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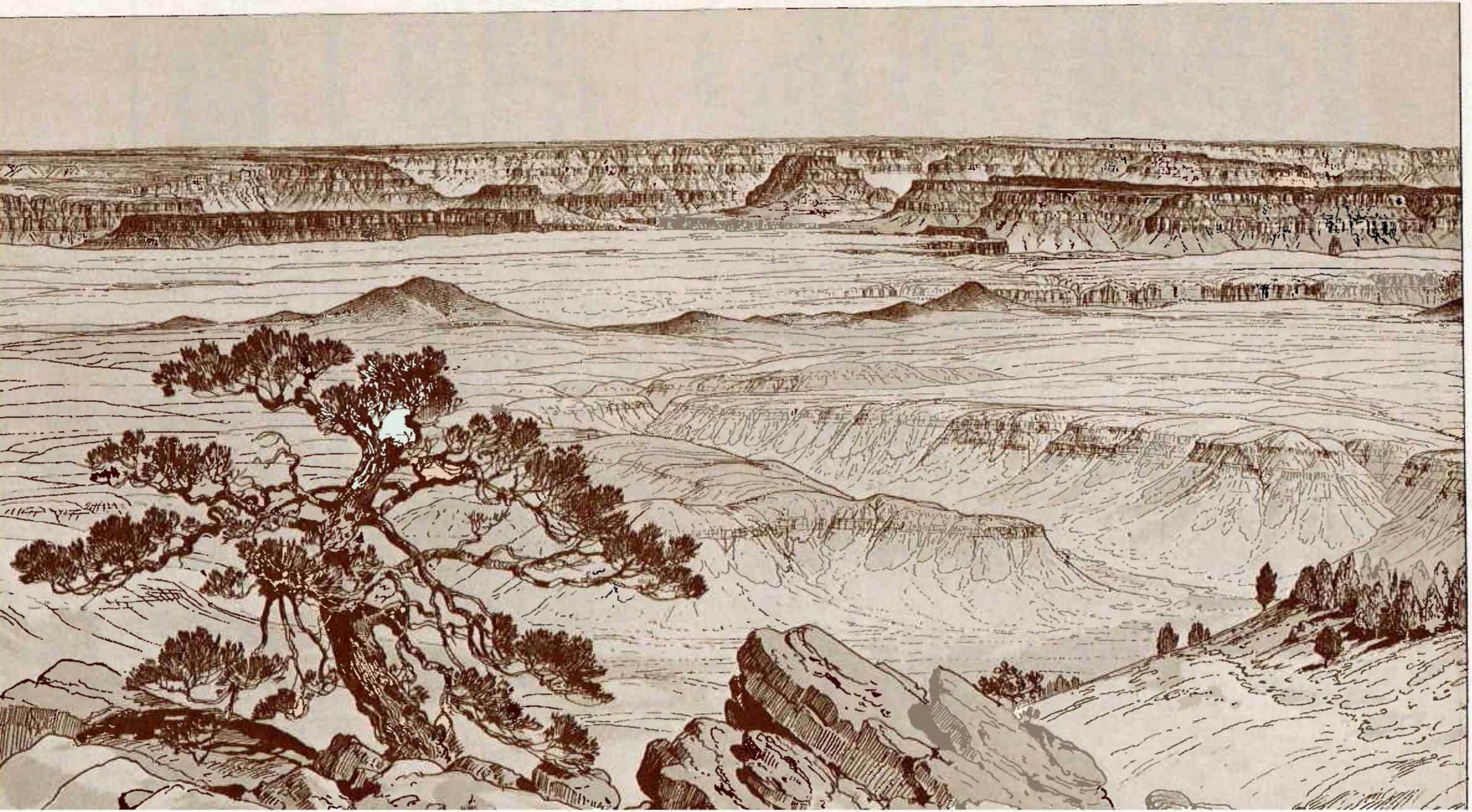

Cover Picture

DUTTON'S 1882 REPORT ON THE GRAND CANYON

Since this is the bicentennial year of the U.S. Geological Survey, what could be more appropriate for the *Notes* cover than this sketch from one of the first publications of the Survey? This illustration (Atlas Sheet IX), taken from the USGS Monograph (v. II) *Tertiary History of the Grand Cañon District* (published in 1882; reprinted in 1977 by Peregrine Smith, Inc.), was drawn by W. H. Holmes, artist with this early survey of the Grand Canyon conducted by Capt. Clarence E. Dutton. Dutton, who was appointed head of the Division of the Colorado by P. B. King, first director of USGS (see related article in this issue, p. 63), conducted many such expeditions into the Rocky Mountain region.

The sketch is a view looking toward the east from Mount Trumbull and shows the Grand Canyon in the distance. On the horizon is the summit of the Kaibab Plateau; glimpses of the canyon in the Kaibab are given as distances from 45 to 85 miles. The opening of Kanab Canyon is seen on the left. In the foreground is the upper part of Toroweap Valley.

Certainly this is the year to remember the great naturalists (geologists, biologists, artists) who explored and described the wonders of our country, both as scientists and poets. As Dutton said, "The thoughtful mind is far more deeply moved by the splendor and grace of Nature's architecture."

—*Judy A. Russell*

Editorial staff: William D. Rose, Elizabeth A. Ham, Judy A. Russell.

Oklahoma Geology Notes is published bimonthly by the Oklahoma Geological Survey. It contains short technical articles, mineral-industry and petroleum news and statistics, an annual bibliography of Oklahoma geology, reviews, and announcements of general pertinence to Oklahoma geology. Single copies, $1.00; yearly subscription, $4.00. All subscription orders should be sent to the address on the front cover.

Short articles on aspects of Oklahoma geology are welcome from contributors. A set of guidelines will be forwarded on request.

This publication, printed by The University of Oklahoma Printing Services, Norman, Oklahoma, is issued by the Oklahoma Geological Survey as authorized by Title 70, Oklahoma Statutes 1971, Section 3310, and Title 74, Oklahoma Statutes 1971, Sections 231-238. 1,500 copies have been prepared for distribution at a cost to the taxpayers of the State of Oklahoma of $1,990.00.

WATER-QUALITY-MANAGEMENT PLANNING IN OKLAHOMA

Kenneth V. Luza[1]

Introduction

One of the principal goals of Public Law 92-500, the Federal Water Pollution Control Act of 1972 (subsequently amended by Congress, Clean Water Act of 1977, Public Law 95-217), is to make the nation's waters suitable for swimming and boating as well as a favorable habitat for fish, shellfish, and wildlife by 1983. Section 208 of these laws establishes the procedure for developing a comprehensive, areawide, waste-treatment-management plan. The initial phase usually involves the collection and evaluation of information necessary to develop a plan that will meet or maintain the 1983 water-quality standards. Generally, this activity is referred to as 208 planning.

In May 1976, the Environmental Protection Agency (EPA) awarded the Oklahoma Department of Pollution Control (DPC) a $1-million grant, under section 208, to develop and implement a statewide waste-treatment-management plan. During the course of this 3-year project, some of the goals will include (1) a statewide water-quality plan, (2) an evaluation of alternatives for future water-management programs, and (3) establishment of policies that will aid in solving water-quality problems in Oklahoma on both a short- and long-term basis. The planning effort, thus far, has involved industry; local elected officials; and local, State, and federal agencies involved or interested in water-quality programs. Public participation is an important requirement of 208 planning because action taken within one region may well affect water quality in other places. Therefore, throughout the course of the project, interim reports as well as file reports are evaluated by the public through a review and approval process before plan implementation.

Richard Gunn, Oklahoma Department of Pollution Control, reviewed the manuscript and made several helpful suggestions for its improvement.

Planning Region and Process

The planning area involves all or parts of 61 counties and 9 substate-planning districts covering 65,535 square miles (fig. 1). Planning districts ARKOMA (Sebastian and Crawford Counties in Arkansas; Sequoyah and Le Flore Counties in Oklahoma), INCOG (Indian Nations Council of Governments), and ACOG (Association of Central Oklahoma Governments) are excluded from the project because they have 208-planning programs under way. However, their results will be integrated into Oklahoma's statewide plan.

The Oklahoma DPC serves as the program-management agency for statewide 208 planning; the Oklahoma Water Resources Board, the Oklahoma

[1] Geologist, Oklahoma Geological Survey.

