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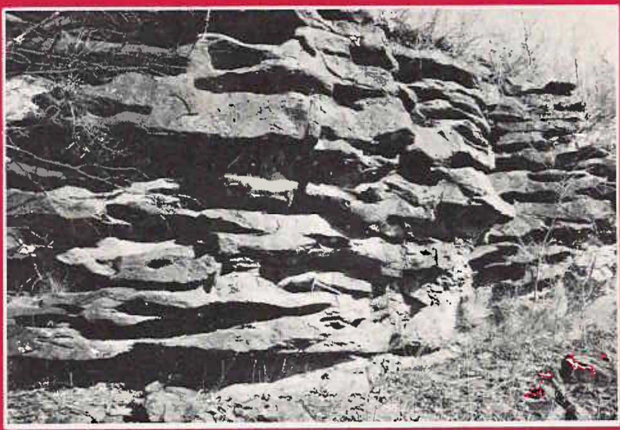
OKLAHOMA GEOLOGICAL SURVEY / THE UNIVERSITY OF OKLAHOMA, NORMAN, OKLAHOMA



OKLAHOMA GEOLOGY NOTES

VOLUME 28, NUMBER 4 AUGUST 1968

Cover Picture

Differential Weathering in Morrowan Sandstones

Rocks of Morrowan (Early Pennsylvanian) age crop out in numerous narrow exposures on the southwest flank of the Ozark Mountains in northeastern Oklahoma. In this area, they rest unconformably on rocks of Mississippian age, most commonly on the Pitkin Formation. They have been subdivided in Arkansas into the Hale (below) and Bloyd Formations, but, because of marked facies changes, these names are not easily applied to many exposures of the Morrowan in northeastern Oklahoma. The greatest variation in lithology and thickness is at the base of the section, apparently as a result of variation in depositional patterns arising from the irregularity of the Mississippian erosional surface.

The cover photograph shows an outcrop where the basal "Hale" sandstones are particularly well developed and form a distinct cliff about 25 feet high. The marked irregularity of the cliff profile is due to differential weathering caused by the variation in the percentage of calcareous cement. This cliff is exposed in a power-line cut on the southeast side of Jackson Mountain, in SE¼ SE¼ sec. 17, T. 15 N., R. 24 E., western Adair County.

—*Patrick K. Sutherland* and *Thomas W. Henry*

OKLAHOMA GEOLOGICAL SURVEY

ANNUAL REPORT

July 1, 1967-June 30, 1968

INTRODUCTION

ESTABLISHMENT AND PURPOSE OF THE SURVEY

Awareness of the potential mineral wealth of the State led the framers of Oklahoma's Constitution to the foresighted act of providing for the establishment of a geological survey. Article V, Section 38, of the State Constitution reads, "The Legislature shall provide for the establishment of a State Geological and Economic Survey." The Oklahoma Geological Survey is thus the only one of the 47 state geological surveys to be established in this manner.

The Survey began operation on July 25, 1908, under an enabling act of the First Legislature that defined its responsibilities:

First. A study of the geological formations of the State, with special reference to its mineral deposits, including coal, oil, gas, asphalt, gypsum, salt, cement, stone, clay, lead, zinc, iron, sand, road-building material, water resources, and all other mineral resources.

Second. The preparation and publication of bulletins and reports, accompanied with necessary illustrations and maps, including both general and detailed descriptions of the geological structure and mineral resources of the State.

Third. The consideration of such other scientific and economic questions as, in the judgment of the commission, shall be deemed of value to the people.

ADMINISTRATIVE STRUCTURE

The Oklahoma Geological Survey is on The University of Oklahoma campus and is under the direction and supervision of the Board of Regents of The University of Oklahoma. The Board, on September 10, 1953, established the following administrative relationships for the Oklahoma Geological Survey:

> In the administration of the Survey, the Director shall bear the same relation to the President of the University as the Deans of the several schools and colleges in the University. The general administrative officers of the University, such as the Vice-Presidents, the Director of Purchasing, the Controller, the Accounting Office, the Bursar, the Physical Plant Department, and other officers of general administration have the same relation to the Survey that they have with other departments, colleges, or divisions of the University.

The Survey staff comprises two categories, professional (permanent and part-time) and technical. The professional category includes those personnel involved in geologic mapping (both surface and subsurface), mineral-resources investigations, and technical information and assistance. The technical category includes those persons involved in the support of the professional staff members. The technical areas include: analytical chemistry, core and sample library, drafting, editing, and secretarial and maintenance services.

SUMMARY AND HIGHLIGHTS OF PROGRAM

During the past fiscal year, the Survey engaged in a variety of activities, ranging from basic geologic investigations to public services. Ten geologic mapping programs and five State and Federal cooperative projects were either continued or initiated. Increased emphasis was placed on mineral-resources investigations and public information and assistance.

Internally, the Survey expanded its technical-service activities with the employment of additional staff and expansion of research facilities. The completion, at a cost of more than $50,000, of the 3rd floor addition to the Survey building provided four additional office-laboratories for professional staff members. Other building modifications included a vacuum-frame room for the drafting section, remodeling of the analytical chemistry laboratory, and reorganization of the secretarial section.

In addition to their professional and public-service activities, many staff members participated in the organization and operation of the 1968 Annual Meetings of the American Association of Petroleum Geologists—Society of Economic Paleontologists and Mineralogists in Oklahoma City. Dr. Ham served as vice-chairman for the SEPM and led a field trip to the Arbuckle Mountains. Dr. Branson served as a field-trip coleader on an excursion to northeastern Oklahoma to examine stratigraphic relations and sedimentary structures of the Bartlesville-Bluejacket Sandstone. Dr. Mankin served as chairman of the SEPM Research Committee and organized the research symposium on *Environmental Aspects of Clay Minerals*. Mr. Roberts prepared and supervised the joint display by the School of Geology and Geophysics and the Oklahoma Geological Survey.

Several Survey staff members presented papers at national meetings (appendix C) and published reports in national journals (appendix B). These activities, together with the countless hours of professional consultation with individuals and companies, provided an active and rewarding year.

FORECAST FOR 1968-1969 FISCAL YEAR

During the coming fiscal year, the Oklahoma Geological Survey will continue to expand its activities in mineral-resources investigations. In addition, an expansion of cooperative projects will enable the Survey to develop a more diversified geological program. A cooperative research program with the U. S. Bureau of Mines will involve examination of selected samples of clays and shales for their potential in the manufacture of vitrified clay pipe, lightweight expanded aggregate, and structural ceramic materials. Additional investigation of gypsum reserves, added copper production potential, and other nonmetallic and metallic resources will be conducted in an effort to provide opportunities for the expansion of mineral-oriented industries in Oklahoma.

Enlargement of the water-resources program with the U. S. Geological Survey and closer coordination of this activity with the Oklahoma Water Resources Board will be undertaken during the coming fiscal year. A thorough knowledge of the water-resource potential is vital to the future industrial growth and development of the State.

Feasibility studies will be made during the coming fiscal year for future comprehensive investigations into urban geology. Such investigations are long overdue, and their need is becoming more critical each day. However, because of the shortage of qualified investigators and financial resources, they cannot be pursued at this time.

Under the wise leadership of its several former directors, the Oklahoma Geological Survey has built a reputation on integrity and response to areas of concern in the earth sciences. This policy of dedication to the wise utilization and controlled development of our natural resources will continue to be the central theme of this organization.

Program During Fiscal 1967-1968

BASIC GEOLOGIC MAPPING

A thorough evaluation and subsequent utilization of the mineral resources of the State cannot be accomplished without a continuing and vigorous basic mapping program. During the fiscal year, nine surface and one subsurface mapping projects were actively conducted. Five involved the Survey staff and five were under the direction of part-time investigators. The projects are in all parts of the State (fig. 1) and involve stratigraphic units ranging from Ordovician to Holocene in age. When completed, each map will be accompanied by a detailed description of the geology and mineral resources of the area covered, and it is anticipated that all will be published as bulletins of the Oklahoma Geological Survey.

Project priorities are governed primarily by the potential yield of geologic information needed for further investigation and development of the mineral resources of an area. Among the projects listed below, for example, those concerning the Blaine Formation, the evaporites in Cimarron and Texas Counties, and the Antlers Sand in Choctaw County are worthy of note. The Blaine Formation contains huge quantities of gypsum that should prove to be of great economic importance as the development of the Midcontinent and the Southwest progresses. Also, the underlying Flowerpot Shale may contain additional reserves of copper, a possibility that cannot be confirmed without prior detailed surface mapping. The salt deposits underlying Cimarron and Texas Counties represent both a potential mineral resource and a water-pollution hazard; knowledge of the exact nature and distribution of these subsurface deposits will enable future investigators to evaluate both aspects. The Antlers Sand is a potentially significant ground-water

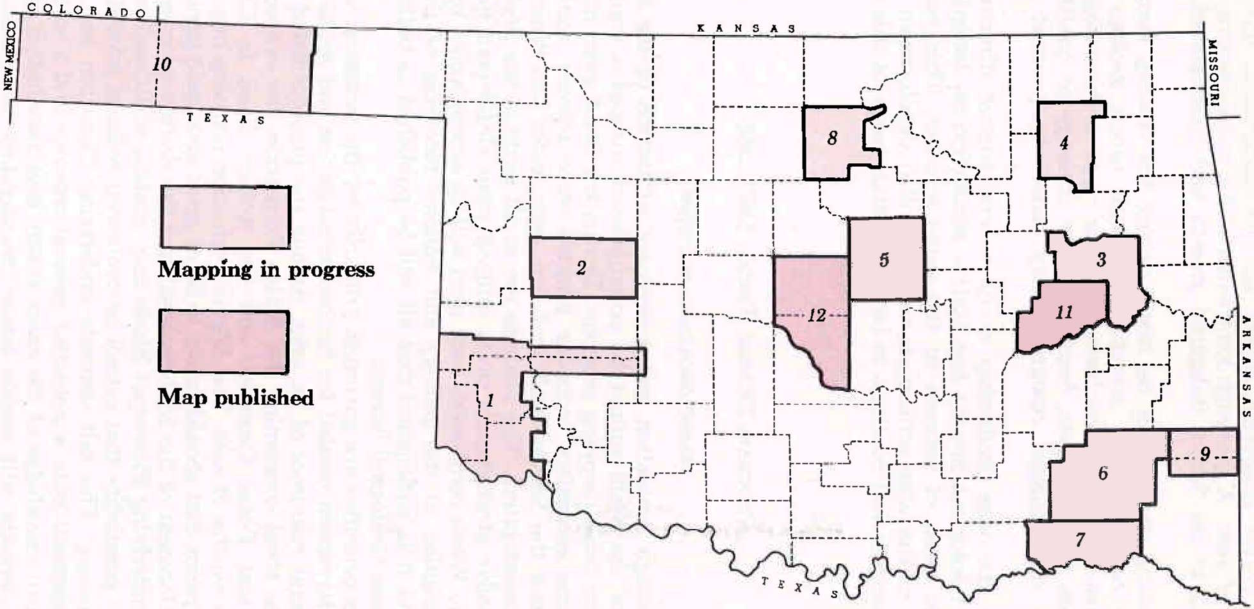


Figure 1. Geologic mapping in Oklahoma, 1967-1968 fiscal year.

