation, which has come with experience, and with faster, more precise determinations made possible through improved instruments, gravity surveys will undoubtedly prove to be more effective in the future than they have been in the past.

To geophysics is due, in large part, a "revolution in outlook" of geologists in Kansas, which though "long in the making" bids fair at last to "change all our ways of thought".