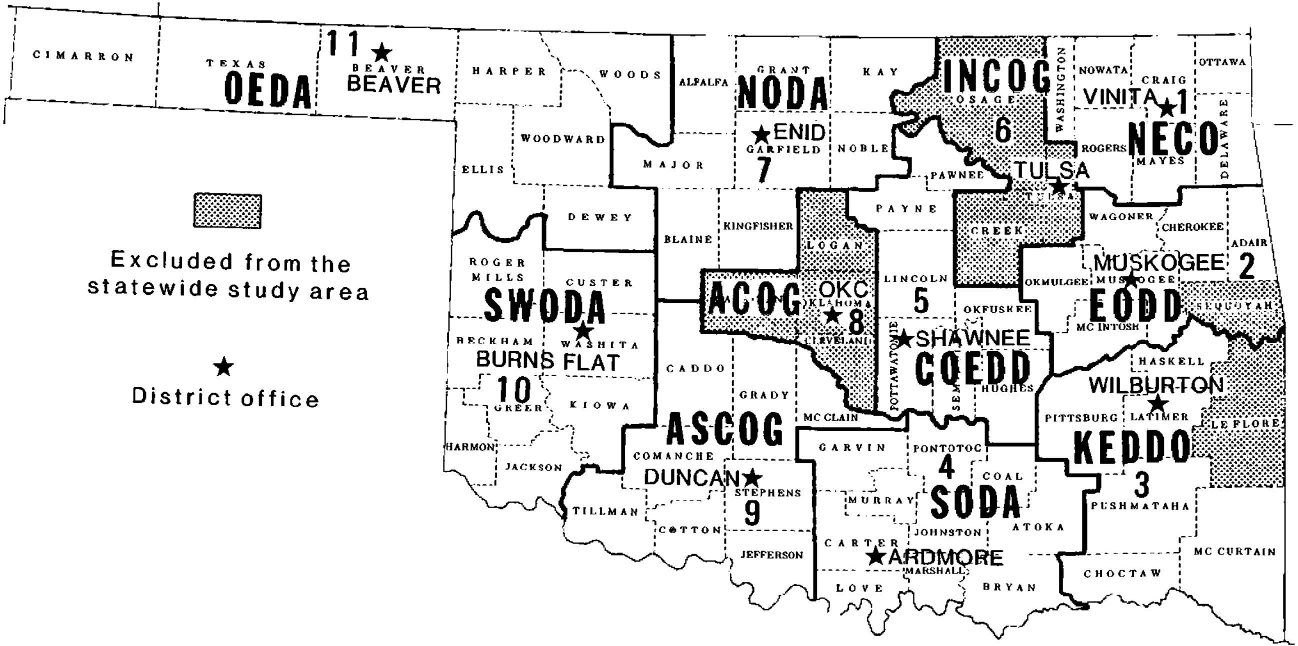

Figure 1. Map showing Oklahoma's 11 substate planning districts: 1—Northeast Counties of Oklahoma Economic Development Association; 2—Eastern Oklahoma Development District; 3—Kiamichi Economic Development District of Oklahoma; 4—Southern Oklahoma Development Association; 5—Central Oklahoma Economic Development District; 6—Indian Nations Council of Governments; 7—Northern Oklahoma Development Association; 8—Association of Central Oklahoma Governments; 9—Association of South-Central Oklahoma Governments; 10—Southwestern Oklahoma Development Association; 11—Oklahoma Economic Development Association.

Department of Health, and the Oklahoma Conservation Commission serve as agency consultants. These agencies as well as private consulting firms are responsible for the preparation of reports relevant to the project study. Such reports include (1) the identification of point and non-point sources of pollution and their individual and composite impact on water quality in a specific area and (2) the establishment and verification of a comprehensive point and non-point source waste-load-allocation methodology. Much of this information, along with data from ongoing water-quality-monitoring programs, is being used to develop a statewide water-quality-management plan.

Water-Quality Management

To aid in water-quality management of Oklahoma's streams and rivers, DPC prepared a plan in which the State was subdivided into seven water-quality-planning basins (fig. 2; table 1). The seven planning basins were further subdivided into 59 stream segments. Boundaries were chosen, in most instances, at a reservoir dam or at the confluence of a tributary and the main stream segment (Oklahoma Water Resources Board, 1978).

Basin 1, Middle Arkansas, which is located in northeastern Oklahoma, consists of nine stream segments and includes the Arkansas River (from Webbers Falls to Keystone Dam), Bird Creek, Caney River, Verdigris River, Grand River, Pryor Creek, and Illinois River.

Haskell County and parts of Le Flore, Latimer, Pittsburg, McIntosh, Muskogee, Sequoyah, Cherokee, and Adair Counties make up Basin 2, Lower Arkansas. This basin contains four stream segments, Poteau River, Arkansas River (from Webbers Falls to the Arkansas state line), North Canadian River (Eufaula Dam to Arkansas River), and Canadian River (Calvin to Eufaula Dam).

Basin 3, Upper Red, which encompasses most of southwestern Oklahoma, is composed of 14 stream segments that include Washita and Little Washita Rivers, Red River (Ryan to Lake Texoma Dam), Beaver Creek, North Fork of Red River, and Salt and Elm Forks of Red River.

Basin 4, Lower Red, is situated in southeastern Oklahoma. It is composed of eight stream segments that include Red River (below Lake Texoma Dam), Little River, Boggy River, Kiamichi River, Blue River, and Island Bayou and adjacent Red River.

Basin 5, Canadian, occupies central Oklahoma and extends westward to the Texas state line. Eleven stream segments make up this basin and include the North Canadian River (Eufaula Dam to Canton Reservoir), Canadian River (Calvin to Texas state line), Deep Fork, and Little River of central Oklahoma.

Basin 6, Upper Arkansas, which occupies north-central Oklahoma, is composed of nine stream segments that include the Arkansas River (Keystone Dam to Kansas state line), Salt Fork, and Cimarron River (excluding Cimarron County).

Basin 7, Panhandle, includes northwestern Oklahoma and the Panhandle counties. The North Canadian River (Canton Dam to Texas state line) and the Cimarron River are the principal streams in Basin 7.

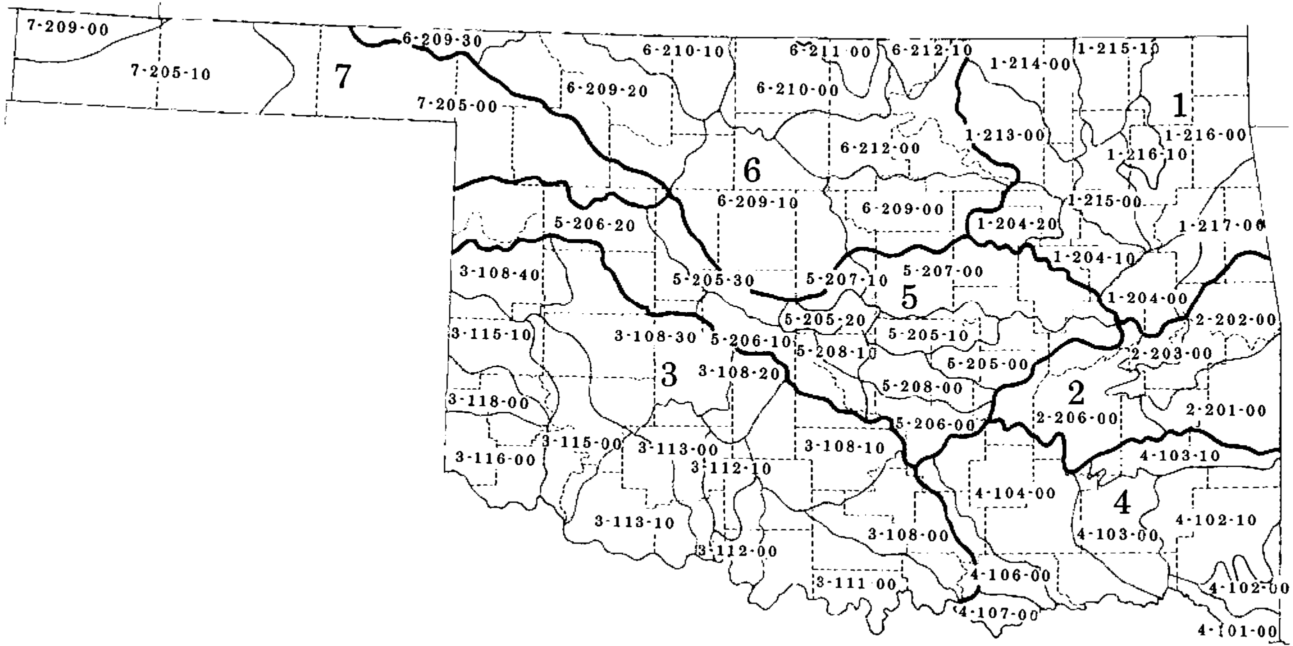

Figure 2. Water-quality-planning basins of Oklahoma and their stream segments. Stream-segment name and corresponding number are found in table 1 (modified from Oklahoma Water Resources Board, 1978).