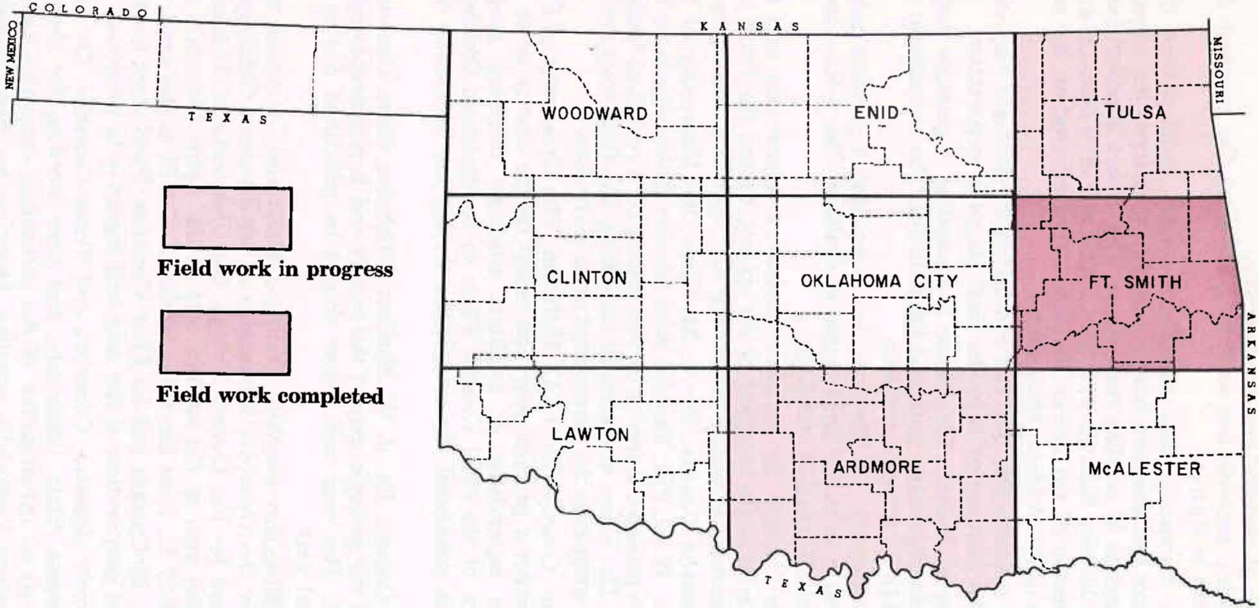


Figure 2. Areas covered by the Hydrologic Atlas series.

reservoir and may contain buff-burning clay, a mineral commodity for which there is high demand and short supply.

The mapping projects are summarized below; the numbers indicate areas shown in figure 1.

1. *Blaine Formation and associated strata, southwestern Oklahoma.* Drs. Ham and Johnson have essentially completed the mapping, and the manuscript is nearing completion. The report is scheduled for publication as Survey Bulletin 110. The report will be a detailed stratigraphic description of the Lower Permian strata exposed on the north and west sides of the Wichita Mountains.

2. *Custer County.* Dr. Fay has completed the geologic map of the county, and the manuscript is in the final stages of preparation.

3. *Muskogee County.* Mr. Oakes is compiling a geologic map of the county from previously gathered information. The manuscript map is approximately 75 percent complete.

4. *Rogers County.* Dr. Branson has completed a geologic map of the county, and it is in the final stages of drafting. The written report is approximately 80 percent complete.

5. *Lincoln County.* Dr. Branson undertook supervision and field checking of the geologic mapping of the county during the fiscal year. This project should be completed during the 1968-1969 fiscal year.

6. *Pushmataha County.* Dr. L. M. Cline, the University of Wisconsin, and Dr. W. D. Pitt, Eastern New Mexico University, have been involved in the geologic mapping of this county on a part-time basis for several years. Dr. Cline is currently compiling the final map and expects to begin preparing the manuscript at an early date.

7. *Choctaw County.* Dr. G. G. Huffman, The University of Oklahoma, is preparing a geologic map and report on the county as an outgrowth of his supervision of graduate students' mapping projects along the edge of the Gulf Coastal Plain in southeastern Oklahoma. This project is scheduled for completion during the 1968-1969 fiscal year.

8. *Noble County.* Dr. J. W. Shelton, Oklahoma State University, has completed the geologic map of the county and is now preparing the written report. The map and report should be published during the 1968-1969 fiscal year.

9. *Lynn Mountain syncline, Ouachita Mountains.* A special mapping project in the Ouachita Mountains of southeastern Oklahoma is being completed by Dr. Garrett Briggs, the University of Tennessee. Specifically, the area is the eastern end of the Lynn Mountain syncline in Rs. 23-27 E., from the north border of T. 2 N. to the south border of T. 1 S., McCurtain and Le Flore Counties. Field work has been completed, and preparation of the map and report is in progress.

10. *Evaporite deposits, Cimarron and Texas Counties.* Dr. D. L. Vosburg, Arkansas State University, has been working for the past two summers on an investigation of the subsurface evaporite deposits of the two western Panhandle counties. Mapping has been completed and the manuscript is being written, with publication scheduled for the 1968-1969 fiscal year.

Because of the overlapping of interests and functions among various Federal and State agencies, much of the activity of the Oklahoma Geological Survey is devoted to cooperative projects that eliminate duplication of effort and enable more efficient utilization of professional skills and available funds. Such cooperation is achieved through formally defined projects and through informal consultation and assistance. During the fiscal year, the Survey participated in five cooperative projects with three Federal and two State agencies. The Survey also cooperated informally with many other agencies.

Water Resources Division, U. S. Geological Survey. A significant area of cooperation is the annual water-resources-investigation program, carried out with the Water Resources Division of the U. S. Geological Survey on a matching-fund basis. The most recent product of this cooperative effort is the publication by the Oklahoma Survey of the report of ground-water resources of Cleveland and Oklahoma Counties.

Because of the ever-increasing need for basic hydrologic data for economic planning and development, the current objective of the program is to make a water-resources inventory of the State. The results of this inventory will be published by the Oklahoma Survey as a series of nine Hydrologic Atlases (fig. 2), each comprising four sheets. Three of the sheets will be maps at a scale of 1:250,000, showing the geology, availability of ground water, and chemical quality of ground water for the area covered by each atlas; the fourth sheet will display precipitation and surface-water data. The nine atlases will cover all of the State exclusive of the Panhandle, which is being investigated as a cooperative project of the Oklahoma Water Resources Board and the U. S. Geological Survey. Field work has been completed on the Fort Smith quadrangle, intended for publication within the 1968-1969 fiscal year. Field work is progressing on the Tulsa and Ardmore sheets, with the expectation that these investigations will be completed within the next 15 months.

These atlases should provide an accurate assessment of the water resources of the State and thus enable municipal, agricultural, and industrial planners to utilize these resources more effectively. They will also provide a much needed basis for detailed investigations of special hydrologic problems.

Oklahoma Water Resources Board. A similar, but differently oriented, program is being conducted in cooperation with the Oklahoma Water Resources Board. The Board is preparing a series of publications designed to furnish information on the total economic and natural-resource environment of each of the drainage basins of the State, and the Survey is providing the geologic and mineral-resources information for the series. The geology and ground-water sections of these publications are intended as interim appraisals to be used until more comprehensive analyses become available through other sources.

U. S. Bureau of Mines. Because of the vital importance of such information, the Oklahoma Geological Survey participates in a cooperative program with the U. S. Bureau of Mines for the compilation of mineral statistics. These statistics are needed in order to forecast mineral development, judiciously plan mineral investigations, and promote the industrial development of the State. For example, the gross mineral production of the State in calendar 1968 was $1.02 billion. Of this amount, approximately 95 percent came from oil, gas, and petroleum products. However, examination of the statistics reveals that the nonmetallic and metallic minerals, which constitute the remaining 5 percent, are showing a substantial and significant increase in dollar value. Current exploration and development activities will expand the contribution of these mineral commodities to the income of the State.

Oklahoma Economic Development Foundation. The industrial expansion of the State is enhanced by the wide variety of natural resources available. To aid those agencies that are promoting such expansion, the Survey cooperated with the Oklahoma Economic Development Foundation in the preparation of a directory of mineral producers of the State. The directory, which will be revised annually, lists all nonmetallic and metallic mineral producers by commodity and geographic location.

U. S. Bureau of Public Roads. The immediate economic benefit of the highway-building program in the State is accompanied by an indirect benefit that can be of equal long-range value. Excavations for Interstate Highway 35 through the Arbuckle Mountains make available to geologists information that would otherwise be impossible or prohibitively expensive to obtain. To take full advantage of this opportunity, the Survey is engaged in a two-year program with the U. S. Bureau of Public Roads to make a comprehensive geologic and paleontologic analysis of the rocks exposed along the right-of-way. During the first year of the program, a large quantity of lithologic and paleontologic material has been collected. This material will undoubtedly yield biostratigraphic and lithostratigraphic information of incalculable value and help solve some of the more complex problems of Oklahoma geology.

Informal Cooperation. The Survey cooperates with the Oklahoma State Department of Highways by providing geologic information for road construction and maintenance. The U. S. Department of Agriculture receives geologic information from the Survey for its soils-mapping program. The Survey assists the Topographic Branch of the U. S. Geological Survey by providing information for and review of new topographic maps of the State. Among the numerous other State and Federal agencies that use the information and skills available at the Oklahoma Geological Survey are the U. S. Bureau of Reclamation and the U. S. Army Corps of Engineers.

MINERAL-RESOURCES INVESTIGATIONS

More than sixty years ago, Dr. Charles N. Gould, the first state geologist of Oklahoma, emphasized the vast undeveloped mineral resources of the State. The diversity of these resources should be a significant factor in the industrial expansion of the State. Yet, despite the extensive development of oil and gas resources, few of the nonmetallic and metallic deposits have been adequately investigated or exploited. For this reason, an increasing proportion of the Survey's budget is being given to the investigation of these fallow natural resources.

In recent years, members of the Survey staff have helped develop new mineral industries or expand existing ones. Notable examples of this work are the efforts by Drs. Ham and Johnson in the development of copper mining in southwestern Oklahoma; by Dr. Kerns and others in the more effective utilization of ceramic raw materials; and by Drs. Branson, Wilson, and others in providing stratigraphic information needed for the current expansion of the coal industry.

Several mineral-resources projects were initiated during the fiscal year and more are planned for the 1968-1969 fiscal year.

PROFESSIONAL INFORMATION AND CONSULTATION

Most staff members of the Oklahoma Geological Survey devote a large portion of their time to providing information to and consulting with individuals and companies. Such information ranges from data on drilling activities in the Anadarko basin to opinions about the possibility of rare-earth elements in Oklahoma. All open-file information and all information collected in the public domain by staff members of the Survey are readily and freely provided upon request. All conversations are given thorough consideration and are deemed confidential, unless declared otherwise by the party involved. It is through this exchange of information that the Survey is able to keep abreast of the varied developments taking place in the mineral industry of the State.

The current policy of the Survey is that staff members may not engage in private consulting within the State of Oklahoma. They may engage in consulting activities outside the State, providing (1) they receive prior approval from the director of the Survey and (2) such consultation is done on leave without pay.

PUBLIC INFORMATION AND ASSISTANCE

As a public agency, the ultimate obligation of the Oklahoma Geological Survey is to the people of the State. Although this obligation is fulfilled primarily in an indirect manner through the other activities described in this report, the Survey does offer a variety of services directly to the general public. The Survey provides, upon request, rock, mineral, and fossil specimens to public-school children; more than 500 such specimens were distributed during the fiscal year. Field trips are conducted for public-school and civic groups by members of the Survey staff. During the past spring, 830 students from junior high schools in Oklahoma City, Edmond, Midwest City, and Chickasha were taken on one-day field trips to the Arbuckle and Wichita Mountains. Throughout the year staff members give public lectures to civic and school groups in all parts of the State. Innumerable requests by land owners or lessees for specific information concerning the geology of their property are answered each year. Of equal importance is the assistance the Survey gives to out-of-state visitors who inquire about scenic and geologic areas of interest.

CORE AND SAMPLE LIBRARY

The Oklahoma Geological Survey, jointly with the School of Geology and Geophysics of The University of Oklahoma, maintains a permanent core and sample library on the South Campus. The library is under the supervision of Mr. Roberts and is maintained by two full-time Survey staff members assisted by part-time employees provided by the school.

During the fiscal year, several oil companies contributed cores from more than 100 wells and donated approximately 14,000 boxes of samples. The library now contains more than 75,000 boxes of samples and 25,000 boxes of cores. The cores are from 920 wells, representing approximately 75,500 feet of hole. *Core Catalog 2* was issued in February 1968.

Because of the importance of the library, the Survey is preparing a proposal for the construction of a new facility that will house not only the present collection and its anticipated additions but also the electric logs, scout tickets, and other data now in the collection of the Oil Information Center on the North Campus. The incorporation of these two activities will bring together under one roof the most comprehensive documentation of subsurface geologic information available for the State.

BASIC RESEARCH

The eventual applications of basic research are rarely predictable, but the benefits of such work are so obvious that few organizations involved in the practical problems of a modern economy can ignore research without impairing their effectiveness. For this reason, the Survey maintains a small but active research program that involves most professional staff members for a portion of their time. The information thus acquired can prove invaluable in helping the Survey make significant contributions to the future development of the State's mineral resources.

One example of such an outcome is the work of Dr. Amsden, who has spent several years on a biostratigraphic and lithostratigraphic study of the Devonian and Silurian rocks exposed in the Arbuckle Mountains and east-central Oklahoma. His intimate knowledge of these rocks enabled him to compile a map (Survey Map GM-14) showing their stratigraphic subdivision and distribution in the subsurface. His map differs markedly from earlier interpretations, which were based primarily upon electric-log data. Dr. Amsden's interpretation is based upon application of his surface studies to a detailed examination of cores, most of which are stored in the Core and Sample Library. In view of the exploration activity current in the Anadarko basin, the publication of his map is most timely.

Publications Issued

The information obtained from detailed geologic investigations is of little value unless it is made easily available to those best qualified to apply it to mineral-resource problems of the State. The dissemination of such information is accomplished in many ways, but the most fruitful is the publication of Survey reports and maps that can be made available to the public at reasonable cost and can be referred to in libraries throughout the world. An example of the value of such documents is the impetus given to the Oklahoma coal industry by the recent decision of several Japanese firms to purchase coal from the State. Their interest in Oklahoma coal arose from reviews of the geologic reports of both the United States and Oklahoma Geological Surveys. Some of these reports are old and, consequently, outdated. Nevertheless, the information they contain was sufficient to stimulate further investigation into the possibilities of exporting coal from Oklahoma to Japan.

During the fiscal year, the Survey published eight documents and nine issues of *Oklahoma Geology Notes.* The documents comprise two bulletins, two circulars, two maps, and two miscellaneous items (appendix A). In addition, Maps GM-10 through GM-13, which constitute the general series *Pipelines and Oil and Gas Fields of Oklahoma, 1965,* were reprinted because the original edition was depleted. Educational Series Map 3, *Mineral Map of Oklahoma,* was also reprinted because of short supply.

The new publications issued are listed in appendix A. The circulars and bulletins represent approximately 800 manuscript pages and include colored geologic maps of McIntosh (area 11, fig. 1) and Oklahoma and Cleveland Counties (area 12, fig. 1). The subjects covered are trilobites of the Henryhouse Formation; Permian vertebrates; geology, mineral resources, and petroleum in McIntosh County; and ground-water resources in Oklahoma and Cleveland Counties.

Circular 71, which details the ground-water resources of the Oklahoma City metropolitan area (Oklahoma and Cleveland Counties), and Map GM-14, which shows the distribution and subdivision of the Hunton Group throughout most of the State, are particularly pertinent at this time.

In addition to issuing its own publications, the Survey cooperates informally in the publication of the Memoir series of the Paleontological Society, under the editorship of Dr. P. K. Sutherland of The University of Oklahoma. The editorial staff assisted Dr. Sutherland in the preparation of Memoirs 1 and 2 during the fiscal year. Memoir 1, *Articulate brachiopods of the St. Clair Limestone (Silurian), Arkansas, and the Clarita Formation (Silurian), Oklahoma,* was written by Dr. Amsden and was published in July 1968.

As part of its contribution to the 1968 annual meetings of the American Association of Petroleum Geologists and the Society of Economic Paleontologists and Mineralogists, the Survey produced a limited edition of a guidebook for a postconvention field trip to the Arbuckle Mountains. The book, *Regional Geology of the Arbuckle Mountains,* was written by Dr. Ham and will be published by the Survey as Guide Book XVII within the fiscal year.

Charles J. Mankin

Charles J. Mankin, Director
July 19, 1968

APPENDIX A

List of Survey Publications Issued, 1967-1968 Fiscal Year

Bulletin 111.—*Geology and petroleum of McIntosh County, Oklahoma;* Part 1, Geology and mineral resources of McIntosh County, by Malcolm C. Oakes and others; Part II, Petroleum geology of McIntosh County, by Terry Koontz. 88 pages, 13 figures, 4 plates (including geologic map). Issued July 20, 1967.

Bulletin 115.—*Trilobites of the Henryhouse Formation (Silurian) in Oklahoma,* by K. S. W. Campbell. 68 pages, 7 text-figures, 19 plates. Issued November 16, 1967.

Circular 71.—*Ground-water resources in Cleveland and Oklahoma Counties, Oklahoma,* by P. R. Wood and L. C. Burton. 75 pages, 8 figures, 2 plates (including geologic map). Issued April 8, 1968.

Circular 74.—*Early Permian vertebrates of Oklahoma,* by Everett C. Olson. 111 pages, 12 figures, 3 plates. Issued December 29, 1967.

Map GM-14.—*Geologic maps and stratigraphic cross sections of Silurian strata and Lower Devonian formations in Oklahoma,* by Thomas W. Amsden and T. L. Rowland. Scales: one map at 1:750,000 and six maps at 1 inch = 64 miles, all on one sheet. Issued November 14, 1967.

Index Map.—*Index to geologic mapping in Oklahoma—Supplement 2,* by Carl C. Branson, Louise Jordan, and John F. Roberts. Two index maps with bibliographic keys: surface mapping, 1901-1966, and subsurface and geophysical mapping, 1964-1966. Issued November 8, 1967.

Directory.—*Mineral producers in Oklahoma, 1967.* Prepared by the Oklahoma Geological Survey for the Center for Economic Development—State of Oklahoma and the Oklahoma Economic Development Foundation. 42 pages (multilith). Issued November 1, 1967.

Catalog.—*Core catalog 2.* Complete list of cores acquired by the University of Oklahoma Core and Sample Library through February 1968. 29 pages (multilith).

Oklahoma Geology Notes. Nine issues (six monthly, July-December 1967; three bimonthly, February, April, June 1968) containing 244 pages.

APPENDIX B

Publications by Survey Staff, 1967-1968 Fiscal Year

THOMAS W. AMSDEN

Silurian and Devonian strata in Oklahoma: Tulsa Geol. Soc., Digest, vol. 35, p. 25-34.

Conchidium and its separation from the subfamily Pentamerinae: Jour. Paleontology, vol. 41, p. 861-867 (with A. J. Boucot and J. G. Johnson).

Geologic maps and stratigraphic cross sections of Silurian strata and Lower Devonian formations in Oklahoma: Okla. Geol. Survey, Map GM-14 (with T. L. Rowland).

Résumé of Silurian and Devonian strata in the subsurface of Oklahoma: Tulsa Geol. Soc., Digest, vol. 35, p. 22-24 (with T. L. Rowland).

Lower Devonian limestone of post-Hunton age, Turkey Creek inlier, Marshall County, south-central Oklahoma: Amer. Assoc. Petroleum Geologists, Bull., vol. 52, p. 162-166 (with Gilbert Klapper and A. R. Ormiston).

Devonian of the southern Midcontinent area, United States, *in* International symposium on the Devonian System, vol. 1: Calgary, Alberta Soc. Petroleum Geologists, p. 913-932 (with W. M. Caplan, P. L. Hilpman, E. H. McGlasson, T. L. Rowland, and O. A. Wise, Jr.).

Silurian-Devonian relationship in Oklahoma, *in* International symposium on the Devonian System, vol. 2: Calgary, Alberta Soc. Petroleum Geologists, p. 949-959 (with T. L. Rowland).

CARL C. BRANSON

Surface mapping, 1901-1966, *Map I-B of* Index to geologic mapping in Oklahoma—Supplement 2: Okla. Geol. Survey.

Progress in topographic mapping in Oklahoma: Okla. Geology Notes, vol. 27, p. 131-134.

Trace elements in Oklahoma coals [review]: Okla. Geology Notes, vol. 27, p. 150.

Protest against names for trace fossils: Okla. Geology Notes, vol. 27, p. 151.

Geologic publications by Oklahoma organizations: Okla. Geology Notes, vol. 27, p. 195-200.

Contribution of S. W. Lowman to Oklahoma geology: Okla. Geology Notes, vol. 28, p. 32.

Everett Carpenter, 1884-1968 [memorial]: Okla. Geology Notes, vol. 28, p. 110-111.

New topographic maps in Oklahoma: Okla. Geology Notes, vol. 28, p. 12-13.

The Cherokee Group, *in* Geology of the Bluejacket-Bartlesville Sandstone, Oklahoma: Oklahoma City Geol. Soc., Guidebook (AAPG-SEPM Ann. Mtg.), p. 26-31.

Road log—Bluejacket-Bartlesville field trip, *in* Geology of the Bluejacket-Bartlesville Sandstone, Oklahoma: Oklahoma City Geol. Soc., Guidebook (AAPG-SEPM Mtg.), p. 4-25 (with G. S. Visher and R. M. Berry).

ROBERT O. FAY

Geology of region II, *in* Appraisal of the water and related land resources of Oklahoma—Region II, 1968: Okla. Water Resources Board, Pub. 19, p. 16-19.

Edrioblastoids, *in* Echinodermata 1, *pt. S of* Treatise on invertebrate paleontology: New York, Geol. Soc. America and Univ. Kansas Press, vol. 1, p. 289-292.

Parablastoids, *in* Echinodermata 1, *pt. S of* Treatise on invertebrate paleontology: New York, Geol. Soc. America and Univ. Kansas Press, vol. 1, p. 293-296.