TABLE 1. WATER-QUALITY-PLANNING BASINS AND STREAM SEGMENTS (modified from the Oklahoma Water Resources Board, 1978)

Basin	Segment number	Segment name	Basin	Segment number	Segment name
1	1-204-00	Arkansas River (Webbers Falls to Taft)	4	4-102-10	Little River (above Glover Creek)
	1-204-10	Arkansas River (Taft to Bixby)		4-103-00	Kiamichi River (below Jackfork Creek)
	1-204-20	Arkansas River (Bixby to Keystone Dam)		4-103-10	Kiamichi River (above Jackfork Creek)

	1-213-00	Bird Creek
	1-214-00	Caney River
	1-215-00	Lower Verdigris (below Oologah Dam)
	1-215-10	Upper Verdigris (above Oologah Dam)
	1-216-00	Grand River
	1-216-10	Pryor Creek
	1-217-00	Illinois River
2	2-201-00	Poteau River
	2-202-00	Arkansas River (Webbers Falls to Arkansas State line)
	2-203-00	Canadian River (Arkansas River to Eufaula Dam)
	2-206-00	Canadian River (Eufaula Dam to Calvin)
3	3-108-00	Washita River (below Davis)
	3-108-10	Washita River (Davis to Little Washita River)
	3-108-20	Washita River (Little Washita River to Verden)
	3-108-30	Washita River (Verden to Clinton)
	3-108-40	Washita River (above Clinton)
	3-111-00	Red River (Ryan to Lake Texoma Dam)
	3-112-00	Beaver Creek (below Waurika, including Cow Creek)
	3-112-10	Beaver Creek (above Waurika)
	3-113-00	Cache Creek
	3-113-10	Deep Red Run
	3-115-00	Lower North Fork of Red River (below Elm Fork)
	3-115-10	Upper North Fork of Red River (above Elm Fork)
	3-116-00	Salt Fork of Red River
	3-118-00	Elm Fork of North Fork of Red River
4	4-101-00	Red River (below Kiamichi River to Arkansas State line)
	4-102-00	Little River (below Glover Creek)
	4-104-00	Boggy River
	4-106-00	Blue River
	4-107-00	Island Bayou and adjacent Red River
5	5-205-00	North Canadian River (Eufaula Dam to Beardon)
	5-205-10	North Canadian River (Beardon to Harrah)
	5-205-20	North Canadian River (Harrah to Yukon)
	5-205-30	North Canadian River (Yukon to Canton Dam)
	5-206-00	Canadian River (Calvin to Rosedale)
	5-206-10	Canadian River (Rosedale to Bridgeport)
	5-206-20	Canadian River (Bridgeport to Texas State line)
	5-207-00	Deep Fork (below Smith Creek)
	5-207-10	Deep Fork (above Smith Creek)
	5-208-00	Little River (below Thunderbird Dam)
	5-208-10	Little River (above Thunderbird Dam)
6	6-209-00	Lower Cimarron (Keystone to Beaver Creek)
	6-209-10	Middle Cimarron (Beaver Creek to Sand Creek)
	6-209-20	Upper Cimarron (Sand Creek to Kansas State line)
	6-209-30	Cimarron River (Panhandle)
	6-210-00	Salt Fork of Arkansas River (Salt Plains Dam to Arkansas River)
	6-210-10	Salt Fork of Arkansas River (Salt Plains Dam to Kansas State line)
	6-211-00	Chikaskia River
	6-212-00	Arkansas River (Kaw Dam to Keystone Dam)
	6-212-10	Arkansas River (above Kaw Dam)
7	7-205-00	North Canadian River (Optima Dam to Canton Dam)
	7-205-10	North Canadian River (Optima Dam to Texas State line)
	7-209-00	Cimarron River (Cimarron County)

A water-quality-management plan is being prepared for each of the 59 stream segments (Oklahoma Department of Pollution Control, 1979). Each plan contains, as an integral part, an evaluation of water quality by comparing the U.S. Geological Survey monitoring data for water year 1976–77 against the 1976 revised Oklahoma Water Quality Standards (table 2). This comparison provides the basis for classifying stream segments as either *water quality limited* or *effluent limited* (Oklahoma Department of Pollution Control, 1978a, 1978b).

Effluent limited is used where known water quality meets and will continue to meet appropriate water standards even after effluent limitations, such as governmental restrictions on quantities, rates, and concentrations of chemical, physical, biological, and other constitutents, are applied.

Water quality limited is a term which implies that violations of some Oklahoma water-quality standards have occurred or that no monitoring data are available. The comparison also provides a way to identify specific parameters, such as pH, toxic elements, and (or) turbidity, that violate or exceed Oklahoma water-quality standards.

TABLE 2. SUMMARY OF OKLAHOMA'S 1976 WATER-QUALITY STANDARDS AND NUMERICAL LIMITATIONS ADOPTED BY THE POLLUTION CONTROL COORDINATING BOARD FOR 208 PLANNING (Department of Pollution Control, 1979)

Element	Concentration limit (mg/l)	Element	Concentration limit (mg/l)
Ammonia (unionized)	0.2	Nitrate	10.0
Arsenic	.05	Selenium	.01
Barium	1.0	Silver	.000215[c]
Cadmium	.01	Sulfides	2.0
		Zinc	.15 (soft)
Chlorine	.007		.6 (hard)[d]
Chromium (hexavalent)	.05[a]	Cyanide	.014
Chromium (total)	.375[b]	Detergents (total)	.2[a]
		Detergents (ABS)	.35 (hard)[d]
Copper (total)	.01		.45 (soft)[d]
Fluoride	1.4	Phtalate esters	.003[a]
Iron (filterable)	.3[a]	Phtalate esters	.0365[b]
Iron	1.2[b]	Methylene blue active substances	.5[a]
Lead	.05[a]	PCB's	.00075
Lead	.12[b]	Phenolic compounds	1.25
Manganese	.05[b]	Carbon chloroform extract	.15[a]
Mercury	.002	2, 4-D	.1[a]
Nickel	.4	2,4, 5-T	.1[a]

[a] Applies to the public and private water supply beneficial use.

[b] Applies to the fish and wildlife propagation beneficial use.

[c] Amount or lowest detectable limit, whichever is larger.

[d] Water is defined as soft if the concentration of $CaCO_3$ is less than or equal to 100 mg/l. If the $CaCO_3$ is greater than 100 mg/l, then the water is defined as hard.

Note: Other considerations include color, oil and grease, dissolved oxygen, nitrogen/phosphorus, pH, chlorides, sulfates and total dissolved solids, turbidity, pesticides, and aesthetics.

After those parameters are identified as being in violation of State standards, an evaluation begins to determine the cause(s) and perhaps the source(s) that are contributing to the violation. The assessment process attempts to determine whether excess amounts of a particular substance are due to natural background or nonpoint or point sources. After the problem source(s) is identified, then alternatives for controlling the problem as well as a strategy for implementing plans are presented. Such strategies may include voluntary programs for nonpoint sources and more conventional regulatory programs for the various point-source dischargers.

Public Participation

Each segment plan is extensively reviewed prior to final approval by the Oklahoma Pollution Control Coordinating Board and certification by the Governor. A Policy Advisory Committee on the Environment (PACE) was established soon after the contract was awarded to DPC. This committee is composed of approximately 80 persons who represent a cross section of industrial, agricultural, environmental, and development interests—as well as representatives from all levels of government. PACE's principal function is to advise DPC and its consulting agencies on 208 planning. However, some of the committee members act as a liaison between DPC and the local areas from which PACE members come.

In addition to PACE, the DPC holds meetings to discuss individual segment plans. The meeting places are held in a central location within individual segment boundaries and usually arranged through the local substate planning district. Suggestions and comments from the segment-meeting participants, as well as from PACE members, are incorporated into a final segment plan. The segment plans are then incorporated into a basin plan, which, in turn, is combined with other basin plans to produce a statewide water-quality-management plan.

For additional information on Oklahoma's water-quality-management plan in specified areas, readers can contact either their local substate-planning district office (fig. 1) or the Oklahoma Department of Pollution Control, Box 53504, NE 10th and Stonewall, Oklahoma City, Oklahoma 73105.

References Cited

Oklahoma Department of Pollution Control, 1978a, Segment classification rationale: Statewide Water-Quality-Management Report No. 220, 4 p.

——— 1978b, Segment reclassification: Statewide Water-Quality-Report No. 230, 68 p.

——— 1979, Water quality management plan for the Washita River (Spring Creek to Foss Dam): Statewide Water-Quality Report Segment 3-108-30, 50 p.

Oklahoma Water Resources Board, 1978, Water quality planning and segments: Oklahoma Department of Pollution Control, map, scale 1:1,000,000.

AAPG to Hold Fall Education Conference

A 4-day fall education conference that will feature four courses on exploration each day will be held in Houston August 27–30 by The American Association of Petroleum Geologists.

The emphasis of the conference, which will be held in the ballroom complex of the Marriott Astrodome, is to further the professional development of geologists to cope more successfully with the many problems of exploration. Each day, participants can choose one of the four courses offered. A 500-page set of notes for all 16 courses will be provided to every participant. The only scheduled extracurricular activities are 1-hour cheese and wine socials to be held after the daily 6-hour courses.

The cost of the conference is $275, which includes a $25 nonrefundable registration fee. Living costs are not included, although the AAPG has reserved a block of rooms. Hotel-reservation cards will be provided with confirmation of enrollment.

All participants must be enrolled and confirmed in advance, as no on-site or 1-day registrations will be accepted. Registration forms and additional information are available from the AAPG Department of Education, P.O. Box 979, Tulsa, Oklahoma 74101.

Kenneth Johnson to Head Minerals Institute

Announcement was made in September 1978 of the award of a grant to The University of Oklahoma for the purpose of establishing a Mining and Minerals Resources Research Institute for the State of Oklahoma. The institute will be located on the Norman campus of the University.

The grant, for an initial $110,000, which is supposed to be increased $100,000 annually for an unspecified number of years, was given to Oklahoma by the Office of Surface Mining, Reclamation, and Enforcement, U.S. Department of the Interior, in accordance with Interior's program to establish such a center in each of 22 states having significant mining and mineral resources.