Blastoids, *in* Echinodermata 1, *pt. S of* Treatise on invertebrate paleontology: New York, Geol. Soc. America and Univ. Kansas Press, vol. 2, p. 298-445 (with H. H. Beaver, D. B. Macurda, Jr., R. C. Moore, and Johannes Wanner).

WILLIAM E. HAM

Paleozoic epeirogeny and orogeny in the central United States: Amer. Jour. Science, vol. 265, p. 332-407 (with J. L. Wilson).

The mineral industry of Oklahoma, *in* Minerals yearbook 1965, vol. 3, Area reports: Domestic: U. S. Bur. Mines, p. 641-664 (with R. B. McDougal).

Pulchrilamina, a new mound-building organism from Lower Ordovician rocks of West Texas and southern Oklahoma: Jour. Paleontology, vol. 41, 981-987 (with D. F. Toomey).

CHARLES J. MANKIN

Structural charge site influence on the interlayer hydration of expandable three-sheet clay minerals: Clays and Clay Minerals, vol. 16, p. 73-81 (with R. L. Kerns, Jr.).

MALCOLM C. OAKES

Geology and mineral resources of McIntosh County, *pt. I of* Geology and petroleum of McIntosh County: Okla. Geol. Survey, Bull. 111, p. 5-49, 68-85.

JOHN F. ROBERTS

Statistics of Oklahoma's petroleum industry, 1966: Okla. Geology Notes, vol. 27, p. 123-130.

Subsurface mapping, 1964-1966, *map VII of* Index to geologic mapping in Oklahoma—Supplement 2: Okla. Geol. Survey.

PATRICIA W. WOOD

Bibliography and index of Oklahoma geology, 1967: Okla. Geology Notes, vol. 28, p. 39-60.

APPENDIX C

Papers Presented by Survey Staff at National and International Meetings, 1967-1968 Fiscal Year

Clay Minerals Society, Annual Meeting (16th Clay Minerals Conference) Denver, Colorado, August 28-31, 1967

CHARLES J. MANKIN

Structural charge site influence on the interlayer hydration of expandable three-layer clay minerals (with R. L. Kerns, Jr.).

Alberta Society of Petroleum Geologists, International Symposium on the Devonian System
Calgary, Alberta, Canada, September 6-8, 1967

THOMAS W. AMSDEN

Devonian strata in the southern Midcontinent area, United States (with W. M. Caplan, P. L. Hilpman, E. H. McGlasson, T. L. Rowland, and O. A. Wise, Jr.).

Silurian-Devonian relationship in Oklahoma (with T. L. Rowland).

Geological Society of America, South-Central Section Annual Meeting Dallas, Texas, March 29-31, 1968

CARL C. BRANSON

Atoka Series of the Oklahoma region.

L. R. WILSON

Palynological evidence for the age of the Bostwick Member of the Dornick Hills Group (Pennsylvanian) of Oklahoma (with M. A. Rashid).

American Association of Petroleum Geologists—Society of Economic Paleontologists and Mineralogists, Annual Meeting Oklahoma City, Oklahoma, April 22-25, 1968

THOMAS W. AMSDEN

Lower Devonian brachiopod faunas in Oklahoma.

L. R. WILSON

Palynological stratigraphy and succession of Oklahoma Pennsylvanian coal seams.

APPENDIX D

Survey Staff, 1967-1968 Fiscal Year

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[1]Appointed June 1968.
[2]Resigned May 1968.
[3]Resigned October 1967.
[4]Part time.

Statistics of Oklahoma's Petroleum Industry, 1967

John F. Roberts

Exploratory drilling during 1967 declined as did most activity in the petroleum industry except production. Sixty-six counties were explored for new reservoirs (fig. 1). The state-wide success ratio was 23 percent. The northwestern portion of the State experienced the most extensive activity as the search continued for discoveries on the north flank of and down into the Anadarko basin; the success ratio, as in 1966, was 40 percent. The most significant discoveries were in carbonate reservoirs of Mississippian, Hunton, and Viola units. New sandstone reserves were found in numerous Pennsylvanian and Ordovician formations.

The first Ordovician production in the Panhandle was established in Beaver County, sec. 26, T. 4 N., R. 20 ECM, in James F. Smith's 1 Pyle "J," which produced gas from the Viola at the rate of 9.172 million cubic feet per day.

A new depth record for production was set by the Chevron Oil Company in its 1 R. S. U., sec. 8, T. 3 N., R. 7 W., Grady County. The well had a calculated open-flow potential of 7.8 million cubic feet of gas

Table I.—Giant Oil Fields of Oklahoma, 1967

Field	1967 Production (1,000 bbls)	Cumulative Production (1,000 bbls)	Estimated Reserves (1,000 bbls)	Number of Wells
Allen	2,773	102,187	17,813	1,493
Avant	194	105,372	1,629	581
Bowlegs	847	147,538	12,462	170
Burbank	8,795	466,676	33,324	1,295
Cement	2,609	123,274	11,726	1,520
Cushing	3,978	434,933	20,067	1,831
Earlsboro	559	139,089	5,591	176
Edmond West	1,417	118,911	11,089	582
Elk City	287	59,342	40,658	276
Eola-Robberson	4,492	75,287	49,713	483
Fitts	1,654	124,048	2,952	609
Glenn Pool	3,838	291,302	28,698	1,203
Golden Trend	12,952	323,252	171,748	1,667
Healdton	3,386	256,961	23,039	2,158
Hewitt	4,072	182,626	22,374	1,434
Little River	394	132,935	2,065	116
Oklahoma City	1,941	731,743	38,257	442
Seminole	1,025	170,892	16,108	266
Sho-Vel-Tum	32,232	775,067	126,056	7,933
Sooner Trend	16,753	67,892	32,751	2,119
St. Louis	1,467	201,346	8,654	647
Tonkawa	356	129,687	3,644	190

Source: Oil and Gas Journal, vol. 66, no. 6, February 5, 1968.

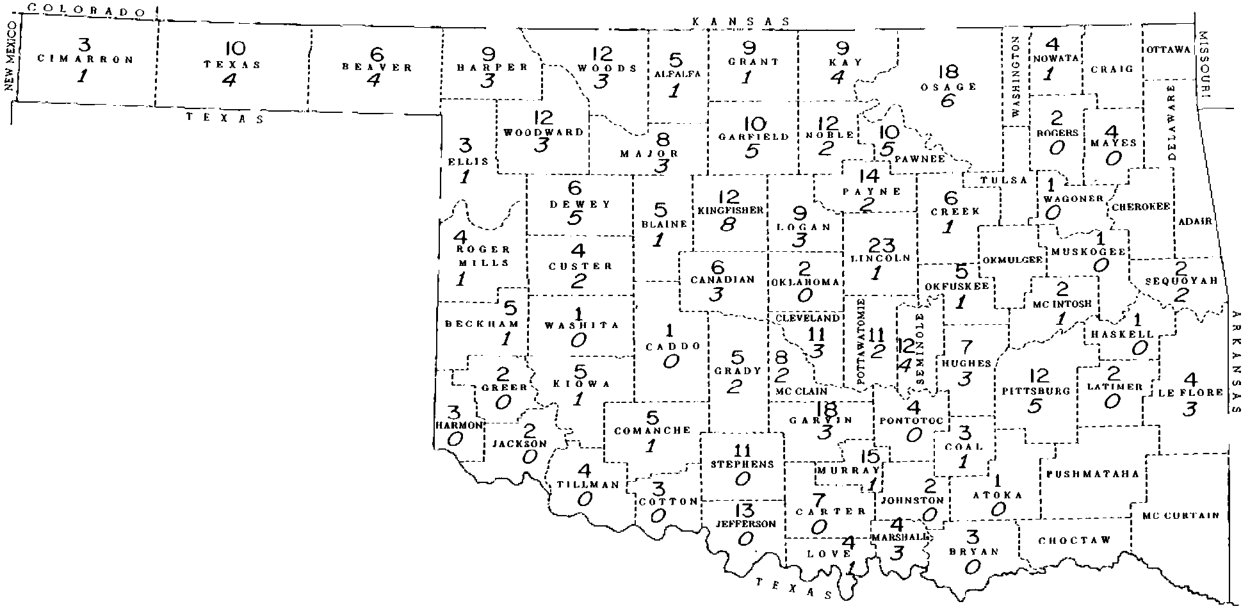

Figure 1. Exploratory drilling, by counties, during 1967. Vertical figures give the number of exploratory wells drilled; slant figures give the number of successful completions. No wells were drilled in Adair, Cherokee, Choctaw, Craig, Delaware, McCurtain, Okmulgee, Ottawa, Pushmataha, Tulsa, and Washington Counties. Source: American Association of Petroleum Geologists in cooperation with the U. S. Bureau of Mines.

TABLE II.—DRILLING ACTIVITY IN OKLAHOMA, 1967

	1967 CRUDE	1967 GAS	1967 DRY	1967 SERVICE	1967 TOTAL	1966 TOTAL	1968 FORECAST
All wells							
Number of completions	1,384	443	1,028	222	3,077	4,112	2,926
Footage					13,821,426	18,441,323	13,167,000
Average footage					4,492	4,485	4,500
Exploration wells							
Number of completions	55	43	321		419	521	432
Percentage of completions	13.1	10.3	76.6		100		
Footage					2,246,402	3,150,032	
Average footage					5,361	6,046	
Development wells							
Number of completions	1,329	400	707	222	2,658	3,591	2,494
Percentage of completions[1]	54.6	16.4	29.0		100		
Footage					11,575,024	15,291,291	
Average footage					4,355	4,258	

Source: Oil and Gas Journal, annual forecast and review issue, vol. 66, no. 6, February 5, 1968.
[1]Excludes service wells.

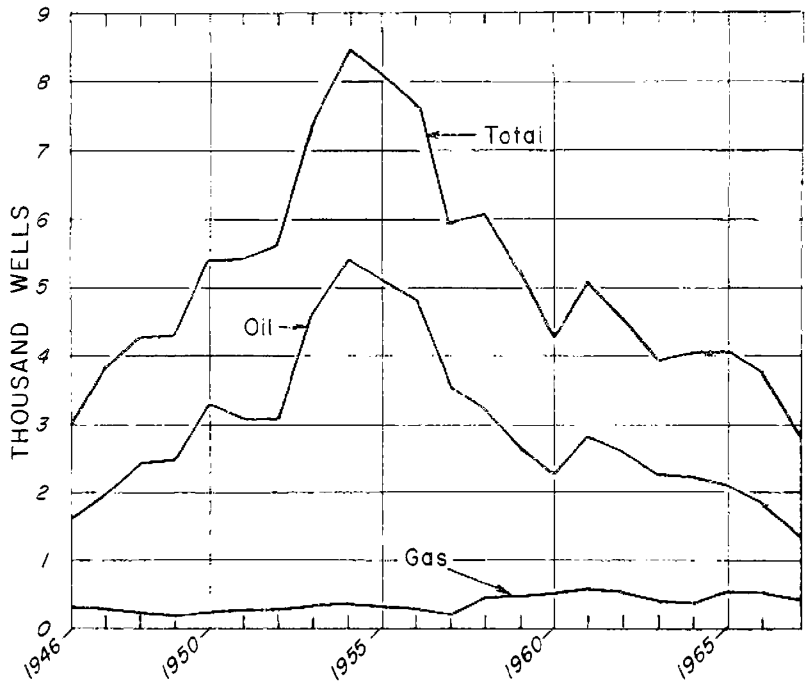

Figure 2. Graph showing total wells drilled, oil wells completed, and gas wells completed in Oklahoma, 1946-1967. Source: Oil and Gas Journal.

per day from perforations opposite Springer sands to a depth of 18,643 feet.

The 22 giant fields in Oklahoma are listed in table I. A giant field is one that has an estimated ultimate recovery of more than 100 million barrels of oil. These giants produced 46 percent of Oklahoma's oil during 1967; they account for 52 percent of the State's estimated ultimate yield and contain 45 percent of the remaining reserves.

Table II summarizes drilling activity during 1967. Fewer wells were drilled in all categories than in 1966; the only increase forecast for 1968 by the *Oil and Gas Journal* is in the number of exploratory wells.

Table III lists cumulative and yearly production and value of all petroleum products to January 1, 1968. Total value of these items is $23.3 billion.

Table IV compares petroleum production of the past two years. Production of all items increased during 1967 due to increased allowables occasioned by restriction of imports, which afforded the opportunity to test Oklahoma's productive capacity.

The American Petroleum Institute's Committee on Reserves and Productive Capacity issued an initial report on the United States crude-oil productive capacity, as of January 1, 1968. This report resulted from a series of meetings extending over a period of 18 months.

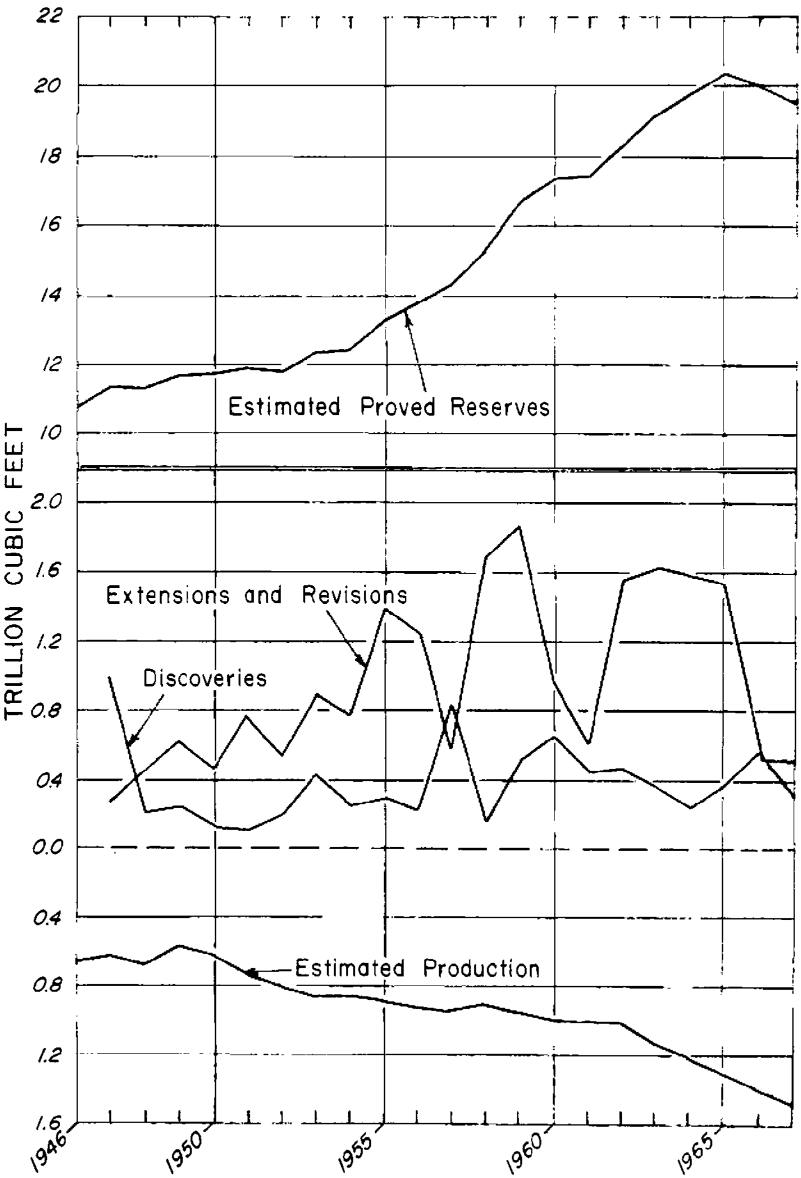

Figure 3. Graph showing statistics on estimated proved reserves of natural gas in Oklahoma, 1946-1967. Estimated production is plotted in reverse direction (increasing downward) to indicate subtraction from reserves. Source: American Gas Association, annual reports.

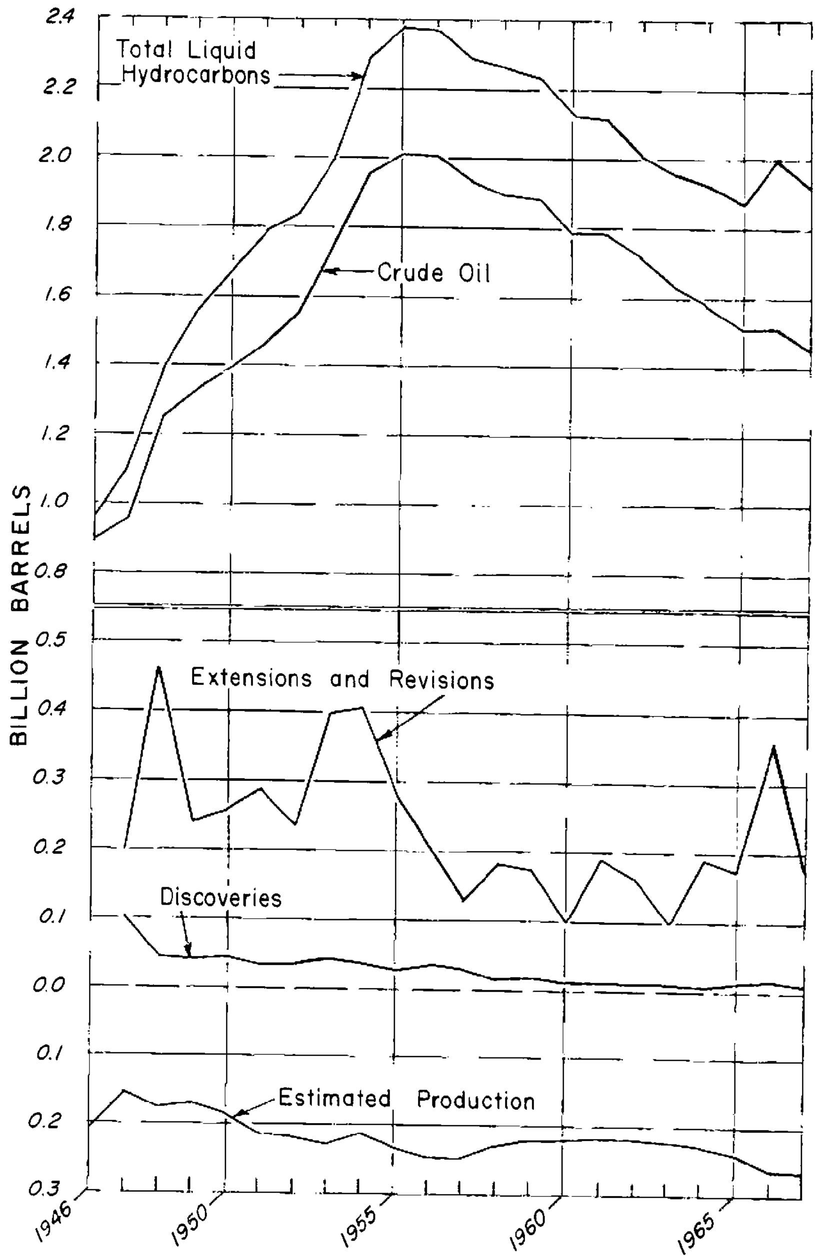

Figure 4. Graph showing statistics on estimated proved reserves of total liquid hydrocarbons in Oklahoma, 1946-1967. Estimated production is plotted in reverse direction (increasing downward) to indicate subtraction from reserves. Source: American Petroleum Institute, annual reports.

TABLE III.—CUMULATIVE (THROUGH 1955) AND YEARLY (1956-1967) MARKETED PRODUCTION AND VALUE OF PETROLEUM, NATURAL GAS, NATURAL GASOLINE, AND LIQUEFIED PETROLEUM GAS IN OKLAHOMA[1]

	Crude Petroleum		Natural Gas		Natural Gasoline and Cycle Products		Liquefied Petroleum Gas	
Year	Volume (1,000 bbls)	Value ($1,000)	Volume (MMCF)	Value ($1,000)	Volume (1,000 gals)	Value ($1,000)	Volume (1,000 gals)	Value ($1,000)
Through 1955	7,230,010	11,443,269	12,977,332	1,378,370	14,420,482	890,729	3,673,364	120,097
1956	215,862	600,096	678,603	54,288	489,963	26,543	579,101	23,427
1957	214,661	650,423	719,794	59,743	460,644	25,329	587,140	21,824
1958	200,699	594,069	696,504	70,347	440,798	26,029	657,114	25,822
1959	198,090	578,423	811,508	81,151	448,353	29,443	675,869	27,070
1960	192,913	563,306	824,266	98,088	531,995	33,074	762,258	32,409
1961	193,081	561,866	892,697	108,016	521,237	33,358	817,082	30,141
1962	202,732	591,977	1,060,717	135,772	552,795	35,764	838,903	25,223
1963	201,962	587,709	1,233,883	160,405	555,467	35,131	810,894	28,981
1964	202,524	587,320	1,323,390	166,747	554,053	34,011	880,804	28,055
1965	203,441	587,944	1,320,995	182,297	570,129	34,561	894,665	32,208
1966	224,839	654,281	1,351,225	189,172	576,124	35,715	968,254	44,381
1967[2]	231,600	694,710	1,421,000	203,203	577,700	36,395	1,027,800	49,334
	9,712,414	$18,695,393	25,311,914	$2,887,599	20,699,740	$1,276,082	13,173,248	$488,972

[1]Figures from: Minerals Yearbook of the U. S. Bureau of Mines. Totals for crude petroleum differ from those compiled by the U. S. Bureau of Mines and the American Petroleum Institute principally because of the exclusion from U. S. B. M. and A. P. I. compilations of an estimated production of 26,355,000 barrels for the years 1905-1906.

[2]Preliminary figures for 1967.

TABLE IV.—HYDROCARBON PRODUCTION IN OKLAHOMA

	1966	1967
Crude oil and lease condensate		
Total annual production (1,000 bbls)[1]	224,839	231,600
Value ($1,000)[1]	654,281	694,710
Cumulative production 1891-year (1,000 bbls)	9,480,814	9,712,414
Daily production (bbls)[2]	615,997	634,521
Total number of producing wells[2]	81,477	80,971
Daily average per well (bbls)	7.6	7.8
Oil wells on artificial lift (estimated)[2]	77,477	76,971
Natural gas		
Total annual marketed production (MMCF)[1]	1,351,225	1,421,000
Value ($1,000)[1]	189,172	203,203
Total number of gas and gas-condensate wells[2]	7,841	7,726
Natural-gas liquids		
Total annual marketed production (1,000 gals)[1]	1,562,378	1,604,500
Value ($1,000)[1]	80,096	85,729

[1]Item for 1966 is U. S. Bureau of Mines final figure. Item for 1967 is U. S. Bureau of Mines preliminary figure.