Governors of the states are responsible for seleeting sites, and, according to J. R. Morris, who made the preliminary announcement last summer as acting president of OU, then-Governor David Boren chose the University because of its long history of geological, geophysical, and petroleum-oriented programs. The presence on campus of the Oklahoma Geological Survey, with its extensive record of involvement in the development of economic mineral deposits and its work in mining-land reclamation, was also a significant determinant. Other on-campus strength comes from the School of Geology and Geophysics and the School of Petroleum and Geological Engineering. Charles J. Mankin, OGS director, was instrumental in obtaining the funding, and an OGS staff member, Kenneth S. Johnson, has been named director of the new institute.

Johnson, as geologist with the survey from 1962 to 1965 and from 1967 to the present, has played a major role in the OGS mineral-resources program. He is widely known for his work on Permian copper, salt, and gypsum deposits and is currently working on a U.S. Department of Energy grant program to assess uranium occurrences in Oklahoma (see *Oklahoma Geology Notes*, v. 38, April 1978, p. 65–66) and also a project funded by the U.S. Geological Survey to inventory past and current mining activity for all metallic and nonmetallic minerals in Oklahoma's 77 counties. He also functions as an environmental geologist, having conducted an inventory of surface-mined coal lands in eastern Oklahoma, which, with an assessment of reclamation practices, was published in 1974 as OGS GM-17. The more comprehensive mining-activity inventory mentioned will also incorporate a reclamation assessment. Ken has served as an adjunct professor to the OU School of Geology and Geophysics for several years, teaching courses in economic geology and environmental geology, and for 3 years he led an energy-fuels field course that will be repeated this summer.

In addition to this year's $110,000 grant, the University has received a scholarship fund of $160,000 to be used over a 4-year period, thus giving the institute an impact not only in sponsoring research and gathering data but in providing personnel trained in mineral exploration and mining technology.

Reports on DOE Uranium Program to Be Indexed

A cross-indexed listing of more than 5,000 reports dealing with the uranium-resource-assessment program of the U.S. Department of Energy's office in Grand Junction, Colorado, will be developed by a local college in Grand Junction, DOE announced recently.

A $38,000, one-year contract has been signed between Mesa College and Bendix Field Engineering Corp., the operating contractor for the department's facility in Grand Junction. The college will prepare a comprehensive bibliography of all the Grand Junction office reports, including those prepared by contractors. The bibliography will be indexed by author, key words, and, where applicable, by geographic location (state and county) and by National Topographic Map Series 1° x 2° quadrangle. It will be arranged numerically according to each report's identifier codes.

The main purpose of the project is to catalog the reports in such a manner that they will be easily accessible to the public and for use in the department's National Uranium Resource Evaluation (NURE) program.

Part T of Treatise (Crinoidea) Released

Of interest to all paleozoologists and other geologists who use invertebrates in their work is the publication of a new section of the *Treatise on Invertebrate Paleontology*. The 1027-page, three-volume set, released recently by The Geological Society of America and The University of Kansas, constitutes Part T, Echinodermata 2 (Crinoidea). Robert O. Fay, geologist with the Oklahoma Geological Survey, is one of the authors of the publication. Initial work on Part T dates back almost to the beginning of the monumental task of preparing the multivolume compendium.

The concept of the *Treatise* arose from a long-recognized need to integrate the mass of knowledge appearing in print on invertebrate fossils. In 1947 the councils of the Society of Economic Paleontologists and Mineralogists and the Paleontological Society joined forces to set in motion a project to fill this need; and Raymond C. Moore, the multifaceted paleontologist and stratigrapher of The University of Kansas and the Kansas Geological Survey, agreed to serve as editor for the prospective publication. Work by many of the foremost paleontologists of the world began shortly thereafter, and as each section (21 to date) has been issued it has become an authoritative reference.

Fay has been involved in the project since 1949 as both author and illustrator. Thomas W. Amsden, stratigraphic paleontologist with the OGS, has also served as a contributing author for previous volumes. The late Carl C. Branson, former director of the Survey, was a contributing author and also a member of the early SEPM council.

Echinodermata 2 (Crinoidea), Part T of the *Treatise on Invertebrate Paleontology,* can be obtained from The Geological Society of America, Publication Sales Department, 3300 Penrose Place, Boulder, Colorado 80301. The price is $55.00 for the set of three volumes. Purchased separately, Volume 1, a comprehensive text, is $27.00; Volume 2, systematic descriptions, is $26.00; and Volume 3, taxonomy, is $13.00.

Report on 1978 Uranium Seminar Issued by DOE

The development of the uranium market is one of the discussion topics reviewed in a report on the October 1978 Uranium Industry Seminar held in Grand Junction, Colorado.

The 245-page report, *Uranium Industry Seminar Proceedings, October 17–18, 1978,* was issued by the U.S. Department of Energy. DOE staff members from the Grand Junction office and from the department's headquarters in Washington, D.C., and representatives from the U.S. Nuclear Regulatory Commission and the U.S. Geological Survey presented 16 papers at the seminar. The topics of the papers included uranium-enrichment policies and plans, status of national uranium-resource programs, foreign exploration, uranium-ore reserves and potential resources, uranium-production trends and capability, and an update of uranium-mill licensing.

The department also announced that the 1979 Uranium Industry Seminar will be held October 16–17 at the Two Rivers Plaza in Grand Junction.

The report on the 1978 seminar, GJO-108(78), is available for $10 from the Technical Library, Bendix Field Engineering Corporation, P.O. Box 1569, Grand Junction, Colorado 81501.

OKLAHOMA HOSTS COAL FORUM

The Third Forum of Coal Geologists of the Western Interior Basin was held in Norman, Oklahoma, February 28–March 1, 1979, at The University of Oklahoma. The first day was highlighted by reports from coal geologists representing the various states involved. Topics ranged from progress of research projects to changes in annual coal-production figures to special problems concerning the impact of coal mining on the environment. S. A. Friedman, senior coal geologist from the Oklahoma Geological Survey, chaired the meeting.

Lawrence Brady, Kansas Geological Survey, said that Kansas is making a comeback in coal production. In all, 1,450,000 tons was produced in 1978, representing an increase of 38 percent over the previous year's production. All of the Kansas production came from strip mines.

Charles Robertson, Missouri Geological Survey, reported that coal production in his state during 1978 was slightly down from the previous year, owing in part to a soft market. A total of 5,800,000 tons was produced, all from surface mines. The Missouri Survey is starting a detailed county-by-county coal-mapping project. The maps will be published at a scale of half an inch to the mile and will be directed primarily toward use by coal operators.

Matt Avcin, Iowa Geological Survey, said that the market for Iowa coal has also been soft and that its comparatively high sulfur content makes it noncompetitive with western coal at this time. Production for 1978 was quoted at 600,000 tons, with 250,000 tons coming from underground mines and the remainder from surface mines. A special study concerning collapse of underground tunnels in coal mines under the city of Des Moines, dating back as far as 100 years, is currently being made by the Iowa Survey.

S. A. Friedman, Oklahoma Geological Survey, reported that Oklahoma coal producers once again set a new all-time production record, for the second consecutive year. A total of 5,400,000 tons was mined, all from surface mines. No underground mines are presently operating, although two are on standby. LeRoy A. Hemish, Oklahoma Geological Survey, presented a slide show and reported on the progress of the coal-mapping project in Craig and Nowata Counties, northeastern Oklahoma.

Others making contributions to the program included Don Menzie, OU School of Petroleum and Geological Engineering, who discussed the role of the recently established Energy Resources Center in relation to coal and some of the research projects currently being funded by the center. These research projects involve topics such as characterization of liquids and gases in the coal-conversion system; flame structure and the governing physical process of the burning of coal in oil spray; *in situ* desulfurization of coal using high-temperature, high-pressure reaction methods; and measuring trace elements in coal. Neil Livingston, Kansas Geological Survey, reported on a stratigraphic study of deep coals in the Kansas part of the Forest City Basin; Mel Marcher, U.S. Geological Survey, Water Resources Division, Oklahoma City, talked about hydrologic studies in progress in eastern Oklahoma and their relationship to coal mining (past, present, and future); and Joe Hatch, USGS, Denver, reported on the progress of investigations of trace elements in coal samples.

The second day of the meeting was spent in the field visiting one of Oklahoma's leading coal-producing strip mines—the P&K Mine at Henryetta. Mining methods used here include removal of overburden with drag lines, scrapers, 'dozers, and front-end loaders, and also augering of coal up to 200 feet back from the final cut once the economic limit for removing overburden has been reached. Reclamation plots were observed, and impact of the mining operation on the local environment was discussed.

The next annual meeting of the Coal Geologists of the Western Interior Basin has been scheduled tentatively for Rolla, Missouri, in the early spring of 1980.

—*LeRoy A. Hemish*

First Volumes Issued of Energy Bibliography

The first two volumes of *Energy Bibliography & Index*, a publication which in five volumes will list and abstract over 25,000 documents dealing with all energy sources, have been issued recently by Gulf Publishing Co.

The publication deals with literature dating from the turn of the century to the present, and the documents are indexed by subject, keyword, personal author, and corporate author. Also featured is a cumulative index.

Each entry in the bibliography section provides nine types of information: (1) an accession number, which remains the same in the four indexes; (2) personal or corporate authors; (3) title; (4) publisher, publisher's location, and number of pages; (5) date of publication; (6) additional bibliographic information; (7) location within the library; (8) subject descriptors for cross-referencing related documents; and (9) 50- to 100-word abstracts.