[2]World Oil, annual forecast and review issue, vol. 166, no. 3, February 15, 1968.

Estimated "90-day" productive capacity of crude oil was established for each state under the following definition.

> The crude oil productive capacity is the maximum daily crude production rate at the point of custody transfer that could be achieved in ninety days with existing wells, well equipment and surface facilities—plus work and changes that can be reasonably accomplished within the time period using present service capabilities and personnel—and with productivity declining as it would under capacity operation. It is assumed that there would be no change in crude oil prices or costs of materials, equipment and/or labor, no statutory restrictions on production rates (but no relief from surface regulations on gas and/or water production), no restrictions on storage or transportation beyond the point of custody transfer, and no marketing constraints.

The estimated daily average capacity for the United States was 12,289,473 bbls; for Oklahoma, 619,000 bbls, or 5 percent.

The same API committee estimated ultimate recoveries according to reservoir lithology and type of entrapment. Oklahoma estimates are as follows.

	ESTIMATED ULTIMATE RECOVERY	RESERVOIR LITHOLOGY		TYPE ENTRAPMENT	
		SANDSTONE (%)	CARBONATE (%)	STRATIGRAPHIC (%)	STRUCTURAL (%)
Crude oil (1,000 bbls)	11,071,160	93	7	52	48
Natural gas (MMCF)	48,695,459	76	24	70	30

Oklahoma continues to rank third in the nation in production and estimated reserves of natural gas and fourth in crude oil.

Taxonomic Crisis in Pre-Pleistocene Palynology

Gerhard O. W. Kremp* and J. G. Methvin*

At the 9th International Botanical Congress in Montreal in 1959, it was impressive and informative to learn of the tremendous amount of palynological research publication that was being done in Russia. L. A. Kupriyanova reported that in 1953 there were 70 palynologic laboratories in the U. S. S. R., with 350 working palynologists, and that in 1959 the science had grown to 150 laboratories, with 1,000 palynologists. The non-Russian delegates questioned these figures but were forced to accept them when, in 1961, Kupriyanova prepared a directory that listed 480 accredited Soviet palynologists and gave their full academic backgrounds. At that time the United States had only 200 palynologists, most of whom were employed by the petroleum industry.

A comparison of Neyshtadt's bibliographies (1952, 1961) with the listings in our reference materials showed that about 67 percent of the Russian literature published during the period 1952-1957 had been overlooked by all the otherwise thorough non-Russian reference services. It seems probable that the Russian literature in pre-Pleistocene palynology is about 50 percent of the world output (compared with 4% produced by the United States), based upon references available for 1961-1964 (fig. 1).

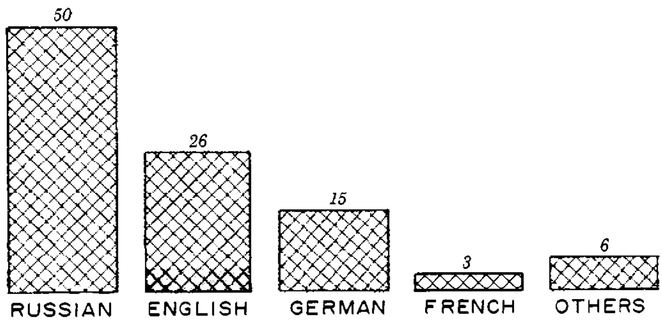

Figure 1. Distribution of publications on pre-Pleistocene palynology, issued during 1961-1964, according to language. Numbers are percent. Shaded portion at base of second bar represents American publications (4%).

According to our calculation, world palynology produced a total of 4,200 publications through 1966 and is now speeding ahead at the rate of about 330 papers a year (fig. 2). These figures are based on the references of Erdtman (1927-1957), Neyshtadt (1952, 1960), Roger (1952-1966), van Campo (1959, 1964), and other accessible sources.

Figure 3, the cumulative curve of the number of new descriptions of fossil pollen and spores named and validly published during the per-

* University of Arizona, Tucson.

iod 1930-1966, is based on new information regarding Russian literature and all other information available.

A preliminary study had indicated that, at the end of 1957, there were about 4,300 newly published species names contained in 738 publications. Only 40 percent of this literature was actually available to us and counted for our calculations. Forty-two percent was strictly stratigraphic in content, as indicated by the absence of reference to illustrations in the listings. The number of new names in the remaining 18 percent was roughly estimated by means of the number of pages, plates, and text-figures. We later found that two-thirds of the Russian literature was not listed in any Western reference service. It was necessary to estimate the missing Russian figures on the basis of the one-third that was available. All these calculations together indicate that at the end of 1957 we probably had, not 4,300, but more nearly 6,600 new descriptions. By extrapolating our figures to 1966, we arrived at a total of about 14,300 new species in the literature.

With this many newly described species already published, we can forecast that, at the present rate of production, a cumulative total of 20,000 new species descriptions will have been published by 1975.

Two questions present themselves: (1) Would this 20,000 represent the total? (2) Can the human mind work with such a total?

As shown by table I, there are more than 380,000 living plant species with recorded botanical names, grouped under more than 17,000 genera. Many of the phyla are recognized among the fossil palynomorphs, but some produce spores too delicate to be preserved or, if preserved, to be extracted with present techniques.

Since Darwin's time we have known that no static picture of species, genera, and families adequately describes the rolling waves of invasion of new forms, with old forms being left behind to become the objects of paleontologic study. Living species probably constitute no more than 1 percent of the total number of species, past and present. With today's new concept of chronological development, which is being constantly refined by new findings, more precise facts are available.

Rensch (1966, table 3) made a thorough study of the different phyla in the animal kingdom, in which the species and the genera are more easily recognized than in the plant kingdom. His conclusion was that the life spans of species range from a few hundred thousand years to a few million years, depending upon the phylum.

Any such calculation for the plant kingdom is subject to numerous objections, particularly because palynologists are limited to working with organ-genera only. Thomson and Pflug (1953) assumed that what is commonly recognized as an organ-species of fossil pollen or spores can be interpreted as the pollen or spores of a whole genus existing at that time. In some cases the classification cannot be reduced to a real genus, and the organ-species must be regarded as evidence of a taxonomic group as large as or larger than a family, as in the Gramineae and Compositae.

It would be interesting to estimate the number of genera represented by organ-species of fossil pollen and spores that may have existed in the higher plants during Earth history, taking into account the number of living genera and a rough approximation of the life spans of the various orders of plants in millions of years. Based on Rensch's findings, it is here tentatively assumed, for this rough approximation, that the life span of the genera of pteridophytes is 50 million years; of the genera of the gymnosperms, 35 million years; and of the genera of the angiosperms, 15 million years (table II).

By adapting Rensch's technique to the plant kingdom, we attempted to estimate the number of organ-genera of fossil pollen or spores that actually existed in the history of plant life and might eventually be found in the fossil record. The calculation yielded a figure of about 34,000 genera or organ-species of fossil pollen and spores. Whatever may be the flaws of this method, the total number of genera must be more than 20,000.

This same number proved decisive in the fate of diatom research a century ago, and such a fate threatens palynological research as well. Although burdened with the handicap of inferior tools, work on diatoms flourished until about 20,000 species were described in the literature (Matthes, 1956). Then interest waned and few new researchers were attracted to the field.

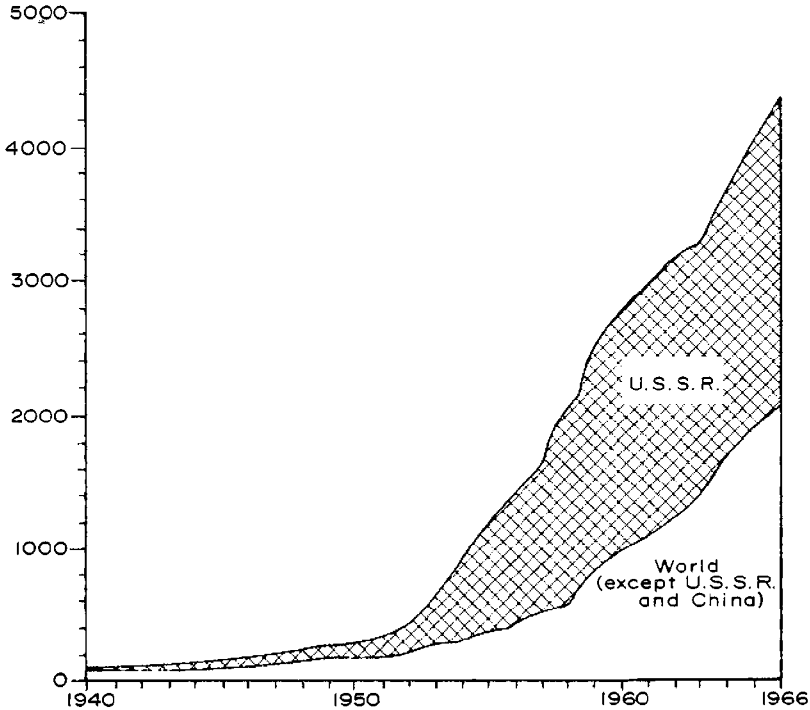

Figure 2. Cumulative curve for the number of papers on pre-Pleistocene palynology published during 1940-1966.

Today many enthusiastic students who begin the study of diatoms soon transfer their attention to other problems. The more frequent reasons given are the excessive number of fossil species described, the unavailability of much of the literature, the age and poor physical condition of much of the older literature, and the excessive time consumed by taxonomic complexities.

The diatom information is contained in old volumes. The pictures were made with inferior microscopes and cameras and, in many cases, lack sufficient morphologic detail. However, the species names are fixed, and most of the species with which we now work have already been named according to the old nomenclature. The result is that the interested student becomes stuck in a taxonomic bog.

Despite such difficulties and contrary to popular opinion, diatom research is capable of effectively solving a number of stratigraphic problems. Excellent recent examples of what can be accomplished are the works of Benda (1965) and Zhuze (1960).

Had the workers of the last century been able to use the magnetic-tape memory and data-retrieval systems available today, had they catalogued their findings and worked constantly to refine the descriptions of their species and type specimens, and had they kept their information on type localities up to date, we could now make fruitful use of the information they labored to accumulate.

If pre-Pleistocene palynology follows the same taxonomic pattern, the number of described species will become so great that young students will find the study too time-consuming for the results achieved.

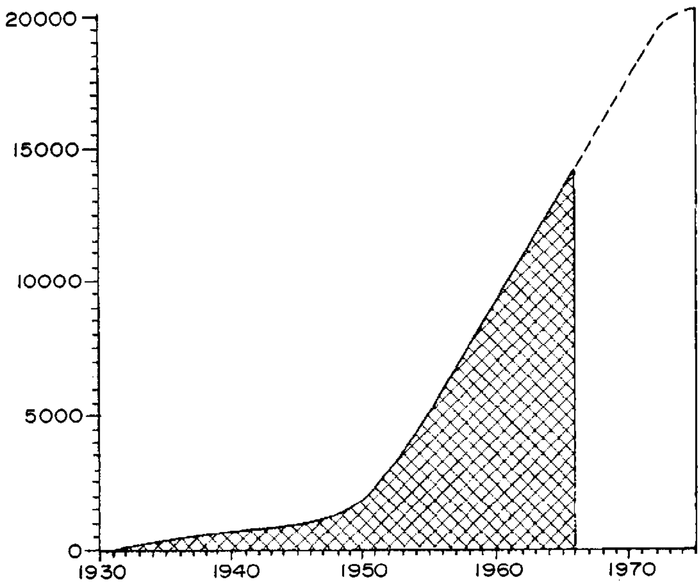

Figure 3. Cumulative curve for the number of new descriptions of fossil pollen and spores validly published during 1930-1966.

TABLE I.—NUMBER OF LIVING SPECIES AND GENERA OF THE PLANT KINGDOM

PHYLUM	NUMBER OF LIVING SPECIES	NUMBER OF LIVING GENERA	SPORES[1]
Angiospermae	250,000	11,000	+
Gymnospermae	700	57	+
Pteridophyta	10,600	315	+
Bryophyta	22,700	500	+
Chlorophyta	5,700	256	+
Euglenophyta	400	25	?
Chrysophyta	10,000	300	+
Pyrrophyta	1,100	150	+
Phaeophyta	1,500	240	?
Rhodophyta	4,000	500	?
Glaucophyta	12	6	?
Lichenes	20,000	400	+
Eumycophyta	56,000	3,300	+
Myxomycophyta	500	60	?
Cyanophyta	1,400	160	?
Protophyta	1,600	150	-
Total	386,212	17,419	

[1] +, produces identifiable palynomorphs.
?, spores too delicate for extraction by present techniques.

Eventually, only those currently in the field will remain. With no new blood coming into the palynologic group, the number of researchers will decline, and the study will become moribund. Pre-Pleistocene palynologists can realistically expect their taxonomic jungle to become impenetrable by the year 1975, and by the year 2075 they will be confronted with the same situation that faces today's students in regard to diatom literature.

These are inescapable facts. Many of the pioneer descriptions in our pollen and spore work are no longer adequate and will be impossible to work with a hundred years from now. The slides we prepare now will be useless by then. The tremendous advances in photomicrography are making the first descriptions and illustrations of our work obsolete, but, if new workers can be attracted to the field, they can apply themselves to replacing inadequate illustrations of type specimens with better photographs. Geological information can be refined. However, if palynology is neglected, much of the work, including that being done now, will be judged inaccurate and inadequate within a few decades.

Few people are now able to penetrate the chaotic regions that house the diatom information and to find such useful stratigraphic applications as those of Zhuze and Benda. It is interesting, however, to imagine how problems concerning the geologic history of Antarctica could be solved and how oil exploration in Alaska could be implemented with information gained from an easily accessible literature of diatom research. Only a few workers have had hardihood enough to pen-

TABLE II.—ESTIMATED NUMBER OF GENERA OF LIVING AND FOSSIL HIGHER LAND PLANTS

PHYLUM	CLASS OR ORDER	APPROXIMATE LIFE SPAN (M.Y.)	NUMBER OF LIVING GENERA	APPROXIMATE LIFE SPAN OF GENUS (M.Y.)	ESTIMATED TOTAL NUMBER OF GENERA
Angiospermae	Dicotyledoneae	120	9,500	15	27,000
	Monocotyledoneae	120?	2,000		4,000
Gymnospermae	Cycadopsida	350	4	35	320
	Coniferopsida	370	53		710
Pteridophyta	Pteropsida	390	308	50	1,000
	Sphenopsida	380	1		180
	Lycopsida	405	4		700
	Psilotopsida	?	2		5
	Psilophytopsida	50	-		30
Total			11,872		33,945

etrate this diatom jungle. Significantly, only one paper was given on fossil diatoms at the 2nd International Conference on Palynology (Utrecht, 1966), despite the expectation that diatom workers would be well represented at such a meeting.

Perhaps in a hundred years there will be a number of phenomena in palynology of the sterling quality of Ruth Patrick, who at present contributes so much to diatom literature. But how terrible it is to be almost the only worker in the field, even for one so fruitful, if nobody can evaluate your work or, what is worse, if nobody is interested in it!

Hutchinson (1964, p. 3) expressed the wish that a "super-botanist" might arise, who would be able to grasp many branches of knowledge at once: palynology, cytology, genetics, pollen morphology, taxonomy, nomenclature, and phylogeny. Hutchinson's "super-botanist" is already with us in the form of electronic computer mechanisms.

Sokol (1966) correctly stated that

> Automatic data retrieval processing will revolutionize the storage and retrieval of taxonomic information for museums, catalogs, etc. The approaches of numerical taxonomy have already done much to de-emphasize the legalistic, sterile aspects of naming organisms. It is likely that developments in automatic data processing will rapidly relegate problems of nomenclature to the position of relative unimportance which they merit. Some of the birth pangs of automation will be felt in taxonomy as in other fields, and traditionally many workers will presumably resist the changes. The controversy about numerical taxonomy will doubtless continue for some time to come until a new synthetic theory of taxonomy accepting what is found from various schools becomes commonplace. The revolution the computer has brought in taxonomy has only just begun.

All who attended the taxonomic sessions of the International Committee on the Microflora of the Paleozoic at the Utrecht Conference are probably aware of how far taxonomic confusion has advanced, of how much time must be wasted by the best palynologists to straighten out only a few of the mistakes. Electronic data-processing systems could take all these descriptions and release them in an organized way. These systems are not restricted to binomial names, but can compare hundreds of morphologic characters in a split second.

An immediate objection is that few of us know how to develop a computer program. However, it is something to be learned. With the present rate of educational progress, computer programming will probably be in the curriculum of the 8th grade in our lifetime.

We have the best machines available. We can try different methods and find the one best adapted to our problem. The program could start in many centers at once, because none of the computed facts need be lost. Once they are on tape, they can be reshuffled at will. The need to pool our efforts in order to compile all available information from the literature of stratigraphic palynology seems mandatory. Of particular value will be the recording of Russian palynology as the publications become available.

By thus accumulating and organizing our data, analysis will be easier, and we can move on to synthesis, the goal of scientific research—synthesis which can add to the store of general knowledge.

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New Theses Added to O.U. Geology Library

The following Master of Science theses were recently added to The University of Oklahoma Geology Library:

Subsurface geology of Wheatland area, Cleveland, McClain, Grady, Canadian and Oklahoma Counties, Oklahoma, by Mir Ahmeduddin.

Areal geology and petrology of the igneous rocks, Santa Ana quadrangle, Sonora, Mexico, by Guillermo Armando Salas.

Geology of the Cumberland area, Bryan, Johnston, and Marshall Counties, Oklahoma, by Robert W. Ganser.

Geology of the Ada area, Pontotoc County, Oklahoma, by Kenneth Lance Lowe.

Mississippian rocks of northeastern Osage County, Oklahoma, by Ray William Rhoads.

OKLAHOMA ABSTRACTS

The University of Oklahoma

Quantitative Study of the Cherokee-Marmaton Groups, West Flank of the Nemaha Ridge, North-Central Oklahoma

BERG, ORVILLE ROGER, The University of Oklahoma, Ph.D. dissertation, 1968.

Cherokee-Marmaton (Desmoinesian) rocks of a portion of north-central Oklahoma have been studied in subsurface. The area of investigation included approximately 7,000 square miles; information from 820 mechanical logs and 30 sample logs was utilized. Electric well logs were incorporated into a series of intercorrelated cross sections which formed a network of control across the entire area.

Utilizing marker beds which were readily traceable throughout the area, the rock sequence was subdivided into "genetic increments" of strata. Each increment was isopached to portray over-all thickness relations. Isopach maps revealed rapid southwestward thickening toward the Anadarko basin, minor southeastward thickening toward the Arkoma basin, local thinning along the Nemaha ridge, and northward thinning onto the shelf. Isoliths of genetic increments within the Cherokee Group show the nature and distribution of sandstone bodies; these are confined largely to the eastern side and appear to have a northern or northeasterly source.

Isoliths of lower Marmaton (Oswego, Labette, and Big Lime) reveal major limestone-bank developments (undaform-edge banks) along the northeastern hinge line of the Anadarko basin. These "shale-out" southwestward into the basin and their frontal margins regress northward with time toward the shelf. Isoliths of upper Marmaton (Seminole increment) reveal a major east-west trending sand body crossing the middle part of the area, irregular bodies of sandstone (Cleveland) throughout the northern part of the area, and thin wedges of sandstone in the southern portion.

Shelfward migration of Marmaton limestone "banks" and distribution pattern of sand bodies in the upper Marmaton suggest a southerly source of clastics during part of Marmaton time.

(Reprinted from Dissertation Abstracts, Pt. B., vol. 28, no. 9, p. 3748-B)

OKLAHOMA ABSTRACTS is intended to present abstracts of recent unpublished papers on Oklahoma geology. The editors are therefore interested in obtaining abstracts of formally presented or approved documents, such as dissertations, theses, and papers presented at professional meetings, that have not yet been published.

Palynology of a Portion of the El Reno Group (Permian), Southwest Oklahoma

MORGAN, BILL EUGENE, The University of Oklahoma, Ph.D. dissertation, 1967.

Palynology of the El Reno Group (Permian) of southwestern Oklahoma is described. The El Reno Group comprises, in ascending order, the Flowerpot Shale, Blaine Formation, and Dog Creek Shale. Cores of portions of the El Reno Group from Blaine, Greer, and Harmon Counties yielded 14 well-preserved palynomorph assemblages. The spore and pollen assemblages consist of 55 genera containing 105 species. Ten new genera and 69 new species are described but are not assigned binomial names. In addition, one species of Fungi imperfectae and one species of Acritarch are identified. Relative percentages of 8 different species have been plotted as histograms and show that the floral assemblage may be used to differentiate the several formations of the El Reno Group.

The following conclusions are drawn from the palynological investigation of the El Reno Group:

1. The spore and pollen assemblage is predominantly composed of bisaccate pollen, monosaccate pollen, and rare spores. An age of Guadelupean Stage of the Permian is supported by the spore and pollen flora.

2. Four major palynological assemblages characterize the El Reno Group:

A. *Strotersporites* assemblage of the Flowerpot Shale.

B. *Lueckisporites* assemblage of the Lower Blaine Formation.

C. *Psophosphaera* assemblage of the Blaine Formation.

D. *Striatites physema* assemblage of the Dog Creek Shale and Van Vacter Gypsum Member.

3. The depositional environment of the Flowerpot and Dog Creek Shales was nearshore, probably marine to brackish, while the Blaine Formation was largely marine as interpreted from the palynologic content.

(Reprinted from Dissertation Abstracts, Pt. B, vol. 28, no. 7, p. 2902-B)

Palynological Investigation of Desmoinesian and Missourian Strata, Elk City Area, Oklahoma

SANDERS, ROBERT BRUCE, The University of Oklahoma, Ph.D. dissertation, 1967.

Palynological analyses were made of 141 samples from a thick Desmoines and Missouri "granite and carbonate wash" wedge of the subsurface of the Anadarko basin. This deposit is interpreted as a fluxoturbidite caused by intermittent movements along the flank of the Amarillo-Wichita uplift during Pennsylvanian time. The samples were from well cuttings and cores from a 576-square-mile area centered about Elk City, Oklahoma. The principal objectives of the study were the location of the Desmoinesian-Missourian unconformity and the intra-Desmoinesian unconformity observed in seismic data.