The *Energy Bibliography & Index* is being compiled by the Texas A&M University Library. Volumes 1 and 2 are available for $295 each from Gulf Publishing Co., Book Division, Department 135M, P.O. Box 2608, Houston, Texas 77001. A quarterly update is available at $90 per year, and a subscription to the entire set includes a 10-percent discount for each volume. The last three volumes will be sent annually.

USGS Publishes Land-Resource Bibliography

A bulletin that may be of interest to Oklahoma geologists has recently been published by the U.S. Geological Survey.

Bulletin 1442 is a selected bibliography and index of earth-science reports and maps relating to land-resource planning and management published by the USGS through October 1976. The contents were compiled by M. F. Eister.

The 76-page bulletin is available for $2.20 from USGS, Branch of Distribution, 1200 South Eads Street, Arlington, Virginia 22202.

USGS: THE FIRST HUNDRED YEARS

The USGS we have always with us—a constant source; provider of information; classifier; evaluator; custodian; mapper of lands, seas, moons, planets; provider of research funds; cooperator.

It has not always been so, however.

During the first century of life in these United States of America there was no U.S. Geological Survey. There were explorers, prospectors, surveying parties—mostly topographic mappers—under one authority or another: the U.S. Army, the Department of the Interior, the General Land Office, railroads. There were a few state geological surveys. There were geologists tacked onto various expeditions, rather like afterthoughts or, as Clarence King says, "camp-followers," and with little or no status (King, 1880, p. 4). Early scientific explorers, like Powell, Hayden, King, and Wheeler, conducted expeditions under one branch or another of the United States government, and sometimes their purview overlapped that of others; sometimes they ran into each other and came to verbal, if not physical, blows. In any case, it all cost a lot of money (Darrah, 1951; Meadows, 1952). Thus, there was need for a master plan that would get the work done more efficiently. The congress became convinced, and the National Academy of Sciences drew up such a plan in 1878.

Coordination had been urged earlier by several geologists, including Joseph Henry, president of NAS and secretary of the Smithsonian Institution, but Henry failed to push his proposal and died before it could be put into effect. Clarence King and John Wesley Powell picked up the baton (see Wilkins, 1958; Emmons, 1904; Rabbitt, 1969).

The federal survey was established by the 45th Congress on March 3, 1879, through enactment and approval of a bill allocating $6,000 in salary for a director of the survey "who shall be appointed by the President, by and with the advice and consent of the Senate." This officer was to have direction of "the classification of the public lands, and examination of the geological structure, mineral resources, and products of the national domain." (It reads rather like the establishment of the Oklahoma Geological Survey, more than a quarter century later, only on a larger scale.)

Clarence King, who was named first director of the USGS by President Rutherford B. Hayes, had trouble with the ambiguous designations "public lands" and "national domain" (King, 1880, p. 5; Wilkins, 1958, p. 246; Rabbitt, 1975, p. 7). King chose discretion as the better part of what private ownership in settled states and the Land Office might consider an invasion of their territory and restricted his "classification" to federally owned lands, which meant confining activities to the western states and territories. He divided all the region west of the 101st meridian into four districts, naming a division chief to each one (names which have since become famous): Samuel F. Emmons, geologist-in-charge for the Division of the Rocky Mountains; G. K. Gilbert, Division of the Great Basin; Arnold Hague, Pacific Division; Captain C. E. Dutton, Division of the Colorado.

King was an excellent choice to head up the new bureau. Well trained,

John Wesley Powell talking to a Paiute Indian during a northern Arizona survey more than 100 years ago. (Photo courtesy of U.S. Geological Survey.)

well experienced, a true scientist, he embodied the developing professionalism that had been lacking in the field of geology (see Rabbitt and Nelson, 1979). He acted as peacemaker between rival government surveys (Emmons, 1904) and was an outstanding administrator. After three years of exploring and evaluating significant geological discoveries in the Sierras and the California deserts for the Geological Survey of California, he proved his mettle in 1867 at the age of 25. At this time he planned, secured approval, organized, and staffed the famous survey along the 40th parallel which resulted in a massive 7-volume set of reports covering all phases of geology plus mining, botany, and zoology. He carried the project through to its completion in 1878 with the summary publication of the final volume on *Systematic Geology*.

King had accepted the post of director of the U.S. Geological Survey with the understanding that his term would end when the new bureau got going, and his resignation was accepted regretfully in 1881 by President James A. Garfield, who then appointed John Wesley Powell to the post.

John Wesley Powell, most famous for his daring explorations of the Colorado River, was a romantic figure—shaggily bearded and with a forearm lost to the Battle of Shiloh—who looked like a cross between a soldier of fortune and an avenging, fire-and-brimstone fundamentalist preacher. He was a much different quantity from Clarence King, the urbane, sophisticated, Yale-educated Renaissance-type man (see Hague, 1904).

Powell, the son of an abolitionist Methodist minister in antiabolitionist territory, was removed from primary school for his own safety, and although he received inspirational tutelage from naturalist friends he was largely self-taught, with only brief periods of formal education. Nevertheless, he taught school, working overtime to keep ahead of his young students. He was made principal and then school superintendent, and following almost 4 years of extremely active army duty he progressed to become professor of geology at Illinois Wesleyan University and then at Illinois State Normal University, where he was also made curator of a State Natural History Society Museum (Meadows, 1952; Darrah, 1951). If self-taught, he seems to have had an excellent teacher.

His field explorations in the West began with a trip in 1867 to Middle Park and South Park in the Colorado Rockies with some of his students and a few amateur naturalists. This expedition was financed by scrounging and by asking for and receiving grants from Illinois Industrial University and the Chicago Academy of Sciences. In addition, he obtained passes from the railroads, army rations issued on order of General U. S. Grant, and scientific instruments lent by the Smithsonian; he also contributed his own salary. Support for an 1868 expedition was gained in the same way. He went to Congress for help for the 1869 Colorado River exploration and was turned down, so he went through the process again. It was partly this need to raise funds and backing that impelled him to go to Washington and do some politicking. He first received federal appropriations for his work in 1870, when he took a second trip down the Colorado.

Powell became much interested in the American Indian during his western explorations and was a strong voice for the Indian cause. At the time of his appointment by President Garfield he headed the Bureau of Ethnology of the Smithsonian in addition to functioning as senior geologist for the USGS. He also became much concerned with land usage—its orderly development and irrigation—and wrote a report published in 1878 on the "Lands of the Arid Region of the United States," which called for land reforms that were too far ahead of the time to be accepted (Rabbitt, 1969).

He stepped on some toes, and he continued to do so during his directorship. Powell was a different quantity from Clarence King in this administrative position as well as in background and personality, although the two were friends. King was cautious, diplomatic, counciliatory; Powell seems to have been a hew-to-the-line, damn-the-torpedoes type of person. Their concepts of the functions of the federal survey varied. King's focus was on mining geology and mineral resources, with general geology, topographic work, and paleontology auxiliary to the economically oriented research which he saw as the primary need in the continuing industrial development of the expanding nation. Powell's view encompassed more, with topographic mapping of the whole country a fundamental goal, but with general geology, paleontology, hydrology, and land classification essential not only in themselves but as part of the whole geologic field, including development of natural resources.

Powell organized branches of research, starting a division of chemistry and physics, a division of paleontology, a division of hydrography, and also divisions with operative functions, such as a library, a division of engraving, and a division of accounts (Meadows, 1952). Powell did a great deal for his country and its geological bureau, but a lot of people were glad to see him go when he resigned in 1894. He was succeeded by Charles D. Walcott.

James H. Irwin, district chief of U.S. Geological Survey, Water Resources Division, Oklahoma, cuts centennial cake at "mini-celebration" in Oklahoma City USGS offices. Ceremonies conducted March 2 and 3 at the USGS National Center in Reston, Virginia, were attended by Charles J. Mankin, director of the Oklahoma Geological Survey. (Photo courtesy of Michael Johnston, U.S. Geological Survey.)

Walcott, who had a reputation throughout the world for his work in paleontology, particularly the Paleozoic fossils of the West, the Medusae (jellyfish) in the Appalachians, and especially his classification of the Cambrian on the basis of trilobites, had been with the USGS from almost the beginning, starting out as a $50-a-month assistant in July 1879 (King, 1880). Walcott had as broad an outlook as Powell, but there was less resistance to his program. He was instrumental in the establishment of national forests, the Reclamation Service, the Museum of Natural History, the National Park Service, the Carnegie Institution, and the U.S. Bureau of Mines (Yochelson, 1979). He died in office in 1927.

That is how it all started. There have been other directors—seven others, to be specific: George Otis Smith, Walter Curran Mendenhall, William Embry Wrather, Thomas B. Nolan, William T. Pecora, Vincent E. McKelvey, and now H. William Menard; and things have gone up and down, but mostly always forward. There have been a lot of gaps filled in, expansion into new areas; there is a lot left to be done, but it is most remarkable what has been done.

All those in any way involved in the field of geology and associated disciplines are aware to some extent of the USGS as it is today. An indication of the scope of the bureau's present activities can be found in one of its own recent publications, U.S. Geological Survey Circular 777, *A Guide to Obtaining Information from the USGS, 1978* (see Oklahoma Geology Notes, v. 38, p. 101). The circular is free on request from the Branch of Distribution, U.S. Geological Survey, 1200 South Eads Street, Arlington, Virginia 22202.

We congratulate the United States Geological Survey on its first hundred years. It would be good to think that someone will be able to offer congratulations on its second hundred in 2079.

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—Elizabeth A. Ham

Report on Radioactive-Mineral Occurrences in Colorado Placed on Open File at OGS

A report entitled *Radioactive Mineral Occurrences of Colorado and Bibliography* has recently been placed on open file by the U.S. Department of Energy's office in Grand Junction, Colorado.

The two-part, 1,052-page book, sponsored by DOE, was compiled by James L. Nelson-Moore, Donna Bishop Collins, and A. L. Hornbaker, all with the Colorado Geological Survey.

The department describes the report as the most comprehensive bibliography and compilation of radioactive occurrences ever to be published for Colorado and should prove to be an invaluable reference and exploration tool for anyone interested in uranium, vanadium, or thorium in Colorado or adjoining states.

The report, GJBX-5(79), dated 1978, and designated as Bulletin 40 by the Colorado Geological Survey, is on open file at several locations, including the Oklahoma Geological Survey at The University of Oklahoma.

Printed copies of Bulletin 40 are available from the Colorado Geological Survey, Room 715, 1313 Sherman Street, Denver, Colorado 80203, for $37 over the counter or $40 mailed. Only 500 copies of the publication are available, and requests will be filled in the order received.

DOE Releases Three Hydrogeochemical Reports

The U.S. Department of Energy has recently placed on open file hydrogeochemical reports for the Enid Quadrangle in north-central Oklahoma and for the Ardmore and Sherman Quadrangles, which cover parts of southern Oklahoma and north Texas, as part of the National Uranium Resource Evaluation (NURE) program.

The reports, prepared by the staff of the Oak Ridge Gaseous Diffusion Plant in Oak Ridge, Tennessee, are *Hydrogeochemical and Stream Sediment Reconnaissance Basic Data for Ardmore NTMS Quadrangle, Oklahoma*; *Hydrogeochemical and Stream Sediment Reconnaissance Basic Data for Sherman NTMS Quadrangle*; and *Hydrogeochemical and Stream-Sediment Reconnaissance Basic Data for Enid NTMS Quadrangle, Oklahoma.* The reports are on file at several locations in the nation, including the Oklahoma Geological Survey.

Results of uranium analyses of water samples by fluorometric and mass spectrometry-isotope dilution methods are presented in the reports. Uranium in stream sediments was analyzed by fluorometry and by delayed neutron counting.

In the Ardmore Quadrangle, stream-sediment samples were collected from 782 sites, and ground- and surface-water samples from 745 sites. Uranium concentrations in ground-water samples range from 0.20 to 84.11 parts per billion (ppb), and stream sediments from 0.47 to 46.20 parts per million (ppm).

Atomic absorption, plasma-source emission spectrometry, and spectrophotometric methods were used for analyses of 27 other elements in sediments and 24 other elements and ligands in stream-water samples.

In the Sherman Quadrangle, stream sediments were collected at 715 sites, and ground-water samples were collected at 718 sites. The uranium concentrations range from less than 0.02 to 298.20 ppb in water samples, and from less than 0.25 to 4.91 ppm in sediments.

In the Enid Quadrangle, stream sediments were collected at 516 sites, and ground waters were collected from 677 sites. The uranium concentration ranged from less than 0.20 to 148.30 ppb in water samples, and from less than 0.25 to 5.58 ppm in sediments.

In all three reports, analytical data and field measurements are presented in tables, diagrams, maps, and statistical plots. Generalized geologic maps and summaries of the geology of the areas are also included.

The reports on microfiche can be obtained from DOE's Grand Junction, Colorado, office. The 92-page Ardmore report, GJBX–142(78), is available for $5, the 34-page Sherman report, GJBX–134(78), for $6.50, and the 36-page Enid report, GJBX–7(79), for $5. Prepaid orders should be sent to Bendix Field Engineering Corp., Technical Library, P.O. Box 1569, Grand Junction, Colorado 81501.

A computer-readable magnetic tape for each quadrangle, containing measurement, analysis, and location data, is available for $80 each from Frank D. Hammerling, GJOIS Project, UCC-ND Computer Applications Department, 4500 North Building, Oak Ridge National Laboratory, P.O. Box X, Oak Ridge, Tennessee 37830.

OKLAHOMA ABSTRACTS

GSA Annual Meeting, South-Central Section Mountain View, Arkansas, April 9–10, 1979

The following abstracts are reprinted from the *Abstracts with Programs* of The Geological Society of America, v. 11, no. 2. Page numbers are given in brackets below the abstracts. Permission of the authors and of Mrs. Jo Fogelberg, managing editor of GSA, to reproduce the abstracts is gratefully acknowledged.

OKLAHOMA ABSTRACTS is intended to present abstracts of recent unpublished papers relating to the geology of Oklahoma and adjacent areas of interest. 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.

Structure along a Portion of the Nemaha Uplift and the Southern Extension of the Central North American Rift System in East-Central Kansas

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Basement structural information is derived from isopach and structure contour maps constructed on six easily identifiable overlying Paleozoic units. The study area is of importance because it includes the southeastern extension of the Central Kansas Uplift, the southern end of the known basalts of the Central North American Rift System, and the Nemaha Uplift. Two principal sets of fault trends are recognized (NW and NNE). Several periods of tectonism extending into Pennsylvanian time affected the basement and overlying sedimentary rocks. Precambrian basement rocks in the study area consist of granitic to quartz monzonitic and mafic intrusives, metasediments, and sediments of the Rice Formation. It is postulated that the boundaries between them are mostly structural controlled. A major NW trending fault brings the Keweenawan rift basalts in contact with the sediments of the Rice Formation to the south. Aeromagnetic data suggest that the basalts continue farther south at a greater depth. Patterns and rates of sedimentation were influenced by these structures and some of the more pronounced structures can be recognized in today's distribution of rock types and stream patterns. [145]

Mesozoic Charophyte Gyrogonite Orientation—Atopochara Trivolvis **from the Cretaceous Baum Formation of Oklahoma**

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The correct orientation of the gyrogonite of fossil charophyte genera, except the stellatocharaceids and the clavatoraceids was ascertained by Conkin and Conkin (1977); ready orientation of the gyrogonites of these forms has been hampered by the tendency for increased ornamentation of the gyrogonite resulting in a utricle in the clavatoraceids and a trend toward elongation of the apical portion of the enveloping cells resulting in an "apical beak" in the lagynophoraceids. The scheme of orientation of charophyte gyrogonites presented by Conkin *et al.* (1970, 1972, 1974, and 1977), which is consistent with the orientation of modern charophyte oogonia, has been applied to a detailed study of *Atopochara trivolvis* from the Cretaceous Baum Formation of Oklahoma and has substantiated our former suspicions (1977) that the gyrogonites of the Jurassic-Cretaceous clavatoraceids have been oriented upside down; that is, the apical pole and basal pole have been confused with each other. Criteria used in differentiation of the basal pole of *A. trivolvis* are: general outline of the gyrogonite is acutely angled, the basal pore is large and truncates the enveloping cells, the cage superstructure is present and its walls are somewhat concave with pit-like "sags" where it overlaps the cage, and a basal attachment scar is present; in general, the opposite conditions prevail in the apical region of the gyrogonite. This corrected orientation clarifies the phylogenetic patterns within the clavatora-

ceids and their ancestors, the stellatocharaceids, and their descendants, the lagynophoraceids, as well as within fossil charophytes in general. [146]

Methods for Digital-Model Evaluation of Alluvial Deposits of the North Canadian River, Northwest Oklahoma

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Quaternary deposits of the North Canadian River are a major source of ground water in northwestern Oklahoma. These deposits consist of hydrologically interconnected windblown sand and silt, terrace deposits, and alluvium.

Recharge to the aquifer in the 800 square-mile area is from precipitation that annually ranges from 20 inches in the northwest part of the area to 26 inches in the southeast. Discharge from the aquifer is to streams, evapotranspiration, and pumpage. In most of the area, recharge equals discharge; however, pumping during the past 15 years locally has reduced saturated thickness as much as 30 percent.

A two-dimensional finite-difference model is used to quantitatively describe the aquifer. Potentiometric head, base flow of streams, and irrigation pumpage are applied as input in the model. Rocks of Permian age, which underly the aquifer, serve as a relatively impermeable boundary. [146]

Aquifer Characteristics of the Arbuckle Aquifer, South-Central Oklahoma

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The Arbuckle aquifer in south-central Oklahoma is a relatively untapped source of readily available fresh water. Rocks that make up the Arbuckle aquifer crop out in an area of about 375 square miles. The aquifer consists of formations of the Arbuckle Group (Late Cambrian to Early Ordovician age) and the overlying Simpson Group (Ordovician age) that were structurally deformed during Late Paleozoic orogenies.

Most of the aquifer consists of limestone and dolomite. Secondary permeability is provided by joints, fractures, and solution channels.

Techniques used to estimate areal values of specific yield (Sy) and transmissivity (T) of the Arbuckle aquifer include analysis of recession rates from streamflow hydrographs, baseflow analysis, and recession of water levels in a network of observation wells. These preliminary analyses suggest that the aquifer is under water-table conditions at shallow depth but may be partially confined at greater depths.