Samples from throughout the Desmoines and Missouri Series are palynologically characterized by the dominance of well-preserved Chester recycled palynomorphs and highly corroded and pyritized endemic palynomorphs. The poor preservation of the Desmoines and Missouri palynomorphs is attributed to unfavorably low oxidation-reduction potential and high sulfide concentration in the environment of deposition.

Desmoinesian index palynomorphs, especially Cabaniss forms, were in both the Desmoines and Missouri strata, indicating the presence of Desmoines exposures in the provenance area (Amarillo-Wichita uplift) during Desmoinesian time. An unconformity of late Desmoinesian or early Missourian age is indicated in the provenance area, but there is no evidence that this unconformity is present in the Anadarko basin proper. It is believed to be a local feature due to growth faulting along the North Carter and Meers thrusts, among others.

The combination of Missourian recycling of Desmoines palynomorphs and well-caving contamination made stratigraphic zonation impossible in the 127 samples based on well cuttings. Four of the samples from core material were geologically dated, but the remaining 13 such samples were barren of diagnostic forms. The intra-Desmoinesian unconformity is not palynologically reflected.

Fault zones and anticlinal axes were located by application of the principles of tectonically induced palynomorph carbonization. Tectonically induced carbonization was differentiated from the similar effects of unfavorable depositional environmental factors by the carbonization of recycled as well as autocthonous palynomorphs in the samples.

(Reprinted from Dissertation Abstracts, Pt. B,
vol. 28, no. 7, p. 2906-B)

UNIVERSITY OF WISCONSIN

Sandstone Petrology and Stratigraphy of the Stanley Group (Mississippian), Southern Ouachita Mountains, Oklahoma

HILL, JOHN GILMORE, University of Wisconsin, Ph.D. dissertation, 1967.

The purpose of the study was to determine the provenance of the sandstones in the Stanley Group by petrographic analysis. If the nature of the source rocks for the sandstones could be determined, a probable location for the source area could then be established. The petrologic samples were stratigraphically controlled by measuring and sampling partial stratigraphic sections of the Stanley Group. Selected samples were subsequently analyzed in thin section.

The study was mainly confined to McCurtain and southern Le Flore Counties, Oklahoma. Here the Stanley Group consists of about 11,000 feet of dark shale and interbedded argillaceous sandstone and siltstone. It is the lower portion of about 20,000 feet of flysch sediments of Mississippian-Pennsylvanian age. The sandstones of the Stanley Group are mostly turbidite sands, deposited in a deep, marine geosyncline. Thickness and stratigraphic relationships of the basal Stanley and the Hatton Tuff Lentil suggest that structural features of sufficient magnitude to influence sedimentation were present within the geosyncline by the beginning of Stanley deposition.

The Stanley sandstones are mostly very fine-grained, are poorly sorted, and have very high matrix contents. Most are wackes (greater than 10 percent matrix); only a small percentage of the samples examined were arenites (less than 10 percent matrix). The high matrix contents indicate that no significant amount of reworking occurred after the sands were deposited.

Mineralogically, the sandstones are mostly feldspathic wackes and quartz wackes. Some arkosic wackes are found. Five main types of quartz were identified. Most of these have no definite source-rock significance, but some of the quartz can be attributed to a quartzite source. Most of the quartz grains in the sandstones are angular, but about 31 percent are subrounded and rounded, indicating preexisting sediments in the source area.

Feldspar is common in sandstones from all parts of the Stanley Group, except the Chickasaw Creek Formation. Most of the feldspar is too badly altered for definite identification. However, both fresh plagioclase and untwinned feldspars are found. Estimated composition of the plagioclase varies from An_{26} to An_{40}. This is identical to the plagioclase composition in the Stanley tuff beds. The similarity of plagioclase in the sandstones and tuffs and the presence of tuffs throughout the Stanley Group indicate the existence of volcanic activity in the source area.

Rock fragments are rare in the sandstones. Those found consist of metamorphic, volcanic, and sedimentary lithologies. The metamorphics are fine-grained mica-schists and quartz mica-schists, slates, and phyllites. Volcanic fragments consist of fine-grained plagioclase laths in a dark, cryptocrystalline matrix. They were probably derived from volcanic flows. Sedimentary rock fragments are mainly shale chips and have no provenance significance.

The source area for Stanley sandstones is believed to have been a complex association of sedimentary, volcanic, and metamorphic rocks. It probably lay to the south of the present-day Ouachita Mountains in an area now covered by sediments of the Gulf Coastal Plain. Volcanic and metamorphic rocks of Paleozoic age in the subsurface along the Luling overthrust front in Texas are lithologically similar to rock fragments found in the Stanley sandstones. This buried sequence was probably a part of the Stanley source area.

The source area probably consisted of a series of volcanic and tectonic islands forming within the Ouachita geosyncline. Sediments from the uplifted areas accumulated in the shallow water surrounding the islands. Periodic slumping generated subaqueous mass flows and turbidity currents which carried sands far into the environment of dark-mud accumulation, thus producing the typical flysch lithology of the Stanley Group.

(Reprinted from Dissertation Abstracts, Pt. B, vol. 28, no. 8, p. 3339-B)

Petrography and Provenance of the Johns Valley Boulders, Ouachita Mountains, Southeastern Oklahoma and Southwestern Arkansas

SHIDELER, GERALD LEE, University of Wisconsin, Ph.D., dissertation, 1968.

The boulder-bearing Johns Valley Formation constitutes a wild-flysch subfacies of the Late Paleozoic flysch sequence indigenous to the central Ouachita Mountain province. Enclosed clasts exhibit a complete size gradation, ranging from sand detritus to boulders exceeding tens of feet in diameter. Clasts are disseminated throughout the entire formation, where they occur in diverse sedimentary deposits which include structureless and laminated paraconglomerates, orthoconglomerates, and exotic sandstone beds.

Petrographically, the Johns Valley boulders are highly diversified, with carbonate specimens comprising 75 percent of the boulders. The majority of carbonate boulders are dolomitic limestones, which consist of several petrographic varieties. Siliceous specimens comprise 18 percent of the boulders, the majority of which are chert nodules; clastic specimens account for only 7 percent of the boulders, with arenites being most abundant.

Boulders range in age from Croixan through Morrowan, with Ordovician specimens being dominant. The clasts were derived from several stratigraphic units indigenous to the Arbuckle and Ozark facies of the foreland province, as well as from units indigenous to the transitional and geosynclinal facies of the frontal and central Ouachita Mountain provinces, respectively. The sourceland was a single linear element composed predominantly of foreland carbonate strata, but which also contained subordinate quantities of transitional and geosynclinal lithologies. Its paleogeographic location was immediately north of the transitional zone along the flexure which separated the foreland and geosynclinal tectonic provinces. Structurally, the sourceland was manifested as a rising, fault-bounded geanticlinal ridge, which became the locus of an emergent archipelago; the archipelago was composed of at least four prominent islands which functioned as major boulder-dispersal centers during Johns Valley time. Sourceland uplift, accompanied by normal tensional faulting along the south flank, commenced in mid-Chesterian time. Uplift resulted largely from isostatic compensation along the hinge-line flexure, necessitated by deep and rapid subsidence of the Ouachita trough during Stanley-Jackfork deposition. The sourceland reached its culminating stage of development during Johns Valley time and was essentially peneplaned by late Morrowan time.

Throughout Johns Valley deposition, steep and unstable marginal paleoslopes were maintained along the geanticlinal ridge by periodic tectonism and subaqueous erosional processes. Boulders were derived by both subaerial erosion of the archipelago under warm and humid climatic conditions and by submarine erosion of a marginal escarpment and wave-cut terrace. Boulders were transported primarily southward over short distances by a combination of mass-movement media, which were active along the unstable marginal paleoslopes. The prolific introduction of boulders into the Ouachita geosyncline during Johns Valley time resulted in the development of a wildflysch subfacies indigenous to the northern margin of the trough, as contrasted with the turbidite flysch facies of the trough interior. Following deposition of overlying Atoka sediments, the Ouachita facies was compressed and thrust-faulted northward over the denuded geanticlinal ridge, the probable paleogeographic location of which is approximately coincident with the present Ouachita frontal belt.

The paleotectonic significance of the Johns Valley boulders is their indication of subjacent foreland strata beneath the transitional facies of the Ouachita frontal belt, thus substantiating significant northward displacement of the Ouachita facies. In addition, their presence provides testimony to the initial orogenic tendencies of the Ouachita mobile belt, tendencies which were a prelude to major orogenesis in later Pennsylvanian time.

The University of Kansas

Paleontology and paleoecology of the Kiowa Formation (Lower Cretaceous) in Kansas

SCOTT, ROBERT W., The University of Kansas, Ph.D. dissertation, 1967.

The Comanchean Kiowa Formation in most places in central and southern Kansas overlies Permian rocks unconformably and underlies the Dakota Formation with apparent unconformity. Three local fossil zones, *Oxytropidoceras* assemblage zone, *Engonoceras belvidersense* range zone, and *Inoceramus bellvuensis* range zone, verify correlation of the lower Kiowa with the medial Albian Kiamichi Formation in Texas and the upper Kiowa with the late Albian Duck Creek Formation. Six lithofacies contain fossils: dark-gray shale, tan claystone, thin-laminated sandstone, thin-bedded sandstone, mottled sandstone, and shell conglomerate.

Kiowa fossil assemblages are preserved in place or in the neighborhood where the fossils lived or as transported assemblages. Mixed assemblages contain species representing several substrates.

Relative-abundance data, accurate stratigraphic and geographic distribution data, and the Jaccard coefficient define 10 recurring associations of abundant or unique species. The fossil associations are: *Nuculana, Corbula?-Breviarca, Trachycardium-Turritella,* Pteriid-Mytilid, *Gryphaea, Cyprimeria, Crassostrea, Lopha quadriplicata,* *Brachidontes*, and trace-fossil associations. These associations consist of species having similar feeding and dwelling habits and substrate preferences. Because the fossil associations have paleoecologic consistency, they represent parts of ancient communities and can be compared with modern marine benthic communities. Interspecific relationships of predation, trophic levels, competition, and commensalism were not unlike those of present-day marine communities. The climate during transgression and regression of the Kiowa sea was humid, tropical to subtropical. The sea in the nearshore central Kansas area was shallower and less saline than in the offshore southern Kansas region.

(Reprinted from Dissertation Abstracts, Pt. B, vol. 28, no. 8, p. 3344-B)

Carol Patrick Joins Survey Staff

The Oklahoma Geological Survey is pleased to announce the appointment of Mrs. Carol R. Patrick to the position of associate editor. Mrs. Patrick, who has a B.A. degree from Purdue University, held a University of Oklahoma Press Editorial Fellowship during the preceding academic year and brings to her new position skill and knowledge that will contribute materially to the further improvement of Survey publications.

Mrs. Patrick, a native of Indiana, is married to geologist David M. Patrick, who is working toward his Ph.D. degree at the University of Oklahoma. While working toward a degree in European history, she found time to include nine hours of geology, a fortunate occurrence from which the Survey should benefit. The Patricks, who have been married for five years, resided in Indiana, Missouri, and West Germany before coming to Norman.

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