The aquifer is recharged by precipitation on the outcrop area. Annual precipitation, mostly as rainfall, averages about 38 inches. Winter-time baseflow measurements of these streams are used to estimate ground-water discharge from the Arbuckle aquifer. The difference between winter and summer baseflow, together with other data, is used to estimate evapotranspiration by riparian vegetation along the major streams. [147]

Wichita Mountains Geomorphology and Implications for Tectonic History

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Analysis of the landforms in parts of the Wichita Mountains of southwestern Oklahoma indicates:

1) An overall tor topography where underlain by granite.
2) This topography is of Permian age.
3) Tors are more prominent along the southern, and topographically lower, side of the range.
4) Boulder streams are more common along the northern, and topographically higher, side of the range.
5) Boulder size, as noted by other workers, is mostly determined by fracture spacing. However, fracture spacing is not simply or directly related to grain size as has been asserted previously.

The consequences of these observations are that the Permo-Pennsylvanian Wichita tectonic cycle ended with the following sequence:

1) A period of quiescence with deep weathering.
2) Regional uplift which formed the present topography. Faulting associated with this uplift should be sought.
3) Deposition of Post Oak conglomerate whose rounded boulders and cobbles may be due more to weathering than erosion. The origin and character of the Post Oak is thus different than that of the "granite wash" of the Anadarko Basin.
4) Final burial of the eroded Wichita structural axis in a flood of Ouachita-derived sediments. [147]

Occurrence of Microgabbro and Troctolite at Iron Mountain, Wichita Mountains, Oklahoma

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Rocks which comprise Iron Mountain and outcrops to the east are typically medium-grained troctolites with bytownite and olivine making up more than 95% of their total volume. Igneous lamination, found elsewhere in the Wichita Mountains, has been recorded for the first time at Iron Mountain. Mineralogically and texturally, the troctolites are very similar to some of the exposed cumulates of the Glen Mountains Layered Complex, and Iron Mountain is therefore considered to be a part of this complex. Outcrops of mafic rocks south of Iron Mountain were originally included with the troctolites, but now they are thought to represent a separate mafic unit, more appropriately termed a microgabbro. The microgabbro is finer-grained and contains a more sodic plagioclase than the Iron Mountain troctolites. In addition, pyroxene which rarely comprised more than 2% of the troctolites, makes up approximately one third the microgabbro. The orthopyroxene shows two distinct directions of exsolution, and may represent inverted pigeonite, the first reported occurrence of it in the Wichita Mountains. The similarities between the microgabbro found at Iron Mountain and other known occurrences of microgabbro in the Wichita Mountains, suggests an intrusive relationship with respect to the layered complex, and hence with the troctolites of Iron Mountain. [148]

1000 Years of Paleoclimatic History from Northeastern Oklahoma

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Three pollen and four land snail successions from six archeologic sites in Osage County, Oklahoma, are radiocarbon dated from about 700 to 1750 years B.P. The sites occur in the present day post oak-blackjack oak Cross Timbers. The prehistoric pollen record shows that an oak-dominated forest, probably similar to the modern Cross Timbers vegetation, was present at 1600 B.P. Between 1600 and 1300 years B.P. hickory pollen frequencies increase, suggesting that hickory was a more important component of forest vegetation and that the climate was more moist than today. At the same time the snail *Anguispira alternata*, which inhabits moist wooded places in the Plains, was more abundant than today. By about 1300 and no later than 1100 years B.P., hickory abundance decreases to modern values and *A. alternata* drops in frequency. During this period the dry habitat snail *Triodopsis cragini* appears for the first time at one site and greatly increases in abundance at another.

The pollen and land snail evidence both indicate a climate slightly more moist than today's beginning about 1600 years B.P. and peaking about 1300 years B.P. From 1300 to 700 years B.P., pollen and snails indicate an increase in drier habitats. Records dating from the past 700 years in the Southern Plains are sparse and inconclusive. [148]

Late Mississippian Paleogeography along the Ouachita–Southern Appalachian Belt

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Recently proposed tectonic-sedimentation models suggest that thick Carboniferous flysch strata of the Ouachita System were deposited in a remnant ocean basin south of the North American continental margin. The basin was probably bounded on the south by a southward dipping subduction zone and an island arc system attached to another continent (Graham et al., 1975). Collision and attendant subduction progressed through Carboniferous time and with it a wave of deformation and molasse sedimentation migrated from east to west along the suture zone.

Facies patterns of Late Mississippian (Meramec-Chester) shelf clastics and carbonates flanking the Ouachita and Southern Appalachian System, can be interpreted under the constraints established by the aforementioned tectonic model. In north Alabama, NE-SW flowing tidal currents shaped much of the Monteagle Ls. into elongate, oolitic tidal bars. They interfinger to the southwest

with prodelta mud and delta fringe sandstone (Pride Mountain Fm.) which were funneled into the Black Warrior Basin from a major delta system located along the collision suture zone. This delta system also provided much of the sediment comprising the Stanley Group flysch via submarine fans. In north Arkansas fine-grained clastics of the Moorefield Fm. accumulated on a low energy, relatively deep, southeastward sloping shelf that merged with the eastern Ouachita trough. Harmonic amplification of oceanic tidal waves near a regional slope break in northeast Arkansas created high energy conditions and led to the development of widespread oolite shoals (Ste. Genevieve Ls.) on the shelf. Detritus from the Michigan River delta blanketed areas behind the oolite shoals. [148]

Geohydrology of the Antlers Aquifer, Southeastern Oklahoma

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The Antlers aquifer, which is named after the Lower Cretaceous Antlers Sand of local usage, consists of as much as 900 feet of friable sandstone, silt, clay, and shale; it crops out in an area of 1,860 square miles and underlies about 4,400 square miles in southeastern Oklahoma. Precipitation ranges from 34 to 50 inches per year across the outcrop area which is well suited to allow high rates of infiltration. The aquifer contains an estimated 70,000,000 acre-feet of water having less than 1,000 milligrams per liter of dissolved solids. The average saturated sand thickness is 250 feet. Aquifer tests indicate the average transmissivity is 1,480 feet squared per day and the average storage coefficient is 0.0005. Large-capacity wells tapping the aquifer commonly yield 100 to 500 gallons per minute; the maximum measured yield is 1,700 gallons per minute. Water usage from the aquifer is very small, owing to an abundance of surface water. Water quality throughout the central and northern part of the aquifer is generally acceptable for municipal use. A few wells, however, yield water containing concentrations of iron and manganese exceeding the limit recommended for municipal use by the Environmental Protection Agency. [148]

Ring Magnetic Anomalies as Indicators of Basement Calderas in the Central Province

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Several circular ring magnetic anomalies have been identified in the central Midcontinent region. The anomalies are defined by a circular to elliptical pattern of positive magnetic anomalies generally bordered by negative anomalies and ringing a central minimum. Amplitudes of the anomalies are 200-1000 gammas. The characteristic size of the circular magnetic features is 50 km in

diameter. A correlative positive gravity expression is present for some of the ring magnetic anomalies. Based on comparisons with gravity and magnetic signatures of Laramide age and Late Cenozoic calderas and volcanic depressions in the Cordillera and Japan, and modeling of the gravity and magnetic anomalies, the ring magnetic features are interpreted as being caused by thin volcanic rock deposits or ring dike complexes. Although the regional extent of the ring magnetic features in the central Midcontinent is presently unknown, identification of these features in a broad region of the Midcontinent suggests that the calderas may be a widespread feature of the Central Province. The recognition of ring magnetic anomalies is facilitated by high-quality magnetic anomaly maps which are becoming available in the Midcontinent. The volcanic activity is believed to be related to anorogenic igneous events of about 1.3 to 1.5 b.y. age. [149]

The Arkansas Novaculite—a Silica Resource

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Most of the siliceous rocks of the Arkansas Novaculite formation are novaculite, but they also include some chert, siliceous shale, conglomerate, and, rarely, sandstone. Novaculite is defined as a homogeneous mostly white or light-colored rock, translucent on thin edges with a dull to waxy luster and comprised almost entirely of microcrystalline quartz. The most plausible theory of origin for novaculite is that primary silica from submarine volcanism was picked up by organisms and deposited as amorphous silica, which was subsequently converted to microcrystalline quartz (novaculite) through diagenesis. The Arkansas Novaculite formation crops out over an east-west distance of 200 miles in the Ouachita Mountains of Arkansas and Oklahoma. Three divisions of the formation have been defined: a Lower Division almost entirely massive light-colored novaculite; a Middle Division of interbedded dark chert and shale; and an Upper Division of massive calcareous novaculite. The Lower Division and most of the Middle Division are Devonian in age, and the remainder of the Middle Division and all of the Upper Division are Mississippian. The massive novaculites of the Upper and Lower Division attain their maximum development along the southern and central outcrop belts of the formation in Arkansas, and it is these rocks that are the source of current silica production. The calcareous novaculite of the Upper Division weathers readily to a light-colored, porous, less brittle rock, and in places to tripoli deposits. Currently tripoli is mined from a single deposit near Hot Springs, Arkansas, and the rock is processed for highly specialized filler and abrasive applications. In the vicinity of Hot Springs, Arkansas certain novaculite layers from the Lower Division of the formation with unique textural characteristics are quarried and processed into whetstones. Several small quarries produce this rock for two local and one out-of-state whetstone fabricating plants. Chemical analyses of composite samples of novaculite from both the Upper and Lower Divisions taken at widely separated localities average 99 percent SiO_2 indicating a substantial resource of high silica rock.
[149]

Alkali Metasomatism in Anorthosite at Twin Mountains, Kiowa County, Oklahoma

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Twin Mountains, located south of Roosevelt, Oklahoma, represents an eroded pluton of anhydrous Lugert Granite in which a large xenolithic body of anorthosite has been included. The single perthitic feldspar of this hypersolvus granite attests to its low PH_2O. Field observations indicate a sharp contact between the enclave and host, together with a network of minute but ramifying granitic veinlets which invade the anorthosite. Textural relationships reveal a second generation introduction of euhedral hornblende with concomitant introduction of quartz and potassium feldspar into the cooler and more basic enclave. Simple zonation of the anorthosite plagioclases from calcic cores to clear albitic rims suggests release of sodium simultaneous with the replacement of plagioclase by potash feldspar. Movement of calcium is evidenced by the appearance of epidote, sphene, prehnite, and calcite. Introduction of potassium and silica appears to have been along the crude lamination of the anorthosite, the opening of which was facilitated by dilation upon heating by the granite. [150]

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Palynological Evidence for Age Assignment of Basal Cherokee (Pennsylvanian) Strata in Southeastern Kansas

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In southeastern Kansas, shales of the Cherokee Group (Pennsylvanian, Upper Carboniferous) rest unconformably upon Mississippian (Lower Carboniferous) limestone of the Chester Series. Although the Cherokee Group is known to be of Pennsylvanian age some doubt exists as to the correct stratigraphic assignment of the basal shales recovered from the No. 1 Velie Swalley well of the Eagle-Picher Industries, Inc. This well is located in Section 3, Township 35 South, Range 24 East in Cherokee County, Kansas. As an aid to resolving the problem of age assignment palynological evidence has been sought and the results of that investigation are presented in this report.

The Cherokee Group was defined in Kansas where it received its name from exposures in Cherokee County as the strata occurring between Mississippian rocks below the Fort Scott Limestone above. It is recognized as the lower portion of the Desmoinesian Series. The upper portion of that series is known as the Marmaton Group. In Oklahoma the Cherokee Group is divided into the Krebs Group (below) and the Cabaniss Group (above). In Kansas these two groups have been treated as subgroups of the Cherokee Group. The basal formation of the Krebs Group in Oklahoma is presently the Hartshorne; however, there is palynological evidence that the underlying Atoka Formation should also be included in the group. There is a general opinion that in southeastern Kansas, the Hartshorne Formation and a portion of the overlying McAlester Formation are not present. Also there was a possibility that the basal shales in the No. 1 Velie Swalley were older than the Cherokee Group.

Six shale samples were collected from cores of the well at intervals between 32 and 50.5 feet. These were processed by a standard method for palynologic study and all except the top 3 foot sample produced a wealth of fossils. The top sample was a weathered shale, and the bottom sample was in contact with the Mississippian limestone. In addition to the well samples, others were collected from the lowest Cherokee coal, the Riverton, in Cherokee County, Kansas, and at one east-central Oklahoma location in Muskogee County. These coals were collected for interstate correlation and the possibility that the well shales might belong to the Riverton Cyclothem, the lowest in the Kansan Cherokee Group and in Oklahoma a member of the McAlester Formation.

The No. 1 Velie Swalley shales contain 45 species in 37 genera, the Kansas Riverton coal (a channel sample) contains 22 species in 15 genera, and the Oklahoma Riverton coal (segment samples) 18 species in 7 genera. Investigation of the Oklahoma coal is continuing. The genera with the largest number of specimens in the shales are *Lycospora* 12–45%, *Densosporites* 12–20%, *Crassispora* 4–17%, and *Torispora* 4–9%. By contrast the Kansas Riverton coal has *Lycospora* 33%, *Laevigatosporites* 14%, *Torispora* 8%, *Triquitrites* 8% and *Calamospora* 7%. A comparison of the assemblages indicates floristic similarity but statistical and possibly ecological differences are typical of associated coal and shale deposits. The shales contain in addition to specimens of yellow to light brown color, which are considered synchronous with sediment deposition, a number of spores that are dark brown to black and which undoubtedly were recycled from the underlying Chester Series (Mississippian) and possibly Morrowan Series (lowest Pennsylvanian) rocks. Some genera from the Mississippian rocks are species of *Densosporites*, *Cirratriradites*, and *Knoxisporites*. From the Morrowan rocks some species of *Densosporites*, *Cristatisporites*, *Spencerisporites* and *Costatocyclus* appear to have been recycled.

Palynological evidence for an age assignment for the basal Pennsylvanian shales in the No. 1 Velie Swalley well hinges largely on the general composition of the floristic assemblage and certain genera and species of palynomorphs with restricted ranges. The flora listed above reports the genera with greatest abundance and the majority of additional palynomorphs like the former are common Desmoinesian genera and species. Several range from the Mississippian to the lower Desmoinesian strata as for example the genus *Densosporites* which occurs no higher than the middle of the Desmoinesian Series except as recycled specimens. *Cirratriradites saturnii* has approximately the same range. *Alatisporites hoffmeisterii* is known in Oklahoma only from the Rowe coal, Savanna Formation, which overlies the McAlester Formation. In Illinois it is reported from

Relative Abundance of Palynomorph Genera in 1 Velie Swalley Well
and Adjacent Riverton Coal Seam

	Depths below surface and assemblage percentages					
	50-50.5 ft	49 ft	48-45 ft	43-45 ft	38-40 ft	Riverton coal
Acanthotriletes	1.0	0.5	0	1.0	---	0
Alatisporites	.5	0	0	0	1.0	0
Calamospora	.5	0	3.0	0	1.0	7.0
Cirratriradites	2.0	2.0	3.0	2.0	3.0	1.0
Convolutispora	0	.5	0	0	0	1.0
Crassispora	4.0	4.5	17.0	7.0	4.0	1.0
Cristatisporites	0	0	0	0	1.0	0
Densosporites	17.5	19.0	12.0	12.0	15.0	1.0
Dictyotriletes	3.5	6.0	5.0	2.0	1.0	0
Endosporites	2.5	.5	6.0	2.0	3.0	4.0
Florinites	1.0	1.5	6.0	5.0	1.0	1.0
Granulatisporites	3.0	2.0	5.0	3.0	2.0	5.0
Laevigatosporites	4.5	3.0	5.0	2.0	2.0	14.0
Leiotriletes	1.5	1.5	0	2.0	1.0	2.0
Lescheckisporis	.5	0	0	0	0	0
Lophotriletes	0	0	0	0	0	3.0
Lundbladispora	3.5	4.0	4.0	2.0	2.0	1.0
Lycospora	37.5	38.0	15.0	38.0	40.0	33.0
Punctatisporites	5.0	1.5	8.0	9.0	7.0	6.0
Raistrickia	.5	1.0	0	0	1.0	3.0
Reinschispora	.5	.5	0	0	0	0
Simozonetriletes	0	.5	0	0	0	0
Spencerisporites	0	.5	0	0	0	0
Torispora	9.0	6.0	3.0	3.0	7.0	8.0
Triquitrites	1.0	4.0	1.0	5.0	1.0	8.0
Vestispora	.5	1.0	4.0	0	0	1.0
Wilsonites	.5	2.0	3.0	5.0	7.0	0

the Fithian Cyclothem in the McLeansboro Group which is in higher Pennsylvanian position than the Cherokee. *Columinispora ovalis* and *Zosterosporites triangularis* are reported as new occurrences in Kansas. The former occurs in the Murphysboro coal of Illinois which is near the top of the Krebs Group of the Cherokee. The latter was described from the Princess coal of Kentucky, a position near the top of the Cherokee in Kansas. Other genera, *Lueckisporites*, *Striatites*, and *Lundbladispora*, have not been observed lower than the Cabaniss Group of the Cherokee; consequently these occurrences are range extensions. A number of observed species range from older Pennsylvanian strata upward into Cabaniss strata, consequently as age indicators for the basal shales in the No. 1 Velie Swalley well, they have no value. Some species extend into the overlying Permian rocks. The total palynologic assemblage of the basal shales in the No. 1 Velie Swalley well resembles most closely in composition the studied shales and coals of the McAlester Formation in Oklahoma and they are probably best assigned to the McCurtain Shale Member of the McAlester Formation.

Study of Sedimentary Environments Updated

Ancient Sedimentary Environments (second edition), by R. C. Selley, issued recently by Cornell University Press, is a valuable introductory survey on how to recognize depositional environments of sedimentary rocks. Besides discussing the classification of sedimentary environments and evaluating the methods used to identify them in ancient deposits, the book deals with particular depositional environments using case histories as illustrations. Also included is a summary of the diagnostic features of the major environments discussed. The book is aimed at readers with a basic knowledge of geology.

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The Effect of Intrastratal Solution on Heavy Minerals in the Minturn Formation (Pennsylvanian), Colorado, by Drew Robert Goodbread.

Genetic Study of the Northwest Butterly Field, Garvin County, Oklahoma, by Jaime Buitrago Borras.

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